

# Moisture safe cold attics - Assessment based on risk analyses of performance and cost

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# Problems!

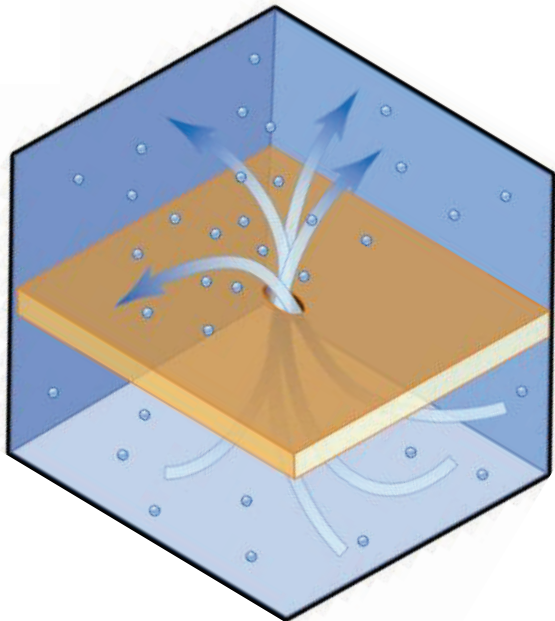
At least 60% (maybe up to 84%) of the existing buildings in the area around Gothenburg have mould growth in their attics!

