INDOOR AIR QUALITY AND COMFORT IN NATIVE AMERICAN SHELTERS

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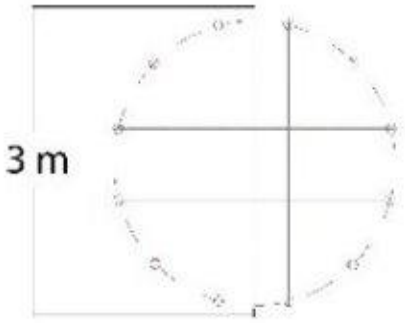
- Constructed by the Algonquian tribes
- Pervasive in the Northeast and wherever tree branches were abundant.

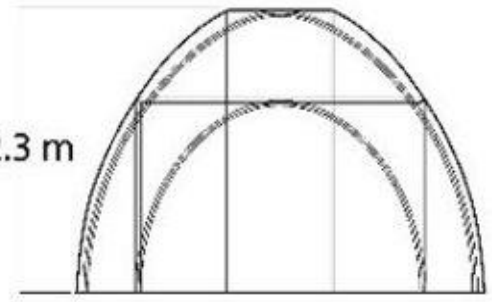
History of the Wigwam

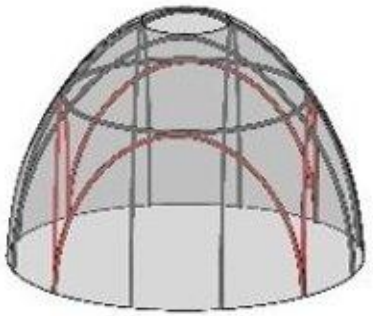
- Historical purpose of a wigwam varied
- An efficient shelter
- Temporary or semi-permanent residency.
- Built on hunting and fishing grounds
- Lodge during seasonal farming months
- Used to smoke meats
- Housed generational families

- Structural pieces left behind
- Coverings taken
- Upon returning, coverings reassembled on the frame

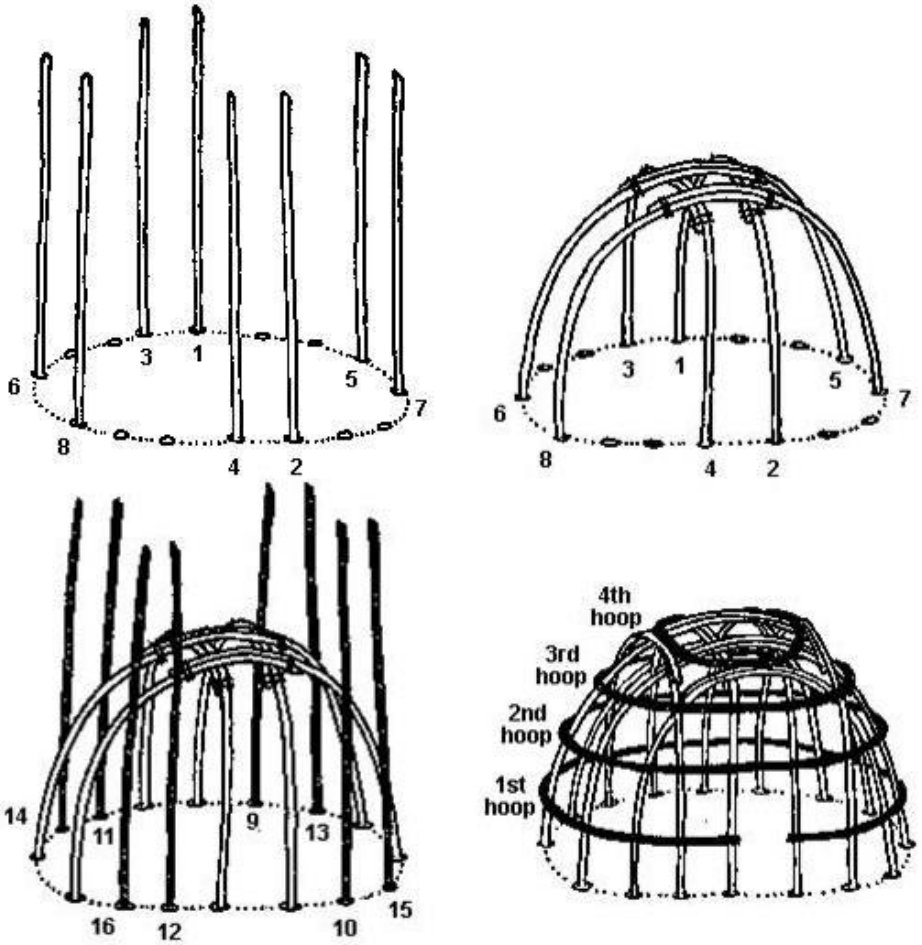
- 2-3m tall and 3-4m in diameter
- Select a relatively level and stable site
- Young tree saplings gathered
- Cut to 3-5m long
- Imperfections removed





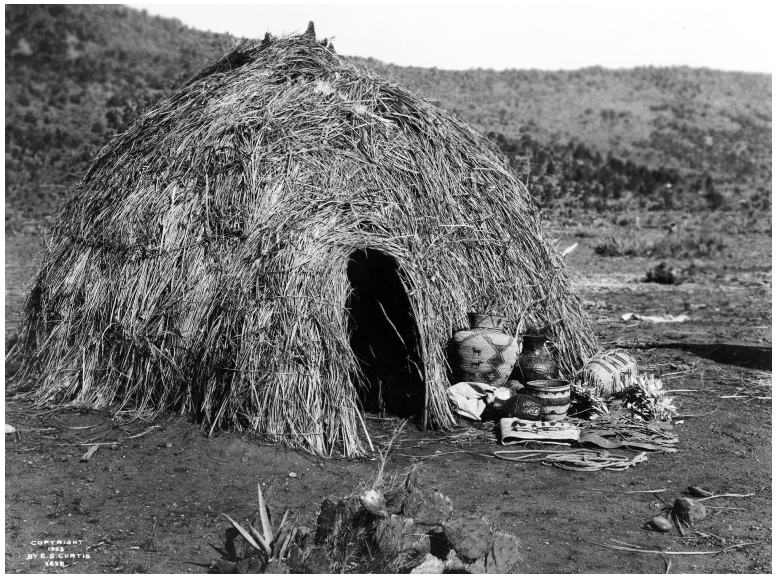


- Outline of a circle traced where the sapling poles will go
- 12 - 16 holes plotted around the circumference
- Tobacco added first to repel ground insects and for ritual purposes
- Saplings bent into arches
- Bark fibers used to tie together saplings
- Sapling bands layered to encircle the mainframe
- Lower bands remain unconnected on East side



History of the Wigwam

- Coverings added to guarantee a watertight seal over the frame.
- Hole at the top left to allow smoke to escape



