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March 21, 2022

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Mr. Michael King, Chair
Town of Wareham Planning Board
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Re: Decommissioning Estimates
Special Permits and Site Plan Approvals
Case No. 9-20 – 150 Tihonet Road
Case No. 7-20 – 27 Charge Pond Road

Dear Chairman King and Members of the Planning Board:

This letter is provided in connection with the extension requests for the above-referenced projects filed by New Leaf Energy (successor-in-interest to Borrego Solar Systems, Inc. and referred to herein as the "Proponent").

In furtherance of the discussions held at the March 13, 2023 meeting, the Proponent is providing the attached revised decommissioning estimates to the Planning Board for each of the 150 Tihonet Road solar project (Case No. 9-20) and the 27 Charge Pond Road solar project (Case No. 7-20) (collectively, the "Projects").

As discussed at the March 13 meeting, the revised estimates incorporate the scope of decommissioning work and provide decommissioning cost estimates based on baseline costs set forth in the February 2021 National Renewable Energy Laboratory report entitled *Best Practices at the End of the Photovoltaic System Performance Period*. In consideration of the Planning Board's willingness to recognize an extension of the lapse period for both Projects, the Proponent is agreeing that the attached decommissioning estimates replace those approved at the time of the approval of the Projects by the Planning Board.

In addition, as requested by members of the Planning Board, we are also attaching information regarding the National PV Recycling Program, as published on the website of the Solar Energy Industries Association (SEIA), that provides resources related to responsible end-of-life management and recycling best practices for the solar storage industry. As specifically outlined in the decommissioning estimates, the Proponent agrees to pursue options for end-of-life of the solar panels that prioritize reusing panels for continued generation at approved generation facilities, followed by options that involve the recycling of panels and associated materials at approved recycling facilities.

If you have any questions or wish to discuss, please contact me.

Best regards,

Womble Bond Dickinson (US) LLP

Gregory Sampson

Attachments

1. Revised Decommissioning Estimate – 150 Tihonet Project
2. Revised Decommissioning Estimate – 27 Charge Pond Project
3. Information Pertaining to Solar Panel Recycling Options

Attachment 1

Revised Decommissioning Estimate – 150 Tihonet Project

See attached.

Decommissioning Estimate/Plan

new leaf energy

Date: 3/21/2023

150 Tihonet Rd
Wareham, MA

This Decommissioning Estimate has been prepared by New Leaf Energy in an attempt to predict the cost associated with the removal of the proposed solar facility. The primary cost of decommissioning is the labor to dismantle and load as well as the cost of trucking and equipment. All material will be removed from the site, including the concrete equipment pads, which will be broken up at the site and hauled to the nearest transfer station.

No salvage values have been assumed in this calculation.

The following values were used in this Decommissioning Estimate:

System Specifications	
Number of Modules	22,500
Number of Racks	938
Number of Inverters	5
Number of Transformers	2
Electrical Wiring Length (ft)	14,215
Number of Foundation Screws	3,752
Length of Perimeter Fence (ft)	14,940
Number of Power Poles	12
Access Rd Material Volume (YD)	9,687
Total Disturbed Area (SF)	267,146
Total Fence Weight (lbs)	10,607
Total Racking Weight (lbs)	797,300
Total Foundation Screw Weight (lbs)	150,080
Total Solar Module Weight (lbs)	1,350,000

Labor and Equipment Costs		
Labor Rate ($/hr)	$	35.00
Operator Rate ($/hr)	$	47.00
Bobcat Cost ($/hr)	$	112.30
Front End Loader Cost ($/Day)	$	932.09
Excavator Cost ($/Day)	$	1,504.82
Trucking Cost ($/hr)	$	140.38
Backhoe Cost ($/hr)	$	112.30
Power Pole Removal Cost ($/pole)	$	1,500.00
Grader Cost ($/day)	$	1,459.90
Gravel Export Cost ($/YD)	$	5.00
Loam Import Cost ($/YD)	$	20.00
Seeding Cost ($/SF)	$	0.10
Fuel Cost ($/mile)	$	0.50

Equipment & Material Removal Rates	
Module Removal Rate (min/module)	1
Rack Wiring Rem. Rate (min/mod)	0.25
Racking Dismantling Rate (min/rack)	20
Inverter Removal Rate (hr/unit)	0.5
Transformer Removal Rate (hr/unit)	1
Rack Loading Rate (min/Rack)	10
Elect. Wiring Removal Rate (min/LF)	0.5
Screw Rem. Rate (screws/day)	300
Fence Removal Rate (min/LF)	1
Days req. to break up concrete pads	5
Days req. with Rough Grader	3
Days req. with Fine Grader	5
Total Truckloads Required	49
Round-Trip Dist. to Trans. Sta.(miles)	11
Round-Trip Time to Trans. Sta. (hr)	0.75

