Climate Impact Assessment Report

Residential Solar PV Loan

Prepared for the Clean Energy Federal Credit Union
October 2018

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CLIMATE IMPACT SCORE

CLEAN ENERGY CREDIT UNION

CERTIFICATE OF ASSESSMENT

Client:	Clean Energy Federal Credit Union		
Loan:	Residential Solar PV Loan		
Amount:	$20,000		
Closing Date:	N/A		
Location: United States		Sectors: Residential	Project Types: Rooftop solar PV

The Climate Action Reserve (Reserve) has conducted an assessment of the greenhouse gas (GHG) impacts of a loan for the installation of a 7kW residential solar photovoltaic (PV) electricity system issued by the Clean Energy Federal Credit Union (Credit Union). Using tools to estimate the expected energy production of the PV system, the Reserve applied its Climate Impact Score methodology to assess the expected future impacts over the 25-year expected useful life (EUL) of the PV systems. The scope of the assessment is the indirect (Scope 2, purchased electricity) reductions in greenhouse gas (GHG) emissions attributable to the solar PV system. The total output of the residential solar PV system is compared to a baseline scenario to determine the expected annual GHG emission and criteria air pollutant reductions. While these impacts were assessed, and are reported here, across all 50 US states, the summary metrics on the Certificate represent the nationwide average metrics. Over its 25-year lifetime, an average PV loan from the Credit Union for a 7 kW system would result in GHG emission reductions of approximately 153.53 tCO2e, which is 100% of the calculated best in class GHG reductions. This represents a GHG intensity of the loan of 7.68 tCO2e/$1000.

GHG REDUCTION TOTAL	GHG REDUCTION INTENSITY	GHG REDUCTION COMPARISON
153.53	7.68	100%
tCO2e GHG emissions reductions	tCO2e reduced per $1,000 invested	of reductions achievable in best in class scenario

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Executive Summary

The Climate Action Reserve (Reserve) has conducted an assessment of the greenhouse gas (GHG) impacts of a loan for the installation of a 7kW residential solar photovoltaic (PV) electricity system issued by the Clean Energy Federal Credit Union (Credit Union). Using tools to estimate the expected energy production of the PV system, the Reserve applied its Climate Impact Score methodology to assess the expected future impacts over the 25-year expected useful life (EUL) of the PV systems. The scope of the assessment is the indirect (Scope 2, purchased electricity) reductions in greenhouse gas (GHG) emissions attributable to the solar PV system. The total output of the residential solar PV system is compared to a baseline scenario to determine the expected annual GHG emission and criteria air pollutant reductions. While these impacts were assessed, and are reported here, across all 50 US states, the summary metrics on the Certificate represent the nationwide average metrics. The annual GHG reductions are then compared to a specified "best in class" scenario of the same category to provide context for the extent to which the funded project achieves the greatest possible reduction in GHG emissions (this assessment of optimal reductions is done regardless of the feasibility of the best in class scenario; see below for further discussion).

Project Background

The Clean Energy Federal Credit Union (Credit Union) is a Federally-chartered credit union, based in the State of Colorado (CO), whose lending activities are focused solely on promoting clean energy and energy efficiency nationwide. Residential Solar loans are available for the installation of any new residential solar photovoltaic or solar thermal system(s). For this assessment, the Credit Union has developed a hypothetical scenario of a $20,000 loan for the purchase and installation of a 7 kW solar PV system, with an EUL of 25 years.

Client	Amount Financed	Summary of Project
Clean Energy Federal Credit Union (Credit Union)	$20,000	7kW residential solar PV system

Methods

The Climate Action Reserve conducted an assessment of the expected GHG benefits of the hypothetical solar PV project financed by the Credit Union. 2017 was utilized as a fixed baseline year to estimate future GHG and criteria air pollutant reductions.[1] This assessment was based on information provided by the Credit Union, supplemented by data sources identified by the Reserve.

