THIN FILM VS. C-SI SOLAR MODULES: CELL CRACKING RISK

Lou Trippel
January 22, 2020

First Solar®

LEADING THE WORLD'S SUSTAINABLE ENERGY FUTURE

FIRST SOLAR AT A GLANCE

Over **25 GW** shipped worldwide and over **$17B** in project financing facilitated

Strongest **financial stability** & **bankability** in the industry

Partner of choice for leading utilities and global power buyers since 1999

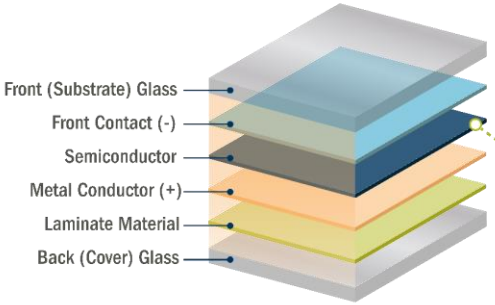
Lowest environmental impacts of all PV technologies on a life cycle basis

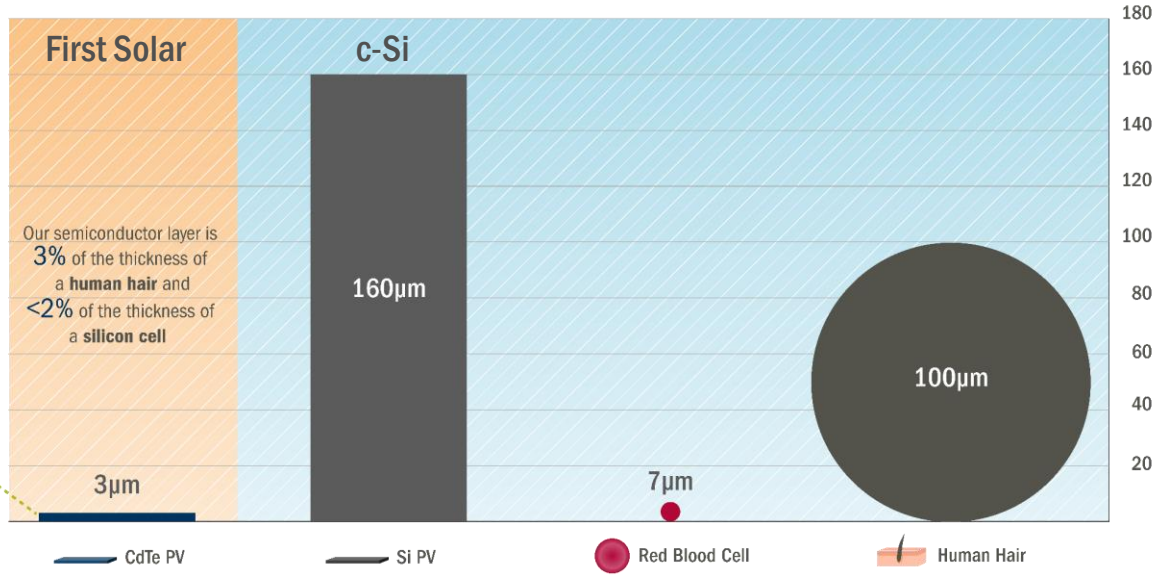
Solar energy that is **economically competitive with fossil fuel**

Industry-leading global PV **recycling** program

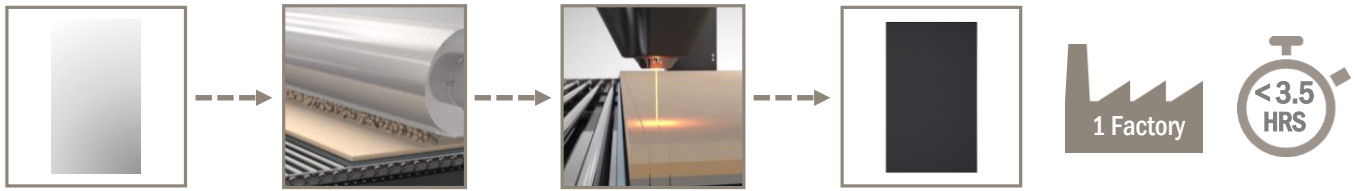
2020 © Copyright First Solar, Inc.