Energy Storage Decommissioning		
Number of Energy Storage Units		10
Battery Disposal Fee	$	25,000.00
Battery Loading Prep Time (hr)		32
Battery Loading Time (hr)		8

Labor, Material, and Equipment Costs

1. Remove Modules

The solar modules are fastened to racking with clamps. They slide in a track. A laborer needs only unclamp the module and reach over and slide the module out of the track.

Module Removal Rate • Total Number of Solar Modules • Labor Rate = Module Removal Cost

Total = $ 13,125.00

2. Remove Rack Wiring

The modules are plugged together in the same manner as an electrical cord from a light is plugged into a wall socket. The string wires are in a tray. A laborer needs only unplug the module, reach into the tray and remove the strands of wire.

Wire Removal Rate • Total Number of Solar Modules • Labor Rate = Rack Wiring Removal Cost

Total = $ 3,281.25

3. Dismantle Racks

The racking is supported by screw foundations. The racking will be disconnected from the foundation and removed seperately.

Number of Racks • Rack Dismantling Rate • Labor Rate = Rack Dismantling Cost

Total = $ 10,943.33

4. Remove and Load Electrical Equipment

Electrical equipment includes transformers and inverters.

(Number of Inverters • Inverter Removal Rate + Number of Transformers • Transformer Removal Rate) • (Operator Rate + Bobcat Cost) = Electrical Equipment Removal Cost

Total = $ 716.85

5. Break Up Concrete Pads

Concrede pads are broken up using an excavator and jackhammer.

Number of Demolition Days • (Excavator Cost + Operator Cost) = Total Concrete Pad Removal

Total = $ 6,540.45

6. Load Racks

Once the racks have been dismantled, they will be loaded onto trucks for removal from the site. The trucking cost associated with this line item represents the additional time a truck will be needed during loading. Please see item # 13 for additional trucking costs.

Number of Racks • Rack Loading Rate • (Operator Cost + Front End Loader Cost + Trucking Cost) = Total Rack Removal Cost

Total = $ 46,849.19

7. Remove Electrical Wiring

Electrical wiring will be removed from all underground conduits.

Cable Length • Cable Removal Rate • (Operator Cost + Backhoe Cost) = Total Cable Removal Cost

Tota $ 18,870.41

8. Remove Foundation Screws

Foundation screws will be backed out of the ground and loaded onto a truck to be removed from site.

(Total Number of Screws / Daily Screw Removal Rate) • (Operator Rate + Excavator Cost) = Total Screw Removal Cost

Total = $ 23,522.79

9. Remove Fencing

Fencing posts, mesh, and foundations will be loaded onto a truck and removed from site. Trucking costs included in this line item are for the removal process. Trucking to a recycling facility are included in item #13.

(Total Length of Fence • Fence Removal Rate) • (Operator Rate + Bobcat Cost + Trucking Cost) =

Total = $ 74,619.08

10. Remove Power Poles

Power poles will be removed and shipped off site.

Number of Power Poles • Pole Removal cost = Total Power Pole Removal Cost

Total = $ 18,000.00

11. Gravel Road Reclamation

Reclamation of the gravel access road will entail removing the gravel material and exporting it off site. The area will then be backfilled with loam and graded.

(Days with Rough Grader + Days with Fine Grader) • (Grader Cost per Day+Operator Cost per Day) + [Roadway Material Volume • (Gravel Export Cost + Loam Import Cost)] = Gravel Road Reclamation Cost

Total = $ 256,853.87

12. Seed Disturbed Areas

Seeding cost includes labor and materials for reseeding all disturbed areas including the reclaimed gravel road area, former electrical areas, and areas disturbed by racking foundation removal.

Seeding Cost • Disturbed Area = Total Seeding Cost

Total = $ 26,714.60

13. Truck to Transfer Station

All material will be trucked to the nearest Transfer station that accepts construction material.

(Total Truckloads • Roundtrip Distance • Fuel Cost) + (Total Truckloads • Round Trip Time • Trucking Cost) = Total Trucking Cost to Transfer Station

Total = $ 5,428.28

14. Remove and Dispose of Energy Storage Equipment

The battery units will be prepared for shipment and loaded onto a truck. A disposal fee will also be required for the disposal company to accept the batteries.

