Salvage and Reuse Value Analysis Executive Summary

We Recycle Solar was retained by Revity Energy, LLC to develop a cost analysis for the decommissioning planning and associated financial guarantee(s) securing funding for closure, for the Frontier Rd Hopkinton RI 10735 kWp Ground Mounted PV Plant. The cost or residual value remaining in the equipment is the primary funding source if positive or the bulk of the closure costs if negative value. The methods of defining the value are typically not well documented or follow good accounting practices.

The following summary of costs related to closure only contemplate the costs of disposal of the solar modules or the residual value remaining in the solar modules. The analysis includes use of typical IRS depreciation conventions and several NGO or Government Agency studies that have be rigorously peer reviewed. In addition, the preparers are specialists in recycling of solar equipment, both reuse and materials recovery.

Our study indicates that the following valuation may be applied to the project site. The solar modules considered for this study include: 23,336 modules manufactured by QCells, model Q.PEAK_DUO XL-G9.3 460Wp planned to be installed in late 2020 or 2021.

We value the modules described in this report, for the 2021 to 2046 timeframe as follows:

Positive Valuation		**Negative Valuation**	
Line Item	**Valuation**	**Line Item**	**Valuation**
Assumed modules available for reuse/repurposing	15,168 modules in 2046	Assumed modules destined for recycling during life of project	8,168 modules in 2046
Valuation of modules for reuse/repurposing	$11.07 per module in 2046	Using the base weight for the modules (from the data sheet) of 57.3 pounds, the total mass of modules for recycling is 468,026 pounds.	
Sub-Total Positive Valuation (Panels)	$167,895 in 2046	The recycling rate for 2046	$0.77/pound
Sub-Total Positive Valuation (Balance of System components, based on today's dollars and scrap prices)	$113,865		
Total Positive Valuation	**$281,760**	**Total Negative Valuation**	**$359,339**
Overall Valuation: $-77,578			

In addition to the above materials valuation, we would estimate the labor and equipment costs in the decommissioning of the site, to be $165,000, based on our experience. Resulting in a total estimated cost of the decommissioning activities and the disposal of materials of $242,578.

This report was prepared by a well experienced Environmental Engineer with experience in the decommissioning of solar plants, operations of recycling plants, and the refurbishment and resale of solar equipment.

This Salvage and Reuse value analysis for the Frontier Rd Hopkinton RI, 10,735 kWp Ground Mounted PV Plant on behalf of Revity Energy, LLC. This value analysis is supported by our contractual obligation to purchase the detailed equipment discussed herein at the valuation stated within this document, within one year of this analysis. We feel this will provide assurances related to the potential scrap value of the modules used in current US dollars.

The solar modules considered for this study include: 23,336 modules manufactured by QCells, model Q.PEAK_DUO XL-G9.3 460Wp planned to be installed in late 2020 or 2021. This study only reports the valuation after a 25-year project life and that no solar modules are replaced over the life to maintain system power levels. This will provide a very conservative estimate of the salvage and reuse value.

At We Recycle Solar, we certainly understand the residual value in solar installation components after what may be considered the useful life in a utility scale development. There are multiple factors that can affect the salvage and/or reuse value for solar modules at anticipated end-of-life, which can be a significant factor in the decommissioning cost estimates prepared (such as the decommissioning cost estimate being supported by this document).

To determine the overall value of the solar modules from an installation, it is compulsory to understand the factors influencing the residual value in the solar modules as well as the rates of failure over the life of the installation.

Additionally, we have only used current scrap prices for the Balance of System, that are tied directly to commodity prices and cannot be estimated in the future. These items are presented in the section Determining Balance of System values.

Determining Solar Module Residual Value

To best understand the value of the solar module at any point in the life of that module, one must consider many factors. In development of this valuation we are considering the following factors:

1. The overall market prices for solar modules should be considered globally. This is influenced by two sub-factors:

    a. Reduction of the mass of raw materials used in manufacturing solar modules.
    b. The overall changes to the prices of solar modules over time.

    As R&D and technological advances continue with a maturing industry, the composition of a typical PV module is expected to require fewer raw materials.

    As far as costs of solar panels changing over time, the maturity of the technology and the market will reduce prices over time. It should be noted that tariffs and other international trade concerns may put additional artificial pressure on the prices. We are not able to assess these cost considerations and feel it is more conservative in detailing the valuation (lower value) by not including these costs.