Information provided by the Credit Union:

- List and descriptions of eligible products and services for clean energy loans
- Direct communication to determine the assumptions used for the loan scenario

Additional data sources employed by the Reserve:

- Avoided Emissions and Generation Tool (AVERT), a product of the U.S. Environmental Protection Agency
- Hourly Load Reduction Tool, a model developed by the Climate Action Reserve specifically for the assessment of energy impacts which vary by time of day or season of the year

[1]The baseline year of 2017 was selected because it is the most recent year where emissions data are available.

- Annual Energy Outlook (AEO) projections of generation and emissions, published by the U.S. Energy Information Administration[2]

For the purposes of the Reserve's Climate Impact Score methodology, the PV system was categorized as an "energy supply" project. The methodology for assessing energy supply projects is discussed below.

Energy Supply

Energy supply projects entail the construction or installation of equipment or facilities that will generate electricity to be used in lieu of a baseline source of electricity generation. This could involve small-scale projects, such as rooftop solar photovoltaic systems or single wind turbines, or commercial-scale projects, such as solar or wind farms that send power into the high-voltage electricity transmission system. As a general rule, small-scale projects will be "behind the meter," or connected through the local, low-voltage distribution system, while large-scale projects will be connected through the high-voltage transmission system. The energy supply project financed by the Green Bank is the installation of residential (i.e., small-scale) solar PV systems. The general process for assessment of the GHG benefits of an energy supply project entails:

1. Categorizing the project;
2. Estimating the annual electrical output;
3. Employing AVERT to identify the specific baseline sources of electricity and the emissions impact of avoiding that marginal generation; and
4. Comparing to the best in class electricity generation scenario.

Below, we detail the approach the Reserve took to address each step of this process.

Categorizing the Project

For ex-ante and ex-post project financing assessments, there are differing levels of certainty regarding the project or activity that is expected to be financed. This certainty could range from having a general sense of the use category (e.g., HVAC) or it could be as detailed as the exact models and specifications for both existing and replacement boilers in a commercial building. The Reserve applies three levels of categorization, with a fourth level optionally applied in cases where data are available:

Level 1.	Sector (energy supply, energy efficiency, transportation, etc.)
Level 2.	Category (HVAC, lighting, building envelope, electric vehicle, etc.)
Level 3.	Sub-category (fluorescent to LED conversion, boiler upgrade, vehicle model, etc.)
Level 4.	Specific technology or performance data

In some cases, the information available to the Reserve may be no more specific than level 1, whereas in other cases it will be as specific as level 4, with details about the equipment being replaced and the equipment being installed.

For the PV loan, we know the technology being employed, and the size of the installation, but not any specific details regarding where the system would be installed. This would be considered Level 3 information, since more specific details, such as angle to the sun, latitude, or shading, could alter the results of the impact assessment for this type of project.

[2] More information is available at: https://www.eia.gov/outlooks/aeo/.

Estimated System Size – Client data or PVWatts

In many cases, the client will at least know the expected size (maximum kW output) of a renewable energy system. In those cases, where the system size or expected output are reported in the client data, those values will be used in the GHG assessment. In other cases, where only the type of system (e.g., solar photovoltaic) and location are specified, an assumption made be made regarding the potential system size. In these cases, the National Renewable Energy Laboratory (NREL) PVWatts Calculator may be used to actually sketch out a PV system overlaid on aerial photography of the target facility. This allows for a very accurate estimate of the potential system size, accounting for the actual building and site characteristics, such as trees, driveways, rooftop units (RTUs), skylights, and other considerations. For this assessment, the Credit Union requested an assumed system size of 7 kW, and thus PVWatts was not utilized.

Estimated Electrical Output - AVERT

For an ex-post assessment, the electrical output is determined through the use of actual operational data from the project. For an ex-ante assessment, electrical output is estimated through the combination of the rated maximum output of the system and a capacity factor that represents the real-world ability of that system to produce electricity. Capacity factors are dependent on the technology, management, and region. For example, two same-sized hydroelectric systems may have different effective capacity factors based on the local priorities for water storage and downstream ecosystem health. AVERT includes region-specific capacity factors for renewable energy projects based on modeling of systems at a sample of actual sites.

