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Moisture-Safe Unvented Wood Roof Systems

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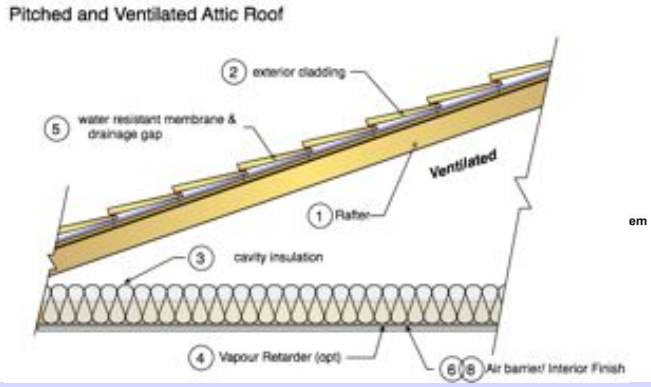
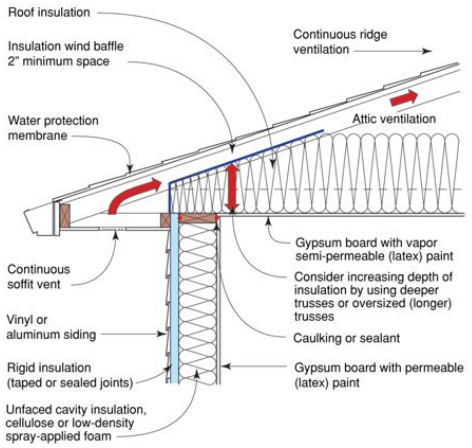
Unvented Roofs

- Background
  - Desire for unvented roofs
  - Code R-values are increased and enforced
  - IRC/IBC now have different rules for vapor control and unvented roofs
- Computer-model study
  - Focus on vapor control
  - Consider impacts of air leakage

The old faithful





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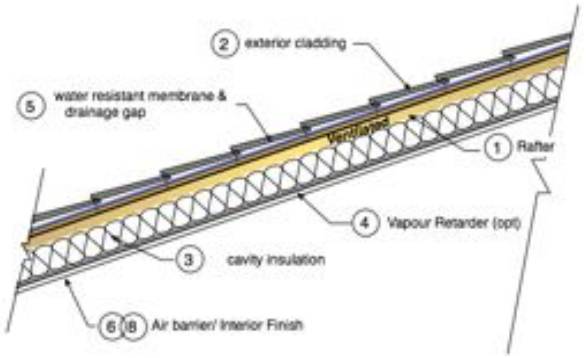
Ventilated Cathedral Ceiling



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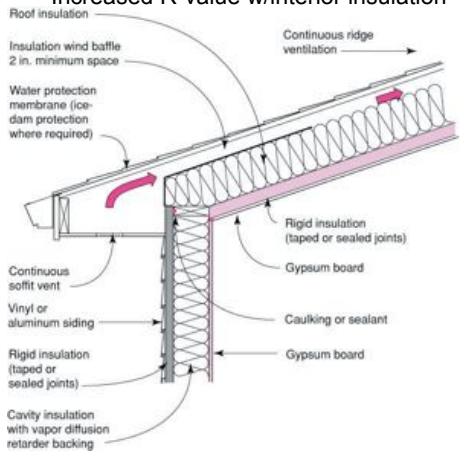
Increased R-value w/interior insulation



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Hard to Vent

– Roofs 9

Vented Attics

- Ductwork placed in ventilated attics!
- Complex roof shapes hard to vent

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Unvented Cathedral Ceilings

- Not absolutely necessary to vent if airtight and vapour tight material in framing,
  - e.g. spray foam
  - beware thermal bridges
- If no wetting, little drying required
  - Demands high performance
- Or warm surfaces
  - E.g. air impermeable insulation on exterior
  - Air impermeable insulation in framed cavity

