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Overview of Solar Panel Recycling for Indigenous Communities

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ABSTRACT

In recent years, Native tribes across the country have embraced solar energy to power their communities. However, in approximately 25-30 years after installation, the solar panels will enter end-of-life (EOL) status, meaning that they will begin to operate less efficiently than upon initial implementation. At this point, tribes can determine the outcome: they can continue to operate the array, or they can dispose of the panels. Recycling is an option that promotes the use of high-value recyclable materials in solar panels in the circular economy. There are several companies across the US that offer recycling of solar panels, but at various costs. It is important that a hazardous waste expert makes an initial assessment of the solar array to identify any solar panels that cannot be recycled. Currently, recycling solar panels is not cost-effective or environmentally sustainable, but significant research into improving the cost and carbon footprint is ongoing.

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The purpose of this report is to inform tribal communities about the options available when their solar array has reached the end of its 25-year warranty, a period known as end-of-life (EOL). No federal regulations for handling EOL panels currently exist, so it is up to the tribes to decide what to do with them. EOL panels are still operable if they are not damaged, though the efficiency of the array will begin to decline.

If a tribe decides their solar array is not worth continuing use, then it can either be recycled or discarded in the landfill. Choosing to recycle a solar array depends on several factors: the amount of money the tribe is willing to spend, the distance from the community to the recycling facility, and the number of recyclable solar panels in the array. Due to the presence of toxic materials in solar panels, hazardous waste regulations prohibit some panels from being thrown in the landfill or recycled. Solar panels that are deemed "hazardous" must instead be discarded as hazardous waste.

Many companies throughout the United States have capitalized on solar panel recycling due to the abundance of high-value recyclables in the panels. These companies each have their own prices for their services, extra costs, and minimums for the number of panels they will recycle. As of today, recycling solar panels calls for methods that either involve the use of environmentally damaging chemicals or require large amounts of energy to power the process. There is ongoing research at the federal and university levels to improve solar recycling methods by making them less expensive and more environmentally sustainable. This report serves as a starting point for tribes to discuss a long-term plan for handling their EOL solar project, one that may not be implemented until it is the next generation's time to lead.

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ACRONYMS AND TERMS

Acronym/Term	Definition
CW	Continuous-Wave
DOE	Department of Energy
EOL	End-of-Life
EPA	Environment Protection Agency
GWh	Gigawatt-hours
kW	Kilowatt
NREL	National Renewable Energy Laboratory
PPA	Power Purchase Agreement
RCRA	Resource Conservation and Recovery Act
SETO	Solar Energy Technology Office
TCLP	Toxicity Characteristic Leaching Procedure
US	United States

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1. INTRODUCTION

1.1. Growth of Solar in Indian Country

With the ongoing climate crisis causing extreme weather conditions and creating more demand for electricity in remote areas, several Indigenous tribes are using solar energy to power community and residential buildings, for-profit ventures such as casinos and hotels, and to sell to utility co-ops via power purchase agreements (PPAs). Solar projects not only expand access to electricity for Native peoples, but they also provide opportunities to strengthen tribal sovereignty and improve conditions for economic development on reservations. In the beginning, tribes implemented solar-powered water pumps, heaters, and small-scale solar systems for residential use one home at a time. Within the past ten years, Native nations have utilized Department of Energy (DOE)-sponsored programs to expand to large-scale solar panel installations, adding megawatts of solar capacity nearly every year (Figure 1a). Based on the metrics shown in Figure 1a, it is estimated that by the end of 2024, a total of 67.6 gigawatt-hours (GW/h) of DOE-sponsored solar energy will have been produced in Indian Country since 2016 (Figure 1b).