Number of Battery Units • ((Loading Prep Time • Labor Cost) + Loading Time • (Labor Rate + Bobcat Cost + Trucking Cost) + Disposal Fee) = Total Energy Storage Removal and Disposal Cost

Total = $ 284,214.00

Salvage Values

Salvage Value Not Included

Panel Disposal

2S. Solar Panel Disposal Cost

The panels can be disposed of at facilities which except electronics. They will be trucked to the nearest acceptable station

(Total Panel Weight)/2000 • Cost per Ton of disposal =

Tota $ 101,250.00

Summary of Decommissioning Costs and Salvage Values

Line Item	Task	Cost	
1	Module Removal	$	13,125.00
2	Rack Wiring Removal	$	3,281.25
3	Rack Dismantling	$	10,943.33
4	Electrical Equipment Loading and Removal	$	716.85
5	Break Up Concrete Pads	$	6,540.45
6	Load Racks	$	46,849.19
7	Electrical Wiring Removal	$	18,870.41
8	Foundation Screw Removal	$	23,522.79
9	Fence Removal	$	74,619.08
10	Power Pole Removal	$	18,000.00
11	Gravel Road Reclamation	$	256,853.87
12	Seed Disturbed Areas	$	26,714.60
13	Trucking to Transfer Station	$	5,428.28
14	Energy Storage System Removal	$	284,214.00
	Sub Total =	$	789,679.10

Additional Item	Task		Value
Salvage Values Not Included			
2S	Solar Panel Disposal Cost	$	101,250.00
	Additional Item Subtotal	$	101,250.00
	Present Value Total with 1.25% Adder =	**$**	**987,098.87**

Task		Future Value
Inflation		
# of Years=	5	
Inflation Rate=	2.5%	
Total • (1+ Inflation Rate)^Number of Years =Grand Total		
Grand Total =		**$ 1,116,811.77**

150 Tihonet Rd
Wareham, MA

New Leaf Energy does not agree with the per megawatt decommissioining amounts outlined in the February 2021 National Renewable Energy Laboratory (NREL) Technical Report titled "Best Practices at the End of the Photovoltaic System Performance Period". However based on discussions with the Wareham Planning Board, New Leaf Energy agrees to use the following stipulated costs for the initial estimated decommissioning costs, provided the Planning Board (1) approves a time extension for good cause as requested by the applicant, (2) a surety bond is accepted as the form of surety, and (3) there is no prohibition on reduction of the financial assurance amount if a future review indicates a reduced estimated decommissioning cost. The report presents a decommissioning amount of $368,000/MW for ground mount systems. An additional amount of $50,000/MW has been added for decommissioning of the energy storage system components. See calculation below.

Decommissioning Bond Calculation

Photovoltaic System Decommissioning = $368,000/MW x 4.99 MW(AC)	=	$	1,836,320.00
Energy Storage System Removal = $50,000/MW x 4.99 MW	=	$	249,500.00
Subtotal		$	2,085,820.00
Bond Amount - Present Value Total with 1.25% Adder =		**$**	**2,607,275.00**

Attachment 2

Revised Decommissioning Estimate – 27 Charge Pond Project

See attached.

Decommissioning Estimate/Plan

new leaf energy

Date: 3/21/2023

27 CHARGE POND ROAD
WAREHAM, MA

This Decommissioning Estimate has been prepared by New Leaf Energy in an attempt to predict the cost associated with the removal of the proposed solar facility. The primary cost of decommissioning is the labor to dismantle and load as well as the cost of trucking and equipment. All material will be removed from the site, including the concrete equipment pads, which will be broken up at the site and hauled to the nearest transfer station.

No salvage values have been assumed in this calculation.