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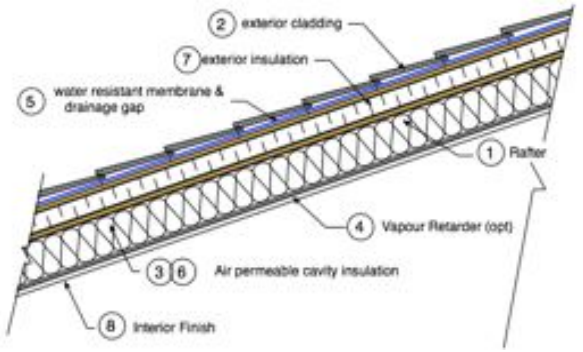
Unventilated Cathedral Ceiling



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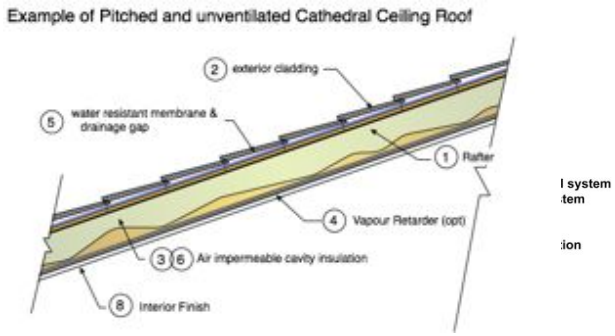
Unventilated Cathedral Roof



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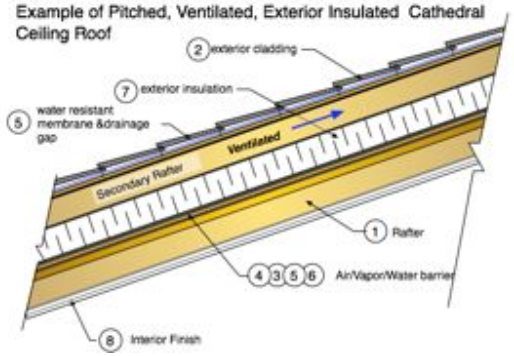
Unvented-vented hybrid



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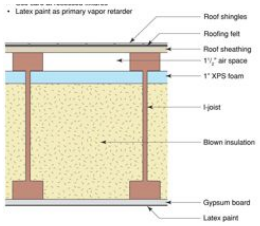
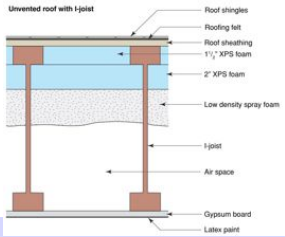
Vented cathedral
Simple gable roofs
Is it airtight enough?



Unvented roof for more complex roof lines



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IRC Required R-values

- Must meet the code minimum's
- Installed R-value
  - Zones 1-3: R30
  - Zones 4-5: R38
  - Zones 6-7: R49

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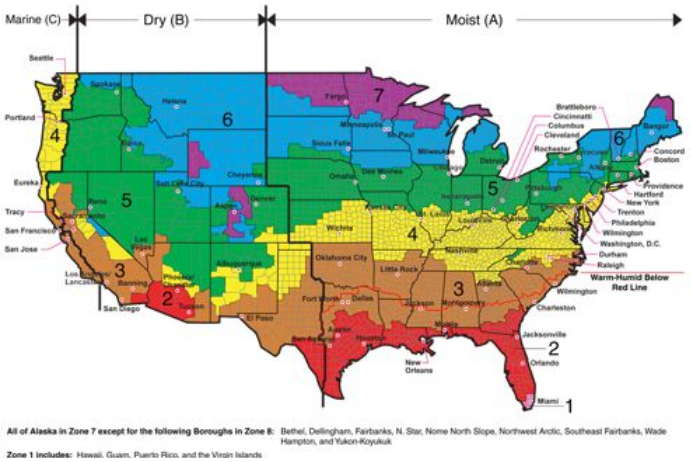
Ottawa/Toronto/Montreal: 6
Calgary/Edmonton/Quebec: 7

