Thermal Energy System Resilience: Thermal Decay Test (TDT) in Cold/Arctic Climates, Methodology & Results

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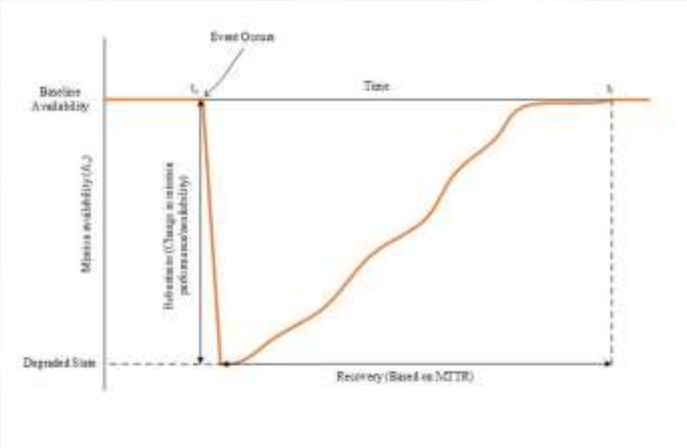
Background: What is Resilience?

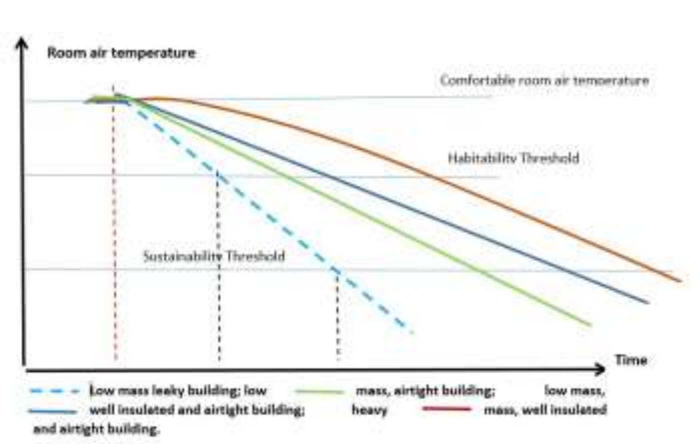
Resilient energy systems are those that can prepare for and adapt to changing conditions, and recover rapidly from disruptions including deliberate attacks, accidents, and naturally occurring threats.

