A Prototype Visualization Tool for Hygrothermal Analysis

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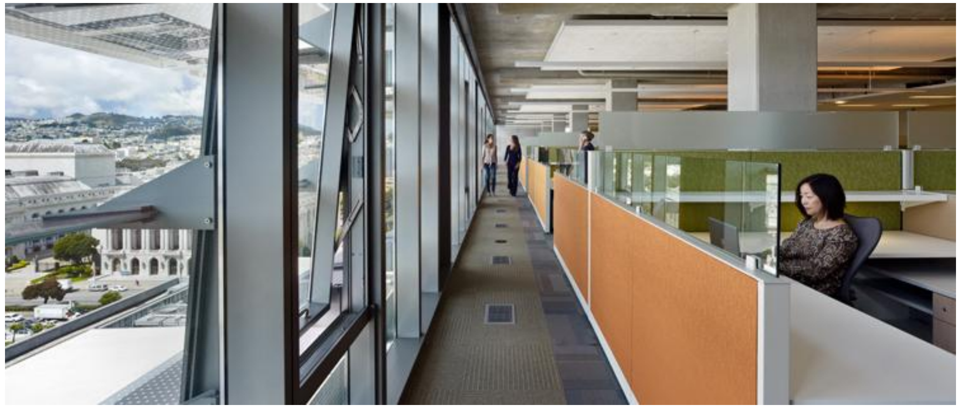
March 9, 2016









Sustainability Practice

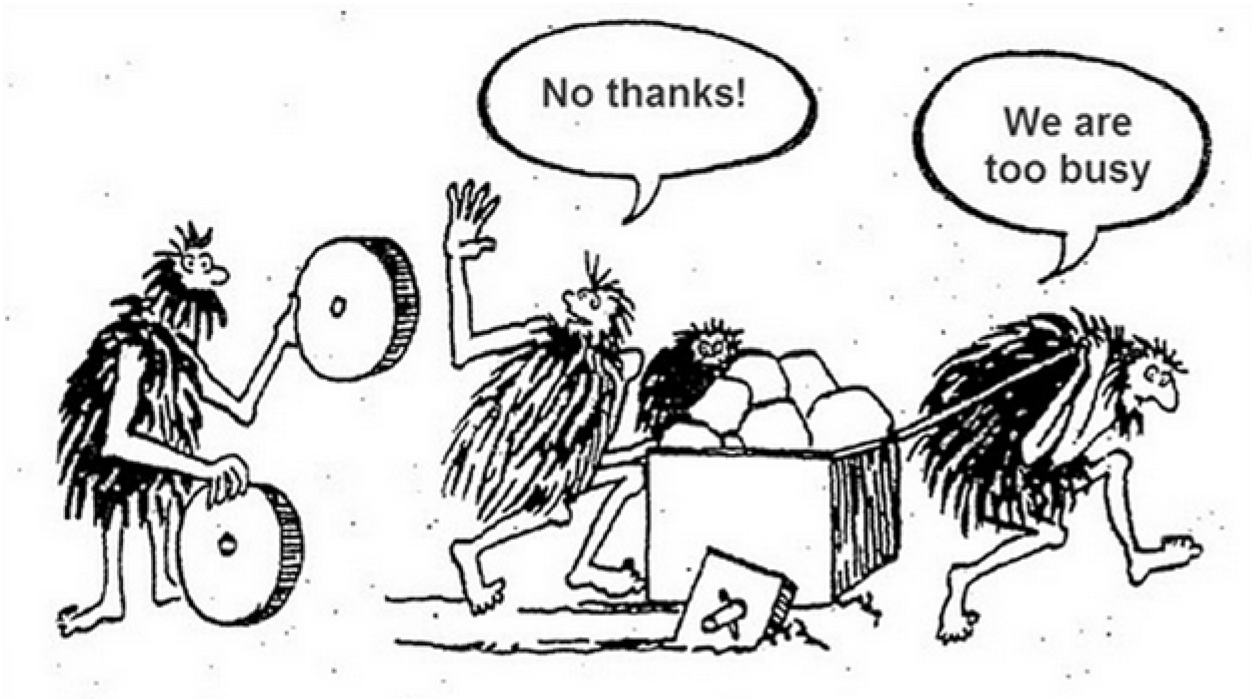
Building Certification

Energy Analysis

Existing Building Sustainability

Sustainability Education & Training

Sustainable Strategies

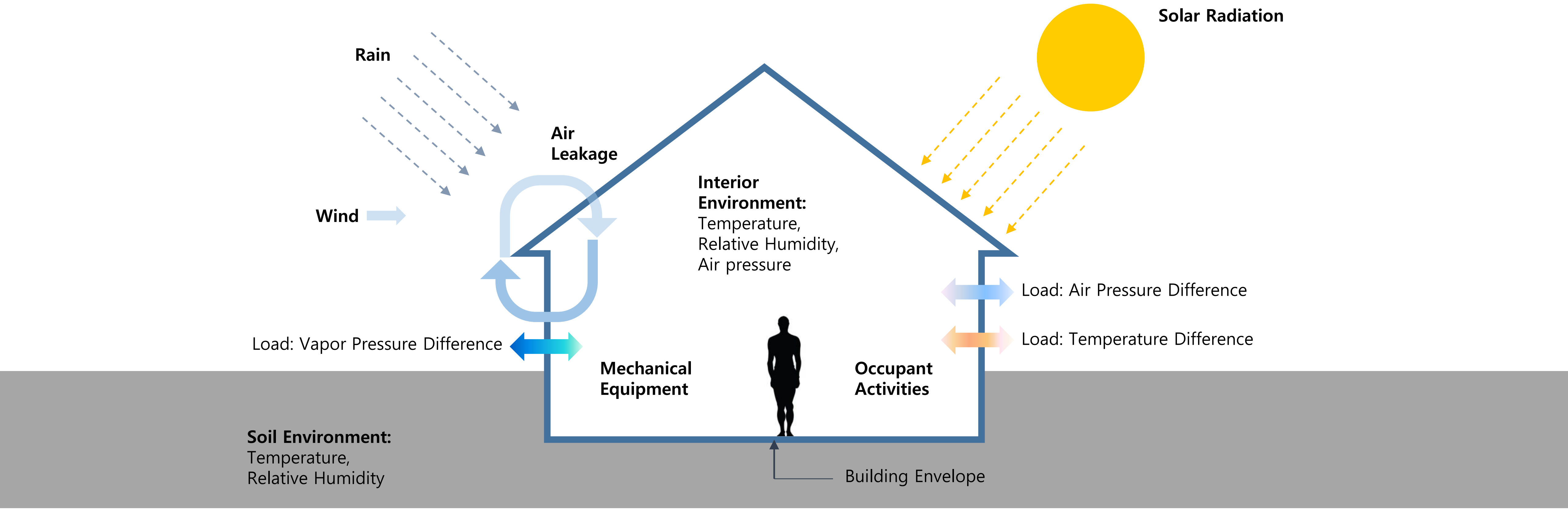

No thanks!
We are too busy

Learning Objectives

1. Integration of hygrothermal analysis into early design phases
2. Sequential steps in evaluating hygrothermal failure criteria
3. A novel data visualization tool integrating varied sets of data

Basics of **Hygrothermal** Analysis

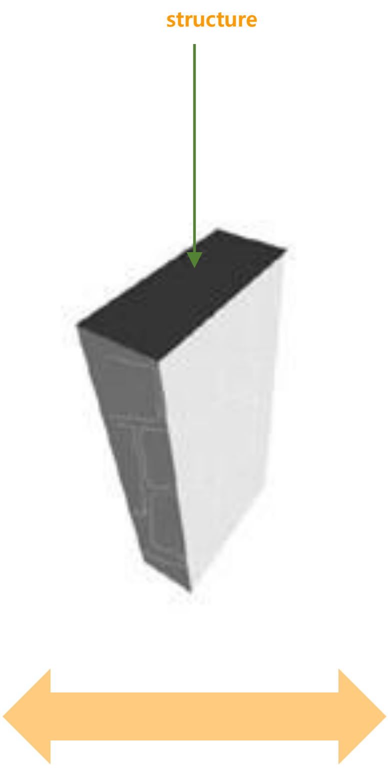
Hygrothermal Conditions



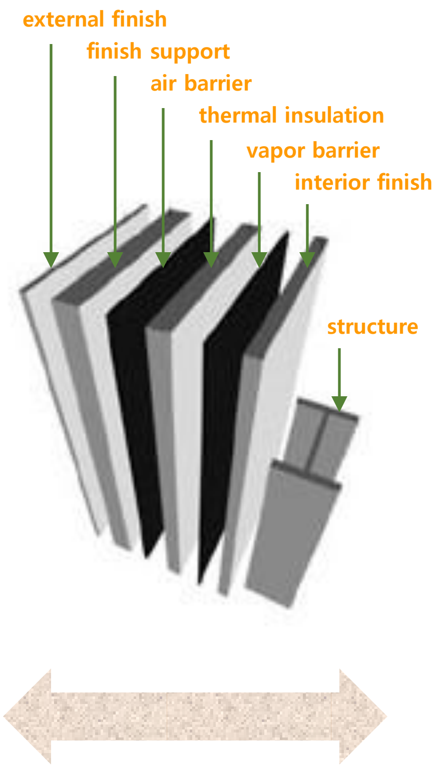
ENVIRONMENTAL LOADS ON
THE BUILDING ENVELOPE

