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26 September 2023

8:00 am – 9:00 am | PDT, Los Angeles

11:00 am – 12:00 pm | EDT, New York City

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pV magazine
webinars

Variables to consider in solar module procurement



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Welcome!

Do you have any questions? ? 

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

You can also let us know of any tech problems there.

We are recording this webinar today. 

We'll let you know by email where to find it and the slide deck, so you can re-watch it at your convenience.  



Variables to consider in solar module procurement

pv magazine webinar

September 26, 2023

Brian Hansen

Paul Wormser



Pre-Covid Module Procurement



[Image Source](#)

Prior Method
Current Variables

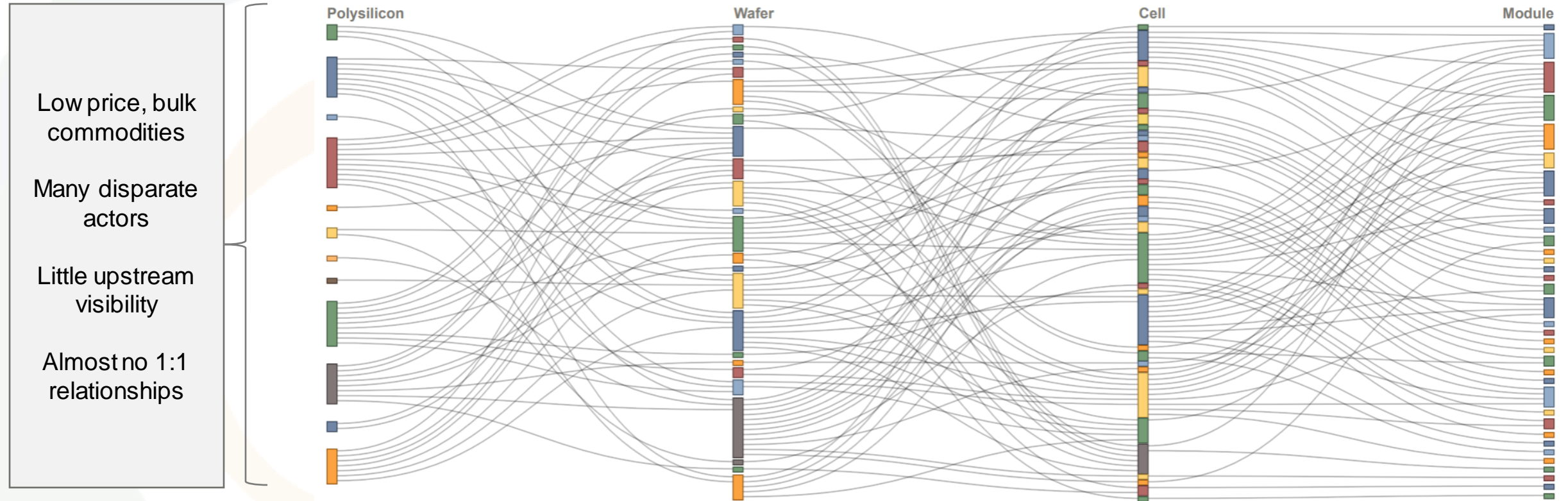
Traceability
Bankability
Domestic Manufacturing
Capacity for US
Commercial Flexibility
Technology Roadmap
Quality

The New Normal: How difficult can a supply chain be?

If only those lines were a little straighter

Illustrative supply chain mapping (inhouse or public announcement relationship mapping)

Quartz / Silicon Metal



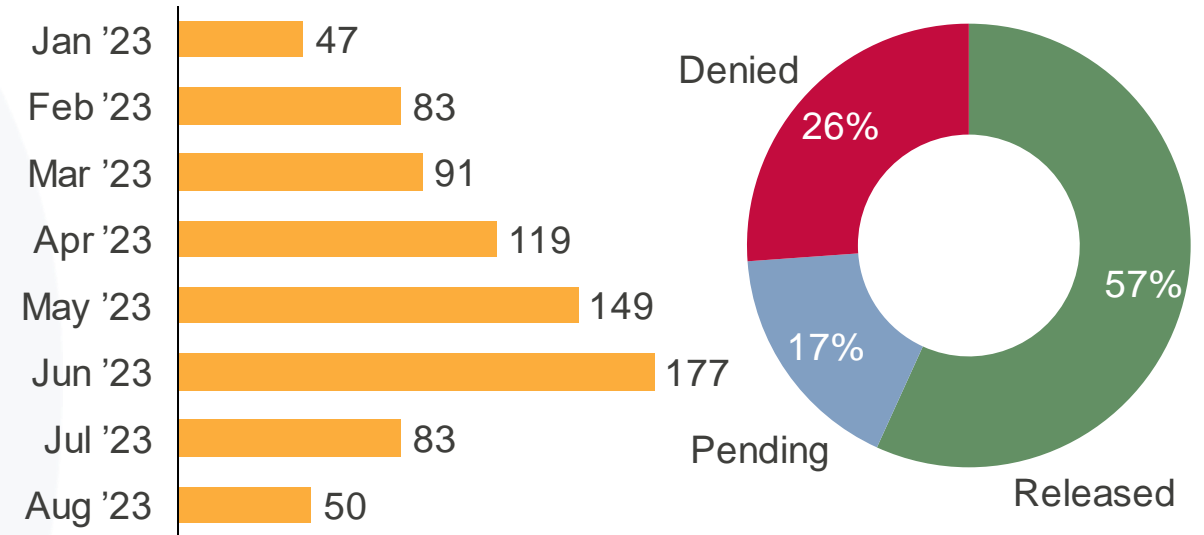
Notes | Supply chain mapping based on public transaction announcements / SMIP interviews, not all existing links are captured, not all links may be currently active.

