

Building Energy and Envelope Performance of a Near Net Zero Energy Building

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NZEB: Presentation Agenda

- **Context**
- **Building features and construction**
- **Building performance**
 - **Energy consumption**
 - **Evaluate wall performance vs. predictions**

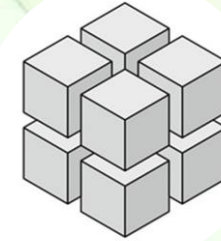
NZEB: Context Philadelphia Navy Yard

- Urban 1,200-acre business campus
- 10,000 employees
- 6.5 million square feet
- Office, industrial, and R&D space

Mission: to be an education and research resource for Smart Grid technologies



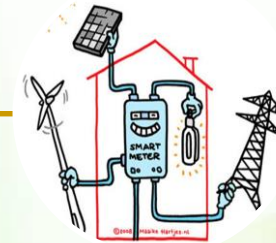
NZEB: Building Features



Modular
Construction



Insulation
Strategy



Smart Grid

NZEB: Modular Construction

- 7 Factory built modules
- Weather protected
- Module on-site assembly completed in 3 days



NZEB: Building Features



NZEB: Super Insulated Building Envelope



NZEB: Wall Hygrothermal Performance

Measurements:

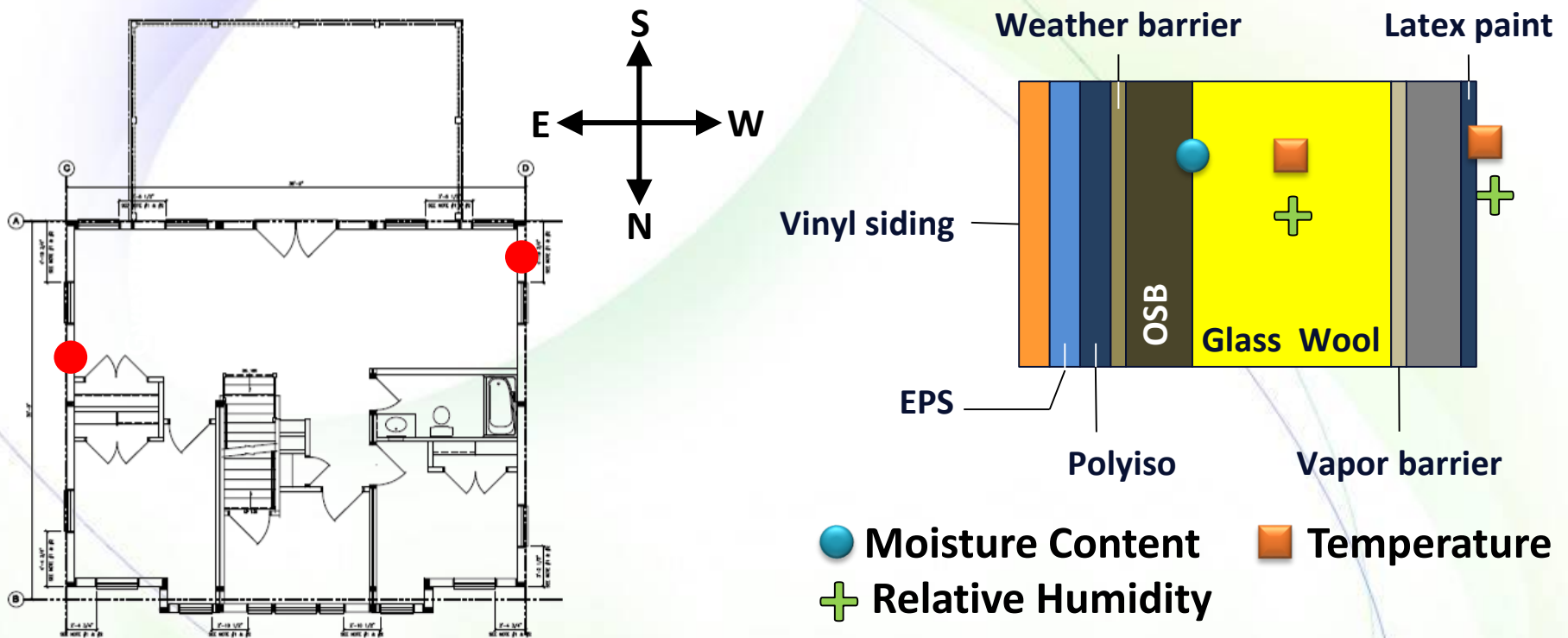
Actual material performance
Includes construction defects
Includes 3D effects

Model Predictions:

Measured material properties
“Perfect” Assembly
1D assumption

DOES THE WALL PERFORM AS EXPECTED?