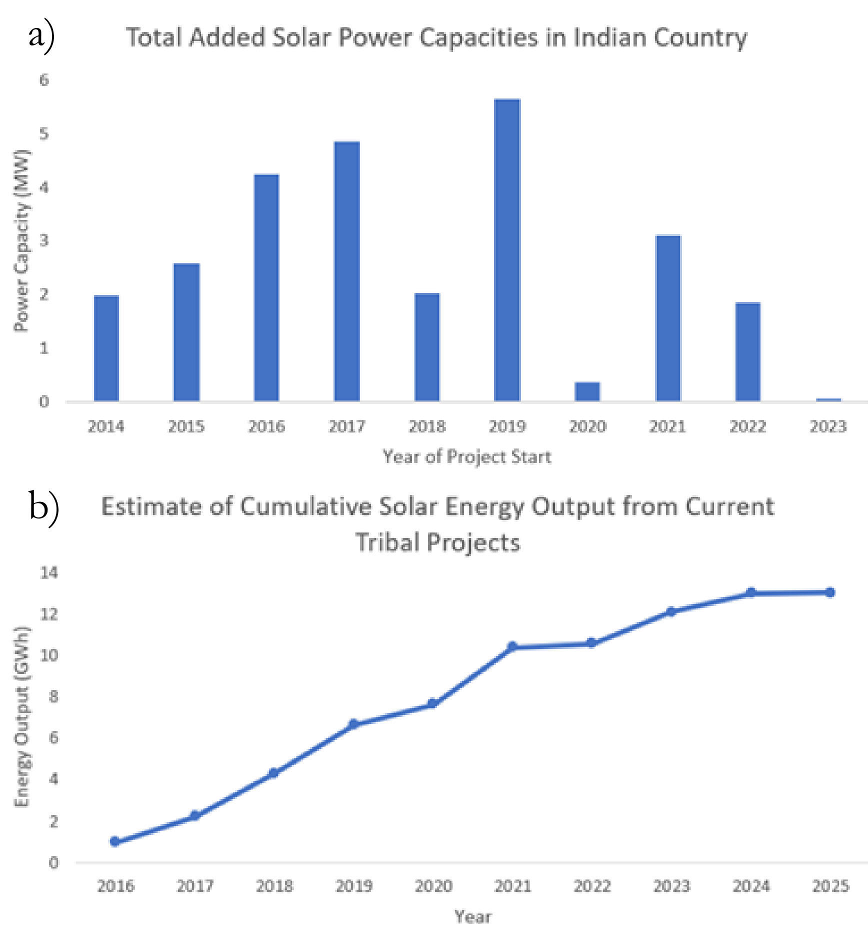

Figure 1. Graphical representation of DOE-sponsored solar energy growth on tribal lands. (a) Annual total installed solar capacity on tribal lands. (b) Annual estimates of solar energy produced by tribal solar projects. See Appendices A.1 and A.2 for notes on calculations. See Appendix A.3 for the list of tribal solar projects used to make the graphs shown above.

Solar panel warranties state that panels only operate at maximum efficiency for 25 to 30 years before they begin to significantly drop in performance. Even before the end of this time frame, solar panels can become damaged from environmental factors (e.g., hail). When a solar panel reaches the end of its warranty or becomes inoperable due to damage, the panel becomes classified as end-of-life (EOL). Tribes with solar panel installations will be forced to decide what to do with their panels once they reach EOL status. In fact, by 2039, almost 5,000 solar panels in Indian Country will have reached EOL status (Figure 2)—that is equivalent to nearly 100 tons of potential waste!

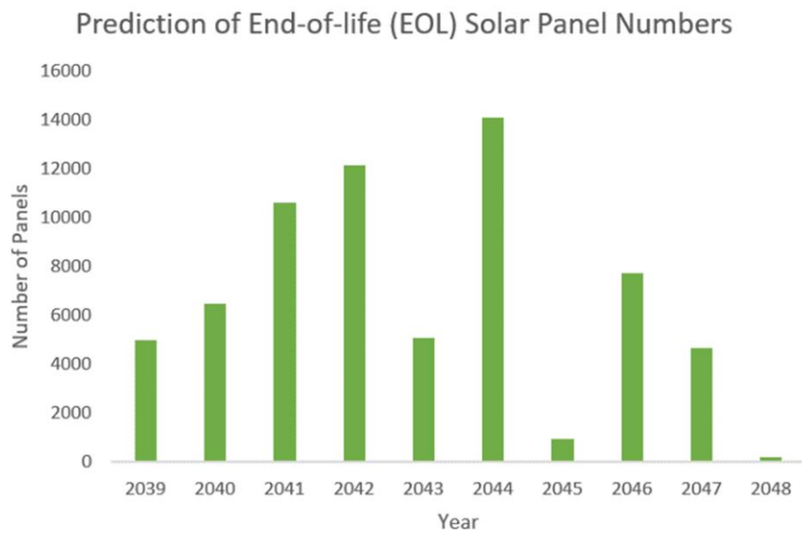

Figure 2. Estimate of panels with EOL status on tribal lands, starting in 2039. See Appendix A.1 for a note on solar efficiency rates.

1.2. Options for End-of-Life Solar

Currently, the United States has no federal regulations for the management of EOL solar. As of today, tribes can create their own solar waste management protocol.

The caveat to the above statement is that if a tribe has received funding from a state, then the tribe will have to follow any state regulations for solar panel waste. Information on solar panel waste regulations by state can be found in the links within Appendix C. Tribes in general have several options for handling EOL panels. The first option is to continue using the panels at reduced performance levels. As long as the panels in the solar array are not damaged, the array will still be able to produce a significant amount of electricity [1]. The efficiency of the solar panels will continue to decline over time, but the decrease in performance may not be an immediate issue if the array is still able to provide enough energy to power the community. Assuming that solar panels decline in efficiency at a rate of 0.7% per year, it will take 30 years for the performance to drop to 80% of the initial efficiency, and 70 years to drop to 50% the initial efficiency [3]. The advantage to this option is that there are no additional investments incurred by continuing to use an EOL solar array, though costs associated with operations and maintenance may increase over time [1]. If a tribe uses their solar array to generate revenue through a PPA, they should expect to receive less money each year due to the decline in efficiency.

Alternatively, tribes could refurbish their solar arrays (Figure 3), which would extend the life of the EOL panels while minimizing reductions in performance. Refurbishing the array would include intensive inspections, fixing any problems with the solar system, and replacing outdated components, but would not be able to stop the continued decline in performance that the EOL panels will inevitably experience [1]. This option could cost upwards of $750 per kW of solar energy capacity while extending the life of the system by 10 to 15 years [1].