Robustness Recovery Time Availability Quality

Maximum Allowable Downtime



System response to a disruptive event



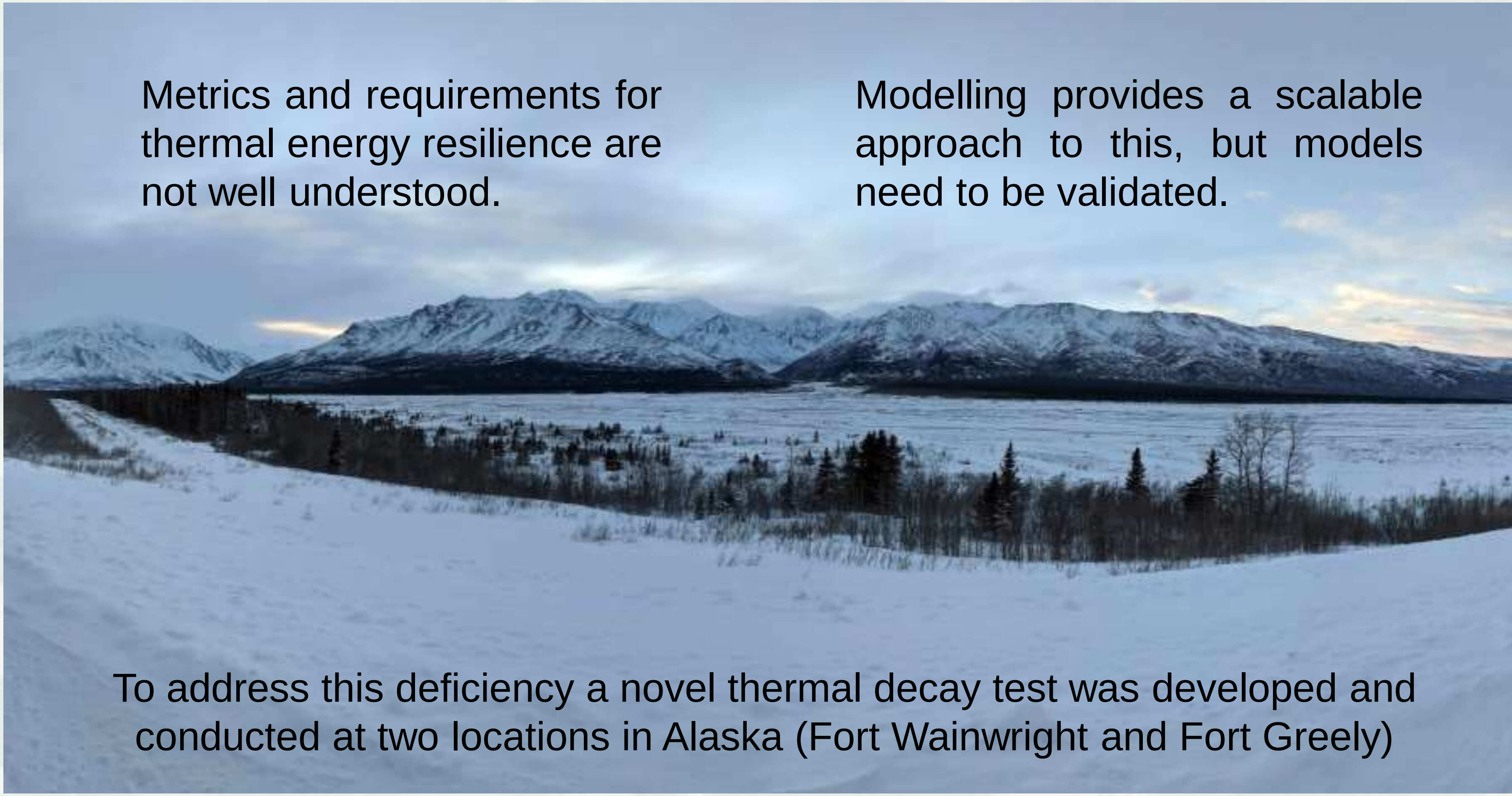
Building envelope design affects rate of thermal decay

Major Factors Influencing Maximum Allowable Downtime:

- Difference between interior and exterior temperatures
- Building envelope air leakage rate
- Building envelope insulation properties
- Internal thermal loads

Additionally, the thermal mass of the building structures enables the building to absorb and store heat, providing a thermal “inertia” against thermal fluctuations.

Can Maximum Allowable Downtime be Predicted?



Metrics and requirements for thermal energy resilience are not well understood.

Modelling provides a scalable approach to this, but models need to be validated.

