Item 6.1.1: Weatherization of Wind and Solar Resources

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Reliability and Markets Committee Meeting

ERCOT Public
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Overview

- **Purpose**
  Provide information on practical limits of winter weatherization technologies associated with wind and solar generating resources

- **Voting Items / Requests**
  No action is requested of the R&M Committee or Board; for discussion only

- **Key Takeaways**
  - Many weatherization measures already exist for wind and solar
  - Some anti-icing or de-icing technologies used in other climates do not make practical sense in ERCOT because of the relative infrequency of icing events

Weatherization Measures for Wind and Solar

- COMMON TO WIND AND SOLAR
  - HVAC on control buildings, control cabinets, and inverters
  - Gas (SF6, N2) pressure in transformers and breakers
  - Seasonal preparation and training
  - Remote monitoring

- WIND
  - Gearbox oil heaters
  - Cold-weather grease and oil
  - Control algorithms

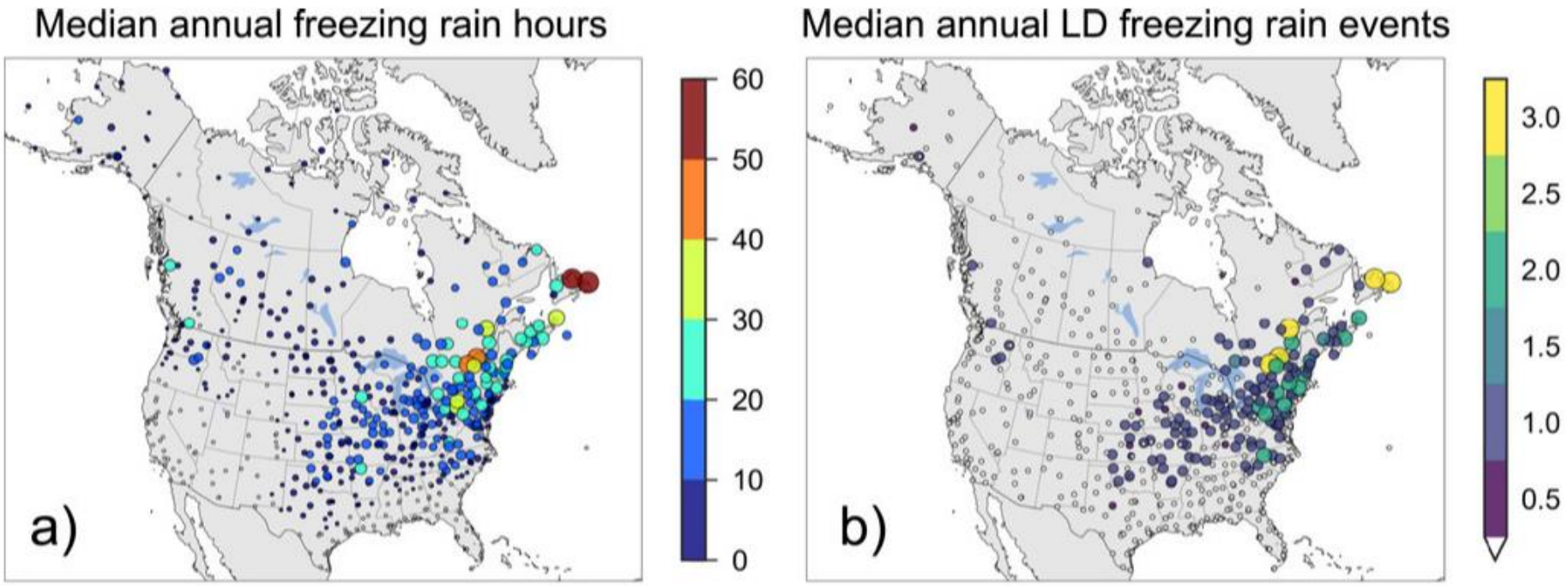
- SOLAR
  - For solar fields with tracking systems (97+% in ERCOT), store panels overnight during snow/ice in an inclined position instead of a horizontal position
  - For solar fields with personnel in reasonable proximity, snow brushes can be used to accelerate removal

Other Cold Weather Technologies for Wind Turbines (not necessarily ice)

- CURRENTLY AVAILABLE ON NEW TURBINES
  - Heated electrical components, cold weather grease and oil
  - Controls to limit blade pitch and turbine yaw
  - Higher ductility steel for tower structures
  - Automated heater activation, automatic shutdown
  - Gearbox oil and hydraulic system heaters
  - Nacelle heaters

- RETROFIT OPTIONS FOR EXISTING TURBINES
  - Replacing tower structures is infeasible, unless at end of life and even then foundations will likely require modification/rebuild
  - Replacing blades or generator nacelles infeasible
  - Nacelle and equipment heaters may have reasonable ROI
  - Control software modifications can be beneficial