Figure 3. Example of a solar array. [2]

If a tribe decides that their solar system is not worth continuing use, then the panels can be discarded in a landfill or recycled. Solar panels thrown in landfills may present environmental and human health hazards, such as the leaching of toxins including cadmium, lead, chromium, and nickel into the groundwater. The possibility of metals leaching from solar panels is such a prominent issue that hazardous waste policies prevent some solar panels from being discarded in the landfill—a topic that will be explained later in this report. Currently, it is much less expensive to dump panels in a landfill than to recycle them, but DOE Solar Energy Technology Office (SETO) is funding research to reduce the cost of recycling solar panels to < $3/module or < $150/ton by 2030 [3].

Recycling the solar array both reduces waste and conserves the United States' (US) supply of expensive, rare earth metals that make up a small fraction of solar modules. As of 2023, China was generating 60-70 percent of the world's rare earth metal supply while the US was only generating about 14% [4]. A map illustrating the countries from which the US imports minerals (many of which contain rare earth metals) is shown in Figure 4. As renewable energy infrastructure proliferates throughout the US and the world, the demand for these rare earth metals grows even stronger. The global demand for rare earth metals for renewable energy technology is projected to increase by 400 to 600 percent in a few decades [4]. Importing high-demand materials from adversarial countries like China presents an inherent risk to the US solar industry—one that could be mitigated by recycling the rare earth metals in EOL solar panels.

Figure 4. Countries from which "nonfuel mineral commodities" were imported for use by the United States in 2020 [5].

Solar panel recycling can lead to a greater return on investment for solar arrays as well. In addition to rare earth metals, there are other high-value recyclables in solar panels, namely silicon, silver, and copper [6]. Other recyclable materials in solar panels include the aluminum frame and glass panels. The abundance of recyclables in solar panels opens up a market for EOL devices, one that could reduce the overall cost of recycling. More information on the financial costs and credits associated with solar recycling will be discussed later in this report.

1.3. Structure and Function of Solar Panels

To understand the solar recycling process, a detailed description of how solar panels are assembled and operate is included in the infographic on the subsequent page (Figure 5). Solar panels are multi-layered devices consisting of a semiconducting electron transport layer (usually made of silicon) which generates electricity in the form of photocurrent. The solar module, which contains the electron transport layer, is encapsulated by various materials to protect it from environmental damage.