NZEB: Instrumentation Overview

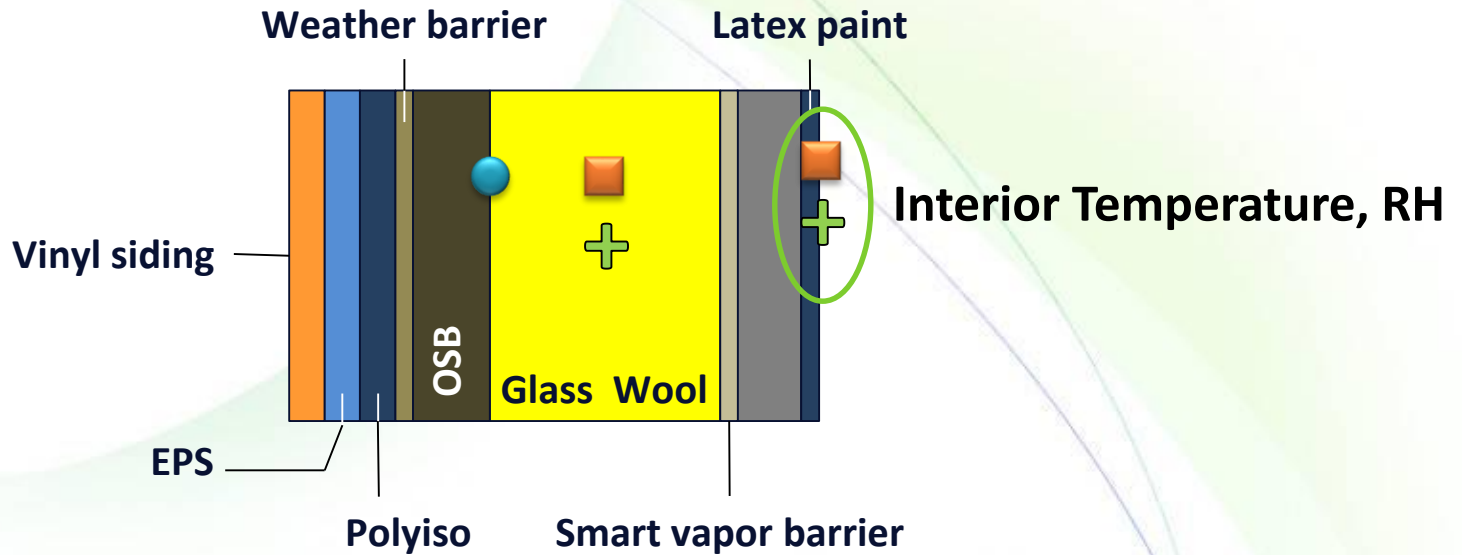


- Long-term data collection
 - Temperature: interfaces, glass wool cavity
 - Relative humidity: interfaces, glass wool cavity
 - Moisture Content: OSB sheathing

NZEB: Simulation Overview

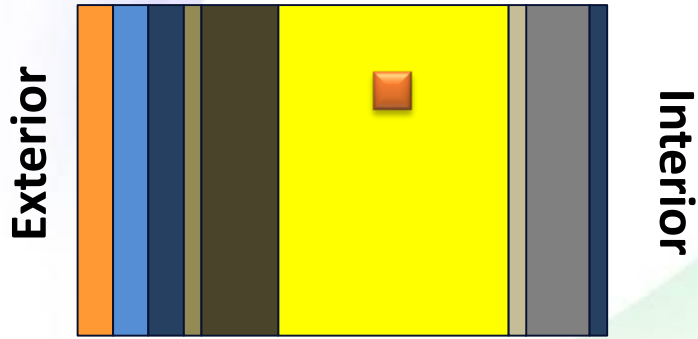


Weather Data



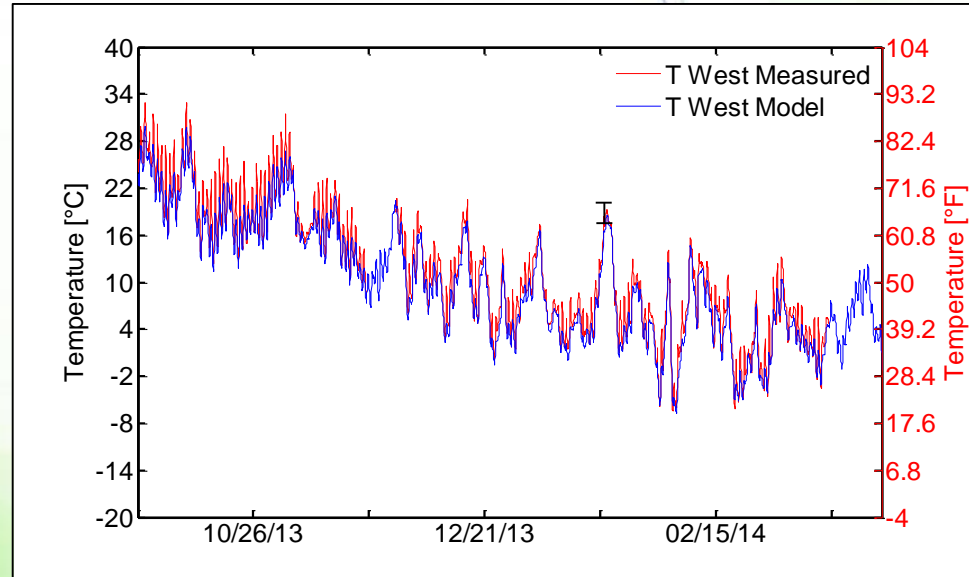
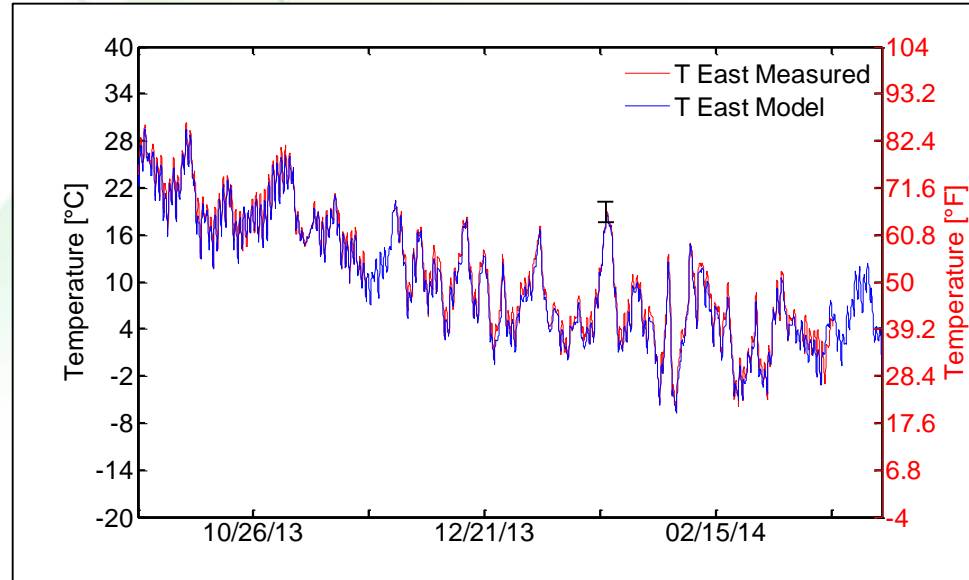
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- WUFI®Pro - 1D model
 - Boundary Conditions
 - PHL-Airport weather (1-year)
 - Measured surface temperature & relative humidity
 - Infiltration: Measured (2.3 ACH @ 50Pa)
 - 3-year simulation: to achieve periodic state

