

Solar Recycling

University of Maryland Global Campus

Capstone Classes

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UMGC Capstone Classes

- Identify locational concerns for a Regional Solar Recycling Center
- 2 classes completed, 8 reports to date,
- 1 class in progress
- 1 future class

Can Solar Modules be Reused?

- Four (4) categories of use
 - Immediate reuse (little to no inspection)
 - Recertified (tested to meet a standard) (allow use on projects)
 - Repaired
 - Recycle to base materials (physical or thermal/chemical)

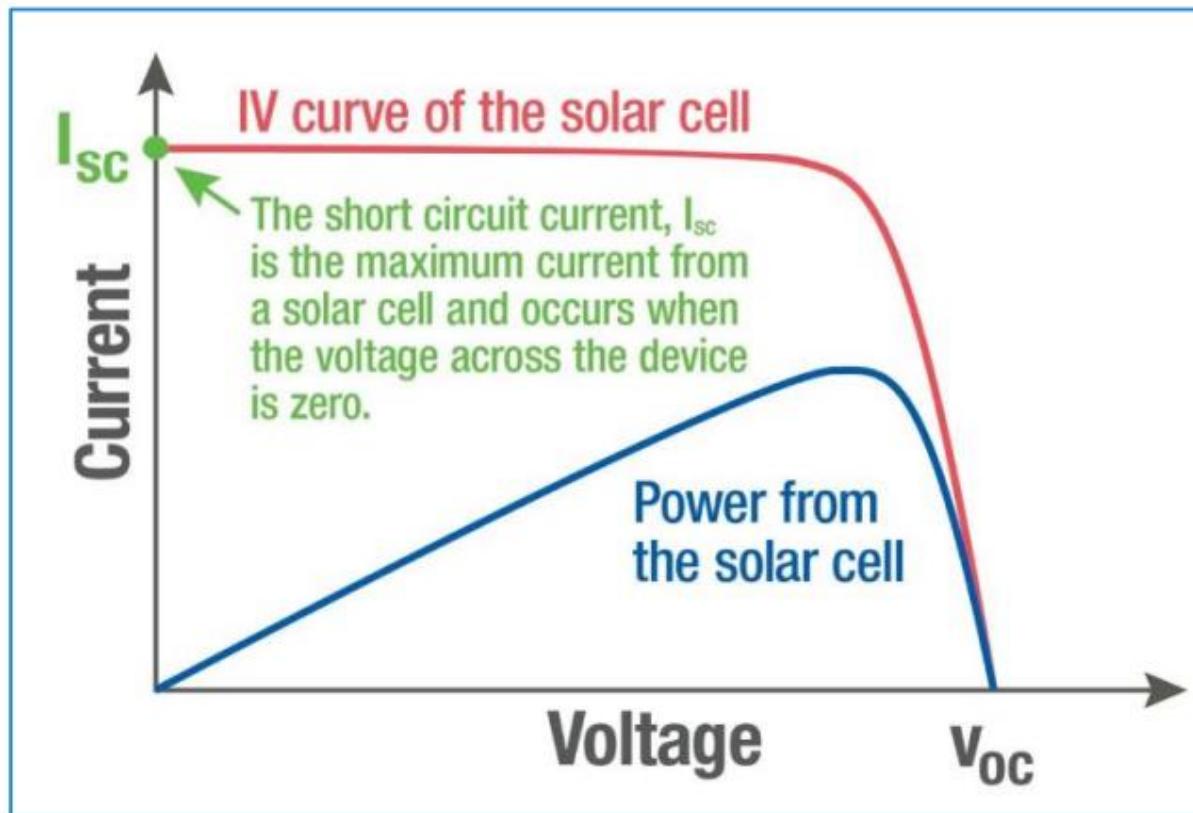
Immediate Reuse

- A small but evolving market.
- Uses that do not require reliability.
- For prices, look at websites for SunHub, SanTan Solar and Solar Steals