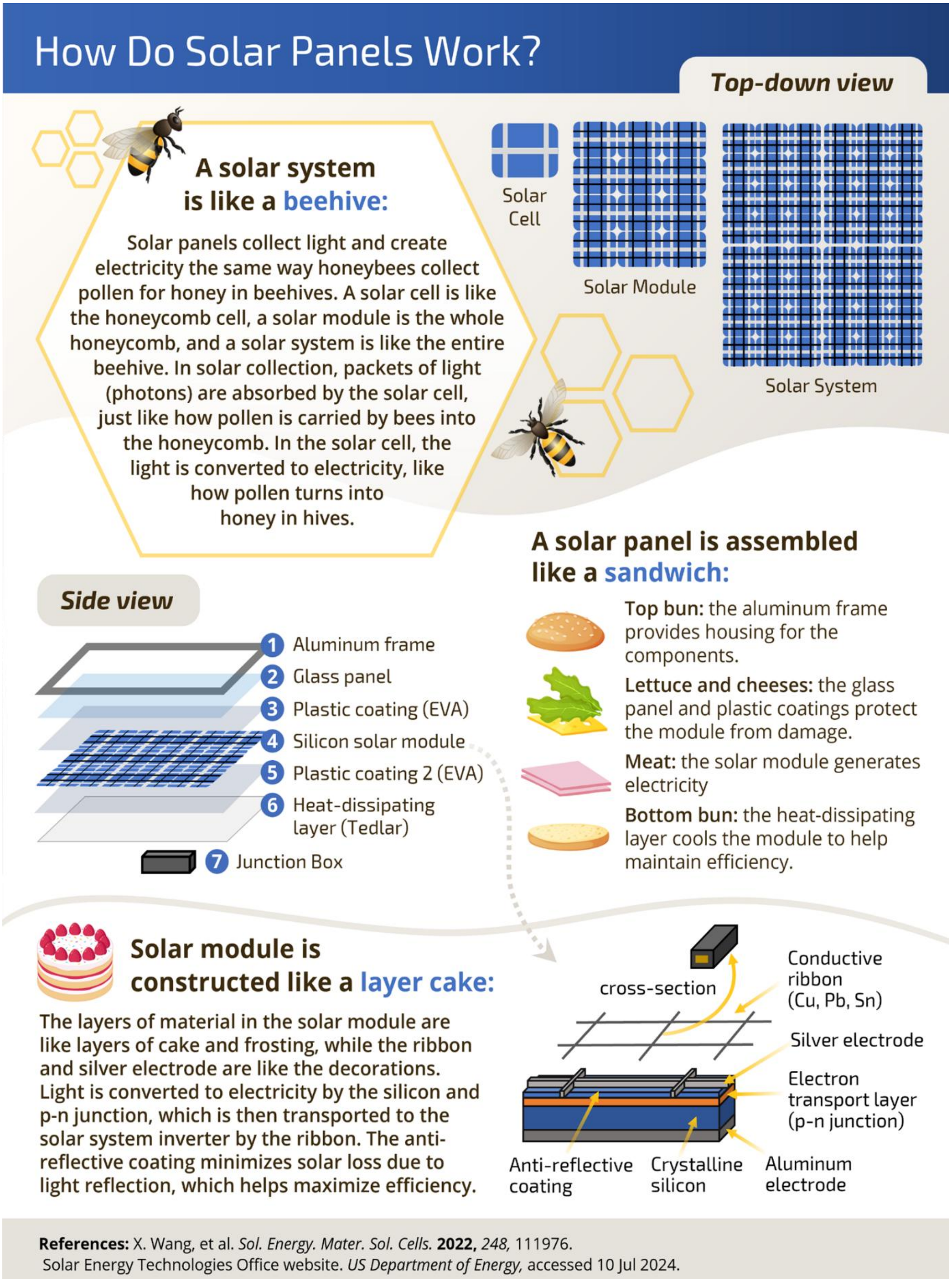

Figure 5. Solar panel assembly and operation. Reproduced from [6].

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2. PROCESS FOR SOLAR PANEL RECYCLING

2.1. In Brief

Though recycling in the solar industry is still relatively new, there are several companies already capitalizing on solar panel recycling nationwide. The map in Figure 6 illustrates the locations of solar recycling companies across the country. See Appendix B for a list of solar recycling companies organized by state.

The process for recycling solar panels varies from company to company, but generally begins with the site of the solar array. First, the solar array must be assessed to identify any panels that could be classified as hazardous waste. Afterwards, the panels *not* classified as hazardous waste are dismounted and palletized so they can be loaded onto trucks. From there, the panels are delivered to the company's recycling facility [7]. Panels that are still in working condition can be refurbished and re-sold for smaller-scale solar projects, such as off-grid living, mobile homes, and farms. Panels that are not suitable for refurbishing are mechanically crushed. The solar panel fragments are then separated based on the material identity and used for new applications such as insulation, reflective paints for roads, and even new solar panels [7].

2.2. In Detail

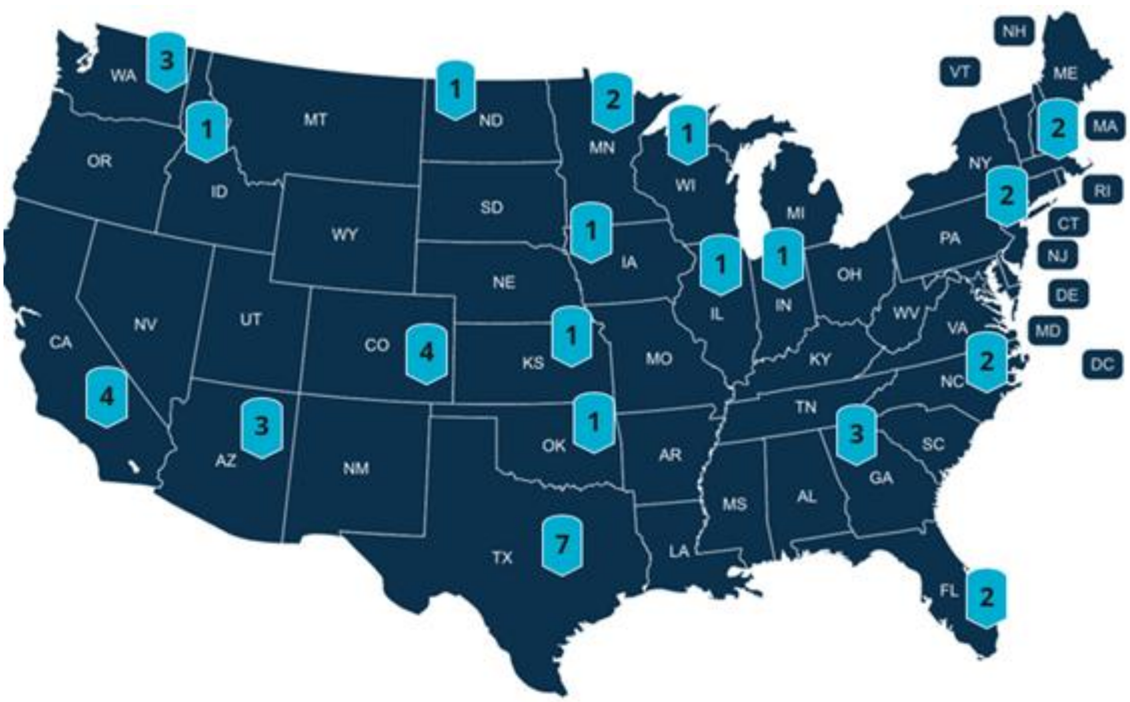

Figure 6. Locations of solar panel recycling facilities in the US. Companies located in Hawaii and/or Alaska are not included on this map.

The initial solar array assessment is perhaps the most critical step to the solar panel recycling process because its result can determine the outcome for an EOL solar array. This assessment involves recruiting a hazardous waste expert—either from a solar recycling company or a solid waste facility—to survey the solar array for dangerous materials. As previously mentioned, many solar panels contain toxic metals that pose a threat to both human and environmental health. Because of this, EOL solar panels can be—but are not always—classified as hazardous waste by the Resource Conservation and Recovery Act (RCRA) [8]. This classification comes with regulations that must be followed when recycling EOL panels. For example, people handling damaged panels with leachable, toxic metals could be exposed to the dangerous materials. To mitigate this risk, federal regulations under the RCRA state that, prior to recycling, EOL panels must pass the Environmental Protection Agency's (EPA) toxicity characteristic leaching procedure (TCLP) [8]. This test measures the quantity of leachable, toxic material in the solar panel. If the amount is below the threshold, then the solar panel is *not* considered hazardous waste and can be recycled. If the amount of toxins is above the threshold, then the panel cannot be recycled and must be discarded as hazardous waste [8].

