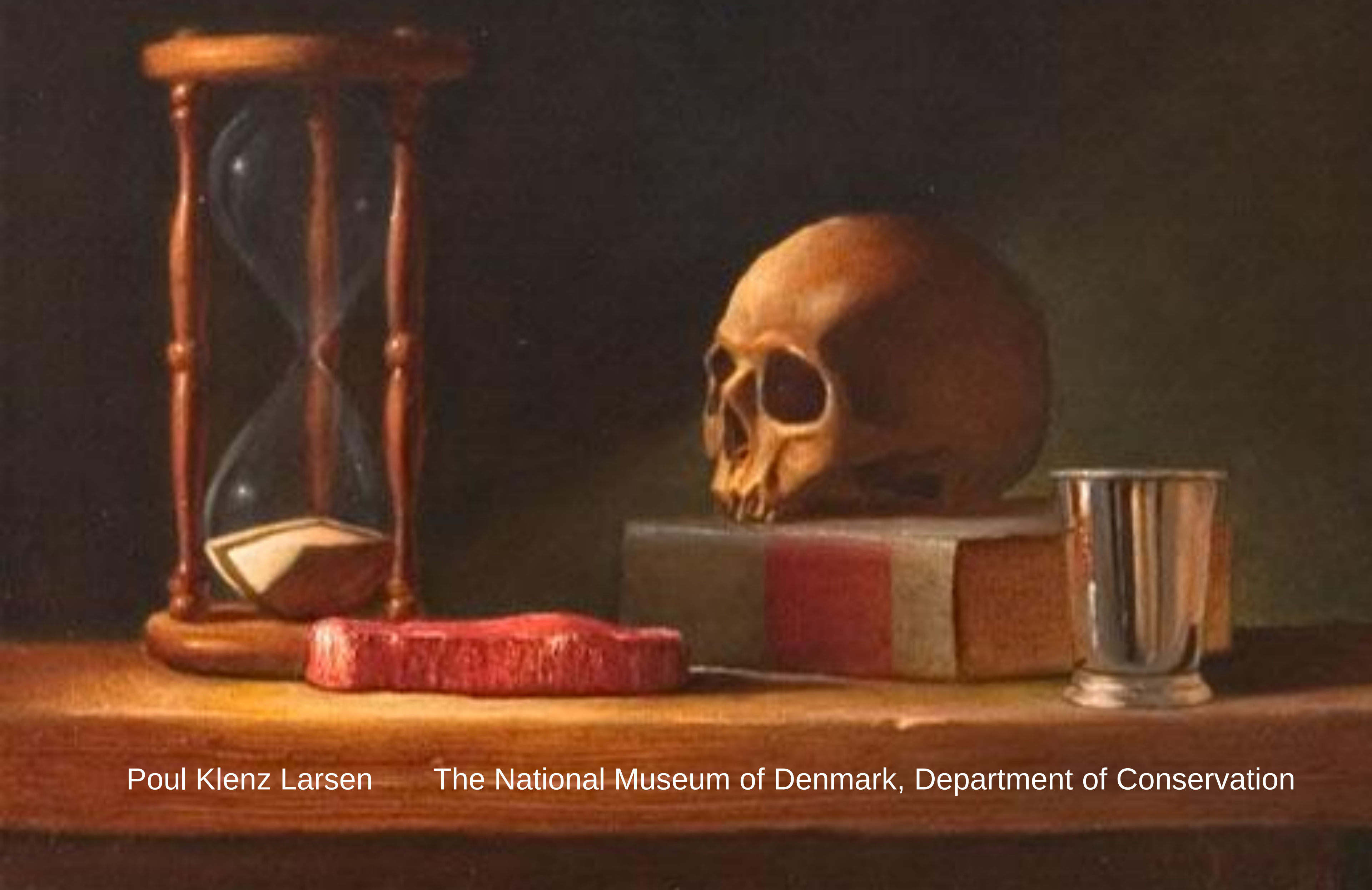
Energy efficient climate control in museum stores - Conservation heating or dehumidification ?



Poul Klenz Larsen The National Museum of Denmark, Department of Conservation

A shelter for fighter airplanes protecting against a nuclear strike.