NZEB: Temperature comparison

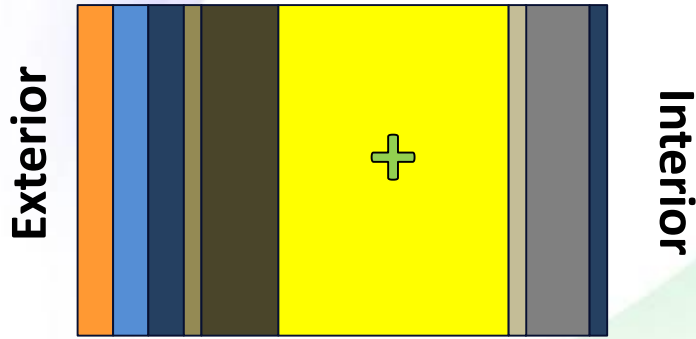


- 6-month detail

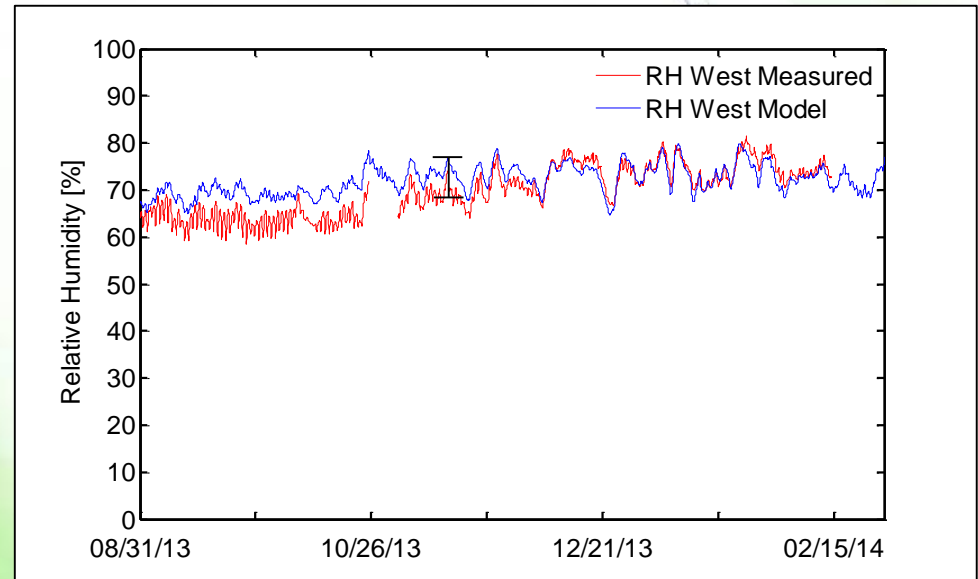
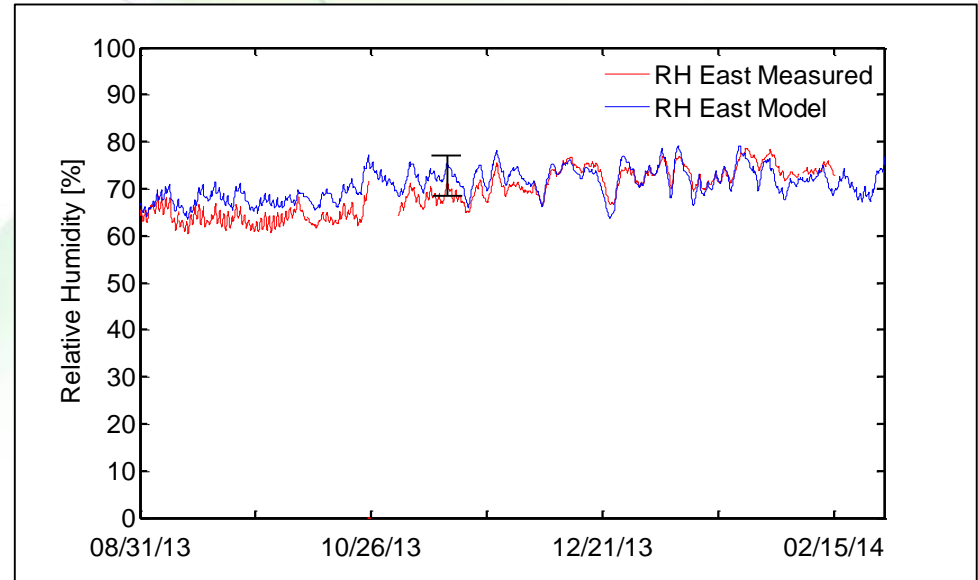
- Simulation vs. Measurement agreement at both wall locations (East / West)