Solar Module Tests

- I-V Curve (done in the field on strings or on separate modules)

IV Curve



Solar Module Tests

- Infrared Imaging (IR) (Thermal scan) (normally done in the field by drone)

IR Testing

Figure 1: Anomaly of a Single PV Module
(Vasanth, et al., 2023)

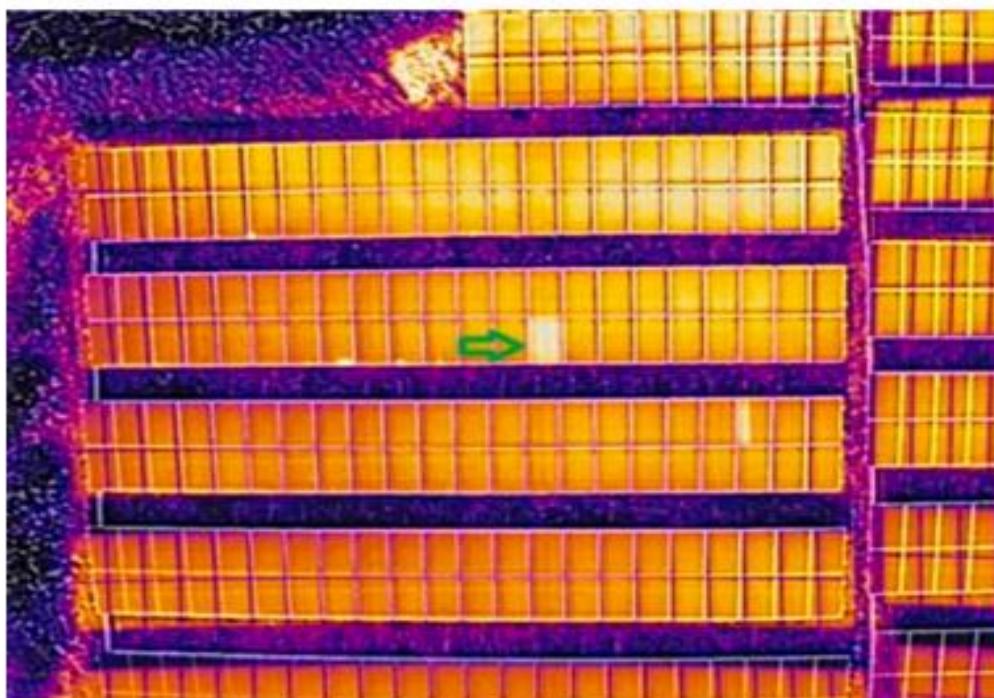
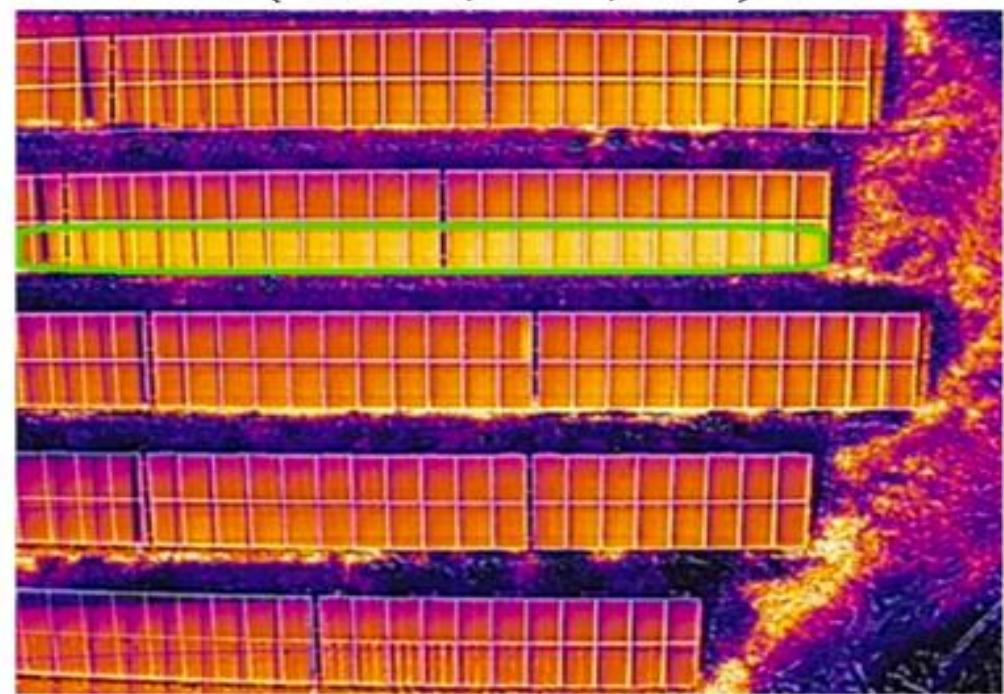