In Sweden: Approx 2 million buildings, 73 +/-7 % have cold attics

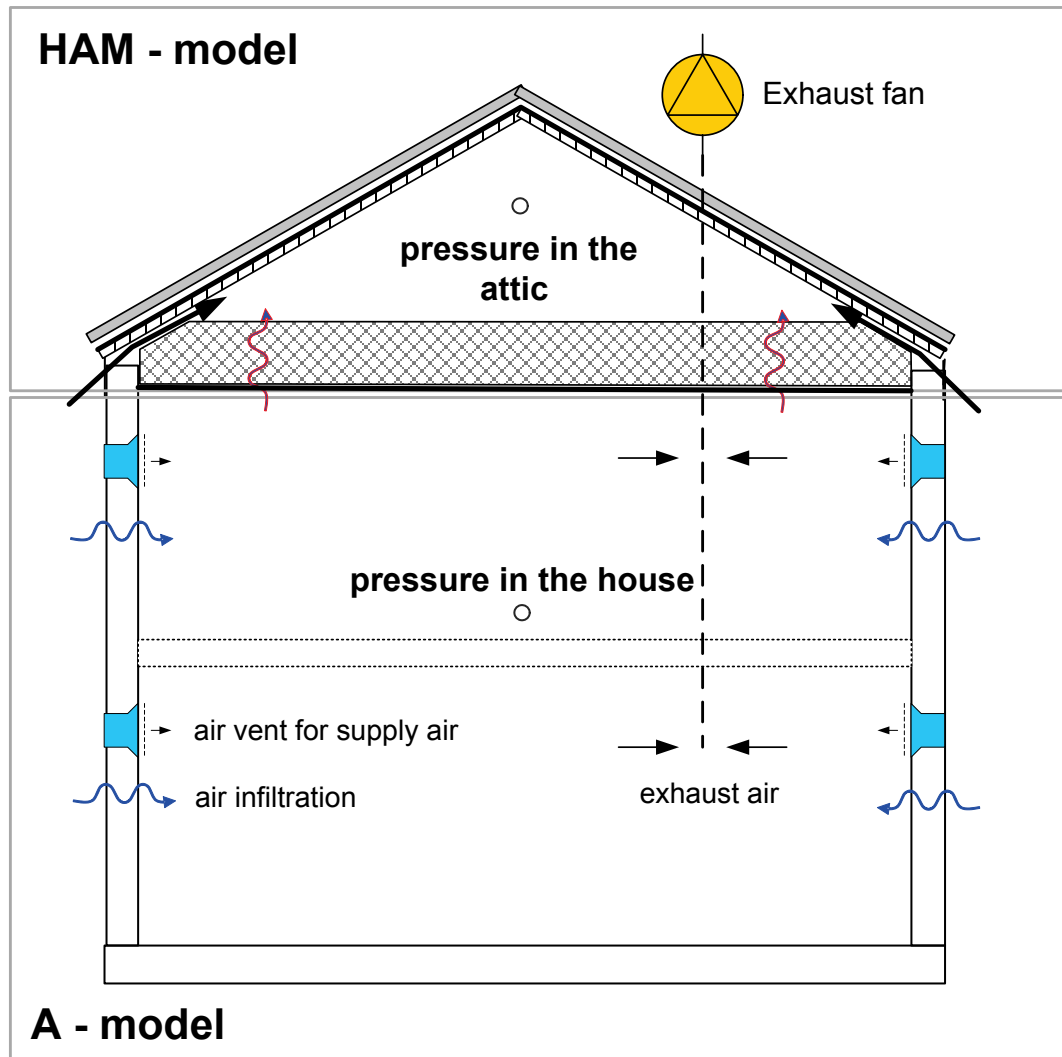


# Difficult to design!

- An air tight attic floor should be achieved – but is difficult to guarantee
- Ventilation system, heating system, moisture production and external climate influences the performance.

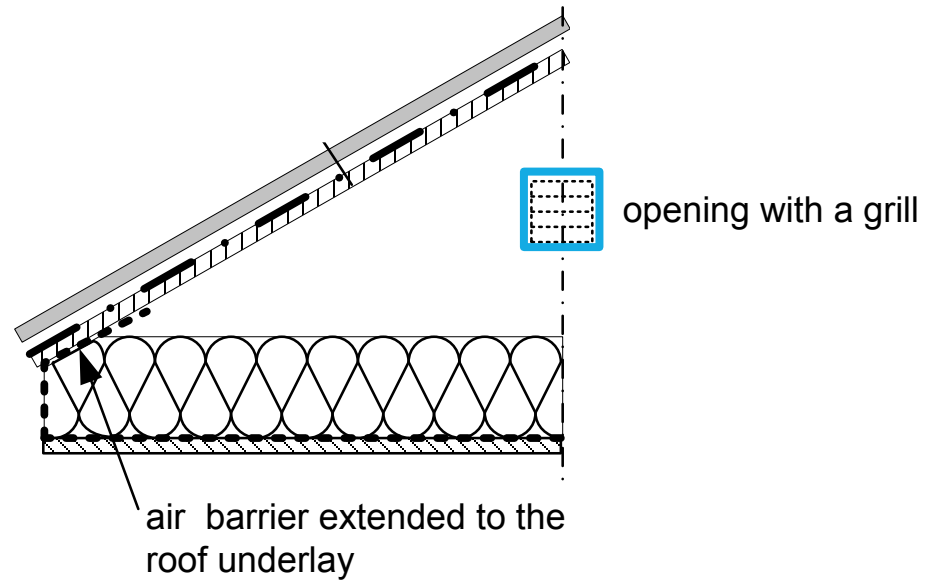
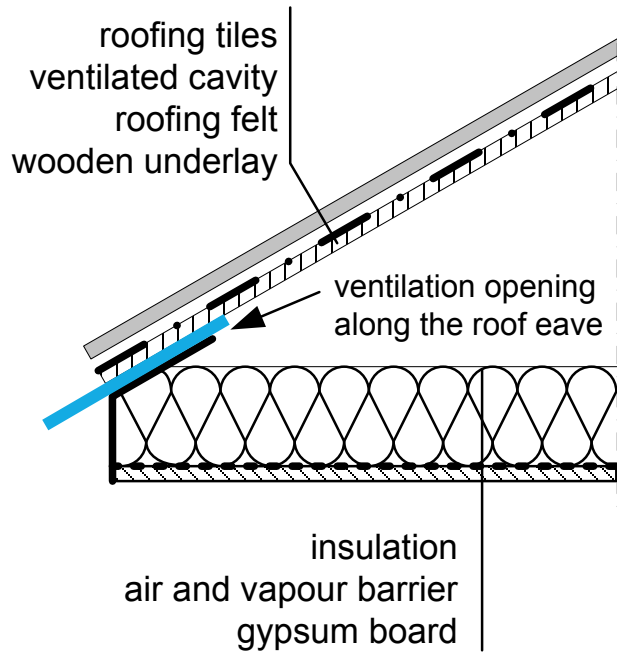