COMPARISON OF PV MODULE CELL TECHNOLOGIES





First Solar Fully Integrated, Automated & Continuous Process



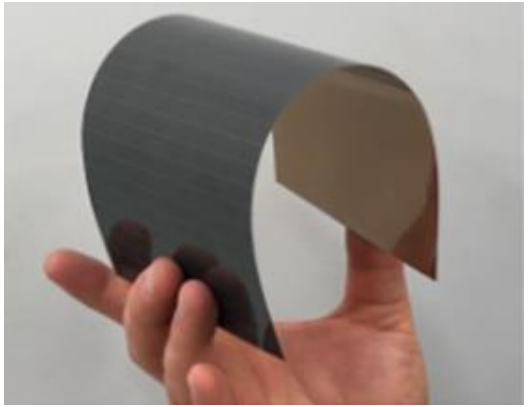
1 Barnes, et. al, High Efficiency Flexible CdTe Superstrate Devices; Photovoltaic Specialist Conference (PVSC), 2014 IEEE 40th; 2014

2020 © Copyright First Solar, Inc.

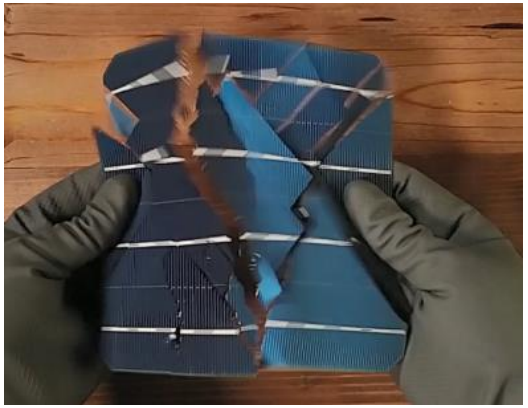
COMPARISON OF PV MODULE CELL TECHNOLOGIES

First Solar's thin-film CdTe cells are **immune to cell cracking** due to their minimal thickness that cannot fracture under stress

Thin Film CdTe



c-Si

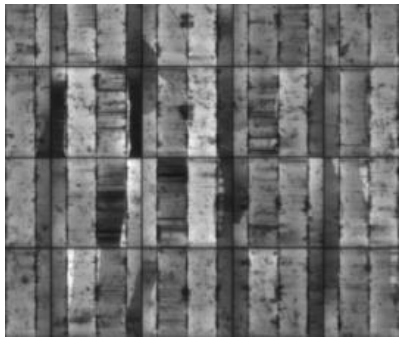


https://www.enrg-inc.com/solar-pv

- First Solar's thin-film semiconductor cells are just a **few microns thick** and **conform to substrate surfaces**
- **Multiple applications** of thin-film PV cell technologies like CdTe in flexible solar applications **have been demonstrated**

2020 © Copyright First Solar, Inc.

OVERVIEW OF CELL CRACKING



Cracked c-Si Cells

- Cell-cracking has been a **known failure mode** for decades, heightened by recent trends like thinner wafers and increased narrow-mount tracker applications
- Results in several percent field **power loss**
- Can happen **throughout** life-cycle
- Damage is **not** easily observed by naked eye
- Common PV module **standards have a 'blind spot'** — they do not test for effect of continued environmental stresses after c-Si module cell-cracking failures and therefore fail to test sufficiently for cell-cracking power output loss

c-Si module cell-cracking is a critical issue in the PV industry

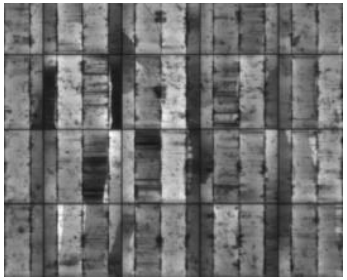
2020 © Copyright First Solar, Inc.

