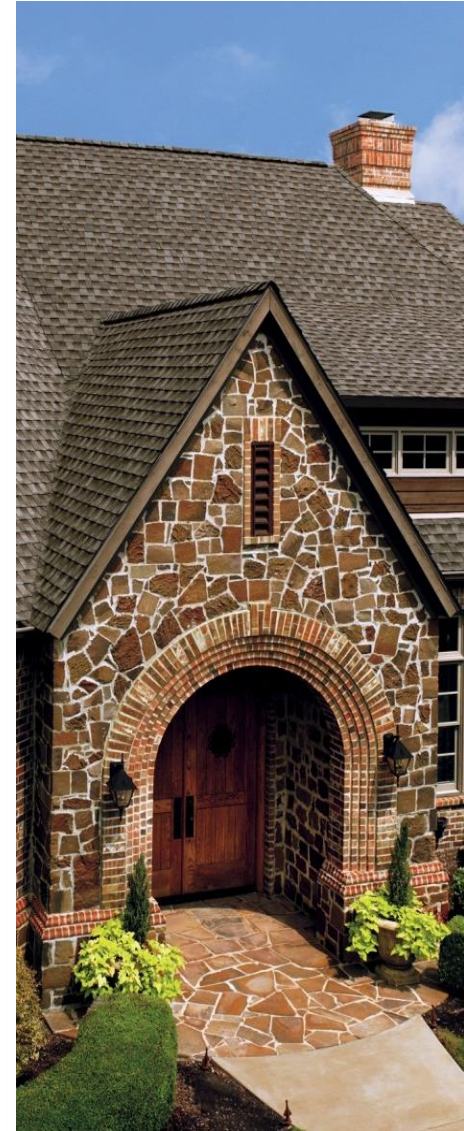


Field Study on the Thermal and Hygrothermal Performance of Insulated Ventilated Nail Base System

Buildings XIII International Conference

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GAF R&D, Parsippany, NJ

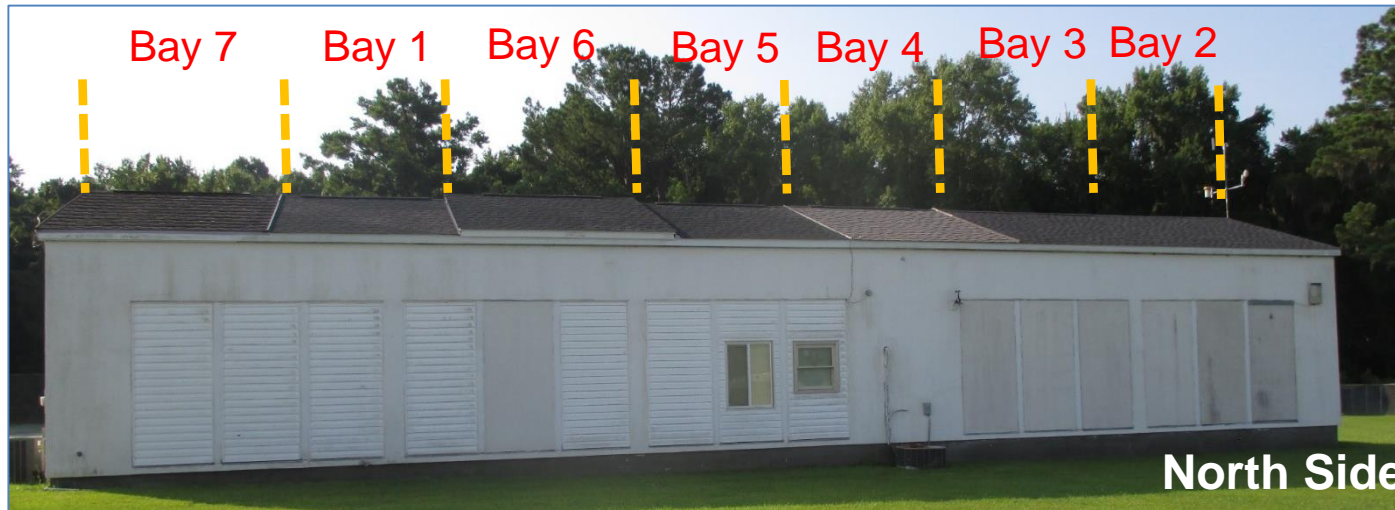
William A. Miller, Ph.D.; Andre Desjarlais, Ph.D.
ORNL, Oak Ridge, TN



Objectives

- **Conduct field study to understand the thermal and hygrothermal performance of attics having insulated vented nail base (IVNB) system or attic fitted with shingles having increased solar reflectance**
- **Compare and contrast their energy performance to typical 1:300 vented attic**
- **Investigate field performance of various attic configurations for potential above-sheathing solutions in deep energy retrofit of roofing assemblies**

