MINNESOTA POLLUTION CONTROL AGENCY

Solar Panel Recycling & Reuse Policy Work

MACPZA

Amanda Cotton and John Gilkeson

October 4, 2024

Background and Recap

MN solar panel stakeholder process – end of life options

Goal Statement:

Collaborate to develop and implement PV panel end of life management policy and programs that conserve resources, protect health, promote renewable energy, and support PV panel recycling infrastructure and technology

Recap of goal and process

Collaboration:

- SEIA, MnSEIA, and Dept. of Commerce
- Regular communication with counties through AMC, SWAA, MACPZA
- Illinois: Regular communication with IL Sustainable Technology Center and their stakeholder process
- North Carolina: participated in webinars and commented on 2021 draft plan
- Washington: regular communication with state agency staff
- Communications with NREL, recovery/recycling companies, manufacturers

Recap of goal and process

All webinars and surveys were open to anyone interested in participating.

Seven webinars over 18 months:

- June 27, 2019: Introduction, white paper, first survey on issues
- Oct. 9, 2019: National/Regional overview - SEIA, IL STC, NREL
- Dec. 11, 2019: PV forecasts & LCA, urban mining - NREL, manufacturers, recyclers
- March 18, 2020: Product Stewardship 101 and EPEAT
- June 11, 2020: Program options/survey, Commerce/Decommissioning, local govt
- Dec. 10, 2020: NREL - R&D Roadmap for PV Recycling; EOL/circular economy, local govt
- Dec. 17, 2020: Expanded discussion of program options, followed by a survey

4 Policy Models discussed

- Commerce/PUC Decommissioning model extended to solar facilities under 50 MW, plus reuse/recycling requirement: permittee individual responsibility
- Product Stewardship model: permittee pays stewardship assessment to manufacturer/Product Stewardship Organization at purchase; manufacturers/PSO operate statewide program
- Rate payer funded/statewide program model
- Permittee funded/statewide program model

Minnesota Decommissioning Framework for solar

- Decommissioning framework: all energy facilities >50MW plus wind >5MW
- Plans must be updated every 5 years or at ownership change; financial assurance starts at year 10
- ~1.2 GWdc solar installed
- 80 percent of capacity in installations <50MW, not covered by decommissioning
  - Three facilities >50MW currently permitted and operating [262 MW]
- Facilities >50MW in process:
  - Xcel Energy Sherco permitted for 460 MW [replacing Sherco coal]
  - Hayward, Byron, others in permitting process

Challenges and Feedback

Challenges

- Counties
  - Counties receiving varying recycling decommissioning estimates from developers
  - Can’t rely on scrap value and commodity markets to offset recycling costs
- Developers/Installers
  - Thin margins
  - Tough to find panels for projects
- Manufacturers
  - Worry about any additional money put on the price for a panel that would go towards recycling at EOL
  - Perceived barriers to MN installations
  - Future: Design to be less toxic, easy to recycle, but durable to withstand the elements
- Collection, reuse, recycling
  - Limited collection and recycling infrastructure in MN and the US
  - Lack of data on MN discards
  - How to ensure high recovery for high value materials that can go back into new panels, e.g., rare earths
  - Cost of recycling
  - Reuse: certification, warranty, value, market

Feedback from the industry

- Perceived barriers that
  - increased costs will prevent many companies from doing business in MN (installations)
  - solar module manufacturers might choose not to do business in MN
  - a Product Stewardship model on a regional, national or international scale would mitigate any competitive disadvantage
  - Coal, nuclear, natural gas, wind don't have to follow Product Stewardship
- Prefer market based or private sector-led strategy
- This isn't an issue for another 15-20 years.
- Industry will recycle without needing a law (industry over 50 MW)

Consensus policy ideas raised by stakeholders in webinar conversations and written comments

1. require recycling and reuse with landfill ban;
2. manufacturers tied in for design;
3. costs internalized to the project or developer (permittee);
4. no costs that create disadvantages for anyone;
5. consistent and predictable approach for everyone;
6. applies to all installations, residential to utility scale

- Survey results showed strong preference for permittee-funded options, in part because this is the funding/responsibility model in the solar sector.