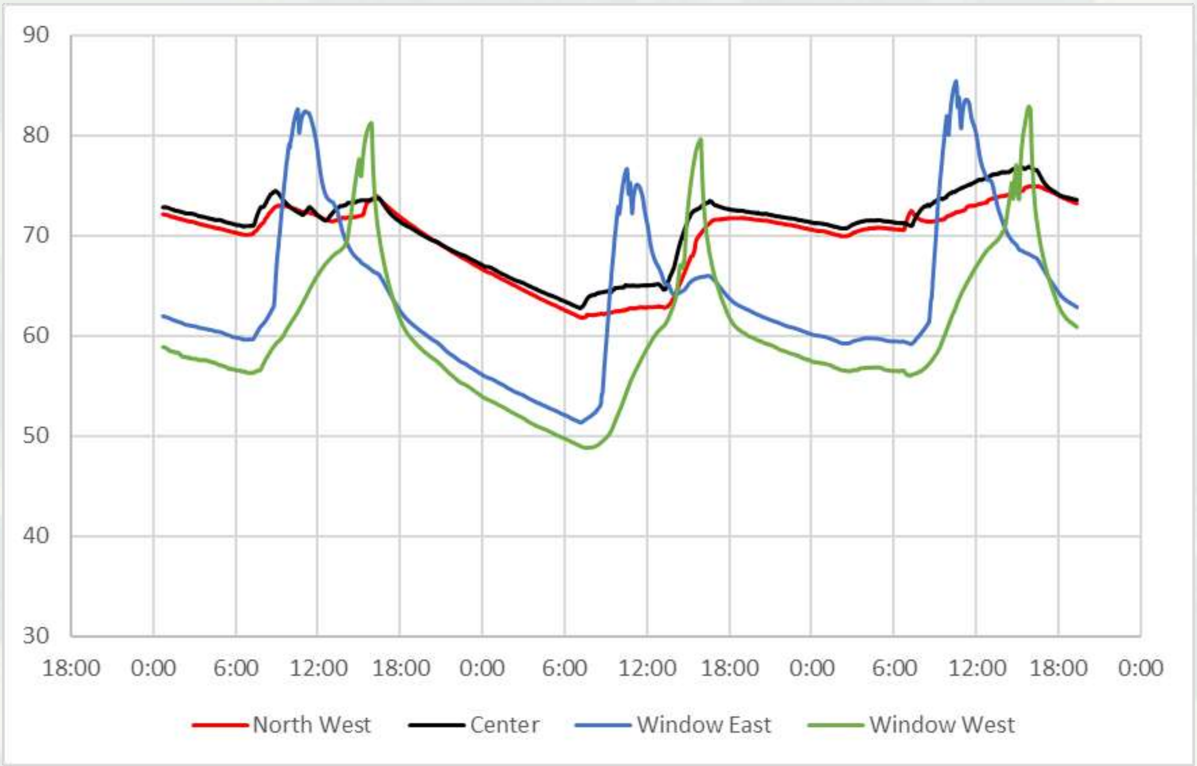
To address this deficiency a novel thermal decay test was developed and conducted at two locations in Alaska (Fort Wainwright and Fort Greely)

Temperature Decay Test: Methodology

Buildings were instrumented with temperature and relative humidity sensors. Weather stations were used to obtain exterior temperatures and wind conditions.

Researchers monitored buildings every 2 hours until the critical temperature threshold was met.