The roof is 50 cm solid concrete covered with plastic paint

In use as temporary store for collection of furniture

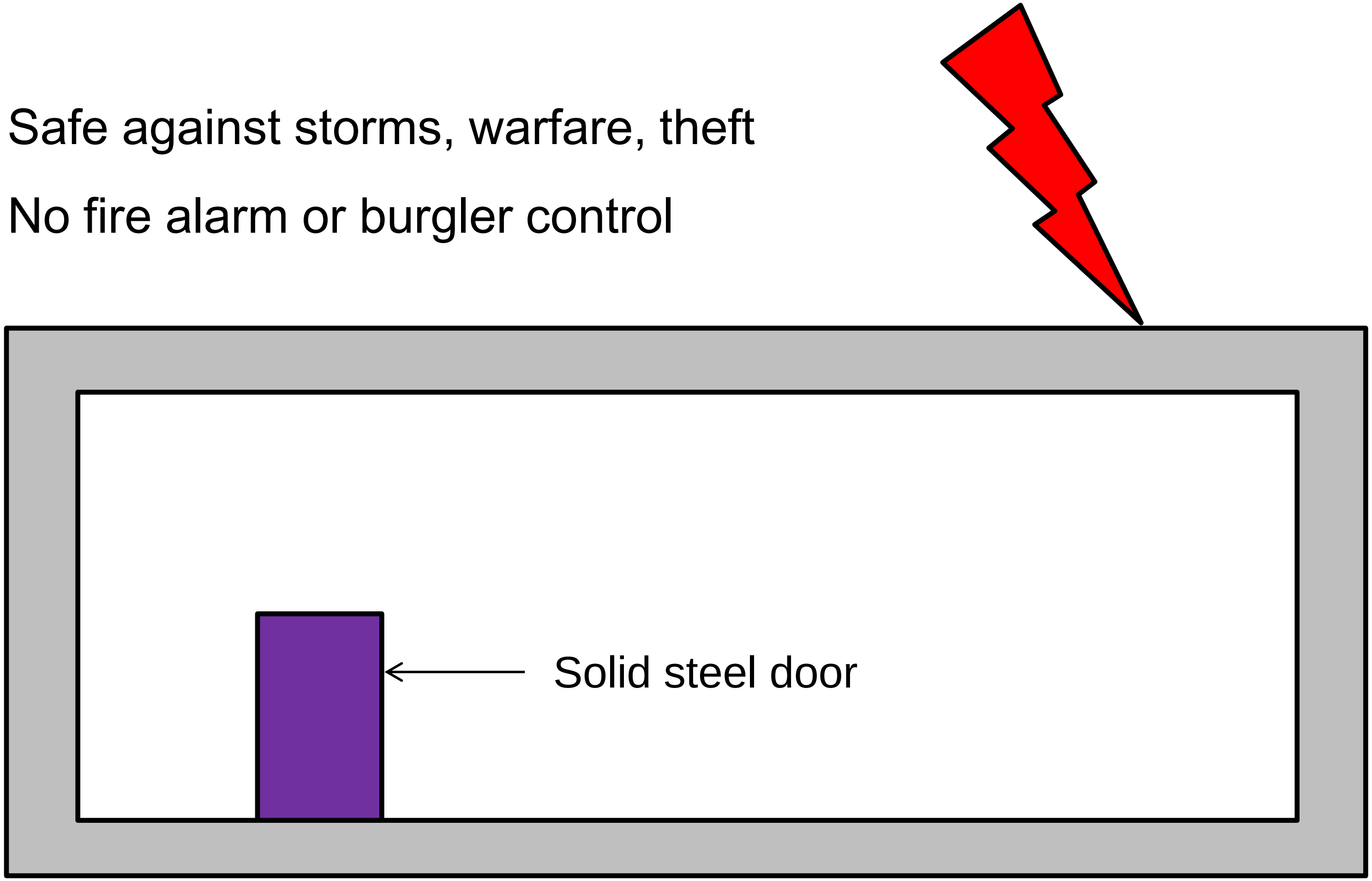
The store is densly packed with moisture sensitive wooden objects

