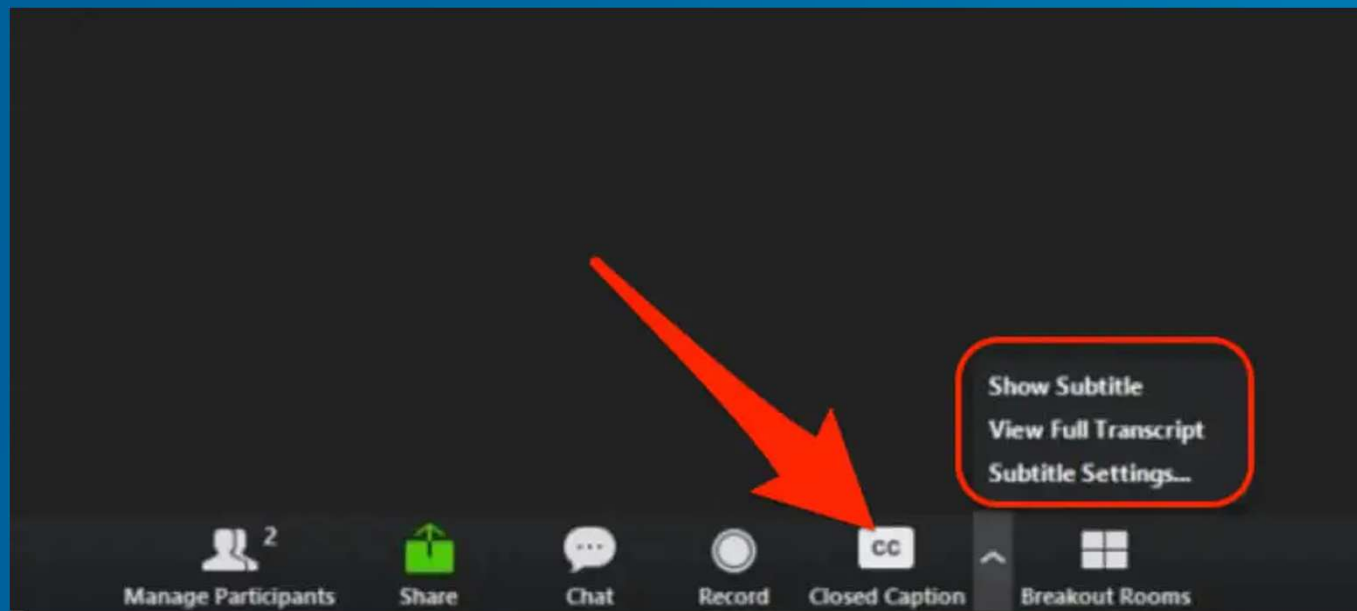


Recycling and Repurposing Strategies for Clean Energy Sites

April 23, 2024

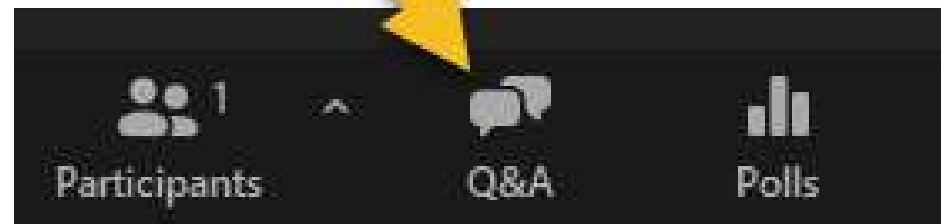


Closed Captions



Please drop questions Q&A

Here, your questions won't get lost and are most likely to get answered.



Today's Program is Being Recorded

- The recording will be available to you in ACP's streaming library by the end of this week.
- The slides will be shared with you in the chat as a downloadable pdf.



Speakers



MODERATOR

Josh Rogers

Senior Director, Safety,
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Director, Business
Development
FabTech Enterprises



Ally Peters

Environmental Associate
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Cara Libby

Technical Executive,
Renewable Energy
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Brian Donahue

Managing Partner
Canvus





Poll: What do you think is the biggest challenge to recycling?

