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Snow Shedding Differences between Framed and Frameless Modules

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Abstract

Energy losses due to snow coverage can be high in climates with large annual snowfall. These losses may be reduced with region-specific system design guidelines. One possible factor in snow retention on PV systems could be frame presence and/or shape. Sandia is studying the effect of module frame presence on photovoltaic module snow shedding for a pair of otherwise-identical PV systems in Vermont. The results of this study provide a summary of the findings after the 2018-2019 winter period. The results clearly show that the presence of a frame inhibits PV performance in mild winter conditions.

Background

Existing snow-loss models predict the amount of snow that will slide from a PV module under given environmental conditions [1]. However, the presence of a frame on PV modules may affect the snow's tendency to slide, and is currently unaccounted for in the models.

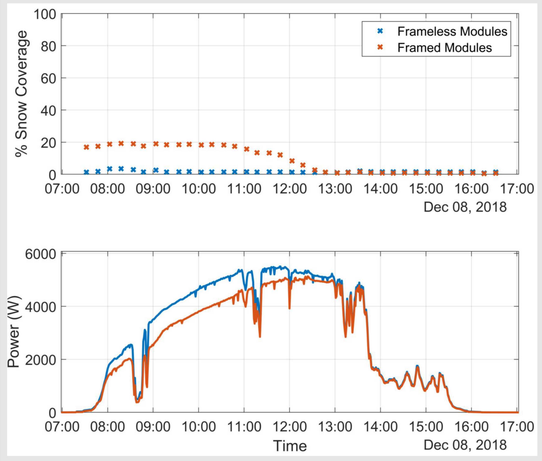
To provide quantitative data on the impact of the presence of a frame on snow shedding from PV, we monitored a pair of adjacent 6 kW PV systems. The PV modules in each system were identical, differing only in the presence or absence of an aluminum module frame. The PV systems were in Vermont, with a south-facing fixed-tilt rack, tilted at 35 degrees. The systems were measured for module temperature, DC current and voltage. A camera captured a picture of the systems every 15 minutes.

The open source Fiji/ImageJ analysis software is used to automatically process the photographs to determine the percent of snow coverage of the centermost 18 modules of each system.

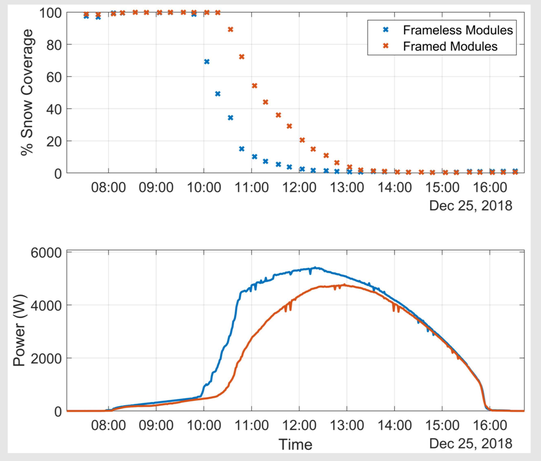
The two PV systems at the VT field site on December 25, 2018. Left modules are framed, right modules are frameless. Highlighted modules are used for snow-coverage analysis.

Note the much larger quantity of snow accumulation under the frameless modules.

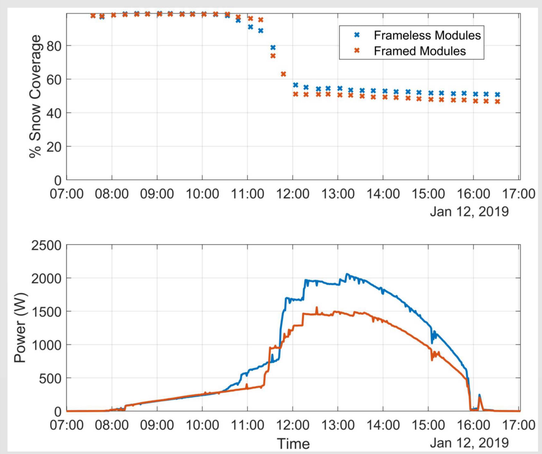
Snow shedding at different rates at 9:15 December 8, 2018. Note that 20% snow coverage causes significant energy losses.



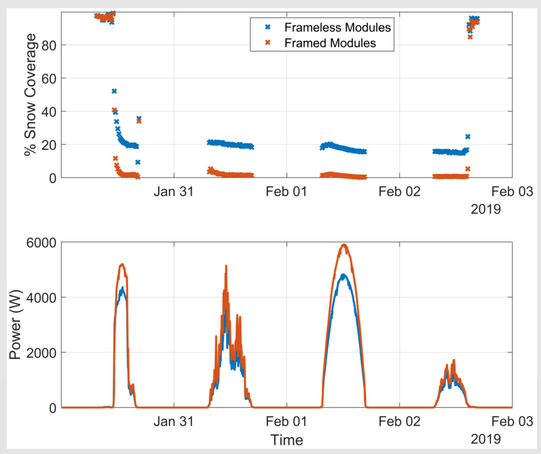
Snow shedding at different rates at 10:45 December 25, 2018.



Snow shedding similarly for each system at 14:15 on January 12, 2019. Low ambient and module temperatures inhibited sliding and reduced the benefit of frameless modules.



Rapid snow shedding of the frameless modules causes more ground accumulation and blocks further sliding on January 30, 2019.



Results & Discussion

Snow storms on December 6 and December 24, 2018 deposited snow evenly on both PV systems. By December 8 and 25, ambient temperatures rose above -10 °C and module temperatures easily exceeded 0 °C. In these cases, and in other cases not shown, the frameless modules shed snow more quickly than modules with frames. On December 8, the frameless modules produced 9% more energy than the framed modules; while on December 25, the frameless modules produced 13% more energy than the framed modules.

As temperatures decrease, however, and snow sliding off the PV modules is inhibited, the advantage of frameless modules is reduced. A snowfall on January 9, 2019 did not slide from the systems until January 12 due to cold ambient and module temperatures. As sliding progressed on January 12, the frameless modules did not shed snow faster than the framed modules.

Improvements to the snow shedding model, specifically those made by SunPower [2], account for snow accumulation beneath the modules after sliding. As the snow accumulates and reaches the lower edge of the modules, it may prevent further sliding. In the snow shedding models, all snow is assumed to slide from the modules and accumulate on the ground. However, we have found that more snow accumulates beneath frameless modules due to the fact that the snow has shed more quickly and had less time to melt on the surface of the PV modules. Thus, frameless modules may accumulate snow to the point of preventing further sliding more quickly than framed modules. This occurred on our PV systems by January 30

Conclusion

When snow sliding is the primary mechanism for PV systems shedding snow, the presence of a PV module frame impedes snow sliding and thereby reduces energy production. The Sandia-led research team's goal is to characterize energy losses in snowy climates and make strides to reduce this energy loss. One clear method of reducing energy losses could be to install PV modules without frames, or with frames designed to aid snow shedding. However, system designs that facilitate snow shedding may also require additional ground clearance to allow for more snow accumulation at the foot of the PV modules.

[1] B. Marion, R. Schaefer, H. Caine, G. Sanchez, "Measured and modeled photovoltaic system energy losses from snow for Colorado and Wisconsin locations," in *Solar Energy*, vol. 97, pp. 112-121, 2013.

[2] D. Gun, G. Kimball, M. Anderson, "Dynamic Snow Loss Model and Validation," in *Proc. PVPMC 2018*, May 2018.

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