



Power loss and safety risks –
recoverable vs. non-recoverable?

Duramat workshop

Breckenridge, CO

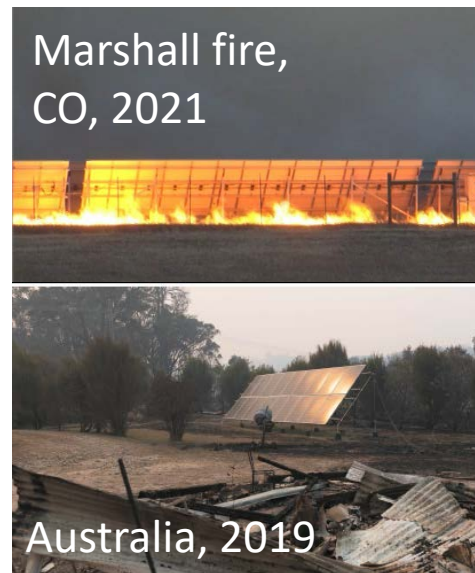
Dirk Jordan

8/31/2022

Motivation: Long lifetime and resilience

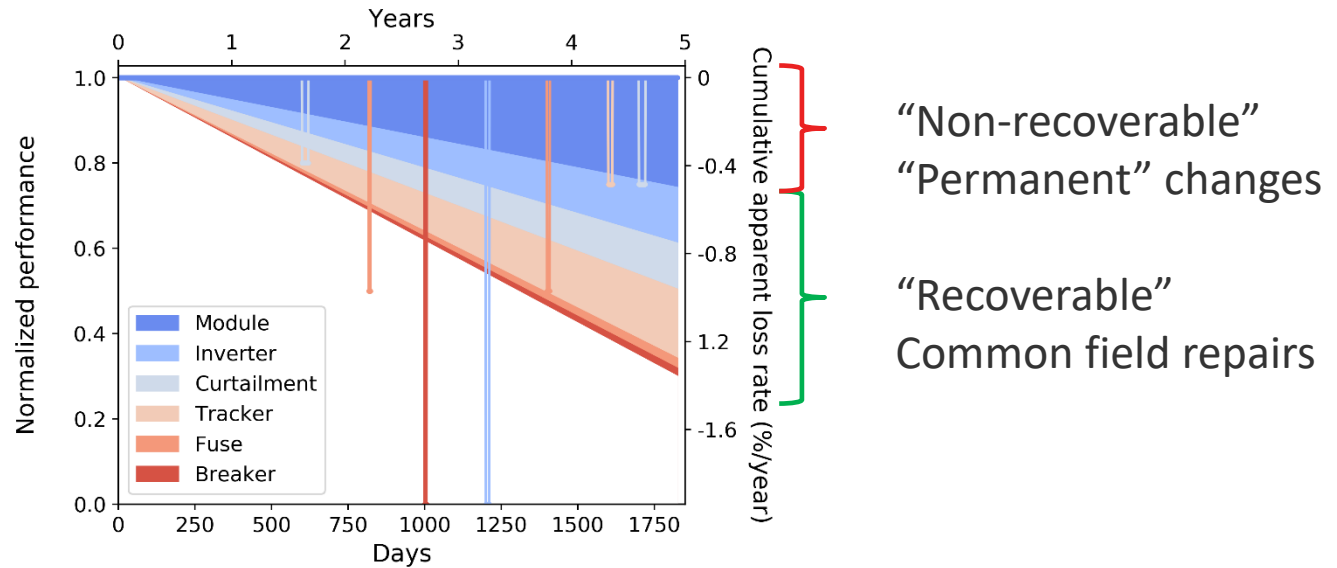
Long lifetime → greater probability of extreme weather exposure

High quality ~~could~~ will save lives.



Minimizing (recoverable) losses so they don't underperform when needed most

Recoverable vs. non-recoverable losses

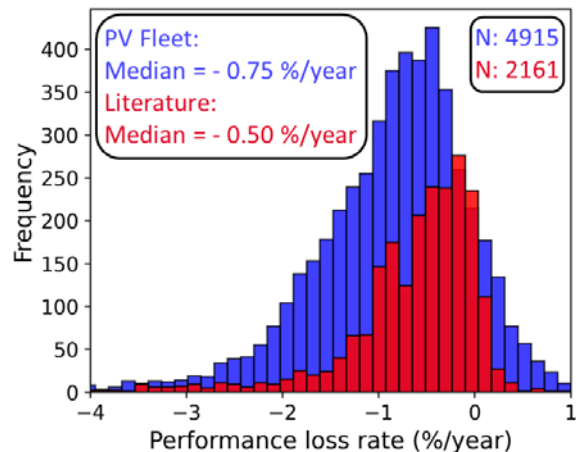


Gray area: “non-recoverable” is changing → in-field backsheet cracks repair

System (performance loss rate) may be higher than module degradation

Performance loss rates + O & M

USA



Jordan et al., Progress in PV, 2022.