- Different state waste classifications and regulations
- Financial
- Separation of materials
- Lack of understanding the composition of materials
- Lack of data on decommissioning

The Why

Resource Conservation: Conserves valuable resources such as metals, minerals, and composite materials, reducing the need for raw material extraction.

Environmental Impact Reduction: Proper disposal practices minimize the environmental footprint of the clean energy industry by reducing landfill waste, preventing pollution, and conserving energy.

Circular Economy Promotion: Fosters a circular economy within the clean energy sector, promoting sustainability and reducing dependence on finite resources.

Cost Savings: Can lower production costs for renewable energy systems, making clean energy more economically viable and competitive.

Regulatory Compliance: Adhering to recycling and disposal regulations ensures compliance with environmental laws and demonstrates commitment to responsible stewardship within the industry.

Social Responsibility: Demonstrating commitment to environmental stewardship through responsible waste management practices enhances public perception and social responsibility, fostering trust and support for the clean energy industry.



WHAT QUALIFIES FOR REUSE?

DOES NOT QUALIFY

BROKEN GLASS 01

SEVERE BACKSHEET/VINYL DAMAGE 02

LOW WATTAGE/VERY OLD PANELS 03

WHEN COST TO REPAIR OUTWEIGHS SALES VALUE 04

DOES QUALIFY

APPROXIMATELY 10 YEARS OLD OR LESS, OVER 300W TYPICALLY. 01

SLIGHT DAMAGE SUCH AS BENT FRAMES, MINOR BACKSHEET SCRATCHES, GLASS SCRATCH, BROWNING CELLS, AND SNAIL TRAILS MAY AFFECT VALUE, BUT STILL USABLE AND POWER IS NOT IMPACTED 02

DAMAGED JBOXES CAN BE REPLACED IN VALUABLE PANELS 03

CASE STUDY: Renewable company saves \$40,000 in recycling/freight and is paid \$35,000 instead...

SITUATION

Site decommission leaves **1,642** 300W solar panels with slight backsheet cracking to be disposed of Recycling/Freight cost: **\$40,000**

SOLUTION

1,642 shipped to Fabtech, **60** needed to be recycled and **1,582** could be refurbished and resold.

RESULTS

Fabtech paid the customer for the good panels minus the recycling cost for the 60 panels.

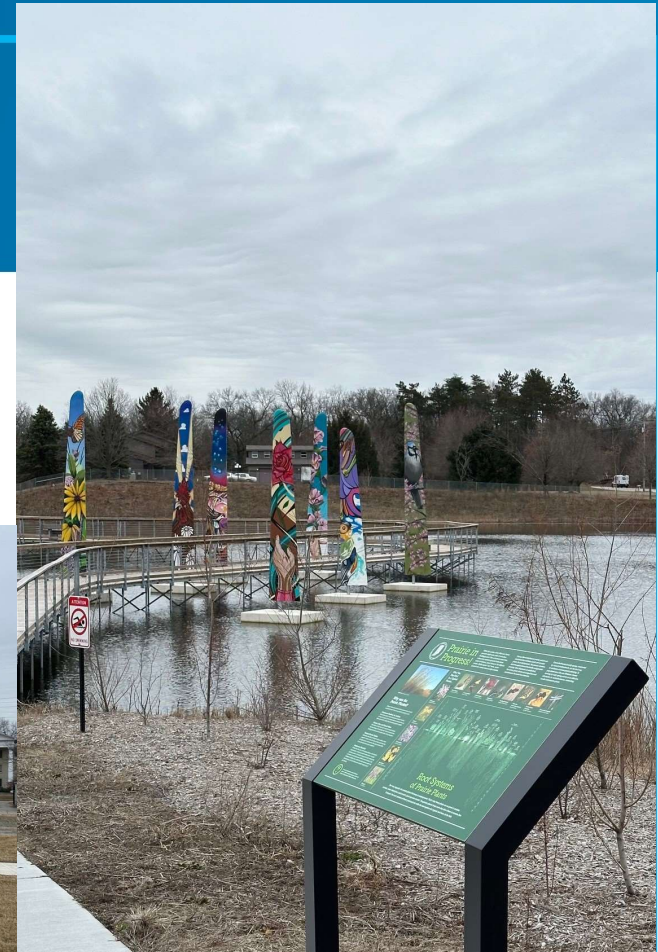
\$35,000 paid to customer
\$12,000 freight paid by Fabtech

www.fabtech.net



1,582 solar panels were diverted from the landfill and went to produce off-grid power for over 160 customer's DIY projects