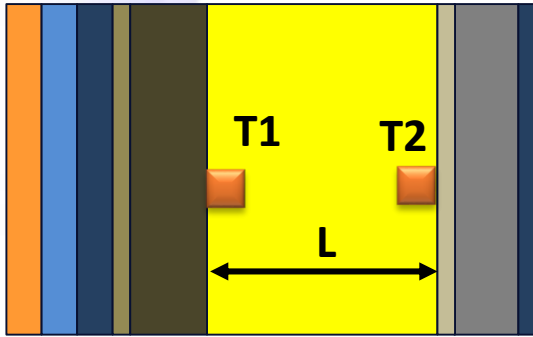
NZEB: Relative Humidity Comparisons



- 6-month detail
- Simulation vs. Measurement agreement at both wall locations (East / West)



NZEB: Heat flux comparisons (East)

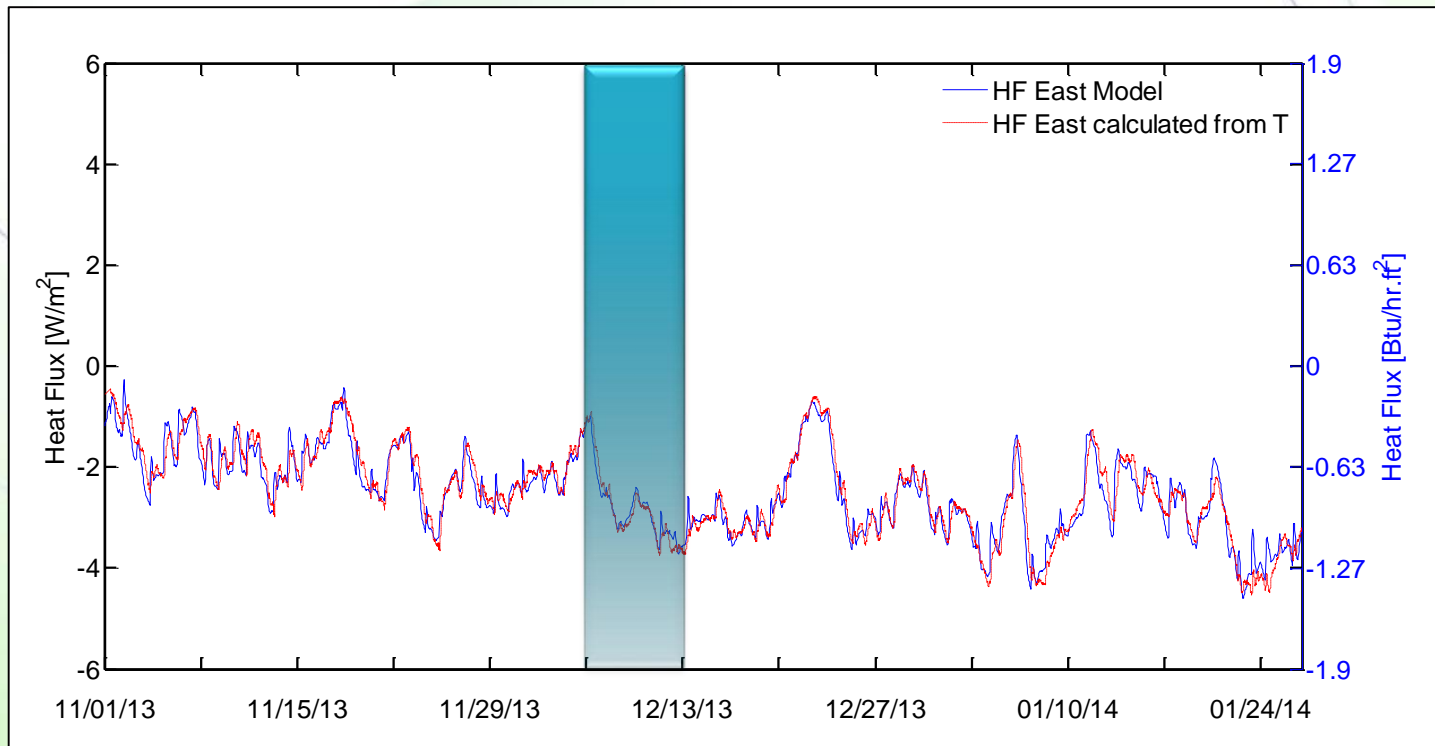


$$q = \frac{k\Delta T}{L}$$

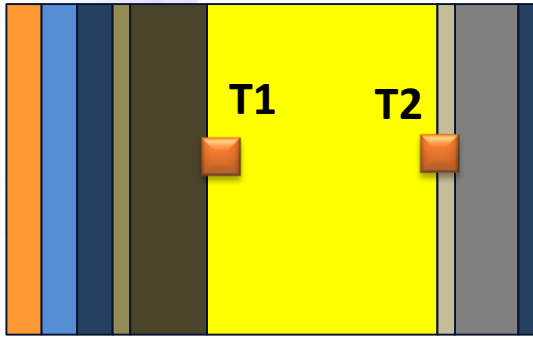
Compare:

- HF calculated from measured temperatures T1 and T2
- HF from WUFI simulation

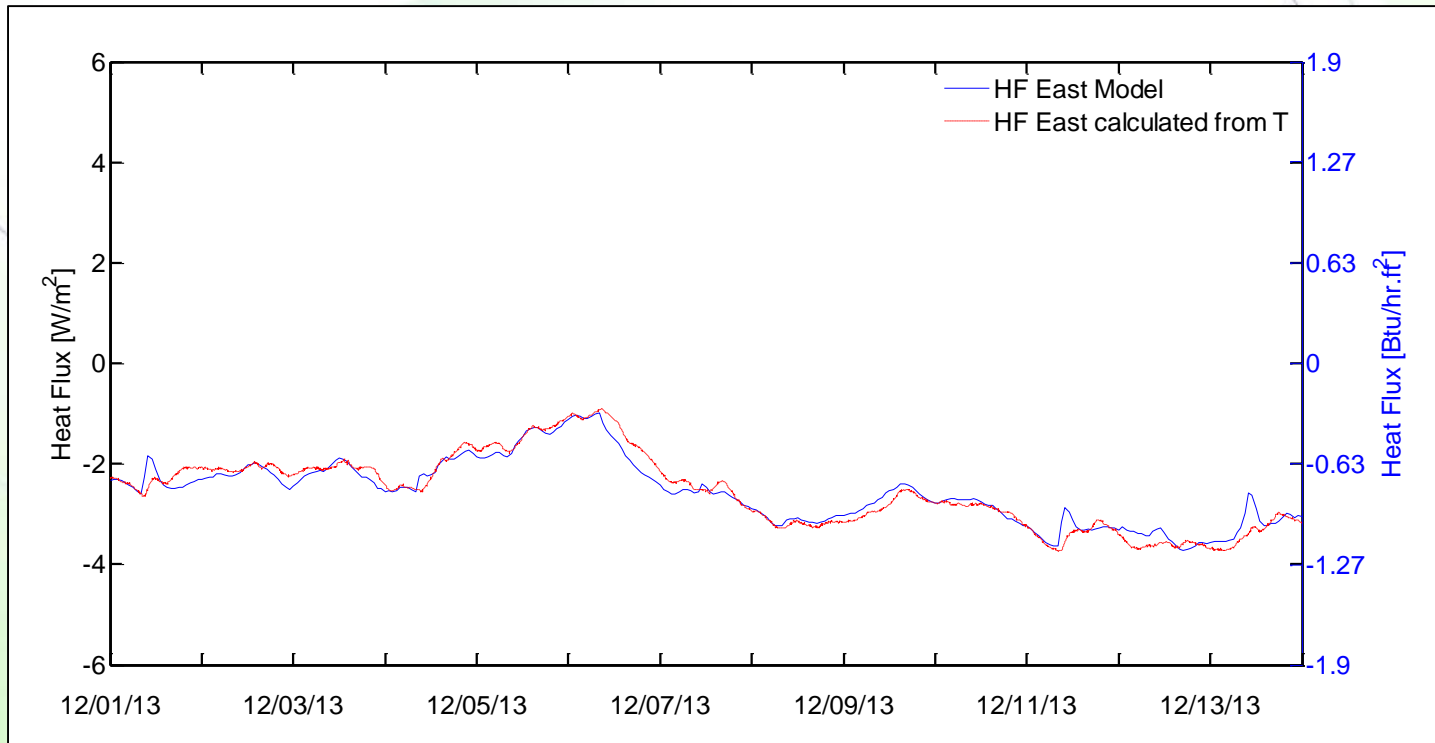
3 month comparison



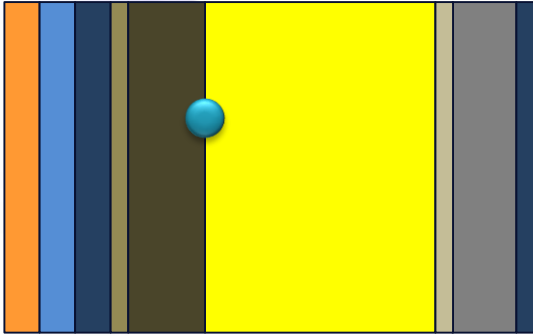
NZEB: Heat flux comparisons (East)



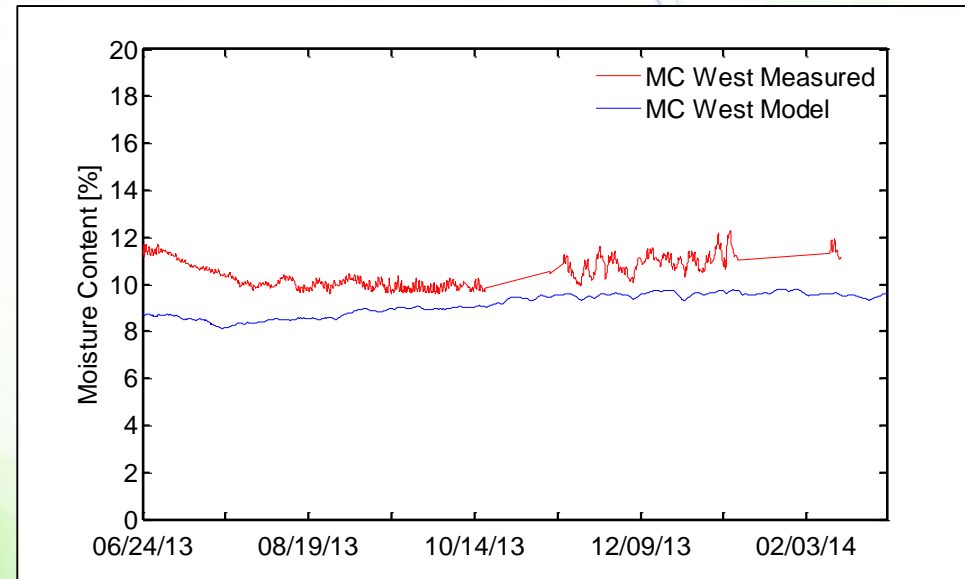
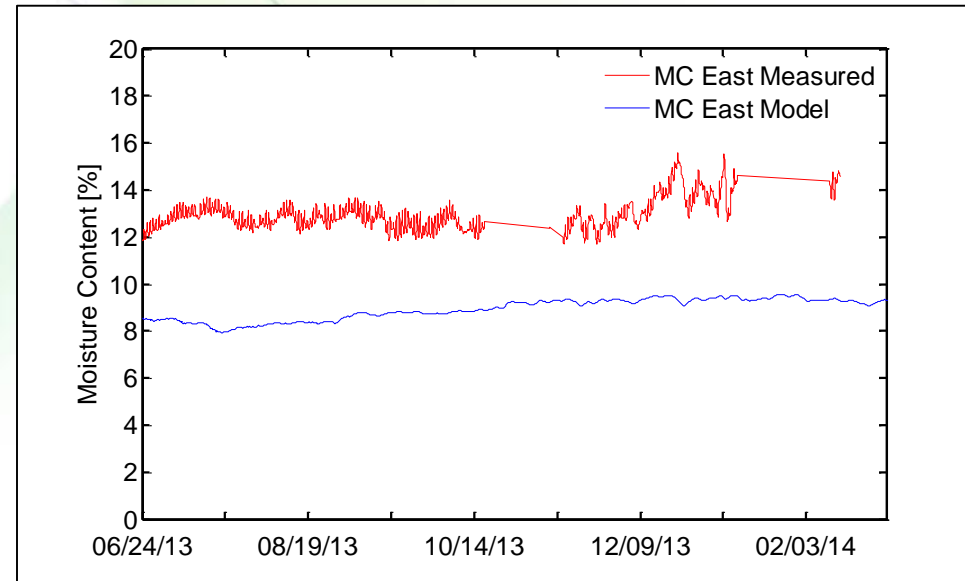
2 week comparison



