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Navigating quality risks for U.S. module buyers: From warehoused modules to new factories

20 March 2025

9:00 am – 10:00 am | PDT, Los Angeles
12:00 pm – 1:00 pm | EDT, New York City
5:00 pm – 6:00 pm | CET, Berlin

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Welcome!

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Do you have any questions? ❓ 🙋

Send them in via the Q&A tab. 👉 We aim to answer as many as we can today!

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We are recording this webinar today. 📹

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Navigating Quality Risks for U.S. Module Buyers: From Warehoused Modules to New Factories

Presenters

Brian Hansen
Director, Supply Chain Management

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Senior Engineering Manager

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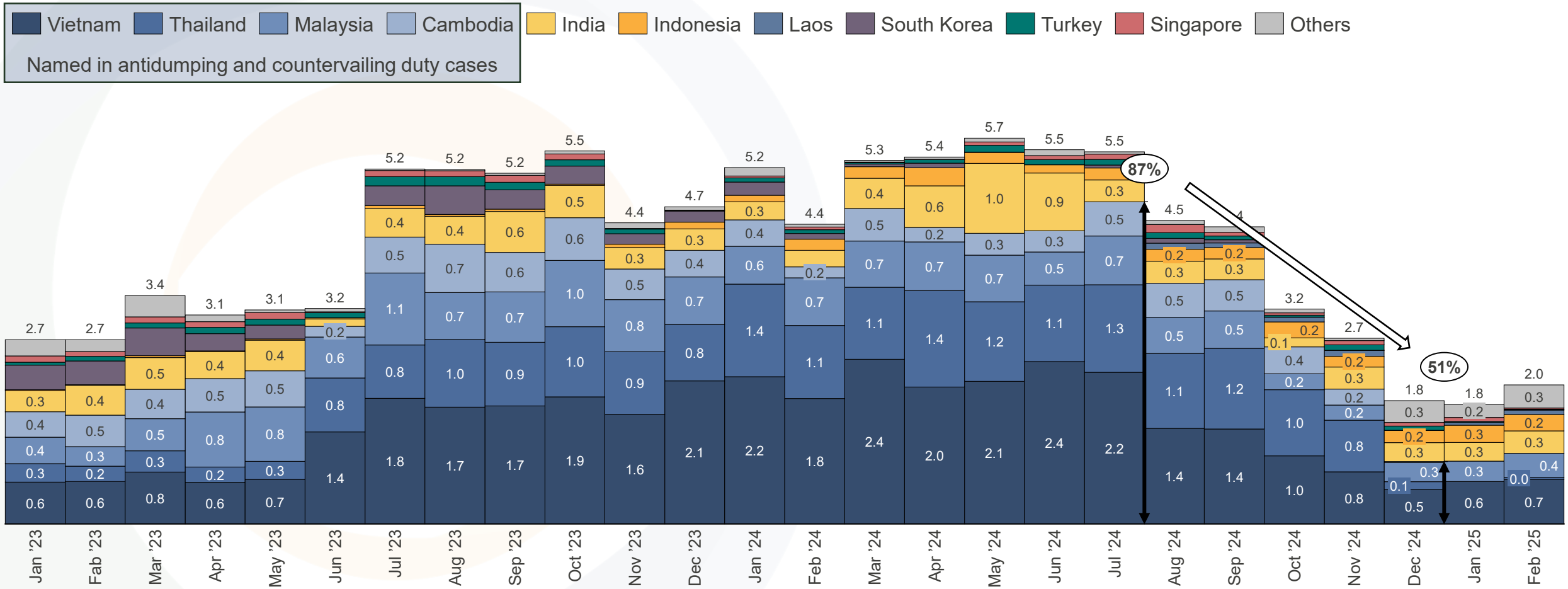
Imports between July 23 – July 24 exceeded 67 GW

Vietnam/Malaysia sustained by First Solar; Cambodia/Thailand down to <100 MW

US PV Module Imports by Country (GW)