PV Fleet (blue): 100% systems

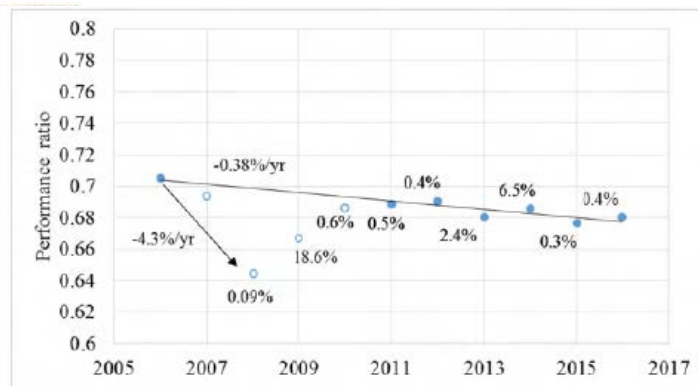
Literature (red) 80% modules

Proactive monitoring & maintenance → reduced loss



Closely monitoring of systems

Replacement of modules with hot-spots

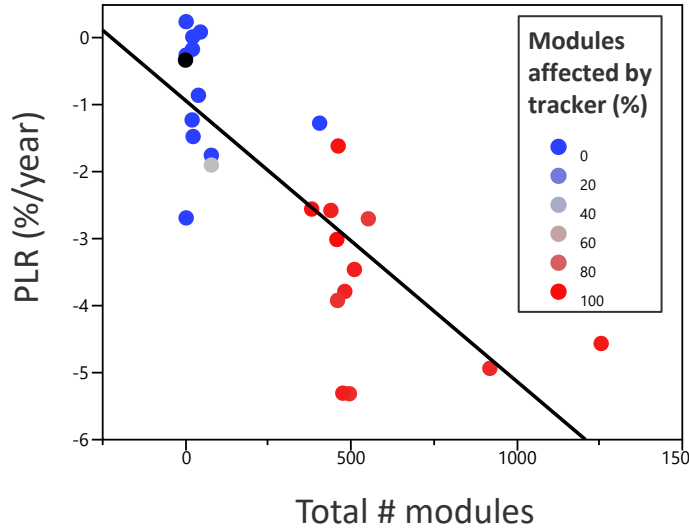


Pascual et al., Progress in PV, 2021.

Early detection & maintenance helped lower performance loss rates (PLR)

Recoverable losses & trackers

Recoverable loss (tracker stow/fault)



Utility PV site, 20+ inverters

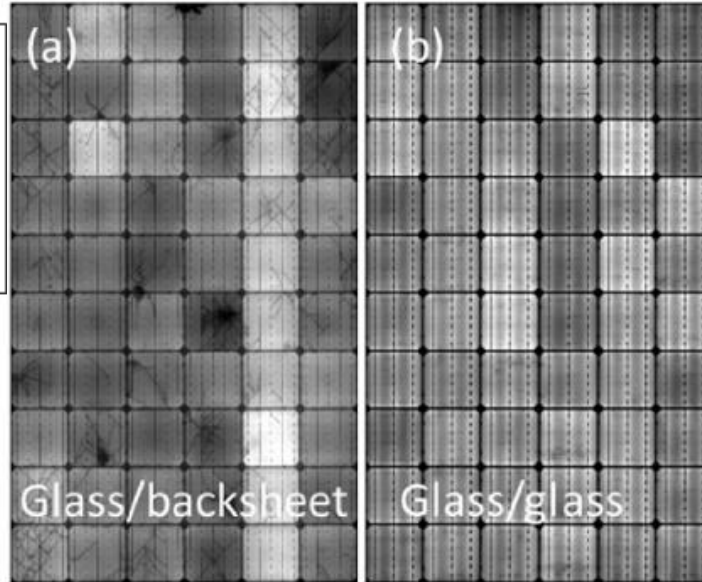
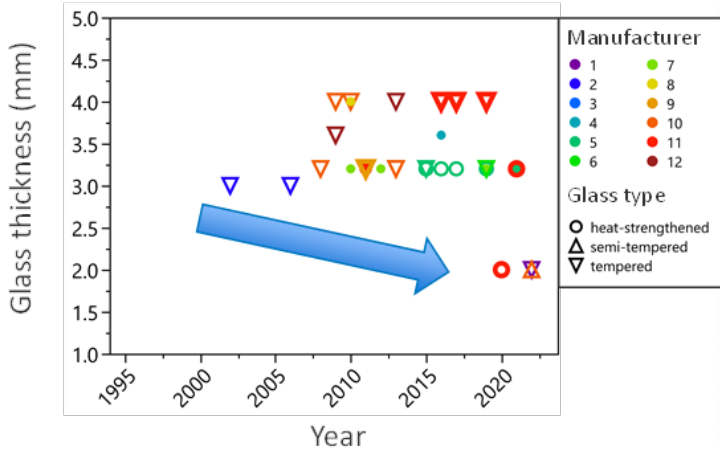
RdTools loss analysis (removed soiling – recoverable loss)