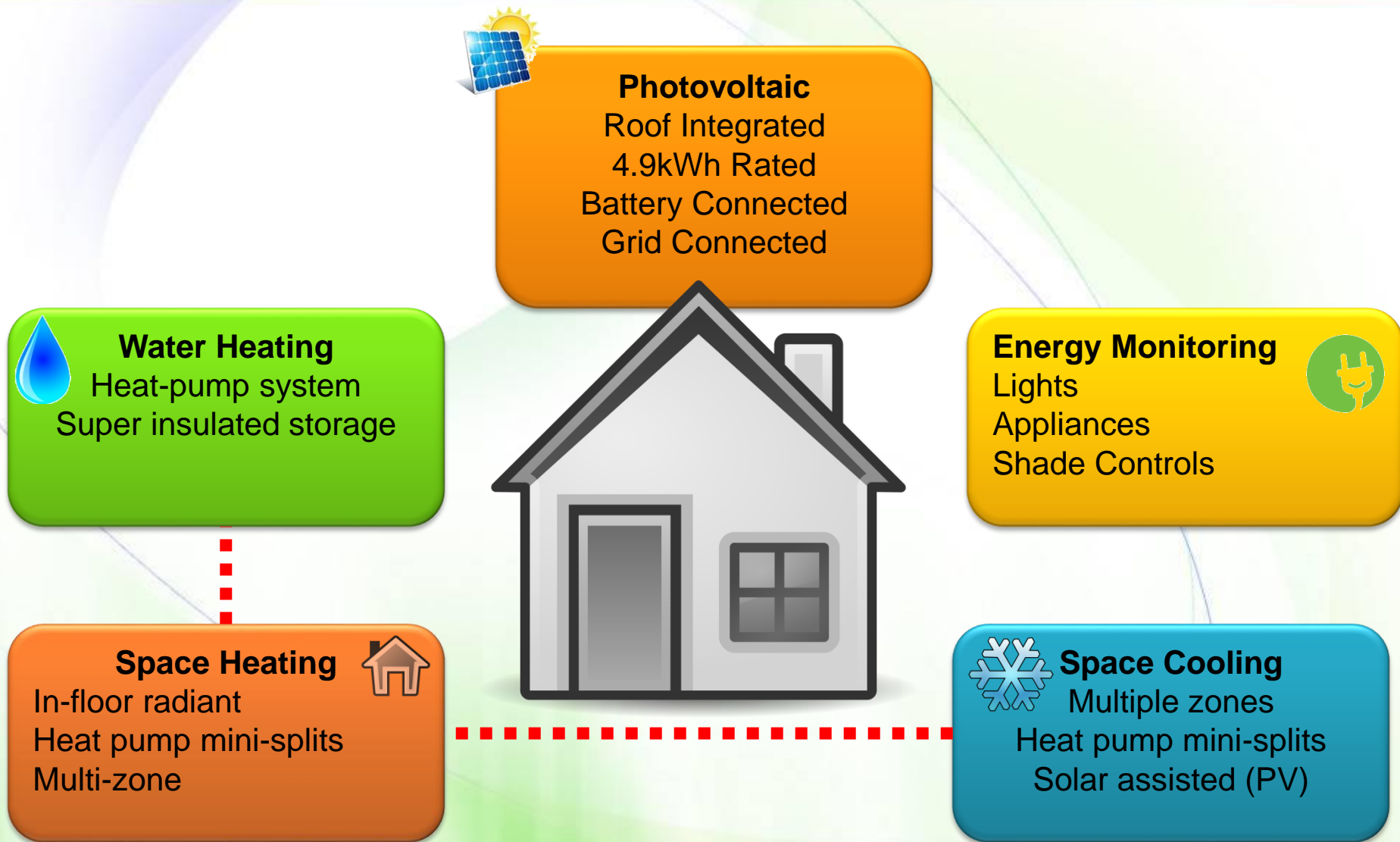
NZEB: OSB moisture content comparisons



- Trends and absolute MC value do not agree
- Periodic regime (model) vs. actual building state
- Actual measurements well below the 20% threshold