- All of the models, except ratepayer funded, represent a type of permittee funded model.

Minnesota Legislative Proposal, 2022

MPCA proposed a Product Stewardship (PS) model for solar module legislation that most closely aligns with the criteria expressed by stakeholders in our surveys and webinar discussions, including:

- PS covers all solar modules regardless of manufacturer, purchaser, user, date of installation or the regulatory body with jurisdiction over siting, zoning, operations, and decommissioning
- A stewardship assessment fee on each solar module is visible, fair, and equitable to everyone – manufacturers, installers, permittees [internalized costs are an option]
- PS is the only model that ties in manufacturers for solar module design and material considerations, which affect end of life costs, technologies, etc.
- PS provides one end-of-life management program for the entire state that isn't dependent upon individual responsibilities or decisions by permittees, or permittee compliance

Cost of recycling

- Today, it costs $25 to $45 to process a solar panel in the USA. (cost depends on condition, type, brand and location of the solar panels.)
- In Europe, the price is $0.70 cents per panel to collect, transport and process under WEEE and PV Cycle collection and recycling program.

Credit: Sam Vanderhoof with Recycle PV Solar

PV Panel recycling costs in context of life cycle costs?

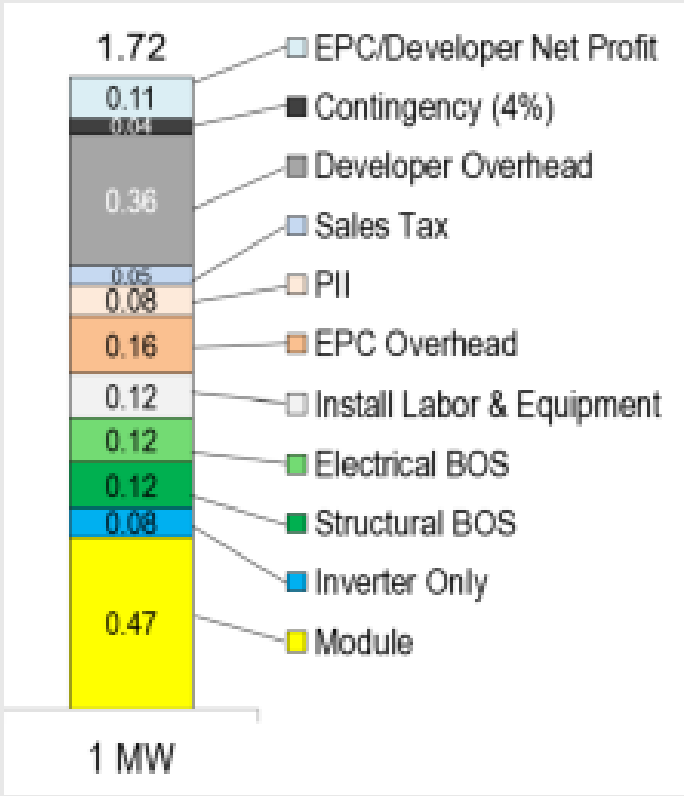
PV Recycling/Transportation Costs:
$20-$24 per 300 Wdc panel or $0.066-$0.08 per Wdc;
Equivalent to cost of inverter in installation and <5% of system installation cost

PV Life Cycle Income:
Unknown

PV Decommissioning Costs:
Unknown

(Wdc = Watts dc)