Kankakee Welcome Center

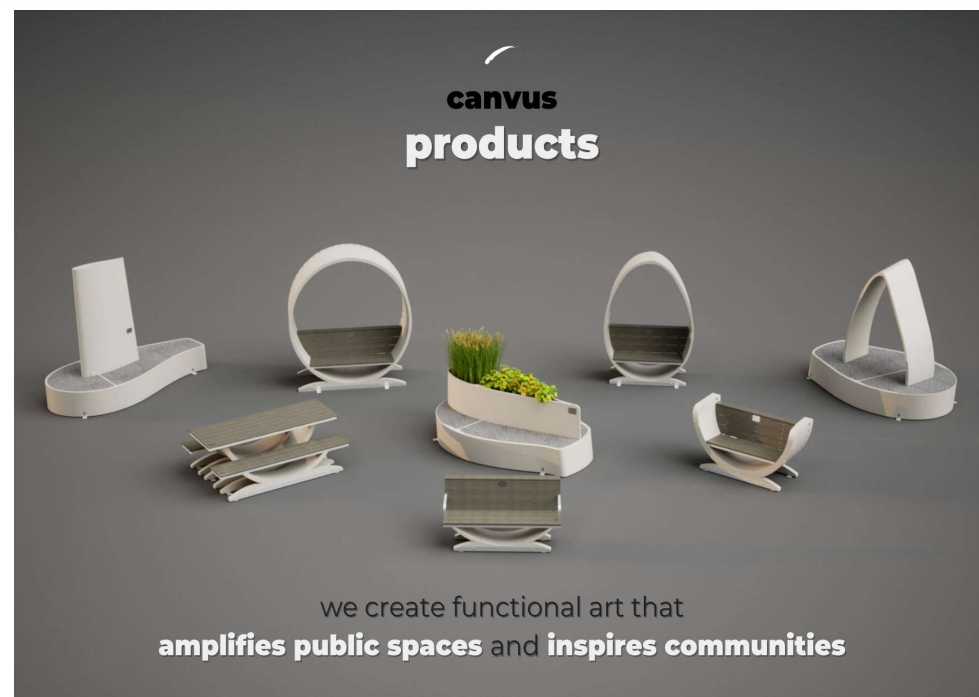
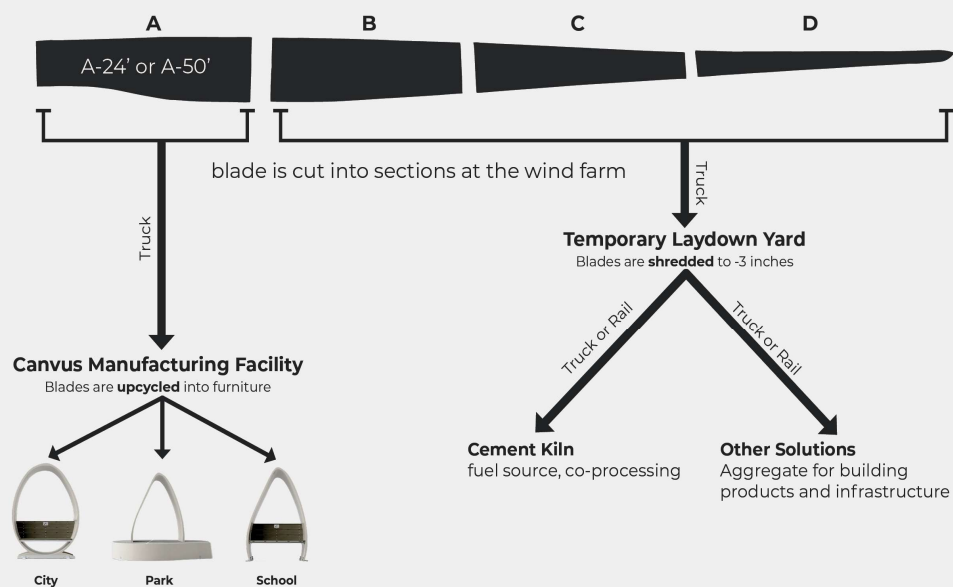


Recycling Examples



Canvas Products

Blade Processing



PAR – Primed and Ready



PAR (Primed and Ready) offers a canvas for communities to reimagine their public spaces, inviting artists to paint one-of-a-kind works of art.