UFLPA impacts on solar supply: September 2023 update

Detention volumes continue to fall; volume of denied product continues to rise

- The September 2023 update to Customs' online UFLPA dashboard shows a second month of decline in detentions
 - "Electronics" (solar) detentions fell to \$50 million in August – the lowest level since January 2023
 - CEA estimates that this represents **~170 MW of modules**
- The volume of product denied also continued to rise
 - Product denied rose from \$329 million to \$392 million
 - This means **~210 MW** of modules were denied in August
 - Most the product denied to date was first detained from July through November 2022
- \$256 million in "electronics" was still detained as of September 1, 2023
 - This represents **~850 MW of PV modules still detained**
- **~2.8 GW of solar PV product has been released** as of September 1, 2023

Customs and Border Protection UFLPA "Electronics" detentions (\$M) and cumulative value of shipments



\$1.5 billion of shipments

CEA estimates ~5 GW of solar shipments have been detained and ~2.8 GW have been released

Notes | Source: CBP, information as of 9/1/23, "Electronics" primarily represents solar detentions, and is the largest by number of detentions and value

The New Normal: Anti-Dumping and Countervailing Duties are coming

Do you have processes in place to protect your investments?

Material	Current Locations	Migration To SEA	Additional Cost In SEA	Material Usage
Wafer	China, Malaysia, Vietnam, etc.	1 – 3 years	\$0.015-0.020/W – market/size dependent due to higher energy costs and CapEx/scale disadvantages	Silicon discs without the ability to convert sunlight to electricity
Or				
Silver Paste	China, South Korea, Japan, USA	< 1 year	None – silver paste is already sourced globally	Highly conductive material that collects generated power (Cell only)
Glass	China, Vietnam, Malaysia	1 – 3 years	None – more capacity is based in China due to China's larger demand base	Provides integrity and protection to the encased cells / highly transparent
Backsheet	China, USA	< 1 year	None – costs are nearly equivalent as the main cost is material inputs (resin)	Protects cells from exposure to various environmental factors
Aluminum Frame	China	< 1 year	\$0.01/W – energy pricing is less competitive vs. fixed energy prices in China	Provides structural integrity and allows for easier mounting
EVA	China, Thailand, Vietnam, USA	< 1 year	None – costs are nearly equivalent, but China has scale advantages	Adheres cells to glass and backsheet components / highly transparent
Junction Boxes	China, Vietnam	< 1 year	None – costs are nearly equivalent, but China has scale advantages	Terminal and connector components linking PV modules to a system

Notes | Module costs to a standard dimension 72-cell, 182 mm TOPCon module. Wafer costs include margin and polysilicon price; cells and modules do not include margin additions. Other items included in total cost calculations are labor, utilities, depreciation, SG&A/R&D, and maintenance.



Are your PV modules bankable?

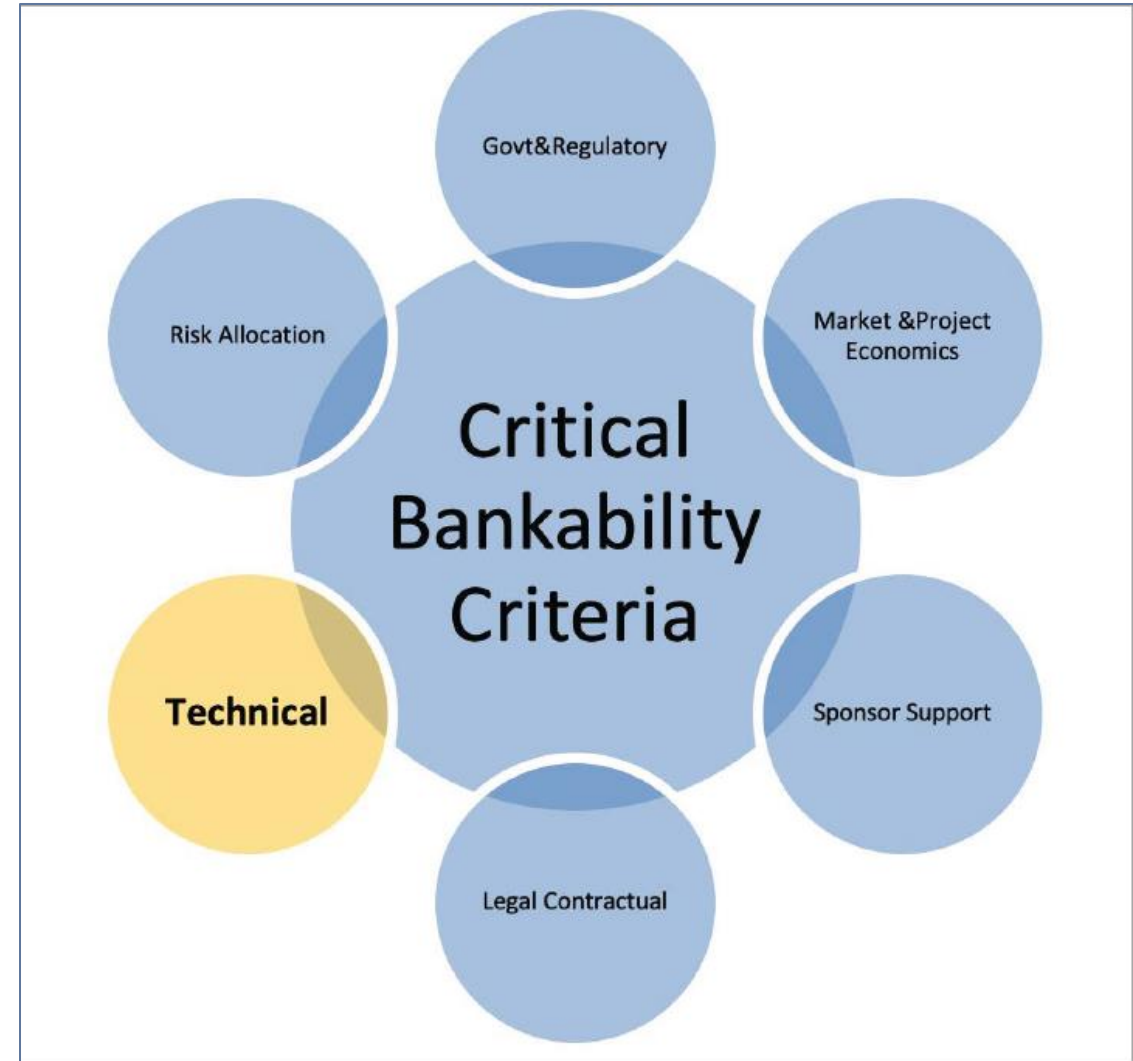
Technical Due Diligence

- Technology Assessments
- Factory Audits
- QA Control and Certifications



Finance Due Diligence

- Financial Stability Investigation
- Production Capacity Analysis
- Sales Analysis
- Warranty



The Future of Supply: Should I buy domestic?