After an assessment of the solar array is complete, the tribe can decide what disposal option and/or recycling company best suits their needs. Some solar panel recycling companies have wattage minimums for their services. For example, SolarCycle only offers services to places with large-scale solar projects, requiring a 500 panel minimum (approximately 200 kW solar capacity). First America, another solar recycling company, has a 5,000 pound minimum, roughly equivalent to 125 panels or a 50 kW solar capacity (see Appendix A.1). These panel minimums, combined with the hazardous waste rules mentioned previously, could prevent some solar arrays from being eligible for recycling. For instance, if a tribe with a 400-panel solar array experiences a severe hail storm that damages 75% of the panels to the point that toxic metals are exposed, then the damaged panels will have to be thrown out as hazardous waste. The number of intact panels remaining would not be enough to meet the weight minimum to use First America's services, and so those panels may have to be discarded in the landfill if a company with a smaller panel minimum cannot be found.

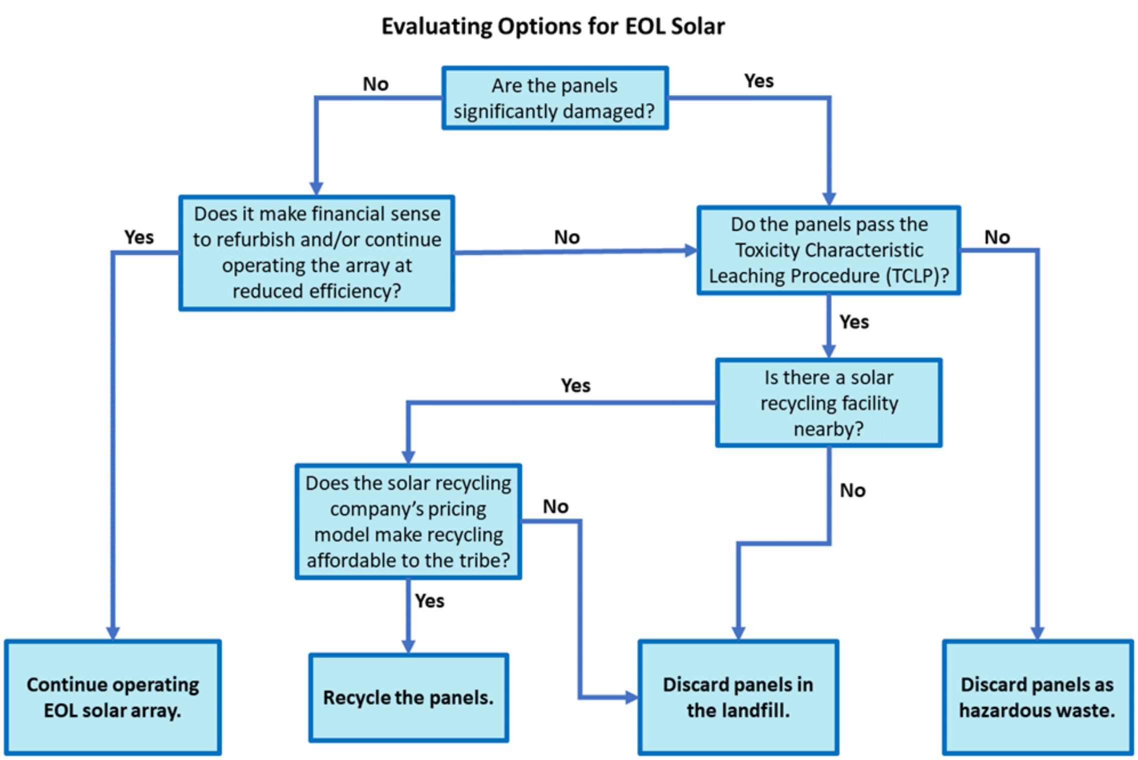

Figure 7. Decision tree for evaluating options at EOL. This decision tree serves as a general framework for understanding the factors involved in deciding how to handle an EOL solar array.

Solar recycling companies each have their own rates for their services, but in general, intact panels are cheaper to recycle than damaged ones. For instance, at First America, damaged panels cost between $0.15 and $0.45 per pound to recycle, but panels suitable for refurbishing can be *sold* to the company at a price of $0.05 per pound. On the other hand, FabTech, a solar recycling company with locations in seven states, will recycle damaged panels at a rate of $0.30 to $0.60 per watt. Panels in good condition also cost money to recycle at FabTech, but at a discounted rate of $0.08 to $0.12 per watt. Some additional costs associated with recycling services include palletizing and delivery charges, but tribes can reduce these costs by using their own resources to palletize the panels. Delivery charges will vary based on the distance from the solar array to the recycling facility. Refer to the decision tree in Figure 7 to understand how these factors influence the options for handling EOL solar panels.