Reference: “Building Envelope Design” by SAB Magazine

Hygrothermal Conditions



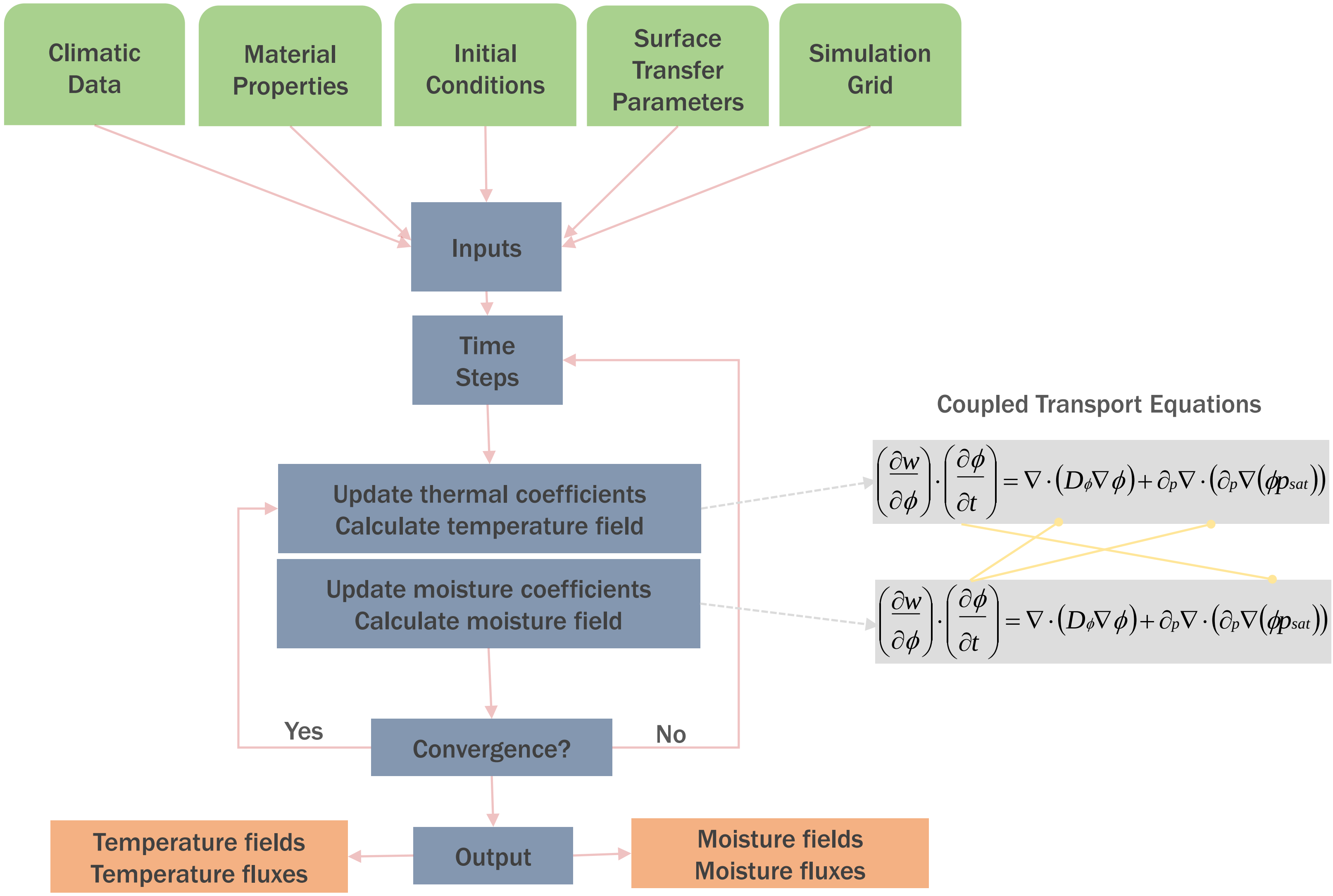
Large moisture buffer, ease of wetting and drying



Low to moderate moisture buffers, wetting and drying process more complicated

Reference: Whole Building Design Guide

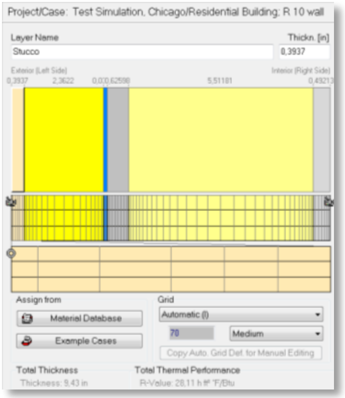
Moisture Modeling Using WUFI



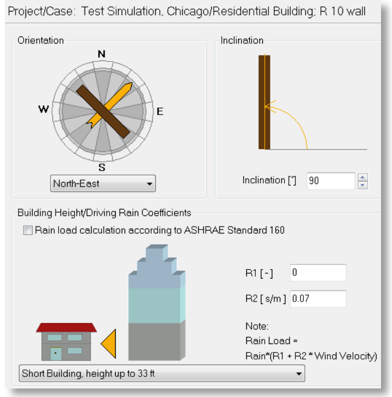
Reference: H.M. Künzel, A. Karagiozis, and A. Holm, WUFI Fundamentals

Moisture Modeling Using WUFI

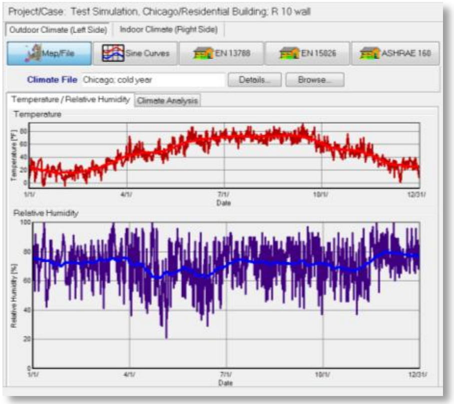
INPUTS



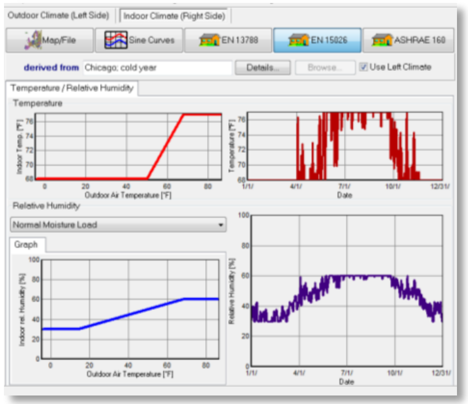
Material Properties



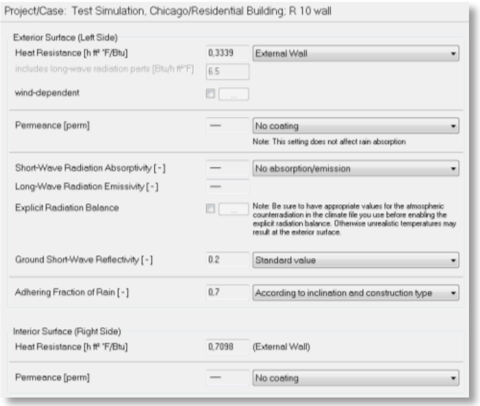
Initial Conditions



Climatic Data (Outdoor)

