

# Life after 30 years—a PV system in Colorado

## PV Reliability Workshop

virtual

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2/22/2021

# PV system in Fort Collins, CO, USA

Fixed tilt system, tilt adjusted 2x /year



1-axis tracker system



System size: 6.6 kW

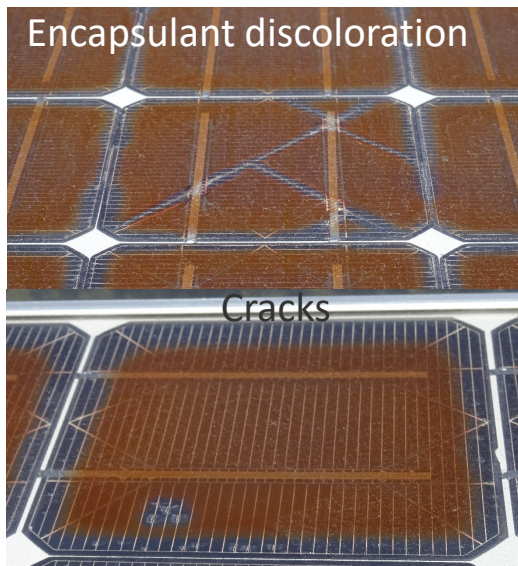
Location: Fort Collins, CO, USA

Commissioned: 1987

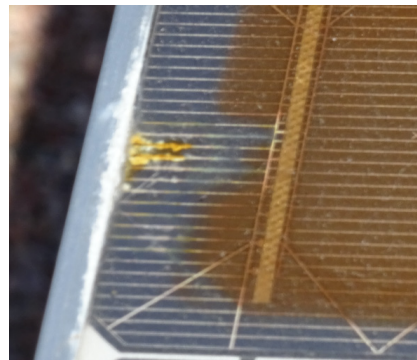
Decommissioned: 2017

Sample of 20 modules brought to NREL, 4 were remounted outdoors

# Field observation



Corrosion



Cracked cable from J-box



Point-like cracks may be caused by hail

| Failure mode     | # modules with defect | # modules examined | % modules |
|------------------|-----------------------|--------------------|-----------|
| Eva browning     | 153                   | 153                | 100       |
| Cracked cells    | 94                    | 153                | 61        |
| Hot spots        | 2                     | 78                 | 2.6       |
| Burn marks       | 7                     | 153                | 4.6       |
| Cracked grommets | 11                    | 153                | 7.2       |
| Cracked wires    | 2                     | 153                | 1.3       |
| Bent frames      | 2                     | 153                | 1.3       |
| Cell corrosion   | 1                     | 153                | 0.7       |