Figure 2: Anomaly from a Single PV Module String
(Vasanth, et al., 2023)



While infrared thermography using UAVs is a validated method for onsite PV inspection, readings can be adversely impacted due to instability of the UAV coupled with the low image quality often rendered by infrared cameras (Vasanth, et al., 2023).

Solar Module Tests

- Cleaning
- Visual Inspection
- Flash Test
- Electroluminescence (EL) Imaging
- Ultraviolet Fluorescence (UVFL) Imaging (new – in testing)
- Photoluminescence Imaging (new – in testing)
- Safety/Ground testing, (wet leakage)
- Advanced stress testing – sample

Reliability Curve



Figure 4: Okorieimoh, C., Norton, B. Conlon, M. (2021). The effects of the transient and performance loss rates on pv output performance. DOI: 10.6084/m9.figshare.14736087.

* Is there some combination of tests that, if passed, provide high confidence of XX years of reliable future performance, i.e., extend the reliability curve out to the right?

Recertified modules

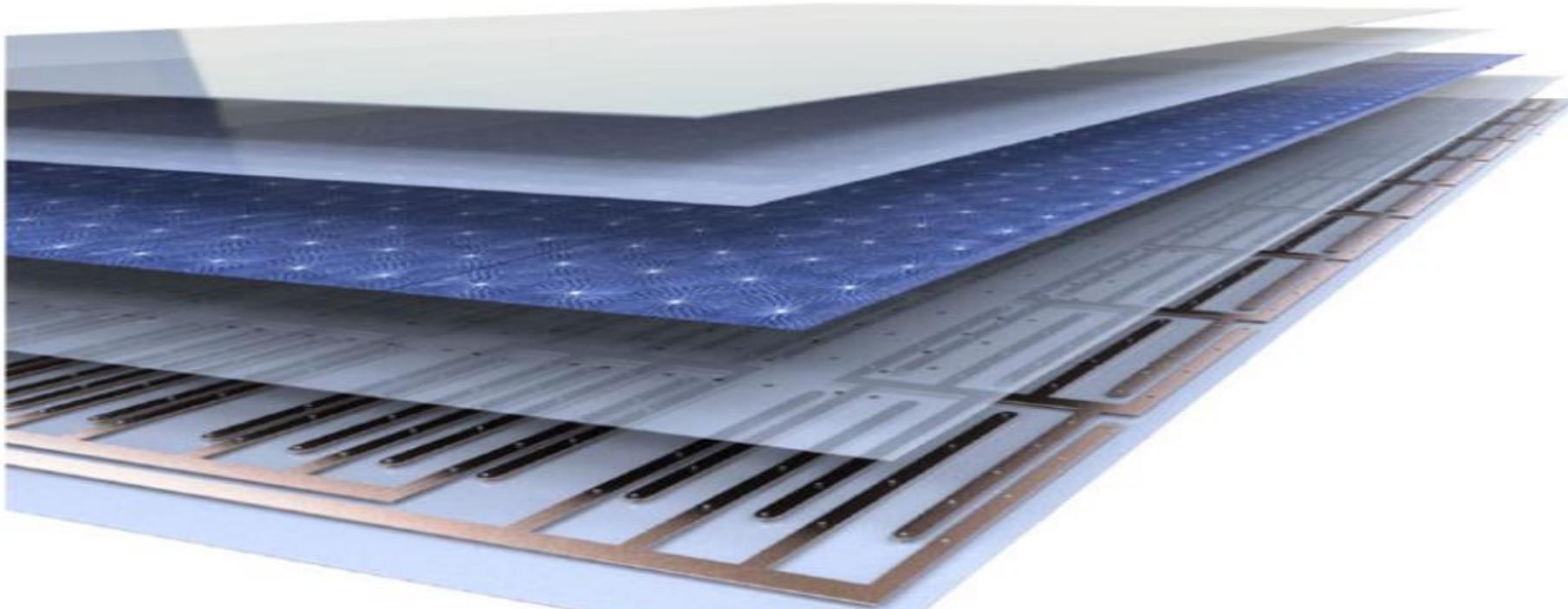
- Are additional tests needed to recertify? If so, what tests?
- Will there be a recognized standard?
- Will the finance/insurance industry accept recertified modules?
- What markets will consider recertified modules?
- Can module recertification be conducted in a cost-efficient manner such that the modules can be resold at a discount.
- Is there a minimum capacity at which recertification is inappropriate?