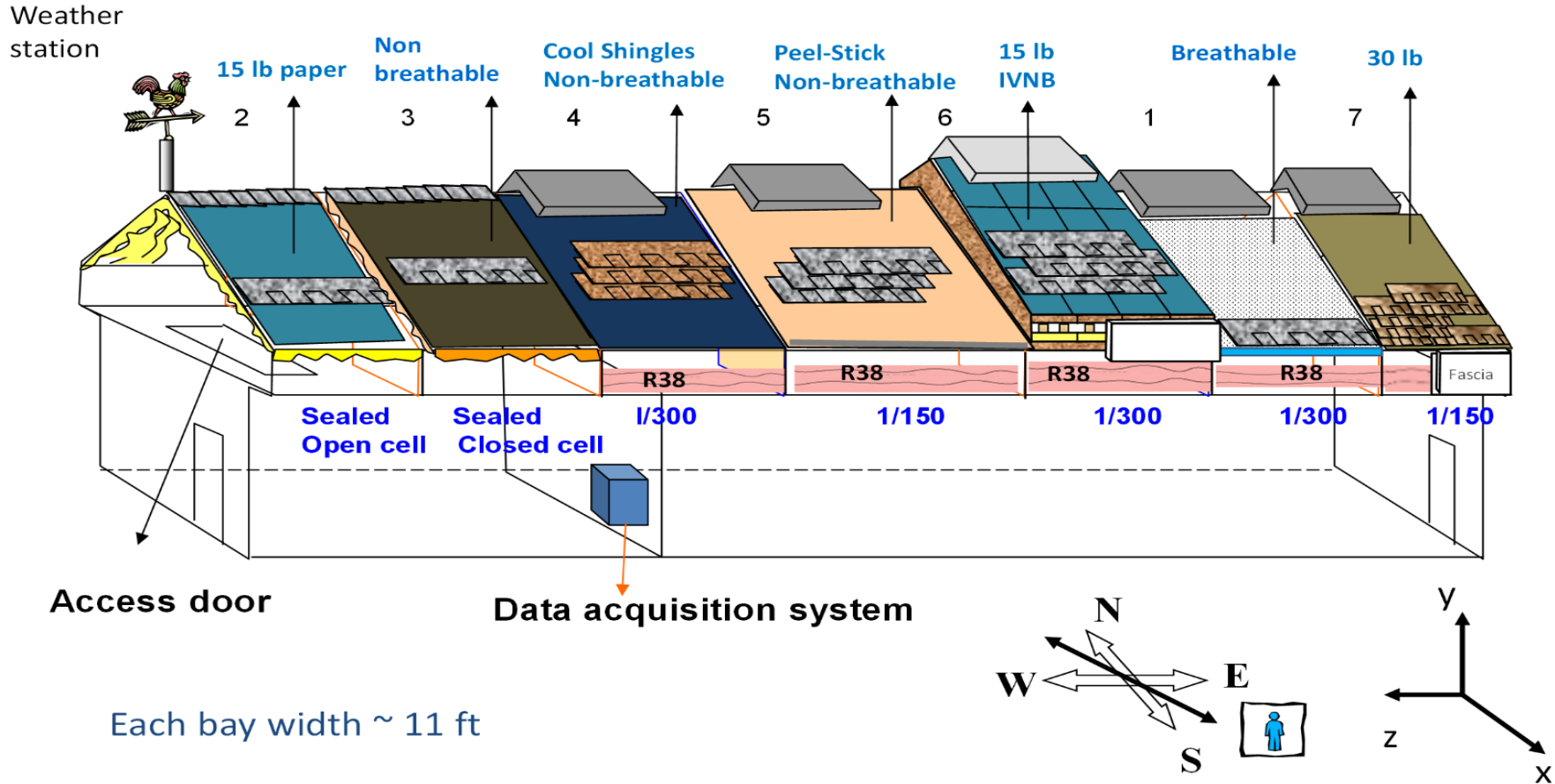
ORNL Natural Exposure Test Facility



Attic No.	Attic Insulation	Attic Ventilation	Underlayment	Roof Deck Configuration	shingle solar reflectance
1	R38 on attic floor	1/300 soffit-ridge	Synthetic breathable film (16 perm)	Asphalt Shingle	TSR=0.03
2	5.5" open cell spray foam on roof sheathing	None	15lb felt (8 perm)	Asphalt Shingle	TSR=0.03
3	5.5" closed cell spray foam on roof sheathing	None	Synthetic non-breathable (0.04 perm)	Asphalt Shingle	TSR=0.03
4	R38 on attic floor	1/300 soffit-ridge	Synthetic non-breathable (0.04 perm)	Asphalt Shingle; BIPV on south deck	TSR=0.28
5	R38 on attic floor	1/300 soffit-ridge	Peel and Stick non-breathable	Asphalt Shingle; BIPV on south deck	TSR=0.03
6	R38 on attic floor	1/300 soffit-ridge	15lb felt (8 perm)	IVNB (1/100) & Shingle	TSR=0.03
7	R38 on attic floor	1/150 intake-ridge ventilation	30lb felt (5 perm)	Metal Shingles	TSR~0.10