Freezing Rain Occurs in Texas at a Low Frequency*

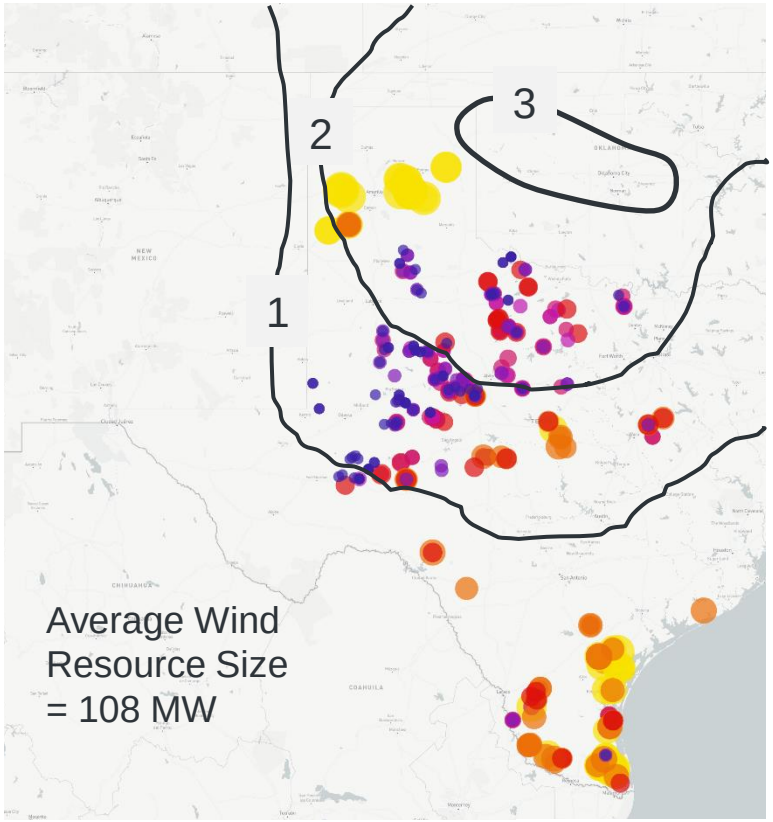


- Texas does see freezing rain events but at a relatively low frequency
- Long Duration (LD, ≥ 6 hours) freezing rain events are even more rare

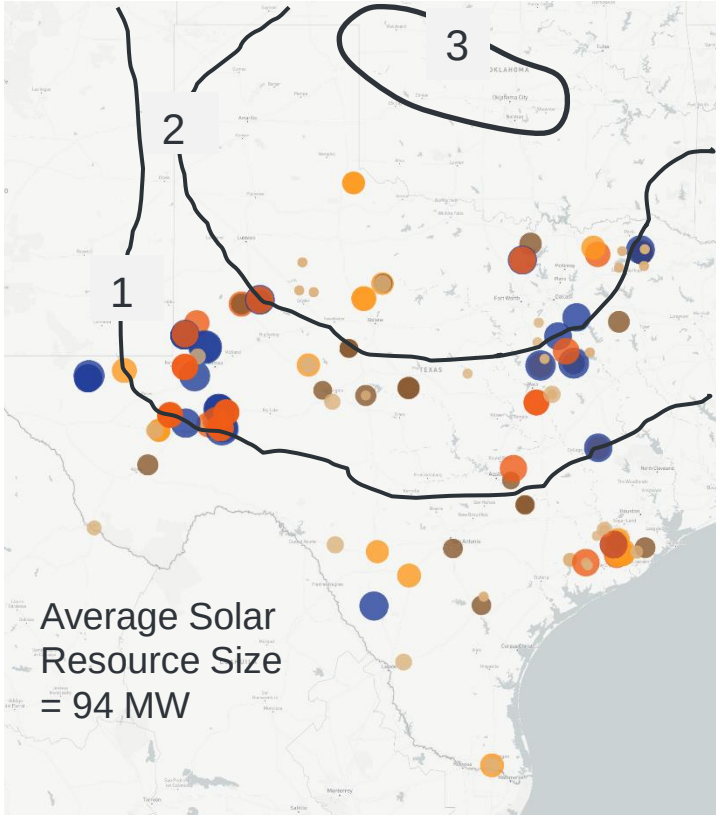
*American Meteorological Society article “Long-Duration Freezing Rain Events over North America: Regional Climatology and Thermodynamic Evolution”, McCray, Atallah & Gyakum, 10 Jun 2019 (1979-2016)