Vancouver / Windsor: 5
Halifax/St Johns: 6



Moisture Study

- Investigate vapor and air control requirements of unvented roofs in all climate zones
- Hybrid insulation of particular interest
- WUFI 4.0 Modeling

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Simulation Matrix

DOE Zone & City (12)	Code Required R-value	Roofing Type (4)	Insulation Type (8)
1 Miami	30	Dark asphalt	Spray fiberglass (1.8 pcf)
2A Houston	30	Tile (ventilated)	1" ocSPF + spray fiber glass
2B Phoenix	30	Light metal	1" ccSPF + spray fiber glass
3A Atlanta	30	Cedar shakes	2" ccSPF + spray fiber glass
3B San Francisco	30		Full-depth ocSPF
4A Kansas City	38		Full-depth ccSPF
4A Boston	38		Kraft-faced batt
4C Seattle	38		Full-depth cellulose
5A Chicago	38		
5B Denver	38		
6A Minneapolis	49		
7 International Falls	49		

Geometry

- 3-in-12 roof pitch
- North-facing
  - worst case, least solar
- Roofing
  - Dark color shingles
  - Light colored metal
  - Tiles: dk red, back ventilated
  - Cedar Shakes: Store rainwater!

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Interior RH Levels

- Very important!
- Depends on ventilation, occupancy, and exterior conditions
- Chose EuroNorm 15026
  - More straight forward
  - Matches our field experience
- High moisture level is normal for maritime

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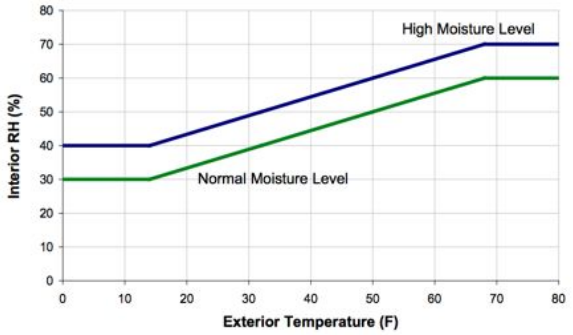
Interior RH Levels



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Material Properties

- Mostly choose default values from WUFI database
- Specific properties of spray fiberglass and open and closed cell foam from manufacturers

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Interpretation

- Choose Moisture Content of inside 1 mm (1/16”) of OSB sheathing
  - Extreme case
  - Framing always drier
- Classes of moisture performance were selected

Class	OSB MC Conditions
0	Below 16% all year
1	Above 16% 1 week or more
2	Above 16% 4 weeks or more Or above 28% 1 week or more
3	Above 28% 4 weeks or more