PV Installation Costs per Wdc:
2018 Commercial PV system cost*

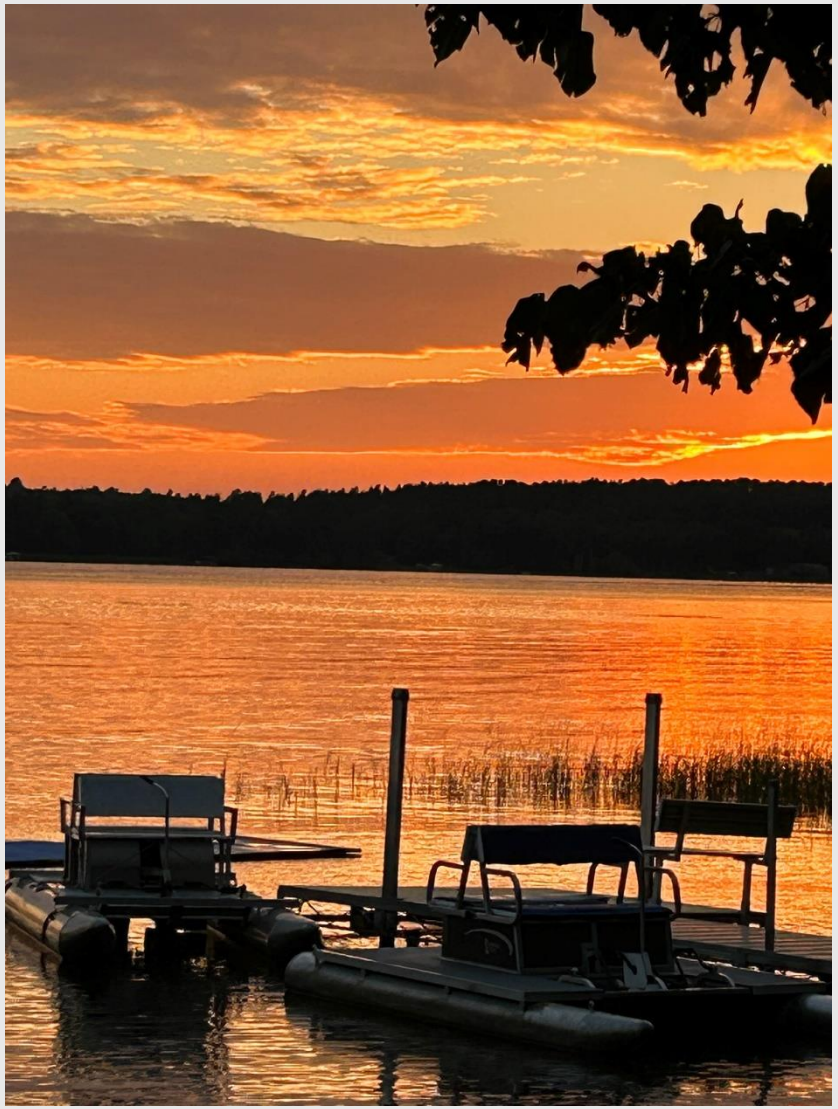


*Credit for graphic and data in previous slide

Graphic is excerpt of:

Figure 20. Q1 2018 U.S. benchmark: commercial PV system cost (2018 USD/Wdc)
U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018.
Ran Fu, David Feldman, and Robert Margolis
National Renewable Energy Laboratory
NREL Technical Report NREL/TP-6A20-72399, November 2018

Why Now?



Why now? MN perspective

- MN landfill diversion goals and recycling goals in state law
- Only panels in installations over 50 MW or owned by investor-owned utilities have an EOL/decommissioning requirement
- County and local government concerns for EOL management in the absence of a statewide program/requirements
- Panels are coming out of service now. These resources should be covered.
- We need to start building collection and recycling infrastructure because this takes time to develop. Can't wait until the volumes are huge (don't want to repeat e-waste)
- Negative press. The public is watching. Solar is not a green technology if the hardware is going in landfills (same with wind)
- Enhance jobs and economic development in the renewable energy and recycling sectors with collection and recycling activities. Siting solar module recycling facilities in Minnesota would be a positive economic and environmental development activity.
- **Renewable energy industry can control its destiny by taking the lead on these initiatives**

Why now? National perspective

- National security concerns:
  - Recover and reuse materials in our own country
  - Reduce our dependence on other countries for scarce materials and finished products
- Environmental justice of extraction impacts on the land and support for human rights in developing nations
- Federal funding opportunities for solar panel recycling/technology development through BIL
- Federal incentives for domestic critical mineral recovery and manufacturing through IRA
- Avoid a patchwork of programs and policies