Annual Average Days* of Freezing Rain in Texas

Wind Resources



Solar Resources



- All of the Wind and Solar Generation Resources currently in ERCOT will generally see an average of less than three days each year with freezing rain

*(1948-2000)

Citation: Journal of Applied Meteorology 42, 9; 10.1175/1520-0450(2003)042<1302:TASVOF>2.0.CO;2

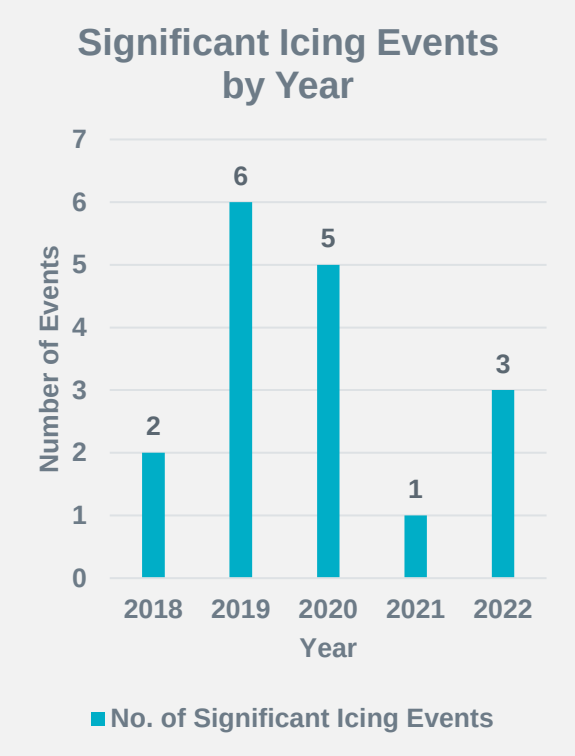
Ice Mitigation Technologies for Wind Turbine Blades

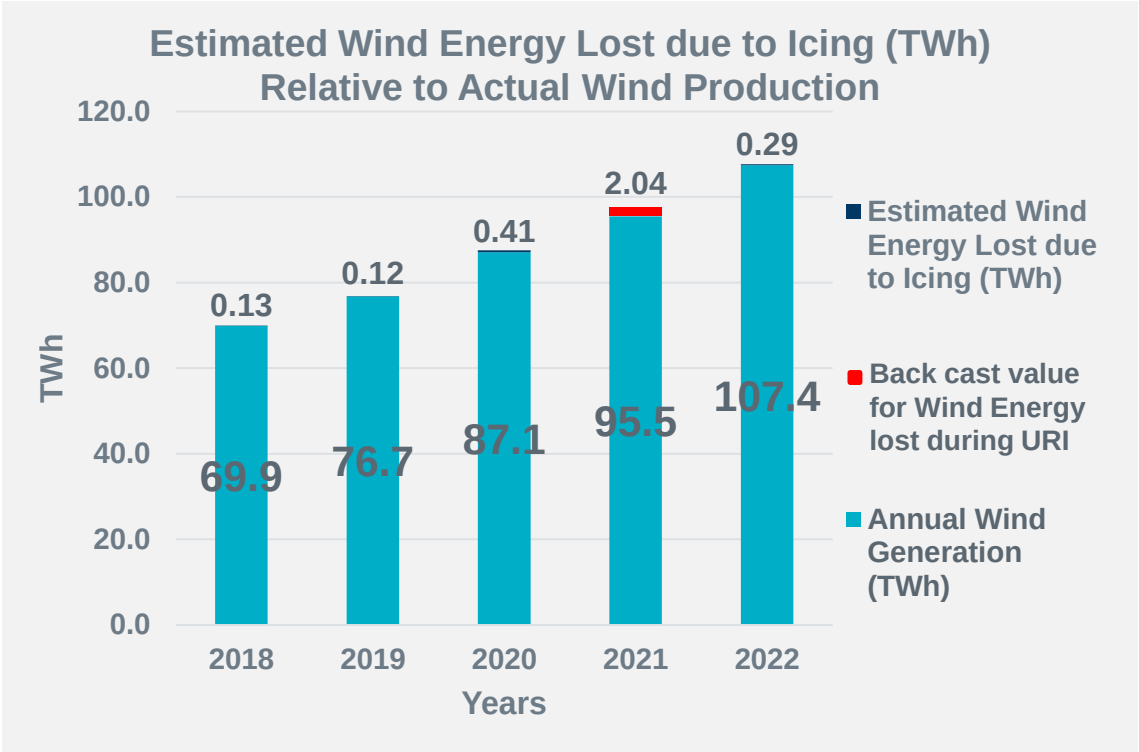
- CURRENTLY AVAILABLE ON NEW TURBINES
  - Blade heating via embedded electro-thermal heating elements
  - Blade heating via hot air circulation within blade
  - Passive icephobic coatings
  - Remote monitoring