HOW DO CRACKED CELLS OCCUR?

RISK THROUGHOUT ENTIRE LIFE-CYCLE

Cell Fab

Shipping



Cracked c-Si Cells

Hail

Snow

Wind

Handling/Installation

Mounting

2020 © Copyright First Solar, Inc.

HAIL DAMAGE

2020 © Copyright First Solar, Inc.

HAIL RISK IS A GLOBAL CONCERN

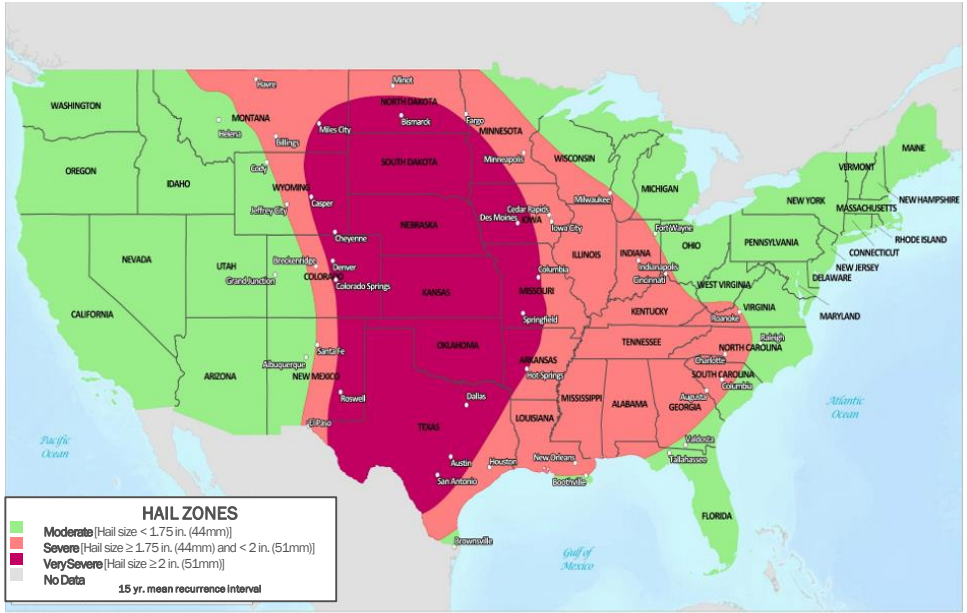
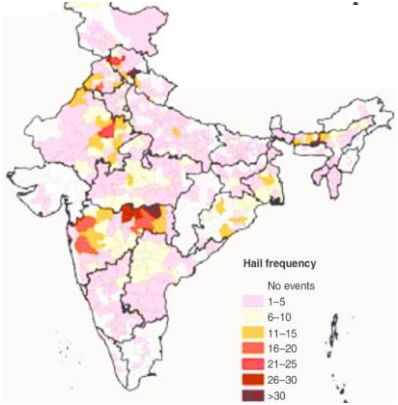


Fig.C-1. Hailstorm hazard map for the contiguous United States (ρ= 0.7g/cm³)

1-34
Page 20
FM Global Property Loss Prevention Data Sheets
Hail Damage



Areas prone to hailstorms in India. Rao et al. (2014)

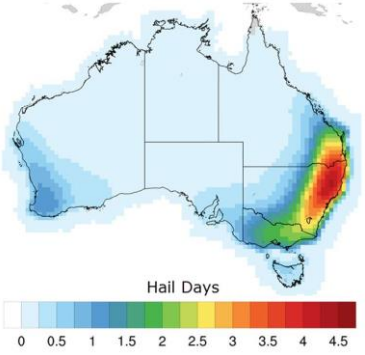
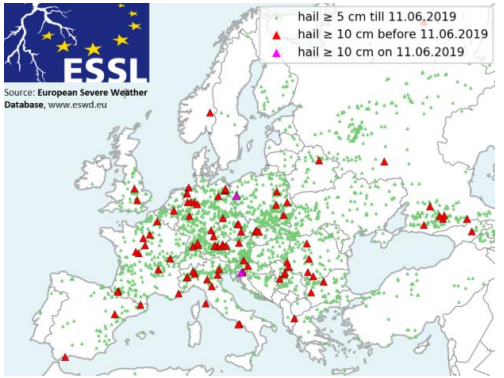