Attic Configurations

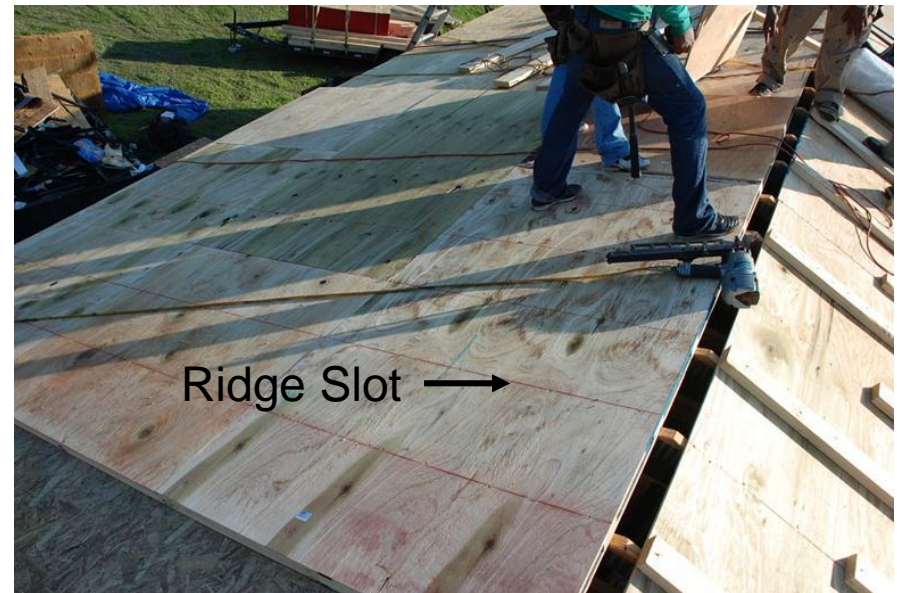
Attic Bay Features Diagram



Deck Installations

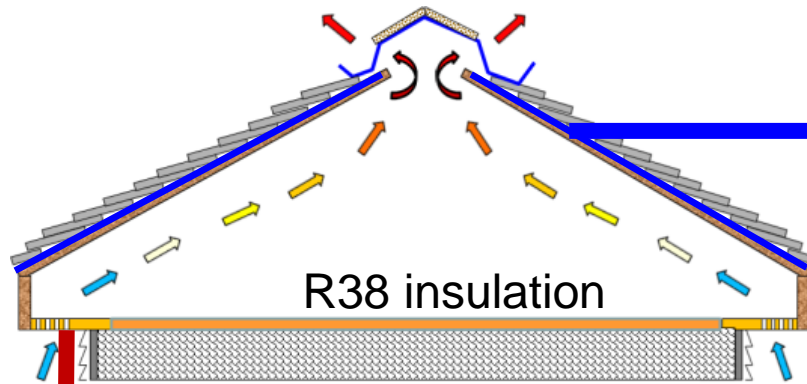


↑
Ridge Slot



Ventilation for Control Attic

Soffit-Ridge 1:300 ventilated attic

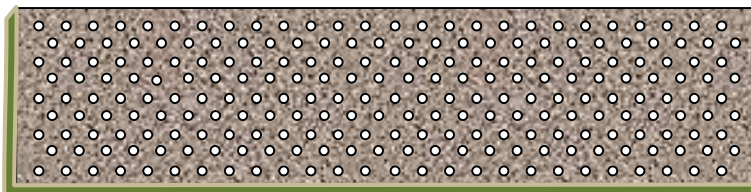


Breathable underlayment
16 perm



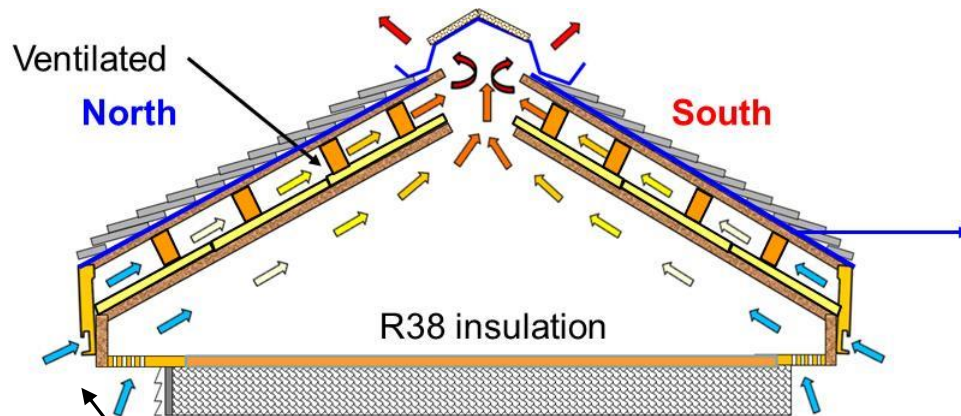
Reduced opening
Ridge NFVA = 9 in²/ft

Perforated Intake vent NFVA = 3 in²/ft

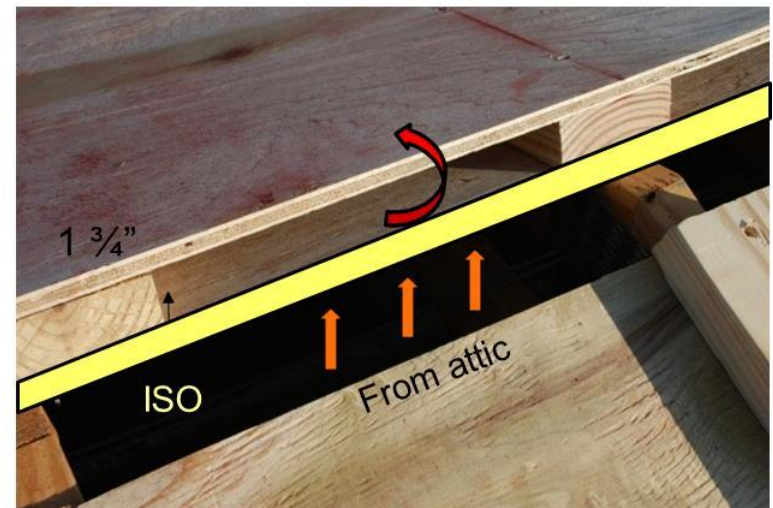


IVNB System in Attic 6

- 2" ISO board over roof sheathing and 1- 1/2" air gap followed by plywood as nail base; 15# felt and dark shingles
- Fascia intake fan on eave to provide 1/100 ridge ventilation



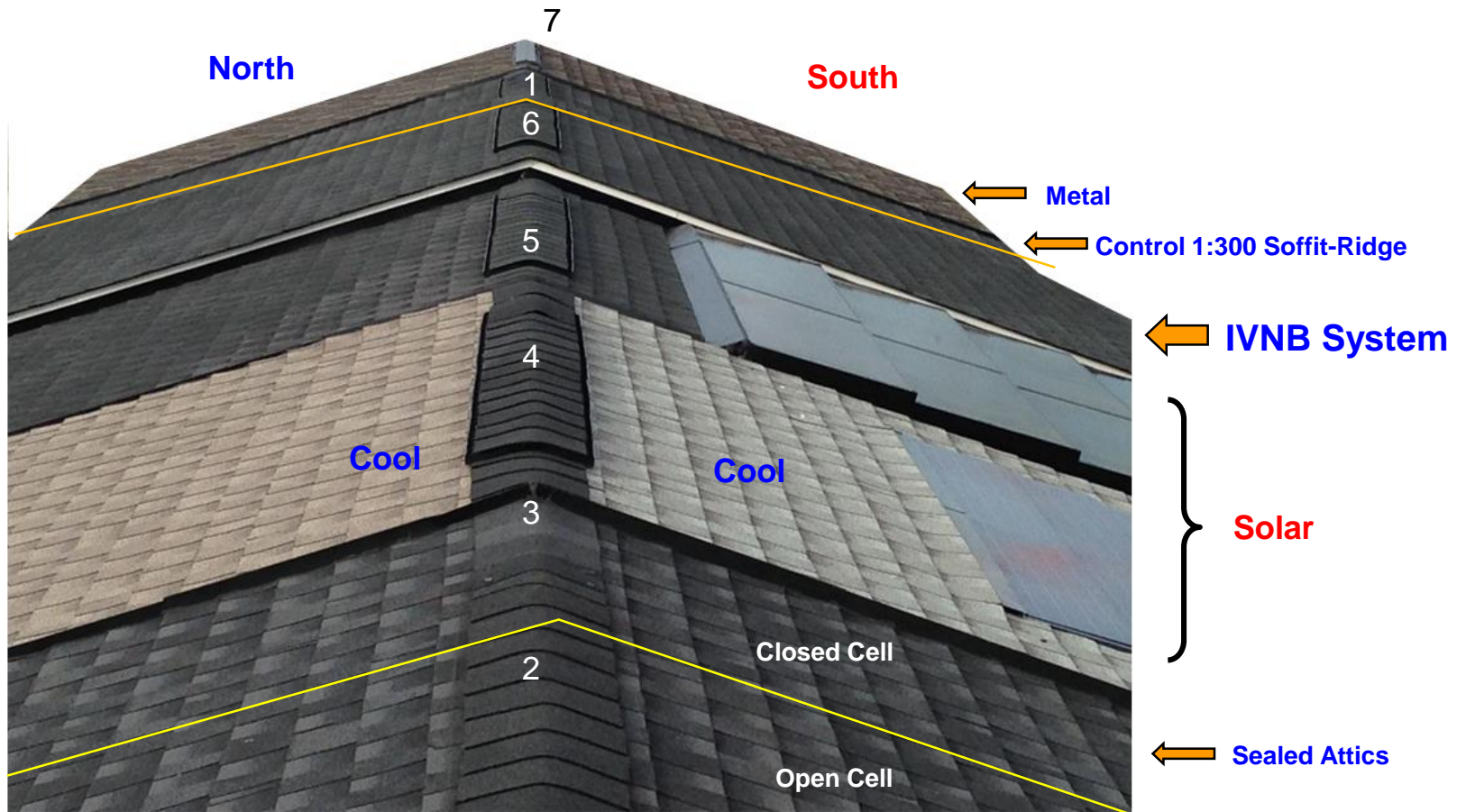
Underlayment
15 lb paper
8 perm



Ridge vent and shingle installation



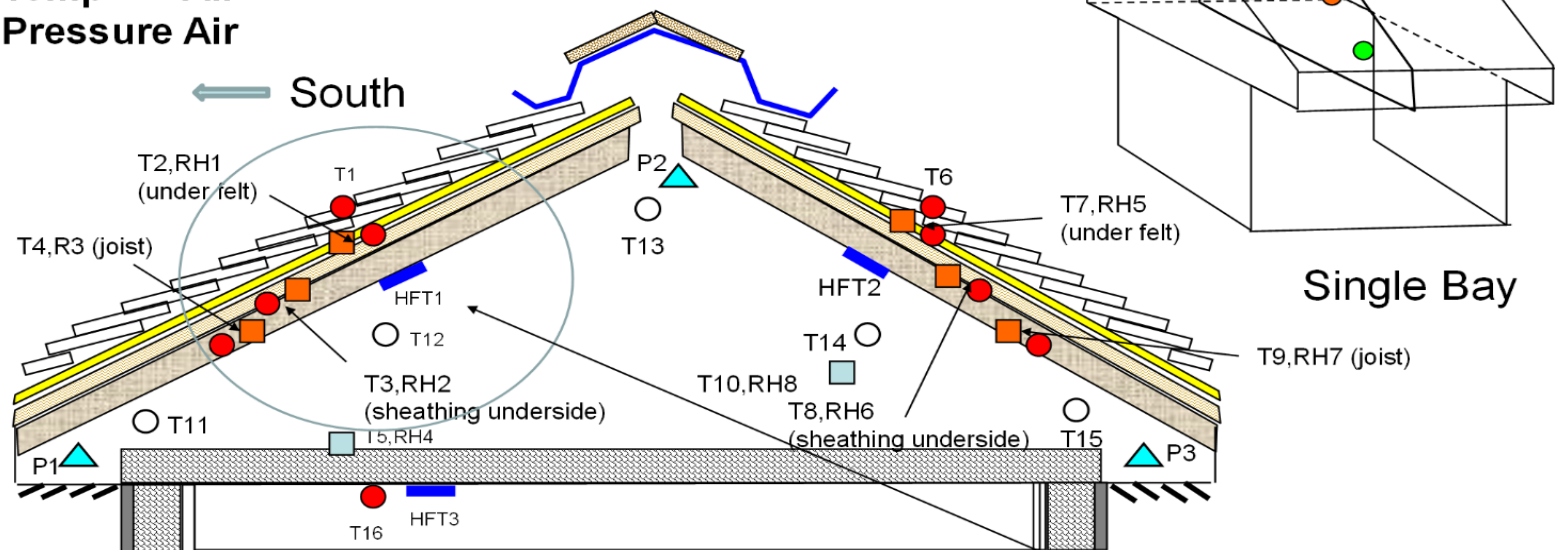
Completed Roof Configurations



Sensors and Instrumentations

ORNL-South Carolina exposure farm sensor C/S view

- Temp Roof surface, Underlayment, deck
- Rh Underlayment, deck, Rafters, Insulation
- Heat flux Roof deck, attic floor
- Temp Air
- ▲ Pressure Air