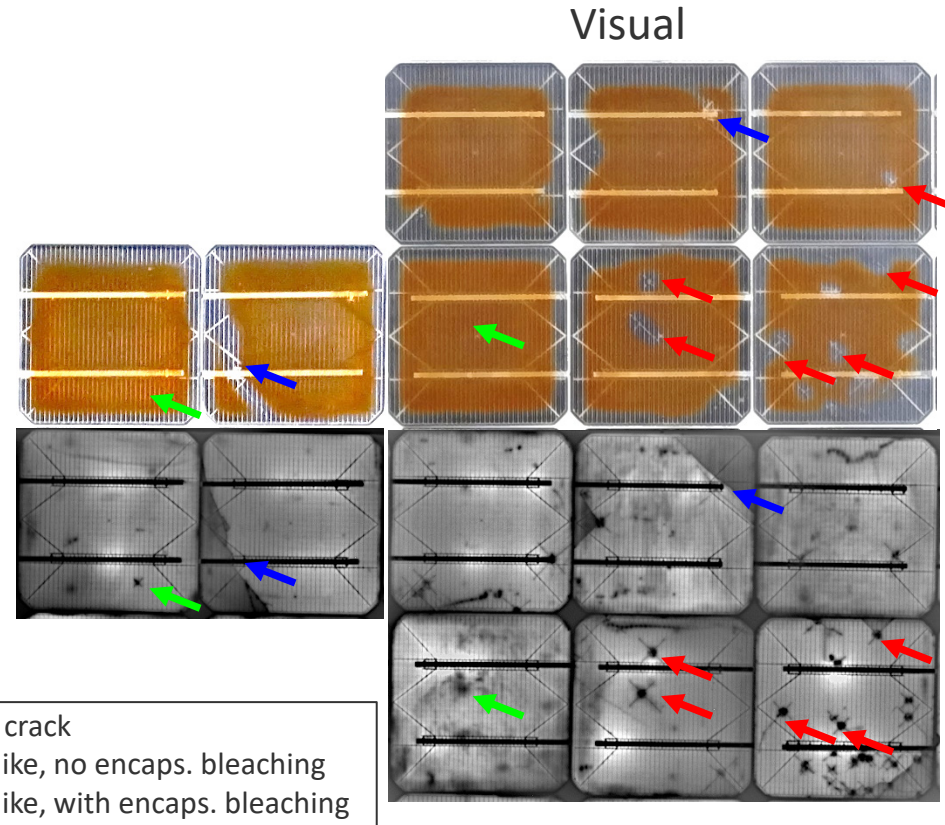
# Crack forensics

## Crack statistic

| Mounting        | Modules cracked (%) |
|-----------------|---------------------|
| Fixed tilt rack | 43                  |
| Tracker 1       | 53                  |
| Tracker 2       | 93                  |
| Tracker 3       | 100                 |
| Tracker 4       | 67                  |
| Tracker 5       | 87                  |

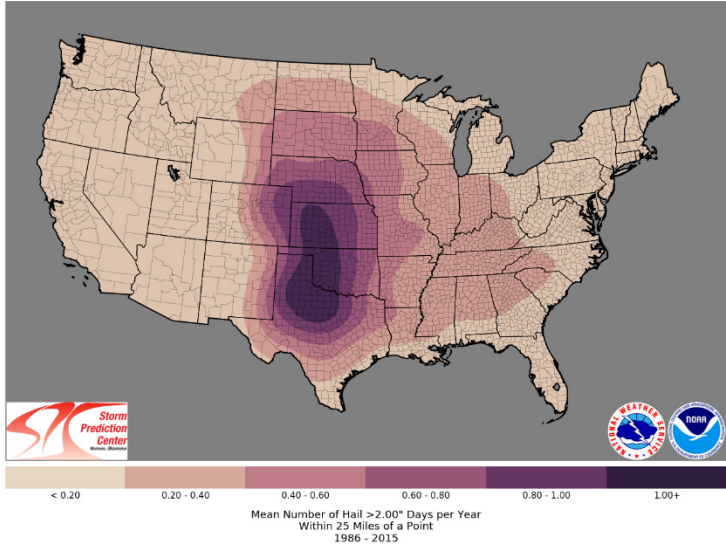
But ...