# Studied Attic

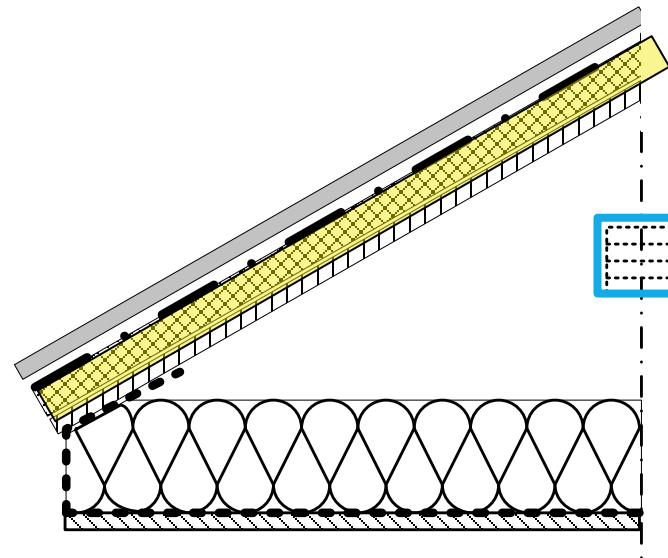
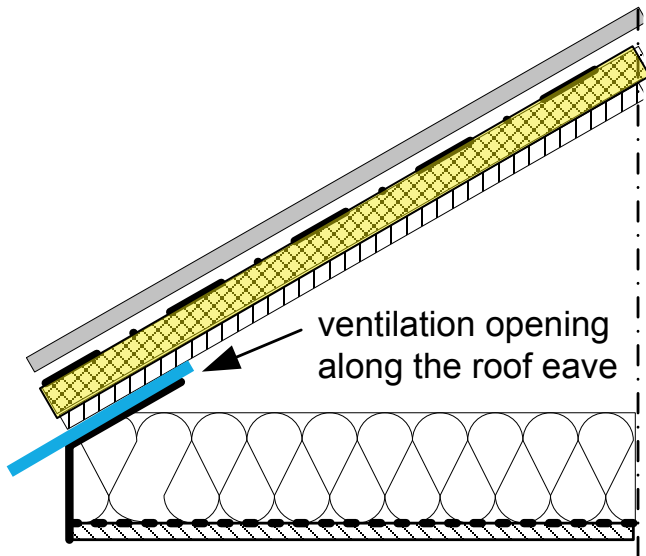


# 1 - Conventionally naturally ventilated attics

## Varying vent opening areas



## 2 - Natural ventilation – Insulated roof

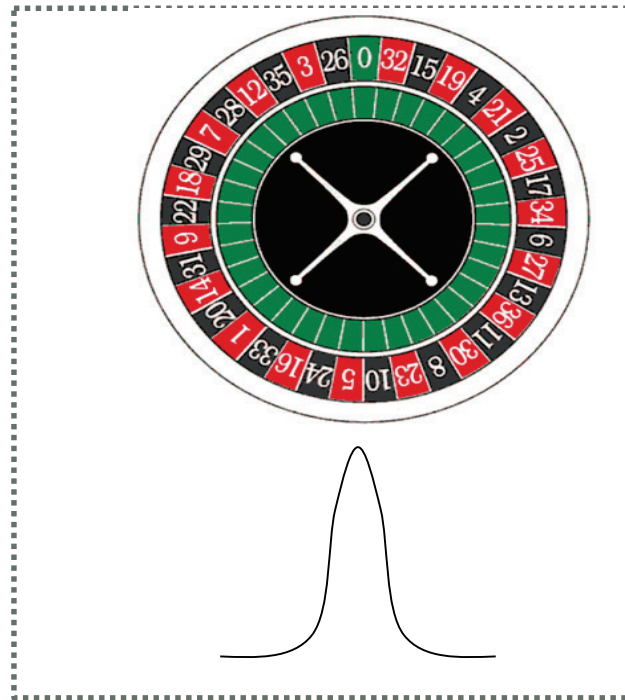




# Probabilistic analysis

## Monte Carlo simulations

### Mould growth risk



Simulation Tools: HAM-Tools (Sasic),  
SimpleColdAttic (Hagentoft, Nik)