2.3. Environmental Impacts of Recycling

Recycling is generally a well-established field, but solar panel recycling is still new, which means it is not a fully sustainable process yet. Due to the multi-layered structure of solar panels (see Figure 5 for more information), different processes are required to isolate the components of the module. For example, the plastic coatings that encapsulate the silicon solar module and the backsheet are thin and sticky, so these layers must be dissolved or thermally decomposed in order to be removed [6]. The dissolution process, also known as chemical delamination or chemical swelling, involves using solvents such as toluene and hexane which are environmentally hazardous, flammable, and harmful to health [6]. The alternative to chemical delamination is called pyrolysis, which uses heat in the absence of oxygen to thermally degrade the plastic layers. This is an energy-intensive method. Typically, in order to remove the plastic layers, the panels need to be heated twice for fifteen minutes each [6]. Considering the hundreds of panels that need to be recycled from just one solar project, this can amount to a massive energy usage.

Another component of the solar panel that requires special techniques to recycle is the solar module. Though mostly made of silicon, this part also contains aluminum, silver, copper, and other metals in relatively small amounts. In order to isolate the silicon from the other materials in this layer, companies turn to chemical etching. Currently, chemical etching is the only way to recover silicon from solar modules in yields as high as 90% [6]. Most of the solar panel recycling companies researched for this report claim on their websites to recover 85 to 90 percent of recyclables in solar panels. Considering that silicon is one of the most abundant recyclable materials in the solar module, this means that companies must continue to use chemical etching to recover silicon from solar panels in order to stay competitive. This process requires the use of extremely toxic, corrosive, and oxidizing chemicals such as hydrofluoric acid, nitric acid, and sodium hydroxide [6]. These chemicals can be severely damaging to the health of recycling employees and seriously harmful to the environment.

Another dangerous technique used in recycling solar panels is hydrometallurgy, a process used to recover silver ions from the electrodes in the solar module. This process, though not as hazardous as chemical etching, uses nitric acid along with hydrochloric acid, sodium hydroxide, and salt [6]. Though less harmful, the nitric acid is very corrosive and could cause an explosion, and the other chemicals could severely damage the environment. More work needs to be done to identify better, more sustainable methods of recovering these high-value materials.

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3. EMERGING TECHNOLOGIES FOR SOLAR PANEL RECYCLING

Scientists are working on new recycling technologies that address the environmental impacts associated with current methods of recycling solar panels. This includes developing new separation techniques and engineering new solar panel assemblies that allow for simpler, less expensive recycling at EOL.

3.1. Electrostatic Separation

Electrostatic separation is not completely novel, as it has been used to recycle general electronic waste for several years. This method is used to separate components of the solar module by conductivity after being crushed into pieces roughly 500 μ to 1 mm in size [9]. This method works because conductive materials can hold static charge better than less-conductive materials. The crushed pieces of the solar module are fed into a hopper, which then deposits them on a moving roller adjacent to an ionizing electrode (i.e., corona) [9]. The more electrically conducive materials (e.g., the copper in the conductive wire of the solar module) experience a strong electrostatic force when being discharged by the corona, which is strong enough to overcome the centripetal force felt by the pieces when on the roller. This leads to ejection of the conductive pieces, which can be collected with a bin positioned a measured distance away from the roller. In contrast, lower-conducting materials in a solar module such as silicon or glass will not experience a strong, discharging electrostatic force by the corona. This means that less conducive materials cannot overcome the centripetal force that keeps them on the roller, so they will be deposited in a bin closer to the roller [9]. In the end, all components of the module will have been separated into different bins. A diagram illustrating this method is included in Figure 8. The entire process requires minimal input of energy and does not create hazardous waste, thus rendering it an environmentally friendly technique.

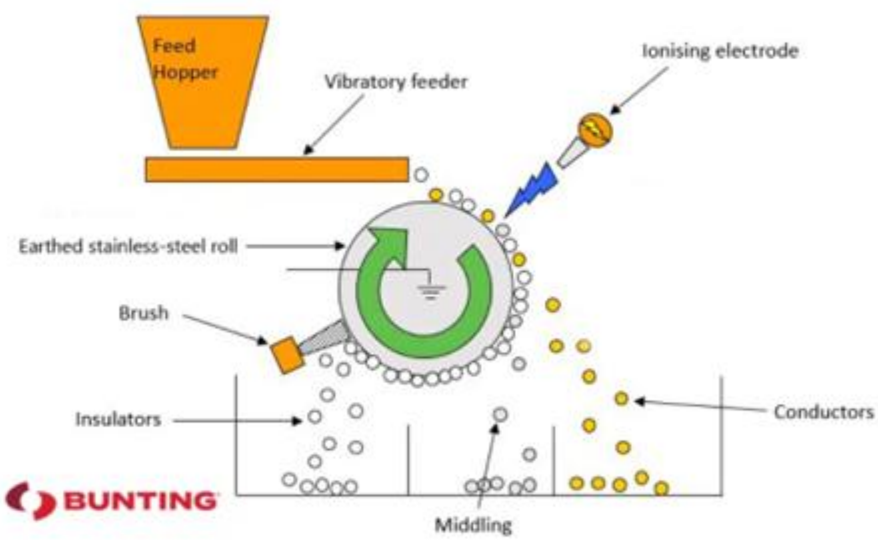

Figure 8. Diagram of electrostatic separation process. Figure reproduced from [10].