Woven rush coverings in the Summer

Birchbark coverings in the Winter

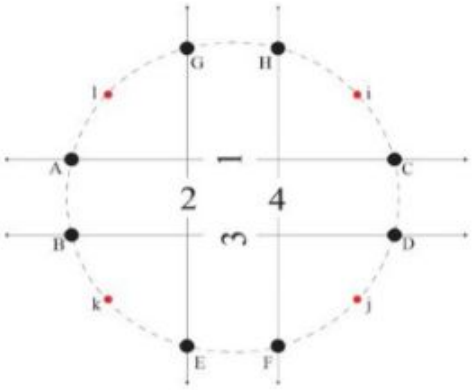
- Determine if these structures supply comfort and safe air quality levels
- Built a full-size example of a wigwam
- Monitor data indoors and outdoors
- Fire introduced for comfortable indoor temperatures
- Analysis of air temperature, relative humidity, CO2,
  VOC, PM2.5 levels, determined indoor air quality and comfort

Project Objectives

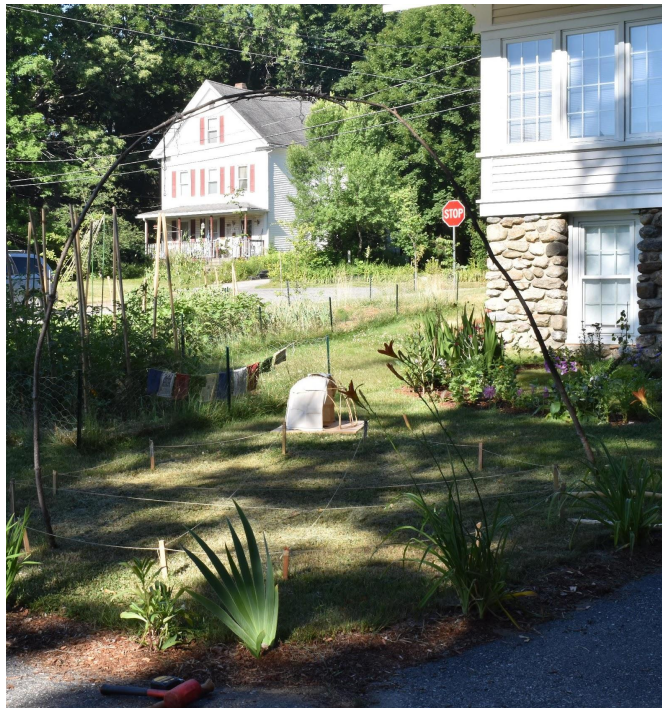
- Health complications associated with the unhealthy level of exposure
- Harmful particulate matter originated from burning biomass with only a small opening to release smoke

- Assess the existing functionality of the traditional wigwam
- Compared our full-sized wigwam to an identical digital version
- Adjusted the properties of the virtual model
- Results congruous to existing westernized standards

Project Objectives



- Wigwam prototype constructed first
- Human scale version constructed during the summer of 2022, in Winchendon, Massachusetts.
  - Flat piece of earth scouted
  - Proposed holes mapped on the ground
  - Eight long poles for the mainframe, each 4m long and 2cm-3cm in diameter
  - Holes dug 3cm in diameter and 20cm-30 cm deep



Construction of the Wigwam

- 8 poles situated in the holes
- Poles bent into arches connecting to the opposite facing pole
- Adjoined together in the middle at the highest point of the curve
- Crossings attached together using string

Construction of the Wigwam

- Biodegradable heavy weight cotton canvas used as "skin"
- Shaped and cut to specific shapes to ensure airtight overlapping.
- Needle and thread used to secure the canvas
- Space delegated to include a flap for the doorway
- A hole at the top was left uncovered to allow smoke to escape

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Construction of the Wigwam

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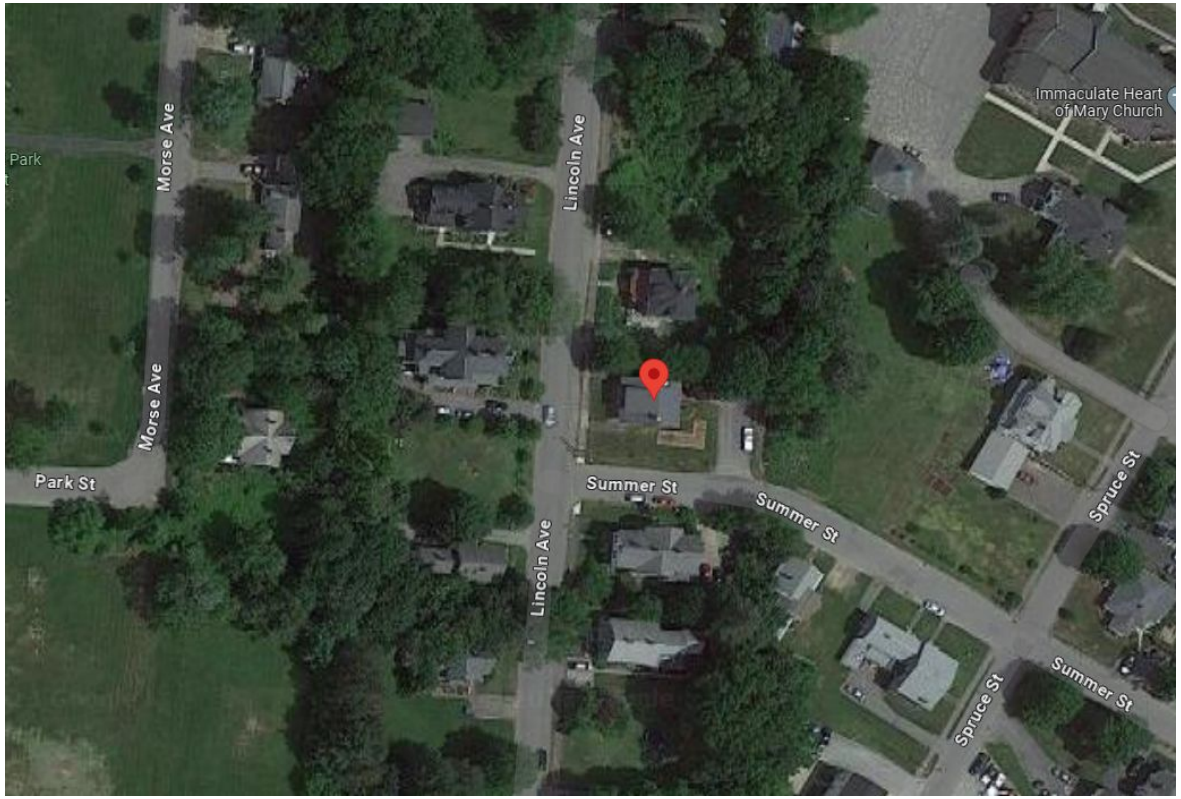

Location and Surrounding Site

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Digital Recreation of the Immediate Site

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Photos of the Finished Wigwam