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RESULTS

Diffusion Only

For North-facing 3:12 pitch wood roof

DOE Zone	City	R-value	Roof Type	Spray fiberglass (1.8 pcf)	Cellulose	1" ccSPF + spray fiberglass	Full-depth ccSPF	Kraft-faced fiberglass batt	1" ccSPF + spray fiberglass	2" ccSPF + spray fiberglass	4" ccSPF + spray fiberglass	Full-depth ccSPF
1A	Miami	30	Tiles	0	0	0	NA	0	NA	NA	NA	0
			Lt Metal	0	0	0	NA	0	NA	NA	NA	0
2A	Houston	30	Dk. Asphalt	2	0	0	0	0	NA	NA	NA	0
			Tiles	3	2	0	NA	0	NA	NA	NA	0
2B	Phoenix	30	Tiles	0	0	0	NA	0	NA	NA	NA	0
		30	Lt. Metal	2/0	0	0	0	0	NA	NA	NA	0
3A	Atlanta	30	Dk. Asphalt	2/1	2/0	2	1/0	0	NA	NA	NA	0
3C	San Francisco	30	Tiles	2	1	2	2	0	NA	NA	NA	0
			Dk. Asphalt	1	0	0	0	0	NA	NA	NA	0
			Lt. Metal	3	2	3	3	0	NA	NA	NA	0
4A	Kansas City	38	Dk. Asphalt	3/3	3/2	3/3	3/2	1/0	0	NA	NA	0
			Lt. Metal	3/3	3/3	3/3	3/3	2/1	0	NA	NA	0
4C	Seattle	38	Dk. Asphalt	3/3	2/1	3/2	3/0+	0	0	NA	NA	0
			Lt. Metal	3/3	3/2	3/3	3/2	3/0+	3/0	NA	NA	
			Cedar Shakes	3/3	2/2	3/3	3/2	0	0	NA	NA	0
4A	Boston	38	Dk. Asphalt	3/3	3/2	3/3	3/2	0+	0	NA	NA	0
			Lt. Metal	3/3	3/3	3/3	3/3	3/1	2/0	NA	NA	0
5A	Chicago	38	Dk. Asphalt	3/3	3/2	NA	NA	NA	0	0	0/0	0
			Lt. Metal	3/3	3/3	NA	NA	NA	2/0	0	0/0	0
5B	Boulder	38	Dk. Asphalt	3/3	2/1+	3/2	NA	0/0	0	0	0/0	0
			Lt. Metal	3/3	3/2	3/3	NA	3/0	2/0	0	0/0	0
6A	Minneapolis	49	Dk. Asphalt	3/3	2/2	NA	NA	NA	0/0	0/0	0/0	0/0
			Lt. Metal	3/3	3/3	NA	NA	NA	3/0	3/0	2/0	
7A	Int. Falls	49	Dk. Asphalt	3/3	3/2	NA	NA	NA	0/0	0/0	0/0	0/0
			Lt. Metal	3/3	3/3	NA	NA	NA	3/1-	3/0	3/0	

Legend

OSB Moisture Content, Inner layer

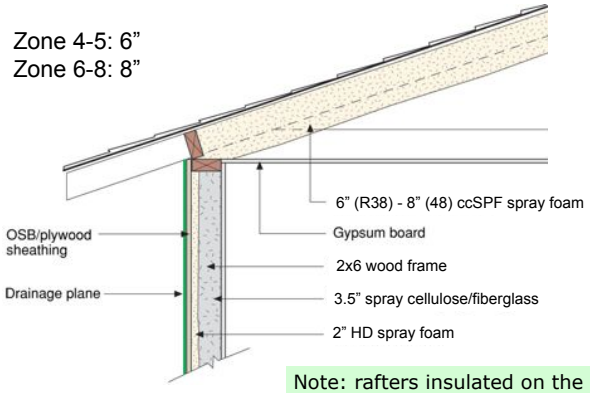
0 - Below 16% all year
1 - Above 16% 1 week
2 - Above 16% 4 weeks
- Above 28% 1 week
3 - Above 28% 4 weeks

Results are for High moisture interior conditions if a single number is given
Results are for High/Normal moisture interior conditions if reported as X/Y.
Color represents performance under High interior moisture conditions
NA means simulations were not conducted - color represents estimated extrapolation
See paper for definitions of High/Normal moisture loads

Indicates danger of convective-air-movement-induced condensation at normal moisture level

Full ccSPF roof

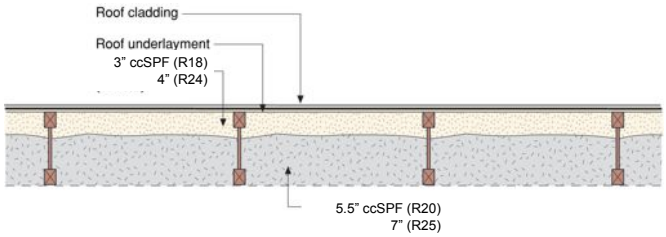
Zone 4-5: 6”
Zone 6-8: 8”



