Snowstorms and blizzards: prevention and mitigation strategies of extreme snow loads

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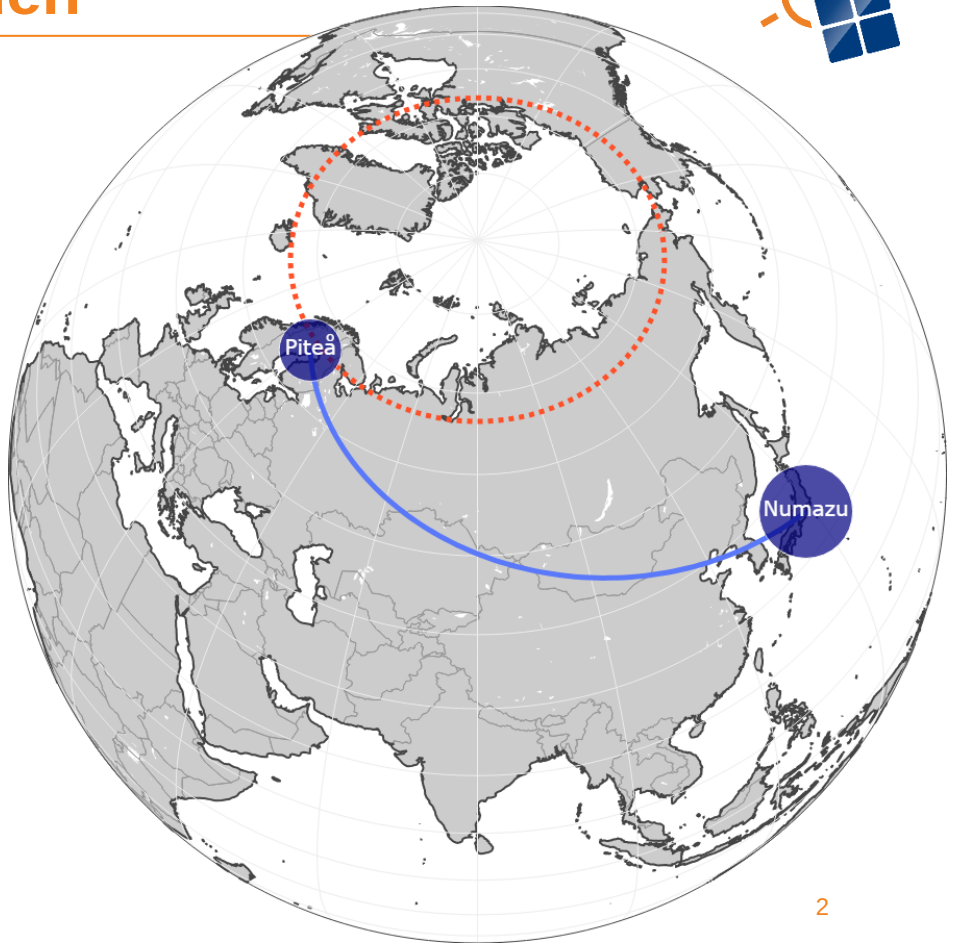


PVPS

Agenda

- Background
- Snow Characteristics
- Snow Accretion & Prevention
  - Typical
  - Extreme – Heavy snow fall
  - Extreme – Snow drifts
- Mitigation
- Key recommendations

Rooftop PV
[Piteå, SE]

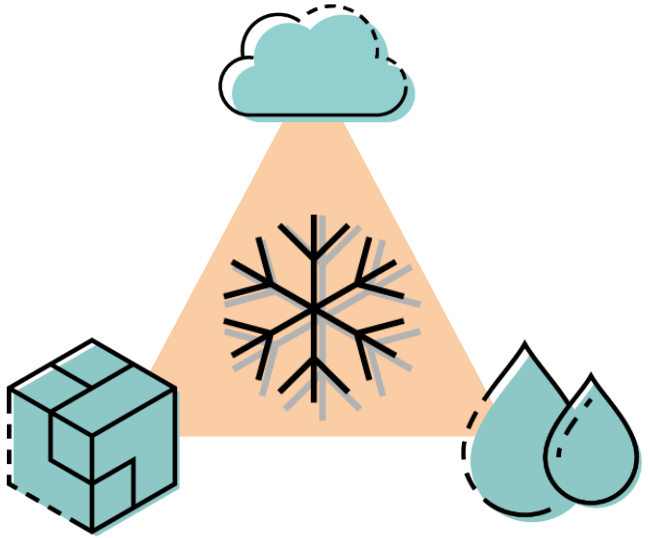
Background

- In the technological lifespan of a PV module, ~25 years, extreme weather is plausible
- Snow fall, behavior, and subsequent loads can vary greatly between regions
- Consequences can range from loss of electricity generation to catastrophic module damage