crack  $\neq$  crack

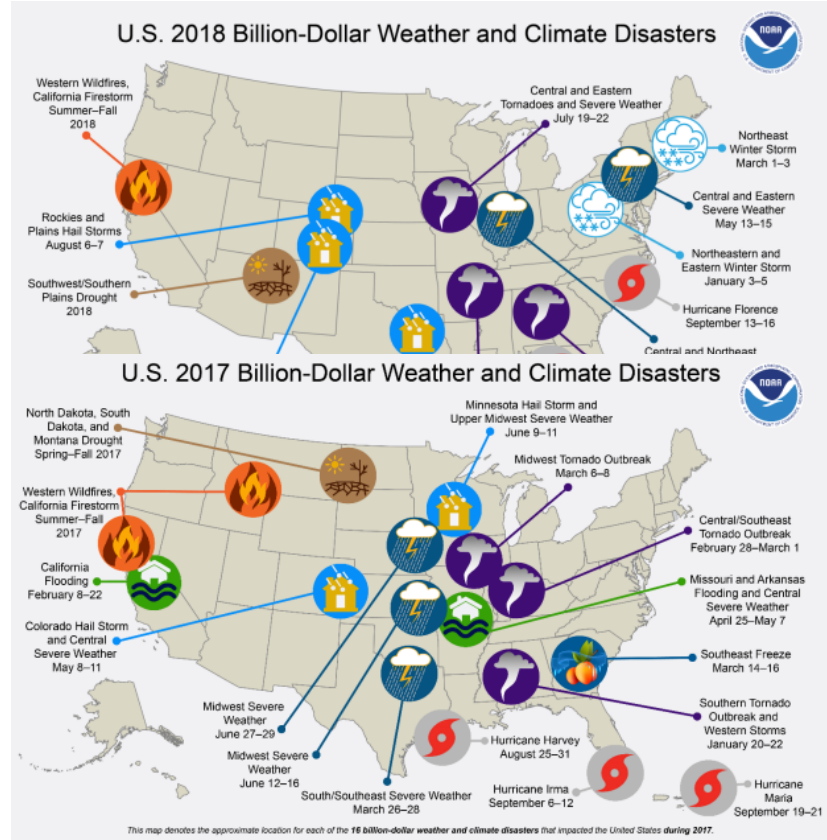


Point-like cracks may have been caused by hail

# Colorado 2<sup>nd</sup> highest hail insurance claims 2017-2019\*



NREL,  
May 2017

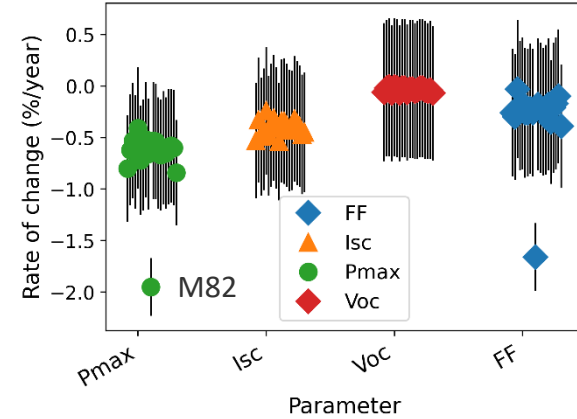
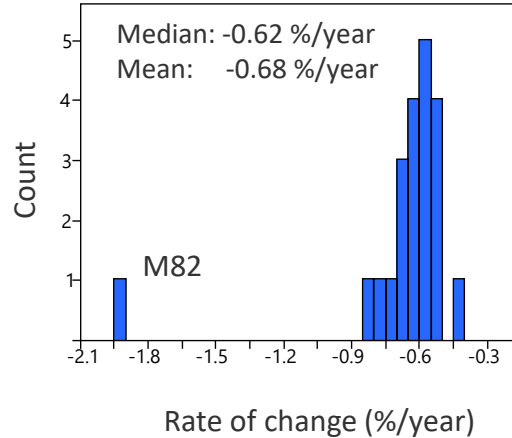
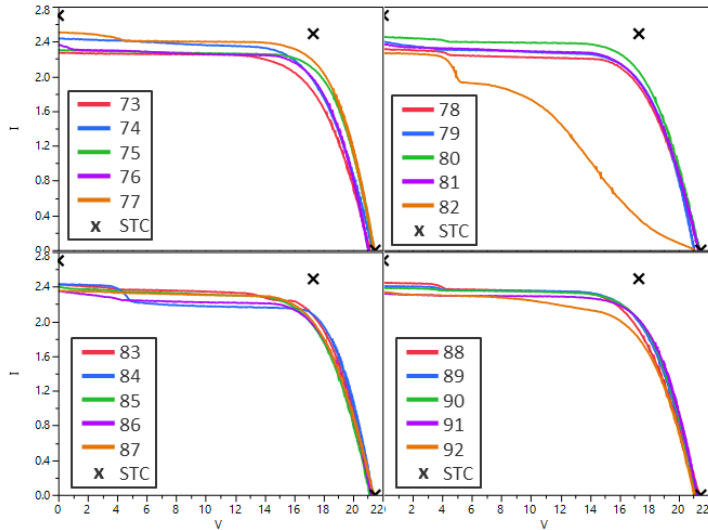


\*April 2020 NICB Hail Report

# Module performance I-V curves

Rate of change ( $R_d$ ) assuming nameplate is accurate

... which we don't know



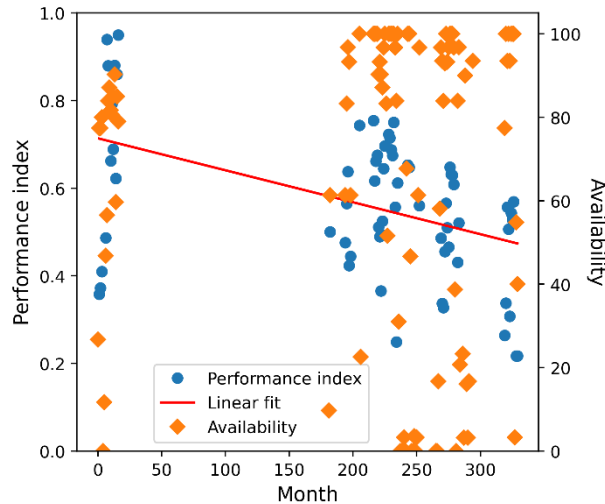
Nameplate tolerance: +/- 10%  
→ Used to calculate uncertainties