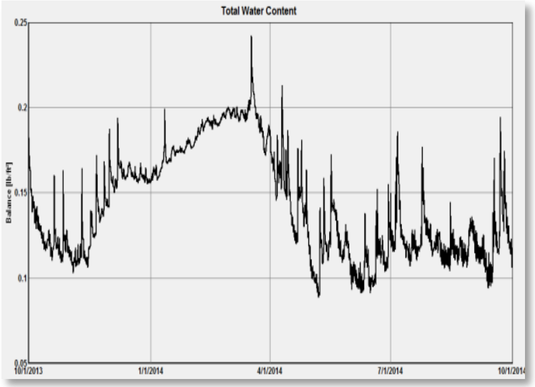


Climatic Data (Indoor)

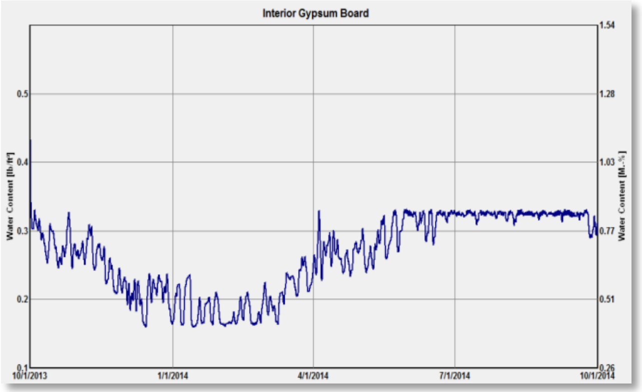


Surface Transfer Coefficients

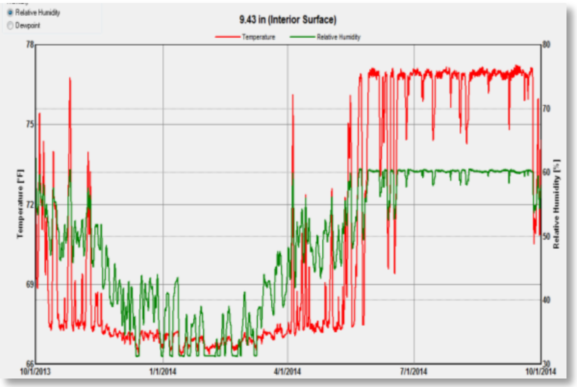
OUTPUTS



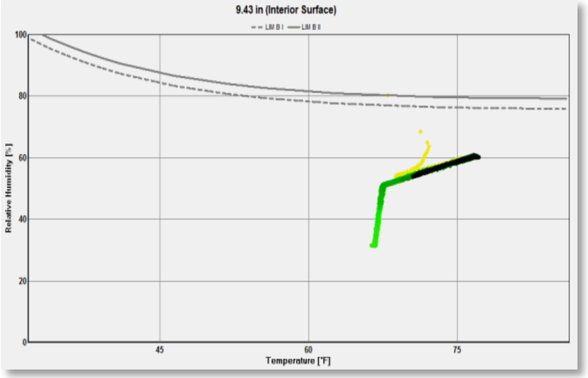
Moisture Content of Component



Moisture Content of Assembly



Temperature and Dewpoint



Limiting Isopleths

Integration of Hygrothermal Analysis into Early Design Phases

Design Workflow Evolution

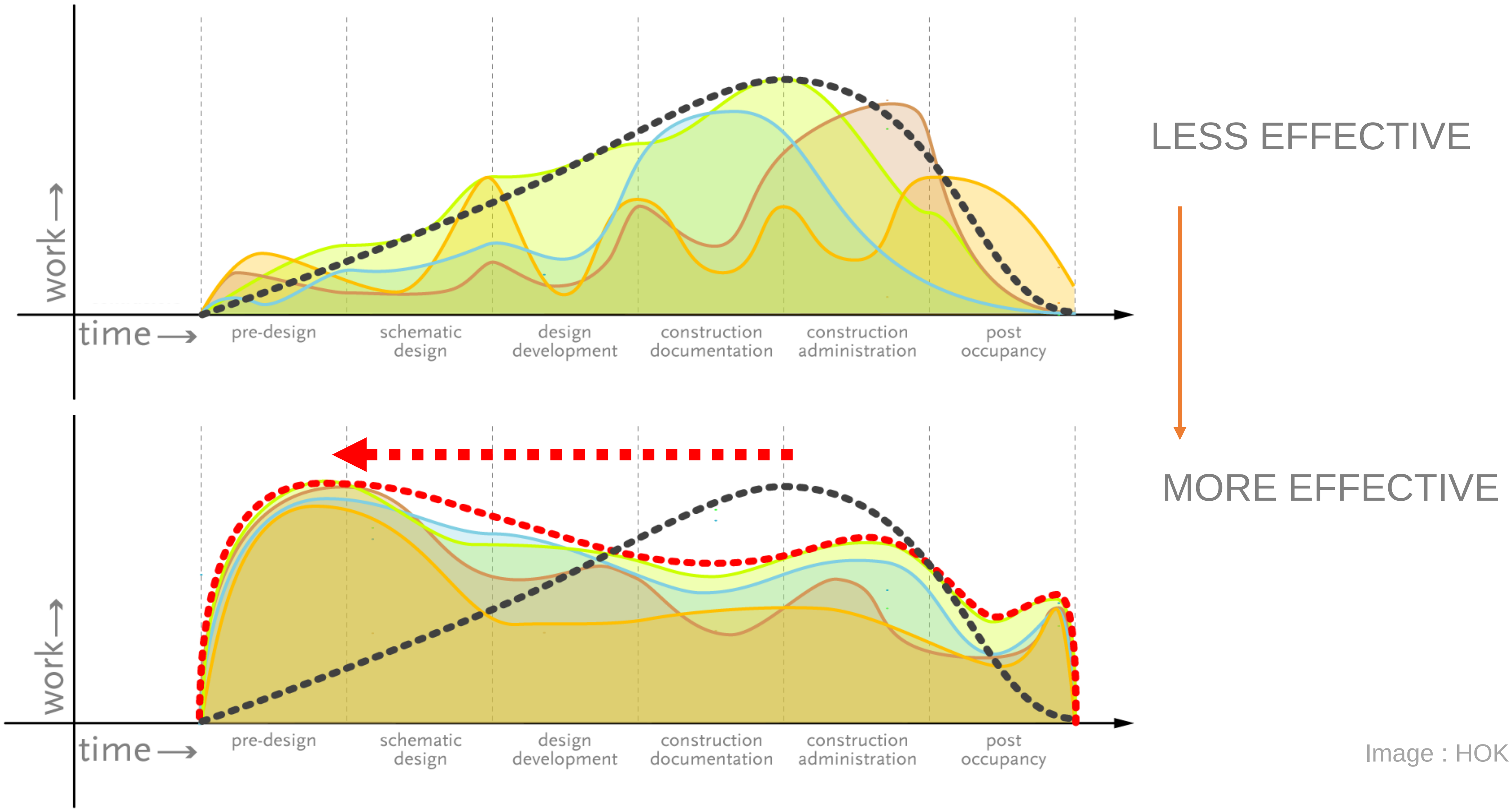
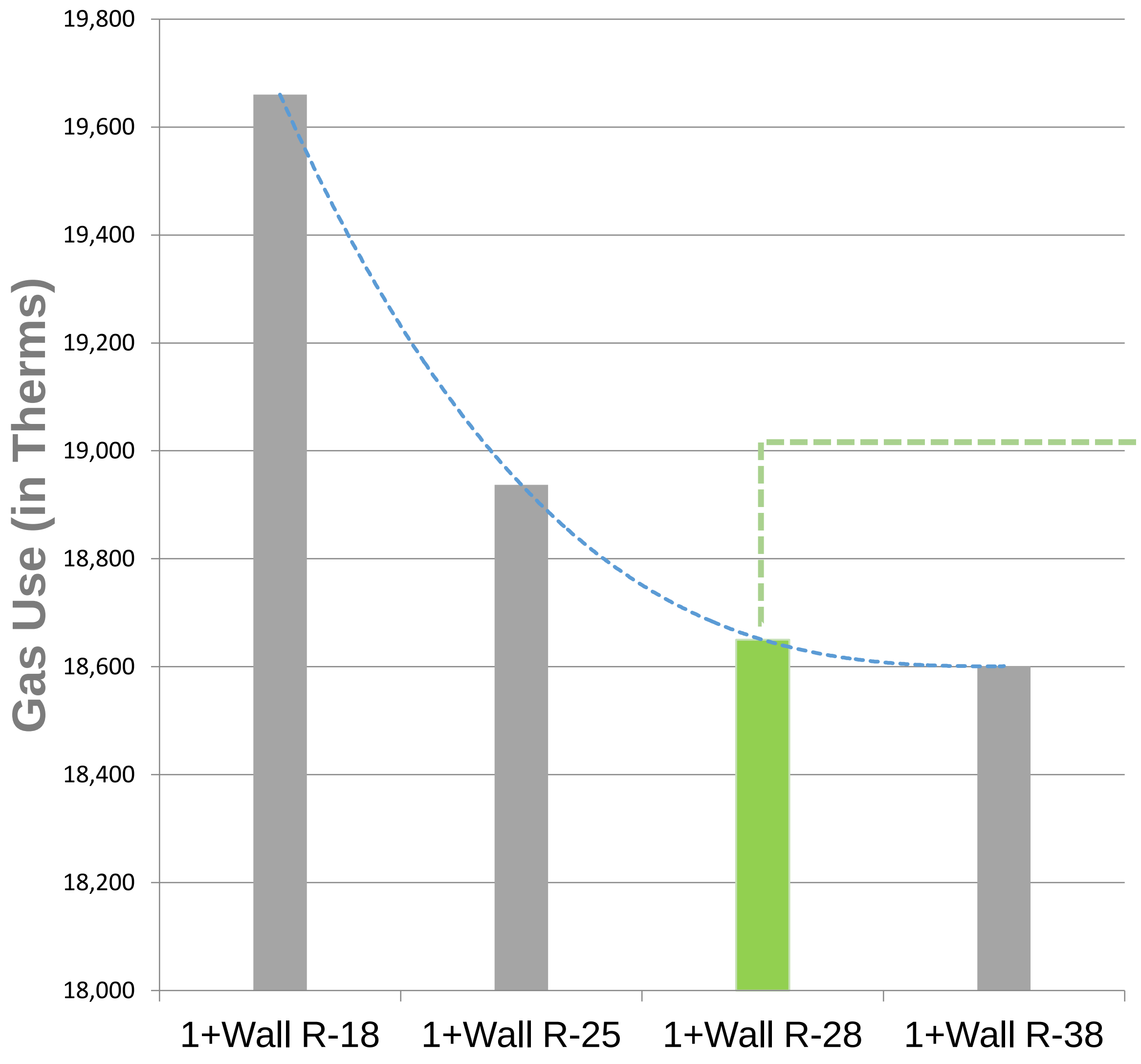