There is only one entrance through a steel door

Security control

Safe against storms, warfare, theft

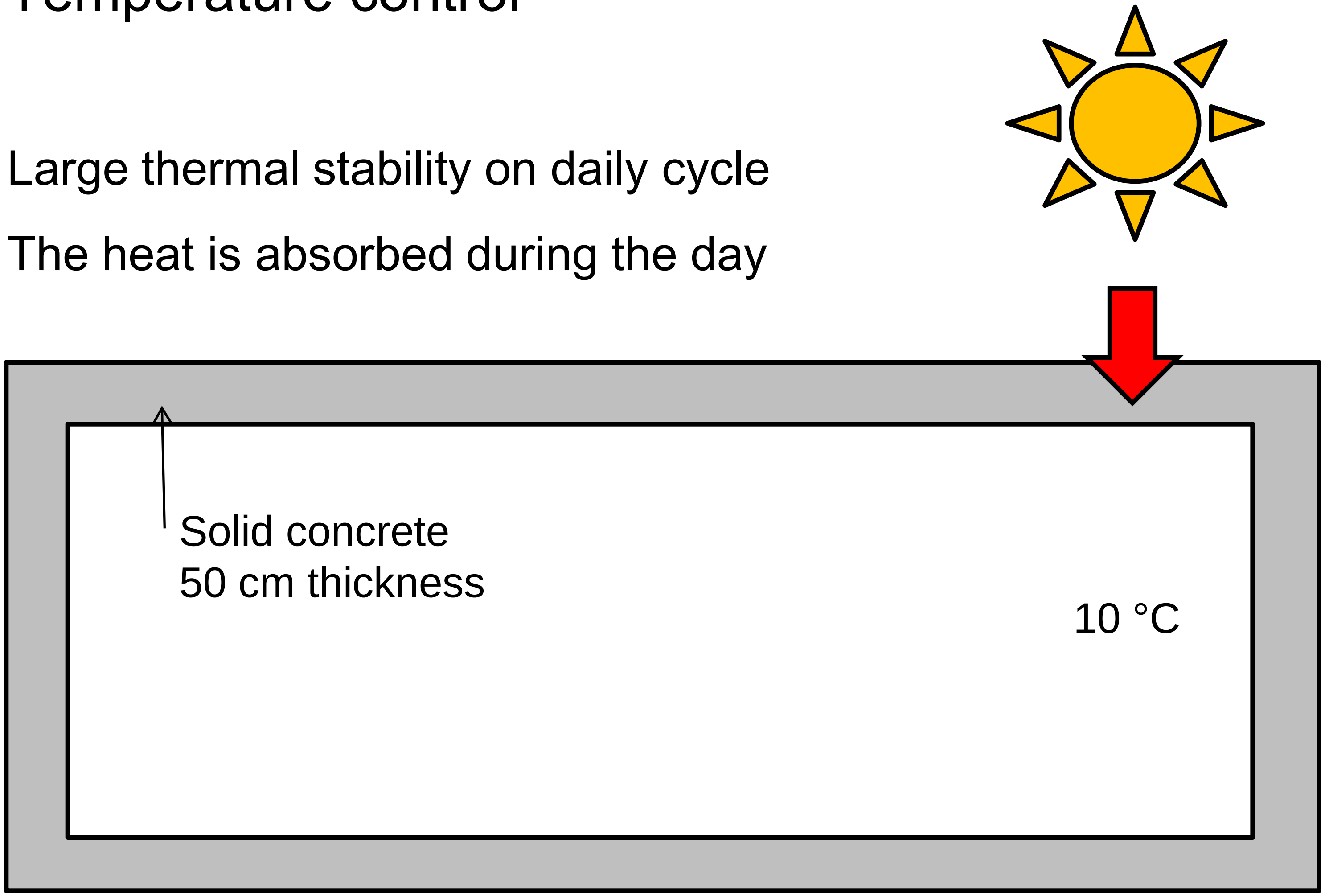
No fire alarm or burgler control



Temperature control

