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Sandia National Laboratories

Cold-Climate Field Laboratory Can Increase Photovoltaic System Performance & Reliability at Northern Latitudes

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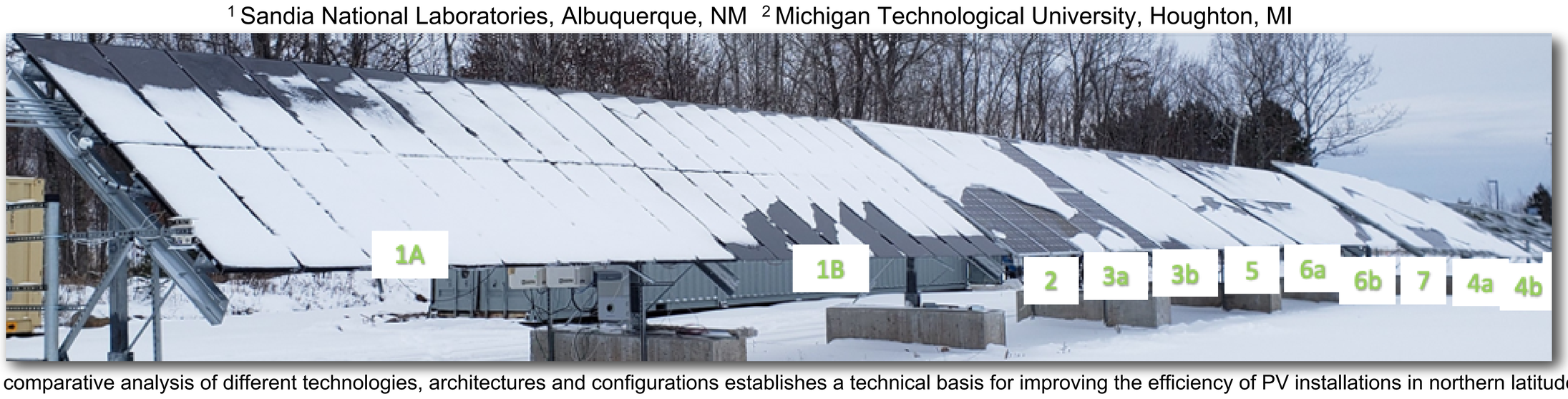
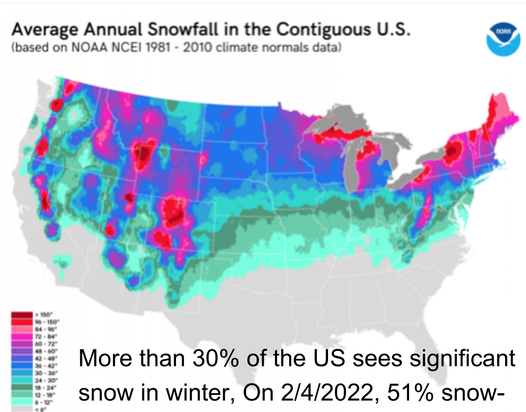


The comparative analysis of different technologies, architectures and configurations establishes a technical basis for improving the efficiency of PV installations in northern latitudes.

WHY PV NEEDS A COLD-WEATHER RESEARCH SITE

1. THE US HAS SIGNIFICANT SNOW



More than 30% of the US sees significant snow in winter, On 2/4/2022, 51% snow-covered. [1]

2. NEW CHALLENGES FACING THE PV INDUSTRY

- Frequency and severity of extreme winter weather is increasing
- Proliferating module and cell designs are untested under heavy snow, cold and wind loading is unknown
- Rapid growth of PV at northern latitudes intensifies impact of snow on energy yields: losses are significant but not well quantified
- Accelerated testing cannot capture the complexity and dynamic interactions of climatic stressors

3. VALUE TO SOLAR INDUSTRY

- High-fidelity instrumentation that includes snow depth and load sensors; also cameras to capture snow shading data.
- Infrastructure, including grid-tied open-racking to enable side-by-side performance comparisons of different technologies and module architectures.
- Framework and protocols to evaluate solar-cell loading under combined snow, cold and wind loading.
- Methods to measure energy losses attributable to partial snow shading.

4. RESEARCH OPPORTUNITIES

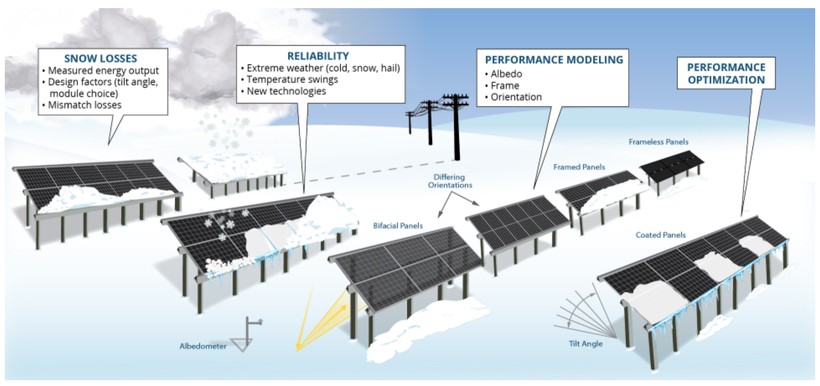
- Advanced snow-shedding models for mono- and bifacial PV systems
- Identification and validation of parameters that increase PV power plant efficiencies in winter
- Rigorous performance evaluations of emerging technologies in a harsh winter climate;
- Research to support new standards for snow/cold/wind loading, for more robust module designs and bills-of-materials.