Note: rafters insulated on the inside

Hybrid Code R & fire protection

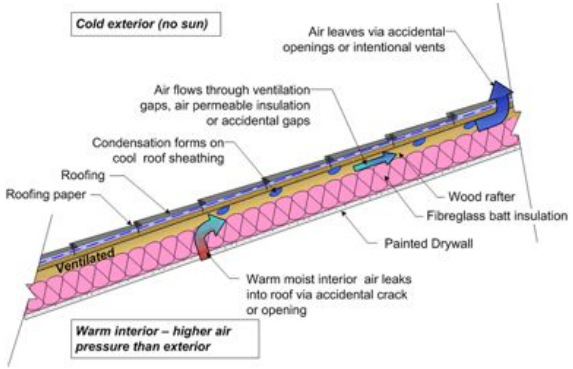
Cold Climate R38: Zone 4/5
R49: Zone 6/7/8



Air Leakage

- Its not all about diffusion
- air leakage is more important
  - But level of leakage varies
- Design value is zero leakage
  - But we know roofs leak *some* air.
  - How much?
  - What paths?

Air Leaks – cathedral ceilings



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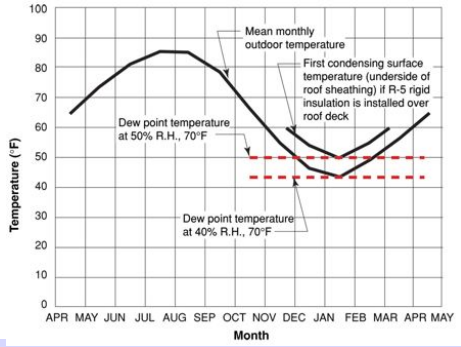
Air Leaks: Monthly Calculation

Compare interior air dewpoint to exterior sheathing temperature



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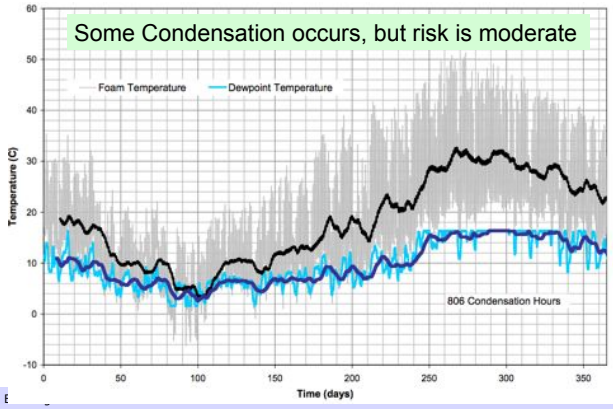
Hourly: Denver, Normal Load



Air leakage condensation

- *Potential* hours of condensation

Zone	City	Roofing	1" ccSPF Normal	1" ccSPF High	2" ccSPF Normal	2" ccSPF High	Kraft-faced batt Normal	Kraft-faced batt High	3" ccSPF Normal	3" ccSPF High
4A	Kansas City	Dk Asphalt	2058	3217	825	2114	3530	3530	34	666
		Lt Metal	2564	3857	1041	2754	2912	4855	58	886
4A	Boston	Dk Asphalt	1889	3297	528	1989	3608	5100	12	344
		Lt Metal	2368	4055	647	2656	3005	3949	14	471
4C	Seattle	Dk Asphalt	1059	3233	9	1245	3397	5673	0	0
		Lt Metal	1282	4111	12	1655	3043	4368	0	0
									4" Closed Cell Foam	
5A	Chicago	Dk Asphalt	2491	3666	924	2477	N/S	N/S	0	0
		Lt Metal	3083	4352	1192	3249	N/S	N/S	0	0
5B	Boulder	Dk Asphalt	2487	3651	806	2347	N/S	N/S	0	0
		Lt Metal	2916	4443	986	2980	N/S	N/S	0	0
6A	Minneapolis	Dk Asphalt	3149	4320	2050	3454	N/S	N/S	182	773
		Lt Metal	3728	4964	2528	4200	N/S	N/S	234	956
7	International Falls	Dk Asphalt	3980	4869	2980	4085	N/S	N/S	777	1738
		Lt Metal	4508	5556	3400	4975	N/S	N/S	875	1919

Legend: Less than 100 hrs per year; Less than 1000 hrs per yr; N/S - not simulated; Over 1000 hrs per year