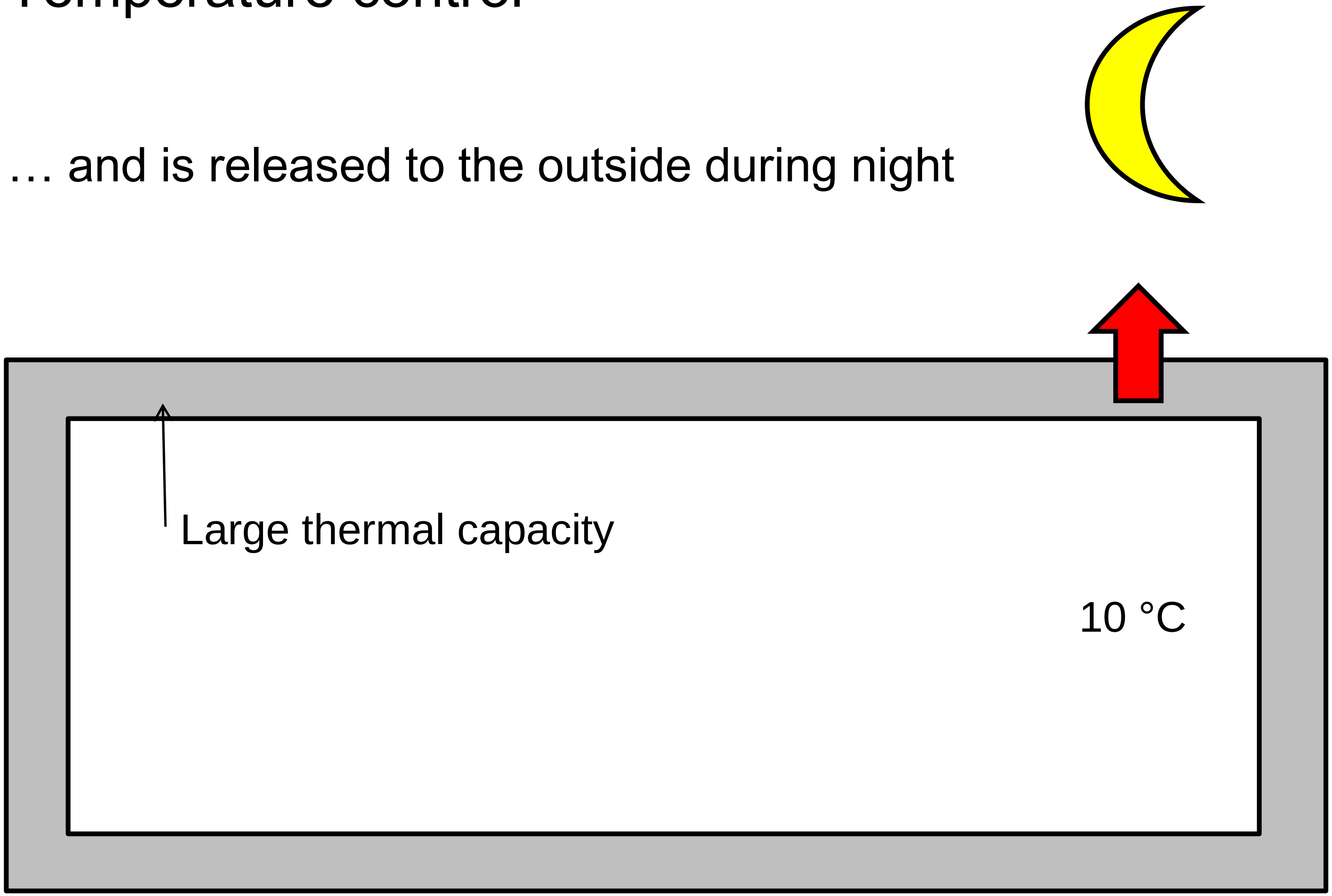
Large thermal stability on daily cycle

The heat is absorbed during the day



Temperature control

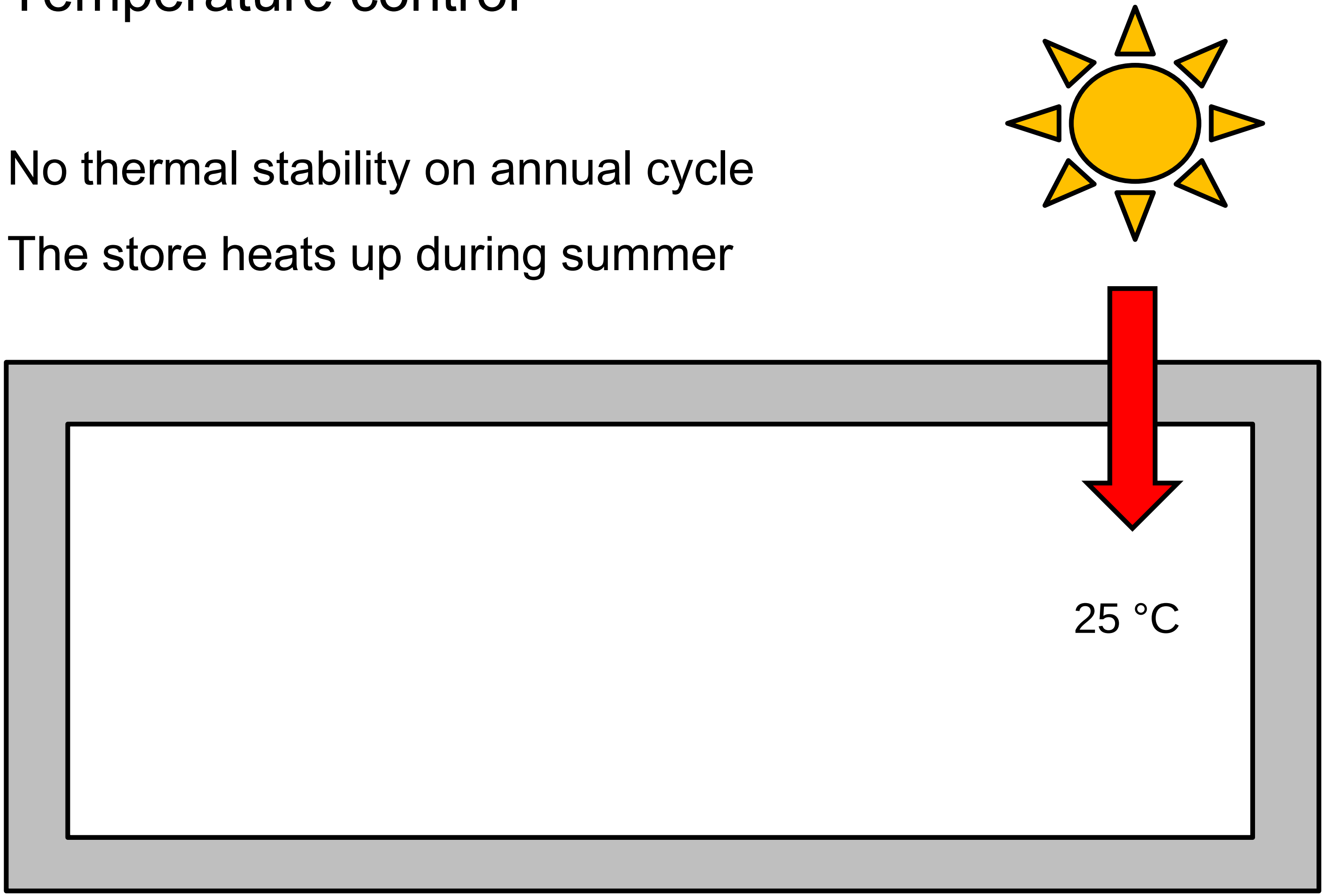
… and is released to the outside during night