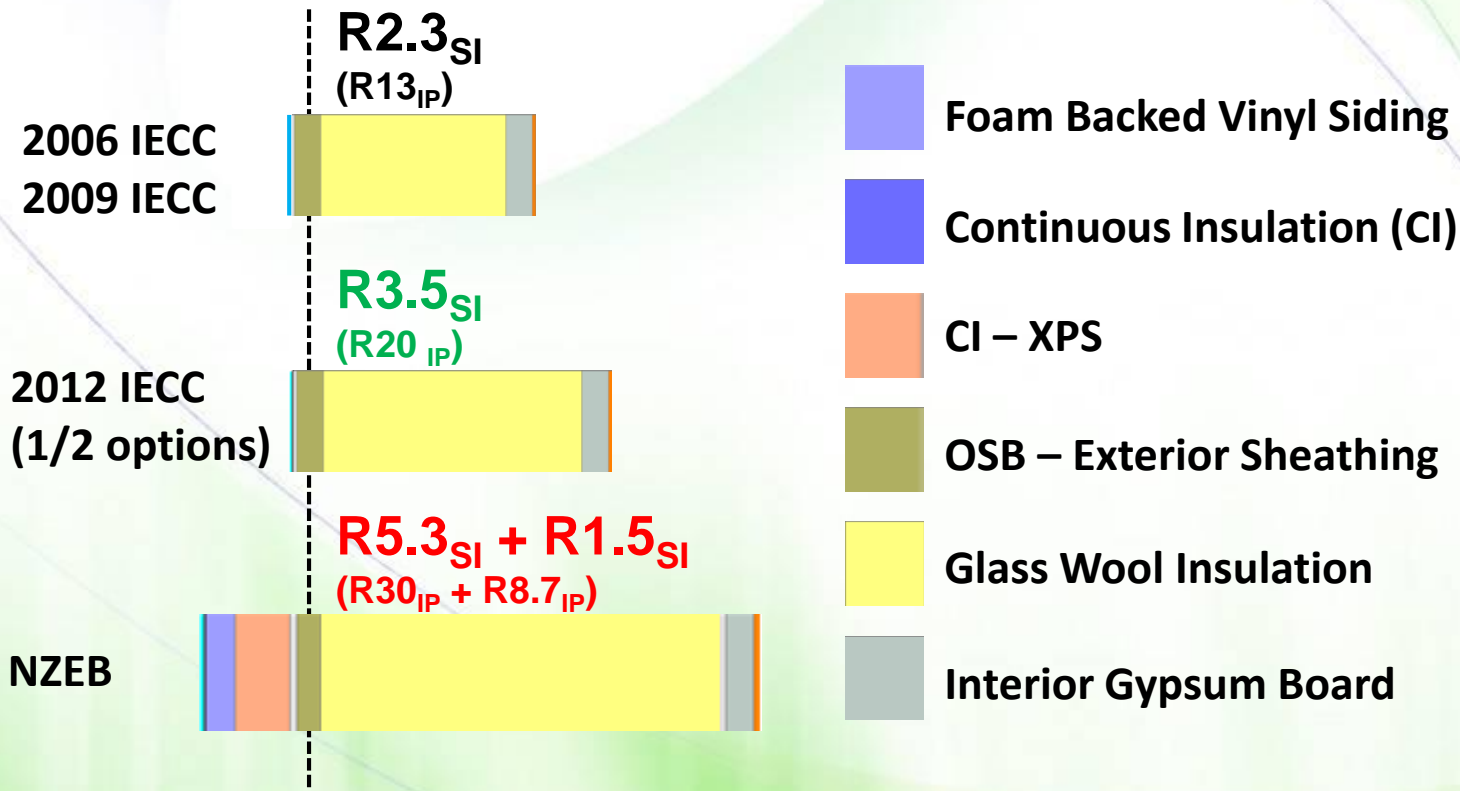


NZEB: Energy Analysis – Building Systems



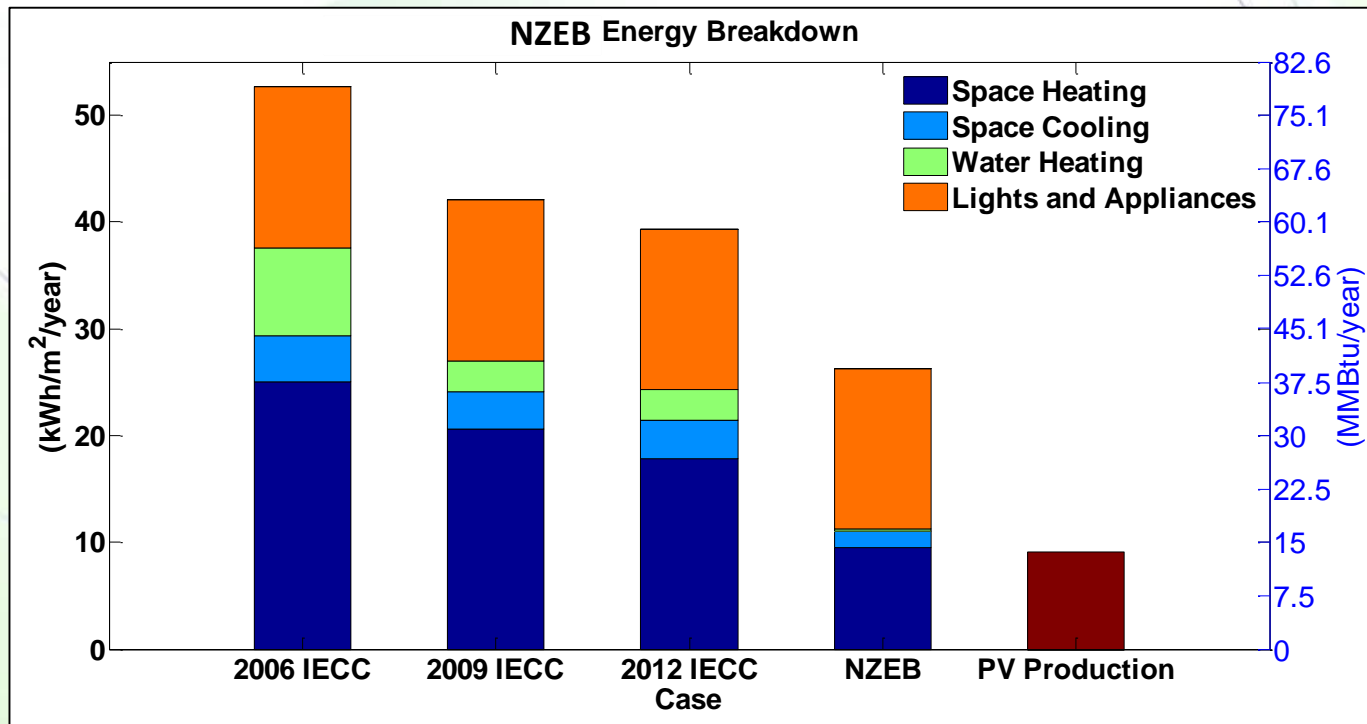
NZEB Energy Performance: Design predictions