Typical module degradation observed  
One outlier module that exhibited severe hot spot

# System performance

Sporadic production data during 30 years allows estimation of degradation only

AC production data



Median availability

Initial phase: 79%

End phase: 89%

**Estimated** rate of change:  $-1.32 \pm 0.32$  %/year

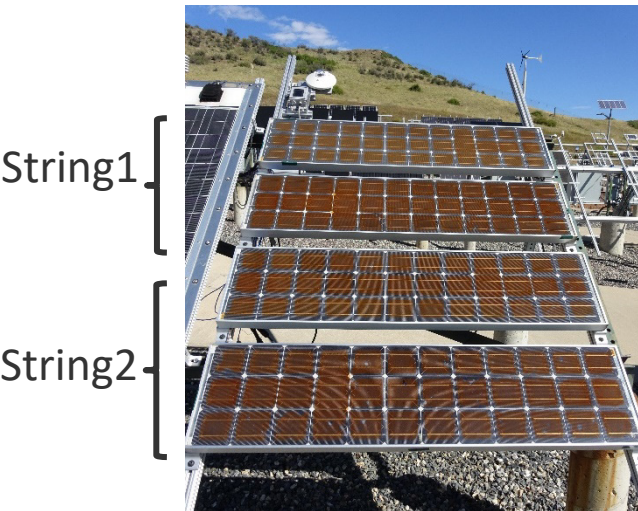
Not enough data to estimate if performance loss is accelerating with age

System performs roughly as the worst modules → system may be limited by worst modules/strings

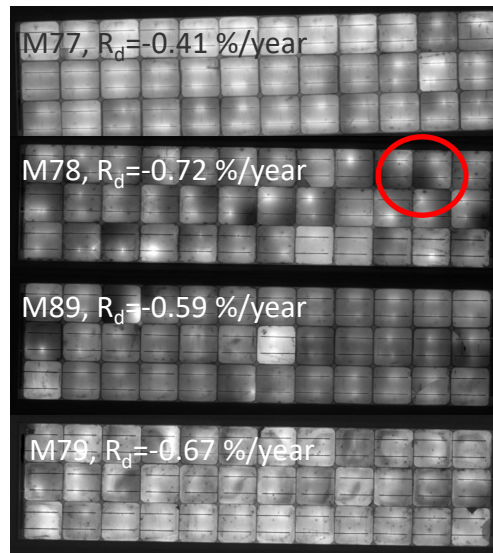
**Worst performers can be easily detected by infrared scans**

**Proactive O&M can increase energy production**

# NREL outdoors installation

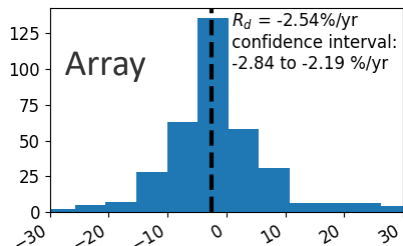


Series resistance maps ( $R_s$ ) –  
High current EL/low current EL



Area of  
new hot-  
spot

Rate of change (%/year)  
from continuous data



Rate of change (%/year) during ca. 3 yrs  
from IV

| Type    | Pmax  | Isc  | Voc   | FF    |
|---------|-------|------|-------|-------|
| Array   | -2.2  | 0.48 | -0.37 | -2.35 |
| String1 | -5.55 | 1.69 | -0.46 | -6.62 |
| String2 | 0.11  | 2.03 | -0.28 | -1.78 |

**New hot spot impacts string1  
& array but array2 shows no  
degradation**



# Conclusion

And it keeps going, and going ....



1987

1997

2007

2017

2027 ??

# Acknowledgments

## Thank you

PV Reliability group  
Tim Silverman,  
Bill Sekulic,  
Byron McDanold

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NREL/PR-5K00-79039

This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