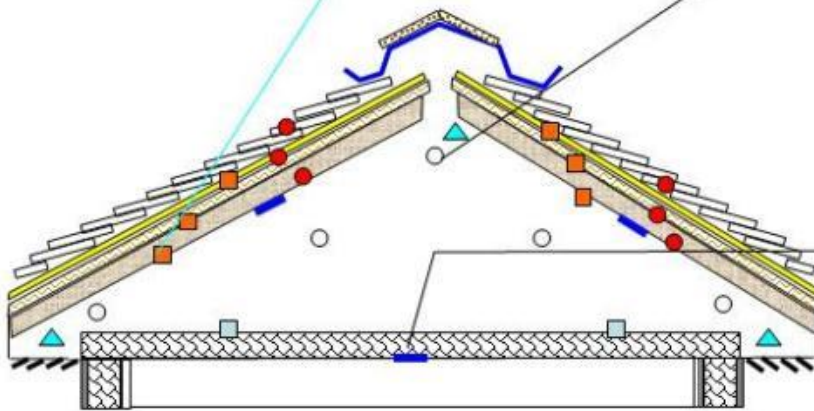
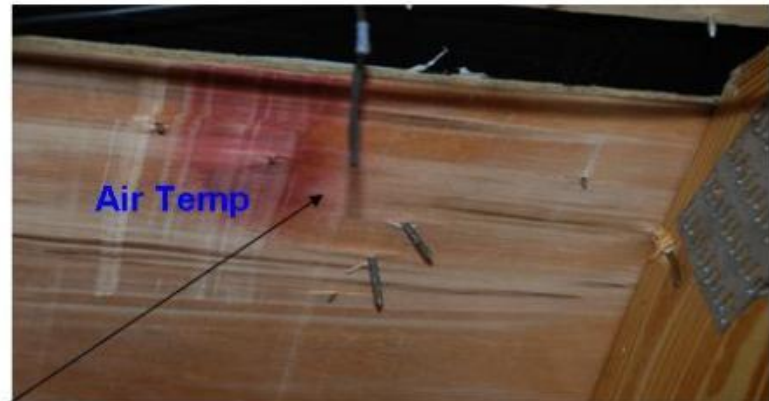
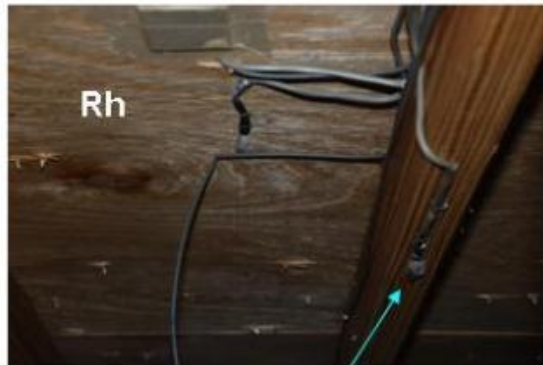


- In each bay
- 6 temperature sensors, 6 Rh sensors, 3 Heat flux sensors
- Total 15 sensors per bay + 5 for air temperature
- 3 attic pressure and 2 sensors for insulation = 25 sensors per bay

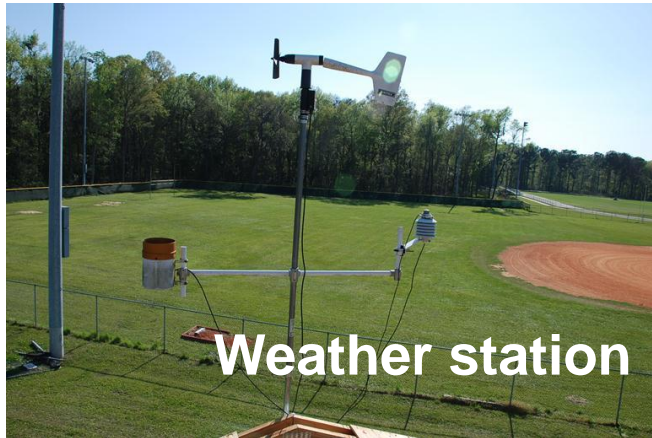
These sensors are all in the Same vertical plane, both sides

Sensors

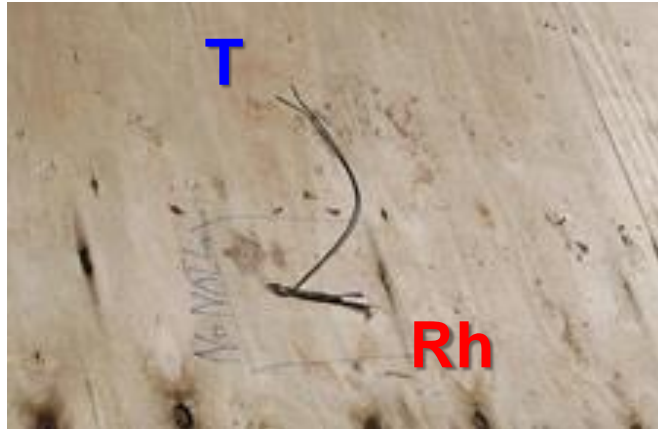
- Temp Roof surface, Underlayment, deck
- Rh Underlayment, deck, Rafters, Insulation
- Heat flux Roof deck, attic floor
- Temp Air
- ▲ Pressure Air