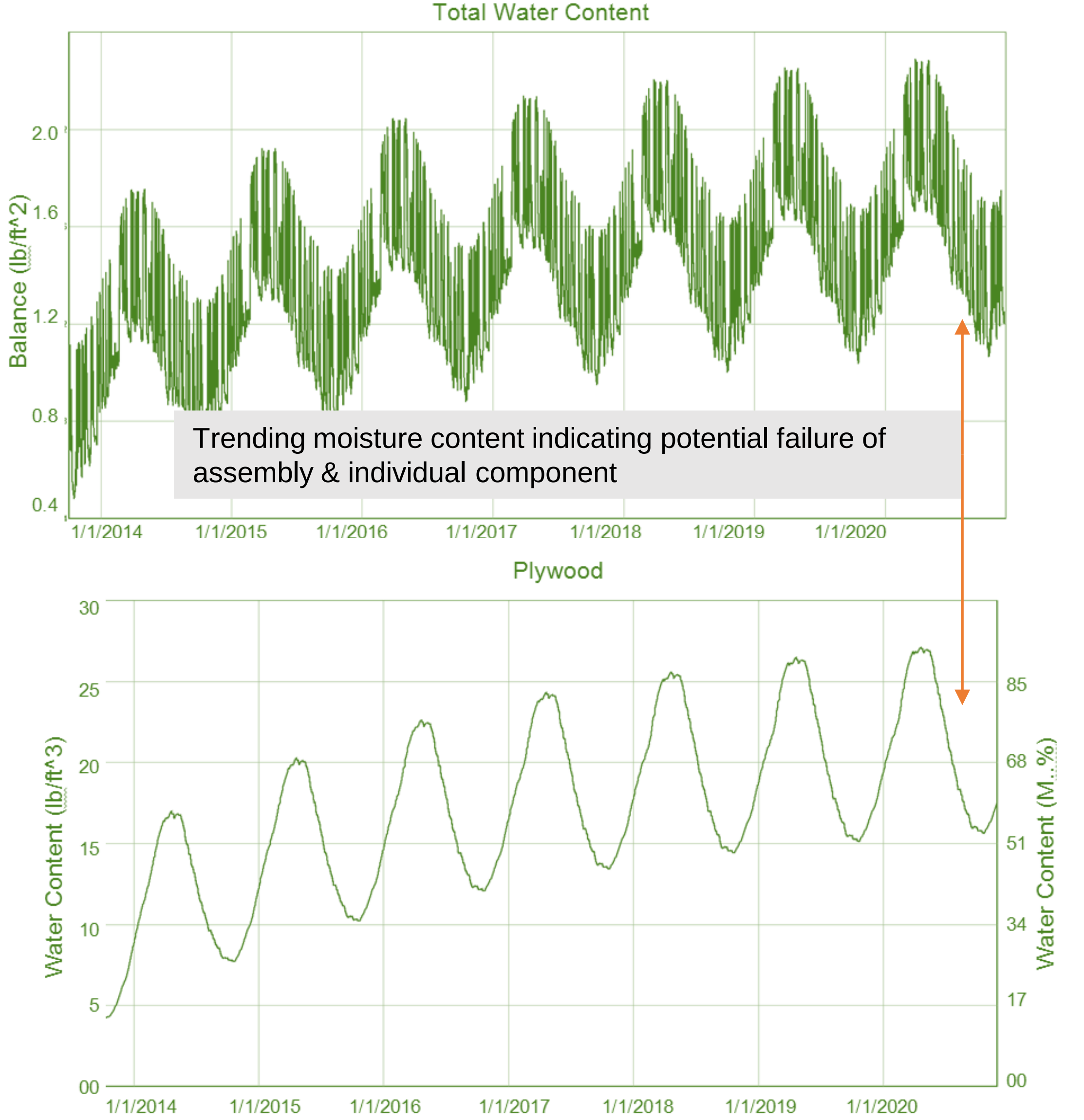
Image : HOK

Disaggregated Data Challenges

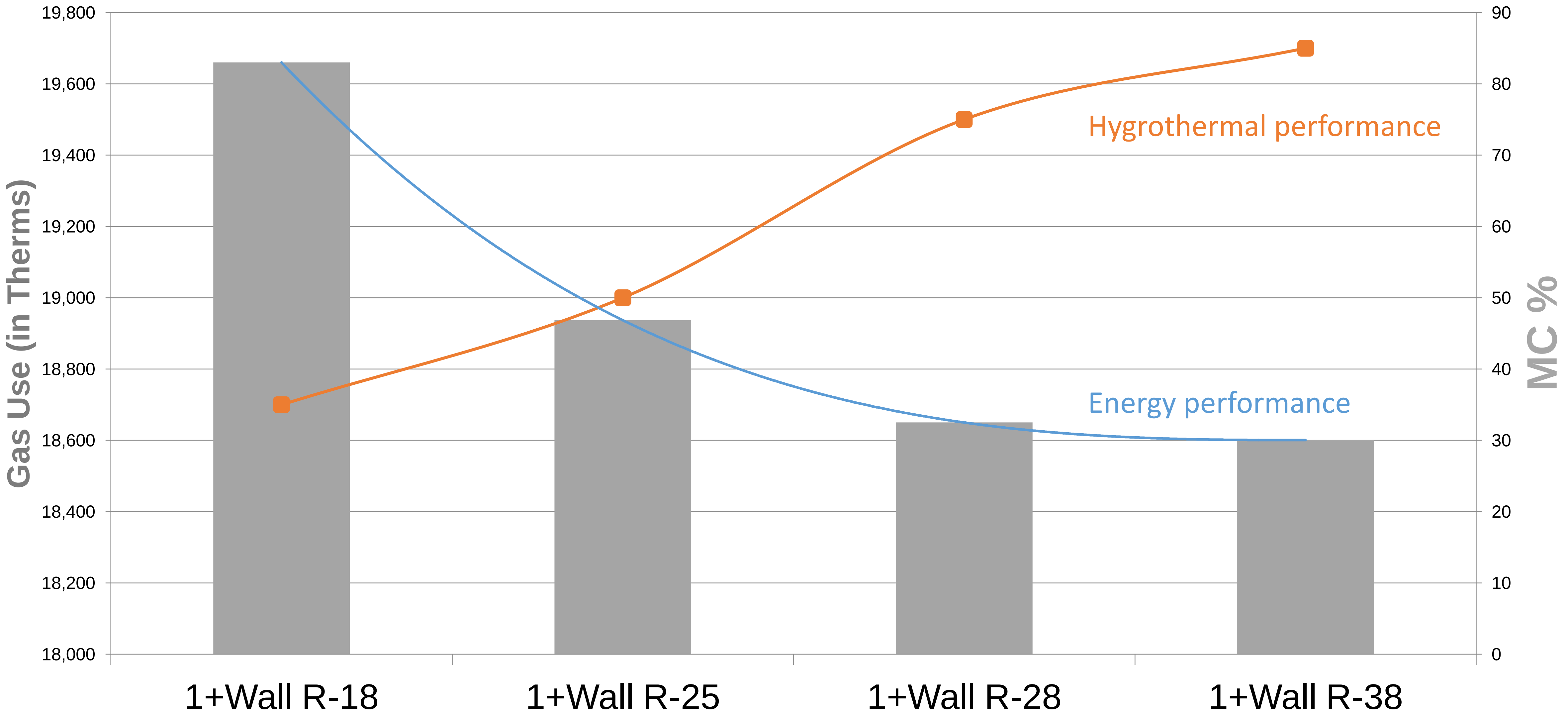
OPERATING ENERGY OPTIMIZATION



HYGROTHERMAL PERFORMANCE



Challenges in Data Integration



Sequential Steps in Evaluating Hygrothermal Failure Criteria

Failure Criterion 1