A recent report by the National Renewables Engineering Laboratory (NREL) in 2018[1] has modeled the costs of different solar technologies and also developed predicted costs of modules in the future. This report has indicated that the minimum sustainable price (MSP) of Mono-Crystalline PERC Solar Modules manufactured in Urban China was $0.37 / W in the first half of 2018. *This report anticipates a MSP of $0.28 / W expected in 2020. For the purposes of this study we only considered the 2020 MSP.*

2. The type and wattage of the module. These factors are typically driven by end user desires and typically only affect pricing on the reuse/repurposing market if they are less than 290 watt or are manufactured in a manner that may create hazardous waste at end of life. *Neither of these cases appear to apply for this analysis.*

3. Brand Recognition: the top tier name brands typically command higher prices. *The modules addressed in this valuation are certainly a top tier brand.*

4. Reuse Potential - Rapid global PV growth may result in an associated secondary market for panel components and materials. Even operational but underperforming panels by standards of the first owner may meet expectations of a second owner. *For the purposes of this valuation we consider the base cost for reuse in the secondary market, can range in valuation (when transferring from installation owner/operator to credible reuse and recycling firms) from 5% to 25% of current market value.* This pricing is driven by the amount of testing required to re-market the modules with the appropriate certifications in place, packaging for safe transportation, and transportation costs to the testing facility.

   However, it should be noted there are several concerns that complicate secondary markets, such as product safety, voiding of warranties, future liability, voiding of feed-in-tariff agreements, and balance-of-system costs. We did not consider the reuse of the early failures in the lifetime of a module repair and reuse opportunities. Potentially, repaired PV modules can be resold on the world market at a reduced market price.

   For the purposes of this valuation, given the above factors, we would value the reusable panels for our purchase at $31.19/module ($0.0875/W) delivered to our processing plant near Prescott Arizona in 2021.

Determining the Solar Module Failure Rates

Salvage and Reuse Value Analysis Report

We have conducted an intense review of available data related to solar module failure rates and found that the report "End-of-Life Management: Solar Photovoltaic Panels," completed by the International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems in 2016[2]. This report provides a compilation of data from across the globe on several subjects including a detailed analysis of failure modes and rates of failure. This data is an important benchmark for this report in predicting failure rates and residual value from solar installations using panels with no significant operational history (as with most installations).
The potential origin of failures for PV panels was analyzed to estimate the probability of PV panels becoming waste before reaching their estimated end-of-life targets. The three main panel failure phases detected are:

1. Infant failures defined as occurring up to four years after installation (average two years).
2. Midlife failures defined as occurring about five to eleven years after installation.
3. Wear-out failures defined as occurring about 12 years after installation until the assumed end-of life at 30 years.

The main infant failure causes include light-induced degradation (observed in 0.5%-5% of cases), poor planning, incompetent mounting work and bad support constructions. Many infant failures have been reported within the electrical systems such as junction boxes, string boxes, charge controllers, cabling and grounding.

Causes of midlife failures are mostly related to the degradation of the anti-reflective coating of the glass, discoloration of the ethylene vinyl acetate, delamination and cracked cell isolation. Causes of frequently observed failures within all phases in the first 12 years—after exposure to mechanical load cycles (e.g. wind and snow loads) and temperatures changes—include potential induced degradation, contact failures in the junction box, glass breakage, loose frames, cell interconnect breakages and diode defects.

In the wear-out phase, failures like those reported in the midlife phase increase exponentially in addition to the severe corrosion of cells and interconnectors. Previous studies with statistical data on PV panel failures additionally observe that 40% of PV panels inspected suffered from at least one cell with micro-cracks. This defect is more commonly reported with newer panels manufactured after 2008 due to the thinner cells used in production.

Annual PV panel waste up to 2050 is modeled by illustrating the evolution of PV panel end-of-life and new PV panel installations as a ratio. This ratio starts out low at 5% at the end of 2020. However, it increases over time to 4%-14% in 2030 and 80%-89% in 2050.

Valuation

Valuation over 25-year operational period		
Year	**2021**	**2046**
% of modules damaged	5%	35%
Number of Damaged Modules	1,167	8,168
Physically Damaged Module cost per pound (57.3 pounds)	-$0.65	-$0.77
Cost of Damaged Modules	-$43,457	-$359,339
Number of Undamaged Modules	22,169	15,168
Undamaged Module value per Watt	$0.0875	$0.0241
Undamaged Module value	$40.25	$11.07
Value of Undamaged Modules	$892,310	$167,895
Overall Valuation	$848,853	-$191,444
Number of Modules 23,336	Rated Power 460 watts	

This valuation does not account for the routine replacement of modules that fail over the life of the system for a worst-case valuation.

Determining Balance of System residual value

In determining the Balance of System residual value, it must first be noted that the reuse of combiners, inverters, and transformers has not been as prevalent as the solar modules. This may be due to the much shorter inherent service life of the equipment, as evidenced by the much shorter warranty periods.

