From: Jennifer Brownie (QEUN)
Sent: 16 November 2021
To: Energy Forecasting
Subject: Solar Output - improving AEMO's forecast by understanding causes and rates of PV degradation

Hi

The Clean Energy Regulator's number of solar PV systems combined with the manufacturers degradation rates are not sufficient to measure the output of the NEM's largest generator going forward.

Can you please advise if AEMO is supporting any research into the accuracy of manufacturers' PV degradation rates, especially in areas impacted by severe weather events such as hail, cyclones and fires.

From US Department of Energy - Office of Energy Efficiency & Renewable Energy - *Technical Research Opportunities for Photovoltaic System End-of-Life Management Request for Information Summary* - October 2021 (link):
On May 19, 2021, the U.S. Department of Energy's Solar Energy Technologies Office released the Technical Research Opportunities for Photovoltaic System End of Life Management Request for Information (RFI) for public response and comment.

The RFI sought feedback from solar and recycling industries, academia, research laboratories, government agencies, and other stakeholders on the current state of PV End of Life (EOL) in the U.S, available data regarding PV EOL, and areas of research needed to reduce the barriers to component reuse and recycling.

In the U.S, PV module and component end-of-life practices, such as recovery, reuse, recycling, and disposal, are not well understood since EOL volumes have been low and there are few policies related to PV EOL.

To solicit feedback about these challenges, the RFI included questions covering four sections:

1) Current Status and Available Data;
2) Reuse Practices;
3) Recycling Practices; and
4) Courses of Action.

1b) What are the common causes of PV EOL?
Components most frequently reach EOL prematurely due to physical damages from a variety of factors. Every response identified component physical damage but did not always specify the reason. **Severe weather events**, **namely fires, hurricanes, and hail, were the most common reasons for irreparable or unacceptable physical damage**. Water damage was also often mentioned. The percentage of respondents who identified at least one of the 6 most frequent causes is shown in Figure 2.

The second most frequent response (65%) was component performance degradation.
Performance degradation is the result of various factors and is included in all solar system performance analyses. Different components degrade at different rates. The encapsulant tends to have a lower life span than most other system components. **Even if severe weather events do not directly cause end of life, damage from them can lower the component's lifespan via performance degradation.** Panel and component obsolescence is another reason for end of life. Component lifetimes are shortened when system owners see financial or aesthetic value in newer, more efficient technologies and replace the older versions of those components. For residential systems, a new system owner who inherited the system may not desire solar and therefore decommission the system. Some respondents mentioned a 'bathtub curve' to describe the failure rates of PV panels throughout a standard panel lifetime. The bathtub shape refers to many failures occurring at the beginning or the end of the PV panel lifecycle, rather than in the middle. "Infant mortalities" can be due to poor shipping and handling practices, manufacturing defects, or problems during installation. The components with the highest failure rates include: encapsulants, inverters, backsheets, diodes, busbars, cables, and connectors.

Technical Research Opportunities for Photovoltaic System End-of-Life Management Request for Information Summary

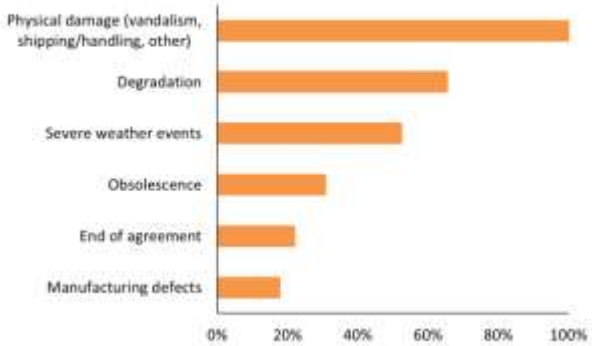

Figure 1: Percent of respondents addressing each of the categories listed related to causes for end of life

Table 1: Common causes for degradation addressed in RFI responses and brief descriptions.

Causes of Degradation	Description
Improper bill of materials	Inaccurate list of materials may affect performance and safety qualities of the PV system
Improper installations	Common mistakes include poor wiring; insufficient inverter ventilation; no lighting protection; and roof perforation without adequate sealing methods
Hot spots	A disproportionate heating of a single solar cell compared to surrounding ones; caused by shading, manufacturing defects, and mechanical damage
EVA Discoloration	Ethyl vinyl acetate (EVA) encapsulant browns as a result of continued UV exposure; this will significantly reduce the performance of solar cells
Thermal cycling	Mechanical stress on components from temperature cycling of day/night and varied solar radiation exposure
Backsheet cracking	Formation of cracks in backsheets from seasonal temperature changes, producing plastic deformation of the backsheet
Water leakage	Reduced performance of component as a result of water ingress
UV Exposure	Exposure to UV rays causes a variety of component performance degradation mechanisms or failures
PID (Potential Induced Degradation)	Existence of stray currents within a PV system, accelerated by high system voltages, temperatures, and external humidity levels
Electromigration	Current-induced transport of activated ions in a semiconductor that can cause short circuits in a module.
Pinholes	Tiny holes in the top layer of a perovskite solar cell that create pathways for water and other gas molecules in air to diffuse through the thin film and degrade the perovskite

Kind Regards
Jennifer Brownie
Coordinator

QEUN

Queensland Electricity Users Network

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