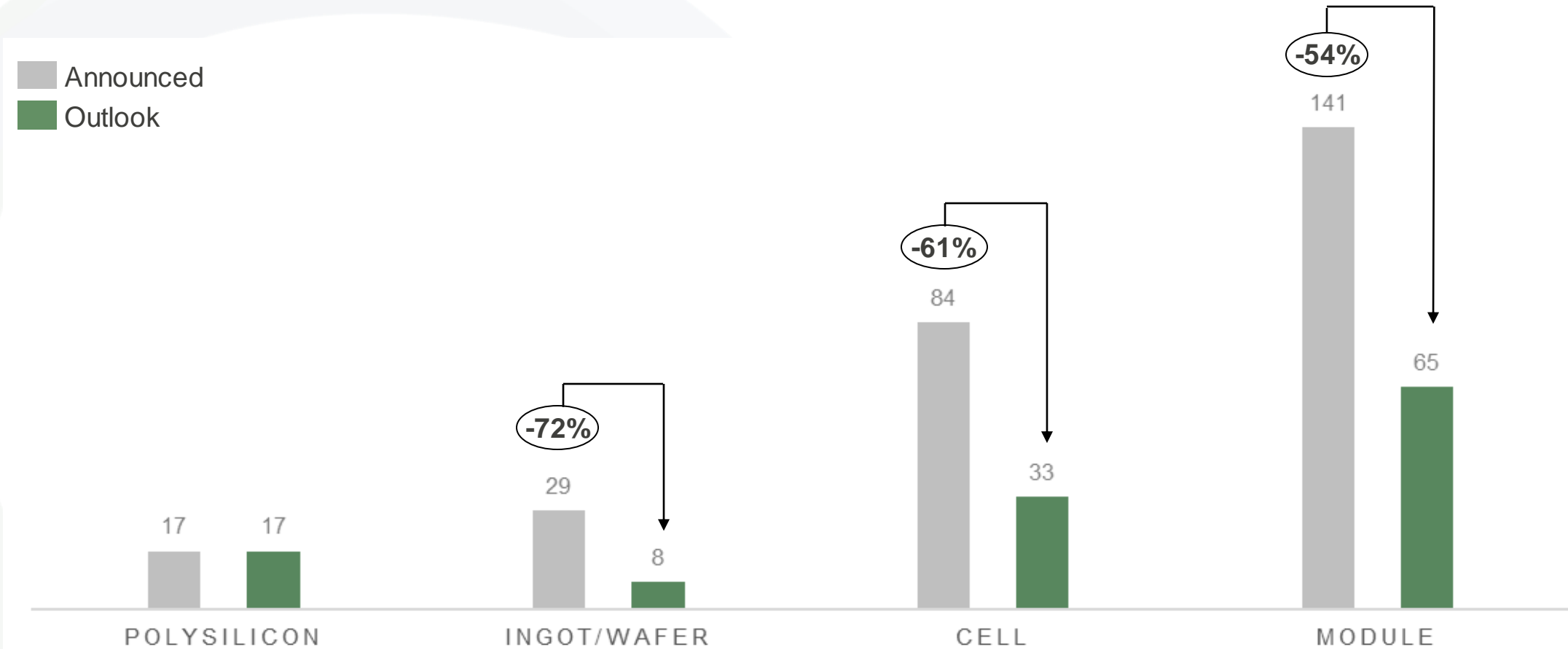
What is the impetus?



Actual capacity forecast to be < 50% of announcements

But what is likely to be built continues to edge upwards with continual plan releases

Existing and announced capacity versus capacity outlook, year-end 2027 (GW)