# SimpleColdAttic (Hagentoft, Nik)

Free software: [www.byggnadsteknologi.se/downloads.html](http://www.byggnadsteknologi.se/downloads.html)

The screenshot shows the 'Attic Calculation' software window. It is divided into two main sections: 'Deterministic Simulation' and 'Probabilistic Simulation'. The deterministic section contains a list of input parameters and their values. The probabilistic section contains a list of input parameters with their distributions and values, and a 'Number of Simulations' field. There are also buttons for 'Load the Weather Data', 'Run the Attic Model', and 'Plotting Results'.

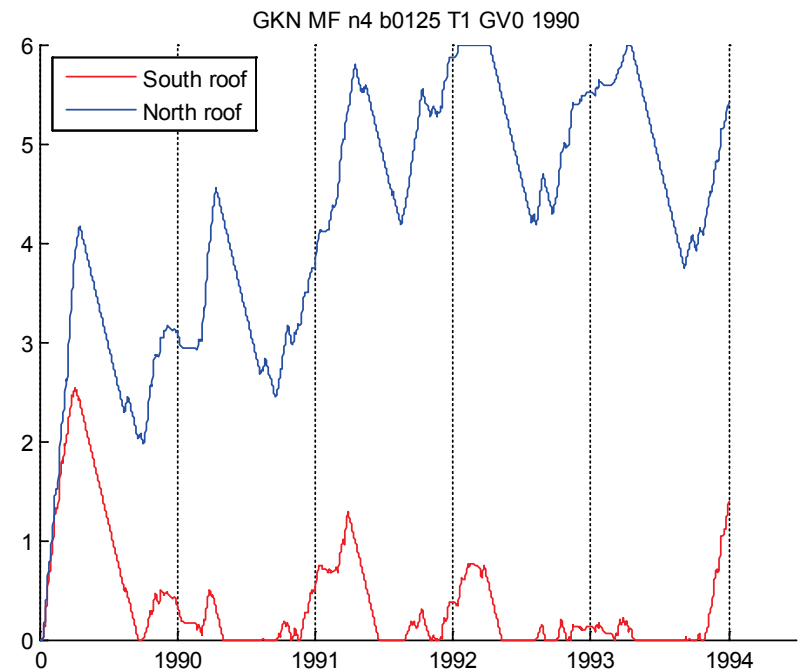
Deterministic Simulation		Probabilistic Simulation	
Height of building [m]	5	U ( 4 8 ) [m]	Number of Simulations 10
Area of ceiling and roof A [m <sup>2</sup> ]	220	U ( 50 200 ) [m <sup>2</sup> ]	Run the Attic Model
Venting area per meter eave Ave [m <sup>2</sup> ]	0.02	U ( 0.001 0.05 ) [m <sup>2</sup> ]	
Length of building (eave side) L [m]	20	U ( 7 20 ) [m]	U: Uniform distribution N: Normal distribution
Thickness of wooden underlay d [m]	0.022	U ( 0.01 0.02 ) [m]	
Vapour diffusion coefficient of wood v [m <sup>2</sup> /s]	1e-6	N ( 1e-6 2e-7 ) [m <sup>2</sup> /s]	
Initial relative humidity of wood RHwi [-]	0.7	U ( 0.5 0.9 ) [-]	
Thermal conductivity of roof wood [W/mK]	0.13	N ( 0.13 0.02 ) [W/mK]	
Thermal resistance of roof insulation Rr [m <sup>2</sup> K/W]	0	U ( 0 1 ) [m <sup>2</sup> K/W]	
Leakage area per m <sup>2</sup> of ceiling Ac [m <sup>2</sup> /m <sup>2</sup> ]	3e-5	U ( 0.001 0.05 ) [m <sup>2</sup> /m <sup>2</sup> ]	
U-value of the ceiling Uc [W/m <sup>2</sup> K]	0.2	U ( 1 5 ) [W/m <sup>2</sup> K]	
Indoor temperature Ti [°C]	21	N ( 20 1.5 ) [°C]	
Indoor moisture supply [kg/m <sup>3</sup> ]	0.002	N ( 0.005 0.002 ) [kg/m <sup>3</sup> ]	
Orientation of one of eave sides (0-180) [deg]	90	U ( 0 180 ) [deg]	
Year of climate data (1-30) [-]	30	U ( 1 30 ) [-]	