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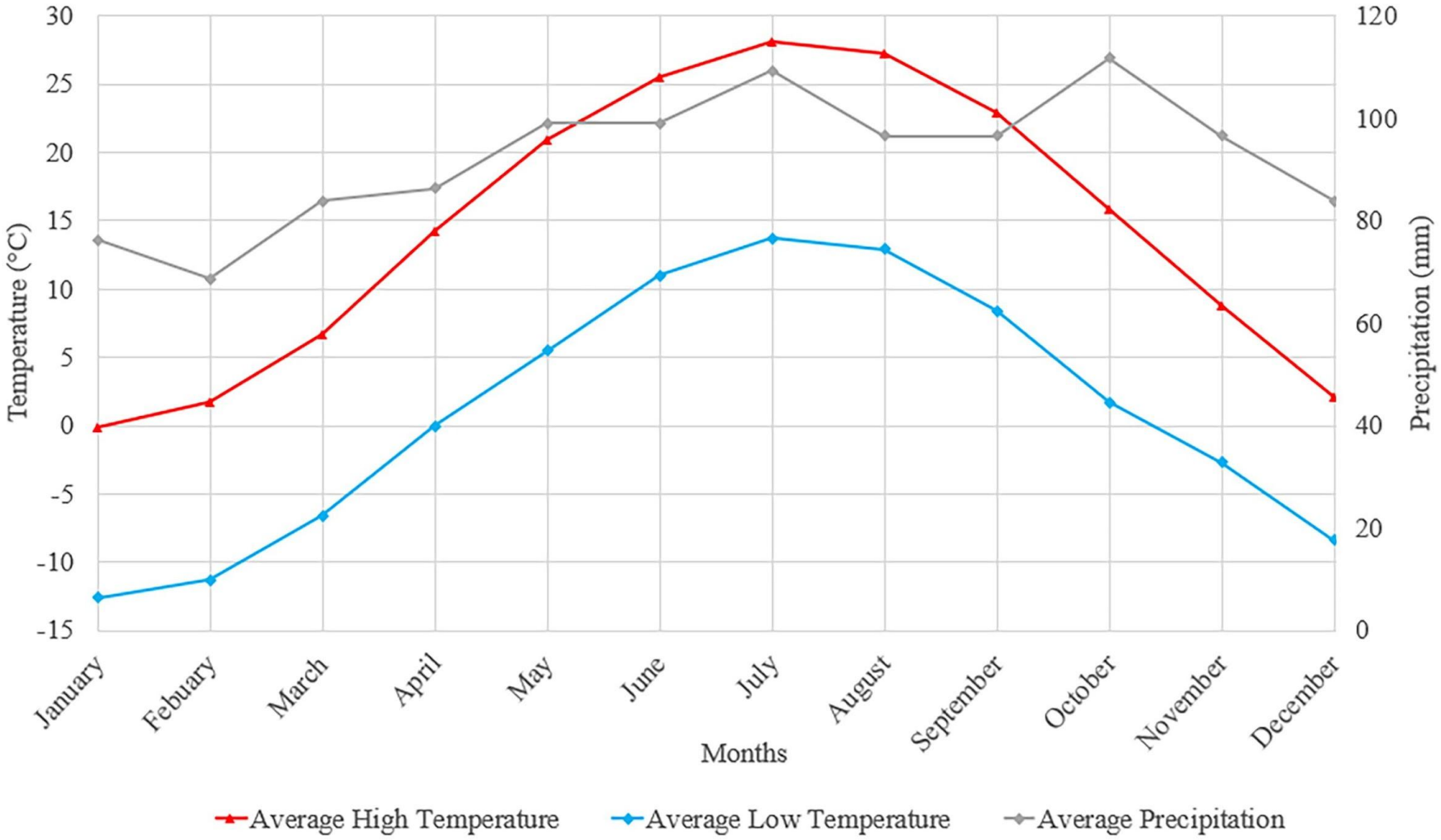

Average Monthly Temperature and Precipitation

AWAIR

Measures indoor air quality of the wigwam

Also records relative humidity, , CO_2, $PM_{2.5}$ (Particulate matter under 2.5 micrometres) and VOC (Volatile organic compound)

ELITECH RC – 51

USB temperature and humidity logger

Located within the Wigwam's canvas skin

Collects indoor relative humidity and temperature every 5 mins

Heat Sources

Materials

Conduct: 0.084 W/mK
Color: Light tan
Thickness: 0.0013 m
Specific Heat: 1620 J/kgK

Open Fire

Wood Stove

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Components of the Wigwam

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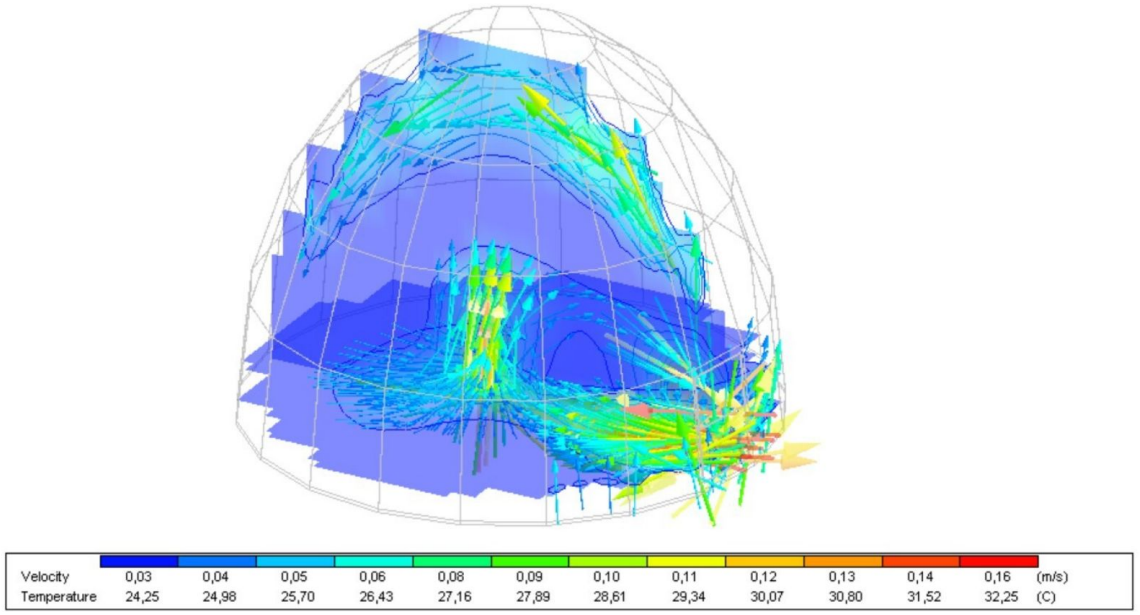
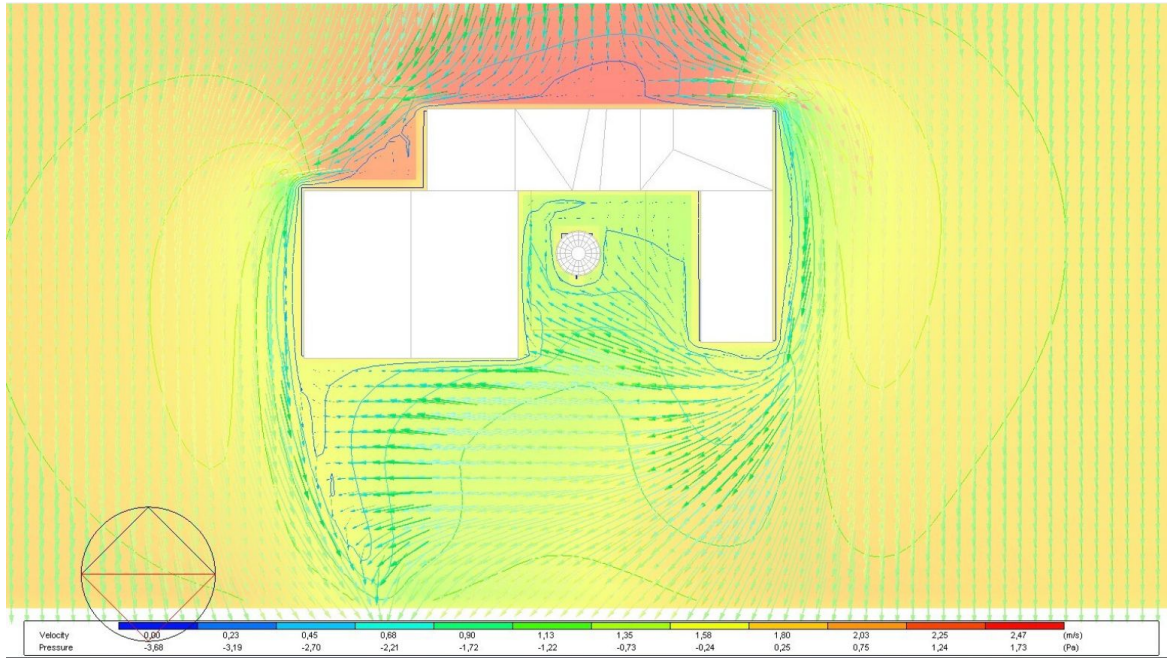