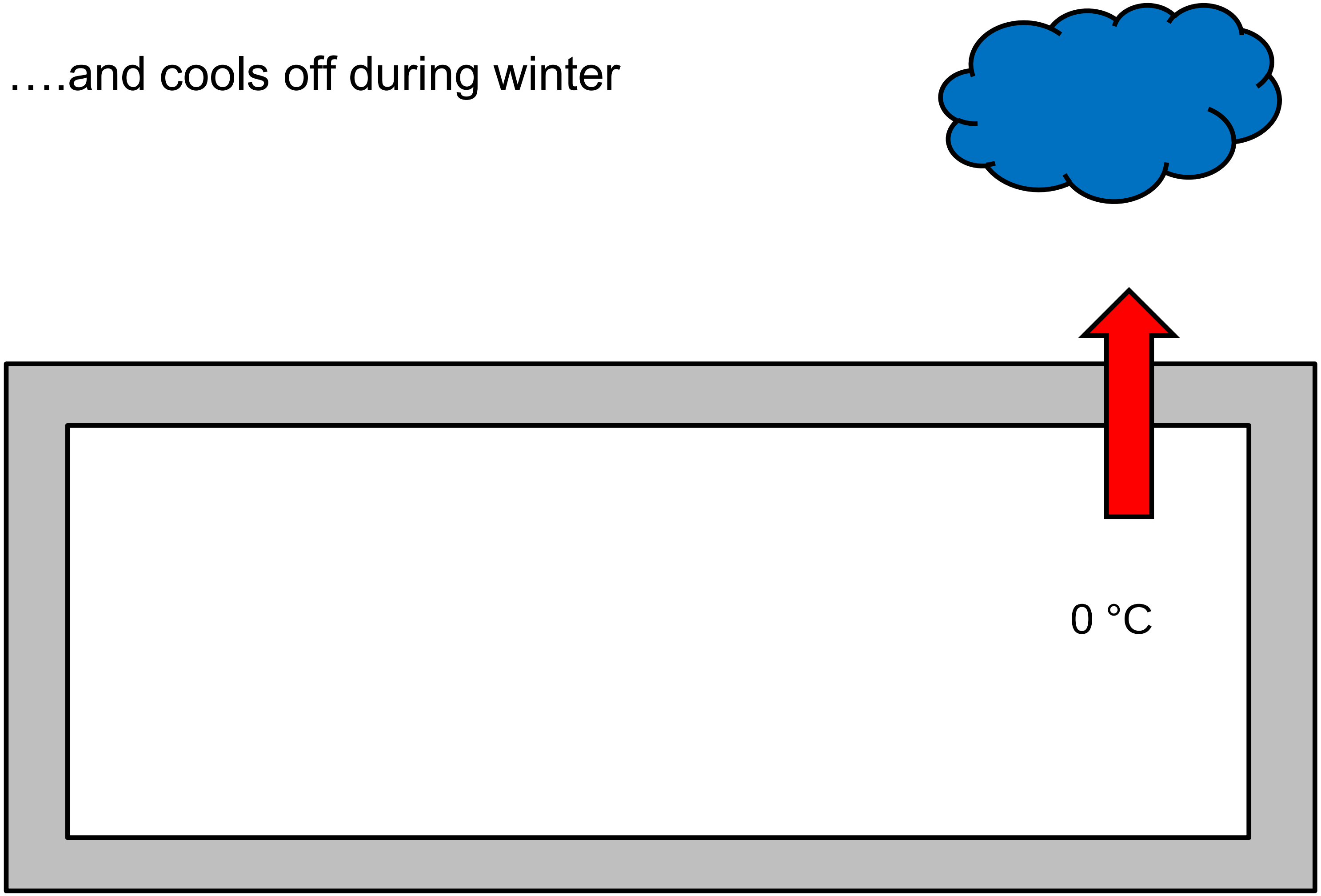
Temperature control

No thermal stability on annual cycle

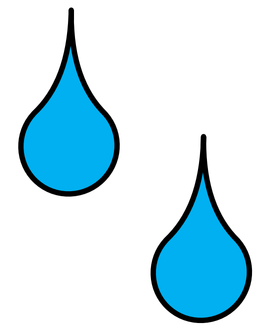
The store heats up during summer



….and cools off during winter