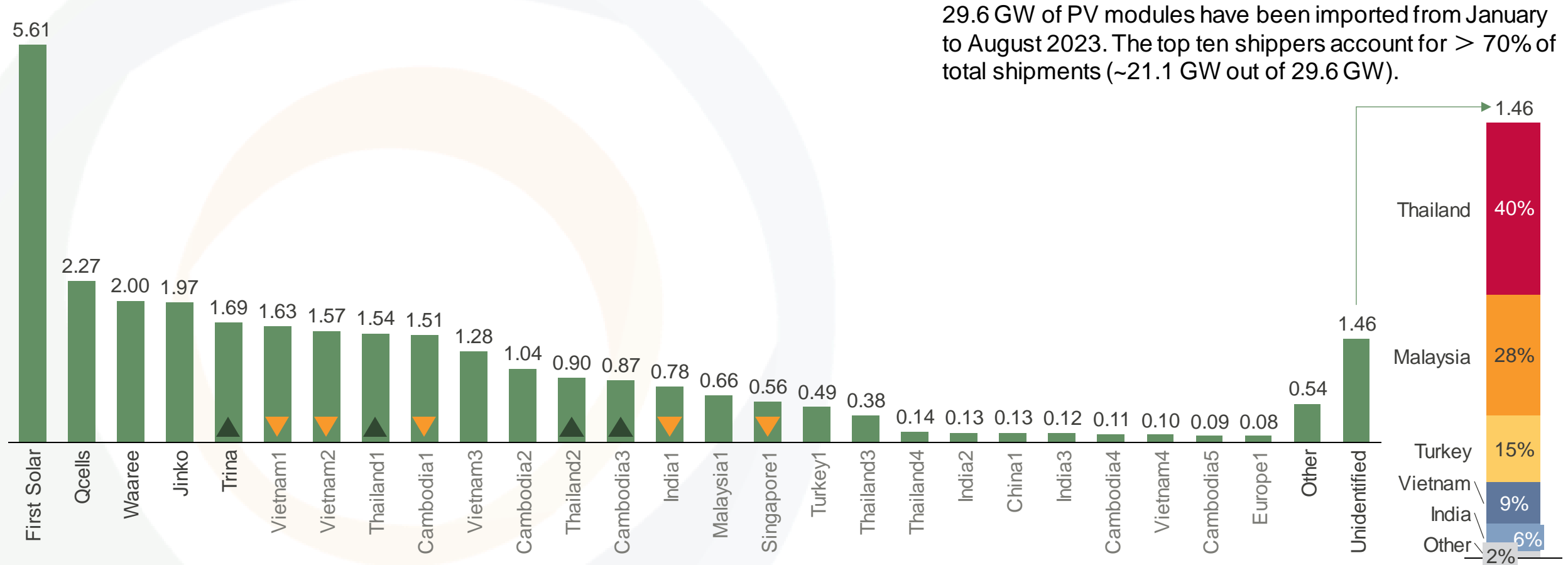


Notes | Data aggregated by CEA based on company announcements and disclosures. Data does not account for utilization, ramp times, or other potential production delays. Timelines are based on supplier statements or industry best practices if no timeline data was reported.

Validate the capacity available for your market

Just because they claim to ship to your market doesn't mean they do

U.S. PV module imports, 2023 (GW)



Notes | Data were reported as of August 31, 2023 by Datamyne; module HTS: 8541.43 (2023). Tonne to W conversion estimated using a conversion of 1 tonne = 0.017 MW. Relative increase in top 10 standing (▲), relative decrease in top 10 standing (▼), ranking is adjusted monthly.

Commercial Flexibility:

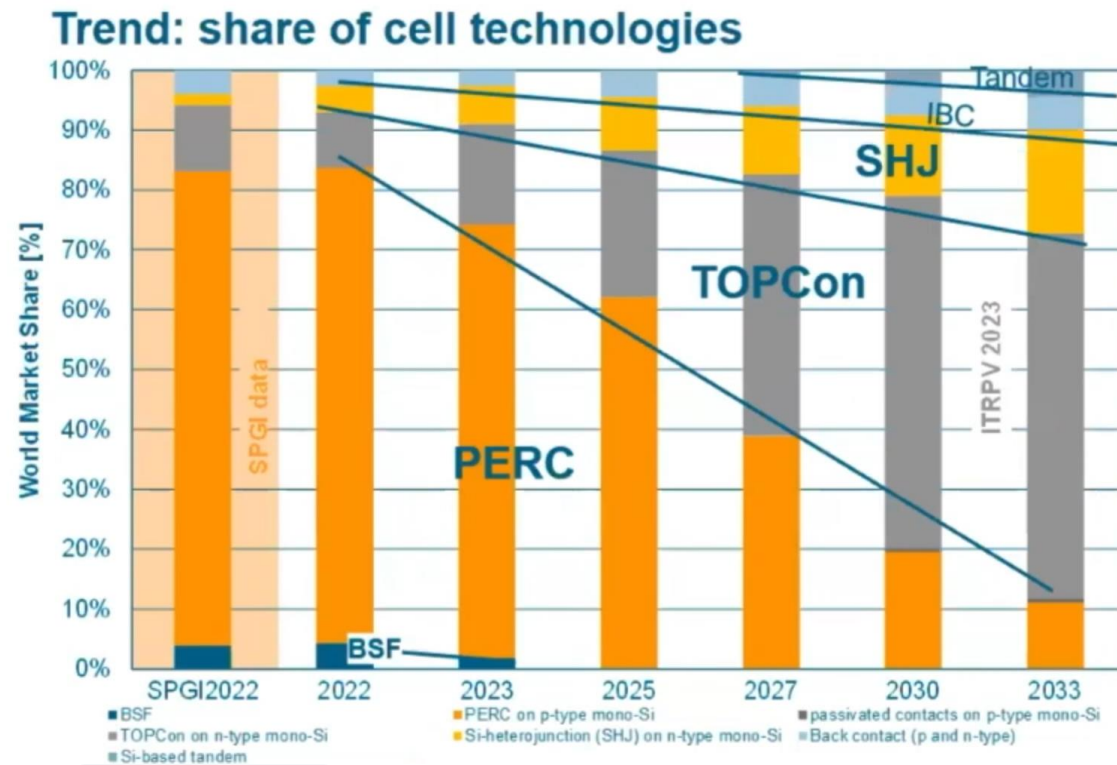
Contract Sticking-points	Variability in Supplier Position
Down-payment, pre-shipment payments, customs clearance	High
BOM Transparency	High
Cancelation period/penalty	High
Quality Exhibits	High
Pricing formulas (cost+ or indexed)	High
Serial Defects	Medium
Incoterms	Medium
Liquidated Damages	Medium

The shift to higher performance cell architectures is underway

n-type TOPCon and HJT will account for at least ~50% of capacity by 2027

Outlook for global announced cell production capacity by technology (GW)

- Technologies based on n-type wafers are expected to approach 50% market share by 2027 based on current announcements
- TOPCon capacity has been ramping up rapidly since 2022 with decreasing cost and improving efficiencies
- TOPCon's share of future capacity will likely be much than what has been publicly announced, given that most PERC capacity can be upgraded to TOPCon at relatively modest CapEx



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Takeaway – focus on the variable that matter most for your project

Supplier	General Score Categories									Total Score
	UFLPA	ADCVD	US Manufacturing	Warranty	Bankability	Price (Expected Positioning)	Tech Roadmap	Quality	Commercial Flexibility	
Supplier1	5	5	5	4.6	5	2.8	2.3	2.6	1	4.2
Supplier2	3.1	4.8	4	4.3	4.5	4.6	3.7	2	3	3.9
Supplier3	2.4	5	4.5	3.7	4	4.6	5	2.4	2	3.9
Supplier4	3.7	4.8	5	4.3	3.8	3.2	1	3	3	3.6
Supplier5	3.6	4.5	3.5	4.3	2.3	4.6	3.7	2.6	2	3.6
Supplier6	2.6	4	3.8	4.3	3.8	4.6	3.7	2.6	2	3.6
Supplier7	3.5	5	3.5	4.3	3	3.4	1.7	2	3	3.4
Supplier8	2	4	4	3.7	4.8	4.6	2.3	1.6	3	3.4
Supplier9	3.2	5	1	3.7	3.3	3.6	1	2	2	3.3
Supplier10	3.7	4	1	3.7	3	4	1	2	3	3.2