(Minimize Surface Mold Growth)

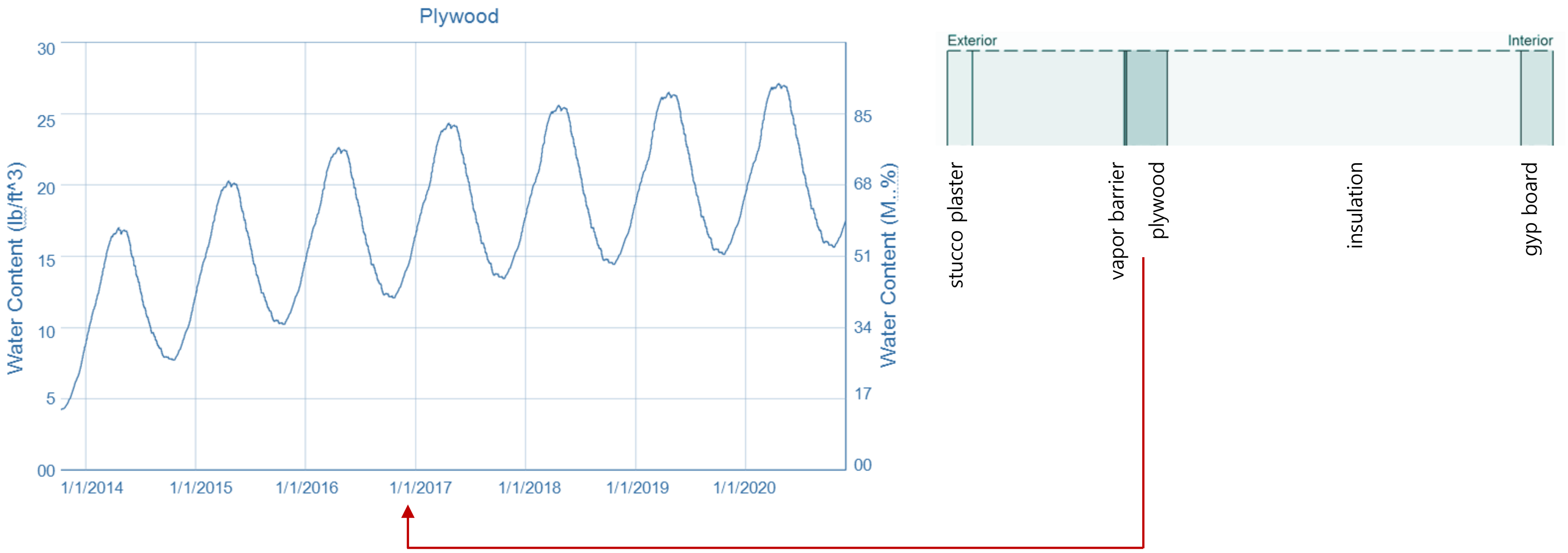
ASHRAE 160 STANDARD

- 30-day running average
  (RH<80%, Temperature > 41°F and < 104°F)

- Criteria is evaluated for materials prone to mold.

Failure Criterion 2

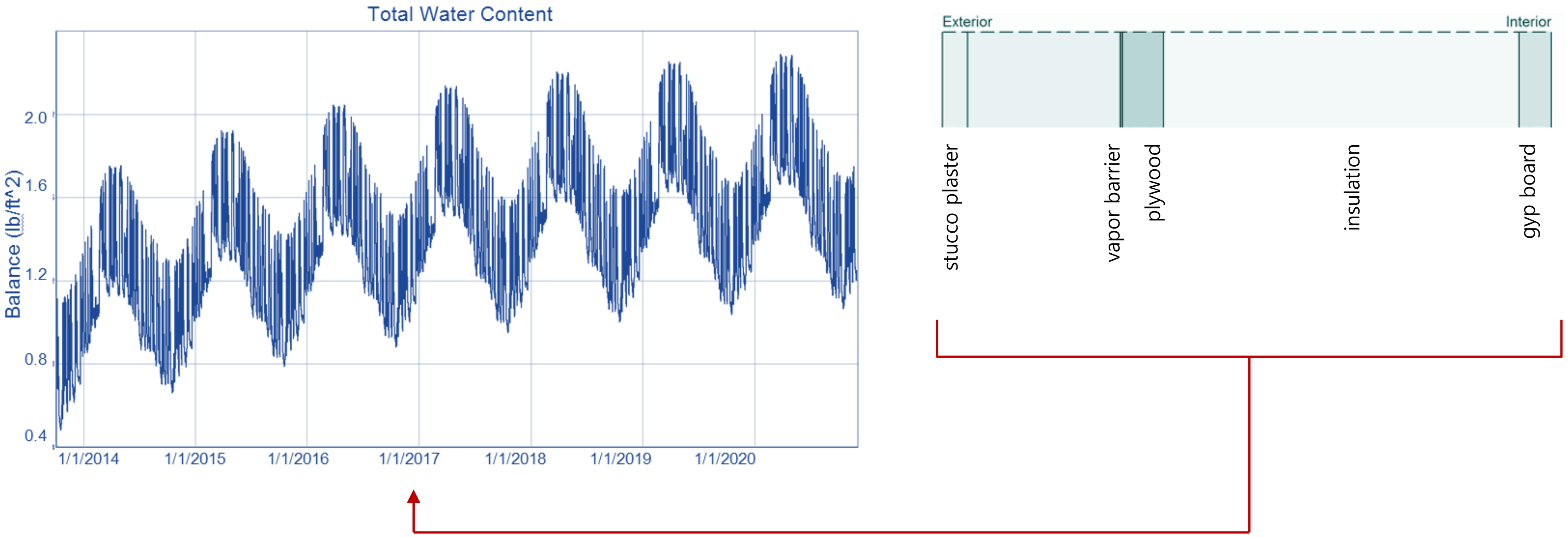
(Moisture Content: Individual Components)