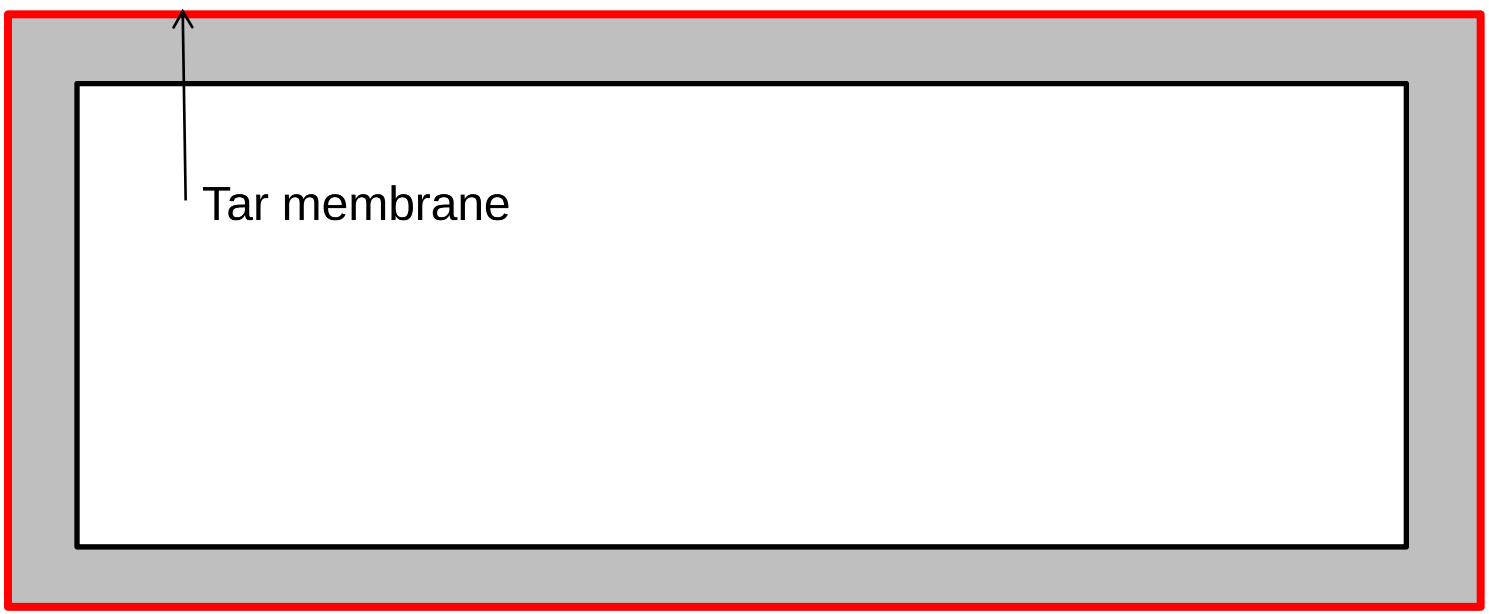


Humidity control



The structure is water tight

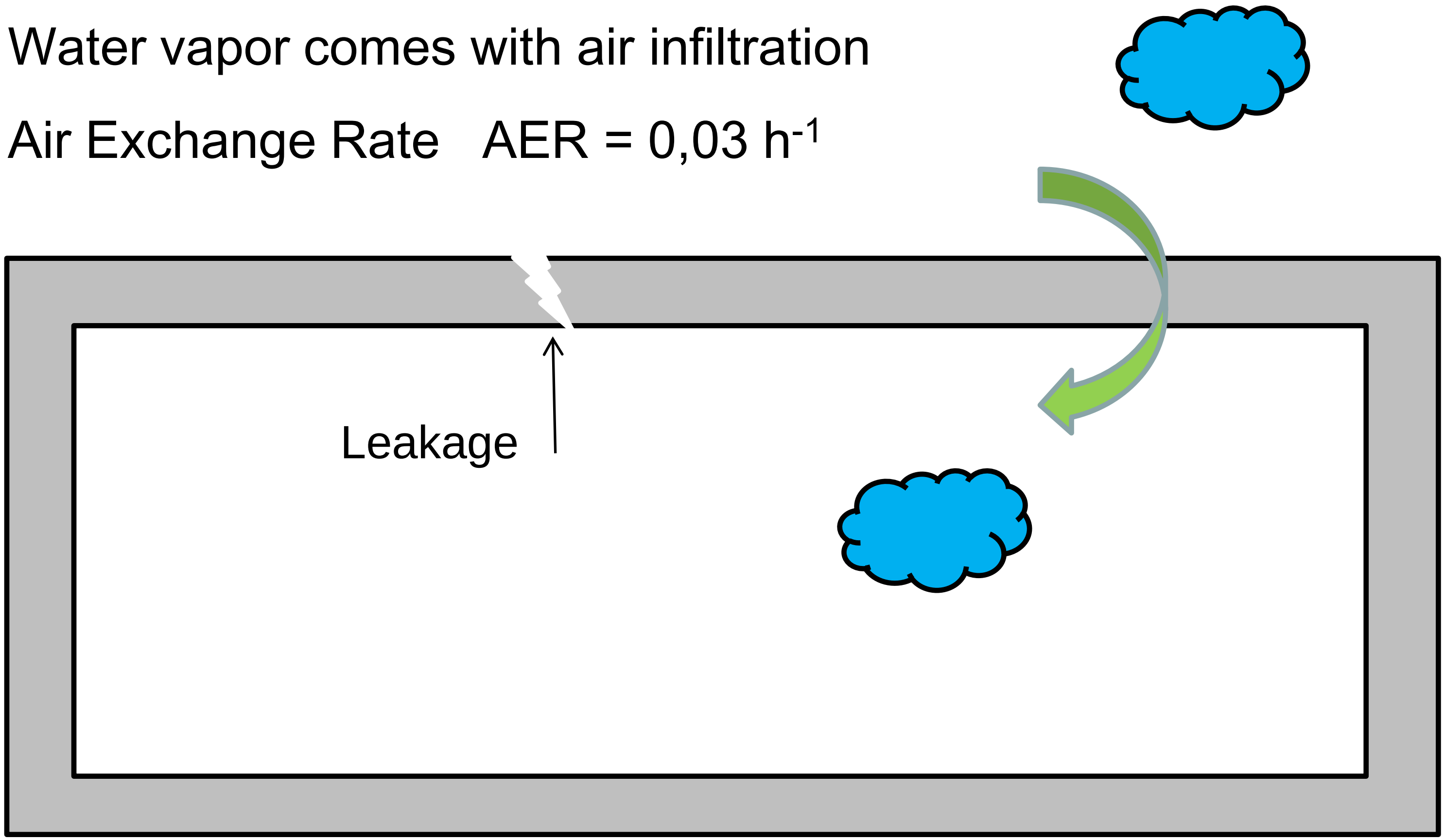
The only source of humidity is the outside air