Figure 1. Model annual frequency of hail events across the modeled region (days per year)). (Source AIR)



Very large and giant reports across Europe based on European Severe Weather Database (www.eswd.eu).

https://www.air-worldwide.com/blog/posts/2019/1/australias-costliest-catastrophe-in-2018-and-hail-risk/

Ch, Srinivasrao & K.A., Gopinath & Prasad, J.V.N.S & Channalli, Prasannakumar & Singh, Anil Kumar. (2016). Climate Resilient Villages for Sustainable Food Security in Tropical India: Concept, Process, Technologies, Institutions, and Impacts. Advances in Agronomy. 140. 10.1016/bs.agron.2016.06.003.

2020 © Copyright First Solar, Inc.

HAIL IMPACT TESTING PER IEC 61215-2 MQT 10.17 STANDARD

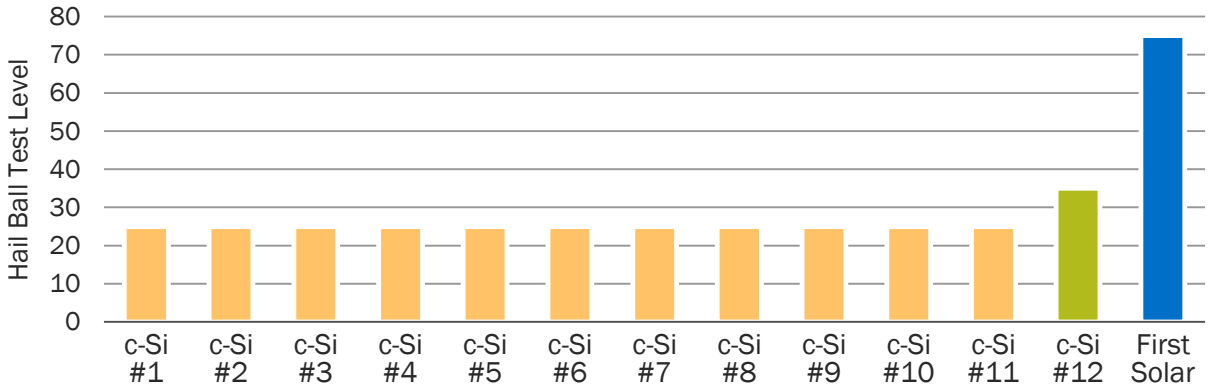
First Solar S4 Test Oct 2019 (pictured) and S6 Test Jan 2020 per IEC 61215-2 MQT 10.17 75mm diameter hail

11 Impacts, Various Locations

Diameter (mm)	Mass (g)	Velocity (m/s)
25	7.54	23
35	20.7	27.2
45	43.9	30.7
55	80.2	33.9
65	132	36.7
75	203	39.5