Why now? Critical minerals and energy

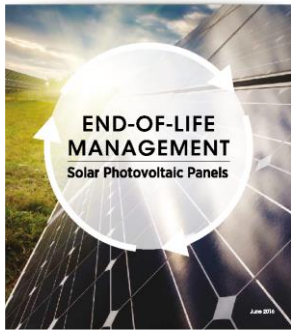
- Reuse and recycling are crucial to managing large future PV waste volumes
- Recycling is important for all PV technologies
  - Environmentally sensitive materials are common in the industry
- Provides socio-economic and environmental benefits
  - **Minimizes life cycle impacts**
  - **Reclaims valuable and energy intensive materials**
  - **Recycling maximizes resource recovery and increases the sustainability of PV**

Credit: First Solar presentation Dec. 11, 2019.

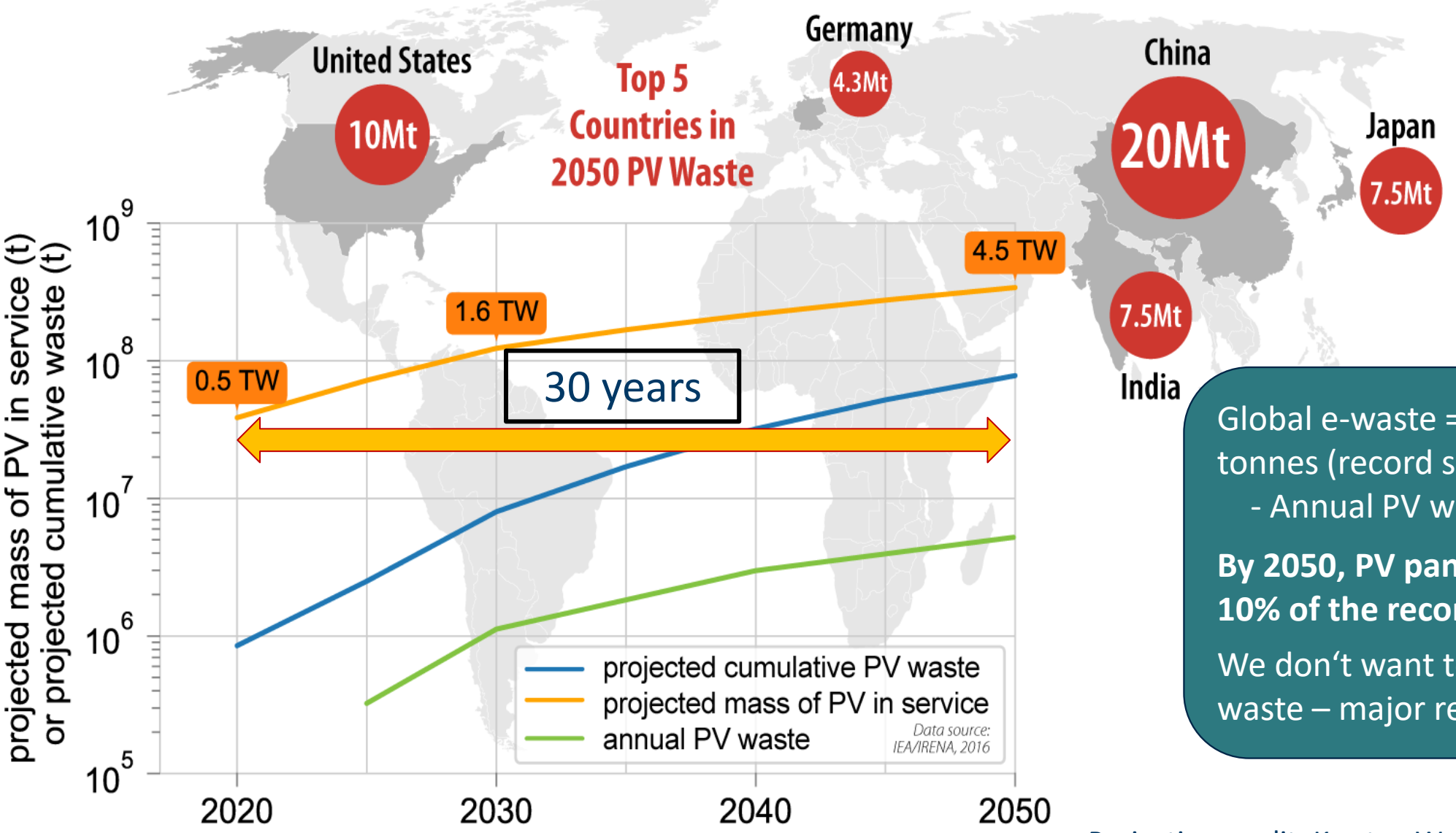
- Recovery of glass, metals, and semiconductor material from PV modules **causes lower environmental impacts** than extraction, refinement and supply of the respective materials from primary resources.
  - 28% to 750x lower across the categories considered (mineral resources highest)