Baseline Electricity Source and Emissions – AVERT

The baseline for an energy supply project represents the energy source that would be used in the absence of the energy generated by the project. For small-scale projects, we assume that the project is simply displacing electricity sourced from the existing regional electrical grid. For utility-scale projects, this assumption would be adjusted to account for the fact that such a large facility would displace other new construction. However, that scenario is not relevant to this project. The baseline emissions attributable to energy supply equal to the amount that would be displaced from the regional grid by the renewable energy projects, and is taken from AVERT.[3] This value is calculated by inputting the sum capacity of each renewable project into the AVERT tool, which runs a simplified hourly dispatch model based on the most relevant year's generation and emissions to determine which existing generation resources would be impacted in the project scenario. For the assessment of the PV loan, AVERT was used to estimate the annual reductions in GHG emissions and criteria air pollutants – particulate matter ($PM_{2.5}$), sulfur dioxide (SO_2), and nitrogen oxides (NO_x) – using the system capacity (MW) of the PV system as the input. The model was run separately for every individual region. Regional results were allocated to the states based on their primary region, and then discounted into the future using projections of grid emissions and generation from the Energy Information Administration.

Comparison to Best in Class

For electricity generation of any scale, the current best in class scenario is one with zero direct GHG emissions. Since solar PV installations do not emit GHGs in order to produce electricity, the PV loan is considered to be 100% equivalent to the best in class scenario.

[3] AVERT does not include emissions data or load profiles for Alaska or Hawaii. For projects located in these states, the annual, non-baseload emission factors from eGRID were employed.

Putting the GHG Reductions in Context

The calculated GHG emission reductions that the project or bundle of projects being assessed achieve is compared to the GHG emission reduction which would be expected from the "best in class" technology, resulting in a measure of achievement between 0% and 100%. 100% indicates that the investment proceeds were used to fund only best in class projects, while 0% would indicate business as usual. The PV loan achieved GHG reductions equal to 100% of the best in class scenario (zero carbon energy generation).

Overall Results

The results of the assessment for the PV loan are summarized in the tables below:

Table 1. Climate impacts (25 years)

State	First-Year GHG Savings (tCO_2e/year)	EUL GHG Savings (tCO_2e)	GHG Intensity of the Loan (tCO_2e/$1000)	Comparison to Best in Class (%)
Alabama	6.74	106.57	5.33	100%
Alaska	4.26	96.02	4.80	100%
Arizona	7.33	161.84	8.09	100%
Arkansas	6.90	164.42	8.22	100%
California	5.58	125.18	6.26	100%
Colorado	7.93	168.85	8.44	100%
Connecticut	4.63	96.38	4.82	100%
Delaware	5.22	116.03	5.80	100%
District of Columbia	5.22	116.03	5.80	100%
Florida	6.74	139.50	6.98	100%
Georgia	6.74	97.48	4.87	100%
Hawaii	10.20	229.90	11.49	100%
Idaho	7.10	173.56	8.68	100%
Illinois	7.29	154.14	7.71	100%
Indiana	5.22	115.13	5.76	100%
Iowa	7.83	280.30	14.01	100%
Kansas	8.13	189.05	9.45	100%
Kentucky	6.61	146.85	7.34	100%
Louisiana	7.08	166.40	8.32	100%
Maine	4.63	96.38	4.82	100%
Maryland	5.22	115.80	5.79	100%
Massachusetts	4.63	96.38	4.82	100%
Michigan	5.62	130.64	6.53	100%
Minnesota	7.83	291.20	14.56	100%
Mississippi	6.74	123.40	6.17	100%
Missouri	7.85	161.17	8.06	100%
Montana	7.21	189.20	9.46	100%
Nebraska	7.86	258.91	12.95	100%
Nevada	7.18	169.68	8.48	100%
New Hampshire	4.63	96.38	4.82	100%
New Jersey	5.20	116.03	5.80	100%
New Mexico	7.46	161.92	8.10	100%
New York	4.63	114.10	5.70	100%
North Carolina	6.74	121.34	6.07	100%
North Dakota	7.82	290.27	14.51	100%
Ohio	5.22	115.13	5.76	100%
Oklahoma	8.13	175.13	8.76	100%
Oregon	7.10	173.56	8.68	100%