Aerial inspection → module, string issues

Inverters affected by tracker stow/faults show higher performance loss

Hail risk & broken cells

Modules at NREL



- Same manufacturer
- Installed @ same time
- Mounted side-by-side

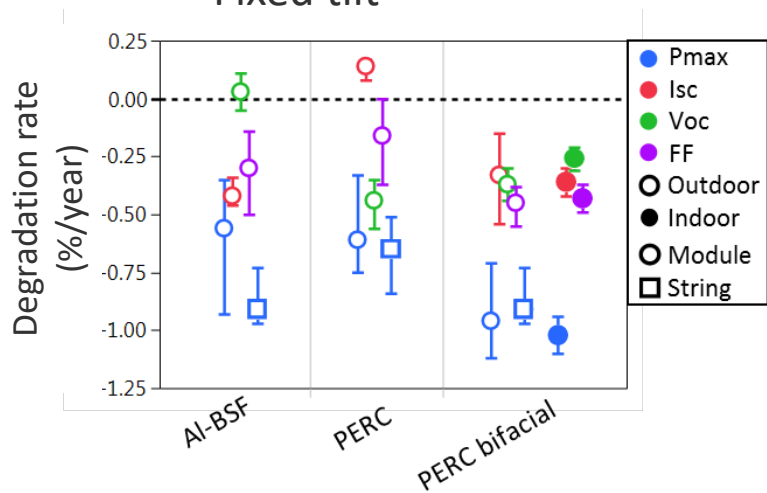


NREL,
May 2017

When does damage lead to power loss in field?