Credit: Life Cycle Assessment of Current Photovoltaic Module Recycling, IEA PVPS Task 12, International Energy Agency Power Systems Programme, Report IEA-PVPS T12-13: 2018. Garvin Heath/NREL presentation Dec. 11, 2019.

Low Volumes Now, End-of-Life (EOL) PV Will be Significant Challenge in Future



IEA/IRENA, 2016



Global e-waste = 41.8 million metric tonnes (record set in 2014).

- Annual PV waste was 1000x less

By 2050, PV panel waste could exceed 10% of the record global e-waste.

We don't want to repeat mistakes of e-waste – major reputational risk for PV.

Projection credit: Karsten Wambach

Where we are at today:
2023 solar module recycling study and policy working group

A report on the development of a system to reuse and recycle solar photovoltaic modules and installation components in Minnesota in consultation with the commissioners of commerce, and employment and economic development, provided to the 2025 legislature.

The report must include:

Options for a **plan to collect, reuse, and recycle solar photovoltaic modules and installation components at end of life that is convenient and accessible throughout the state, recovers 100 percent of discarded components, and maximizes value and materials recovery, including analysis of:**

a) the reuse and recycling values of solar photovoltaic modules, installation components and recovered materials;
b) system infrastructure and technology needs;
c) how to maximize in-state employment and economic development;
d) determination of net costs for the program;
e) potential benefits and negative impacts of the reuse and recycling system on environmental justice and tribal communities.

The report must include a survey of solar photovoltaic modules and installation components coming out of service now and projected into the future in Minnesota, including a description of how they are currently being managed at end of life, and how they would likely be managed in the future without the proposed reuse and recycling system.

Where we are at today: 2023 solar module recycling study and policy working group

MPCA contracted with Eunomia and subcontractor Product Stewardship Institute (PSI) to develop the report analyzing the system options and forecasting installations and end of life in 10-year increments 2025-2055.

MPCA contracted with the MMB management analysis division to facilitate the Policy Working Group.

Policy Working Group representation:

- MnSEIA
- SEIA
- Local governments: MACPZA, Townships
- Manufacturers: Heliene, First Solar
- Recyclers: SolarCycle, Dynamic Lifecycle Innovations, IRT, Cosmic Recycling
- Great Plains Institute
- Xcel Energy, Minn Power
- Department of Commerce, Department of Employment and Economic Development
- Tribal representatives
- EDF Renewables
- BlueGreen Alliance
- Conservation Minnesota
- Clean Energy Economy Minnesota
- CURE MN
- Midwest Renewable Energy Association

Where we are today:
2023 solar module recycling study and policy working group

Draft scenarios being analyzed:

Scenario 1: Decommissioning/recycling requirement with a lower threshold (e.g. 1 MW) than the current >50 MW; disposal ban only requirement for installations under the threshold

Scenario 2: Decommissioning/recycling requirement same as scenario 1; Universal disposal ban with recycling targets for panels in all other installations

Scenario 3: Decommissioning/recycling requirement applicable to all installations and paid by permittee/owner

Scenario 4: Decommissioning/recycling requirement same as scenario 1; EPR to manage all panels

Scenario 5: Decommissioning/recycling requirement for utilities only – low threshold (e.g. 1 MW); EPR to manage all panels not subject to decommissioning

Reuse/recycling requirement applies to decommissioned installations under scenarios 1 and 2 and to all installations under scenarios 3, 4 and 5

Where we are today:
2023 solar module recycling study and policy working group

- Eunomia/PSI and MMB conducted individual interviews to help inform modeling and selection of system options and PWG framework.
- The Policy Working Group reviews the report and must advise the Commissioner of the MPCA on policy recommendations for a statewide system to manage solar photovoltaic modules and installation components.
    - The PWG will review the draft report September/October
    - Eunomia's final report due by the end of October
    - The PWG will advise the commissioner by end of November
- By January 15, 2025, the commissioner must submit the report and the agency policy recommendations to the legislature.