Design Builder
Energy+



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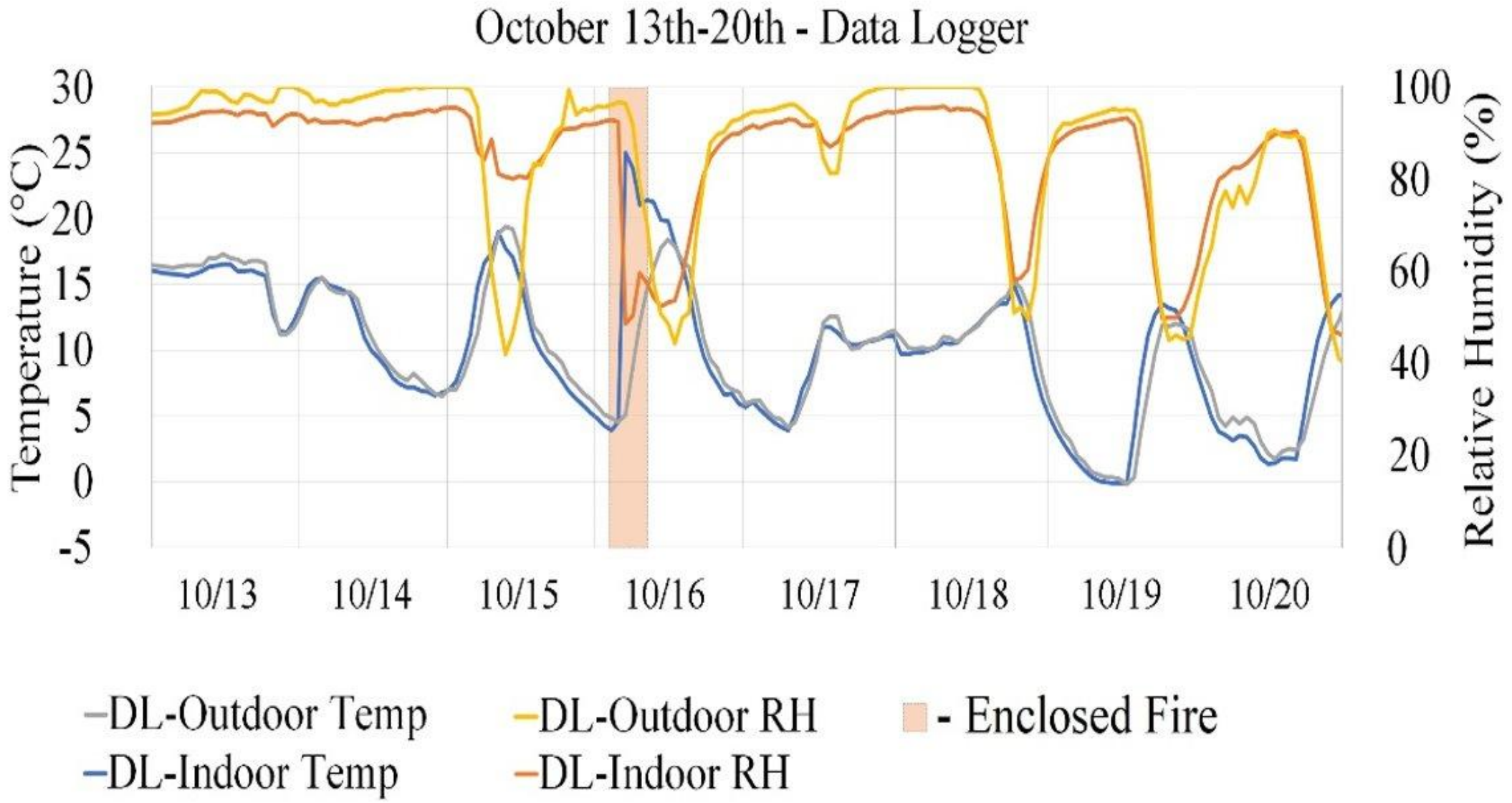
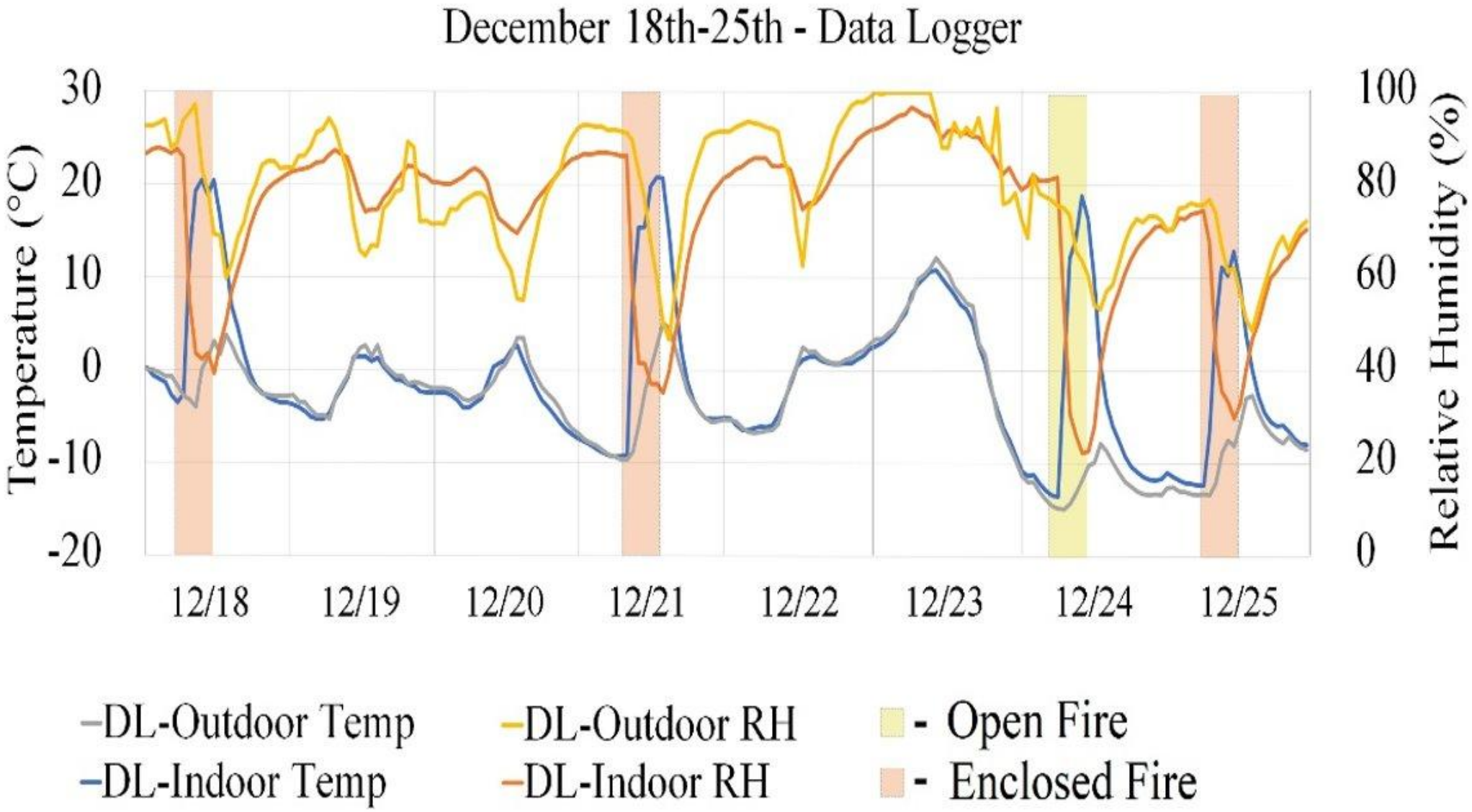
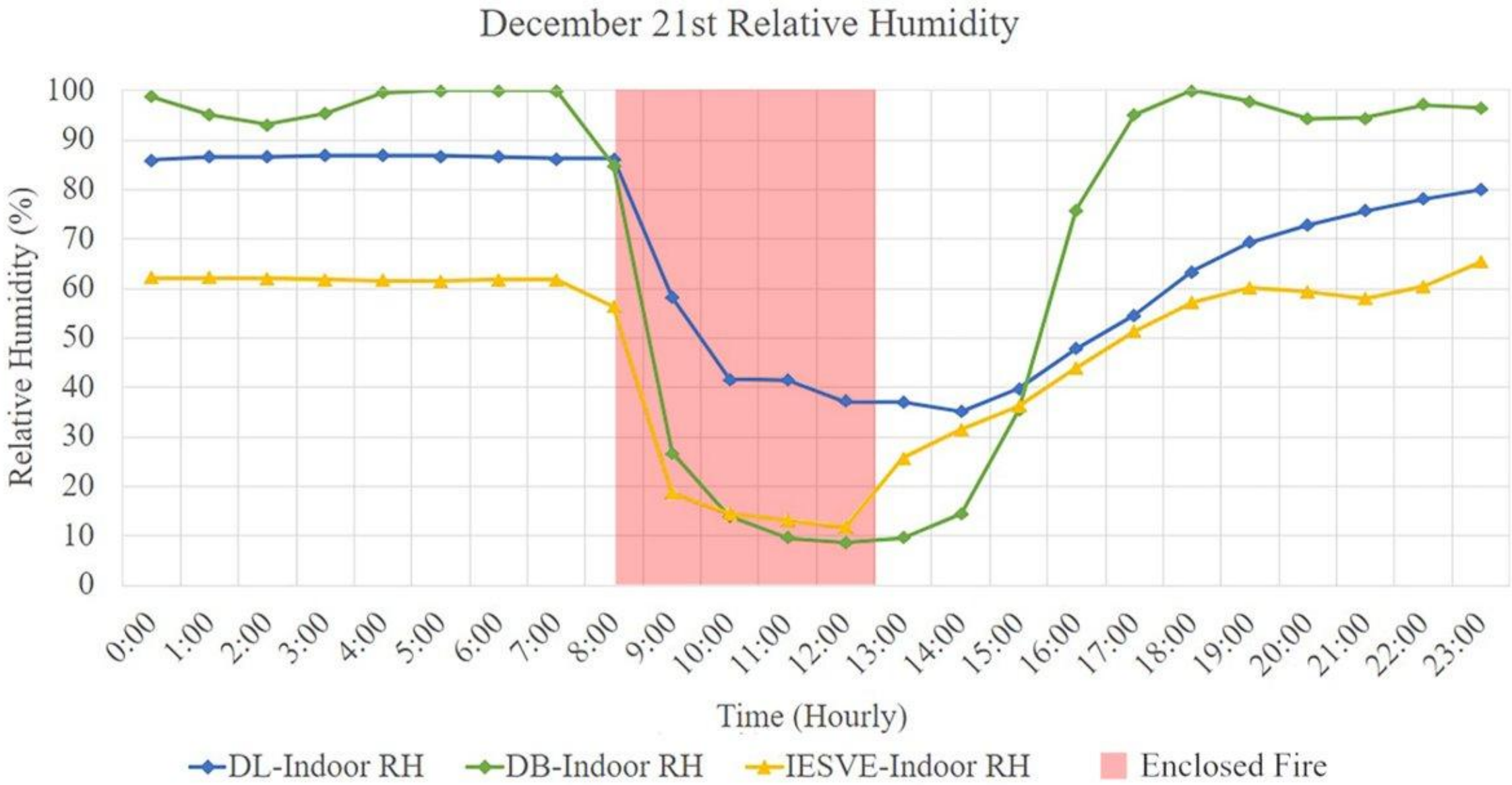
APACHE