State	First-Year GHG Savings (tCO_2e/year)	EUL GHG Savings (tCO_2e)	GHG Intensity of the Loan (tCO_2e/$1000)	Comparison to Best in Class (%)
Pennsylvania	5.22	115.82	5.79	100%
Rhode Island	4.63	96.38	4.82	100%
South Carolina	6.74	119.34	5.97	100%
South Dakota	7.83	282.53	14.13	100%
Tennessee	6.74	150.01	7.50	100%
Texas	6.51	151.67	7.58	100%
Utah	7.11	173.54	8.68	100%
Vermont	4.63	96.38	4.82	100%
Virginia	6.18	120.74	6.04	100%
Washington	7.10	173.56	8.68	100%
West Virginia	5.24	115.28	5.76	100%
Wisconsin	7.55	222.67	11.13	100%
Wyoming	7.58	171.80	8.59	100%
Total US Average	**6.50**	**153.53**	**7.68**	**100%**

Table 2. Other criteria pollutant impacts (first year)

Avoided NO_x (lbs)	Avoided SO_2 (lbs)	Avoided $PM_{2.5}$ (lbs)
8.72	8.80	0.73

Discussion

Over its 25-year lifetime, an average PV loan from the Credit Union for a 7 kW system would result in GHG emission reductions of approximately 153.53 tCO_2e, which is 100% of the calculated best in class GHG reductions. This represents a GHG intensity of the loan of 7.68 tCO_2e/$1000. However, this impact varies widely between different states. This is due in part from varying capacity factors in different regions, as well as to the particular generation mix in each region. The lowest impact from residential solar PV was seen in Alaska, likely due to the limited sunlight throughout the year. The highest impact was seen in Minnesota, in part due to a particularly GHG-intensive generation mix in that region. The Upper Midwest is, generally, a ripe target for new solar installations, in the context of GHG savings.

Assumptions and Uncertainty

There are several sources of uncertainty related to this assessment, detailed below. Some of this uncertainty could be reduced with the availability of additional project details or baseline data prior to assessment, while some requires the availability of ex-post performance data. Other sources of uncertainty are inherent in the methodology. In some cases these may be improved through further refinement of the methodology or access to new data sources. However, there will always be some uncertainty inherent in this type of assessment. For most areas of uncertainty, the absence of detailed project information results in the use of default assumptions, thus exposing the assessment to any uncertainty inherent in the methodology for developing default assumptions.

- *Use of regional assumptions.* Solar PV performance can vary widely based on local conditions. This assessment used some regional assumptions about capacity built into the AVERT model. However, this could be refined in an assessment of a specific PV loan where the actual installation site is known. With that additional level of information, other tools may be brought to bear to more accurately estimate system output.
- *Comparison to best in class energy supply technology.* For energy supply projects, best in class is considered to be zero carbon energy generation (e.g., solar, wind, hydro). This approach ignores the possibility of carbon-negative energy production (e.g., a technology that sequesters more carbon than

it omits), as well as the potential environmental benefits and/or pitfalls of any particular technology. Given the current state of commercially-viable electricity generation technologies, the Reserve believes that this assumption is reasonable.

- *Life-cycle emissions*. This assessment is not, and does not purport to be, a life-cycle GHG assessment of the baseline or project technologies or activities. Certain projects may have more or less favorable climate impacts when viewed in the context of full life-cycle emissions, including upstream and downstream emissions sources. For this assessment, only Scope 2 emissions are considered, excluding Scope 1 and 3 emissions.[4]

Non-Climate Impacts

The scope of this assessment includes the climate impacts of the projects and/or activities funded by the investment. Certain projects may have additional positive or negative impacts on the environment, infrastructure, or society, that are not measured, estimated, or assessed by this methodology. However, in the interest of full disclosure, the Reserve endeavors to highlight any potentially significant positive or negative externalities. It is the opinion of the Climate Action Reserve that the solar PV projects funded by the Credit Union should not cause significant negative impacts to the environment, infrastructure, or society.

[4] Additional information regarding GHG "scopes" may be found at the Greenhouse Gas Protocol: http://www.ghgprotocol.org/.