Quality Considerations

Consider Extreme Weather – over the life of the system

- Massive claims for damage – so choose wisely based on location
- Insurance premiums have increased, coverage decreased and deductible increased; cracked cells are not covered
- Do a weather study – especially if the project is in the hail zone
- See what hail testing the supplier has done
- You might choose based on glass thickness and tempering rather than price
- You are not likely getting “Fit For Purpose” language
- You can make an argument by having factory EL and acceptance EL and post-install EL and post-storm EL

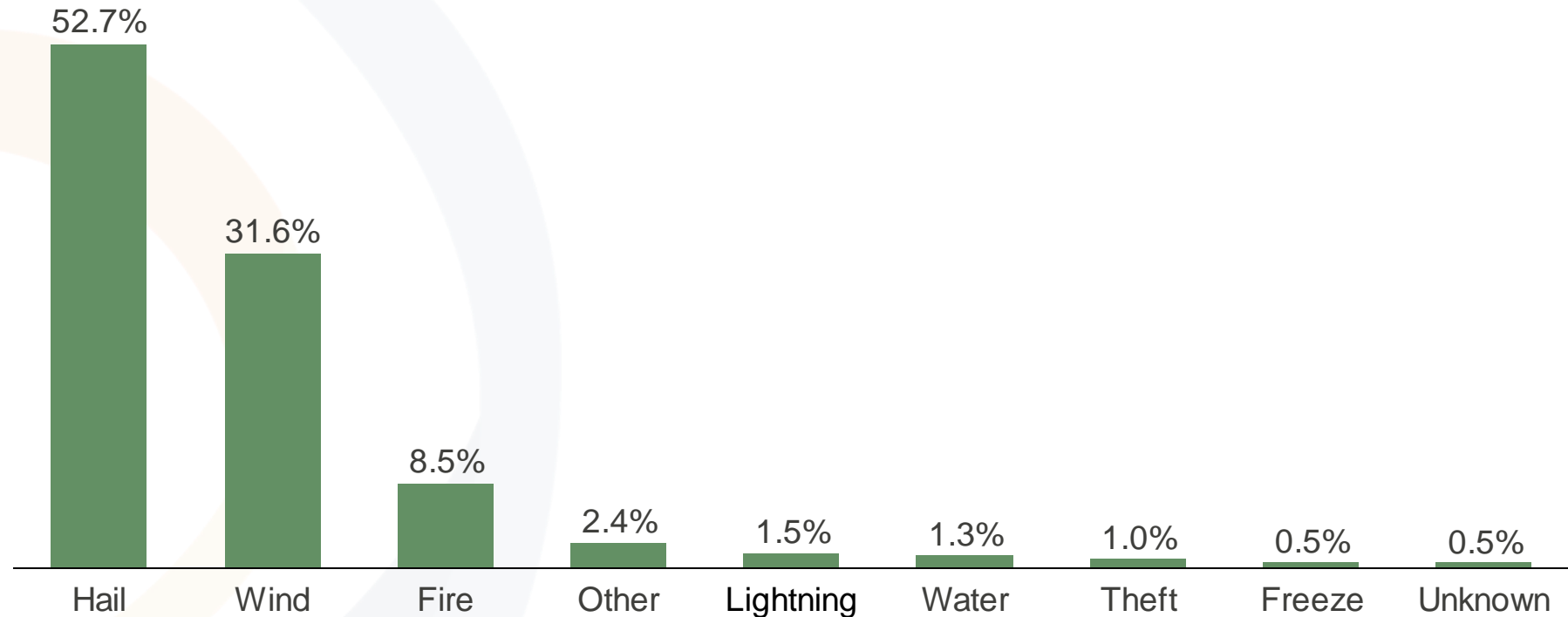


Hail is the most common cause of loss of claims

Hail risk is higher than other weather-related risks combined

- Rapid growth in solar projects expanding to Texas and other mid-west regions
- Hail risk has surpassed wildfires, becoming the main cause of loss of claims for U.S. solar project developers

Different causes of solar system loss of claims (% of claims)