Who can be a Canvas Artist?

Just like the art itself, Canvas Artists are inspirational, one-of-a-kind, and universal. It can be anyone from professionals to your own citizens, students, employees, senior citizens, and veterans.

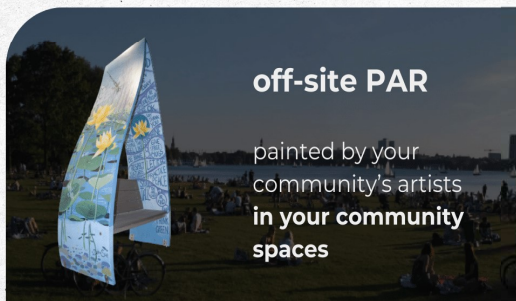
on-site PAR

painted by canvas artists at our design studio in avon, ohio



off-site PAR

painted by your community's artists in your community spaces

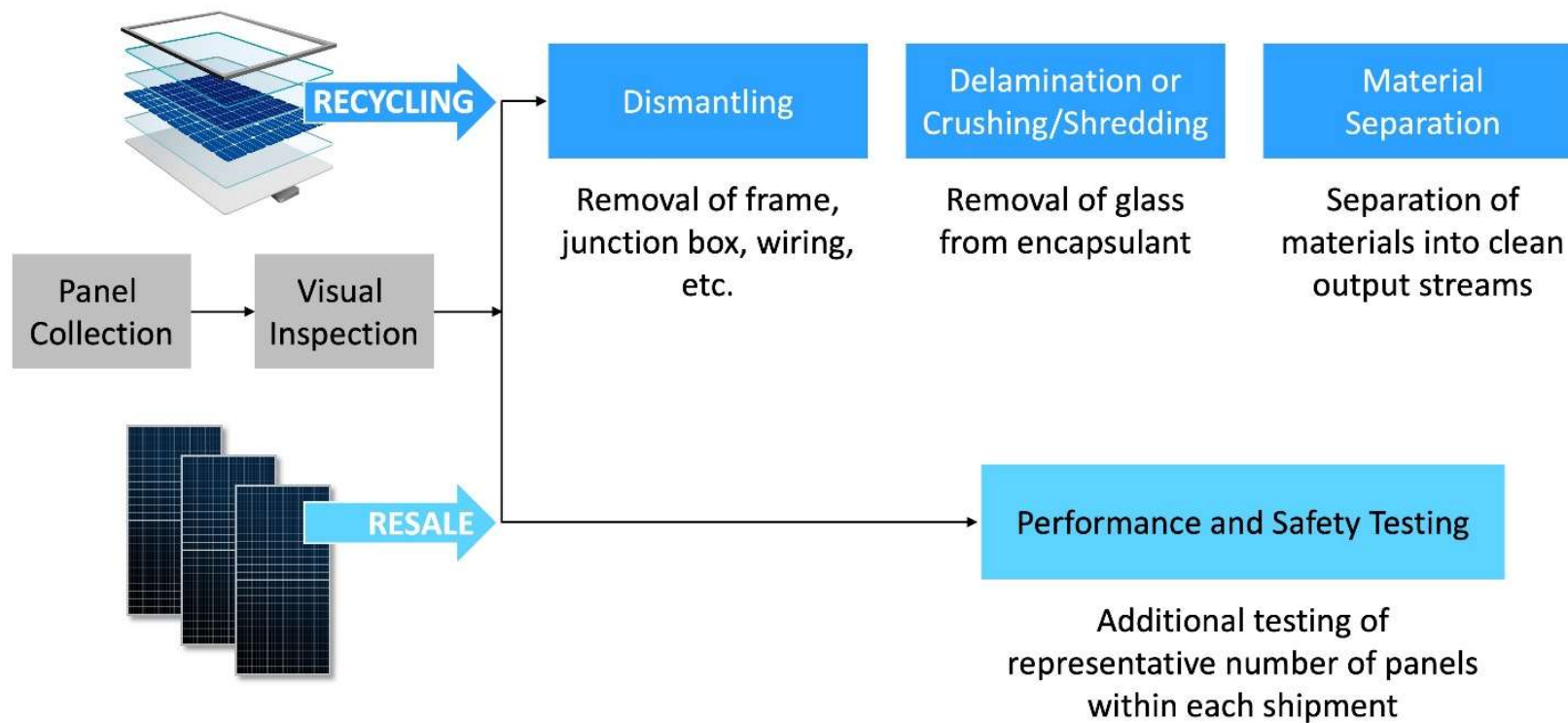




Poll: Approximately what percentage of a solar panel can be recycled?

- 0%
- 30%
- 50%
- 90%
- 100%

PV module dispositioning and processing



Recycling outputs

Glass



Credit: Reiling Glas Recycling



Semiconductors,
trace metals,
and polymers



Aluminum



Upcycling challenges

- **Low value** of recovered materials; silicon and glass are typically downcycled, and silver is rarely recovered
- **No solidified markets** for some process outputs
- Downstream offtakers are concerned about **glass impurities**
- Recovered materials **may not meet upcycling purity specifications**, resulting in material storage or landfill disposal

Markets for Recovered Solar Module Materials



Patented recycling treatments

- Mechanical treatments, such as cutting, shredding, grinding, and blasting
- Thermal measures, such as pyrolysis, incineration, and hydrothermal or polymer melting
- Chemical treatment with solvents, such as water vapor, supercritical CO₂, ionic liquids, salt melts, limonene, and microemulsions
- Treatments complemented by reactive chemicals to remove layers and recover materials of interest, such as alkaline (NaOH, KOH with or without alcohol), HNO₃, H₂SO₄/H₂O₂, and methane sulfonic acid
- Other: electrodynamic fragmentation, laser, or flash lamp annealing

c-Si Treatment	Share of Patents
Mechanical	40%
Thermal	15%
Chemical	19%
Combination	25%

CdTe Treatment	Share of Patents
Mechanical	7%
Thermal	9%
Chemical	7%
Electrochemical	4%
Optical	9%
Combination	64%

Lithium-Ion Battery Decommissioning and Recycling

Preparation

- Start at procurement
- [Guidance for Assessing EOL options...](#)

Providers

- North American [service provider offerings](#)
- How to interview vendors?

Process

- De-energization, Separation, Disassembly, Packing



[Cedartown decommissioning case study](#)