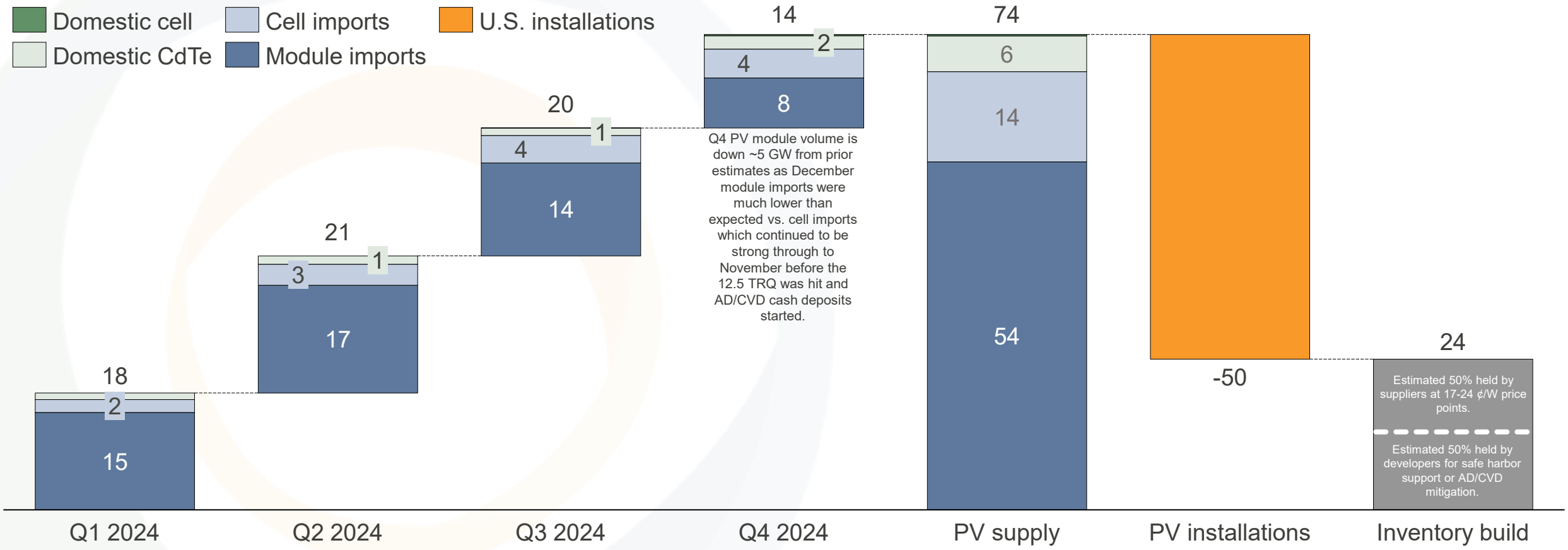
Data were reported as of February 28, 2025, by Datamyne; module HTS: 8541.43 (2023 / 2024). Tonne to W conversion was estimated using the conversion of 1 tonne = 0.017 MW (c-Si modules) and 1 tonne = 0.012 MW (CdTe thin-film modules).

Notes | September data is estimated based on currently available US imports. Antidumping and Countervailing Duties (AD/CVD). Cambodia, Malaysia, Thailand, and Vietnam (SEA4).

U.S. Inventories reached ~25 GW by End of the Year

Q4 PV module imports halve vs. Q1 figures; PV cell imports in Q4 were 2x Q1 volumes

United States PV Module Inventory Build, 2024 (GW)