Recommend 3" ccSPF in Zones 4/5, 4" in 6/7, more if high RH

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Hybrid Roof Insulation IRC

- IRC 2009

TABLE R806.4
INSULATION FOR CONDENSATION CONTROL

CLIMATE ZONE	MINIMUM RIGID BOARD OR AIR-IMPERMEABLE INSULATION *R*-VALUE [A]	ccSPF
2B and 3B tile roof only	0 (none required)	
1, 2A, 2B, 3A, 3B, 3C	R-5	1"
4C	R-10	2"
4A, 4B	R-15	2.5"
5	R-20	3+"
6	R-25	4+"
7	R-30	5"
8	R-35	6"

a. Contributes to but does not supersede Chapter 11 energy requirements.

… or all air impermeable insulation

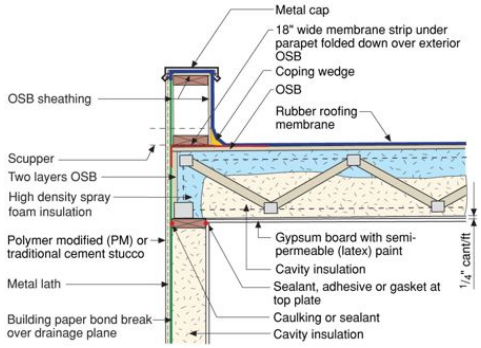
Conclusions

- Unvented cathedral ceilings can be used in all climates
- Full-depth ccSPF works in all climates
- Pure spray fiberglass/cellulose not in most climates
- Hybrid (fibrous+foam) can work well in all climates
- More air impermeable insulation R-value needed as climate is colder

Thanks & Questions

- Johns Manville sponsor

Potential Backup Slides



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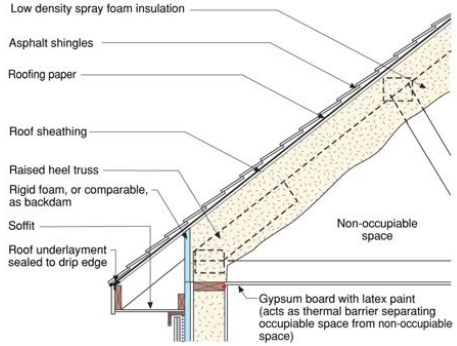
Warmer climates



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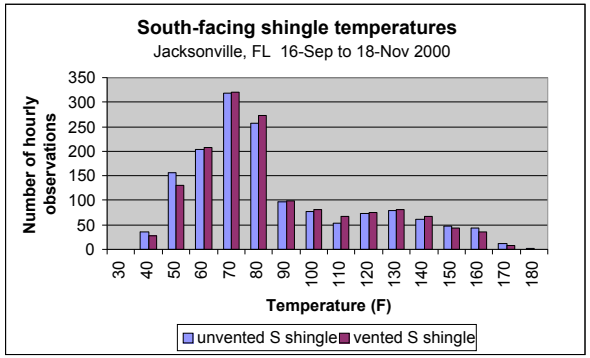
Vented vs. unvented shingle temperatures



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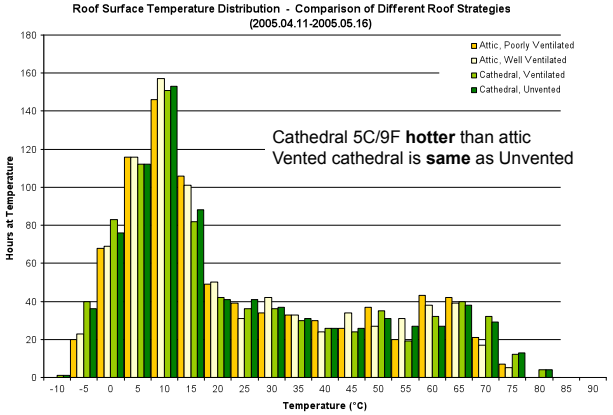
Ventilation & Roof Temperature



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Enough ventilation can provide cooling

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Hybrid: Air, thermal, fire

Warm Climate Zone!