Humidity control

Water vapor comes with air infiltration

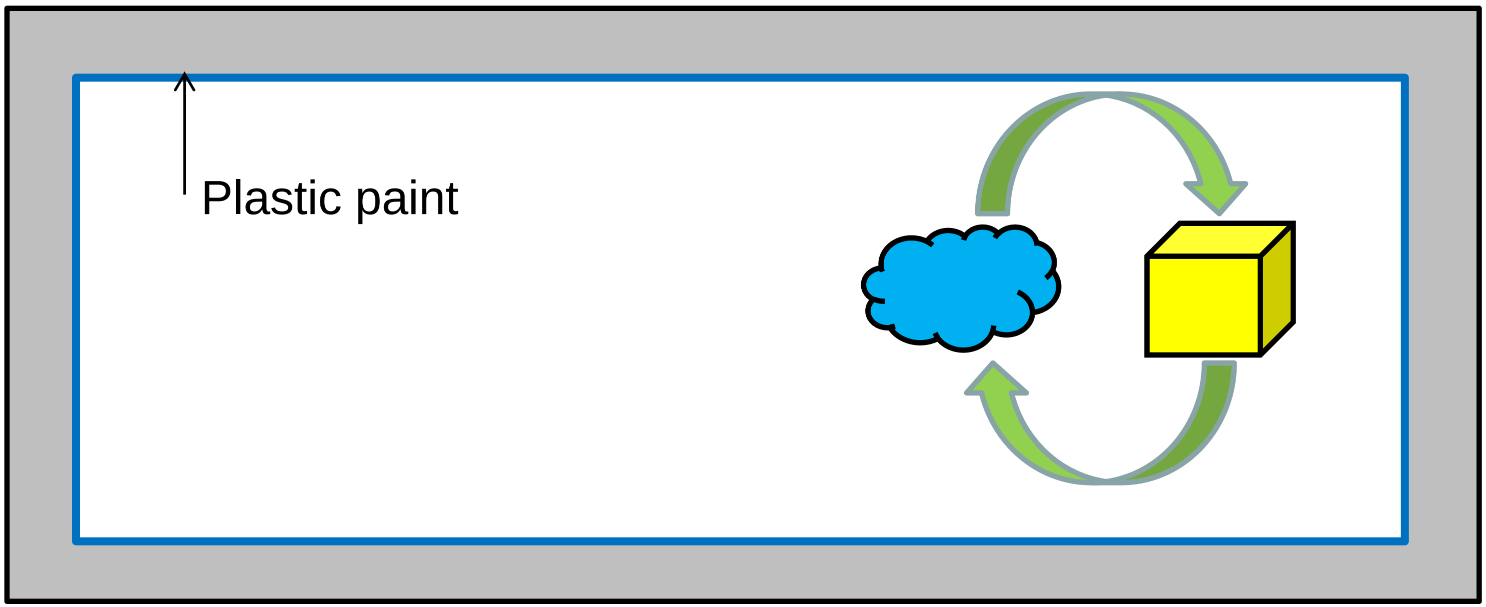
Air Exchange Rate AER = 0,03 h^{-1}



Humidity control

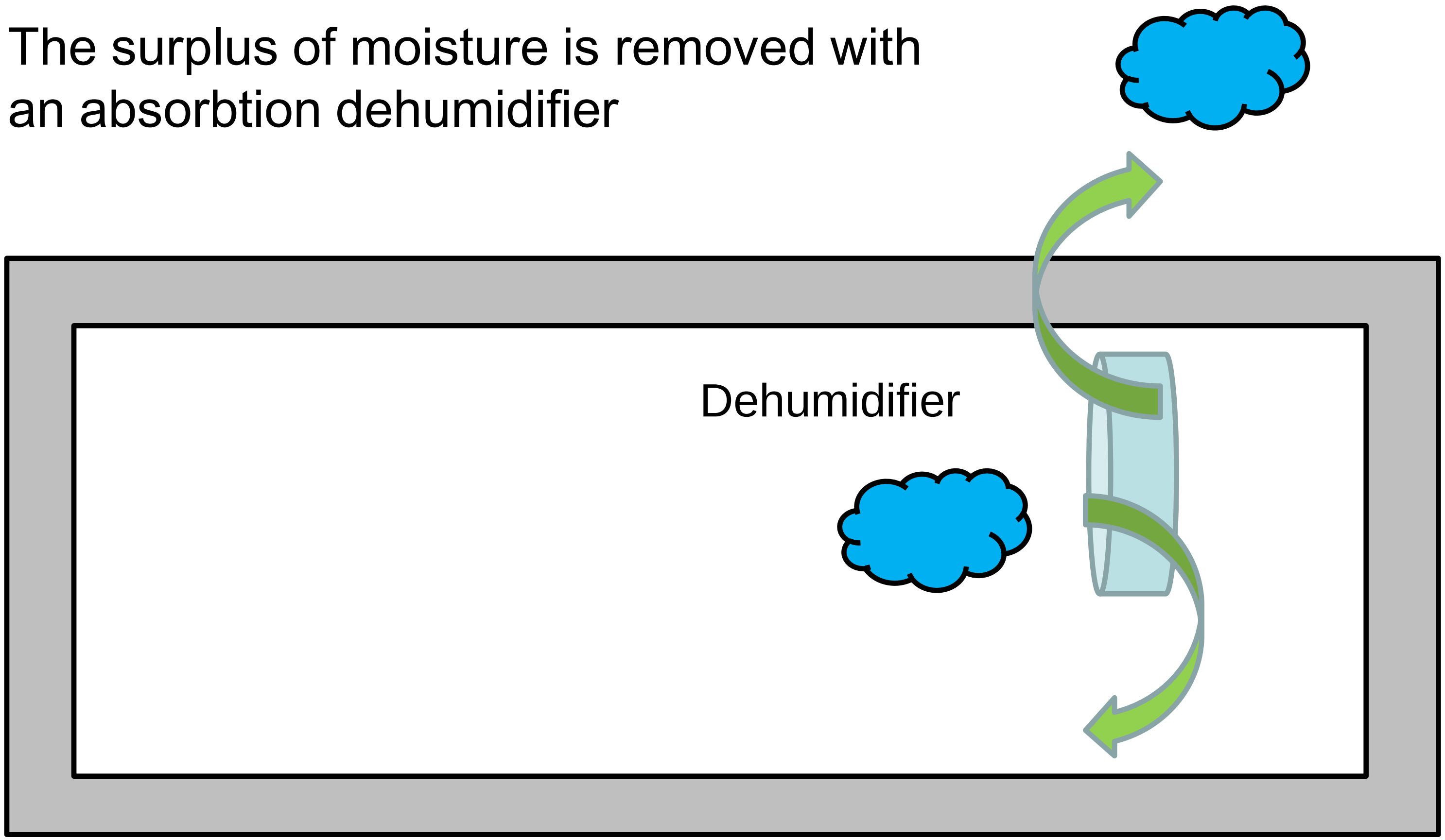
The inside is impermable to water vapor