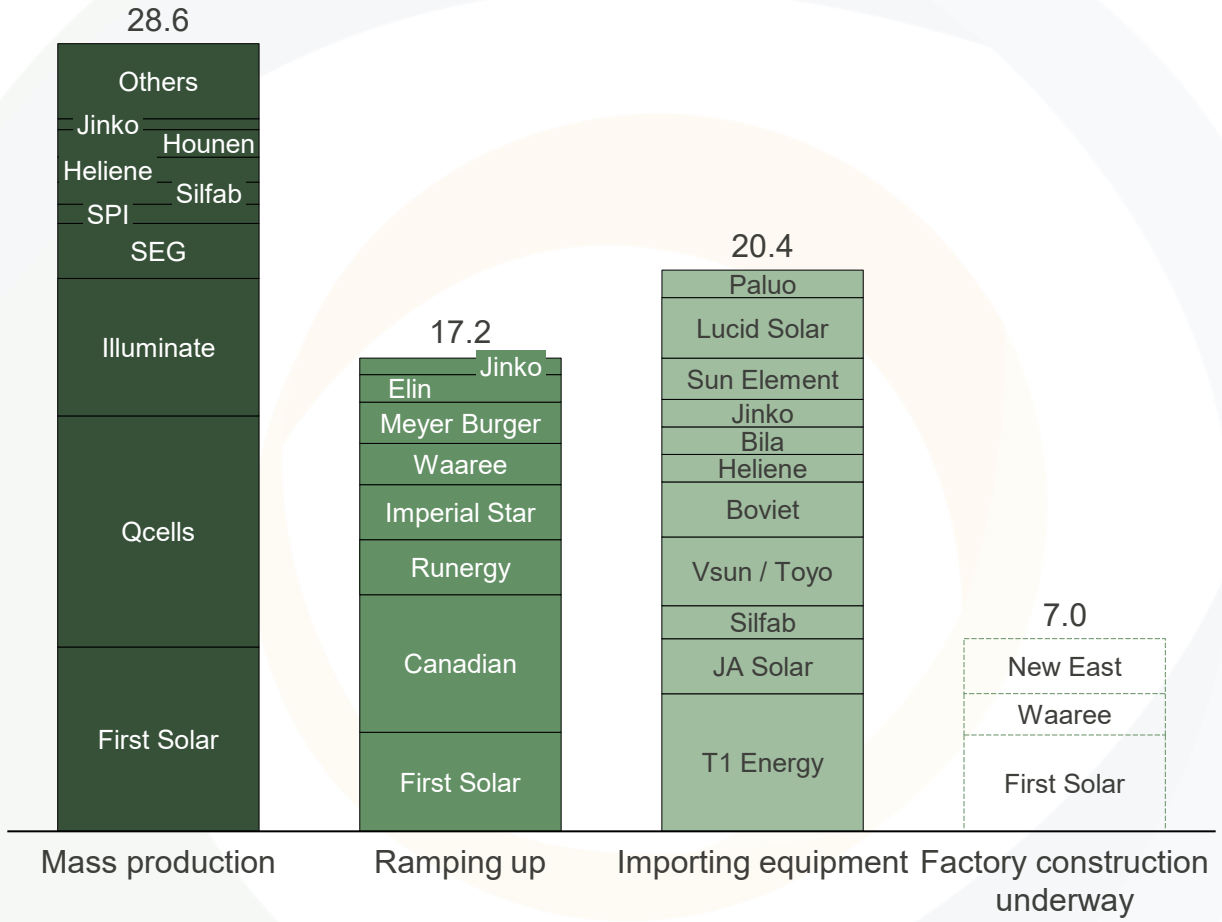


Notes | 2023/2024 module import data were reported by Datamyne. Cell imports by USITC where data is available, and Datamyne for the two most recent months. Installations reported by SEIA. First Solar's U.S. thin film production from First Solar's Q3 2024 earnings call. Thin film module imports reported with crystalline silicon module imports. Antidumping and countervailing duties (AD/CVD).