Repaired

- What repairs are cost effective?
- Laser welding to repair broken leads on the cell face.
- Should repair center be collocated with refabrication or with recycling?
- Module repair companies include Fabtech, Ontility, Go GreenMan Solar, and Solar Steals.

Typical solar module

Trina Solar



Recycle

- Method (mechanical, thermal/chemical, hybrid)
- Modes of Transportation (truck, rail, barge)
- Size of the laydown area
- Proximity to market for raw materials
- Classification of modules (hazardous, universal, solid, etc.)
- Disposal of waste products (especially acids).
- Taxation, incentives
- Cost vs. landfill
- Workforce availability

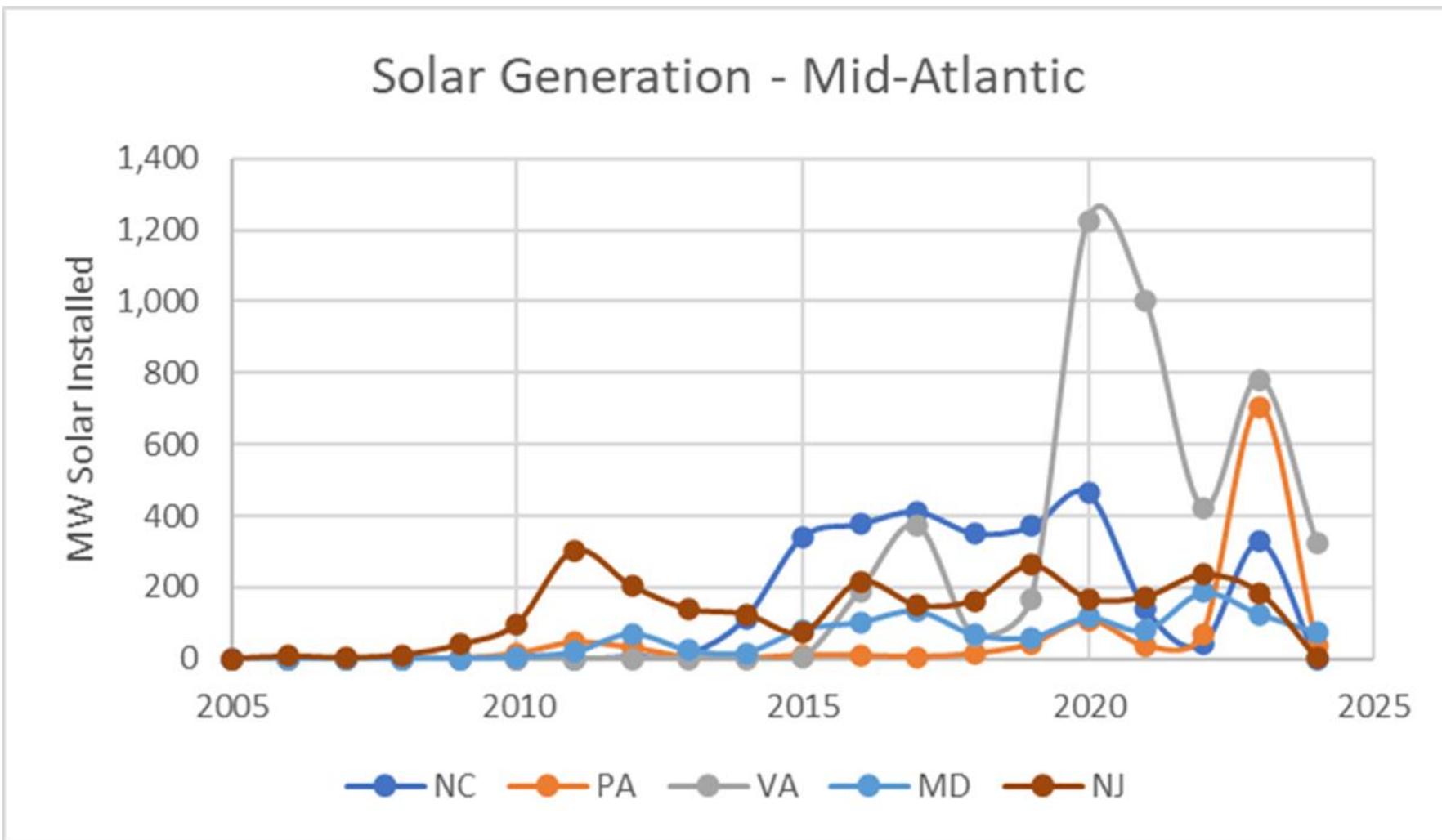
Where to inspect

- Develop mobile testing center – bring to decommissioning site
 - All tests on site.
 - Sort to immediate reuse, recertify, repair, recycle.
- Regional testing centers near large solar arrays
 - I-V and thermal test on site, all other tests at regional testing center.
 - Sort at the regional testing center. Repair at regional testing center or at recycling center
- Centralized Recycling Center
 - I-V and thermal test on site, all other tests at recycling center
 - Sorting at recycling center.