Temperature Decay Test: Results



Building Type: Plans Vault

Era of Construction: 1990's

Date Tested: 26 Feb

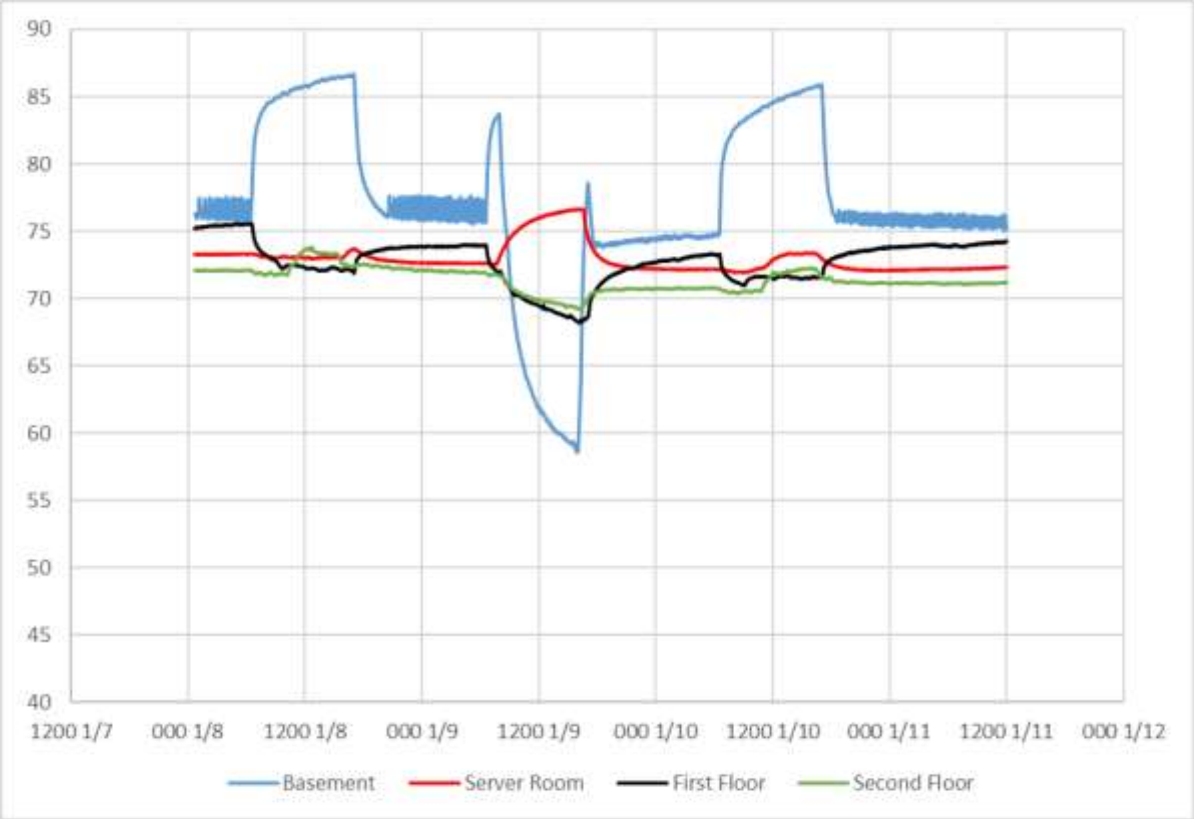
Exterior Temperature: -20°F

Wind: 0 MPH

Test Duration: 29 hours

Heat gained from solar radiation and residual heat in the buildings glycol heating system provided extended operation time, with most rooms not exceeding the habitable threshold.