Measured Results - Data Logger



Measured Results - Data Logger



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Measured Results - Data Logger vs Simulations

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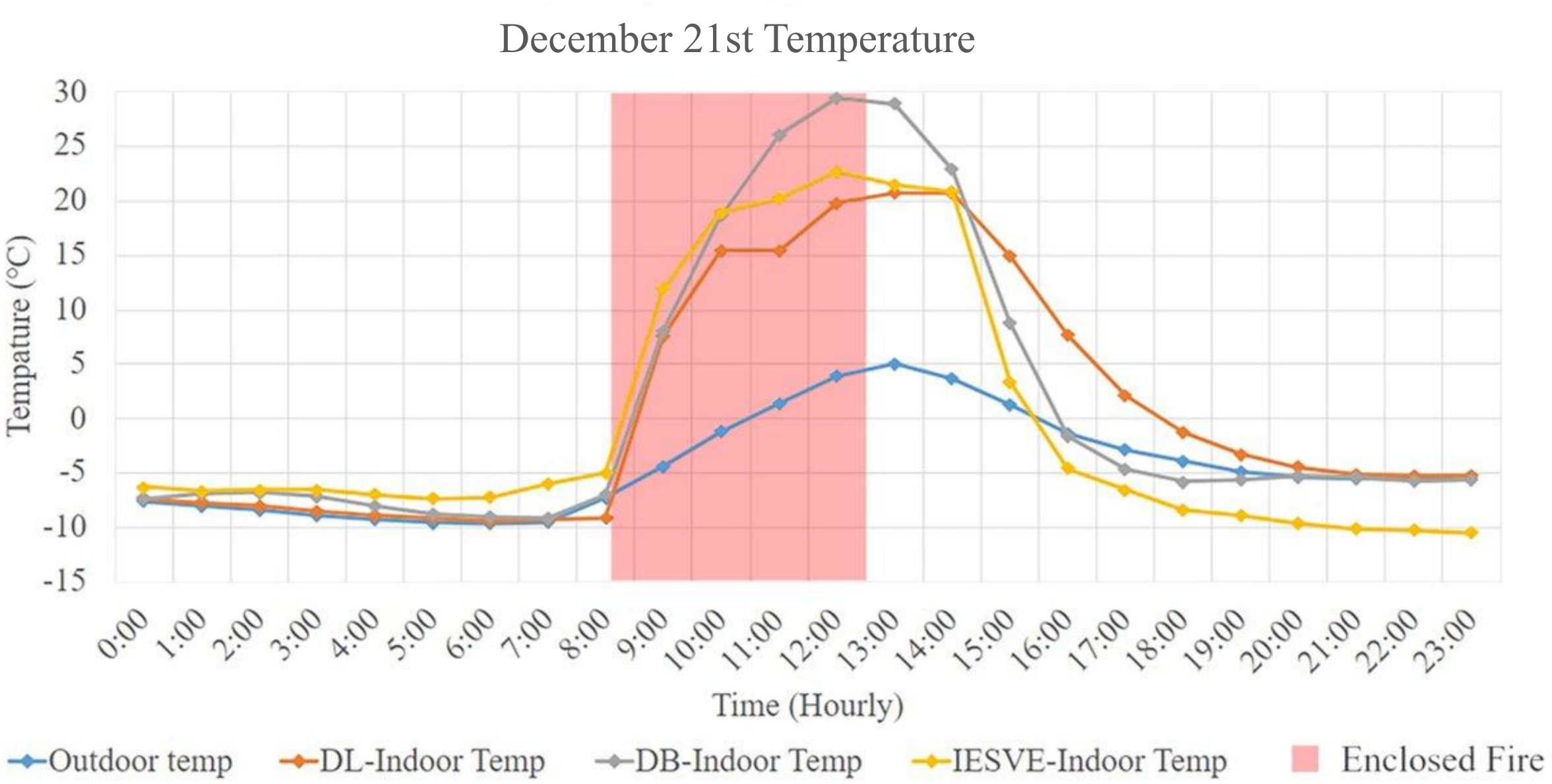
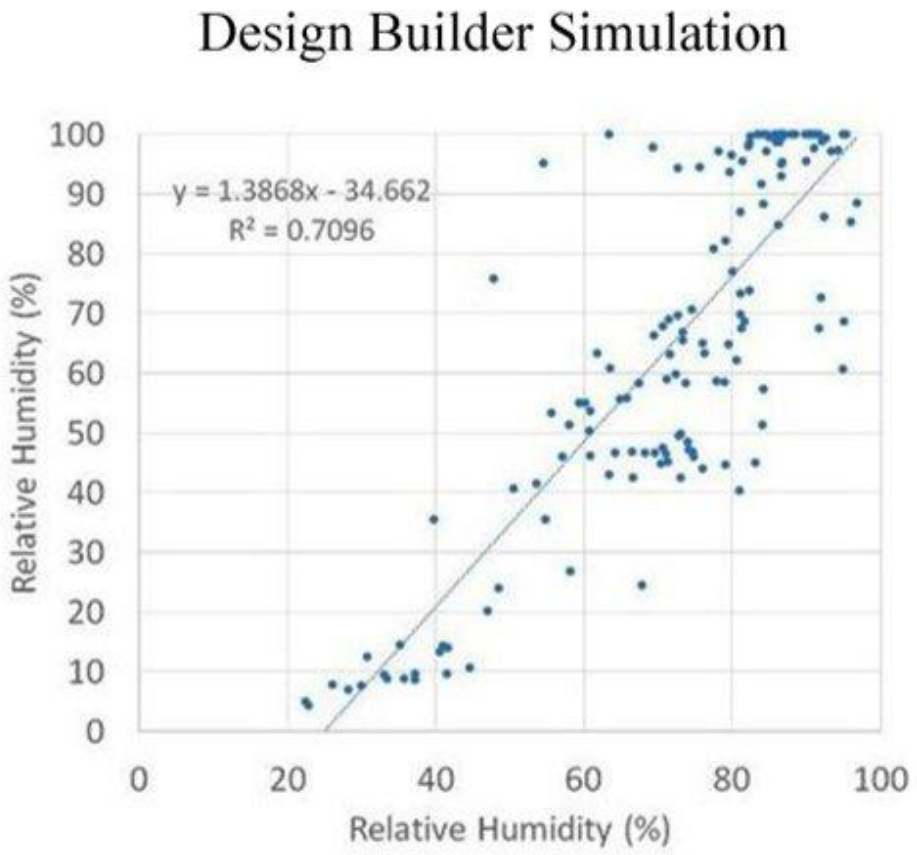
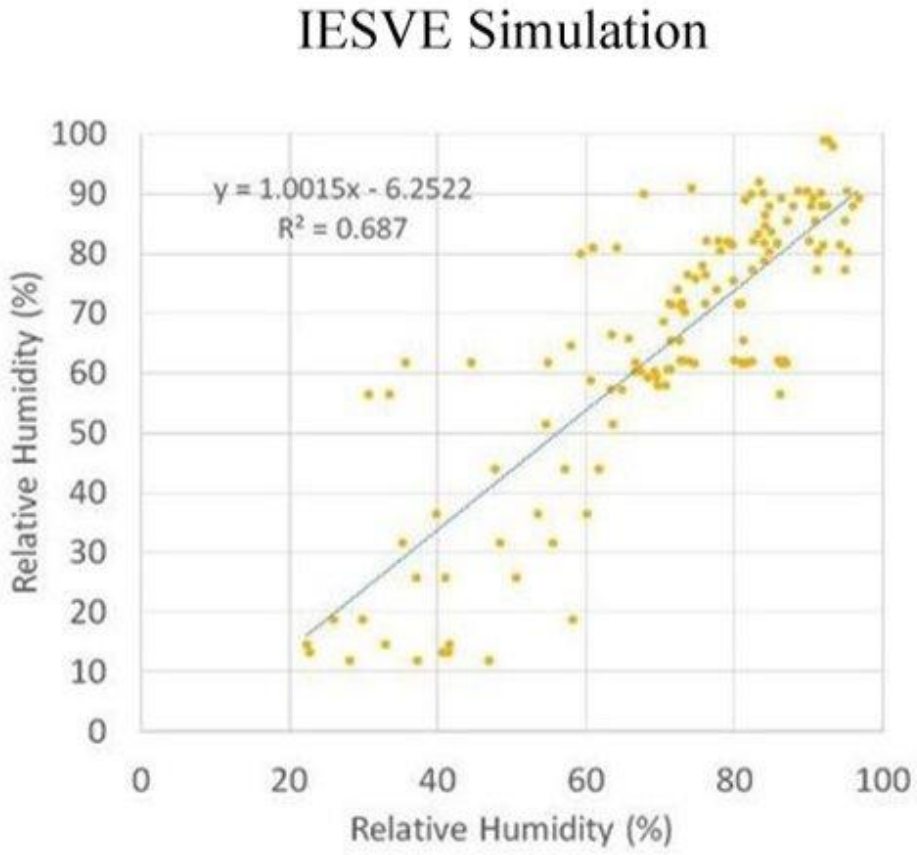
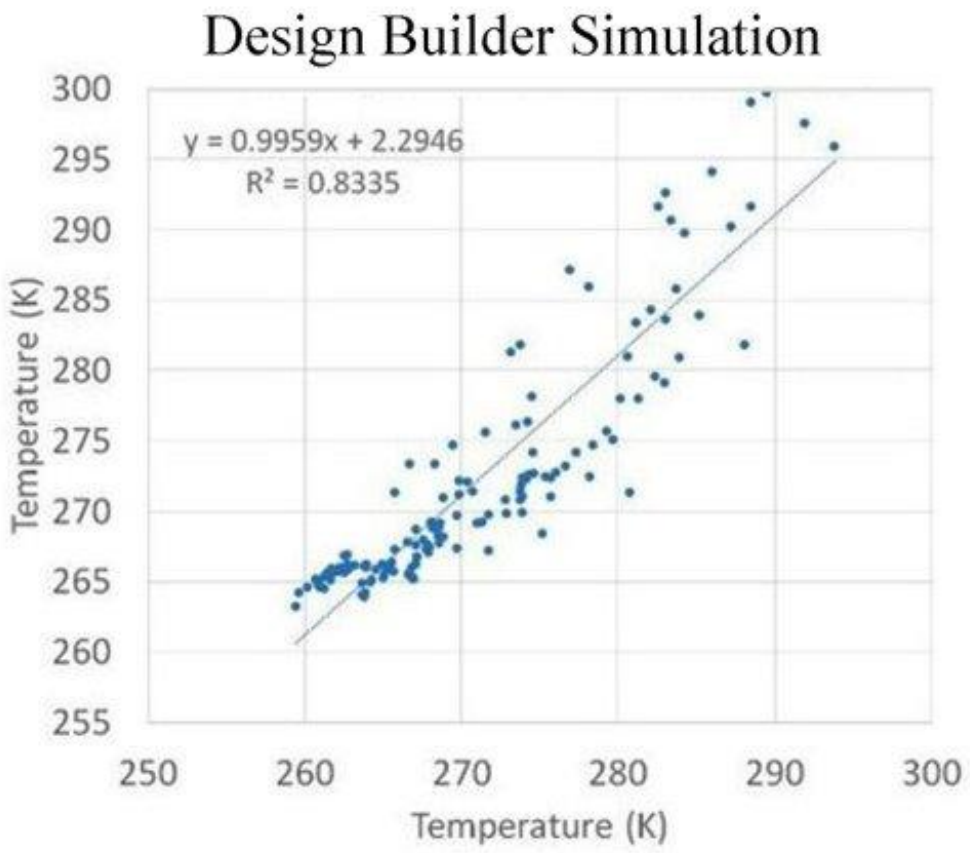