3.2. Laser Debonding

A more cutting-edge recycling method that requires little energy and does not produce hazardous waste is laser debonding, a technique developed by Professor Mool Gupta of The University of Virginia [11]. In this method, an infrared continuous-wave (CW) laser is used to melt the silver electrode off the silicon in the solar module. Laser debonding works because it takes advantage of the large difference in the melting points of the materials that make up solar panels (e.g., pure silicon has a melting point of 1,414˚C, while silver melts at 961˚C). In this process, the solar module is submerged in water such that excess heat from the laser can dissipate. The laser is focused on the silver using a lens, which allows for precise removal of the electrode without melting the silicon. The laser can achieve a precision level as small as 35 μm. This process has been automated using a MATLAB script that can identify areas where silver electrode is present [11], a feature that makes this technique ideal for commercial applications. With further study, laser debonding could be used to isolate a variety of materials in a solar module, including aluminum and copper.

3.3. Laser Welding for Glass/Glass Interfaces

Though the recycling methods explained in sections 3.1 and 3.2 show promise for "greener" solar panel recycling, neither would be able to replace the techniques used to remove the plastic coatings that encapsulate the solar module. In other words, the plastic layers would still need to be removed using either chemical or thermal delamination. However, scientists at the National Renewable Energy Laboratory (NREL) have demonstrated in a proof-of-concept study the ability to use femtosecond pulse lasers to physically weld glass panels together [12]. This means that solar panels have the potential to be assembled and sealed without plastic coatings, which would make recycling them much more environmentally friendly. For reasons beyond the scope of this report, glass/glass welding requires femtosecond pulse lasers that induce localized heating at the interface of the glass panels, thus preventing the glass from becoming brittle upon cooling to room temperature [12]. In fact, a stress test conducted on the panels confirmed that the welded glass can withstand the maximum load of 5,400 Pa for solar panels [12]. Engineering glass/glass interfaces in solar panels is an example of design for disassembly, an emerging technique being used to improve recycling processes. The next steps for this technology will be to assess the performance of a glass/glass weld in an actual solar panel. If successful, the development of a plastic-free solar panel would be a remarkable step forward in making solar panel recycling easier and more sustainable.

4. CONCLUSION

In conclusion, tribes with solar arrays will ultimately have to decide how they will handle their solar panels once they have reached EOL. There are several options for tribes to consider:

- Solar arrays are still operable at EOL, though they will generate less electricity than at initial installation.
- Refurbishing can be performed to reduce the losses in performance, though the module will continue to degrade.
- Disposal options for EOL panels include recycling and depositing them in the landfill, though these options are only available for panels that are not determined to be hazardous waste by the TCLP.

As of today, recycling solar panels is largely only available for larger solar systems, and it is more expensive than depositing panels in the landfill. The current methods of recycling solar panels have some negative impacts on the environment, but there is ongoing research to make recycling less costly and more environmentally friendly, paving the way to make significant changes in the solar recycling industry.

This overview is intended to start the conversation about options for EOL solar in Indian Country. Tribes will need to examine their specific situations in order to determine the best option for their community. For some tribes, determining the outcome for EOL panels may be left to the next generation to decide.

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APPENDIX A. FOOTNOTES ON DATA COLLECTION AND ANALYSIS

A.1. Note on Solar Energy Efficiency Rates

The power capacity and weight estimations from wattage were based on the assumption that one solar panel has about 400 W power capacity and weighs about 40 lbs—specifications that are representative of solar panels installed around 2014. Modern-day solar panels have efficiency ratings higher than 400 W/panel, so the actual metrics may vary from the estimations presented in this paper.

A.2. Calculation of Solar Energy Output

The equation used to calculate solar energy output in Figure 1b was: $power\ output = solar\ capacity \times hours\ of\ sun \times photocurrent\ generation\ efficiency$. The solar capacity values came from data in Figure 1a. Hours of sun were calculated from annual reports of sunlight by state (collected from https://www.currentresults.com/Weather/US/average-annual-state-sunshine.php), averaged by weight depending on the number of DOE-sponsored tribal solar projects in the state. States with no DOE-sponsored tribal solar projects were omitted from the average. A 17 percent photocurrent generation efficiency was used in this equation, which is an underestimate of today's solar efficiency rates, but comparable to the efficiency of panels around 2014. It is also worth noting that the graph in Figure 1b starts at 2016 instead of 2014 like Figure 1a because it takes 1-3 years on average for the solar projects included in these figures to finalize construction and start generating electricity.