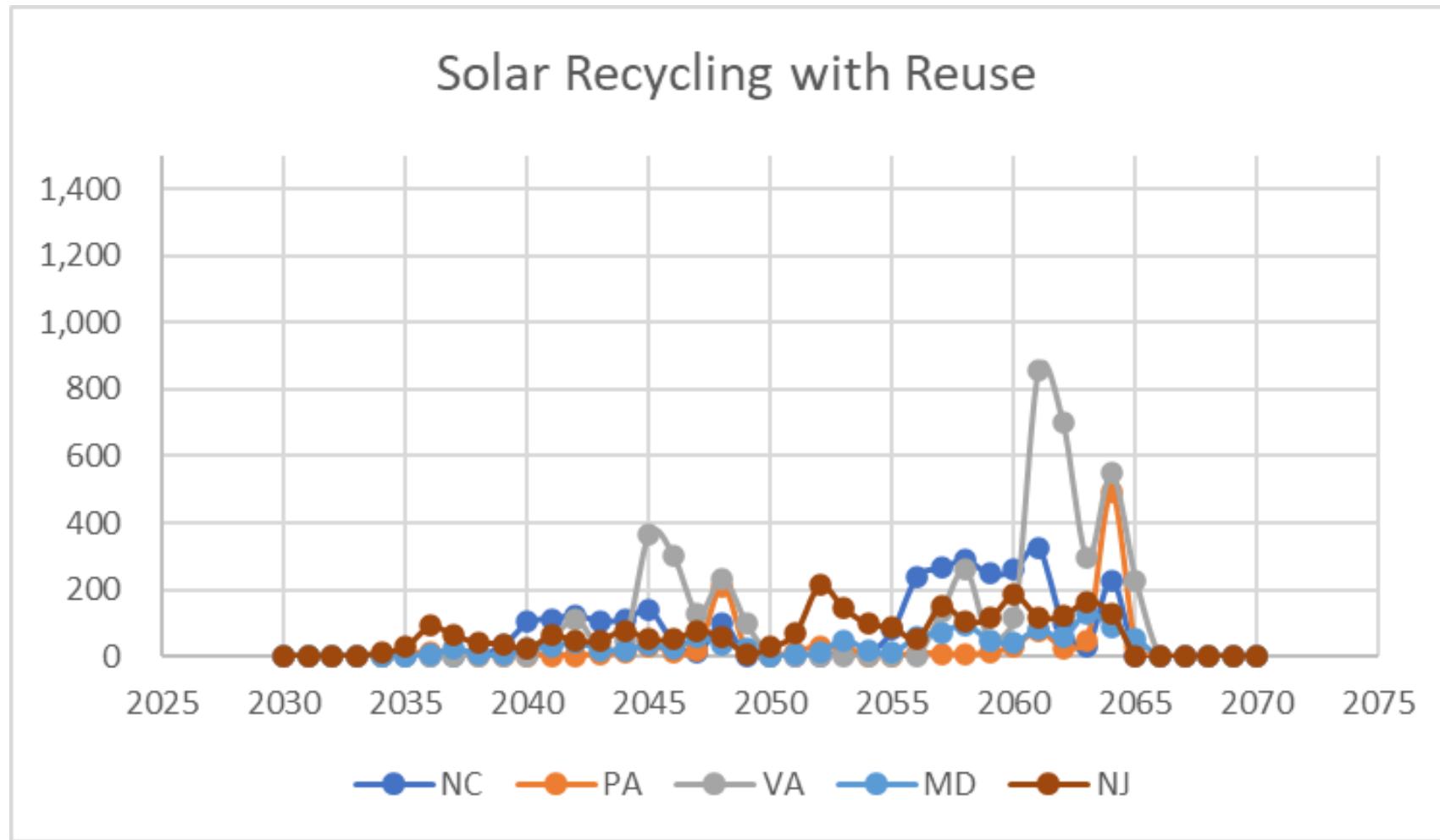
How Many to Expect, and When , Where



Where will Modules come from?



Where will the Modules come from (2)



Packaging and Transport

- Trucking may be cheaper for short distances, otherwise rail.
- Rail may require multiple onloading/offloading operations.
- Trucking most flexible on timing and location of destination.
- 2%-5% breakage rate when shipped on wooden pallets
- Less than 0.5% damage rate when shipped in PVpallet at the same long-term cost as a wooden pallet.

Policy

- Decide if solar modules are solid waste, universal waste or hazardous waste (USDOE), States must accept this decision.
- Consider prohibiting disposal of solar modules in a landfill, or the transport of solar modules to other than an out of state recycling facility.
- Establish reasonable requirements for solar modules stored outside
- Establish a funding source to support recycling. Who pays? (Module sellers? Installer? purchaser? society?)

Module Reuse Considerations

- Provide incentives to companies and resellers offering product and installation warranties for certified refurbished modules.
- Off-grid deployment will remain the primary reuse market until national solar standards are developed to provide guidance on how to safely connect to the U.S. electrical grid.

Concerns

- Need to reduce breakage during decommissioning and transportation
 - Laborer training
 - Better, inexpensive shipping containers.
- Number of handling evolutions
- Unknown recycling chemistry. Must lead and silver be recovered?

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Questions?

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