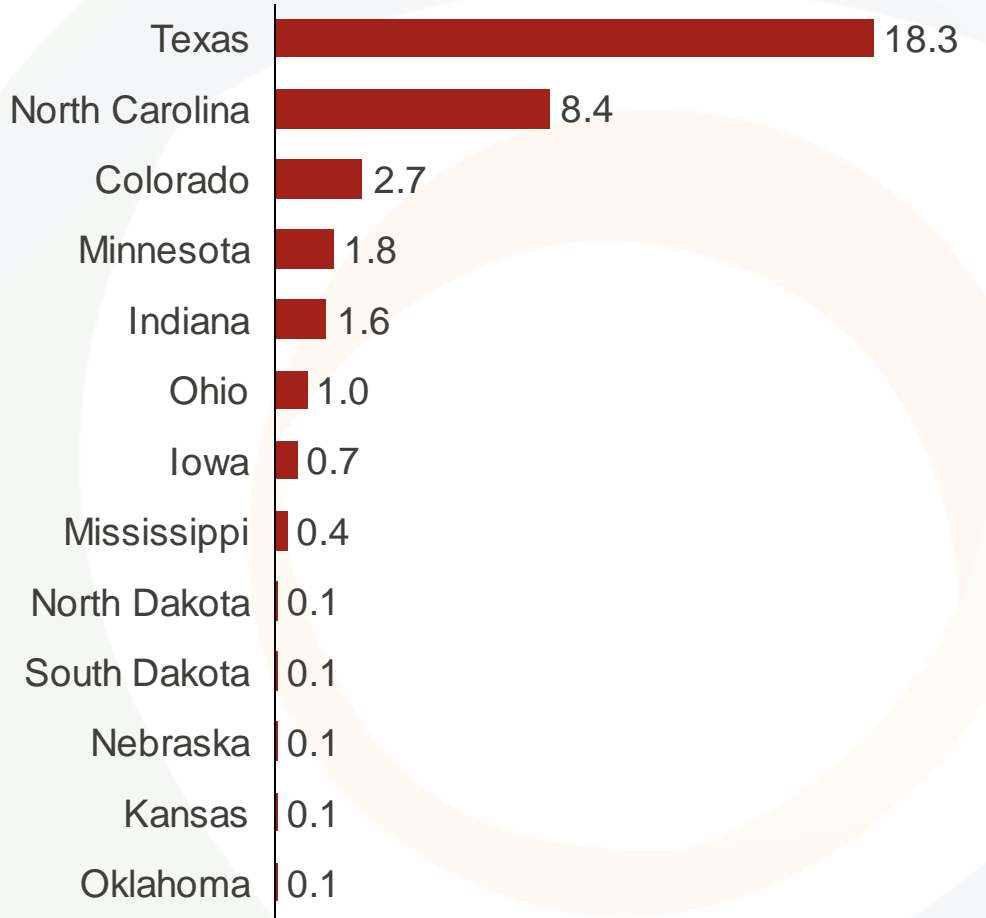


Notes | NREL: Insurance in the Operation of Photovoltaic Plants [HERE](#)

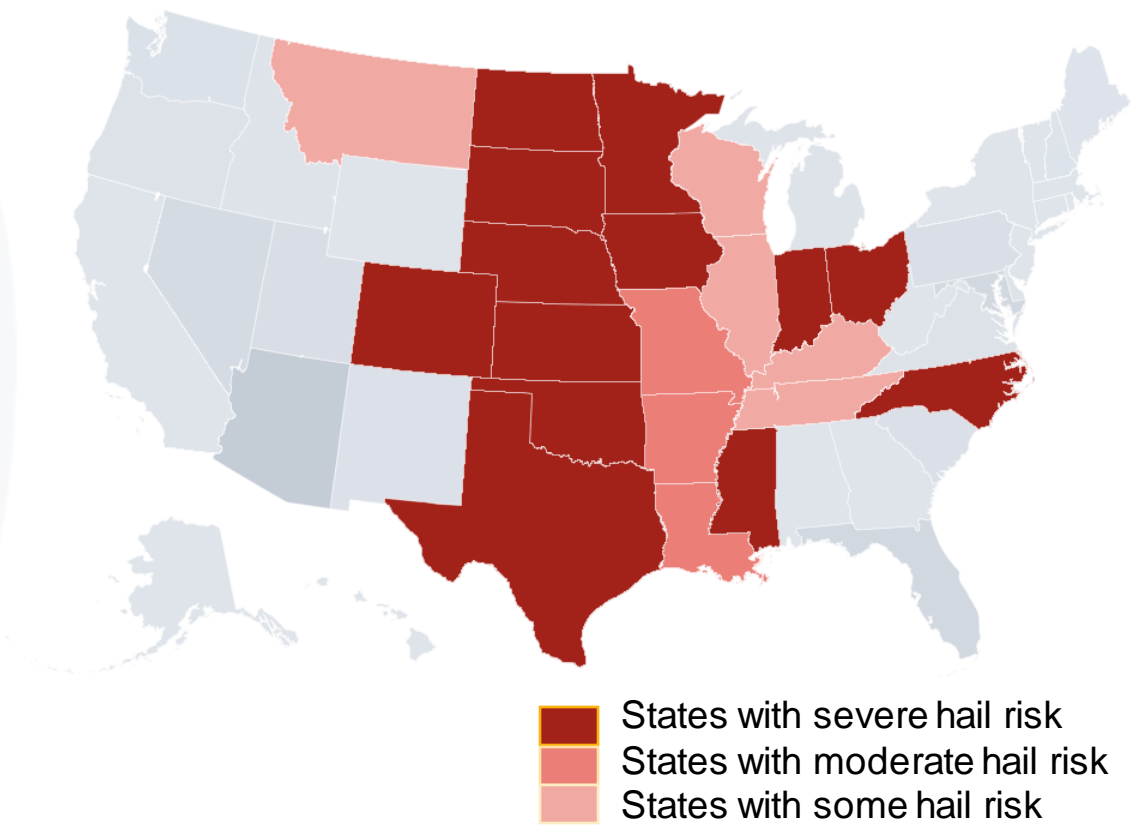
21 U.S. states facing possibility of hail damage to projects

Almost 30% of the U.S. solar PV installed capacities are in the hail danger regions

Installed capacity with the highest hail risk (GW)



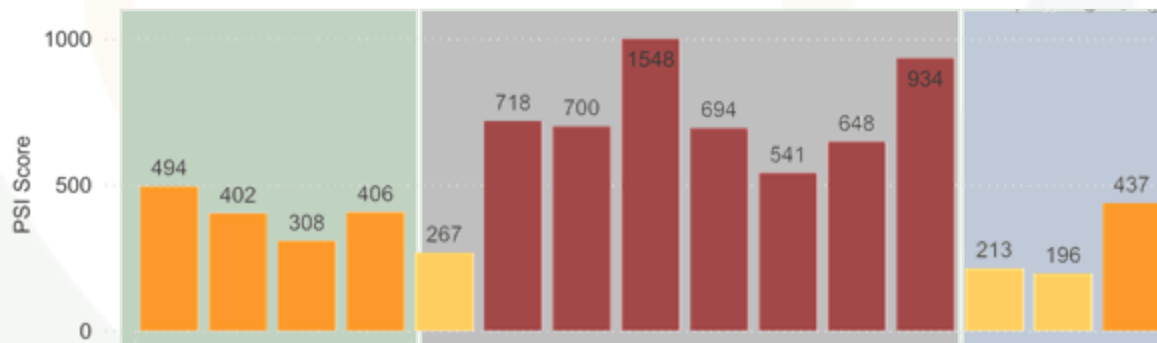
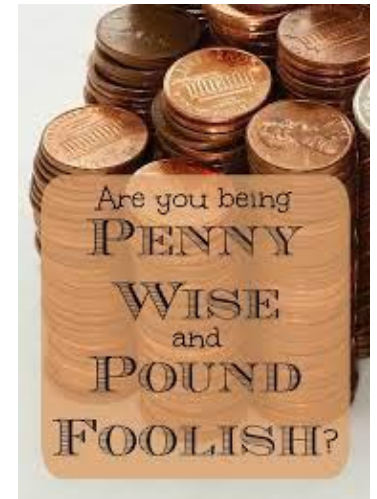
U.S. hail risk