The following values were used in this Decommissioning Estimate:

System Specifications	
Number of Modules	20,440
Number of Racks	852
Number of Inverters	2
Number of Transformers	2
Electrical Wiring Length (ft)	4,053
Number of Foundation Screws	3,408
Length of Perimeter Fence (ft)	8,751
Number of Power Poles	1
Access Rd Material Volume (YD)	6,408
Total Disturbed Area (SF)	175,710
Total Fence Weight (lbs)	6,213
Total Racking Weight (lbs)	724,200
Total Foundation Screw Weight (lbs)	136,320
Total Solar Module Weight (lbs)	1,226,400

Equipment & Material Removal Rates	
Module Removal Rate (min/module)	1
Rack Wiring Rem. Rate (min/mod)	0.25
Racking Dismantling Rate (min/rack)	20
Inverter Removal Rate (hr/unit)	0.5
Transformer Removal Rate (hr/unit)	1
Rack Loading Rate (min/Rack)	10
Elect. Wiring Removal Rate (min/LF)	0.5
Screw Rem. Rate (screws/day)	300
Fence Removal Rate (min/LF)	1
Days req. to break up concrete pads	2
Days req. with Rough Grader	2
Days req. with Fine Grader	3
Total Truckloads Required	44
Round-Trip Dist. to Trans. Sta.(miles)	9.6
Round-Trip Time to Trans. Sta. (hr)	0.58

Labor and Equipment Costs		
Labor Rate ($/hr)	$	35.00
Operator Rate ($/hr)	$	47.00
Bobcat Cost ($/hr)	$	112.30
Front End Loader Cost ($/Day)	$	932.09
Excavator Cost ($/Day)	$	1,504.82
Trucking Cost ($/hr)	$	140.38
Backhoe Cost ($/hr)	$	112.30
Power Pole Removal Cost ($/pole)	$	1,500.00
Grader Cost ($/day)	$	1,459.90
Gravel Export Cost ($/YD)	$	5.00
Loam Import Cost ($/YD)	$	20.00
Seeding Cost ($/SF)	$	0.10
Fuel Cost ($/mile)	$	0.50

Energy Storage Decommissioning		
Number of Energy Storage Units		2
Battery Disposal Fee	$	25,000.00
Battery Loading Prep Time (hr)		32
Battery Loading Time (hr)		8

Labor, Material, and Equipment Costs

1. Remove Modules

The solar modules are fastened to racking with clamps. They slide in a track. A laborer needs only unclamp the module and reach over and slide the module out of the track.

Module Removal Rate • Total Number of Solar Modules • Labor Rate = Module Removal Cost

Total = $ 11,923.33

2. Remove Rack Wiring

The modules are plugged together in the same manner as an electrical cord from a light is plugged into a wall socket. The string wires are in a tray. A laborer needs only unplug the module, reach into the tray and remove the strands of wire.

Wire Removal Rate • Total Number of Solar Modules • Labor Rate = Rack Wiring Removal Cost

Total = $ 2,980.83

3. Dismantle Racks

The racking is supported by screw foundations. The racking will be disconnected from the foundation and removed seperately.

Number of Racks • Rack Dismantling Rate • Labor Rate = Rack Dismantling Cost

Total = $ 9,940.00

4. Remove and Load Electrical Equipment

Electrical equipment includes transformers and inverters.

(Number of Inverters • Inverter Removal Rate + Number of Transformers • Transformer Removal Rate) • (Operator Rate + Bobcat Cost) = Electrical Equipment Removal Cost

Total = $ 477.90

5. Break Up Concrete Pads

Concrede pads are broken up using an excavator and jackhammer.

Number of Demolition Days • (Excavator Cost + Operator Cost) = Total Concrete Pad Removal

Total = $ 2,616.18

6. Load Racks

Once the racks have been dismantled, they will be loaded onto trucks for removal from the site. The trucking cost associated with this line item represents the additional time a truck will be needed during loading. Please see item # 13 for additional trucking costs.

Number of Racks • Rack Loading Rate • (Operator Cost + Front End Loader Cost + Trucking Cost) = Total Rack Removal Cost

Total = $ 42,553.85

7. Remove Electrical Wiring

Electrical wiring will be removed from all underground conduits.

Cable Length • Cable Removal Rate • (Operator Cost + Backhoe Cost) = Total Cable Removal Cost

Total $ 5,380.36

8. Remove Foundation Screws

Foundation screws will be backed out of the ground and loaded onto a truck to be removed from site.

(Total Number of Screws / Daily Screw Removal Rate) • (Operator Rate + Excavator Cost) = Total Screw Removal Cost

Total = $ 21,366.12

9. Remove Fencing

Fencing posts, mesh, and foundations will be loaded onto a truck and removed from site. Trucking costs included in this line item are for the removal process. Trucking to a recycling facility are included in item #13.

(Total Length of Fence • Fence Removal Rate) • (Operator Rate + Bobcat Cost + Trucking Cost) =

Total = $ 43,707.60

10. Remove Power Poles

Power poles will be removed and shipped off site.