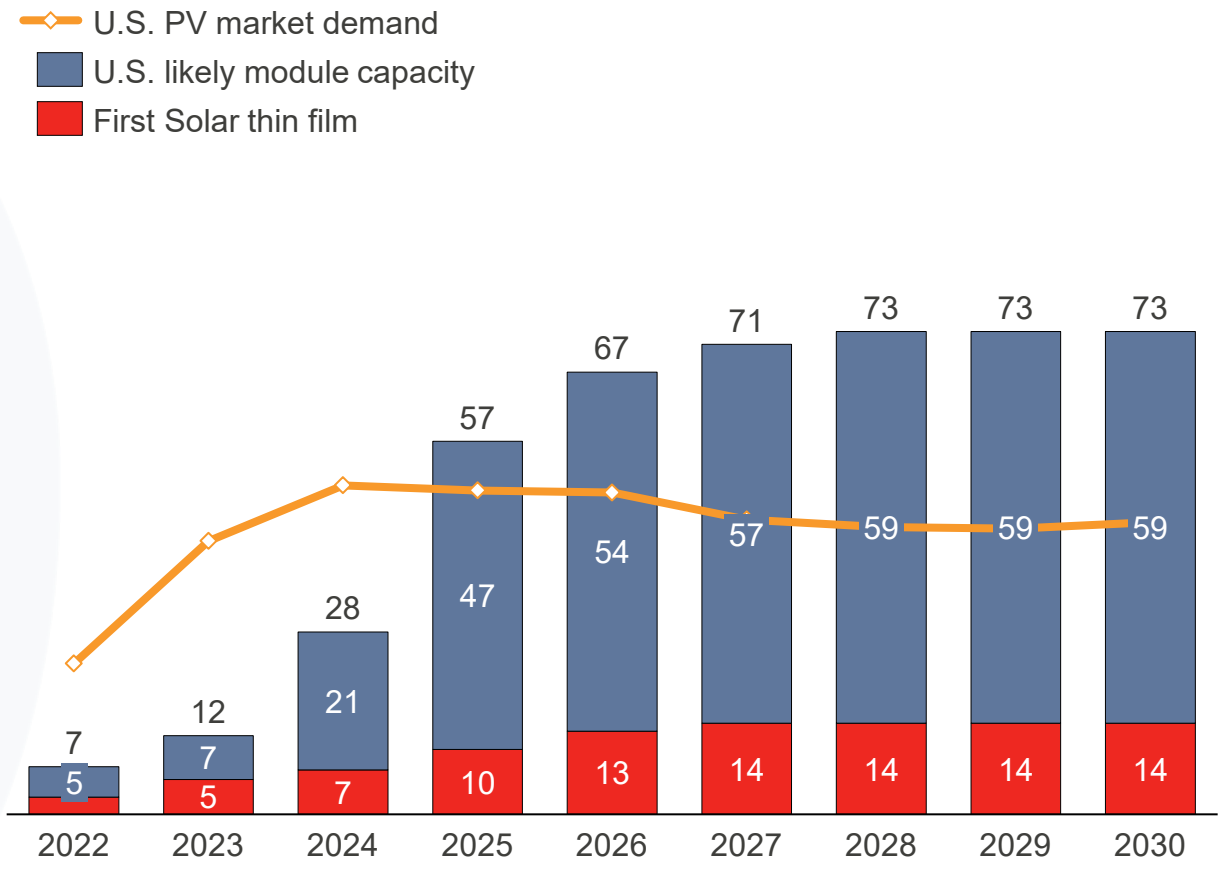
US Investment Prioritizes Module Capacity, to reach ~70 GW by 2027

Module capacity will exceed demand by 10+ GW in 2030

United States Module Capacity by Factory Stage (GW)



Likely Module Capacity Vs. US Installations (GW)



Notes | Data aggregated by CEA based on company announcements and disclosures. Data does not account for utilization but considers reasonable ramp times. Timelines are based on supplier statements or industry best practices if no timeline data was reported. Installation forecasts are reported in the SEIA/Wood Mackenzie Power & Renewables US Solar Market Insight Report.

Mitigation of Risks from Module Storage

Why Modules Stored in Warehouses?

Scenario 1

Supplier imported modules to US and is seeking to sell imported inventory

Scenario 2

Project delays require developer to temporarily store modules until site is ready

Scenario 3

Project Developer chooses to purchase modules in advance

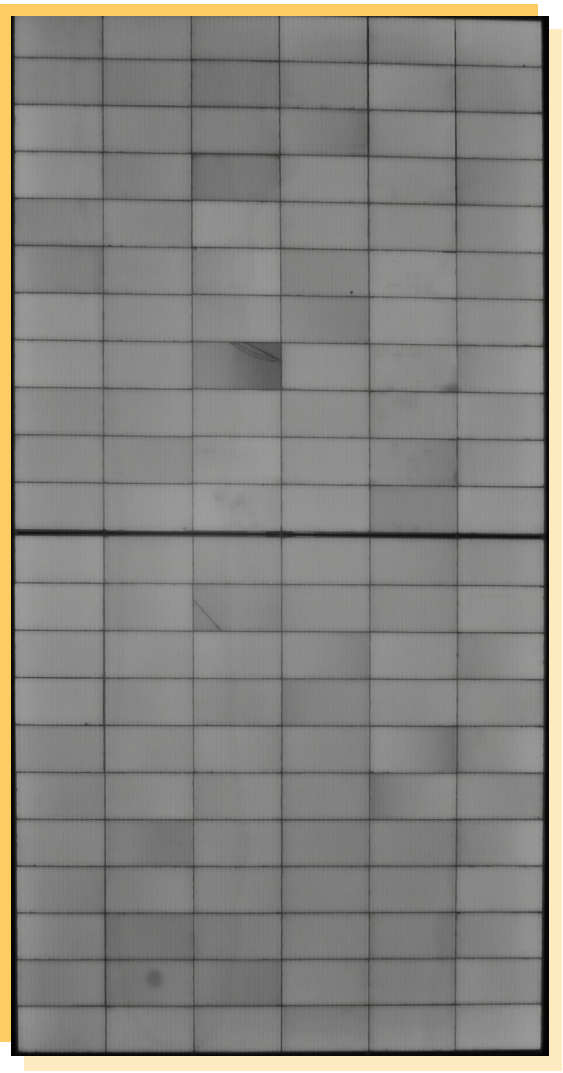
Regardless of why modules are being stored, the risks associated with storage need to be considered and mitigated