This rot/decay applies to wood based products

Failure Criterion 3

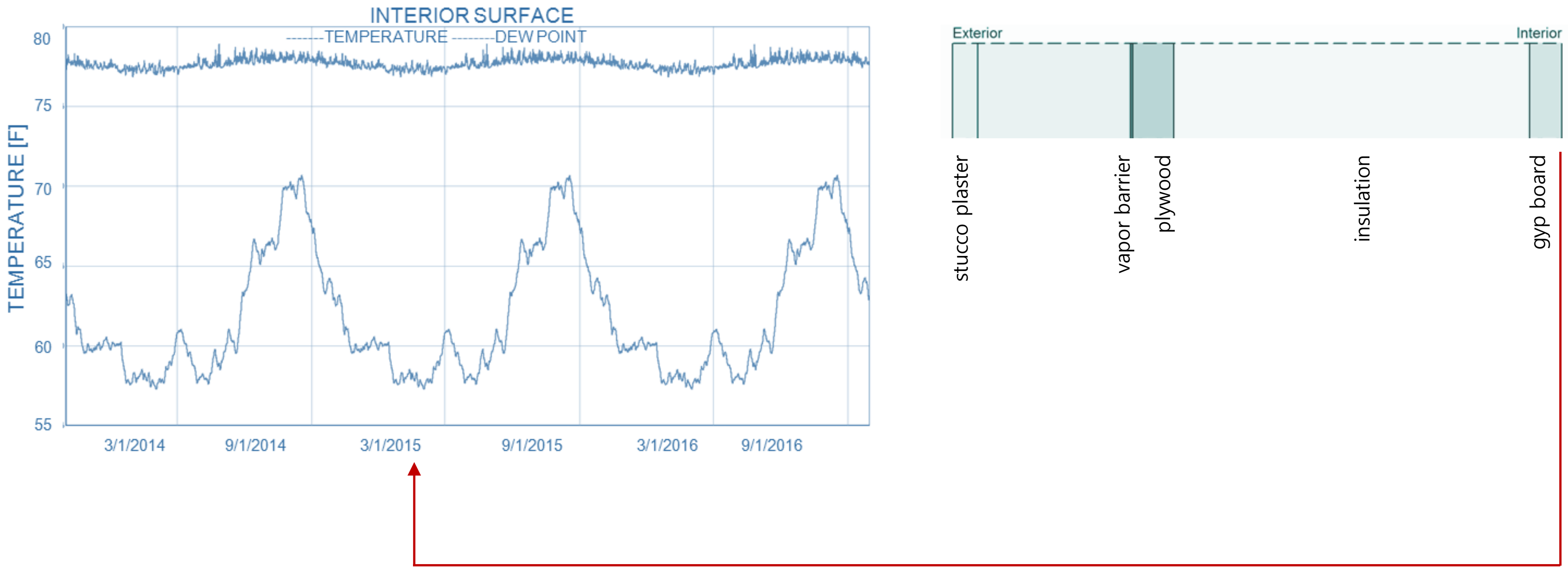
(Moisture Content: Entire Assembly)



The assembly is evaluated to ensure hygric equilibrium is achieved by the end of study period.

Failure Criterion 4

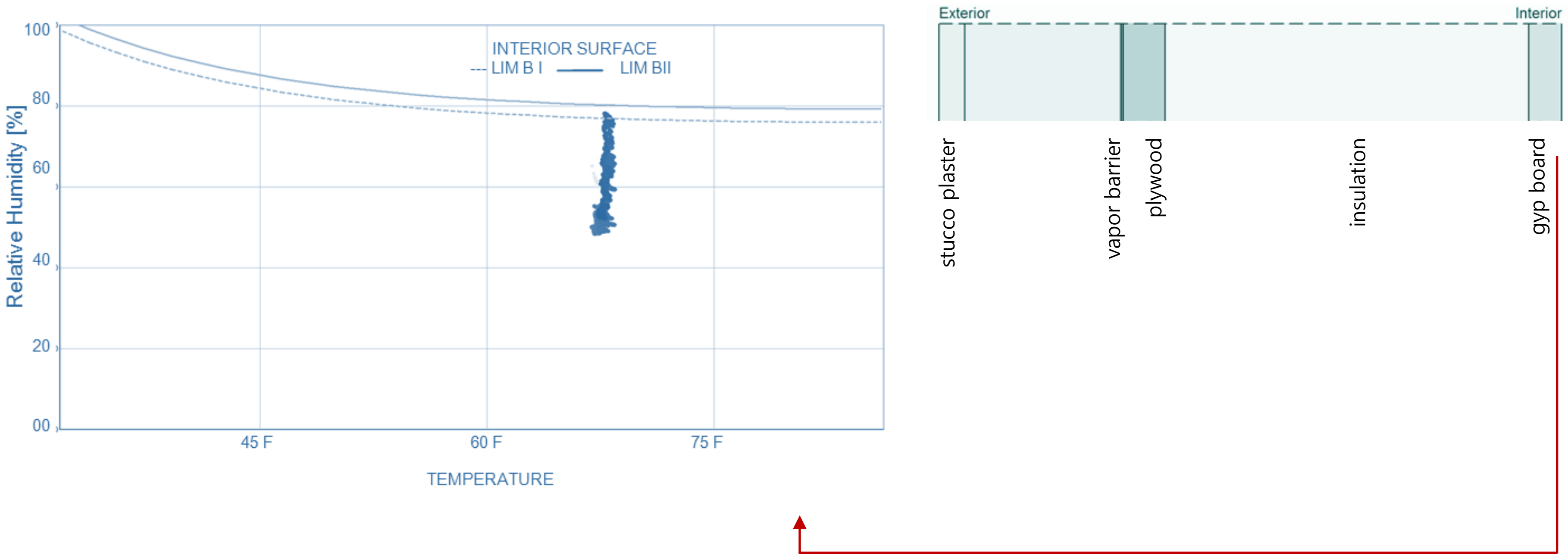
(Surface Condensation Potential)



Material surfaces are evaluated for potential condensation from humid interior air. Evaluated for potential condensing surfaces

Failure Criterion 5

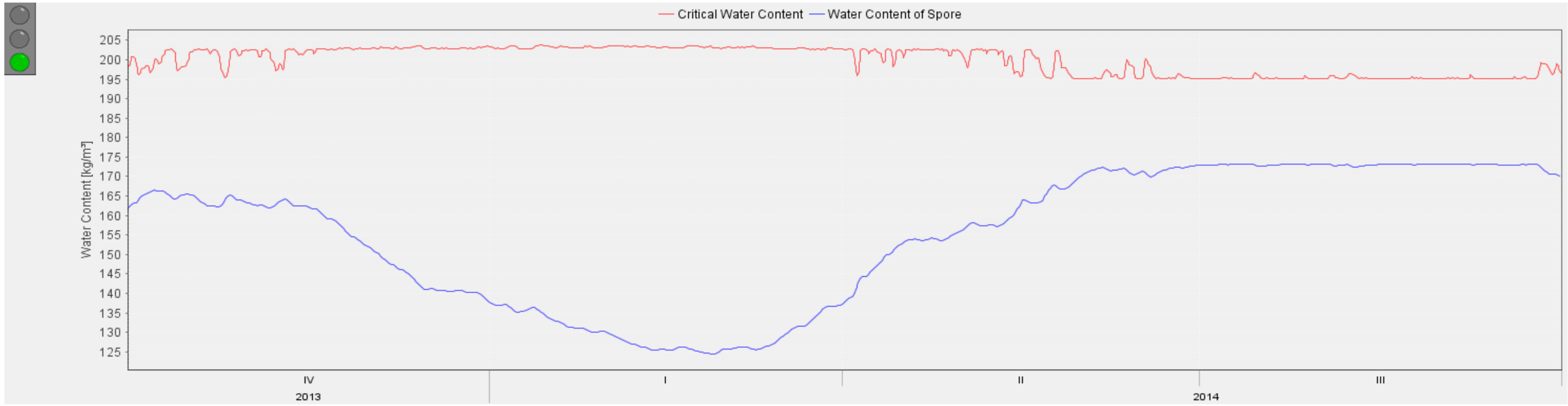
(Isopleths for Mold Growth)



Identifies potential mold growth on the interior surfaces. Mold growth is possible when the conditions lie above the limiting isopleth lines.