Number of Power Poles • Pole Removal cost = Total Power Pole Removal Cost

Total = $ 1,500.00

11. Gravel Road Reclamation

Reclamation of the gravel access road will entail removing the gravel material and exporting it off site. The area will then be backfilled with loam and graded.

(Days with Rough Grader + Days with Fine Grader) • (Grader Cost per Day+Operator Cost per Day) + [Roadway Material Volume • (Gravel Export Cost + Loam Import Cost)] = Gravel Road Reclamation Cost

Total = $ 169,383.20

12. Seed Disturbed Areas

Seeding cost includes labor and materials for reseeding all disturbed areas including the reclaimed gravel road area, former electrical areas, and areas disturbed by racking foundation removal.

Seeding Cost • Disturbed Area = Total Seeding Cost

Total = $ 17,571.01

13. Truck to Transfer Station

All material will be trucked to the nearest Transfer station that accepts construction material.

(Total Truckloads • Roundtrip Distance • Fuel Cost) + (Total Truckloads • Round Trip Time • Trucking Cost) = Total Trucking Cost to Transfer Station

Total = $ 3,793.57

14. Remove and Dispose of Energy Storage Equipment

The battery units will be prepared for shipment and loaded onto a truck. A disposal fee will also be required for the disposal company to accept the batteries.

Number of Battery Units • ((Loading Prep Time • Labor Cost) + Loading Time • (Labor Rate + Bobcat Cost + Trucking Cost) + Disposal Fee) = Total Energy Storage Removal and Disposal Cost

Total = $ 56,842.80

Salvage Values

Salvage Value Not Included

Panel Disposal

2S. Solar Panel Disposal Cost

The panels can be disposed of at facilities which except electronics. They will be trucked to the nearest acceptable station

(Total Panel Weight)/2000 • Cost per Ton of disposal =

Total $ 91,980.00

Summary of Decommissioning Costs and Salvage Values

Line Item	Task	Cost
1	Module Removal	$ 11,923.33
2	Rack Wiring Removal	$ 2,980.83
3	Rack Dismantling	$ 9,940.00
4	Electrical Equipment Loading and Removal	$ 477.90
5	Break Up Concrete Pads	$ 2,616.18
6	Load Racks	$ 42,553.85
7	Electrical Wiring Removal	$ 5,380.36
8	Foundation Screw Removal	$ 21,366.12
9	Fence Removal	$ 43,707.60
10	Power Pole Removal	$ 1,500.00
11	Gravel Road Reclamation	$ 169,383.20
12	Seed Disturbed Areas	$ 17,571.01
13	Trucking to Transfer Station	$ 3,793.57
14	Energy Storage System Removal	$ 56,842.80
	Sub Total =	$ 390,036.75

Additional Item	Task	Value
Salvage Values Not Included		
2S	Solar Panel Disposal Cost	$ 91,980.00
	Additional Item Subtotal	$ 91,980.00
	Present Value Total with 1.25% Adder =	**$ 487,545.94**

Task		Future Value
Inflation		
# of Years=	20	
Inflation Rate=	2.5%	
Total • (1+ Inflation Rate)^Number of Years =Grand Total		
Grand Total =		**$ 798,900.79**

New Leaf Energy does not agree with the per megawatt decommissioining amounts outlined in the February 2021 National Renewable Energy Laboratory (NREL) Technical Report titled "Best Practices at the End of the Photovoltaic System Performance Period". However based on discussions with the Wareham Planning Board, New Leaf Energy agrees to use the following stipulated costs for the initial estimated decommissioning costs, provided the Planning Board (1) approves a time extension for good cause as requested by the applicant, (2) a surety bond is accepted as the form of surety, and (3) there is no prohibition on reduction of the financial assurance amount if a future review indicates a reduced estimated decommissioning cost. The report presents a decommissioning amount of $368,000/MW for ground mount systems. An additional amount of $50,000/MW has been added for decommissioning of the energy storage system components. See calculation below.

Decommissioning Bond Calculation

Photovoltaic System Decommissioning = $368,000/MW x 4.99 MW(AC)	=	$ 1,836,320.00
Energy Storage System Removal = $50,000/MW x 4.99 MW	=	$ 249,500.00
	Subtotal	$ 2,085,820.00

Bond Amount - Present Value Total with 1.25% Adder = $ 2,607,275.00

Attachment 3

Information Pertaining to Solar Panel Recycling Options

See attached.