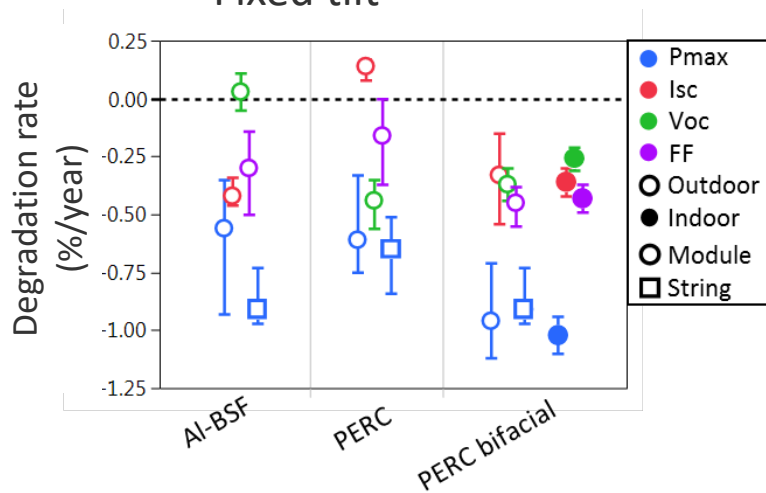
Bifacial performance

Modules & strings
Fixed tilt

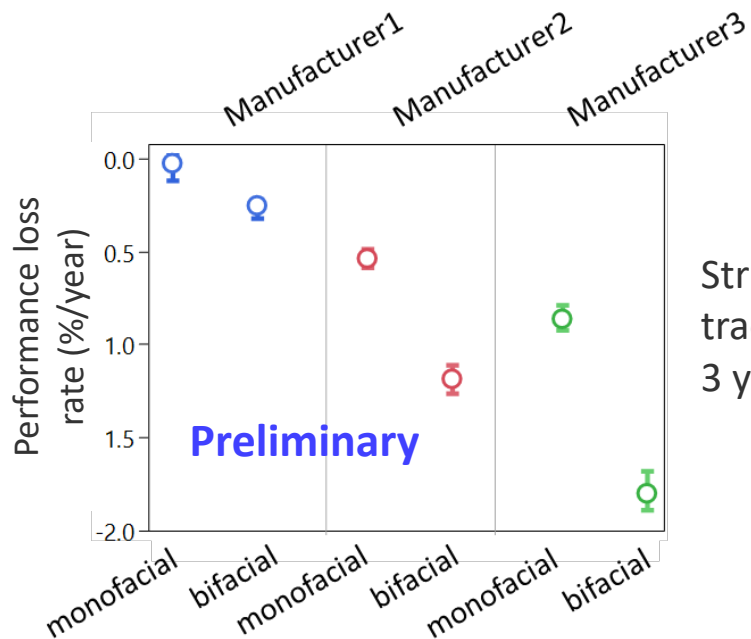


Bifacial performance

Modules & strings
Fixed tilt



Jordan et al. PVSC 2019

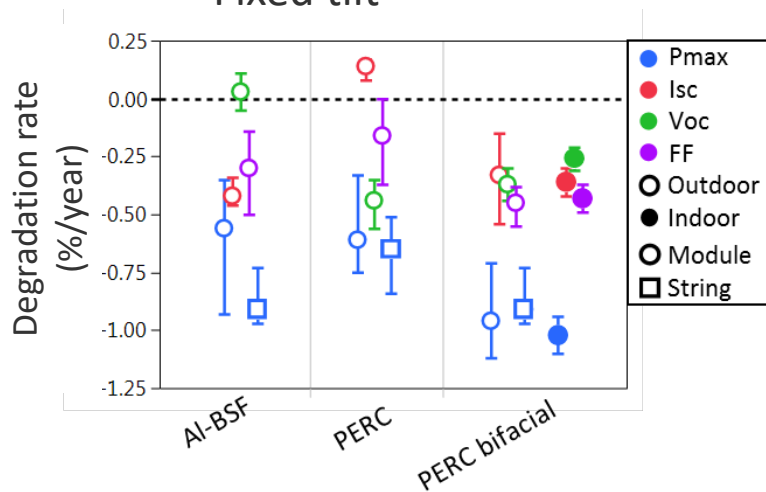


Strings, 1-axis tracker
3 years of data

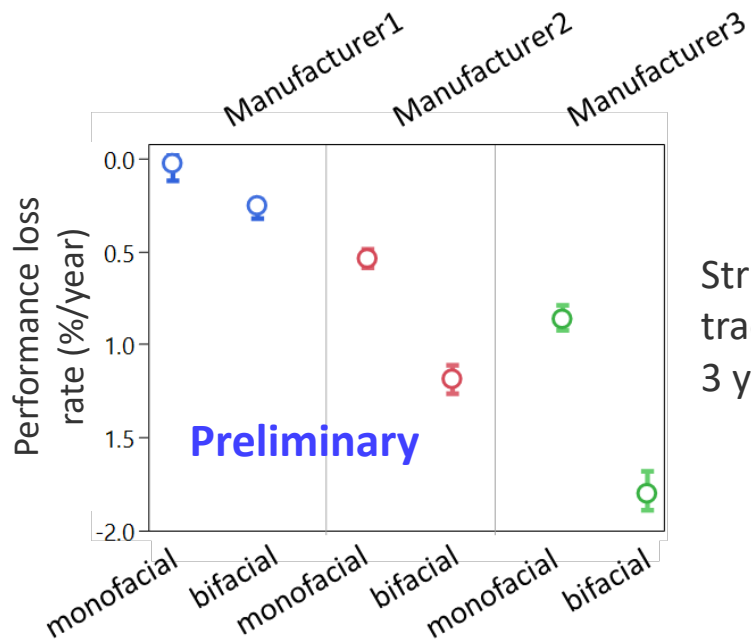
Preliminary

