Building Envelope Program

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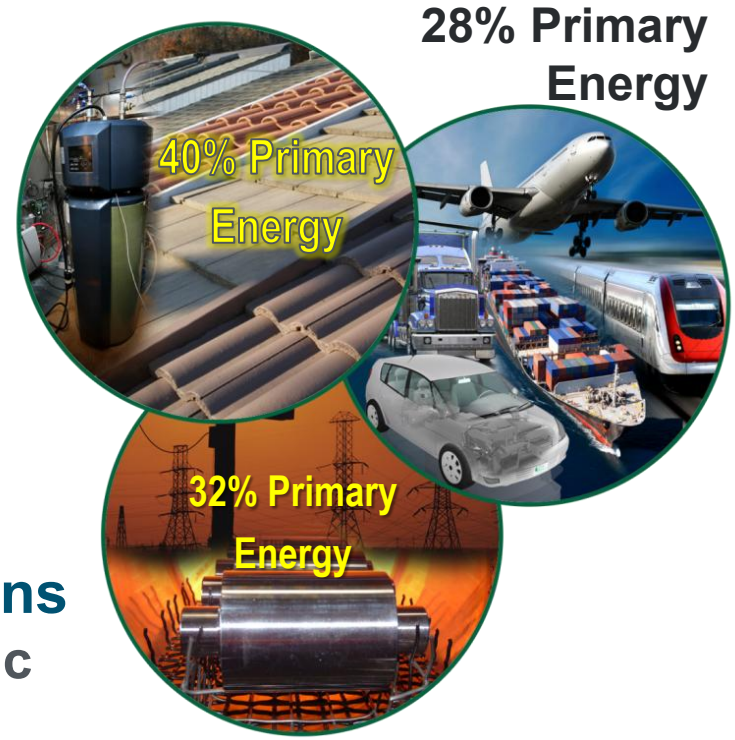
- Dr. Som Shrestha
- Kaushik Biswas, Ken Childs, Jerald Atchley, Phil Childs
- Andre Desjarlais (Group Leader)



Goals: Develop New Roof and Attic Designs

- Reduce Space Conditioning Due to Attic
- Convince Industry to Adopt Designs

Next Generation Attics and Roof Systems

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April 4, 2013

Purpose & Objectives

Problem: Roof and attic subjected to greater temperature extremes than any other component of building envelope.

- Susceptible to heat stress and moisture damage.
- Attributes to 15% of building load (Ducts in Attic )

Impact: Develop new designs to drop space conditioning load due to attics by 50% of IECC 2009.

- Energy saving of order 0.5 Quad for new sealed attic designs
- Green-house-gas (GHG) emissions from buildings exceed both industrial and transportation

Focus: Next generation attic system consistent with BT Multi-Year Work Plan (2011-2015)

- Top retrofit practice for building owners (Replace Roof)
- Market acceptance of new designs for retrofit and new buildings
  - Affordable, efficient, reduce GHG emissions
  - Reduce U.S. energy use

Ventilated Attic Approach

Quarter	**Field and analytical thermal, hygrothermal study** Deliverable/Milestone	Status
1	Attic tracer gas field tests at NET facility	Complete
2	Reduce tracer gas data and benchmark AtticSim	Complete
3	CFD model to formulate and validate air exchange rate correlations	On schedule
4	3M prototype roof and attic field tests	On schedule

General Aniline & Film (GAF). Founded in 1886, GAF has become the largest roofing manufacturer in North America.

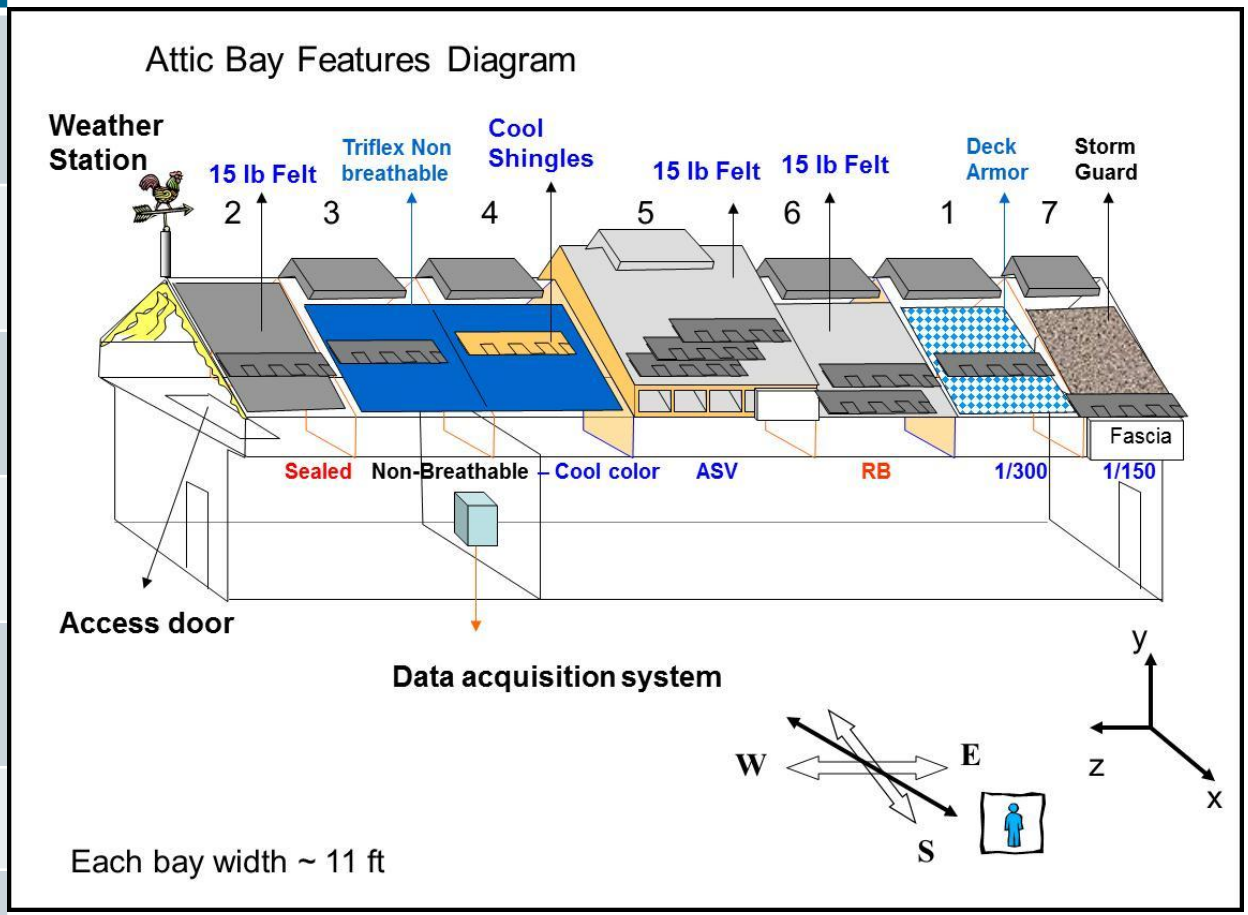
- 24 plants nation wide
- Revenue of $3 billion

formerly **Minnesota Mining and Manufacturing Company**
Revenue of $30 billion in sales, employs 84,000 people, and produces more than 55,000 products.

GAF Collaboration
NET Facility Charleston, SC

Attic Cavity	Acronym
Attic 01	CTRL (16 Perm) Vapor permeable underlayment
Attic 02	SLD (8 Perm) Semi permeable
Attic 03	NB (0.04 Perm) Vapor impermeable
Attic 04	CC (0.04 Perm) Vapor impermeable
Attic 05	ASV (8 Perm) Semi permeable
Attic 06	RB (8 perm) Semi permeable
Attic 07	FF (0.10 Perm) Vapor semi impermeable

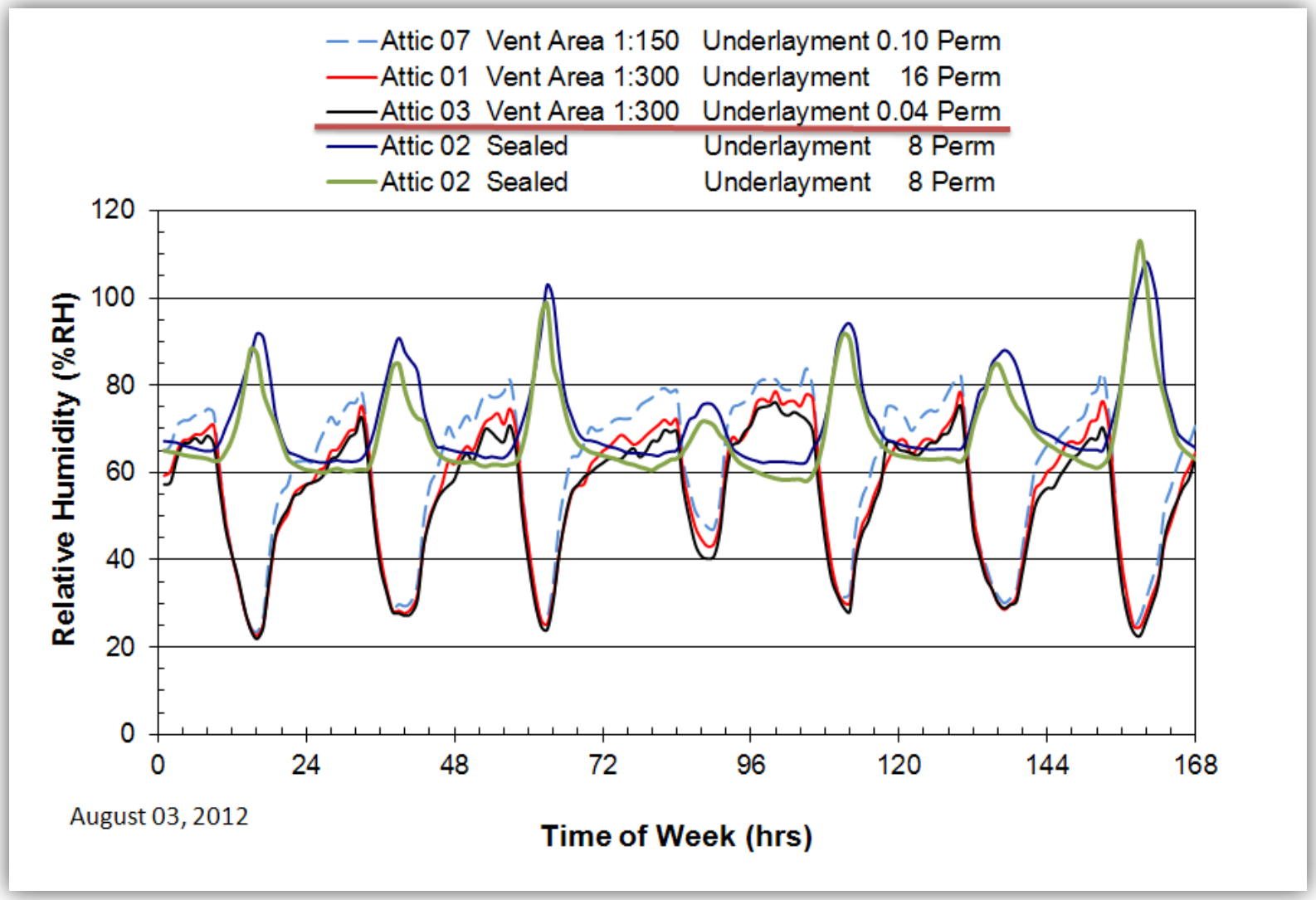
Established Benchmarks for all Attics



Breathability: < 0.1 perm vapor impermeable
> 1.0 and < 10.0 perm semi permeable

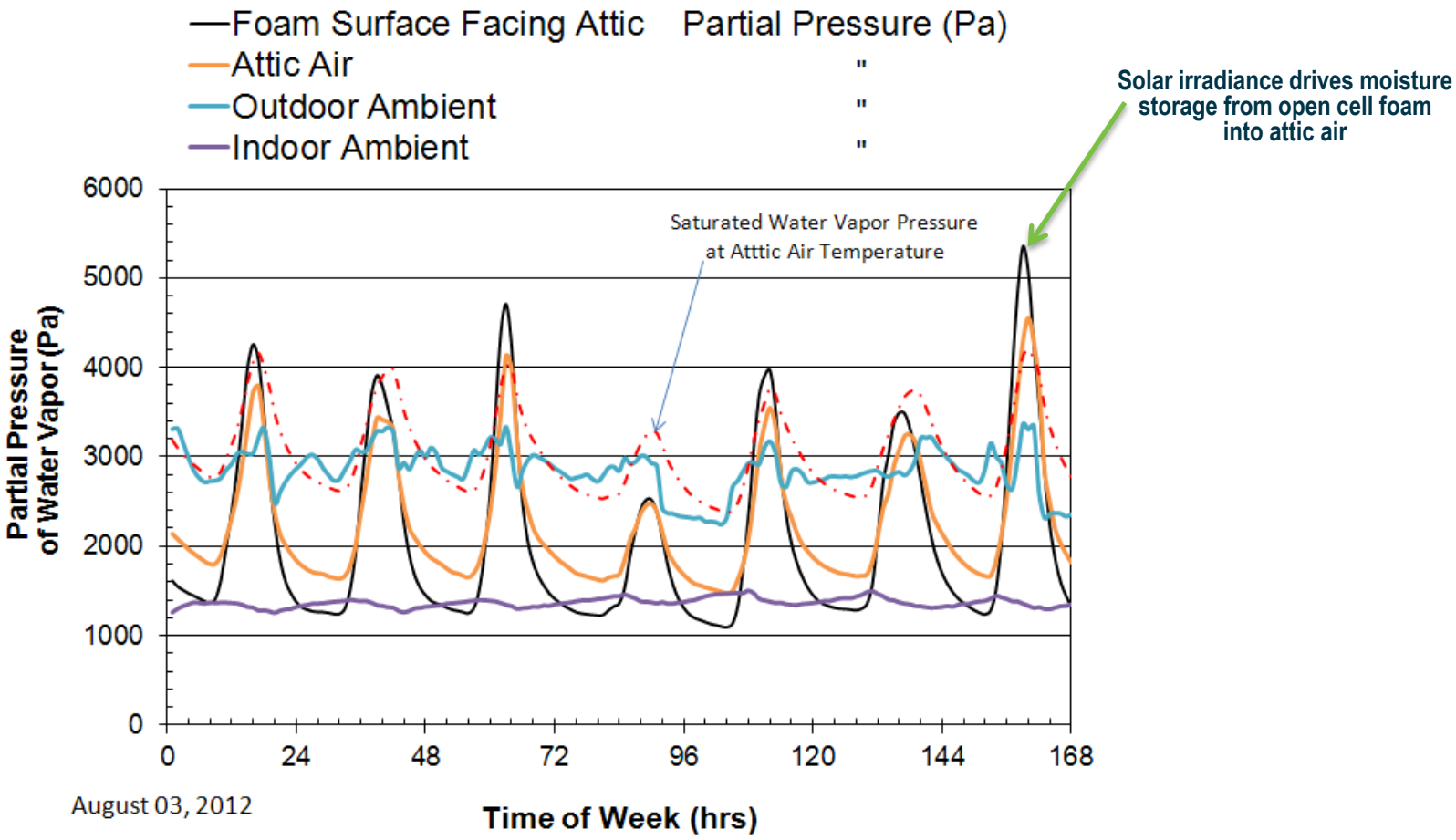
Sealed Attic RH Trends Opposite Ventilated Attics

Charleston SC Natural Exposure Test (NET) Facility

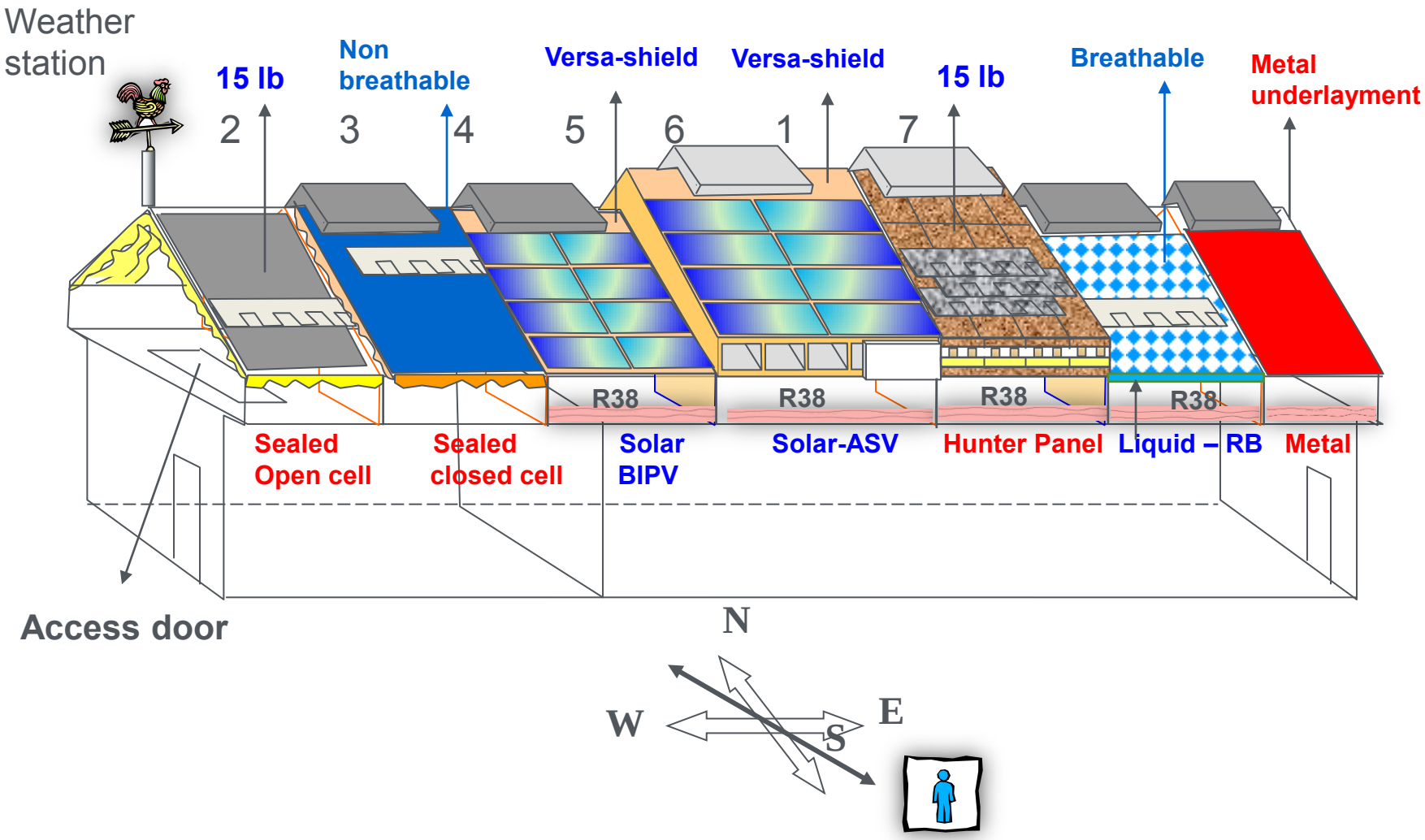


Key Issue: Sealed Attic Occasionally Wet (July – Sept)

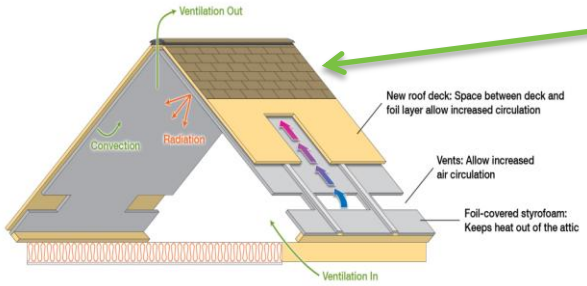
Charleston SC Natural Exposure Test (NET) Facility



GAF and ORNL Phase II



3M Goal Deployment



Insulated and Ventilated Roof & Attic

Manufactured by http://www.billyellisroofing.com

[USA Science & Energy Expo at DOE BT Booth](http://www.youtube.com/watch?v=BWwOC8Hs9S0)

- http://www.youtube.com/watch?v=BWwOC8Hs9S0

3 M Prototype Roof and Attic Test Assembly

- **ORNL Field Test (FY13) 3M Prototype at Decatur, Alabama**
- **3M goal is to license their product nationwide**

Sealed Attic Approach

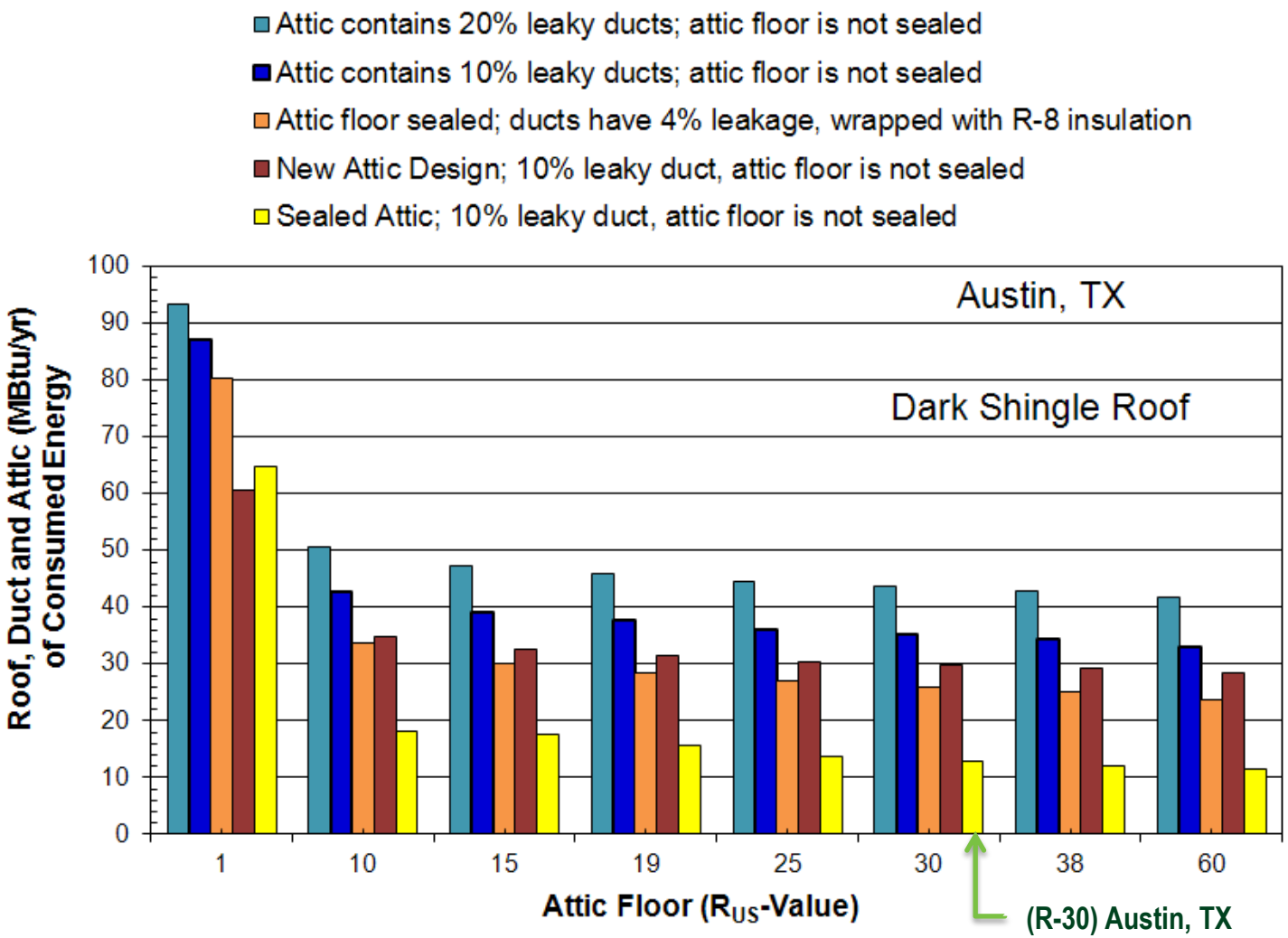
Quarter	**Whole House Demonstration** Deliverable/Milestone	Status
1	Test Plan approved by KB Home and Owens Corning	Complete
2	Cold climate demonstration switched to hot climate. Instrument and commission data acquisition system.	On schedule
3	Develop Energy Plus model of home	On schedule
4	Final report	On schedule

"Most Admired Homebuilder" by Fortune Magazine in 2006, 2008, 2009 and 2011.

KB Home was ranked #1 Overall Green Builder by Calvert Investments in 2010.

In fiscal 2008, the company had revenue of over $3 billion.
In fiscal 2005, during real estate boom revenue exceeded $9 billion

Diminishing Returns for Adding Ceiling Insulation (Leaky Duct Losses ☠)

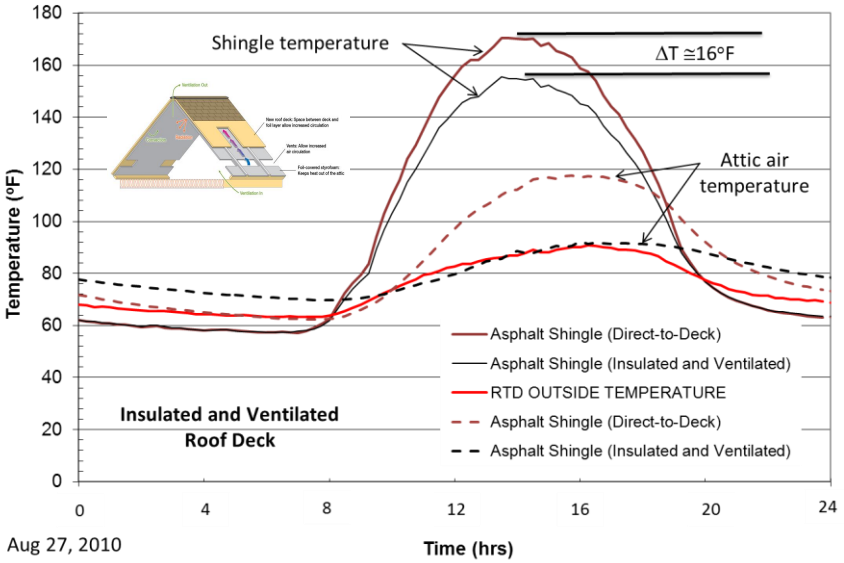


Unique Sealed Attic Concept
ventilated above roof liner

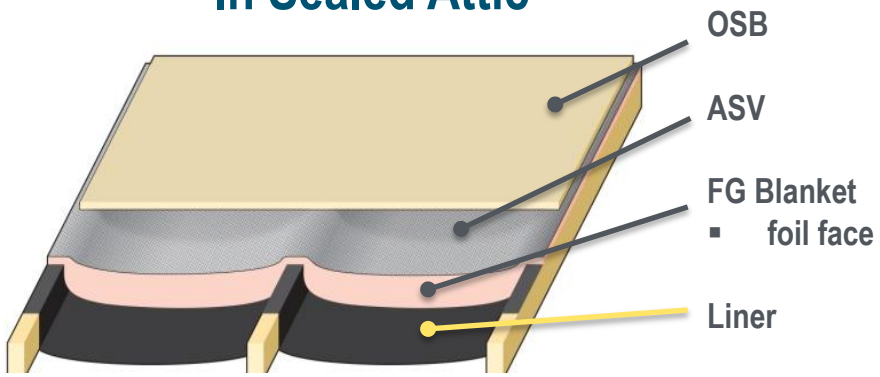
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Key Issues: Heat stress, poor moisture management, air distribution system in an unconditioned attic exacerbates energy penalty, air handler compounds problem by inducing air leakage digressing or egressing the home

Insulated and Ventilated Roof & Attic



Vent Scheme for Moisture Control In Sealed Attic



Sealing accomplished at black liner

[R-30; 9" depth]	Austin, TX	$5.2k	40% Reduction over Spray Foam
[R-49; 15½" depth]	Minneapolis, MN	$6.5k	48% Reduction over Spray Foam

Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Summary	
WBS Number or Agreement Number	
Project Number	
Agreement Number	

Legend	
	Work completed
	Active Task
	Milestones & Deliverables (Original Plan)
	Milestones & Deliverables (Actual)

Task / Event	FY2012				FY2013				FY2014			
	Q1 (Octt-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Octt-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Octt-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
▪ GAF and 3M Experimental and Analytical Attic Study FY 14 BIPV, ASV, Closed Cell Sealed Attic												
▪ Sealed Attic Whole House Demonstration FY 13 Hot Climate FY 14 Cold Climate												
Project Name: Next Generation Attics and Roof Systems												
Q1 Milestone: Complete Attic Tracer gas (TG) tests at NET facility					◆				◆			
Q2 Milestone: Reduce TG data and benchmark AtticSim						◆				◆		
Q3 Milestone: CFD Model to formulate ACH correlation							◆				◆	
Q4 Milestone: Complete 3M Roof and Attic Field tests								◆				
Q1 Milestone: Whole House Test Plan Approved					◆				◆			
Q2 Milestone: Instrument Home and Commission DAS						◆				◆		
Q3 Milestone: Develop Energy Plus model for home							◆	◆				◆
Q4 Milestone: Final (draft) report								◆				

Roofs & Attics Project Budget

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Project Budget: FY13 project budget is $700K.

Variances: No variances from planned budget.

Cost to Date: Budget expended 51% as of 20 March, [$356K spent] .

Other Funding: $150K from GAF in FY12 and FY13 in Work for Others Agreements.

Budget History					
FY2010		FY2011		FY2012	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$200K	$100K	$150K	$0	$1,270K	$550K

Future Plans FY 14

Go/no-go decision points

- Develop sealed attic approach that is superior to conventional spray foam approach
  - Reduce material and labor cost
  - Acceptable health and environmentally friendly materials
    - ❑ Cold climate demonstration
- Reduce space conditioning load due to attics by 50% of homes build to IECC 2009 code
  - Support 3M with simulations to show best retrofit practice
  - Convince industry to adopt practice in most promising U.S. climates
    - ❑ Deployment of Prototype Roof Assembly

Summary : New sealed but ventilated attic approach will resolve thermal and hygrothermal problems incurred in conventional sealed attic construction.

1. Shingles cooled by above sheathing ventilation (ASV)
2. Moisture from previous rains diffusing through deck are removed by ASV
3. Breathable underlayment workable; less expensive that non-breathable option
4. Resolves high humidity in attic caused by irradiance driving moisture into attic
5. Fiberglass less expensive than spray foam
6. Fiberglass is non-flammable and mold resistant
7. Fiberglass has no outgassing of health threatening air borne contaminants
8. Excellent retrofit potential for homes with HVAC ducts in attic

Communications

GAF Phase I, Final report, "*Analytical and Field Study of the Effects of Ventilation on Thermal Performance and Moisture Control in Residential Attics*," ORNL/TM-2013/38

- Desjarlais, A., Miller, W., Railkar, S., Chich, A. "*Energy and Moisture Performance of Attic Assemblies*," RCI Building Envelope Technology Symposium, Phoenix AZ, Oct 22-23, 2012.
- Railkar, S., Chich, A. Desjarlais, A. and Miller, W. 2013. "*Thermal and Hygrothermal Performance of Sealed and Ventilated Attics with and without Breathable Membranes in a Hot and Humid Climate*," to be published Thermal Performance of the Exterior Envelopes of Buildings, XII, proceedings of ASHRAE THERM X, Clearwater, FL., Dec. 2013.

Miller, W.,Desjarlais, A. and LaFrance, M. 2013. "*Roof and Attic Design Guidelines for New and Retrofit Construction of Homes in Hot and Cold Climates*," to be published Thermal Performance of the Exterior Envelopes of Buildings, XII, proceedings of ASHRAE THERM X, Clearwater, FL., Dec. 2013.

Kriner, S., Miller, W. and Desjarlais, A. W. 2013. "*The Tradeoff between Solar Reflectance and Above Sheathing Ventilation for Metal Roofs on Residential and Commercial Buildings*," to be published Thermal Performance of the Exterior Envelopes of Buildings, XII, proceedings of ASHRAE THERM X, Clearwater, FL., Dec. 2013.

Olsen, R., Miller, W. and Graves, R. 2013. "*The Equivalent Thermal Resistance of Tile Roofs with and without Batten Systems*," to be published Thermal Performance of the Exterior Envelopes of Buildings, XII, proceedings of ASHRAE THERM X, Clearwater, FL., Dec. 2013.

Miller, W., S. Shrestha, K. Childs, E. Stannard. "*Field Study and Energy-Plus Benchmarks for Energy Saver Homes having Different Envelope Designs*," ACEEE Summer Study on Energy Efficiency in Buildings, proceedings of American Council for an Energy Efficient Economy, Asilomar Conference Center in Pacific Grove, CA., Aug. 2012.

Thank you for your time!

QUESTIONS??