Risks to PV Modules from Storage and Handling

- Each time a pallet/carton/pack is handled there is risk of damage to the pallet
- Modules stored outside of manufacturer's storage guidelines are at elevated risk of damage during storage and may void the warranty

Risks to PV Modules from Storage and Handling

- Severe damage to the pallet can result in module damage including
  - Glass breakage
  - Frame damage
  - Cell cracking
- Less severe damage creates risk of further damage during storage and transportation to the site
- Timely detection of damage is important for filing logistics claims and avoiding project delays



Avoid Extended Outdoor Storage

- It may be tempting to store modules at the project site instead of in a warehouse, but extended outdoor storage is not recommended!
- Module packaging is not designed for long term exposure to the elements
  - Packaging will degrade
  - Uncapped connectors are vulnerable to moisture

Risk of Purchasing Warehoused Modules

Additional risks are present when purchasing modules that are currently stored in a warehouse

The history of these modules may be unknown creating challenges in assessing the risks associated with the batch of modules

- Unverified manufacturing quality increases the risk that manufacturing defects are present in the batch
- Unknown handling history presents challenges for assessing the risk of handling damage

Risks During Transportation from Warehouse to Project Site

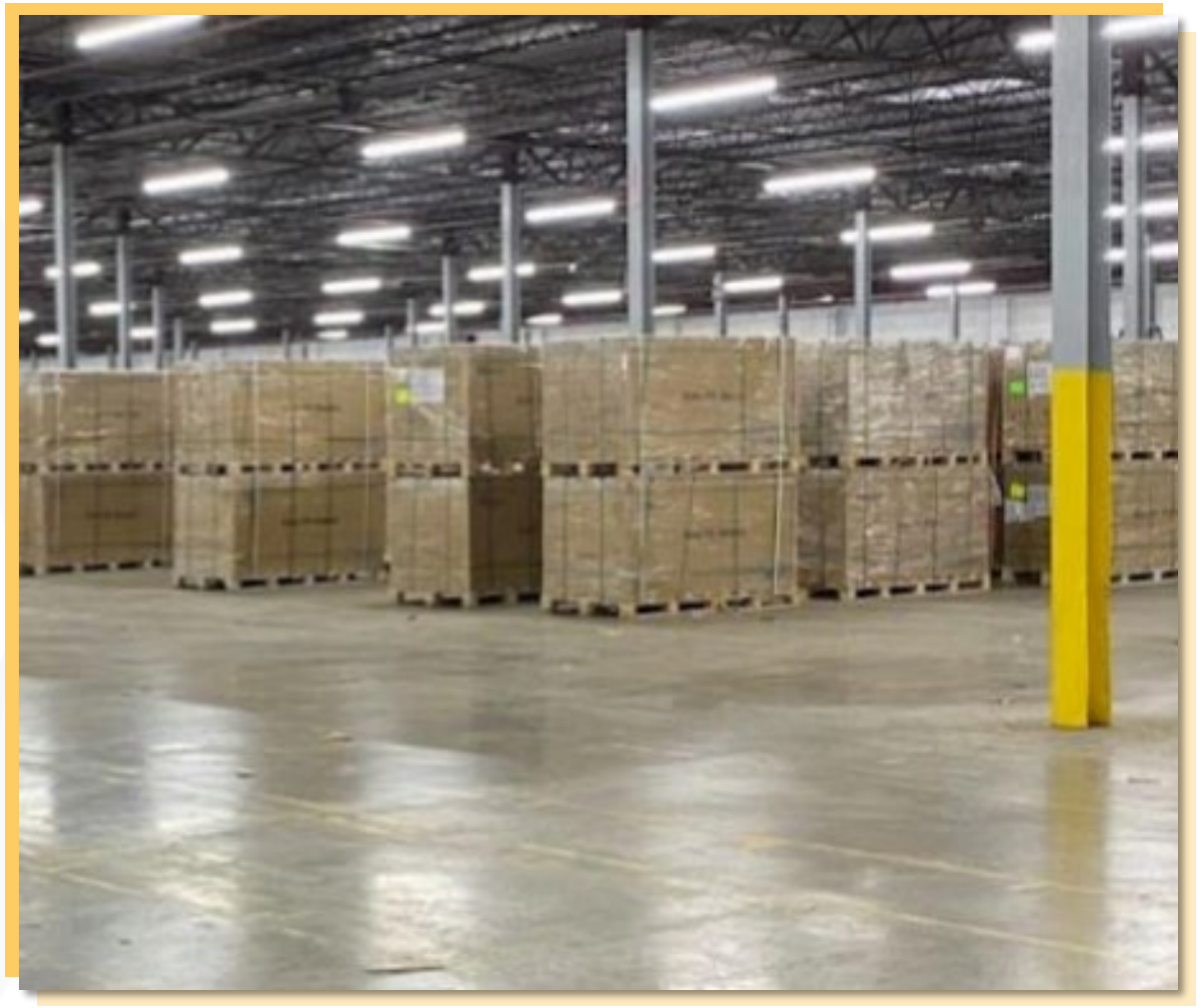
- Transportation of previously warehouses goods to the projects site results in additional risks
- Pallets that have been compromised during handling and storage are at increased risk for further damage during container loading and transportation
- Warehouse staff may not be familiar with correct loading configuration as specified by module manufacturer
    - Incorrectly loaded containers may result in module damage during transportation