A.3. Tribal Solar Projects Used in Data Analysis

Information on solar projects were collected from the DOE Office of Indian Energy Policy and Programs Tribal Energy Projects Database: https://www.energy.gov/indianenergy/tribal-energy-projects-database

Tribal Community	State Location	Period of Deployment	Power Capacity (kW)
Agua Caliente Band of Cahuilla	CA	2015-2017	76.9
St. Regis Mohawk	NY	2016-2019	614.74
Bed River Band, Lake Superior Chippewa	WI	2019-2021	520
Bishop Paiute	CA	2015-2016	189.6
Bishop Paiute	CA	2018-2021	108
Bishop Paiute	CA	2020-2023	67
Blackfeet Community College	MT	2020-2023	53

Tribal Community	State Location	Period of Deployment	Power Capacity (kW)
Chippewa Cree	MT	2016-2018	20.67
Coeur d'Alene	ID	2018-2021	52.4
Coeur d'Alene	ID	2022-2025	35.2
Dry Creek Rancheria Band of Pomo Indians	CA	2021-2024	150.2
Eastern Band of Cherokee	NC	2017-2020	700
Federated Indians of Graton Rancheria	CA	2017-2019	1500
Flandreau Santee Sioux	SD	2019-2021	318
Forest County Potawatomi	WI	2014-2016	875
Forest County Potawatomi	WI	2017-2019	734
Forest County Potawatomi	WI	2019-2022	200
Gwitchyaa Zhee Gwich'in	AK	2014-2015	21.75
Ho-Chunk	NE	2017-2019	279
Ho-Chunk	NE	2018-2020	320
Hughes Village	AK	2016-2019	100
Karuk Tribe	CA	2022-2024	947
La Jolla Band of Luiseño Indians	CA	2022-2024	104
Little Big Horn College	MT	2016-2018	45
Lummi Indian Tribe	WA	2022-2024	100
Match-E-Be-Nash-She-Wish Potawatomi	MI	2023-2025	69
Muckleshoot Indian Tribe	WA	2022-2025	130
NaNa Regional Corporation	AK	2016-2018	625

Tribal Community	State Location	Period of Deployment	Power Capacity (kW)
Northern Cheyenne	MT	2019-2022	1250
Picuris Pueblo	NM	2016-2017	1000
Picuris Pueblo	NM	2018-2024	750
Oglala Lakota	SD	2021-2022	54.5
Oneida Tribe of Wisconsin	WI	2015-2017	695
Pala Band of Mission Indians	CA	2015-2017	94.8
Pala Band of Mission Indians	CA	2021-2024	1070
Paskenta Band of Nomlaki Indians	CA	2022-2024	146
Pueblo of Laguna	NM	2022-2024	53.24
Kongiganak/Purvurnaq	AK	2022-2025	200
Rincon San Luiseño Band of Mission Indians	CA	2019-2022	3100
Rosebud Sioux	SD	2016-2018	58
Rosebud Sioux	SD	2019-2021	250
San Pasquel Band of Mission Indians	CA	2016-2019	170
San Pasquel Band of Mission Indians	CA	2018-2021	184
San Pasquel Band of Mission Indians	CA	2021-2024	223
San Xavier District of Tohono O'odham	AZ	2020-2022	255
Santo Domingo Tribe	NM	2015-2017	115
Seminole Tribe of Florida	FL	2018-2023	445
Seminole Tribe of Florida	FL	2021-2023	475
Soboba Band of Luiseño Indians	CA	2015-2016	1000

Tribal Community	State Location	Period of Deployment	Power Capacity (kW)
Soboba Band of Luiseño Indians	CA	2016-2018	1000
Sokaogon Chippewa	WI	2016-2017	605.36
Southern Ute	CO	2014-2016	800
Spokane Tribe	WA	2017-2019	637
Spokane Tribe	WA	2021-2023	980
Tolowa Dee-ni	CA	2018-2021	113
Tonto Apache	AZ	2014-2015	267
Tonto Apache	AZ	2015-2017	249
Ute Mountain Tribe	CO	2017-2019	1000
Ute Mountain Tribe	CO	2021-2023	144
Ute Mountain Tribe	CO	2022-2024	144
Washoe Tribe of Nevada and California	NV, CA	2015-2016	160.5
White Earth Band of Chippewa	MN	2016-2019	160.5

APPENDIX B. SOLAR RECYCLING COMPANIES BY LOCATION

State	Solar Recycling Companies
Arizona	Electronic Recyclers International, FabTech Enterprises, We Recycle Solar
California	Recycle 1234, Electronic Recyclers International, FabTech Enterprises, We Recycle Solar
Colorado	Electronic Recyclers International, FabTech Enterprises, Interco
Florida	OnePlanet Solar Recycling, We Recycle Solar
Georgia	Solar Panel Recycling, FabTech Enterprises, Interco
Idaho	We Recycle Solar
Illinois	We Recycle Solar
Indiana	Interco
Iowa	Interco
Kansas	Interco
Massachusetts	Zeep Technologies, Electronic Recyclers International
Minnesota	Interco, The Retrofit Companies
New Jersey	Electronic Recyclers International, We Recycle Solar
North Carolina	Electronic Recyclers International, Solar Panel Recycling
North Dakota	Interco
Oklahoma	Interco
Texas	Electronic Recyclers International, Solar Panel Recycling, FabTech Enterprises, SolarCycle, Device Services Group, Echo Environmental Holdings, We Recycle Solar
Washington	Electronic Recyclers International
Wisconsin	Interco

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APPENDIX C. FURTHER READING

Information on Hazardous Waste Policies:

- Solar Panels and Hazardous Waste
- Resource Conservation and Recovery Act
- Toxicity Characteristic Leaching Procedure

Information on EOL Solar:

- Solar Energy Technologies Office EOL Solar Action Plan
- National Renewable Energy Laboratory EOL Solar Best Practices

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