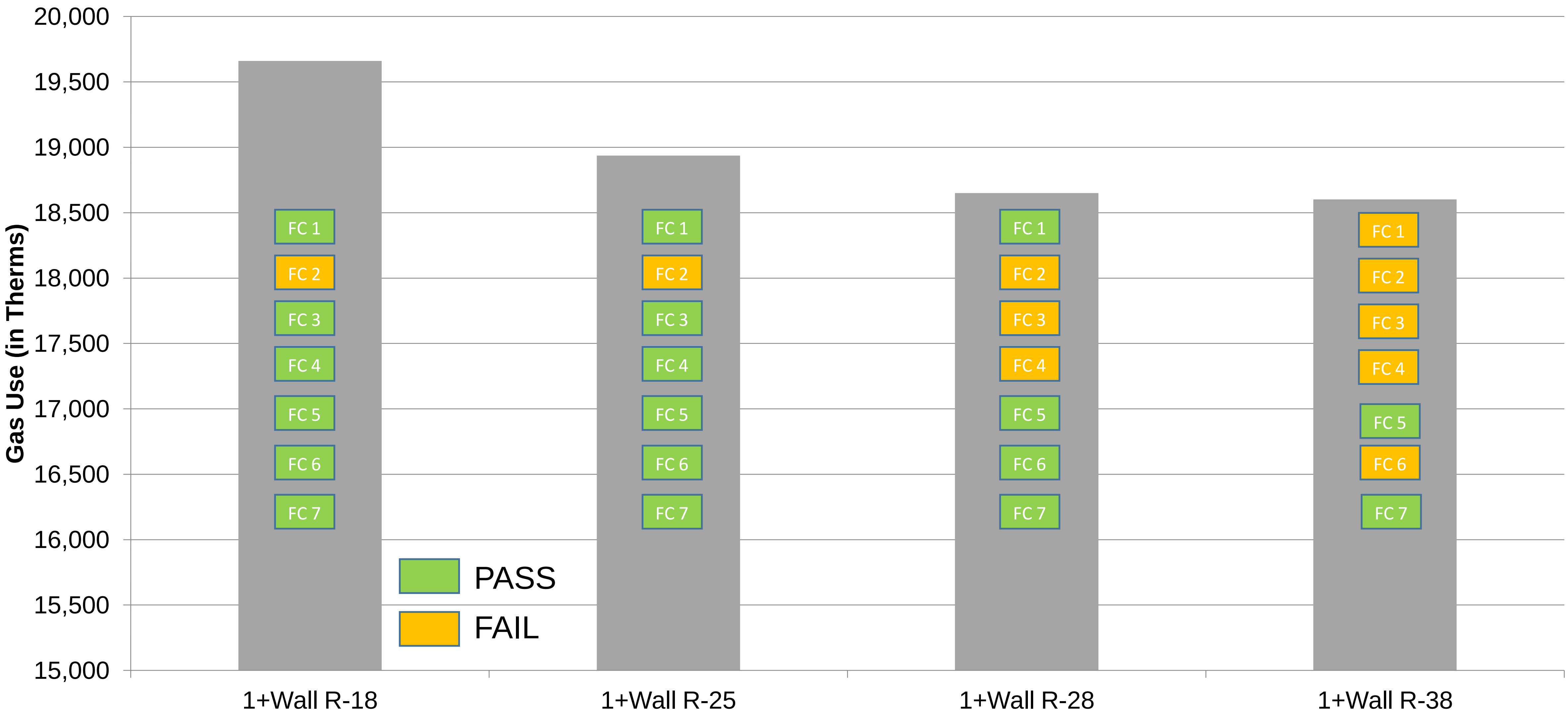
Failure Criterion 6 & 7

- **Frost Damage** **(Primarily for Masonry)**
- **Fungi Growth** **(Using WUFI-BIO)**

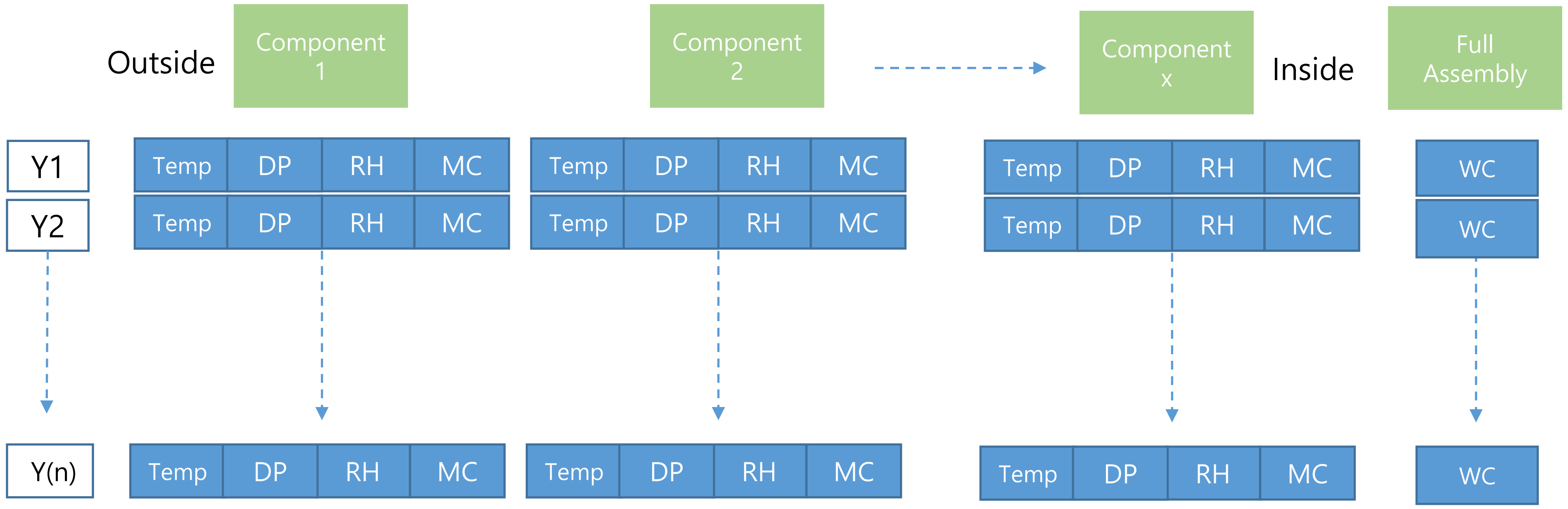


A
Data Visualization Tool
Integrating Varied Data Sets

Integrated Data Analysis



Scale of Data

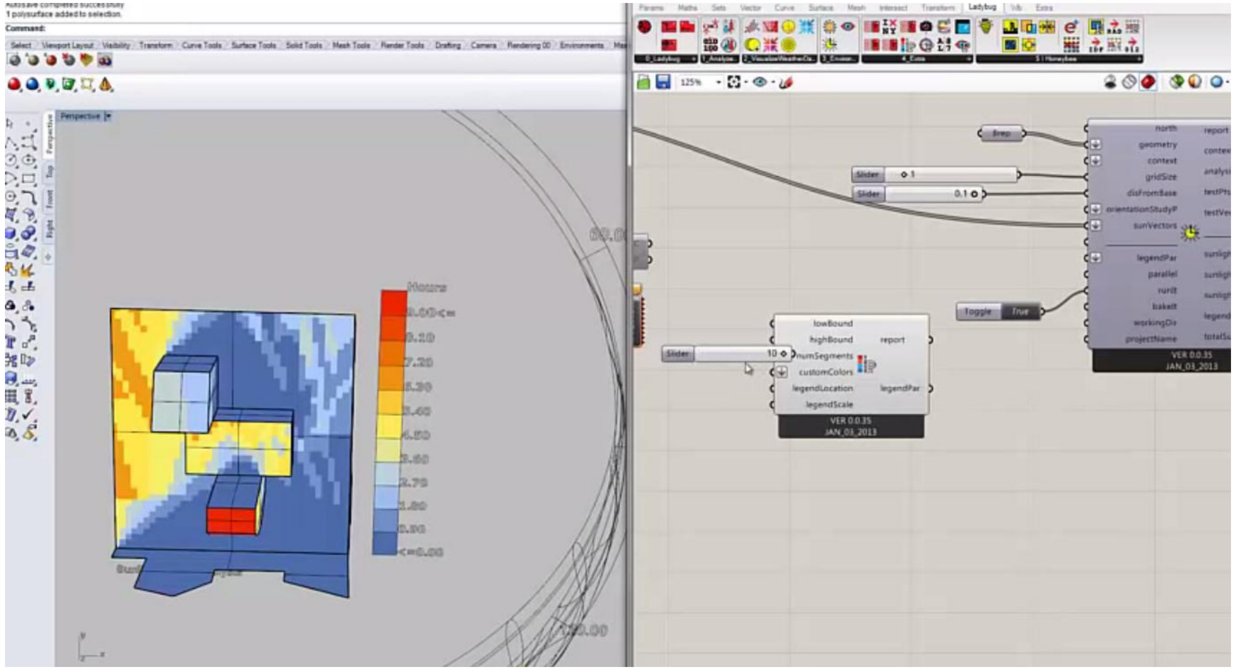


Potential Total Number of Data Points=
8760 x (Number of Simulation Years) x (1 + 4 x Number of Assembly Components)