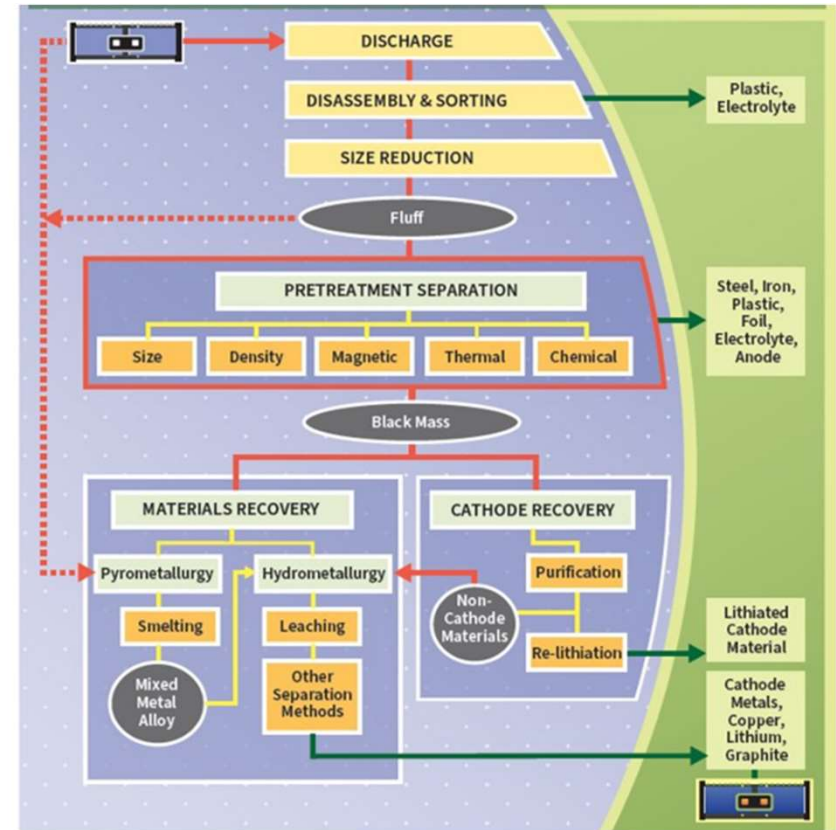
- Reuse vs recycling

Price

- Public cost estimate links: [LIB + Flow Battery Breakdowns and LIB Breakdown](#)
- Full decom. costs for 2MWh NMC modules in a single container: \$34k to \$100k (4 quotes from 2022)

Cost drivers: Module recycling, substantial manual labor to disassemble, and transport costs for hazardous material shipping. Best practice is to find local recycling

Market: LIB recycling capacity is increasing quickly, leading to rapid price decreases. In 2022 1 quote provided free module recycling, 2 provided a salvage value against other project costs, and 1 had module recycling costs. Prices may vacillate over the next 4-5 years as recycling capacity increases then may consolidate or shutter.

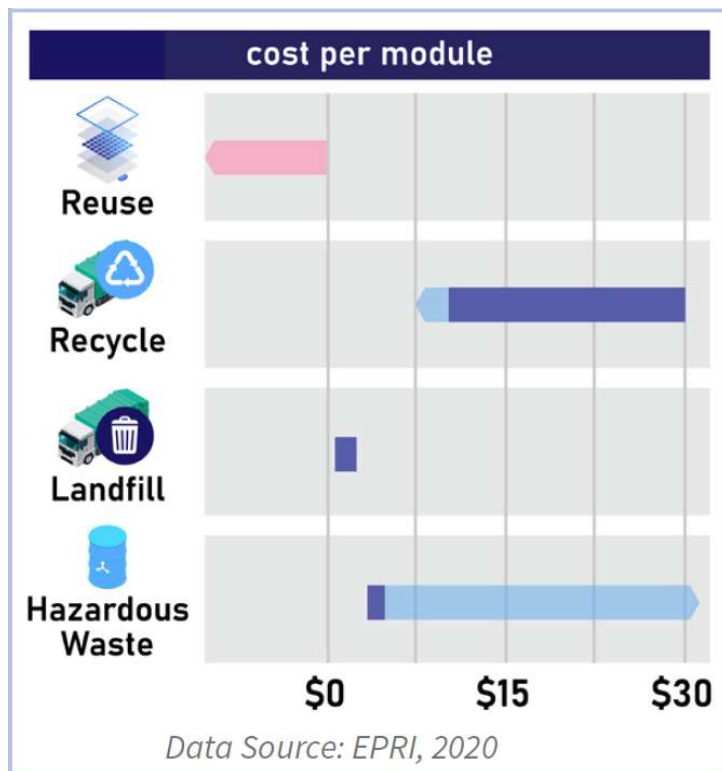




Poll: Do you currently budget for recycling or repurposing site components?

- Yes
- No
- Not sure

Module management economics



- **Reuse** provides opportunity for revenue or tax savings
- **Recycling** crystalline silicon modules is currently ~\$14-\$30 per module (in-house recycling)
- **Landfilling** modules is cheapest option at \$0.50-\$1.80/module
- **Hazardous waste disposal** starts at \$3.60/module, but can be >100x higher depending on volume and treatment method

Questions?



Thank You



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Please Complete Our Exit Survey



ACP PowerCasts Exit Survey

Anonymous • 6 questions

1. Overall, how satisfied were you with this PowerCasts program? *

0: Dissatisfied, 5: Very Satisfied

0 1 2 3 4 5

2. I gained knowledge, skills or understanding relevant to my job and/or my understanding of the clean power industry. *

- Strongly Agree
- Somewhat Agree
- Neutral
- Somewhat Disagree
- Strongly Disagree



Thank you!