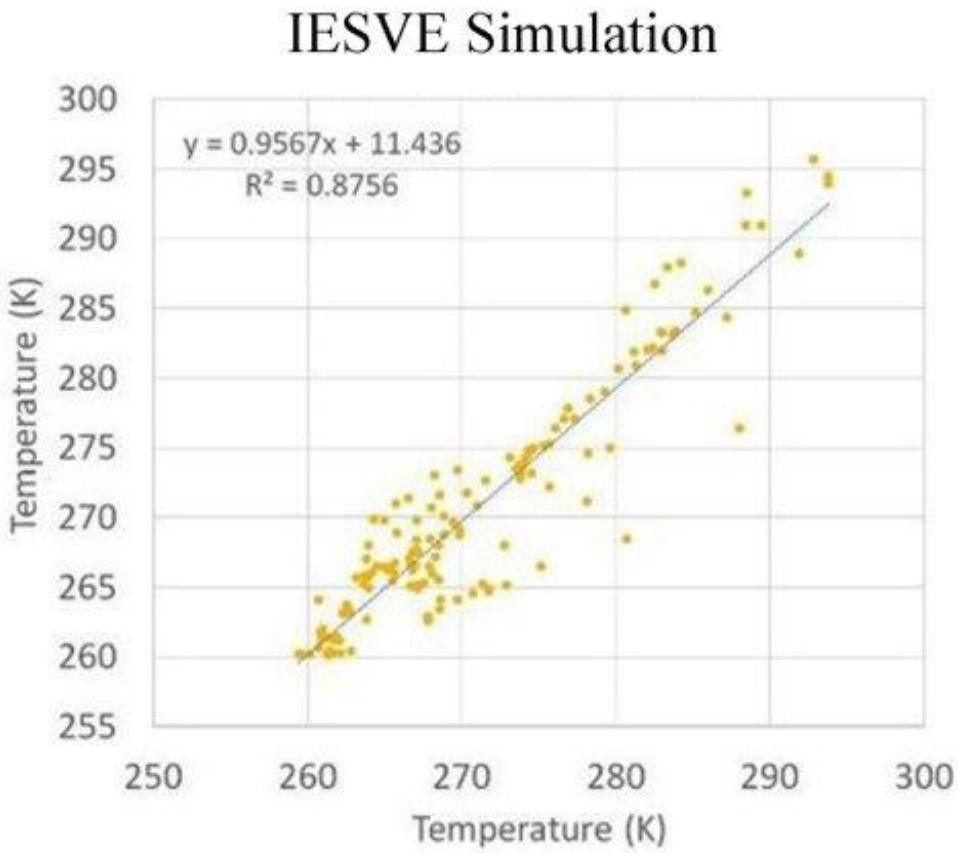
Measured Results - Data Logger vs Simulations