Snow covered rooftop PV
[Piteå, SE]

Snow characteristics

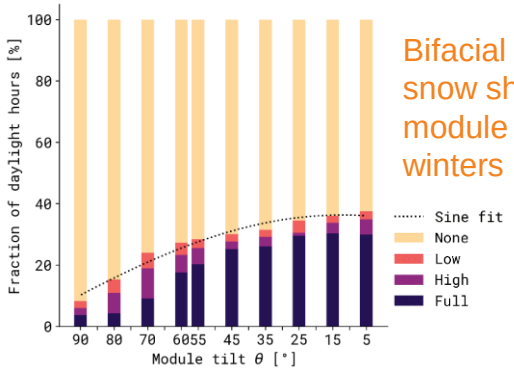
Snow is a substance consisting of ice, liquid water, and air, the relation between these affect snow's behavior



Type	Characteristic	Weather	Behavior
Wet snow	High liquid water content	Humid, near freezing temperatures	Solid-liquid adhesion, easily sinters to other snow, dense/heavy
Dry snow	Low liquid water content	Well below freezing, <-10°C	Solid-solid adhesion, does not easily sinter to other snow or surfaces, powdery

Typical snow accretion on PV

- Cause – snow sticking to module glass by friction or adhesion, or obstruction from frames or racking; frost might form on any cold surface and increase friction and snow accretion
- Consequences – partial or full coverage will cause losses in electricity production throughout the winter, annual losses can range up towards 30 % in some regions.
- Prevention – snow will melt or shed off as it gets warmer, facilitate this with steeper module tilt, frameless modules, or unobtrusive racking.



Bifacial installation and snow shading for different module tilts across two winters [Piteå, SE]

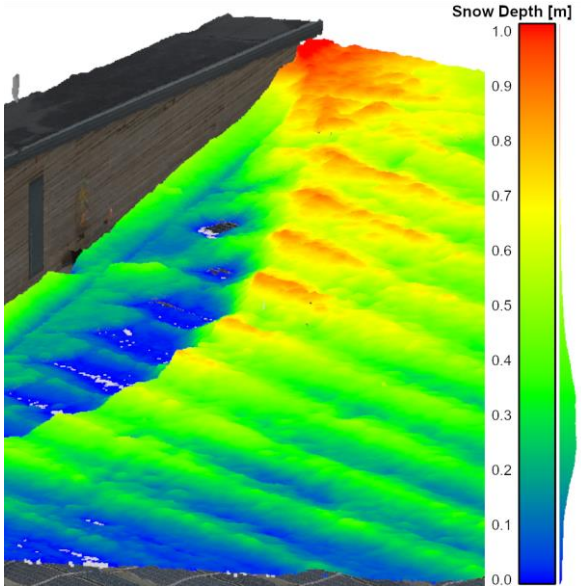
Extreme snow loads from snow fall

- Cause – large snow deposits unable to naturally disperse from modules, i.e. obstructions preventing snow shedding
- Weather – heavy snow fall in short time spans, most common with wet snow and near freezing temperatures
- Consequences – heavy snow loads surpassing module and racking thresholds, breaking cells, glass and/or frames
- Prevention – high quality components certified for heavy loads, proper clamping, short module sub-rows, increase height from ground

PV installation where snow cannot shed [Östersund, SE]

Extreme snow loads from snow drifts

- Cause – strong winds eroding snowpacks and transporting loose snow and depositing it in aerodynamic wakes
- Weather – windy (prevailing wind direction), dry snow, prolonged cold periods
- Prevention – distance from obstacles, increase gap from ground, reduce drag, build snow fence ahead of PV-array



Snow drift on rooftop-PV and broken modules [Piteå, SE]

Mitigation – Electrical heating

- Can be either forward biased modules or integrated/applied resistive heaters

Pros	Cons
Can be automated	Must have electricity
Can be used for dense installations	Can be costly or complex to implement
Can target specific weak points	Unknown long-term consequences of forward biasing

3-module sub-row with bottom module heated
[AIST, Shinjo, JP]

Mitigation – Mechanical removal

- Physically removing snow with hand tools or machinery

Pros	Cons
Non-electrical	Labor intensive - risky
Uses tried and tested conventional equipment	Careless use can cause damage
	Accessibility leads to less effective land use

Snow covered array [Alaska, USA]

Example of snow blower in use [ebertwelding.com]

Key recommendations

- Know your site
  - Expected amount of snow, precipitation types, risk of snow drifts
- Plan accordingly
  - Quality components, racking configuration, maintenance plan(s)
- Evaluate and adjust

Thank you!

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