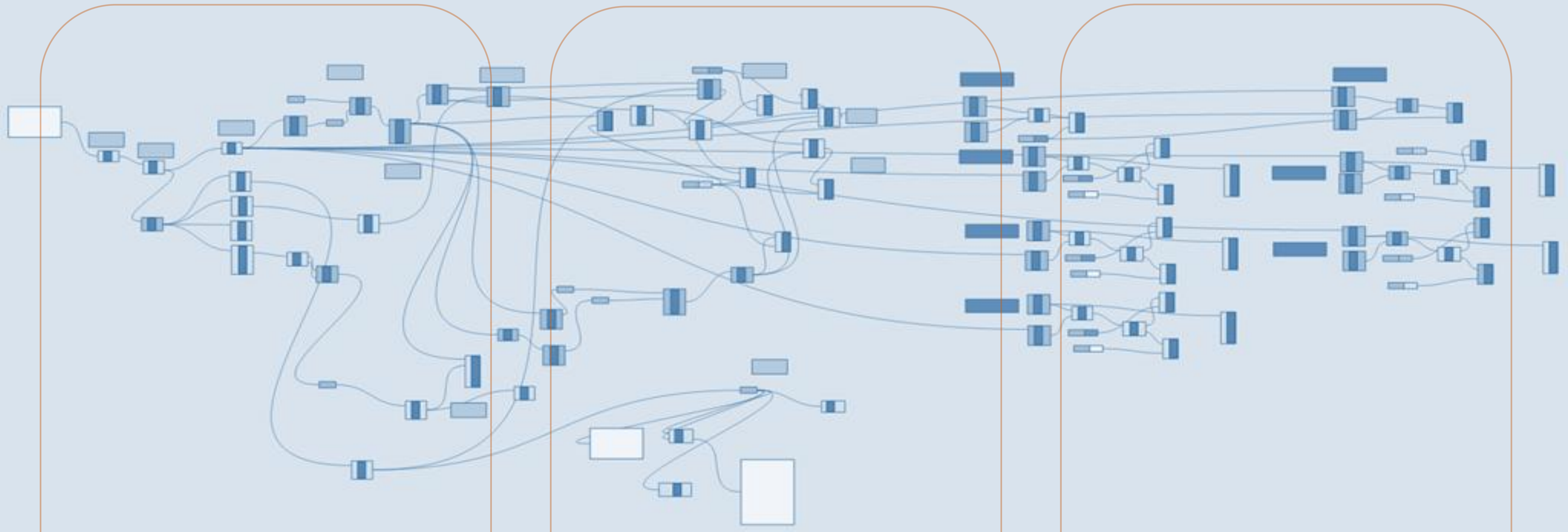
E.g. a simulation run for seven years with six components in the assembly would yield approximately
1.5 million data points

Grasshopper

Screenshot showing the Grasshopper programming environment and an associated visualization



Grasshopper

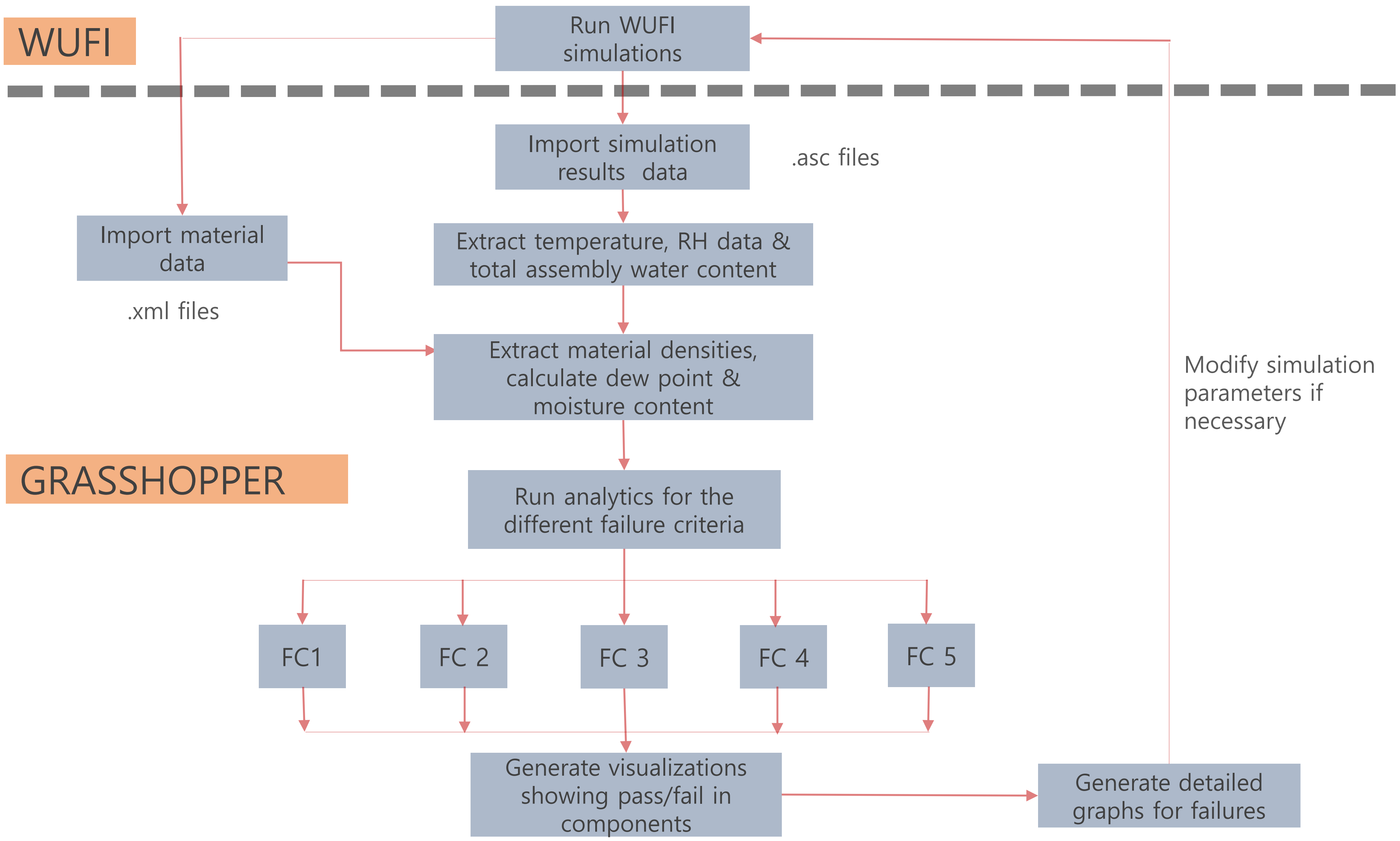


Read file and extract Temperature & RH data, along with time steps

Run analytics

Generate visualizations for results

Proposed Workflow



Visualization Environment

{Video Demo}

Thornton Tomasetti

Wrap Up

Key Conclusions

- Preliminary testing showed that this visualization tool can effectively address some of the challenges of post-processing the data from WUFI.
- The visualization style adopted by this tool aims to reduce the complexity of the data and the associated evaluation criteria into an easily digestible format that would speed up the evaluation process, and also facilitate for its integration with other performance criteria.

Future Work

- Carrying out batch runs, for creating a two-way connection from Grasshopper that would send and receive data.

- Integrate the data from hygrothermal simulations with other design criteria such as energy performance.

- Converting visualizations into interactive objects, rather than as static graphs. This would allow the user to manipulate different aspects of the analysis such as the threshold criteria, and observe the changes that occur.

Questions

Thank You

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