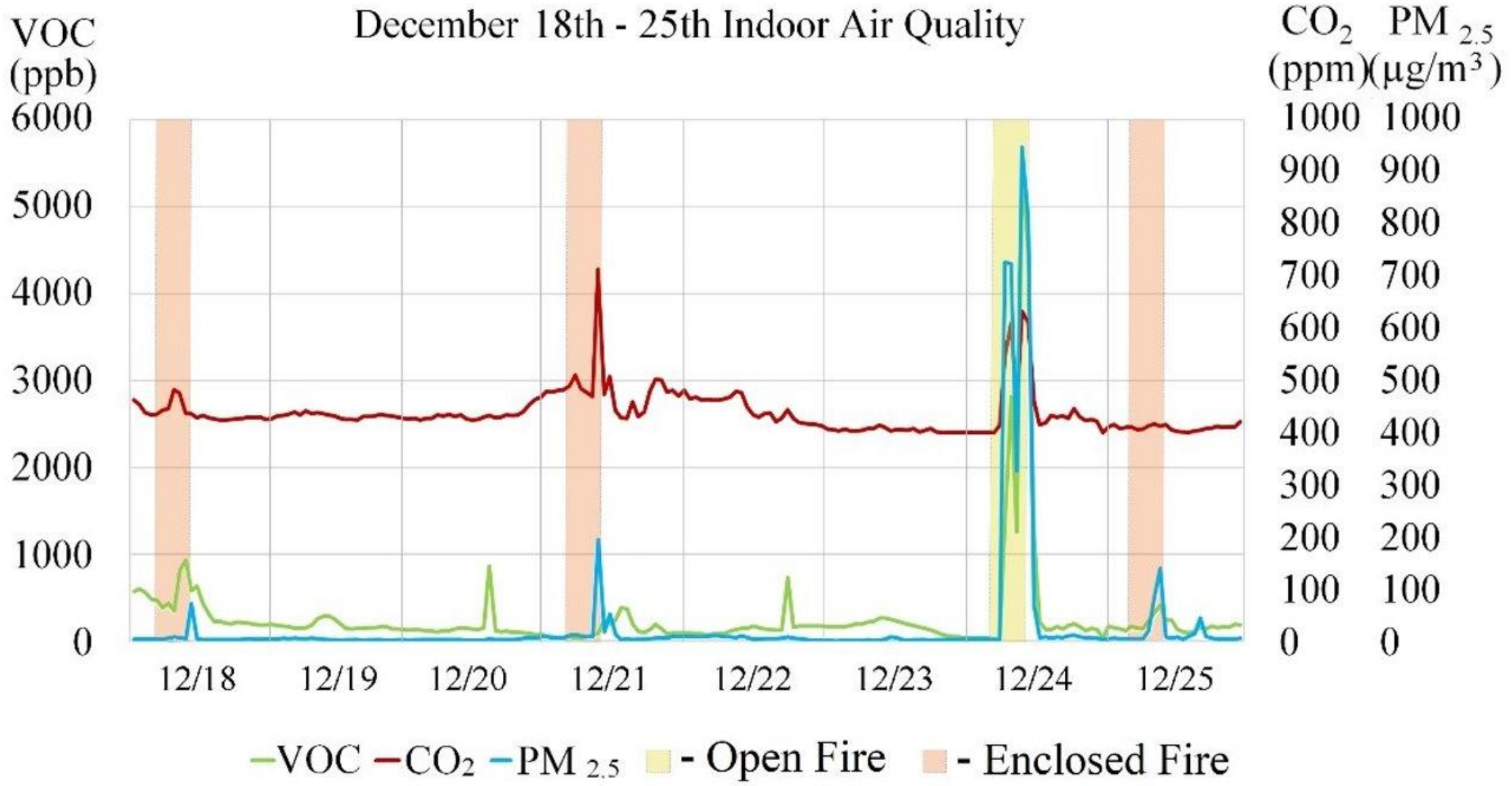


Coefficient of Determination - Relative Humidity

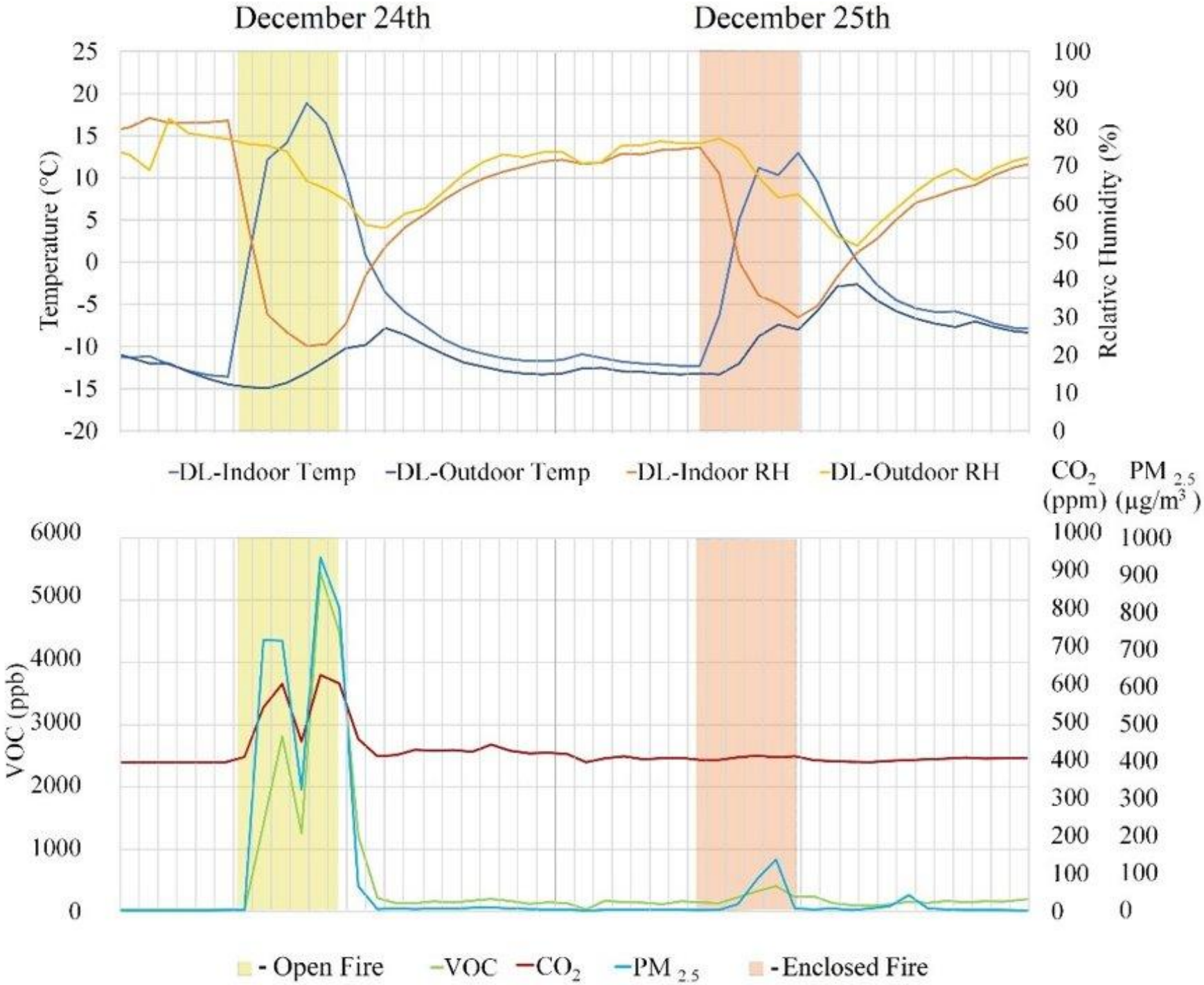




Coefficient of Determination - Temperature



Measured Results – Indoor Air Quality


December 24th
December 25th
Temperature (°C)
Relative Humidity (%)
DL-Indoor Temp
DL-Outdoor Temp
DL-Indoor RH
DL-Outdoor RH
VOC (ppb)
CO2 (ppm)
PM 2.5 (µg/m3)
Open Fire
VOC
CO2
PM 2.5
Enclosed Fire

Possible uses of Native American shelter

- Low cost and local materials
- Application to emergency shelters

Comfort

- Achieved comfort levels in severe New England winter

Indoor air quality

- Open fire resulted in dangerous levels of air quality
- Prolonged exposure can lead to respiratory diseases

Simulation results vs measured results

- Temperature meet ASHAE standards
- Relative humidity did not meet ASHAE standards

Thank you

Questions

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