Compare predictions (REM/Rate™) for NZEB at different IECC Code Requirements

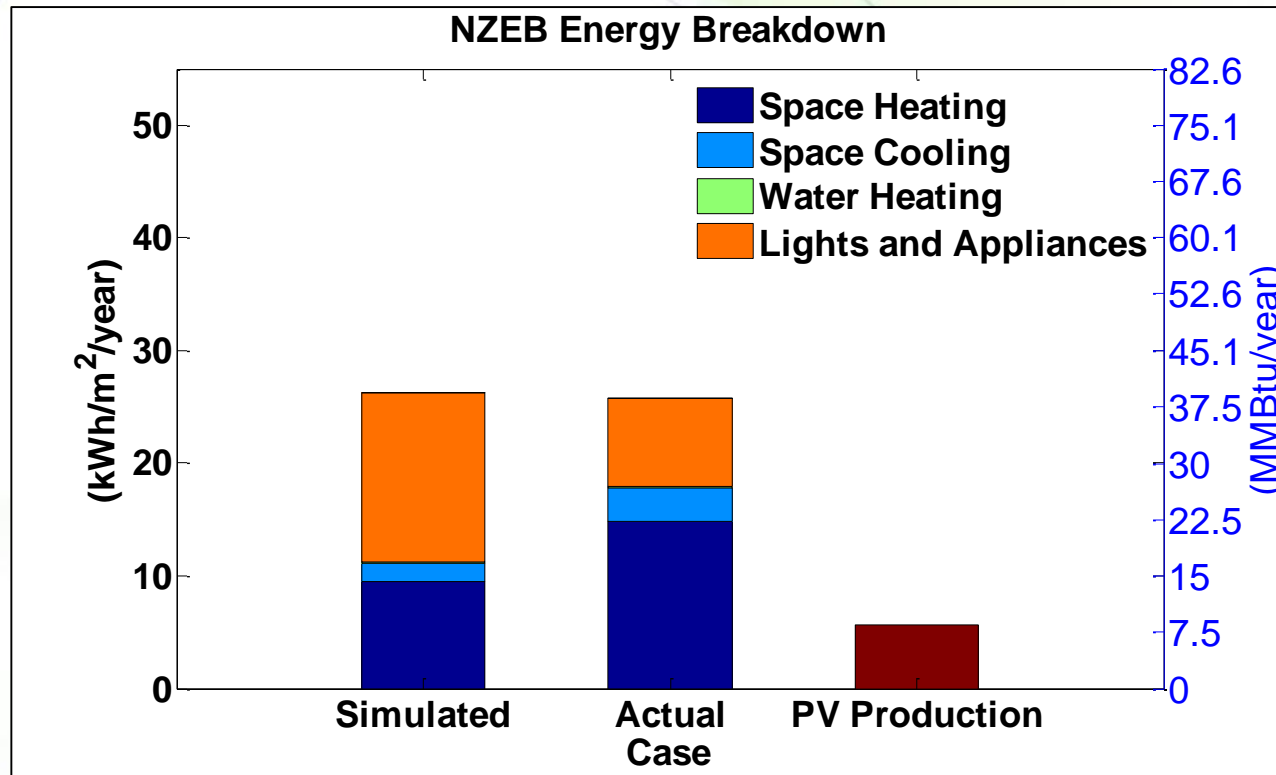


Energy Performance: Design predictions

- Design assumptions vary by code year
 - Occupancy
 - Temperature set points
 - Mechanical equipment performance
 - Infiltration
- Differences seen in predicted energy consumption a combination of insulation strategy and design assumptions



Energy Performance: Prediction vs. Actual



- Overall good agreement in total energy consumption
- Differences in distribution due to:
 - Assumed occupancy (based on single family home) vs. actual occupancy (office building)
 - Complex configuration of heating & cooling

Concluding Remarks

- NZEB modular home demonstrated
 - Unique construction methods
 - Unique wall insulation strategy
- Validated wall hygrothermal performance
 - Temperature, relative humidity, and heat flux measurements agree with simulated results
- Energy consumption
 - Measured total consumption compares well to simulated prediction
 - Breakdown differs largely due to building usage

Thank you!