- ECONOMICS
  - Cost/benefit analyses do not favor heat-based ice mitigation in Texas due to low icing frequency
  - Control algorithms to assure acceptable operating conditions likely make sense across the board

- OTHER
  - Using ethylene or propylene glycol solutions to de-ice turbine blades as done on airplane wings is infeasible due to difficulty of application, fluid capture, environmental concerns, and toxicity

Wind Generation and Lost Wind Energy due to Icing

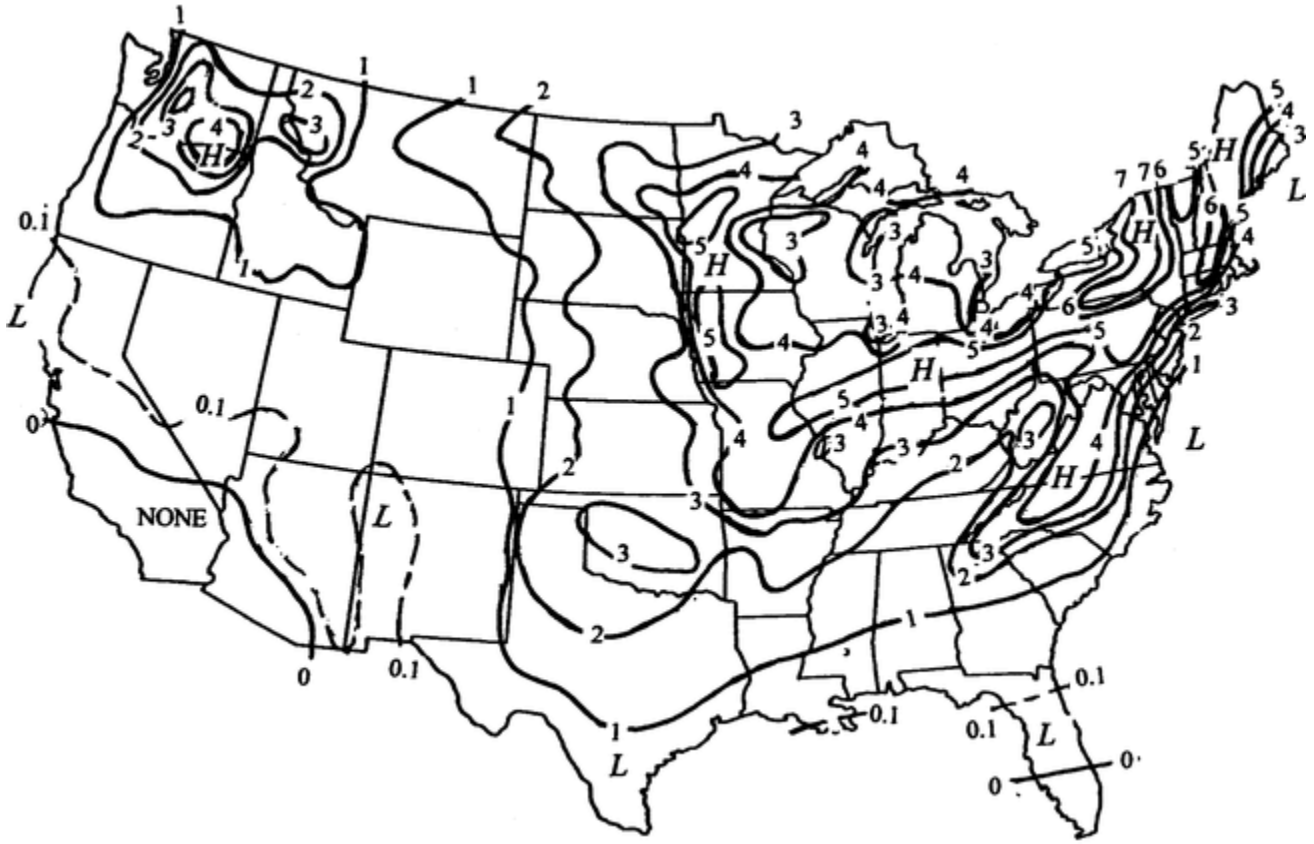




- Estimates for wind energy lost due to icing for all years except 2021 utilize the Effective Load Carrying Capability value of 0.34 for Wind in the Panhandle
- Estimated wind energy lost in 2021 is the back cast value calculated after Winter Storm Uri
- As estimated, the average wind energy lost due to icing over the last five years is approximately 0.64% of the potential wind energy that could have been generated; excluding 2021 that value is 0.27%

Appendix

Average Annual Days with Freezing Rain, 1948-2000



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