Bifacial performance

Modules & strings
Fixed tilt



Jordan et al. PVSC 2019

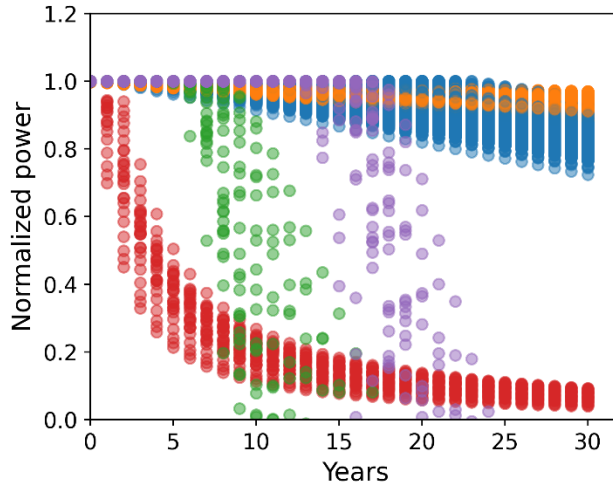


Need more data on bifacial systems

IF bifacial greater loss is confirmed → packaging or cell issue?

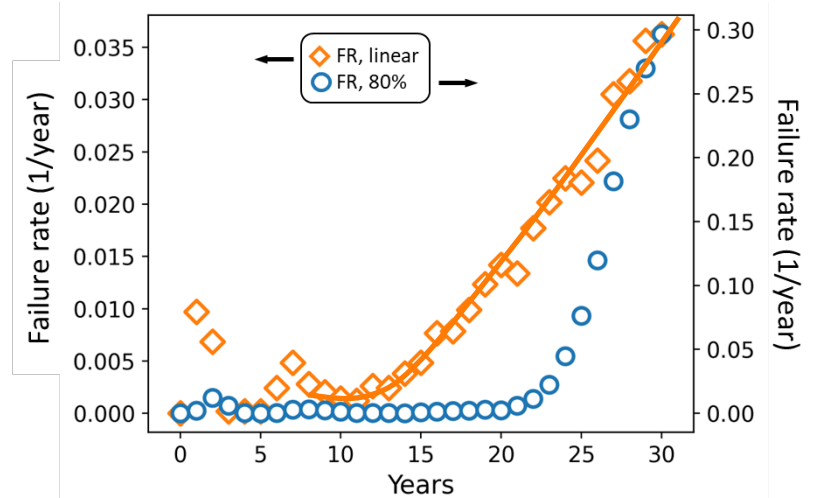
Early wear-out

Module degradation simulation



Jordan et al. Progress in Energy, 2022.