Temperature Decay Test: Results



Building Type: Laboratory

Era of Construction: 1950's

Date Tested: 09 Jan

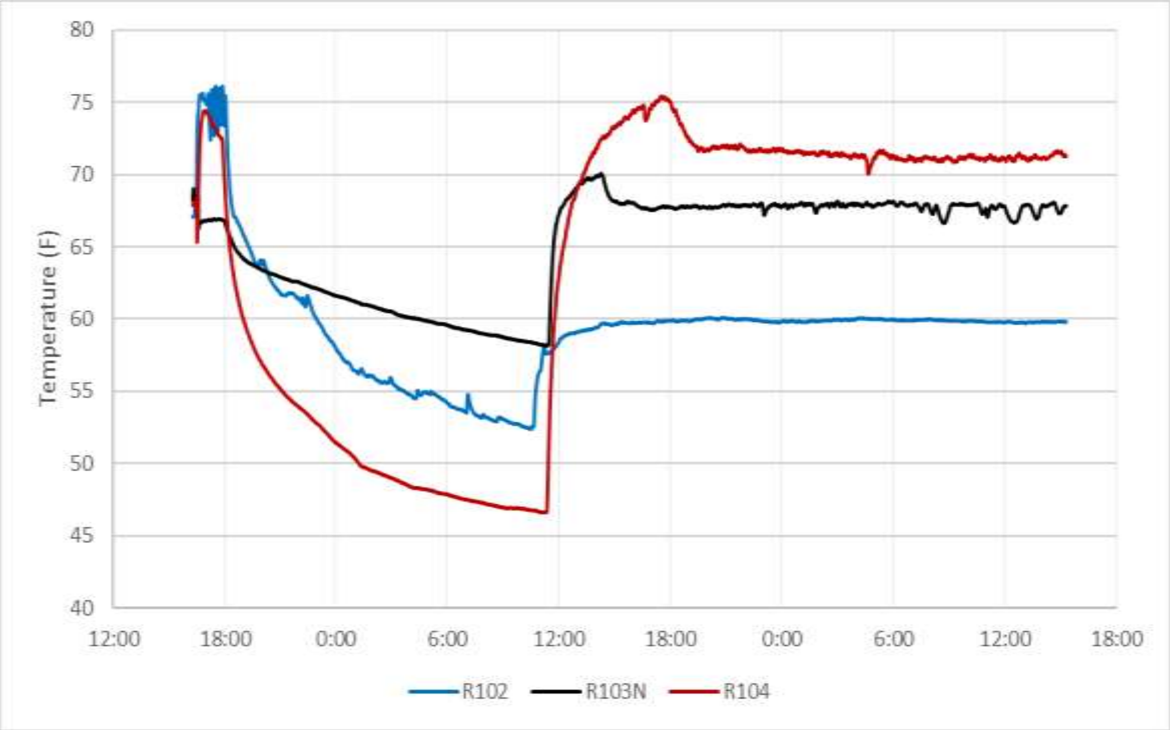
Exterior Temperature: -40°F

Wind: 0 MPH

Test Duration: 8 hours

Rate of decay was distributed somewhat as expected from floor to floor. The basement had a large fenestration area, causing a more extreme rate of decay. Internal loads can significantly impact isolated rooms within the building.

Temperature Decay Test: Results



Building Type: DPW Office

Era of Construction: 1950’s

Date Tested: 18 Jan

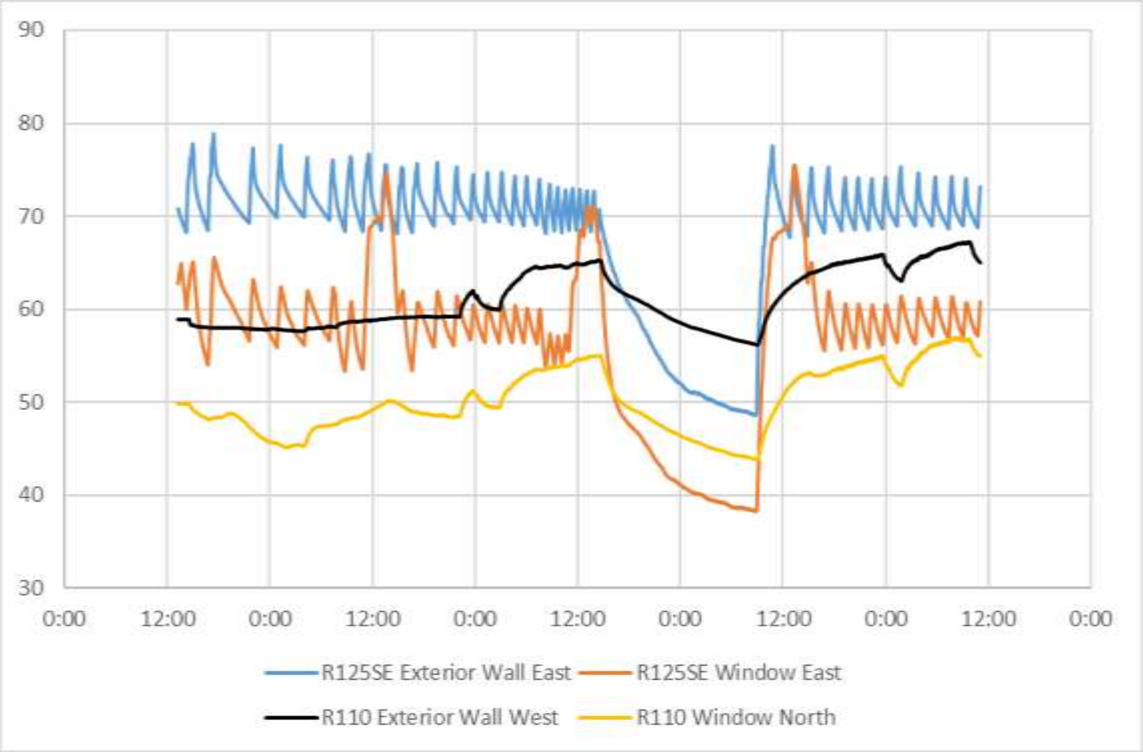
Exterior Temperature: -9°F

Wind: 62 MPH, East

Test Duration: 17 hours

Different building materials were shown to store and retain heat better than others.