Risk Mitigation

When stored properly and handled with care, it is possible to successfully mitigate the risks of warehouse storage of PV modules!

Best Practices for Mitigation of Risks Associated with Storage of PV Modules

- Ensure that PV module manufacturer’s storage, handling, and transportation guidelines are followed
- Minimize re-handling once modules have arrived in the warehouse
- Review warehousing contracts to ensure that guidelines are appropriately specified and that liability for damage during storage is defined



Best Practices for Mitigation of Risks Associated with Storage of PV Modules

Conduct inspections for timely detection of pallet damage and identification of improper storage practices

- Upon delivery to the warehouse
- Any time possession of the modules changes
- Periodically during long term storage, especially if pallets are relocated within the warehouse

Monitor the loading of a selection of containers from the warehouse to ensure the correct loading procedure and configuration is utilized

Best Practices for Mitigation of Risks from Purchasing Warehoused PV Modules

Request and review production quality documentation as available

Conduct a detailed module inspection on a representative sample from each batch to check for manufacturing defects and handling damage

- Visual inspection
- Electroluminescence (EL) imaging

Include terms in the purchase agreement to permit review of module quality

US Module Manufacturing

US Module Manufacturing – Opportunities and Challenges

Technical Partners know what they're doing

- Experience building and ramping factories
- Copy/paste management systems, procedures and policies

US Factories take longer

- Construction, certifications, hiring, training

Rely on overseas resources living in US temporarily

- Language barriers
- Training local resources
- Hand-over to local resources

US Module Manufacturing – Best Practices

- US Factories will have few workers on the floor
- Automation, data management
- MES integration from A to Z → Which stringer?
- Operator/technician login at workstations

US Module Manufacturing – Preventing Quality Risk

Pre-shipment Inspection

- Lot size during ramp – smaller lots, more frequent inspections
- Defined metrics for lot size change – modules / day
- Resist supplier requests for decreasing inspection level
  - Defined metrics
  - Specific trigger for reversal – failed inspections

Inline Production Monitoring

- Execute daily, consider night shift as well
- Track the problem solving – root cause analysis

Container Loading Monitoring

- Define conditions explicitly: container seals, strapping, airbags

Include Traceability Scope in Quality Assurance

- Quality = Traceable
- Domestic Content Requirements
- Prepared for the worst
- Industry Best Practices

Define terms of QA oversight in purchasing agreements

US Module Manufacturing – Final Thoughts

- Re-starting and scaling manufacturing
- Hiring and training must be priority
- Communicate schedules
- Clear expectations and capabilities

Thank You

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Thank you for joining today!