See also:

https://seia.org/initiatives/seia-national-pv-recycling-program

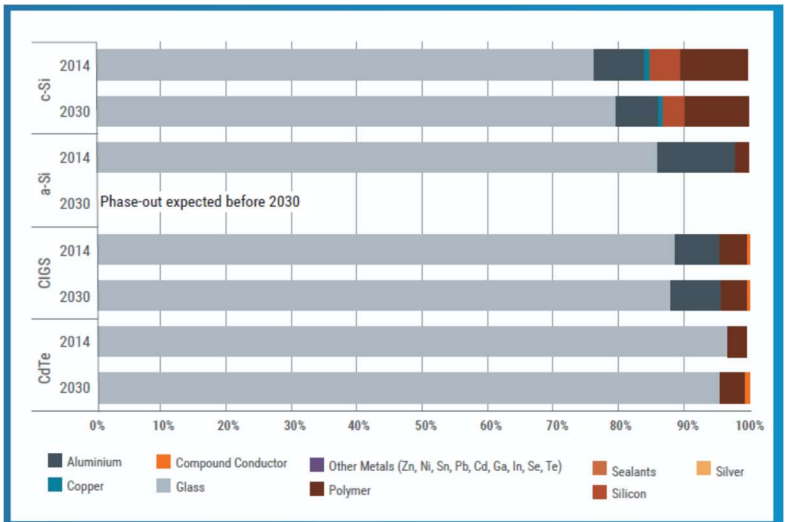
https://onlinelibrary.wiley.com/doi/abs/10.1002/pip.3316

End-of-Life Management for Solar Photovoltaics: Recycling

SEIA PV Recycling Partner Network

SEIA's PV Recycling Working Group has been actively seeking and developing recycling partners across the U.S since 2016. Over 95% of PV modules deployed in the U.S have been installed since 2012, and such modules will stay in service for more than 25+ years. Nonetheless some waste is generated when panels are damaged during production, shipment or installation, determined to be defective, by weather events, and for warranty-related claims.

SEIA's National Recycling Program is preparing now for larger volumes of waste to come in future years. Already SEIA's recycling partners have processed >4M pounds of PV modules and related equipment since the program launched.

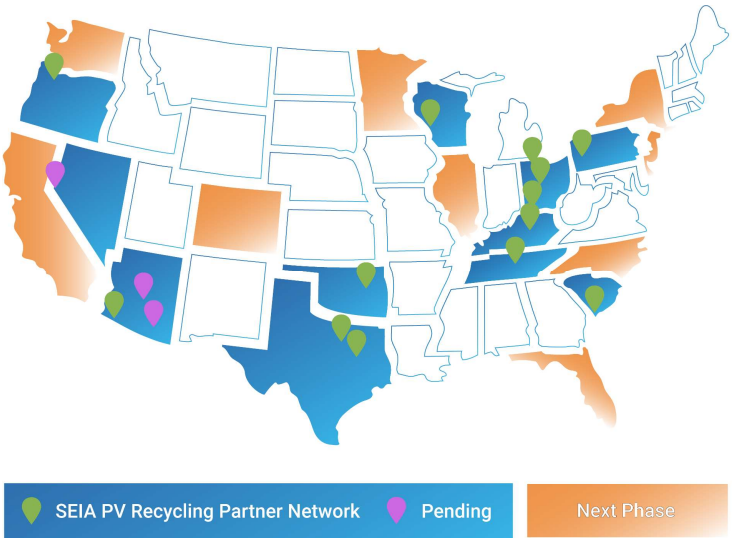


Source: IRENA and IEA-PVPS (2016), "End-of-Life Management: Solar Photovoltaic Panels," International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems.

While they offer specific benefits to SEIA members, the recyclers provide their services to interested installers, project and system owners, developers, distributors and other parties.

SEIA's current partners have prior expertise in recycling glass, polymerics, aluminum, scrap metal, and electronics; all of which provide a good foundation for recycling PV modules, inverters, racking systems and other components of a PV system. Our current network partners offer and provide services to SEIA members and industry throughout the U.S. SEIA is continually working to find new partners in more geographies to make recycling more accessible in areas where solar is installed.

The graphic below shows where SEIA's current partners are located and where we are in process of adding new partners. As we expand our network to more areas, we help partner companies to develop their processes and equipment for our technology. Overall, we aim to add 2-4 new partners yearly and for both new and existing partners to expand their collection and processing locations.