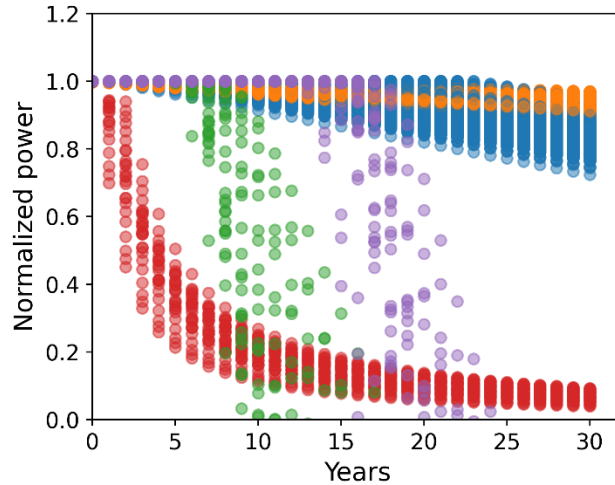
Bathtub Rollercoaster curve



Different colors relate to different mechanisms

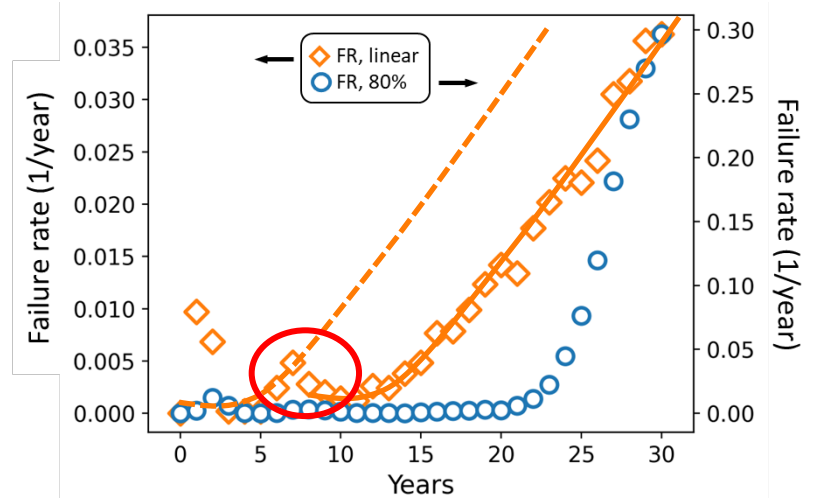
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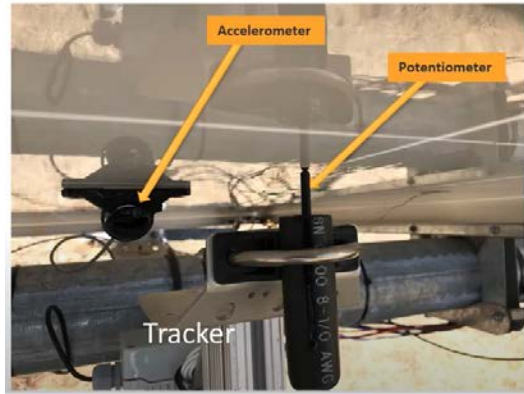
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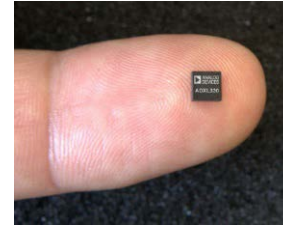
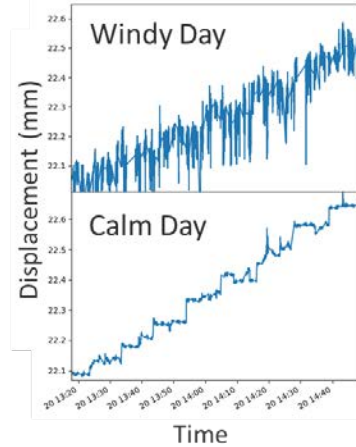
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How do we make sure that latent defects turn into early wear-out?

Monitor changes – smart sensing



Libby et al., Duramat, 2022



Commercial accelerometer

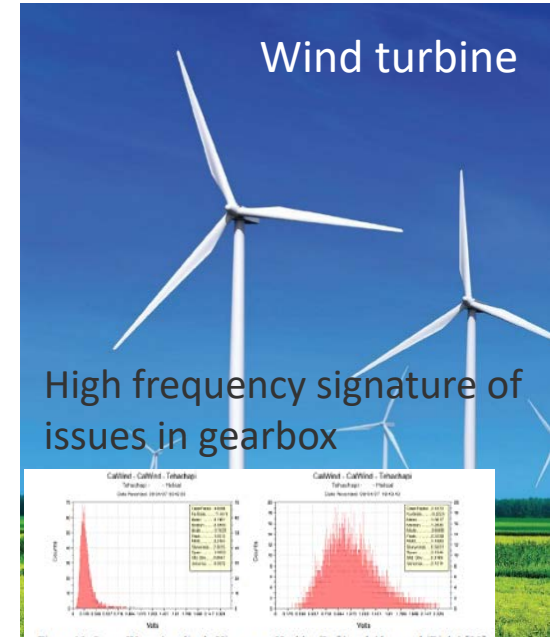
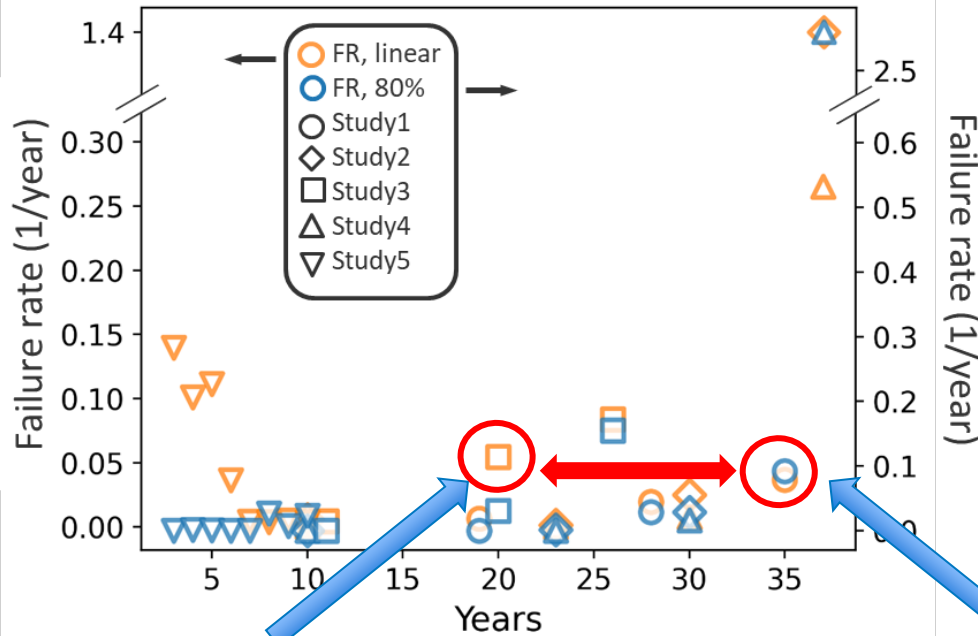