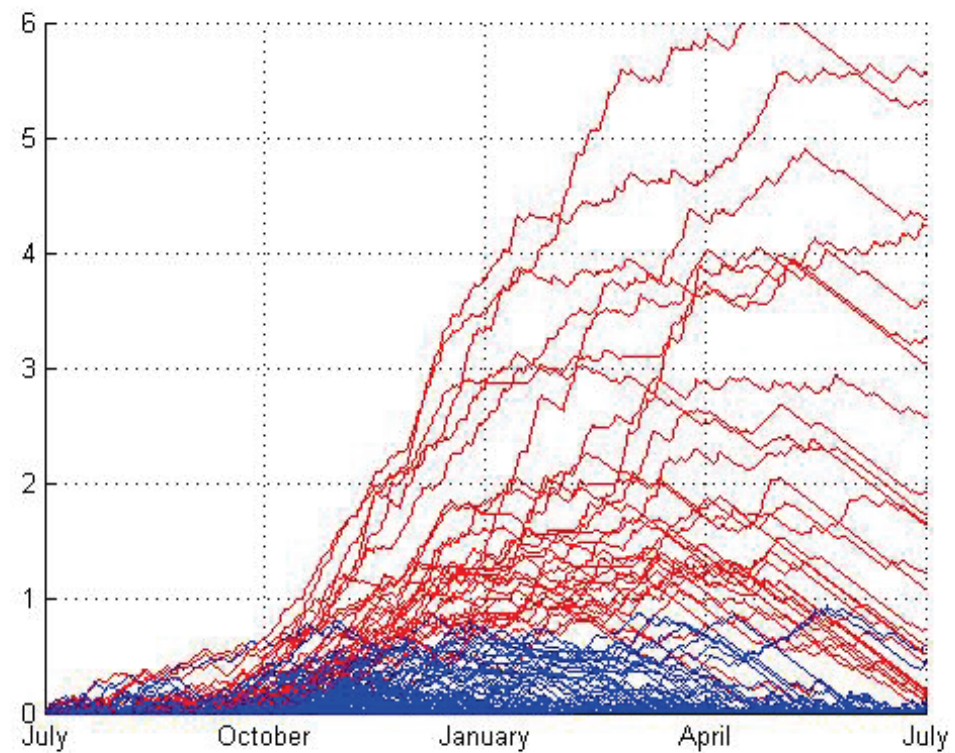
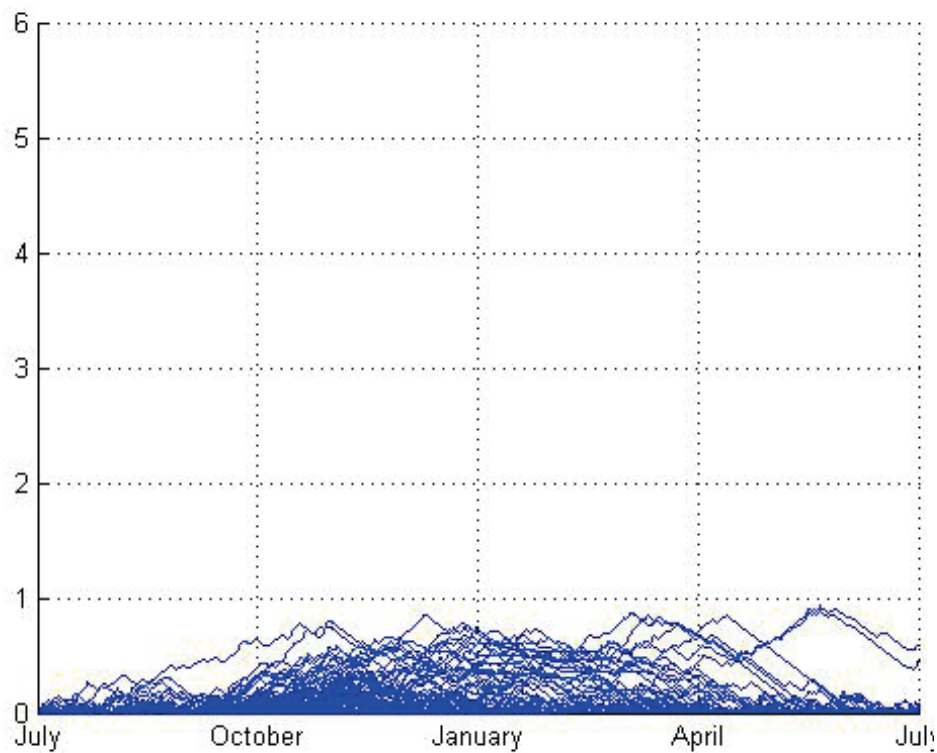
Plotting Results  
Temperature on the surface: Profile CDF  
RH on the surface: Profile CDF  
Mould index: Profile CDF  
Heat flow through the floor: Profile CDF