Notes | SEIA Solar State by State

Factory Inspections: Trust but verify

- We see high variability from factory to factory
- We see high variability within a factory over time
- Insist on inspection rights
- Insist on rejection rights
- Incorporate quality criteria into contracts
- Best Practice:
 - Verify the Factory
 - Verify the Process
 - Select a statistical sample and verify the final Product
- “We ship what you don’t like to other customers who aren't looking”

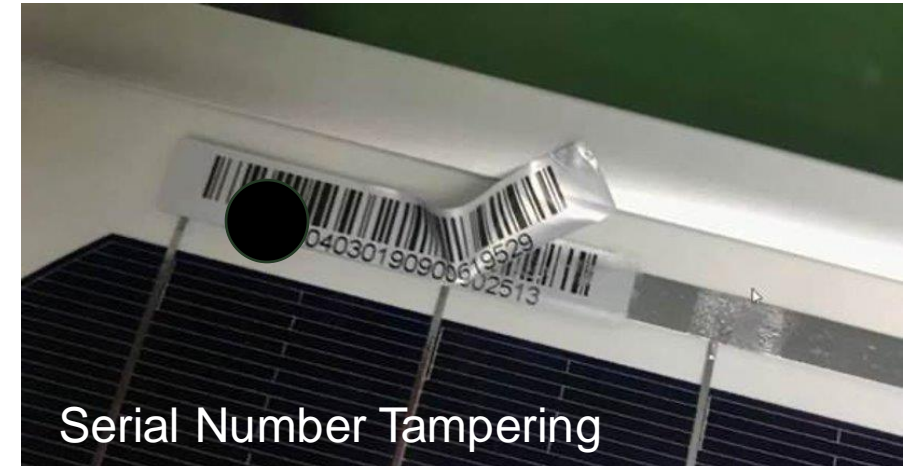


Findings during Pre-shipment Inspections
Same Manufacturer
Three Locations
Changes v. Time

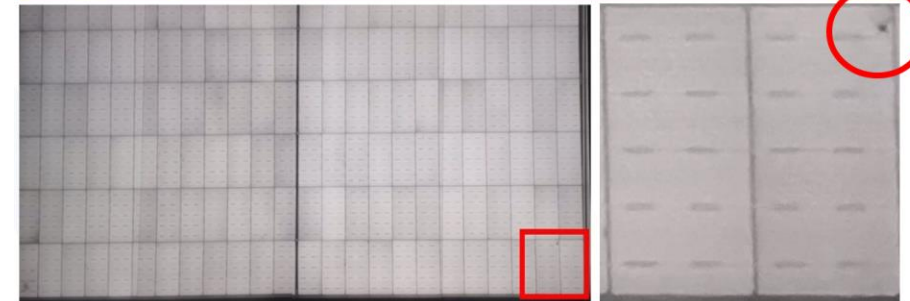
Colum height: tall is not good

Factory Inspections: Trust has to be earned and then sustained

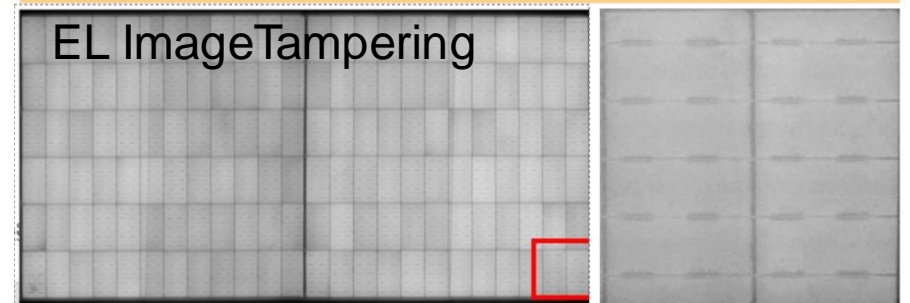
- Most suppliers have good systems and ethics
- We see non-conforming modules “passed” by the Supplier
- We see increasing use of AI-driven image processing – and up to 40% incorrect determinations
- We’ve been *encouraged* to “look the other way” – but we don’t
- We see identical EL images for multiple modules
- We’ve seen the same serial number on 4 modules
- We see “just made” modules in the pre-shipment sample
- We see “Lost Data” when we want to look at historical records



Original picture: Cracks visible



Final EL picture: No visible cracks



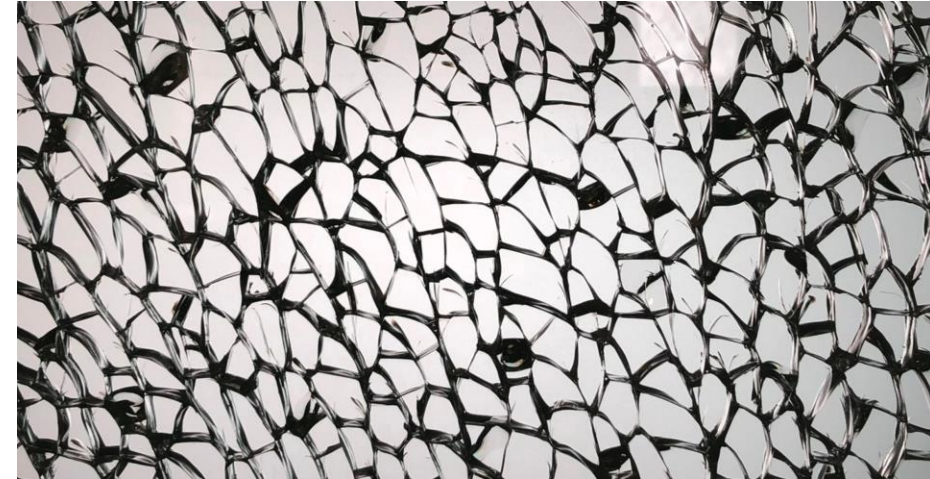
Junction Box Soldering

- Modules typically have 3 small junction boxes; welding between the wires is often robotic
- Seek suppliers with good control over the soldering process, a good design of the junction box and a way of inspecting the workmanship of the soldered / welded joint
- This is a step where zero defects should be allowed yet the soldering systems are likely to be imperfect
- A single instance of improper soldering can lead to a thermal event