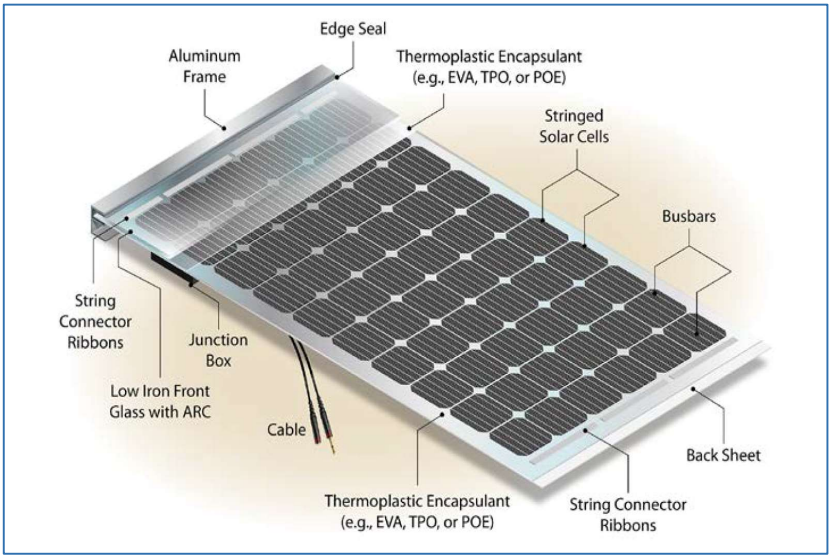
CEM Cascade Eco Minerals
CLEANLITES RECYCLING
DYNAMIC LIFECYCLE INNOVATIONS
Echo Environmental
First Solar
GREEN CENTURY RECYCLING

End-of-Life Management for Solar Photovoltaics: Recycling

Photovoltaic equipment and options for first end-of-life stages

Like many other durable products and construction materials, solar equipment can last for decades, particularly with proper maintenance. In some cases, PV modules can be reused or refurbished to have a 'second life' generating electricity. The other components of solar systems can also be handled responsibly. Inverters can be recycled as e-Waste and racking equipment can be re-utilized with newer technology or recycled like other metals.

SEIA advises manufacturers, system and project owners to consider reuse, refurbishment and / or recycling of first end-of-life PV modules, inverters, racking equipment and associated components when possible.



Source: NREL, Crystalline Silicon Photovoltaic Module Manufacturing Costs and Sustainable Pricing, 2019

Recycling

While most PV panels produced today will have a useful life for decades, there is inevitable waste created during production, when panels are damaged during shipment or installation, determined to be defective, become obsolete or reach their end-of-life. High-value recycling can help minimize lifecycle impacts and recover valuable and energy-intensive materials, thereby increasing sustainability within the PV industry.

PV panels typically consist of glass, aluminum, copper, silver and semiconductor materials that can be successfully recovered and reused. By weight, more than 80 percent of a typical PV panel is glass and aluminum – both common and easy-to-recycle materials. Recycling of solar equipment is increasingly possible as more recyclers accept modules.

Cooperation throughout the value chain

Research and development of PV-specific recycling equipment can optimize the recoverability and purity of reclaimed materials. The start-up and support of new organizations will help the industry extend the useful life of existing products while maintaining the quality and safety of the equipment. Working together with stakeholders from all these areas will help inform and develop policy appropriately so that end-of-life management solutions complement the deployment of solar.

SEIA and its members participate in research studies and projects, white papers, collaborative programs and present information, findings and research at stakeholder meetings, conferences and events to keep industry and others updated on our progress in developing end-of-life solutions.

R&D Organizations, Producers, Academia	Repair/Re-use/ Refurbishment Services	Recycling and Waste Management
• Public institutions • Private organizations • OEM Manufacturers • Component Manufacturers	• Manufacturers • Service providers • Contractors • Installers and EPCs • Operations & Maintenance companies • Waste management companies • Pre-treatment companies	• Public waste agencies • Regulators • Waste management companies • Pre-treatment companies • Manufacturers