Temperature Decay Test: Results



Building Type: MWR Building

Era of Construction: 1950's

Date Tested: 18 Jan

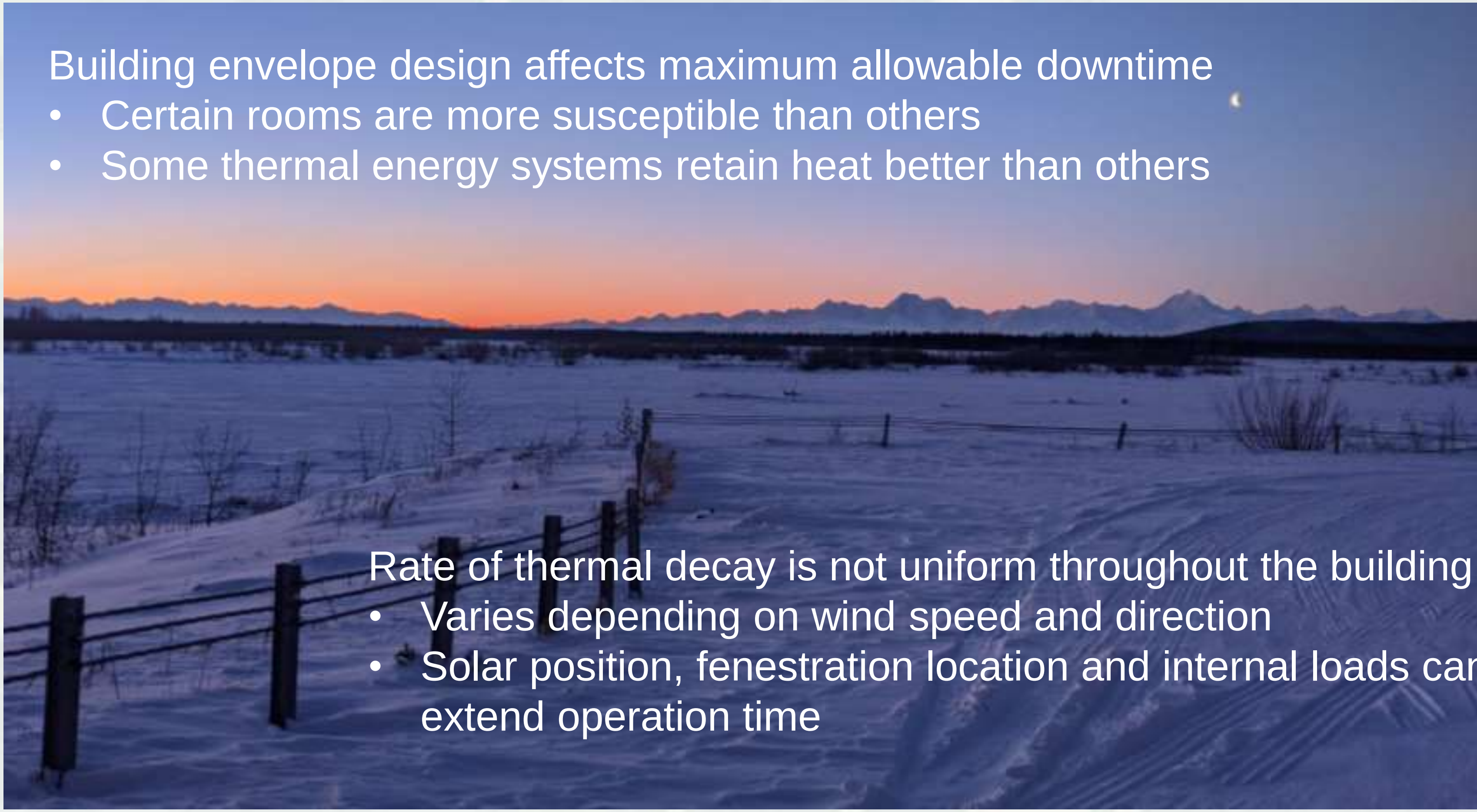
Exterior Temperature: -9°F

Wind: 62 MPH, East

Test Duration: 17 hours

Wind had a significant effect on sections of the buildings that were exposed.

Conclusions



Building envelope design affects maximum allowable downtime

- Certain rooms are more susceptible than others
- Some thermal energy systems retain heat better than others

Rate of thermal decay is not uniform throughout the building

- Varies depending on wind speed and direction
- Solar position, fenestration location and internal loads can extend operation time

Discussion