Field sites with high-fidelity monitoring instrumentation provide real-world data needed to inform financial models and attract long-term equity capital, reduce insurance risk and make better technological and design choices matched to operating environment.

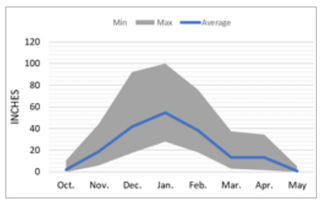
THE MICHIGAN REGIONAL TEST CENTER (RTC)

The MI RTC is the newest and most northern of the US DOE Regional Test Centers for Emerging Solar Technologies, a program started in 2012, to enable long-term, comparative, cross-climate studies of photovoltaic (PV) technologies.

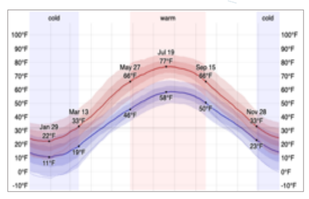
The five RTC sites have world-class meteorological instrumentation, high-fidelity monitoring and open racking for quick installations.



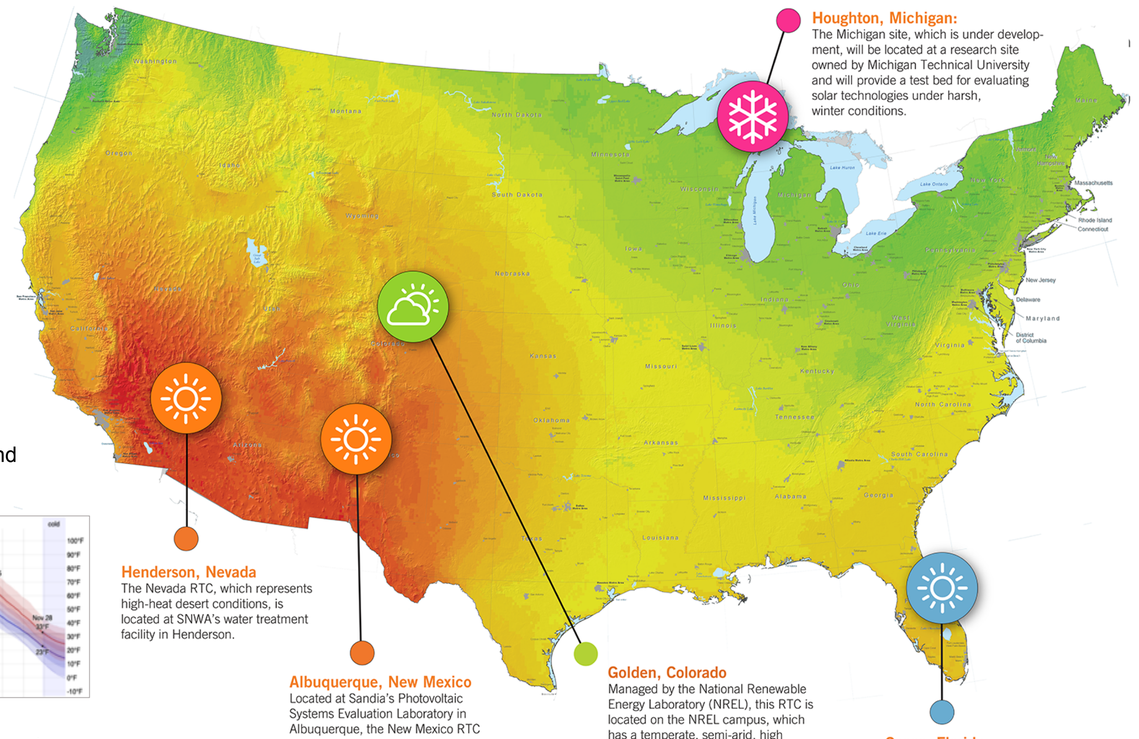
Located in Calumet, Michigan, he MI RTC is the most northern RTC site, located in Calumet, MI and operated by Michigan Technological University.



Average annual snowfall in Calumet is 183 inches, (48” for Boston; 52” for Mpls)



Average annual temperatures in Calumet, MI (high temp in red; low temps in blue),.

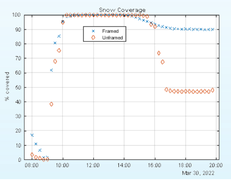


TECHNICAL CAPABILITIES AND FEATURES OF THE MI RTC

Meteorological Instrumentation
- Global Horizontal Irradiance (GHI)
- Direct Normal Irradiance (DNI)
- Diffuse Horizonal Irradiance (DHI)
- Plane-of-Array (POA) Irradianc
- Windspeed and direction
- Ambient tempera
- Barometric press
- Relative humidity

Site Infrastructure
- Grid-tied open-racking
- Simulated rooftop
- Reference PV

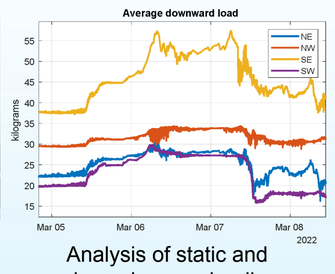
PV System Performance Monitoring
- DC current and voltage
- Back-of-module temperature
- POA irradiance
- Time-series visual images
- IV curve-tracing



Monitoring data for one winter shows that frameless modules shed snow 20% faster than framed modules

Time-series, snow, cold and wind load data…..

Reliability Monitoring
- Snow-load station
- EL imaging



Analysis of static and dynamic snow-loading on a PV module

[1] https://www.ncei.noaa.gov/access/monitoring/monthly-report/snow/202202.

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