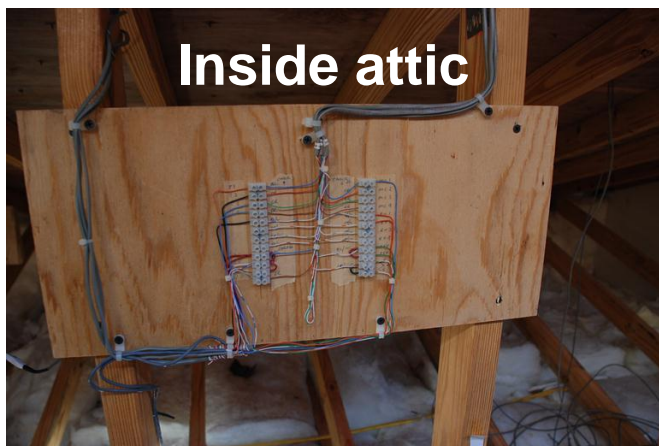
Instrumentation



Sensors on deck



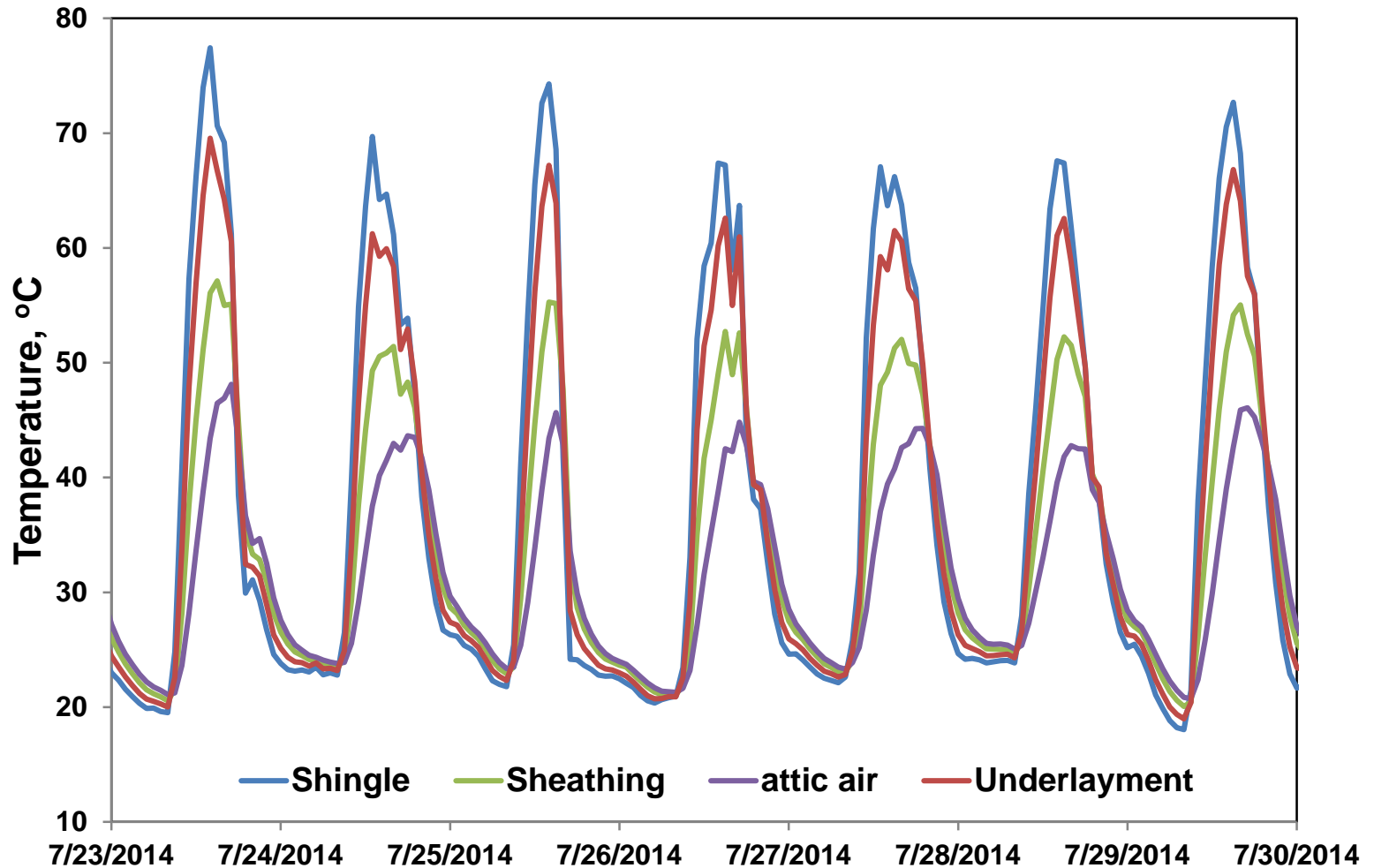
Data acquisition



Temperature profiles across roof deck

- Control Attic – Attic #1 with 1/300 ventilation during summer

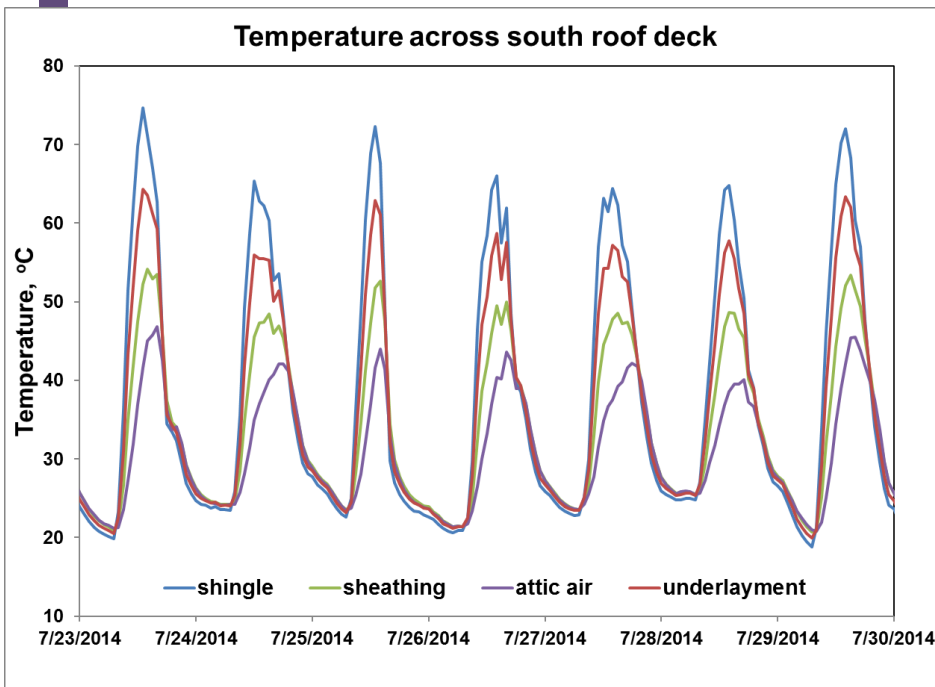
Temperature across south roof deck



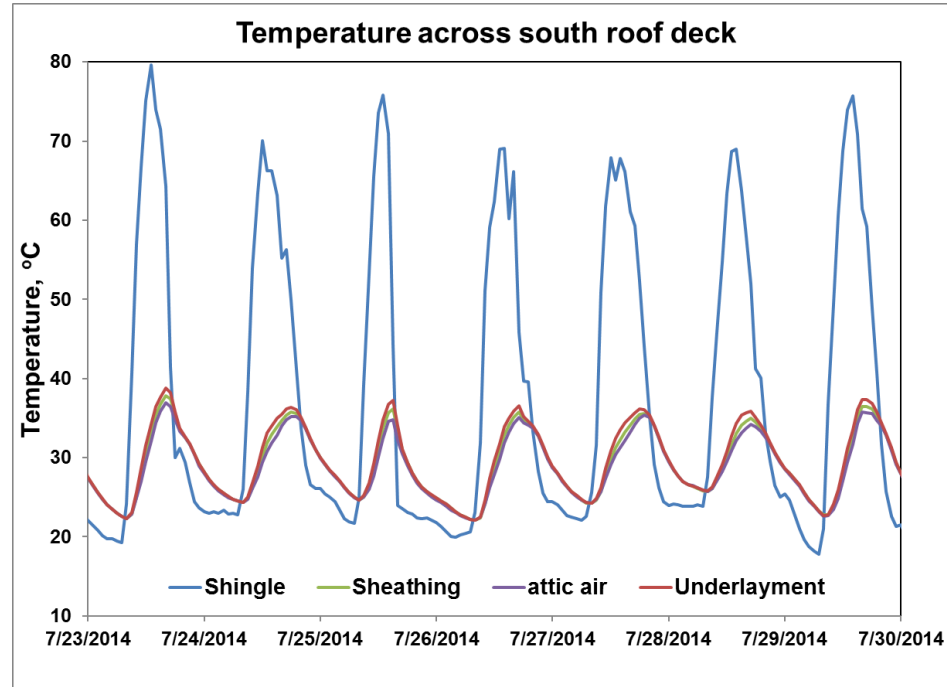
Attic air temperature comparisons

- **IVNB system showed a drop of 10°C in attic air temperatures, despite higher roof temperatures**
- **Attic #4 with increased solar reflectance only showed ~3-5°C drop in attic air**