Building Physics Research Group - Chalmers University of Technology

Index	Growth rate	
0	No growth	Spores not activated
1	Some growth detected only with microscopy	Initial stages of hyphae growth
2	Moderate growth detected with microscopy	Coverage more than 10 %
3	Some growth detected visually	New spores produced
4	Clear visually detected growth	Coverage more than 10 %
5	Plenty of visually detected growth	Coverage more than 50 %
6	Very heavy and tight growth	Coverage around 100 %

## Mould index, (Viitanen)





MGI during a year – Above 1 (once) – The attic is considered damaged!

Only one year is studied

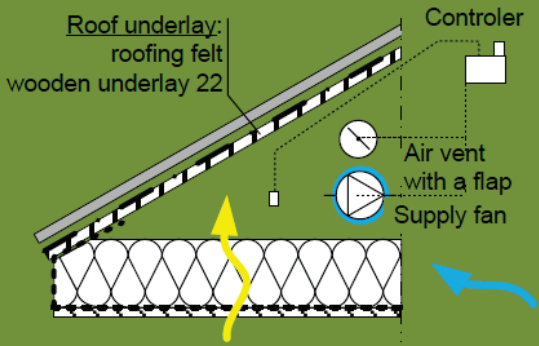
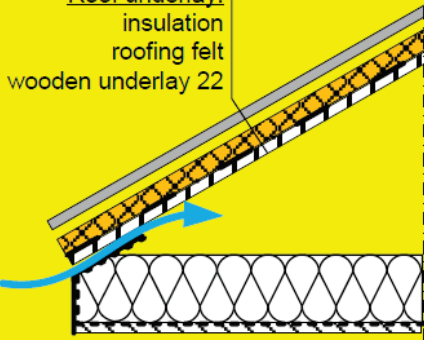
Risk free (green)

Low risk (yellow)

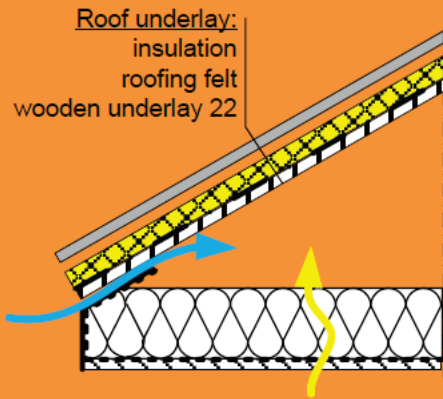
Semi high risk (orange)

High risk (red)