Thank you!

Amanda Cotton
Electronic Waste Coordinator
Minnesota Pollution Control Agency
Phone number: 651-757-2211
Email: amanda.cotton@state.mn.us
www.pca.state.mn.us/electronics

John Gilkeson
Toxics Reduction Coordinator
Minnesota Pollution Control Agency
Phone number: 651-757-2391
Email: john.gilkeson@state.mn.us

MINNESOTA POLLUTION CONTROL AGENCY

Regulations for end-of-life for *commercial entities*

- Subject to RCRA (Resource Conservation and Recovery Act) regulation.
- Per RCRA, all waste streams must be evaluated before disposal.
- If evaluated as Hazardous Waste (HW), dispose in a permitted facility or properly recycle
- To promote recycling, MPCA treats panels as we do e-waste: If properly recycled, considered universal waste, not HW – so no need for evaluation, reporting, transporting as HW. Material is subject to storage time limits and may be subject to other requirements.

Regulations for end-of-life for *households*

- Under Federal exemption of household HW from RCRA, if generated from *households* may be disposed of in municipal solid waste without any evaluation.
- Contractors removing: review contracts
- Contractors and installers may retain end of life management responsibility for leased panels
- Regardless of HW classification, solar panels are resource rich (metals, glass, silver) and Minnesota encourages recovery of materials whenever possible.
- Homeowners should contact vendors to take back and recycle.

Decommissioning - planning and costs

End of life Management Cost Considerations

- Investor-owned utilities must finance decommissioning in the rate base, so they can most likely finance recycling as a capital cost of installation, and receive a regulated rate of return on total capital cost
- Recycling not mandated by law or in decommissioning requirements now
  - Panels are subject to RCRA determination
- New decommissioning plan requirement for one solar facility:
  - “a recycling, reuse and reclamation plan that describes how the project materials will be reused, recycled, or repurposed, to the extent reasonably practicable.”

Challenges

- Counties
  - Counties responsible for zoning/permitting/EOL standards, no statewide decommissioning framework for solar <50 MW
  - Counties receive widely varying recycling/decommissioning estimates from developers
  - Can’t rely on reuse projections, scrap value, and commodity markets 30 years in future to offset unknown reuse/recycling costs
- Developers/Installers
  - Thin margins
  - Tough to find panels for projects
  - Program costs need to be transparent and fall equitably across the industry, no party is advantaged or disadvantaged

Challenges

- Manufacturers
  - Worry about any additional money put on the price for a panel that would go towards recycling at EOL
  - Perceived barriers to MN installations
  - Future: Design to be less toxic, easy to recycle, but durable to withstand the elements
- Collection, reuse, recycling
  - Limited collection and recycling infrastructure in MN and the US
  - Lack of data on MN discards
  - How to ensure high recovery for high value materials that can go back into new panels, e.g., rare earths
  - Cost of recycling
  - Reuse: certification, warranty, value

Recap: Why is end of life management important?

IRENA-IEA Photovoltaic Power Systems Task 12 PV Sustainability

"In addition to its positive impacts on energy security and climate change, PV technology is also among the most environmentally friendly technologies of all energy and electricity generation technologies, particularly when evaluated from a life-cycle viewpoint, including end-of-life management. This means that proper end-of-life management is an indispensable issue for "clean" energy technologies."

"Managing end-of-life PV modules to recover valuable materials that can displace virgin ones is an important step toward meeting the challenge of sustainability."

Report IEA-PVPS T12-10:2018, page 5