Attic #4 – 28% solar reflectance



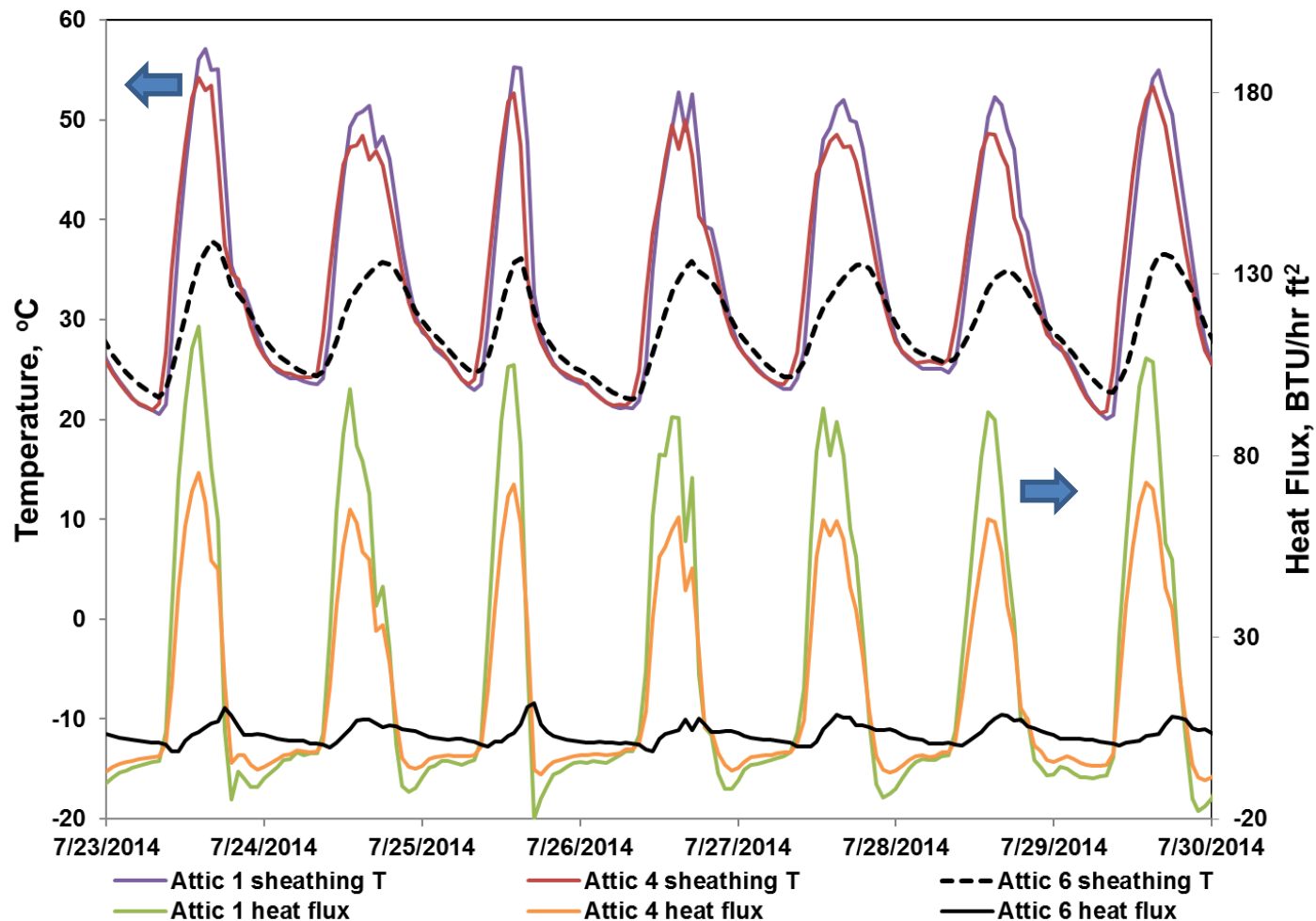
Attic #6 – IVNB system



Heat flow across the roof deck

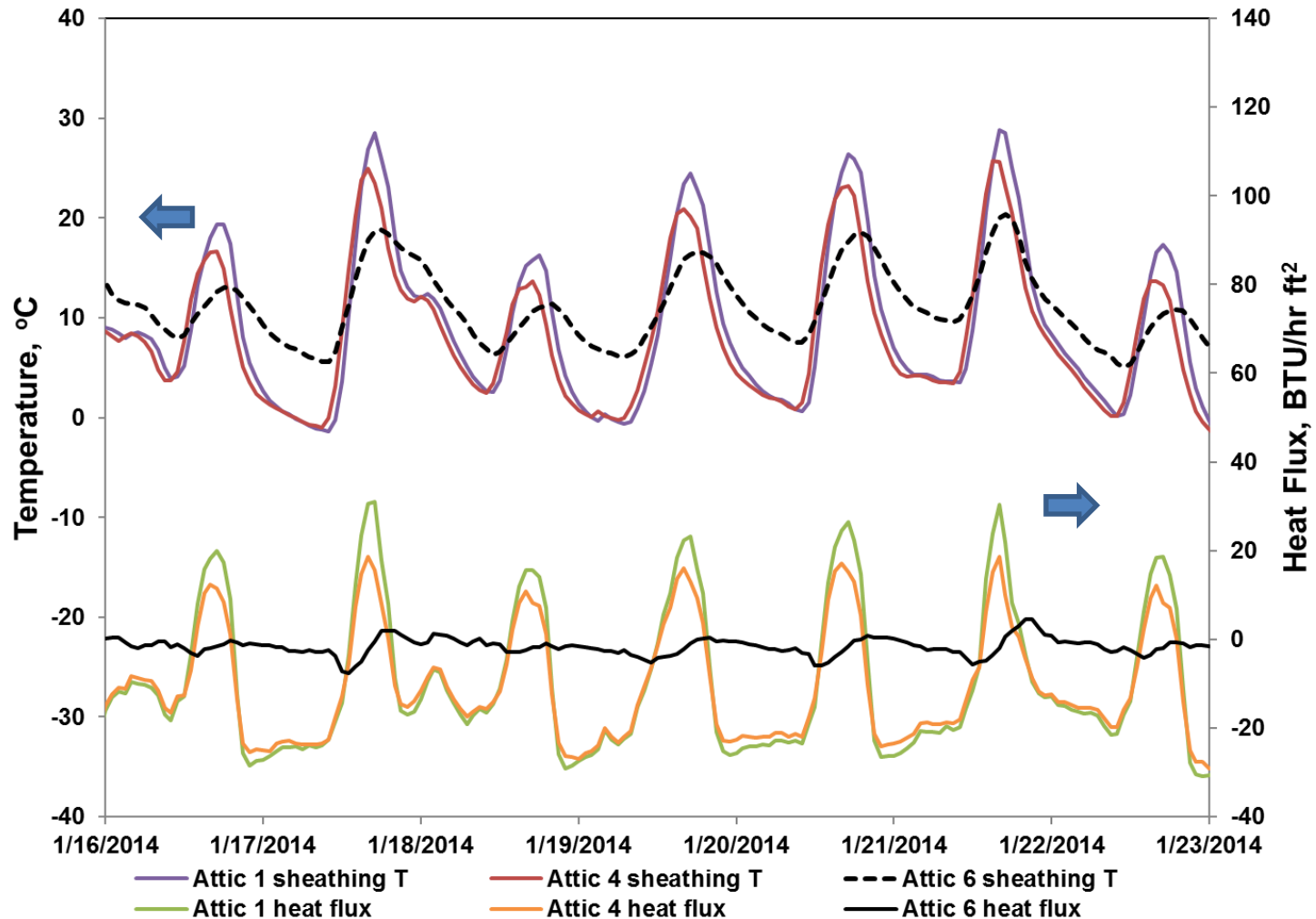
- IVNB system is found to significantly reduce heat flux through roof deck during summer season

Roof temperatures and roof deck heat flux comparison



Heat flow in winter time

- IVNB system can reduce heat loss during nighttime, however, solar heat gain during daytime was reduced



Potential Annual Energy Savings

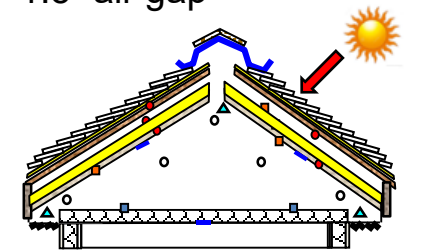
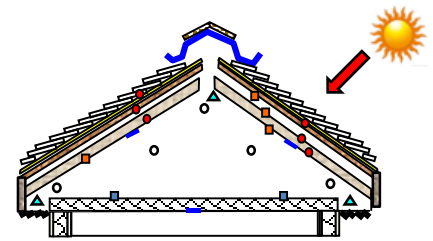
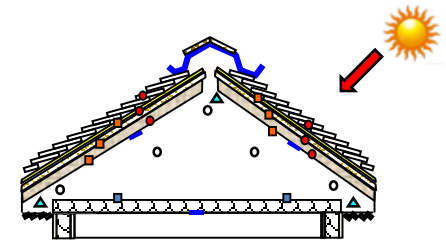
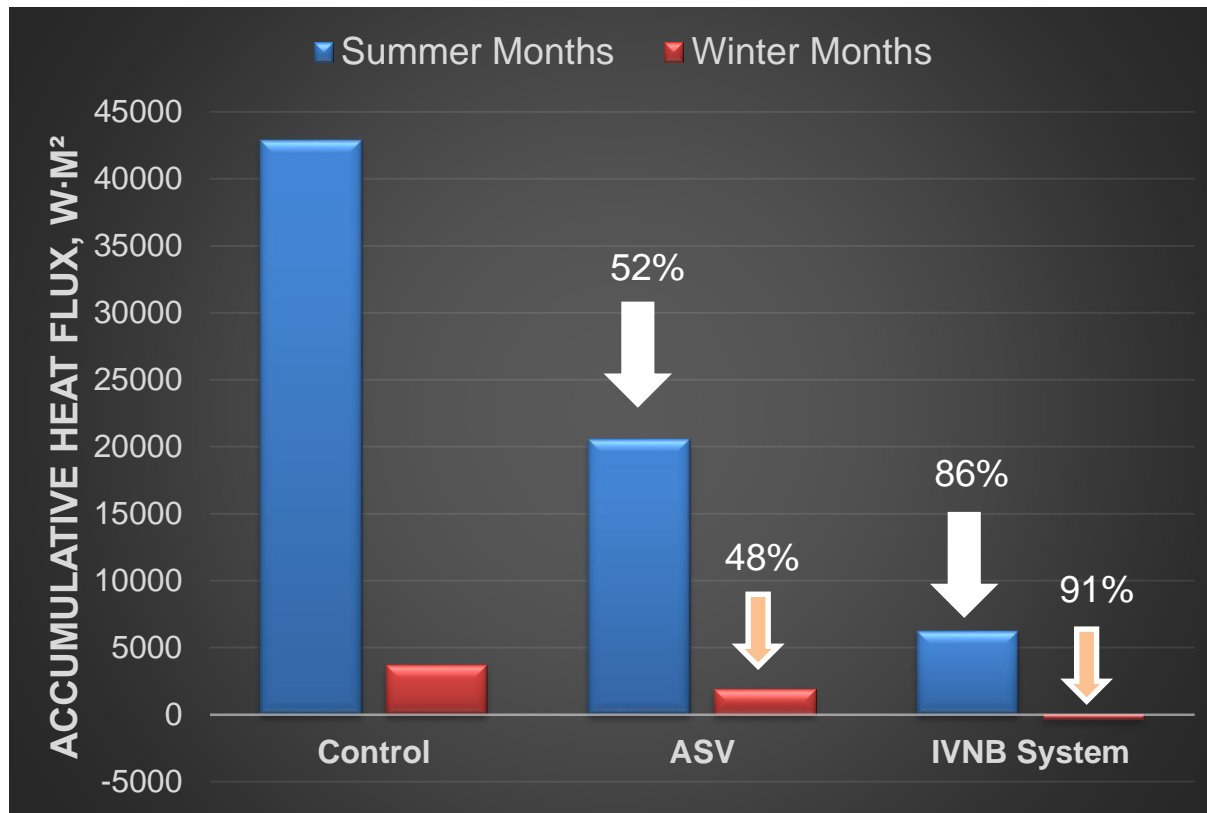
- Energy simulations using ORNL AtticSim model for two ASHRAE cities in zone 2 and 6
- IVNB system shows significant energy reduction over typical attic with 1:300 ventilation
 - 16.5% reduction in energy use in Austin, TX
 - 11% drop of energy consumption in Minneapolis

Attic	Attic Floor/Roof R-Value	Ceiling Heat Flow (kBtu/yr)		Duct Heat Losses (kBtu/yr)		Annual (kBtu/yr)
		Cooling	Heating	Cooling	Heating	
Climate Zone 2, Austin, Tx						
Control	R40/R0	2,123	-1,324	3,525	-4,137	20,089
IVNB	R40/R06	404	-858	2,991	-6,551	16,736
Climate Zone 6, Minneapolis, MN						
Control	R40/R0	453	-5,021	1,390	-22,143	36,755
IVNB	R40/R06	36	-4,519	774	-21,431	32,704

Simulations for ASHRAE Climate zone 2 and 6 for the IVNB attic containing 10” duct wrapped in R-8 insulation and leaking 8%. Attic ventilation set at 1:300

Effect of ISO vs. Air Gap

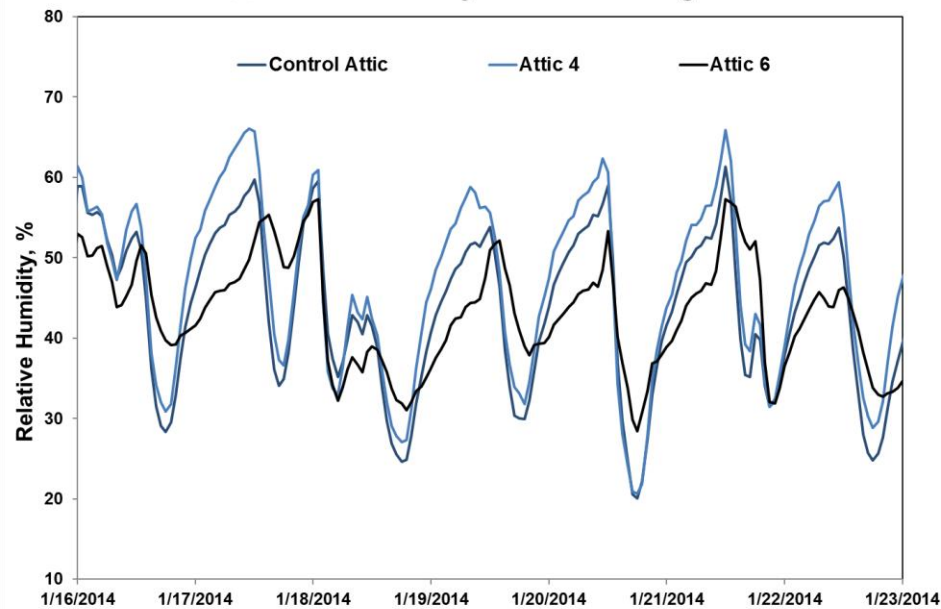
- Separate effect of Air Gap and ISO based on heat flux reduction
- Heat reduction is approximately 20% per inch of ISO insulation on the deck
- Hence to get same effect as IVNB you need 4 inches of ISO on the deck



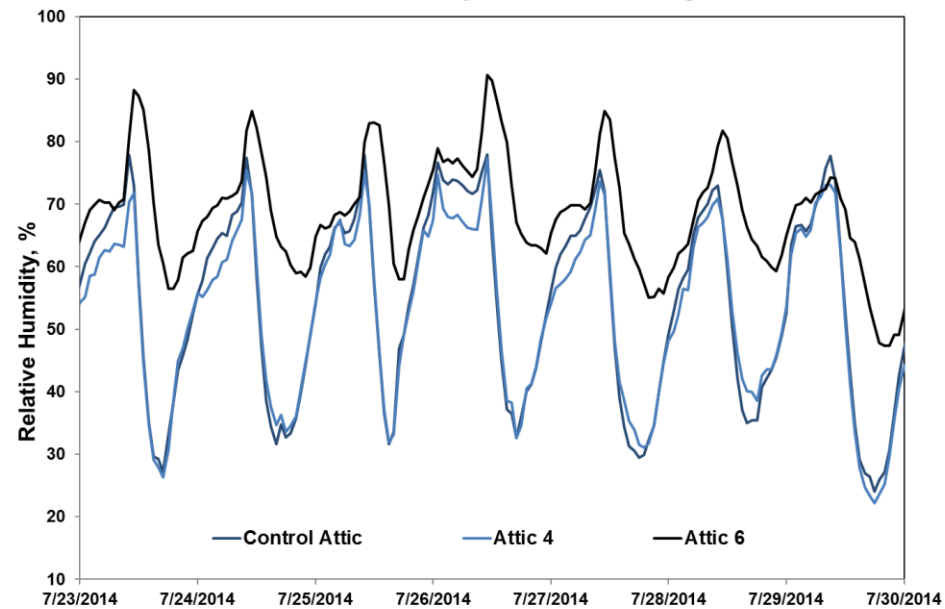
Attic moisture comparison

- The field data revealed that attic air has lower %Rh in IVNB system during cold seasons
- The attic with IVNB system showed higher %Rh in attic air during summer season
 - Lowered attic air temperature resulting in reduction of stratification and lowered air movement

% Relative Humidity of Attic Air during Winter



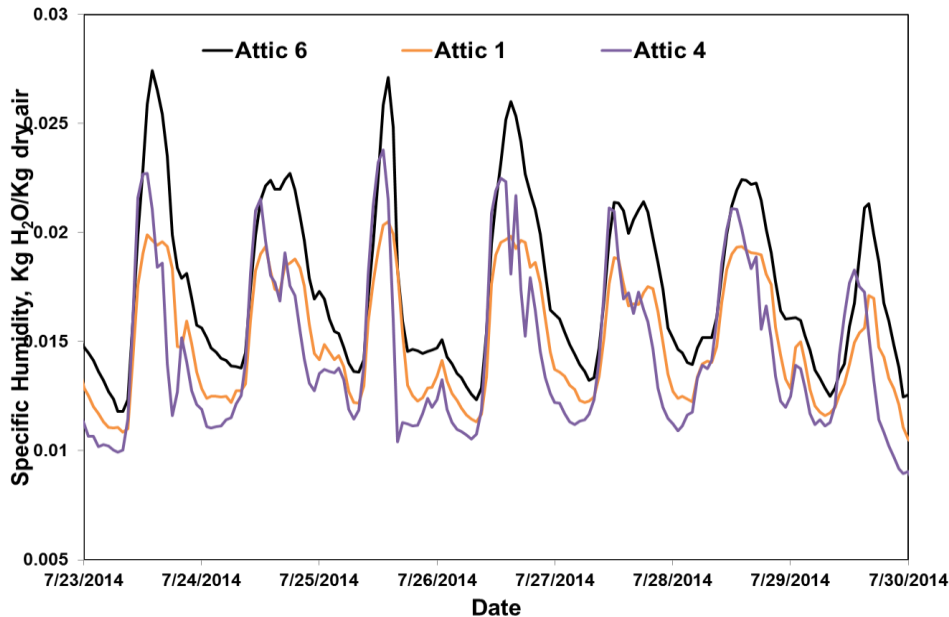
% Relative Humidity of Attic Air during Summer



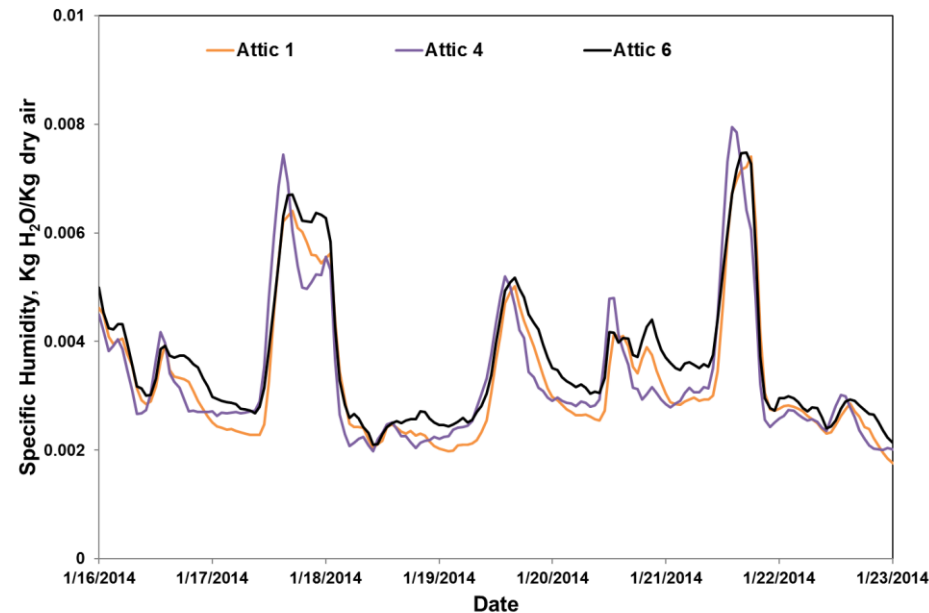
Attic moisture comparison

- Similar specific humidity in attic air during winter
- The attic with IVNB system showed slightly higher moisture level in attic air during summer season
 - Lowered attic air temperature for reduced soffit-ridge attic ventilation

Specific Humidity Comparison in summer - North roof



Specific Humidity Comparison in winter month - north roof



Summary

- **The field performance of attics with IVNB system, with increased solar reflectance, and a standard vented attic were studied in hot, humid climate**
- **The data revealed that IVNB system can drastically reduce heat flux across roof deck and result in significant reduction of energy use**
- **IVNB system was found to provide much higher energy saving potential than the attic with increased solar reflectance**
- **The attic with IVNB system was found to have slightly higher moisture content but the differences are within seasonal fluctuations**
- **The IVNB can be an attractive above-sheathing solution for roof energy retrofit**