Figure 10: Stress Wave Amplitude Histogram: Healthy (Left) and Abnormal (Right) [22]

Sheng et al., ASHMC, 2011

Sensors could provide pathway to faster response time

Long lifetime observations



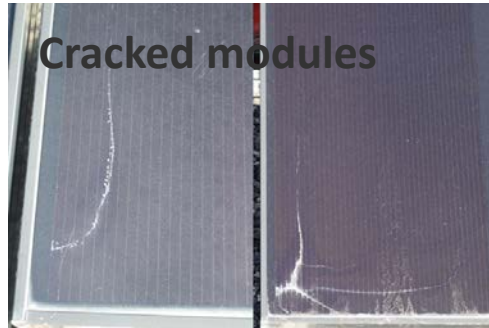
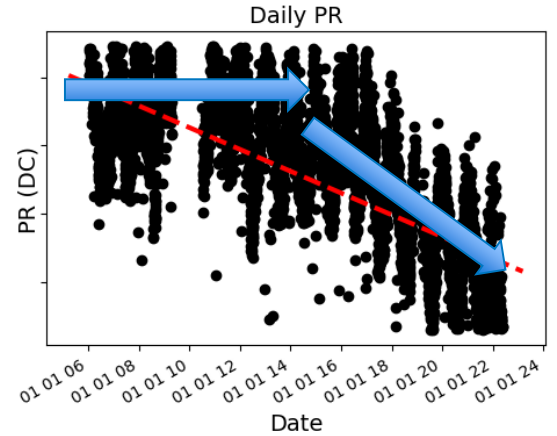
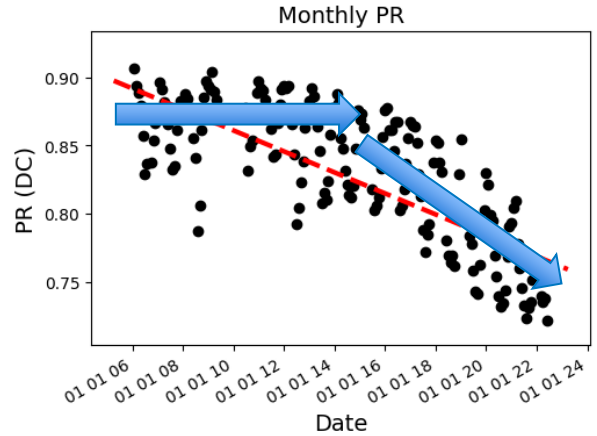
ARCO modules
Different vintage

1. EVA encapsulant
2. No edge seal
3. No stainless steel in backsheet

1. PVB encapsulant
2. Edge seal
3. Stainless steel foil in backsheet

Edge seal

1kW CIS system



Modules:

- Glass-glass module with Tedlar on the back to make it look similar to Si modules
- Used edge seal

Uncracked modules have not degraded!

Conclusion

As PV deployment accelerates what can we do?

- Losses may be recoverable (understand interactions between O&M, installation, module materials, BOS materials)
- Understand degradation mechanism interactions
- Understand bifacial performance loss
- More research into edge seal
- Glass-glass impact resistance
- Early detection and sensors

Conclusion

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“With great(er) power comes great(er) responsibility”

Acknowledgments

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