PV End-of-Life Management

Prepare for recycling PV equipment

Gather information

- ☐ Type of equipment
  - PV modules (mono or polycrystalline, thin-film, shingle-type, etc.)
  - Inverters or microinverters
  - Racking equipment or trackers
- ☐ Collect manufacturer's name and serial numbers of each product to be recycled
- ☐ Identify how many modules and related equipment (such as inverters, racking, etc.) will be processed
- ☐ Determine how the shipment is/will be packaged (stacked, packages, banded, on pallets, etc.)
- ☐ Determine the total weight in pounds for modules and other equipment (separate by type of equipment)
- ☐ Determine if external (third-party) logistics are required for the shipment
  - How will the modules be shipped?
  - Who will pay for the transit?
- ☐ Gather photos or pictures of the modules
- ☐ Identify current storage location and conditions (inside, outside, how protected, etc.)
  - Are there photos of how the modules have been stored while awaiting disposition?
  - Is the storage location accessible by a lift truck or stacker?
  - Is there a lift truck or stacker available on-site or does one need to be brought on-site?
  - What is the address of current location of modules/other equipment
- ☐ Identifying details regarding the condition of the equipment is helpful for advanced preparation of recycling
  - Are the frames are bent or damaged?
  - Is there glass breakage?
  - How long have the modules have been in storage?
  - Are the inverters dented or damaged in any way?
  - Is there any corrosion damage on the mounting rails or pilings?
  - Are you making a warranty claim, and have you noted the damage on the modules by serial number?
- ☐ Obtain a Material Safety Data Sheet (MSDS) or similar information

Choose a recycling partner

- ☐ SEIA members receive specific pricing and other benefits from our partners
- ☐ SEIA's service partners offer their services to other entities
- ☐ Note that some local e-Waste recyclers or glass recyclers may accept PV modules
- ☐ Note that not all recycling processes are the same
  - Some recyclers may have more sustainable processing techniques
  - Ask about material diversion to landfill if this is of concern
- ☐ Check that the recycler has the appropriate R2 or e-Stewards accreditation in addition to complying with EPA permitting requirements
- ☐ Ensure that you will receive a Certificate of Destruction/Recycling for the products sent (COD/COR)
  - Request that this be sent with the invoice (or check if credit is to be owed back to your business for the recycled product)
- ☐ Using your organization's sustainability guidelines, check if the recycler complies.

PV End-of-Life Management

Prepare documentation and arrange shipment for collection, transport or drop-off

- ☐ Provide Material Safety Data Sheet (MSDS) or similar information on the type of PV modules (i.e. Mono/Poly Crystalline, thin-film etc.)
  - If you do not have an MSDS, ask the manufacturer or distributor for a material info sheet/spec sheet
- ☐ Determine whether or not the panel /other equipment should be managed as solid waste, universal waste or other hazardous waste
  - Check your state of local community's waste management criteria or requirements
  - Determine if EPA or state characterization rules apply
- ☐ Determine the total weight in pounds for modules and other peripherals
  - Identify the total weights of each type of equipment separately and then the total shipment weight
- ☐ Provide any Purchase Order #'s or Company Identifying #'s that clearly identify the shipment
- ☐ Label each package or pallet with the Name, Address, and service company's Shipping # (Order# or any # provided by the service company to clearly identify that shipment as matching the Purchase Order # or Identifying #)
- ☐ Provide a detailed packing list with the shipment
- ☐ If external logistics / shipping services are required, identify the pick-up location, and method of packaging to the shipper and the service company

Using Pallets for shipment

- ☐ If using pallets, provide the # and dimensions of the pallets to ensure the right type of truck is arranged to transport the materials to their destination
- ☐ If using pallets, it is recommended that you stack the pallets between 28 and 35 modules high to make them economical to ship and to avoid any further damage to the panels. Ask your manufacturer or distributor for more information on recommended stacking.
- ☐ Too few modules on the pallet and the economy of the space is not optimized.
- ☐ Too many modules and there may be problems with shifting or moving panels, which could increase damage to the panels or the module glass or provide difficulty in fitting the pallet in the truck due to height restrictions, etc.
- ☐ The average truckload of PV modules, when palletized as suggested, can hold between 12 and 13 pallets and weigh an average between 18K and 20K lbs.
- ☐ Band the Modules to the pallet whenever possible to keep modules from shifting or falling. Shrink wrapping the pallets tightly will help prevent shifting and avoid further broken glass from escaping, thus creating a "clean up" issue for the transportation company.
- ☐ Stack like-size modules together whenever possible. When pallets are banded with modules that vary in length and width, they are more susceptible to shifting or tipping over in transit

Schedule the shipment pick-up or transport

- ☐ When scheduling your own transportation, it will be important to coordinate the expected delivery date and time with the service company's customer service/logistics staff, so that an arrival date and time slot can be reserved.
- ☐ It is not recommended to send a shipment without coordination and notification as the receiving and unloading processes may be delayed if the service company cannot accommodate the shipment without notice.