Valuation as of March 30, 2020

Valuation Analysis based on Current Base Metals Scrap Value						
Item	**Make / Model**	**Number of units**	**Weight of each unit (approx)**	**Scrap Value per pound**	**Associated Value**	**Basis**
Inverters	Sungrow SG250HX	34	218.25	$0.08	$593.64	Low grade non-PC boards rate

	1500 Vdc String Inv					
Inverters	Sungrow SG125HV 1500 Vdc String Inv	6	158.7	$0.08	$76.18	Low grade non-PC boards rate
Transformer	Pad mount 2500 KVA	2	14,500	$0.25	$7,250.00	Copper Transformer Rate
Transformer	Pad mount 2000 KVA	2	12,500	$0.25	$6,250.00	Copper Transformer Rate
Transformer	Pad mount 1000 KVA	1	8,200	$0.25	$2,050.00	Copper Transformer Rate
MV Cable	#2 AWG, 35kV, Aluminum, XLPE-133%, MV-105	1,200	1.032	$1.45	$1,795.68	Scrap Al insulated wire rate
MV Cable	2/0 AWG, 35kV, Aluminum, XLPE-133%, MV-105	1,100	0.904	$1.45	$1,441.88	Scrap Al insulated wire rate
Cable	1/0 AWG, 1000V, Copper	100	0.358	$1.18	$42.24	Insulated Copper Cable rate
LV Cable	4/0 AWG, 1000V, Copper	500	0.714	$1.18	$421.26	Insulated Copper Cable rate

Large Project DC Wire String to Inverter	Cu#8	180,200	0.040	$1.18	$8,505.44	Insulated Copper Cable rate
Re-G Project String to Combiner Box	Cu#10	35,400	0.065	$1.18	$2,715.18	Insulated Copper Cable rate
Re-G Project Combiner Box to Inverter	AL350KCMIL	1,800	0.23	$1.45	$600.30	Scrap Al insulated wire rate
Scrap Steel	Various sizes	912.475	2,000	$0.05	$82,122.75	Shreddable Steel Scrap Rate
Total Residual Value in 2020 dollars						$113,865
1) Where weight of 1 used units are pounds. 2) Rates based on categorization under basis as reported on https://iscrapapp.com/ retrieved 3/26/20 or https://www.877ironmike.com/metal-prices retrieved 3/26/20. 3) Steel based on general thumb-rule of 85 tons per MW						

Valuation Summary

- We value the modules described in this report, for the 2021 to 2046 timeframe as follows: Total Modules: 23,336
- Assumed modules available for reuse/repurposing: 15,168 modules in 2046 Valuation of modules for reuse/repurposing: $11.07 per module in 2046 Sub-Total Positive Valuation (Panels): $167,895 in 2046
- Sub-Total Positive Valuation (Balance of System components, based on today's dollars and scrap prices) $113,865

Total Positive Materials Valuation $281,760

- Assumed modules destined for recycling up to 2046: 8,168 modules.
- Using the base weight for the modules (from the data sheet) of 57.3 pounds, the total mass of modules for recycling is 468,026 pound.
- The recycling at a rate of $0.77/pound.

Total Negative Materials Valuation: $359,339
Overall Materials Valuation: $-77,578

Salvage and Reuse Value Analysis Report

Costs Related to Decommissioning Activities

The cost of decommissioning activities is related to the direct field work in removal of the plant and typically returning the site to as near the pre-solar plant condition. In our experience a typical site may be decommissioned for approximately $16,500 per 1 MWp, therefore we feel this site may complete the decommissioning activities for $165,000. This cost is without regard to the Materials Valuation of -$77,578, resulting in a total estimated cost of the decommissioning activities and the disposal of materials of $242,578.

Qualifications of Preparer

Dwight Clark is Director of Compliance and Recycling Technology for We Recycle Solar, Inc. We Recycle Solar is the dedicated, single-source disposal provider for excess, recalled, and end-of-life solar products. Dwight oversees processing, and compliance for 2 primary plants, and the research and development center.

Prior to We Recycle Solar, Dwight was a principal in a firm specializing in returns management and sales One of his roles there was to determine the thresholds to purchase merchandise at as well as initial sales price. He was a significant contributor in the outside sales. During this engagement he had studied the reuse of solar panels both technically and the current marketplace. This has given him the buyers perspective.

In addition, Dwight has over 25 years experience as a Global Environmental Health and Safety Professional working in diverse industries such as hazardous waste treatment storage and disposal (Part B permitted facilities), chemical manufacturing, surface and underground mining, heavy civil construction, energy production, and recycling. He's developed and led programs relating to design and planning for recycling systems, EHS risk management, EHS leadership, culture enhancement, organization design, and enterprise-wide EHS data system selection, implementation and compliance planning. This has given him a uniquely broad perspective on EHS issues in high risk, and diverse environments. He has conducted numerous decommissioning projects in multiple industries to return sites to “Green Field” or “Return to original condition”.

Dwight's education and certifications include a bachelor's degree in Environmental Engineering as well as a Certified Hazardous Materials Manager (CHMM) from the Institute of Hazardous Materials Management (IHMM).

Prepared By:

Dwight Clark, Chief Compliance Officer
We Recycle Solar, Inc.
April 7, 2020

References:

[1]Woodhouse, Michael. Brittany Smith, Ashwin Ramdas, and Robert Margolis. 2019. Crystalline Silicon Photovoltaic Module Manufacturing Costs and Sustainable Pricing: 1H 2018 Benchmark and Cost Reduction Roadmap. Golden, CO: National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy19osti/72134.pdf.

[2]IRENA and IEA-PVPS(2016), "End-of-Life Management: Solar Photovoltaic Panels," International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems.