ABOVE SHEATHING VENTILATION
The Forgotten Cool Roof

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ASV Basics

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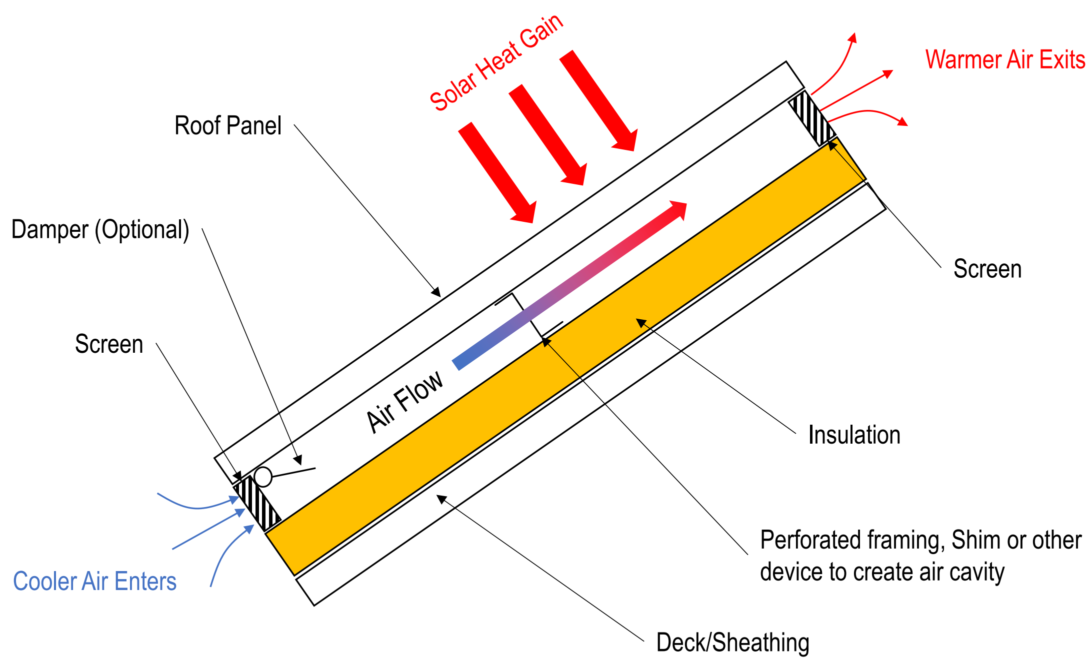
What is ASV?

- ASV is the concept of ventilating the air space between the roof cladding material, the roof deck, and subassembly
- This allows the roof cladding temperature to be closer to the outdoor ambient temperature and reduces heat gain passing through the insulation during summertime scenarios
- This has a similar impact on internal cooling loads as a cool roof*

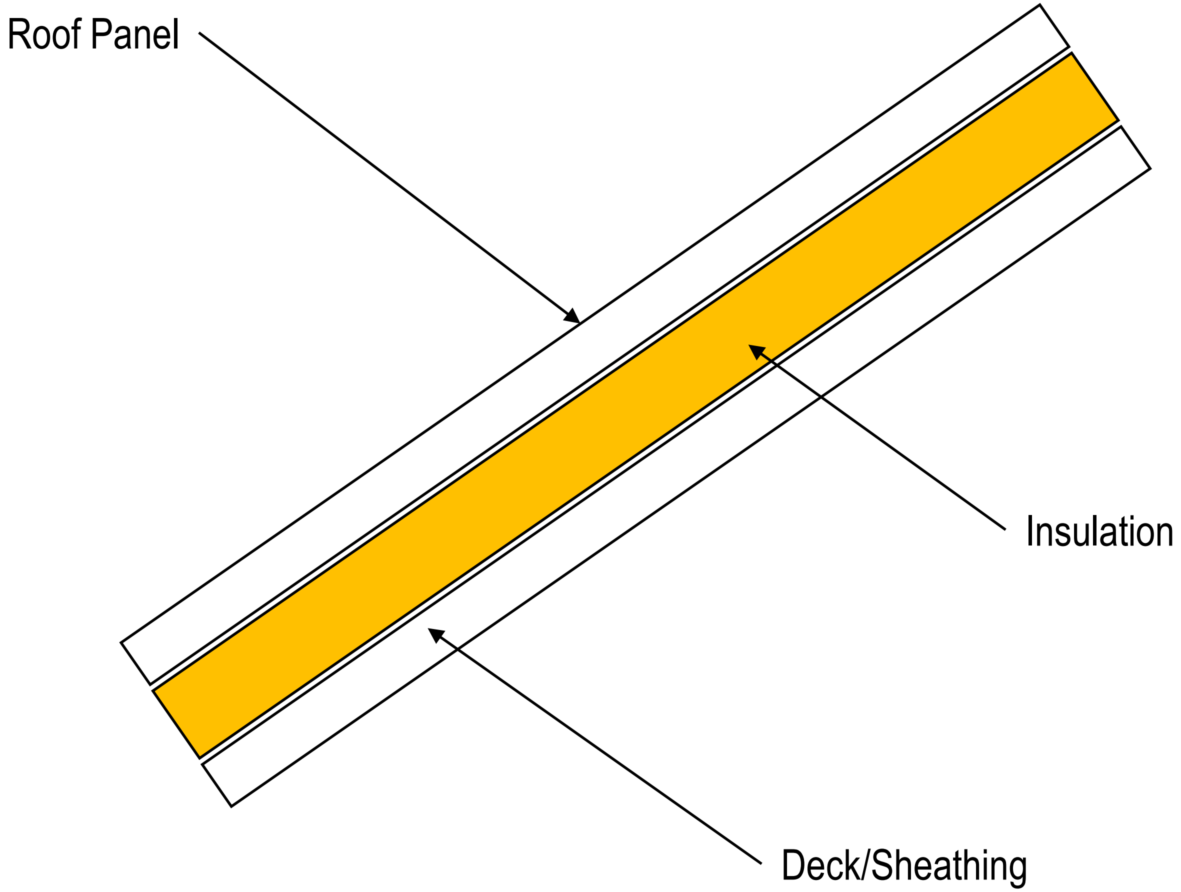


* Heat Island Effect is different phenomenon and not discussed here.

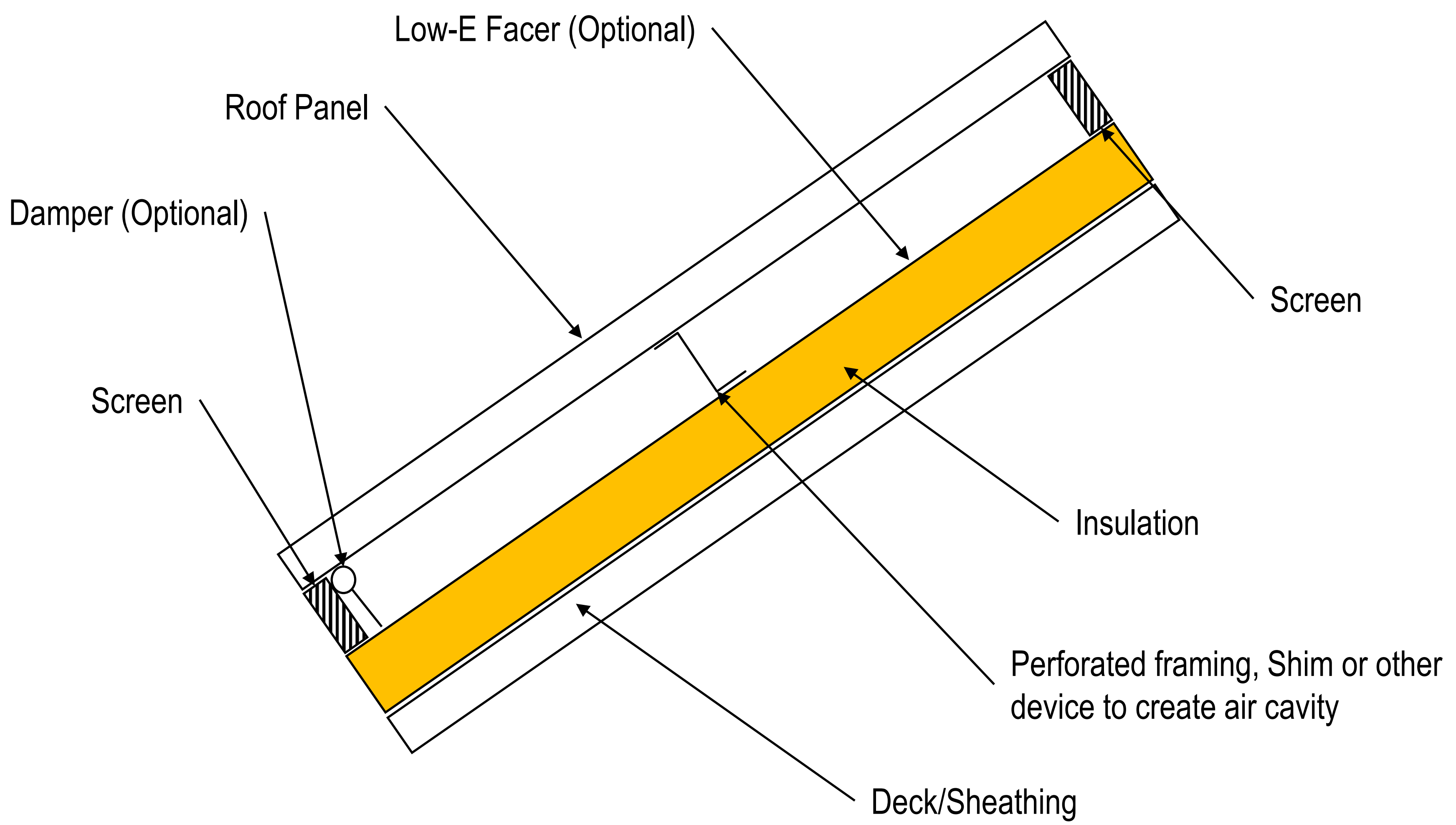
Why is this important?

- Roofs experience much higher temperature fluctuations than any other surface
  - Higher than ambient during sunny days, by 50°F or more
  - Lower than ambient during dry, cloudless nights by 10-20°F
- Ventilation mitigates this effect
  - Decouples thermal connection between panel and insulation
  - Always works to push roof temperature toward ambient outdoor temperature
  - Ventilation may be natural, forced, or throttled
- Solar gain drives ASV; the higher the solar gain, the more air flows through the cavity

Direct-to-Deck Construction

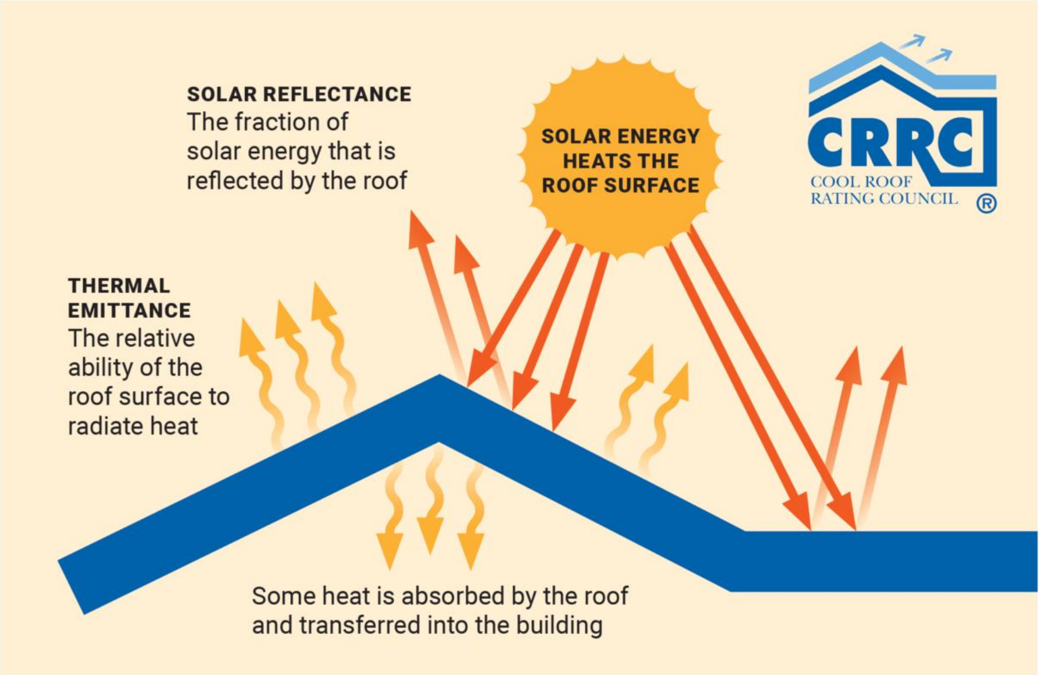


ASV Construction



Cool Roofs and ASV

- Cool Roof coatings and ASV are independent measures accomplishing the same thing: Reduction of roof surface temperatures
  - Cool roof coatings work at the roof surface
  - ASV works underneath the surface
- They can be implemented together or separately
- Because they work independently, they can be combined to maximize benefit



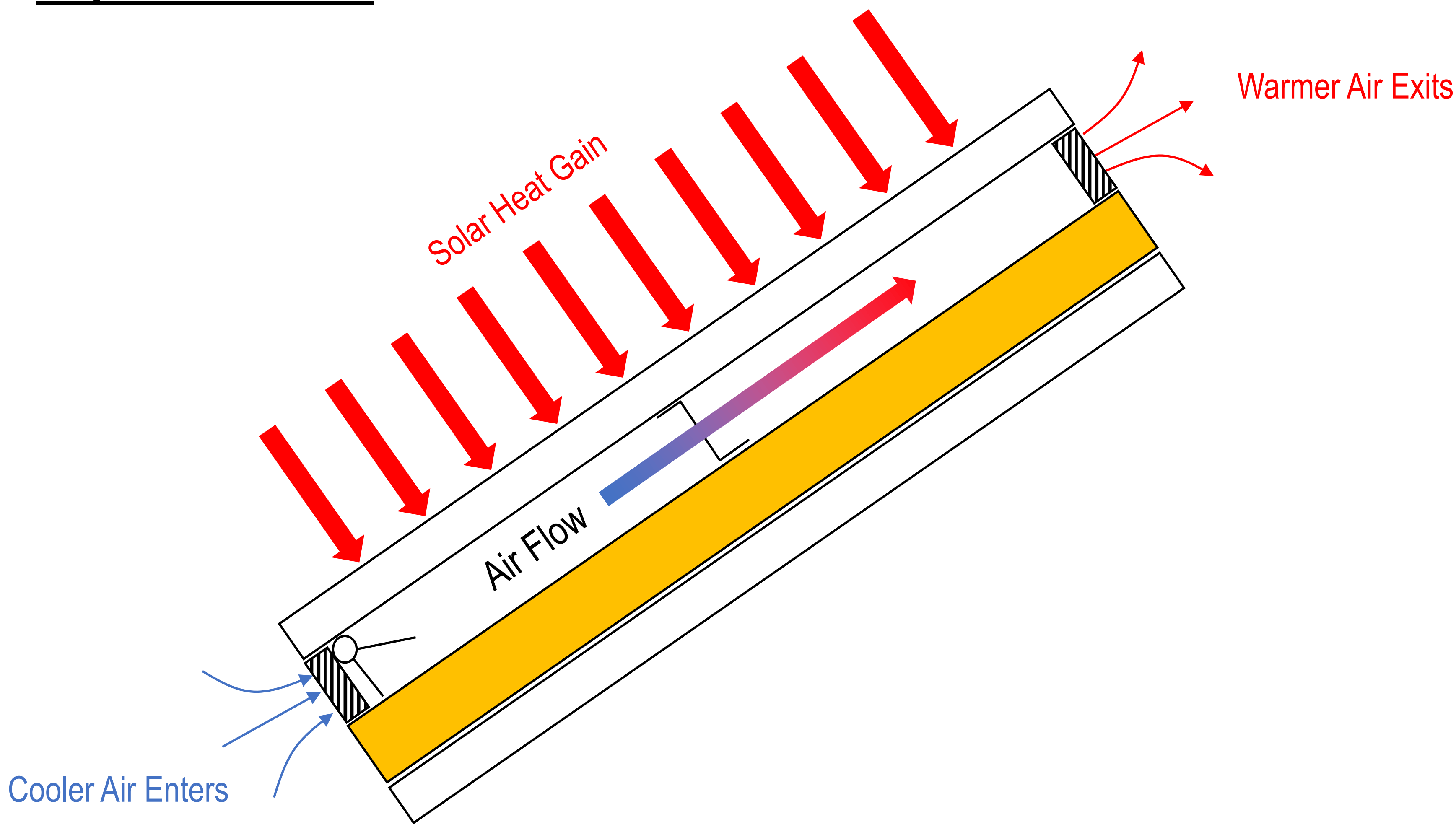
This illustration describes the flow of radiant energy as heat between the sun, roof surface, building interior, and surroundings. The higher the solar reflectance, the more solar energy is reflected away from the roof surface. Some of the solar energy is absorbed by the roof as heat. The higher the thermal emittance, the more of this absorbed heat is radiated away from the roof surface. IMAGE CREDIT: COOL ROOF RATING COUNCIL.

Image courtesy of Cool Roof Rating Council

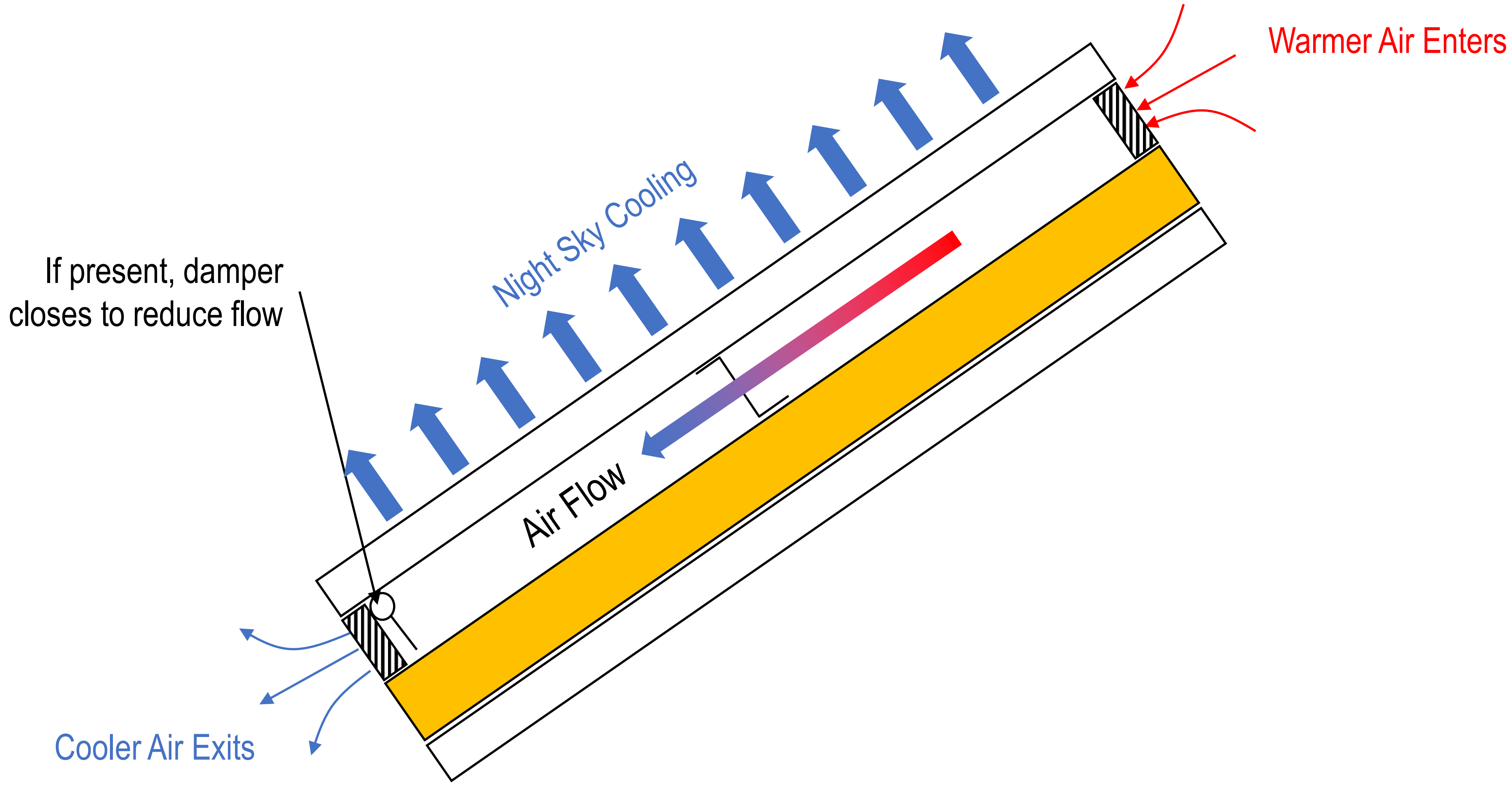
Winter/Nighttime Performance

- Cool Roofs with Direct-to-Deck attachments often have a winter heating penalty
  - Rejected radiation could have been used to offset heating load
  - High emissivity of cool coatings maximizes nighttime cooling
- With ASV, these effects are generally much less pronounced.
  - Airspace isolates cooler roof surface at night
  - Penalty can be further reduced or eliminated with damper or throttle
- This allows ASV to be used with darker colors and still be a net energy saver over the course of a year.
- Many southern climates require cooling during the day and heating at night during the winter
  - Cool Roof + ASV + Low-E faced insulation is ideal in this scenario

Daytime Scenario



Nighttime Scenario



Other Benefits of ASV

- Ventilated roofs have been used for hundreds of years and have been shown to have a longer service life
  - Allow any entrapped moisture to escape, preventing rust and rot
  - Tempers thermal expansion and contraction
- Thermally decouples burning brands from roof deck, enhancing fire performance in wildfire prone areas

Estimating Performance

Equivalent R-Value

The heat gain through the insulation is given by:

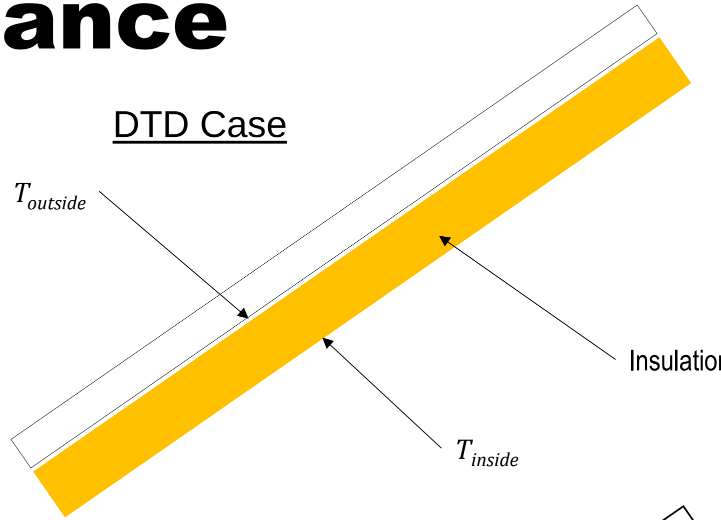
$$q = \frac{(T_{inside} - T_{outside})}{R}$$

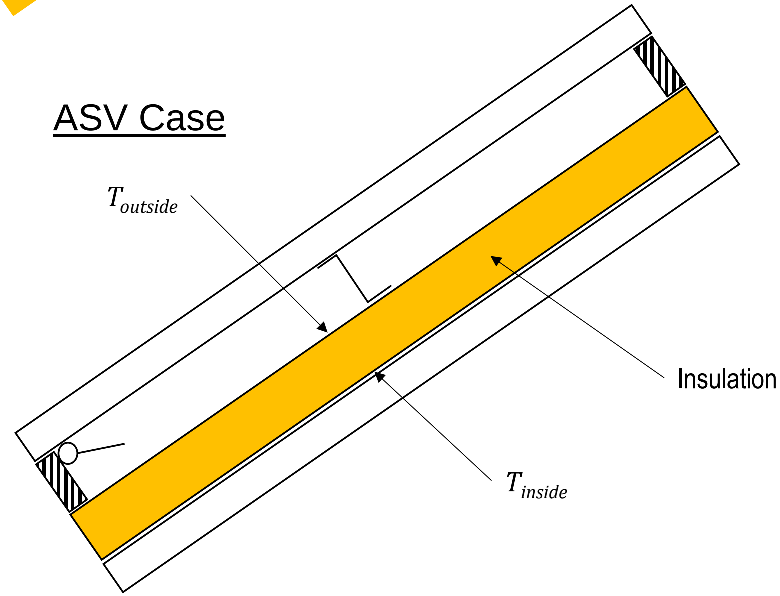
Where:

- q = heat flow per unit area
- T_{inside} = Temperature on inside face of insulation
- $T_{outside}$ = Temperature on outside face of insulation
- R = R-value of insulation

By lowering $T_{outside}$, q is reduced if all else remains unchanged.

Note that this has the same effect as an additional layer of insulation of R_{ASV}





Estimating Performance

- R_{ASV} is a function of:
  - Cavity air temperature
  - Heat flow direction (with/against gravity)
  - Roof slope
  - Cavity dimension
  - Flow distance (roof length)
  - Choking effects of clips, framing, etc.

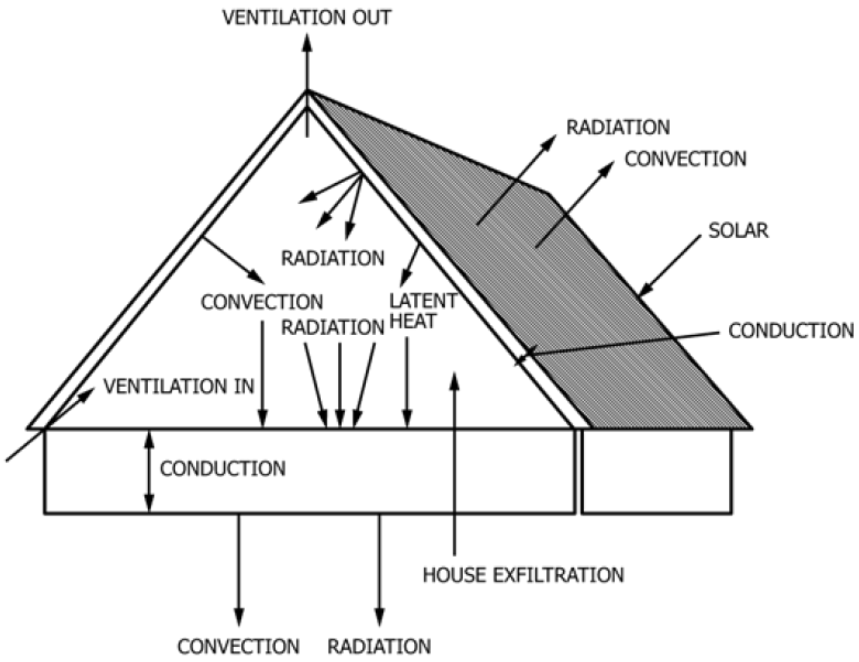
Estimating Performance

- Equivalent R-Value approach simpler but not the best because:
  - R_{ASV} varies greatly based on previous slide
  - Radiation transfer across the cavity is over-simplified
  - Seasonal climate is location sensitive
  - Internal conditions vary and are not always predictable
  - Impact of shading not consistent
- Direct Modeling is needed to ensure accuracy
- Results applied to a whole-building energy model

Estimating Performance

Direct Modeling

- Ventilated Attic Model for Residential Construction
- Developed originally by Oak Ridge National Laboratories
- Adopted by ASTM as Standard Practice C1340
- Calculates heat transfer coefficient on inside sloped surfaces of attic
- Already incorporated in EnergyPlus (whole-building energy modeling software)
- Could be used as a starting point for ASV



Previous Research

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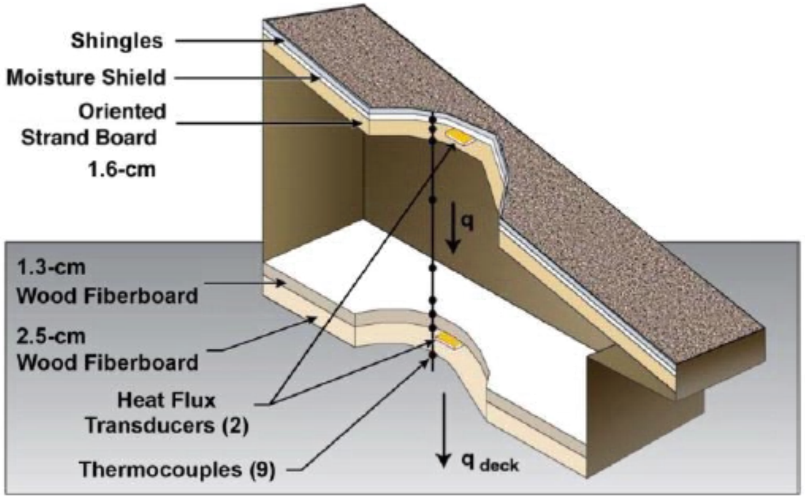
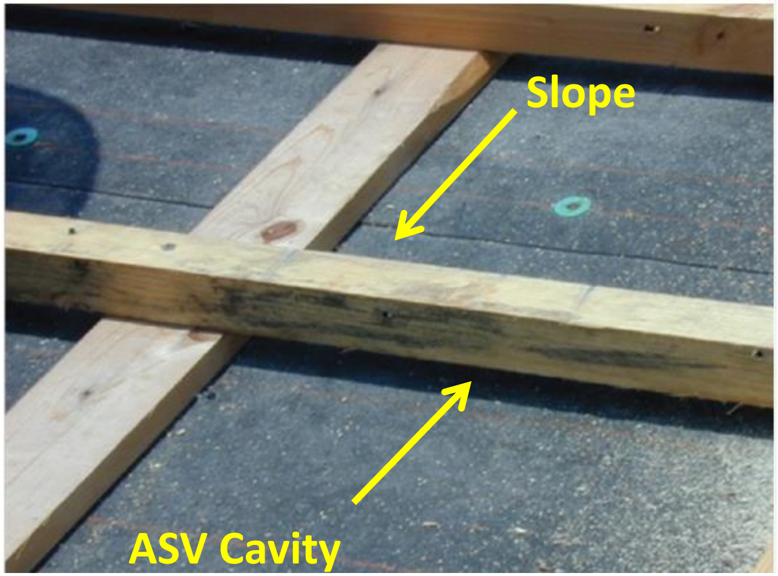
ORNL Studies (Steep Slope)

- Oak Ridge National Labs (ORNL) evaluated ASV in conjunction with other energy-saving technologies in a series of studies from 2008-2015
- 2012 Kriner Paper compared control to
  - Cool Metal DTD
  - Cool Metal ASV (3/4" gap)
  - ASV both with and without Low-e paint
- Various panel profiles used with ASV
- ASV out-performed DTD Cool Roof
- Results used to calibrate an ASV computer model

Control Construction



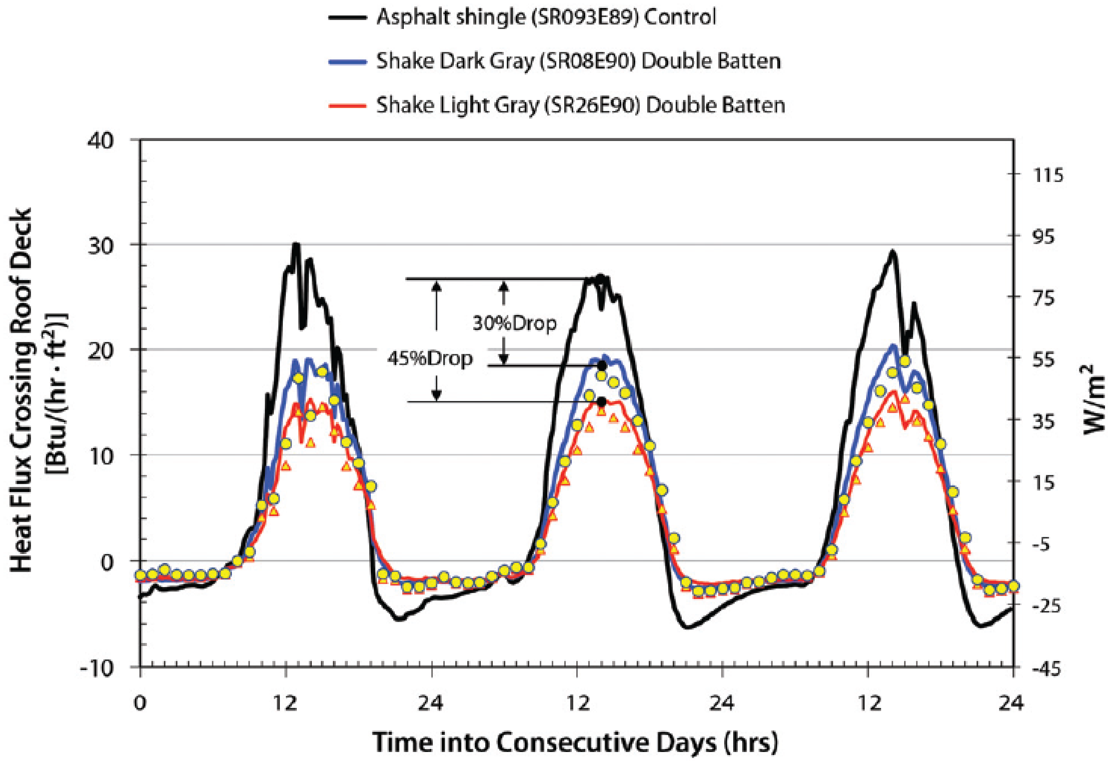
ORNL Studies (Steep Slope) Kriner Paper



"A painted metal roof on a 4:12 roof slope with a ¾" ASV cavity needed only a 0.1 SR to have the same annual cooling load as a 0.25 SR direct-to-deck metal roof"

ORNL Studies (Steep Slope) Kriner Paper

Combining cool pigments and ASV provided a 45% reduction in cooling load. Even non-cool dark colors achieved a 30% reduction with ASV.



ORNL Studies (Steep Slope) Kriner Paper

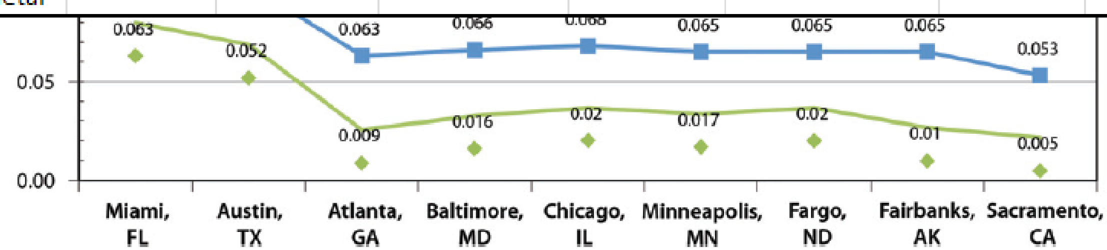
Chart below shows the Solar Reflectance needed to match ASV roof cooling load to cool roof direct-to-deck base case for various climates

	Miami, FL	Austin, TX	Atlanta, GA	Baltimore, MD	Chicago, IL	Minneapolis, MN	Fargo, ND	Fairbanks, AK	Sacramento, CA
HDD_{65}	222	1481	2614	4731	6139	7787	10052	13940	2697
CDD_{65}	9368	7435	4814	3598	2895	2513	1332	1040	1202
R_{US} Ceiling[a]	20	20	20	21	24	29	30	33	20
Direct to Deck	*Inclined air space set at ¾-in (19 mm)*								
SSM[b] Roof	0.103	0.097	0.067	0.071	0.07	0.064	0.064	0.065	0.065
ScM[c] Roof	-0.058	-0.073	-0.135	-0.127	-0.129	-0.142	-0.143	-0.14	-0.141
Direct to Deck	Inclined air space set at 1½-in (38 mm)								
SSM[b] Roof	0.057	0.05	0.014	0.021	0.021	0.015	0.018	0.007	0.016
ScM[c] Roof	-0.134	-0.151	-0.222	-0.21	-0.212	-0.224	-0.221	-0.234	-0.222

[a]ASHRAE 90, 1980 code level of insulation on attic floor

[b]SSM represents standing seam metal

[c]ScM represents stone-coated metal



ORNL Studies (Steep Slope) Kriner Paper

- Study was used to calibrate an existing attic model based on ASTM C1340
- Model and study results showed:
  - ASV out-performed steep slope DTD cool roofs
  - Both a ¾” and 1 ½” cavity had nominally the same effect
  - R_{ASV} values greater than ASHRAE air space values, especially when used in conjunction with Low-E
    - ¾” Cavity R_{ASV} = 0.9 and 5.32 for Low-E
    - 4” Cavity R_{ASV} = 1.3 and 8.74 for Low-E

Note strong impact of Low-E coatings

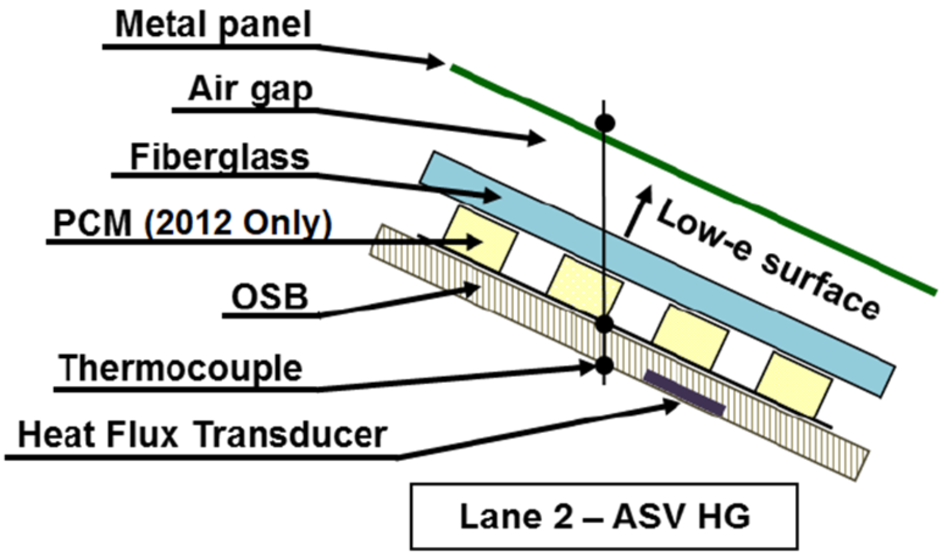
Table 1. R-Value for an Inclined Air Space Computed by AtticSim and Compared to ASHRAE (2005) for the Case of a Closed Air Space. AtticSim Also Computed the Thermal Resistance for an Open Cavity

Air Space for 4-in-12 Pitch Roof	ASHRAE[1] (2005) (Closed Air Space)	AtticSim Simulation[1] (Closed Air Space)	AtticSim Simulation (Open Air Space)	AtticSim Simulation (Low-ε Surface in Open Air Space)
0.75 in. (0.019 m)	0.70	0.68	0.91	5.32
4.00 in. (0.10 m)	0.74	0.77	1.30	8.74

[1]An effective emittance of 0.82 was assumed with a mean temperature of 133°F (56.1°C) having 11°F (6.1°C) temperature gradient for heat flows moving downward across the air space.

ORNL Studies (Steep Slope) Further Work

- In 2012 and 2013, ASV with Low-e insulation was benchmarked versus shingle roof control
- PCM was used in 2012 and then removed for 2013 study
- Data averaged over 15-minute periods (bins)
- Heat flux and attic temperature greatly reduced in both instances
- Low-E greatly improved performance
- PCM was helpful but not by a large amount

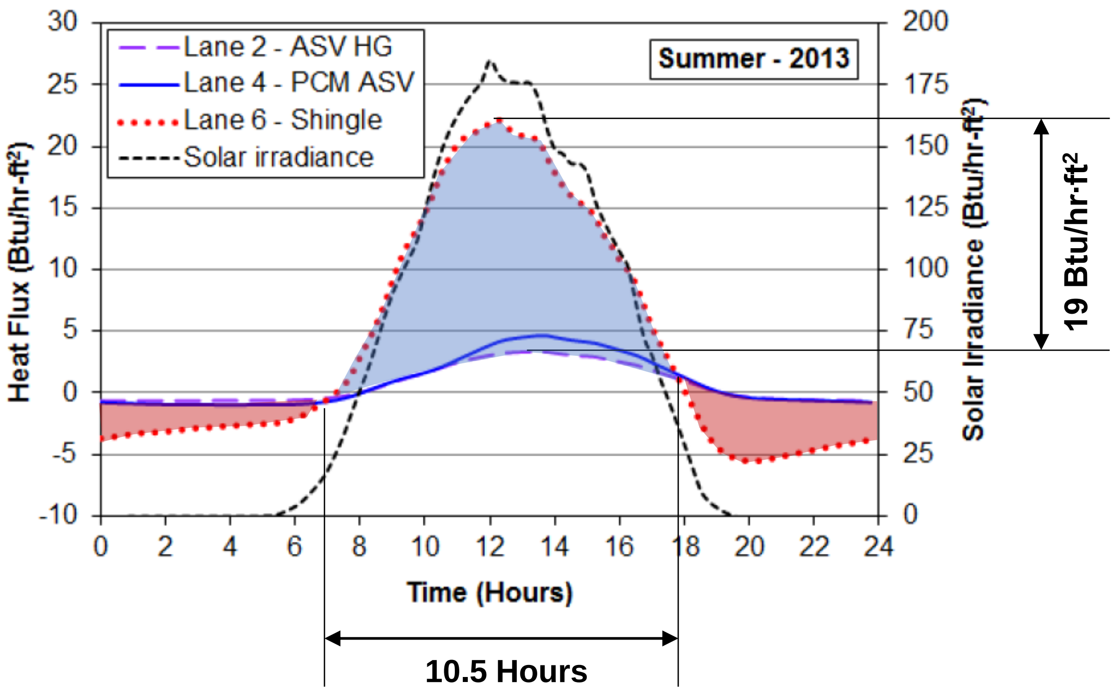


ORNL Studies (Steep Slope) Further Work

Following slides compare these two surfaces

ORNL Studies (Steep Slope) 2013 Results

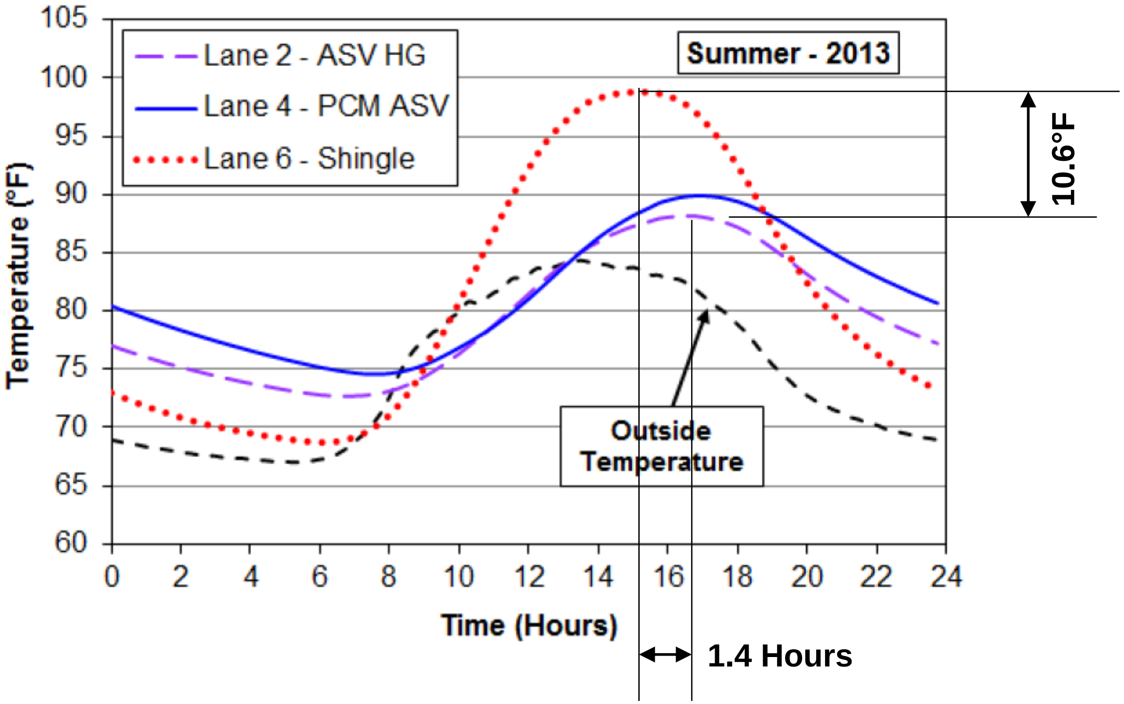
Roof Heat Flux (Summer/No PCM)



- Peak cooling load reduction of 19 Btu/hr·ft^2
- Over a 10.5-hour peak period, a total of 118 Btu/ft^2 of cooling load was avoided. (Blue Area)
- Over 24-hour cycle, a total of 78 Btu/ft^2 of cooling load was avoided (Combined red and blue areas)

ORNL Studies (Steep Slope) 2013 Results

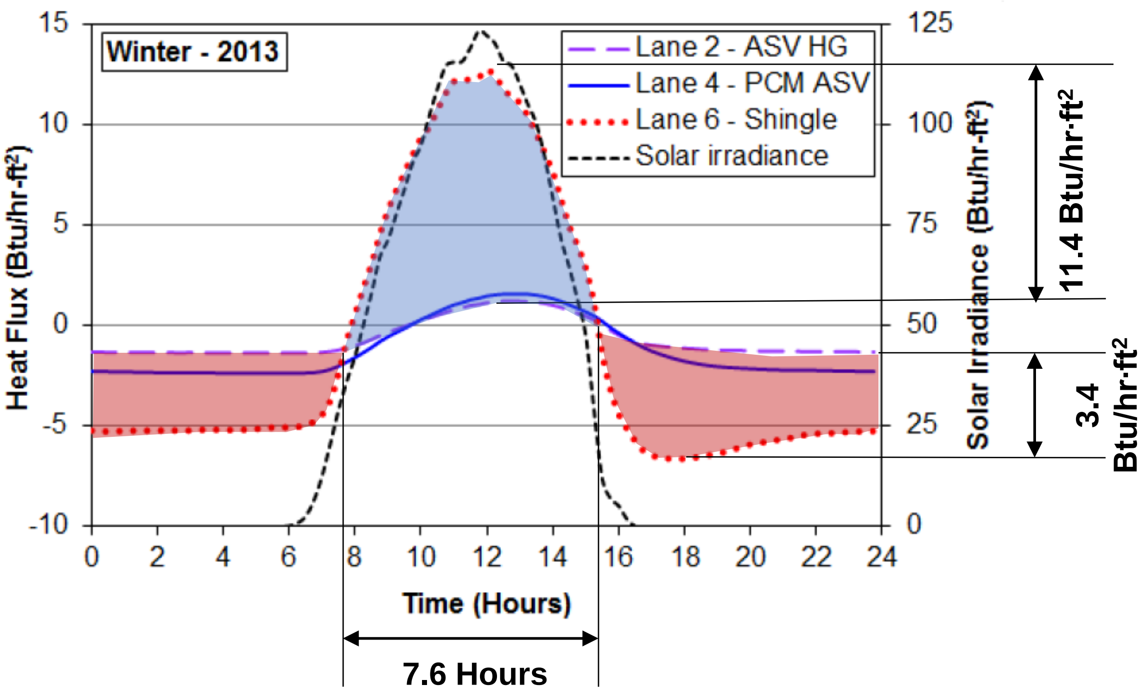
Attic Temperature (Summer/No PCM)



- Peak attic Temperature reduced by 10.6°F
- Peak attic temperature shifted 1.4 hours later

ORNL Studies (Steep Slope) 2013 Results

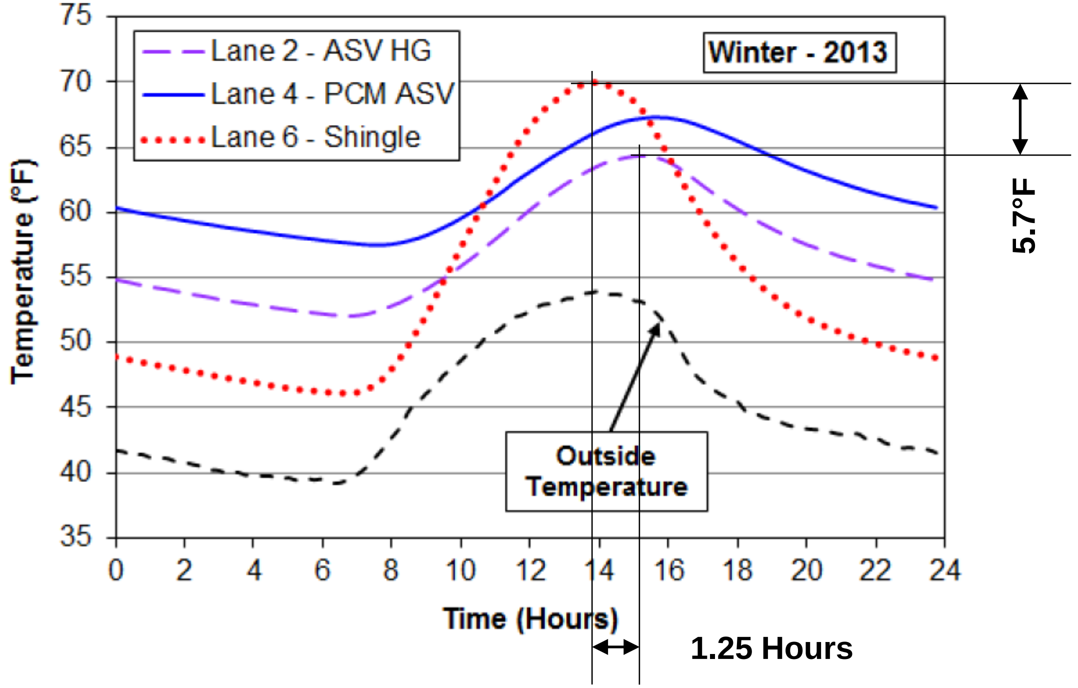
Roof Heat Flux (Winter/No PCM)



- Heat gain during day could be helpful or hurtful, depending on exterior conditions.
- Maximum heat flux reduction of 11.4 Btu/hr·ft^2
- Minimum heat flux increase of 3.4 Btu/hr·ft^2
- Over 24-hour cycle, a total of heat flux of 10.6 Btu/ft^2 inward (Combined red and blue areas)
- Perfect scenario if heating only at night.
- This illustrates winter penalty reduction over DTD Cool Roof

ORNL Studies (Steep Slope) 2013 Results

Attic Temperature (Summer/No PCM)



- Peak attic Temperature reduced by 5.7°F
- Peak attic temperature shifted 1.25 hours later

Implementing ASV

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Implementing ASV

Battens & Sub-Purlins

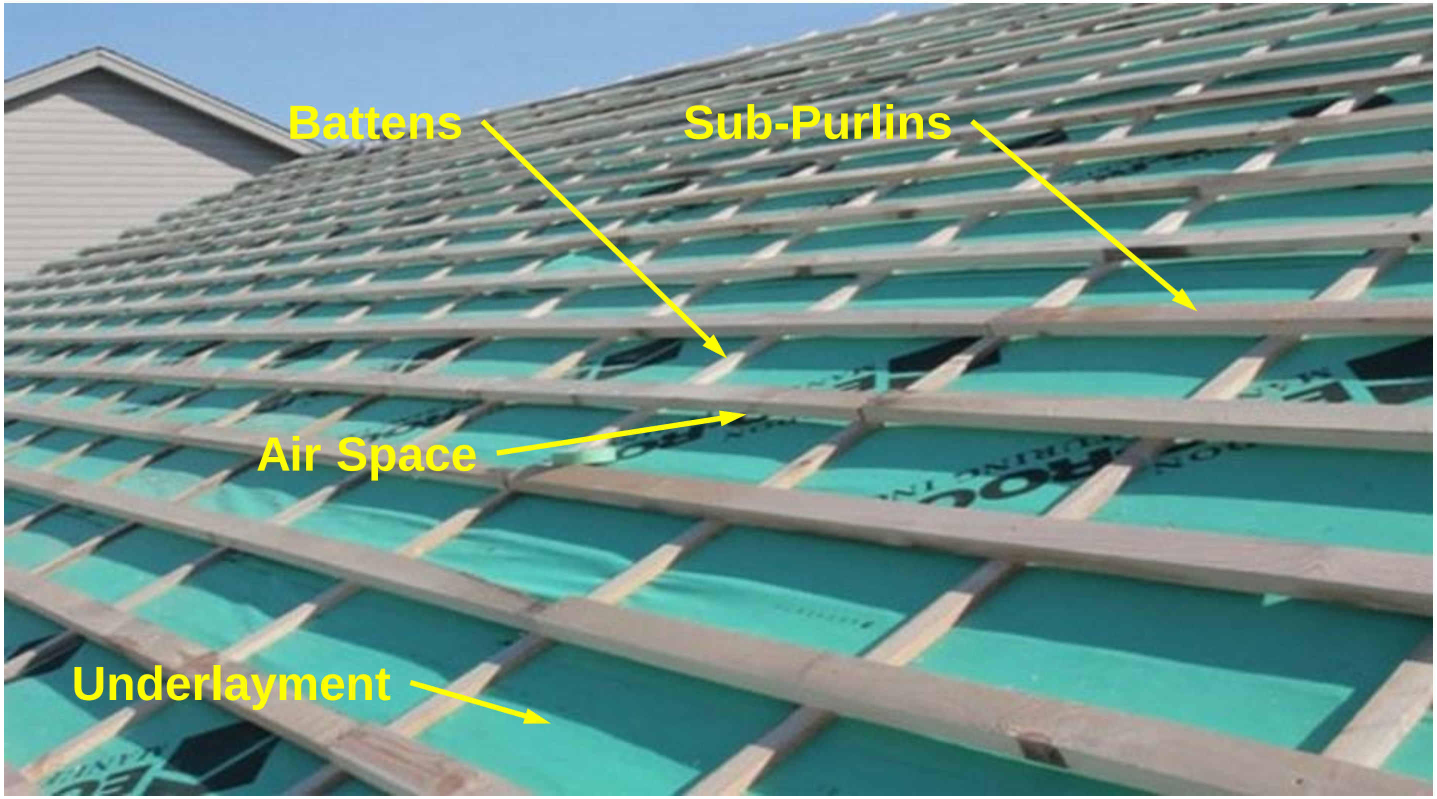


Image courtesy of MBCI

Implementing ASV

Shims/Lifts

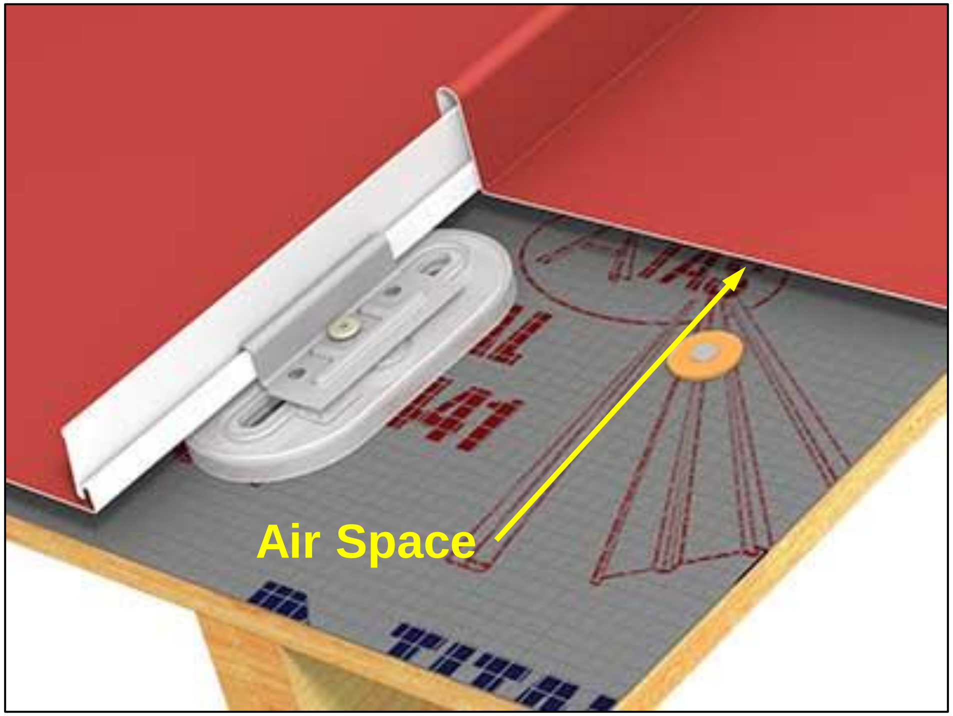


Image courtesy of ATAS International

Implementing ASV

Offset Clips

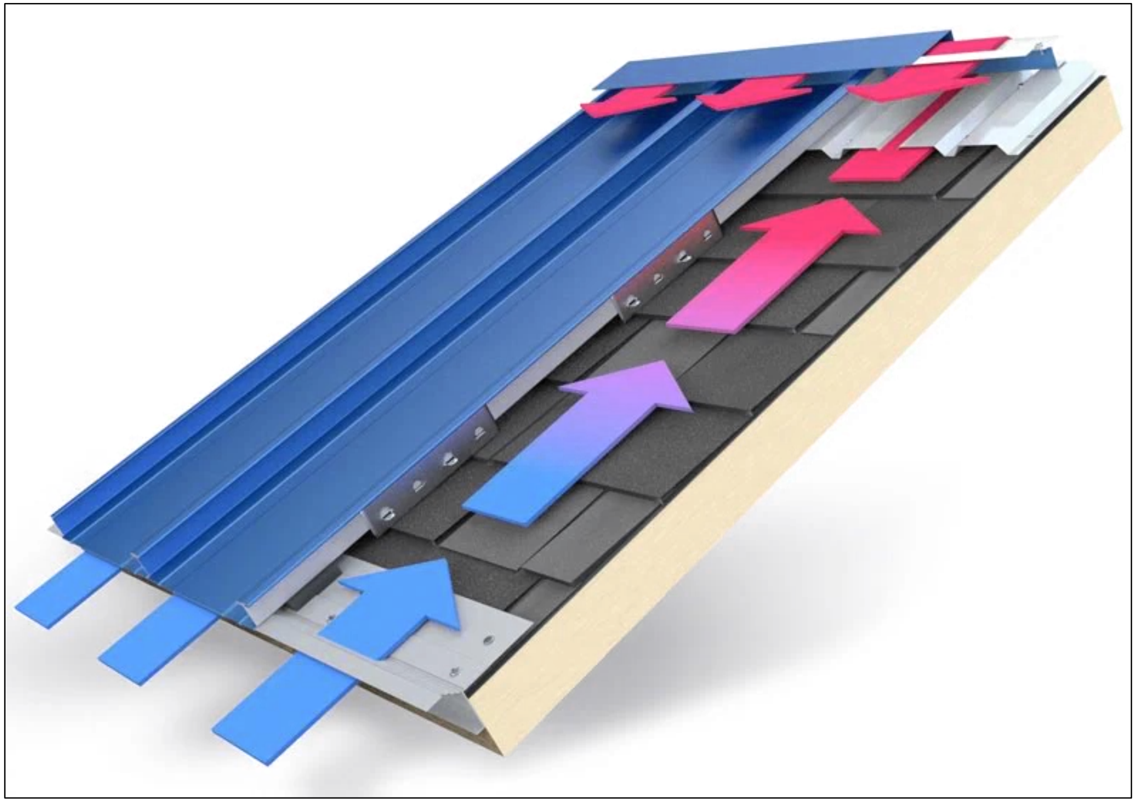


Image courtesy of McElroy Metal

Implementing ASV

Integrated Vent Products

Image courtesy of Metallic Products

Implementing ASV

Perforated Sub-Framing

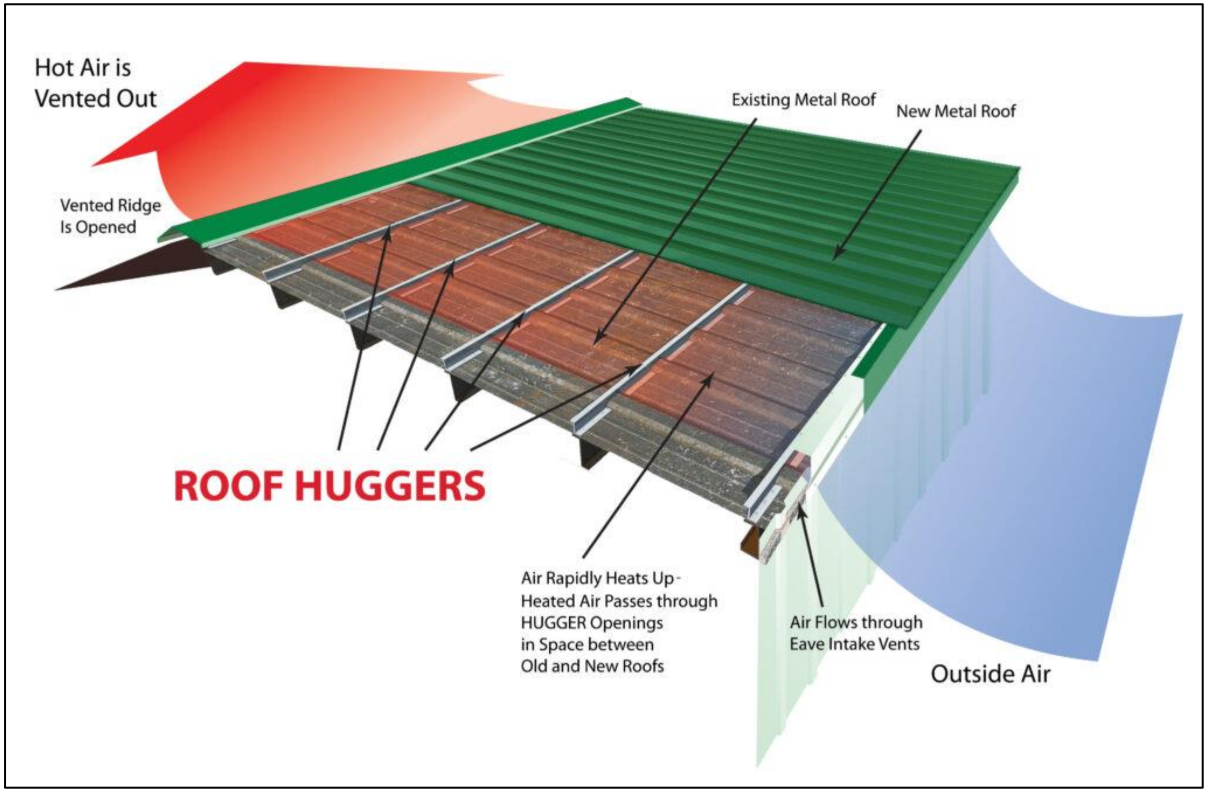
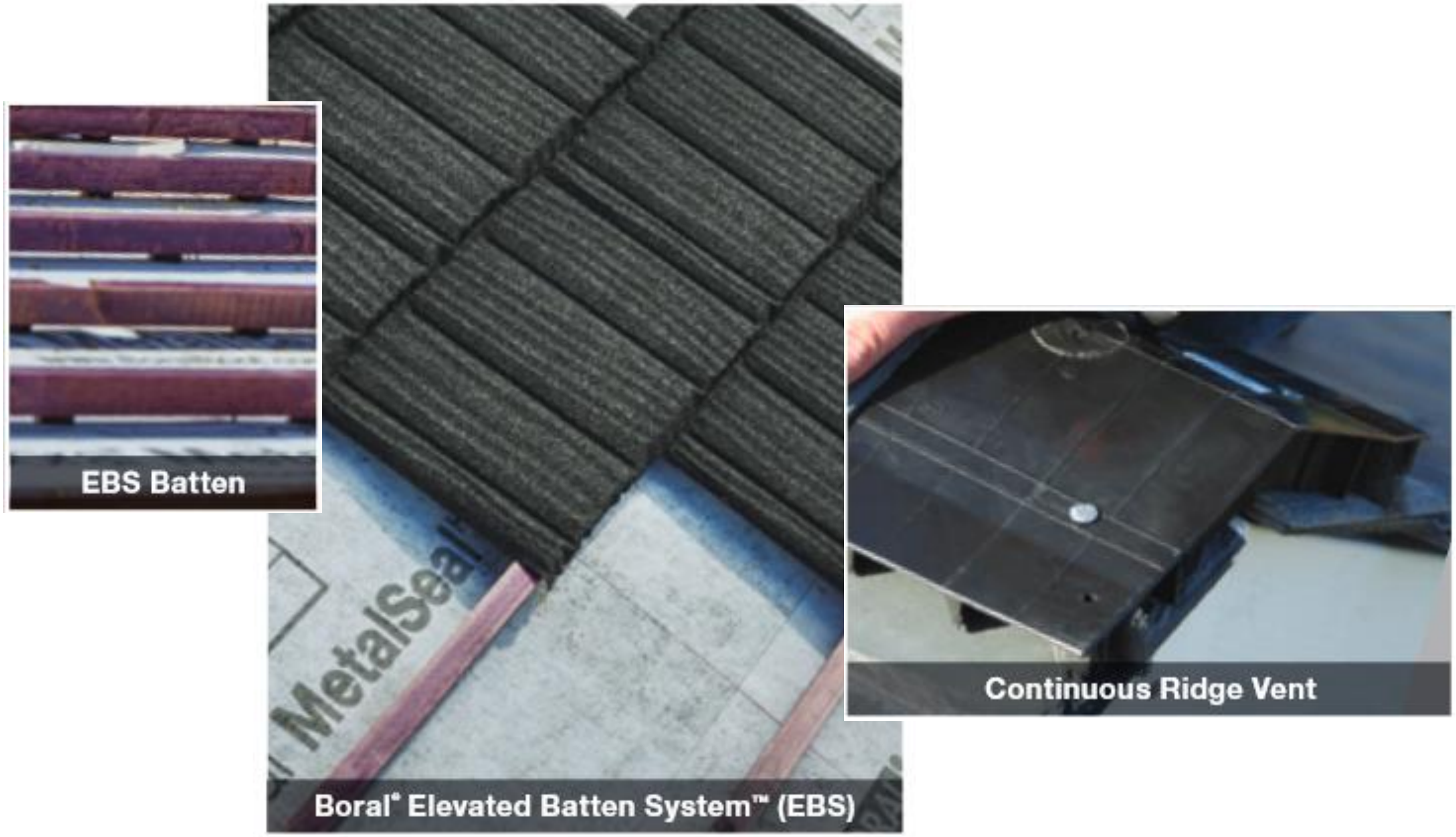


Image courtesy of Roof Hugger

Implementing ASV

Battens/Ridge Vents



Images courtesy of Boral Metal Roofing

Summary

- ASV and Cool Roofs work separately and together to minimize roof surface temperature during the day, reducing cooling loads and saving energy in conditioned buildings
- ASV can mitigate the winter heating penalty of direct-to-deck Cool Roofs
- Where a dark roof is desired, ASV can make it perform like a Cool Roof, even with the lower SR
- ASV is highly effective at reducing unconditioned attic temperature
- ASV performance can be estimated using effective R-values, but modeling is needed for exact answers
- A wide variety of products may be used to implement ASV, particularly for re-roof and retrofit applications

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QUESTIONS?

METAL CONSTRUCTION ASSOCIATION

VISION

Be recognized as the authoritative voice of the metal construction industry

PROMOTE ■ FOCUS ■ EDUCATE

Promote

to building owners, architects, consultants, contractors, and other AHJs

Educate

members, prospects, and industry stakeholders

Focus

on aesthetics, performance, and the value of metal

BUILD LEGACIES METAL