Minimum Criteria

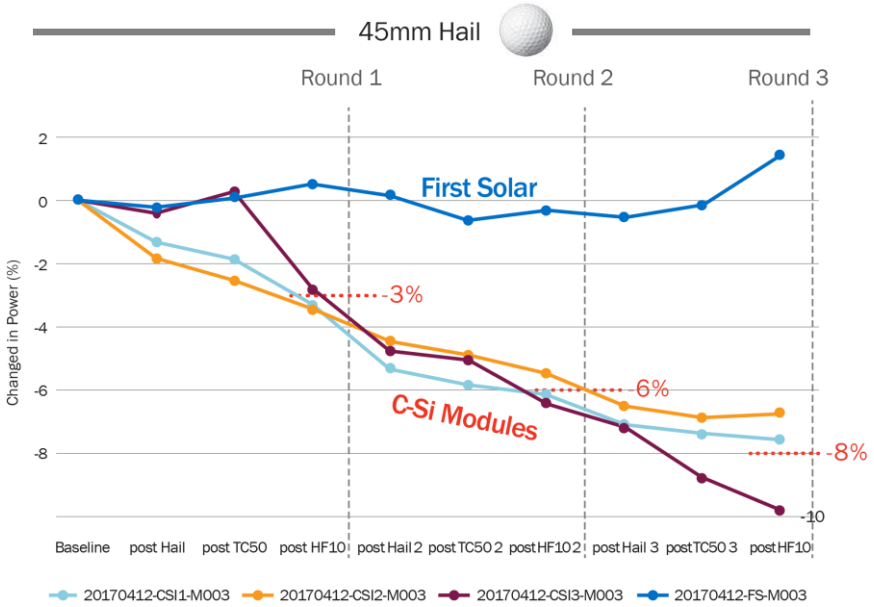
Leading Global Module Suppliers Hail Impact Competitor Datasheet Survey: Aug 2019



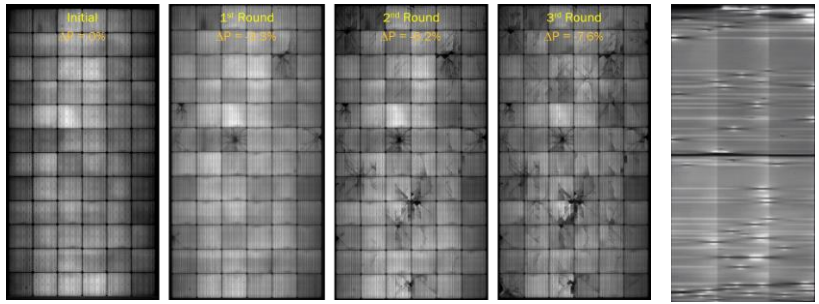
2020 © Copyright First Solar, Inc.

CELL CRACKING POWER LOSS BLIND SPOT

Power loss due to cell cracking in c-Si modules may not manifest immediately or to its full extent after mechanical loading or hail impact, but with subsequent thermal cycling and humidity freeze cycling ('HF10' per MQT 10.12) simulating real word stress over time, power loss is observed. These post-crack environmental stressors are NOT currently required in certification testing.



- Primary required PV module standards: IEC 61215-2: 2016 and UL 61730-2: 2017
- Mechanical load test (MQT 10.16) and Hail impact test (MQT 10.17) referenced by both standards do NOT test for effect of continued environmental stresses after c-Si module cell-cracking failures and therefore fail to test sufficiently for cell-cracking power output loss



First Solar
NO POWER LOSS

'TC50' = Thermal Cycling test per IEC 61215-2 MQT 10.11;
'HF10' = Humidity Freeze test per IEC 61215-2 MQT 10.12

2020 © Copyright First Solar, Inc.

CELL CRACKING KEY TAKEAWAYS

Cell cracking is a phenomenon that **only occurs in c-Si PV modules** and **cannot be seen by the naked eye.**

It **can occur throughout the entire life-cycle** of the module and as a result of fabrication, shipping, installation, wind, snow, and hail.

It could result in significant **STC power loss** and **further incremental energy production loss therefore** loss of owner revenue.

PV plants built with **First Solar modules** are **not subject to cell cracking** and therefore represent a lower risk profile in this regard.

RECOMMENDATIONS

Select an inherently immune module technology (like First Solar).

Advocate **stringent** as-delivered component **requirements** and **warranty terms** that adequately protect you **against power/energy loss risk.**

Join First Solar in advocating for **more thorough module evaluations** and **stronger PV module standards** that remove cell cracking blind spots.

2020 © Copyright First Solar, Inc.

LEADING THE WORLD'S
SUSTAINABLE ENERGY FUTURE