Glass Breakage

- We're seeing a serious rash of glass breakage; could ultimately rival the backsheet problems of a few years ago
- Cannot be repaired and can lead to a safety problem
- Modules are bigger, glass is thinner, glass is only heat strengthened
- Clamps to hold modules on trackers have gotten smaller
- There might be in-situ glass defects (inclusions)
- There is variability in glass strength and in edge quality
- Seek a clause that protects you in the event of glass breakage (including seeking “keep whole” language)
 - This is an uphill battle



Connectors

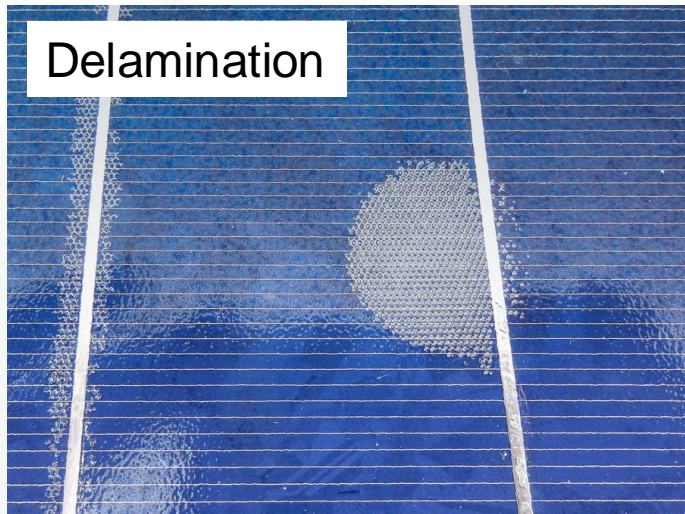
Not a new problem...

- Beware of connector specification; "MC4 Compatible" does NOT mean that you should mate one side to a Stäubli MC4 on the other side (even if it appears to be secure)
- Whatever the connector, be prepared to make whips and home run cables with the same connector and only according the manufacturers' specifications / instructions (including their crimp tool)
- 96% of all systems inspected have some safety issue; connectors are Number 1



Serial Defects (the same defect occurring in many modules)

- The intent is to pre-define conditions that call for replacement / repair of modules in the event a defect is found in % of the total population
- You should try to have this in all procurement agreements
- Seek a long period, a low threshold, clear language on remedy and if the serial defect triggers a remedy for 100% of the modules
- Consider an arbitration clause in the event there is disagreement (and consider third-party analysis)



Carbon Footprint



- On your path to Net Zero – consider the embedded carbon in the PV module
 - Production of silicon metal produces a lot of CO₂
 - Production of polysilicon consumes a lot of electrical energy (often generated from fossil fuels / coal)
 - Production of the monocrystalline ingot consumes a lot of electrical energy



silicon metal



polysilicon



ingot

Recycling

- As Stewards of the Earth – Consider recycling
 - Toxicity (TCLP) testing
 - Availability of Recyclers
 - Cost of Recyclers
 - Use of Glass (e.g., suitable for beverage containers?)



EPA Map of Recyclers [HERE](#)

TCLP Results for PV Module

TCLP Results for PV Module		Lab ID		Limit	
		Customer ID			
		Date Received			
ITEM	METHOD		UNIT		
Arsenic (As)	USEPA 200.8-1994		mg/L	≤5	<0.050
Barium (Ba)	USEPA 200.8-1994		mg/L	≤100	<0.010
Cadmium (Cd)	USEPA 200.8-1994		mg/L	≤1	<0.001
Chromium (Cr)	USEPA 200.8-1994		mg/L	≤5	<0.010
Lead (Pb)	USEPA 200.8-1994		mg/L	≤5	14.2
Selenium (Se)	USEPA 200.8-1994		mg/L	≤1	<0.050
Silver (Ag)	USEPA 200.8-1994		mg/L	≤5	<0.010
Mercury (Hg)	USEPA 7473-2007		mg/L	≤0.2	<0.005

METHOD 1311

TOXICITY CHARACTERISTIC LEACHING PROCEDURE

1.0 SCOPE AND APPLICATION

1.1 The TCLP is designed to determine the mobility of both organic and inorganic analytes present in liquid, solid, and multiphasic wastes.

1.2 If a total analysis of the waste demonstrates that individual analytes are not present in the waste, or that they are present but at such low concentrations that the appropriate regulatory levels could not possibly be exceeded, the TCLP need not be run.

Nuggets:

Past

- Price
- Data Sheets
- Factory inspections (sometimes)

Inspection

Price

Brochure

Present

- Price / Price Risk
- Specifications
- Inspections (Factory & Field)
- Bill of Materials
- Extended Reliability Testing
- Domestic Content
- PV Module Conversion Efficiency
- Harvest (kWh/kW) – including backside gain
- New Technology Risk
- Suitability to Project Location
- Insurance
- Tariff Risk
- Chain of Custody / Detention Risk
- Pandemic Risk
- Carbon Footprint
- Local Representation / Service





Thank You

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Q&A



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7:00 pm – 8:00 pm CEST, Berlin, Paris, Madrid

Tuesday, 10 October 2023

4:00 pm – 5:00 pm CEST, Berlin, Paris, Madrid

5:00 pm – 6:00 pm EEST, Helsinki

Many more to come!

**A manufacturer
guide to
complying with
US module
import laws**

**Powerful data in
PV project
development**

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