# Conclusions in a nutshell Swedish conditions

	Cold attic construction	Requirements and sensitivity
Risk free	 <p>Roof underlay: roofing felt wooden underlay 22</p> <p>Controller</p> <p>Air vent with a flap</p> <p>Supply fan</p> <p>Controlled mechanical ventilation</p>	<ul style="list-style-type: none"><li>• The airtightness of the attic should be at least 10 l/h@50Pa</li><li>• Ventilation should start directly after completeness of attic construction</li><li>• Requires alarm function for failure of mechanical devices</li><li>• Lowest total life cycle cost</li></ul>
Low risk	 <p>Roof underlay: insulation roofing felt wooden underlay 22</p> <p>Insulated roof, good air tightness of the attic floor</p>	<ul style="list-style-type: none"><li>• Requires durable solution for the airtightness of the attic floor.</li><li>• Works better at low moisture excess in the building (well ventilated housing - preferably exhaust only mechanical ventilation system).</li><li>• Sensitive to the building orientation.</li><li>• Some sensitivity to the local and future climate.</li><li>• Should be supplemented with dehumidifiers in the construction phase to eliminate built-in moisture.</li></ul>

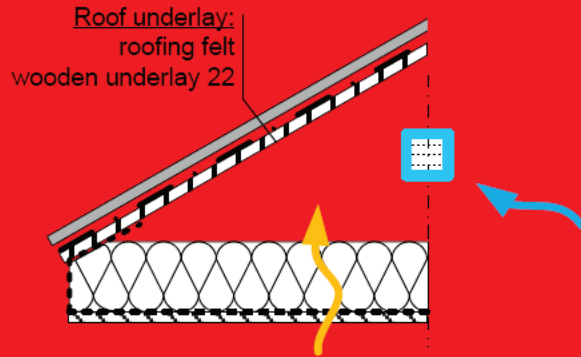
Semi-high risk



Insulated roof, some air leakage in the attic floor

- Works better at low moisture excess in the building (well ventilated housing - preferably exhaust only mechanical ventilation system).
- Sensitive to the local and future climate.
- Should be supplemented with dehumidifiers in the construction phase to eliminate built-in moisture.

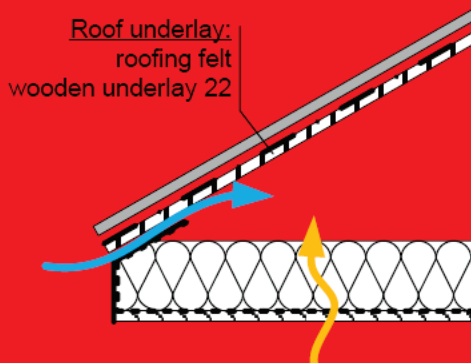
High risk



Reduced ventilation – only through gable vents; air tight roof eaves.

- Extra sensitive to the lack of air-tightness in the attic floor and high moisture excess in the home.
- Should be supplemented with dehumidifiers in the construction phase to eliminate built-in moisture.
- Sensitive to future climate.

High risk



- Extra sensitive to the lack of air-tightness in the attic floor and high moisture excess in the home.
- Sensitive to future climate.
- The most expensive technical solution when lifecycle cost is assessed.
- Should be supplemented with dehumidifiers in the construction phase to eliminate built-in moisture.

# Economical Analysis – Total cost (SEK) per year

Alternative	Base investment	Operation. Cost (SEK)	City	Airtightn. Moisture Supply	Risk MGI>1	Damage investment Cost	Reduction in energy demand (kWh)	Yearly cost (SEK)
1. Convent.	76380	0	GBG	-	100	38400	0	5 739
2 Insulated roof	94135	0	GBG	Good low	10	3840	10 (1%)	4 889
2 Insulated roof	94135	0	GBG	Not good high	50	19200	10	5 657
2 Insulated roof	94135	0	STO	Good low	0	0	10	4 697
2 Insulated roof	94135	0	STO	Not good high	20	7680	10	5 081
3 Controlled ventilation	88427 (80927)	600	-	-	0	0	7 (1%)	4 639

Interest rate is 5% - on initial investment cost

Controlled ventilation: Fan is exchanged every 15 year – Cost: 500 SEK/year, Plus 100 SEK for electricity bill

Renovation costs is included/correspond to a an extra initial investment – when damaged – clean and install controlled ventilation

No ill-will (bad-will) is included

Initial cost for drying of building damp is included with 5000SEK (for the two first cases)

Real value – no inflation

GBG: Gothenburg STO: Stockholm

Thanks!



# Correct ventilation?

- Construction damp → Requires ventilation
- Moisture entering from occupied space → Requires ventilation
- Vapor in outdoor air → Minimize the ventilation