The wooden objects provide humidity buffer

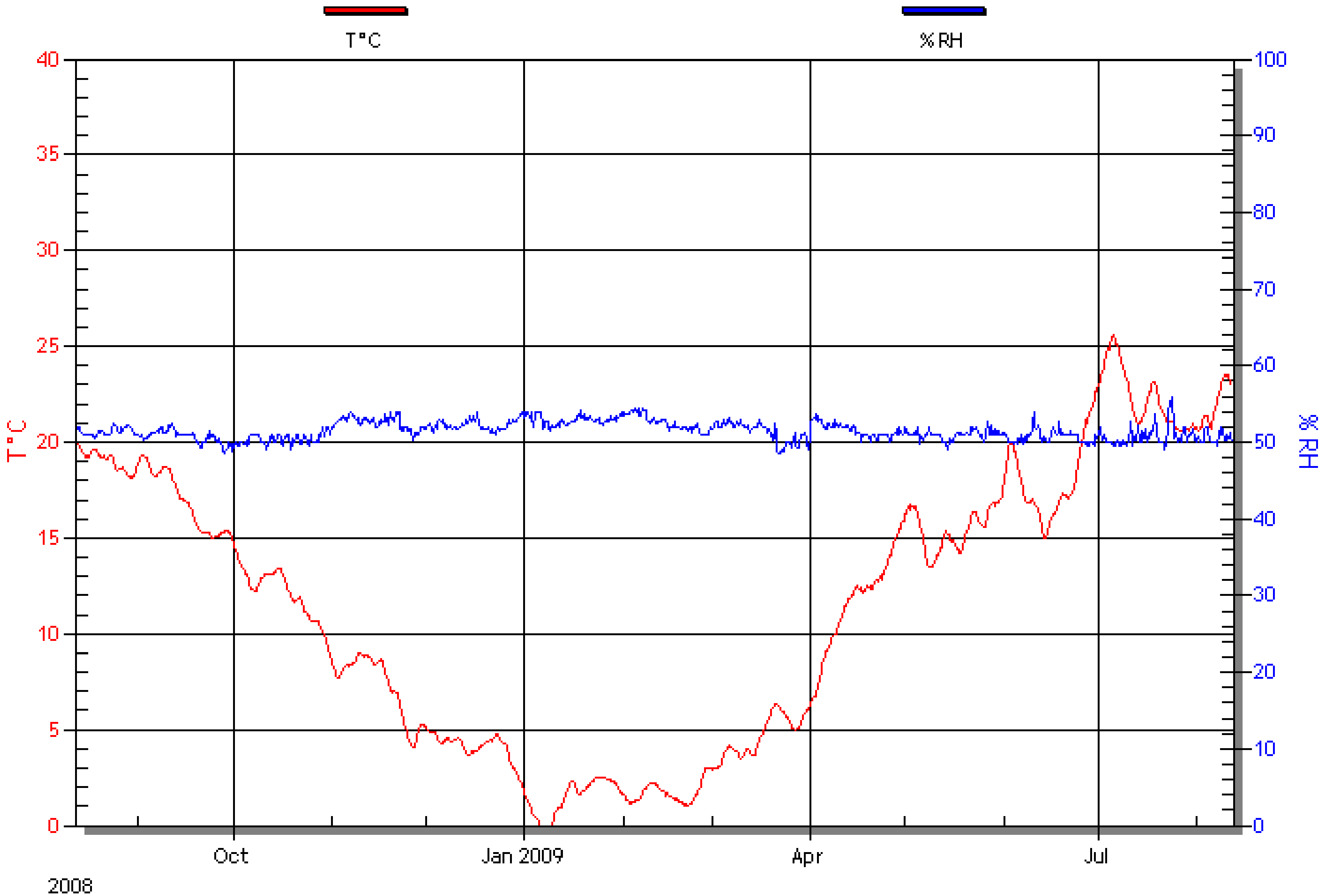


Humidity control

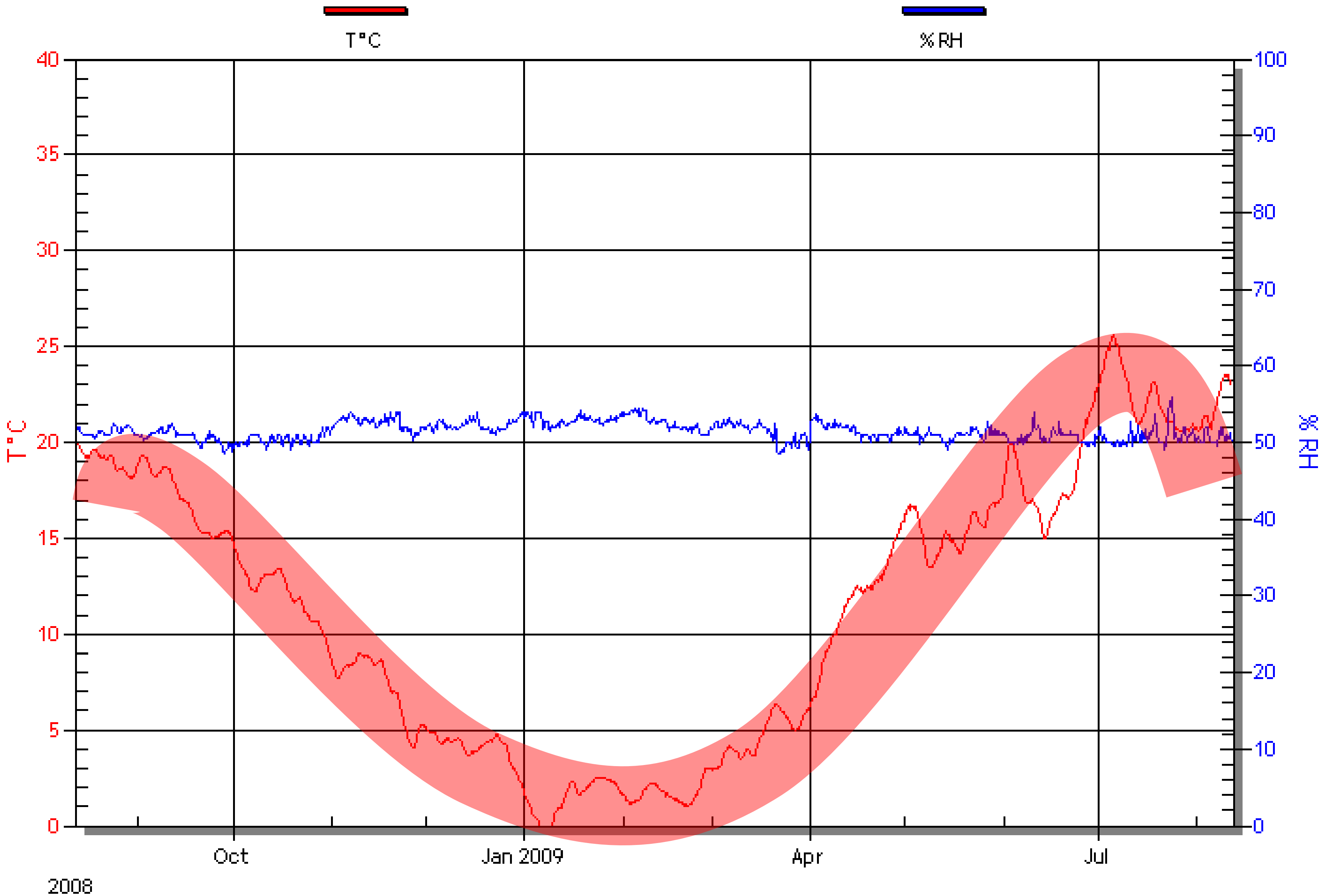
The surplus of moisture is removed with an absorbtion dehumidifier



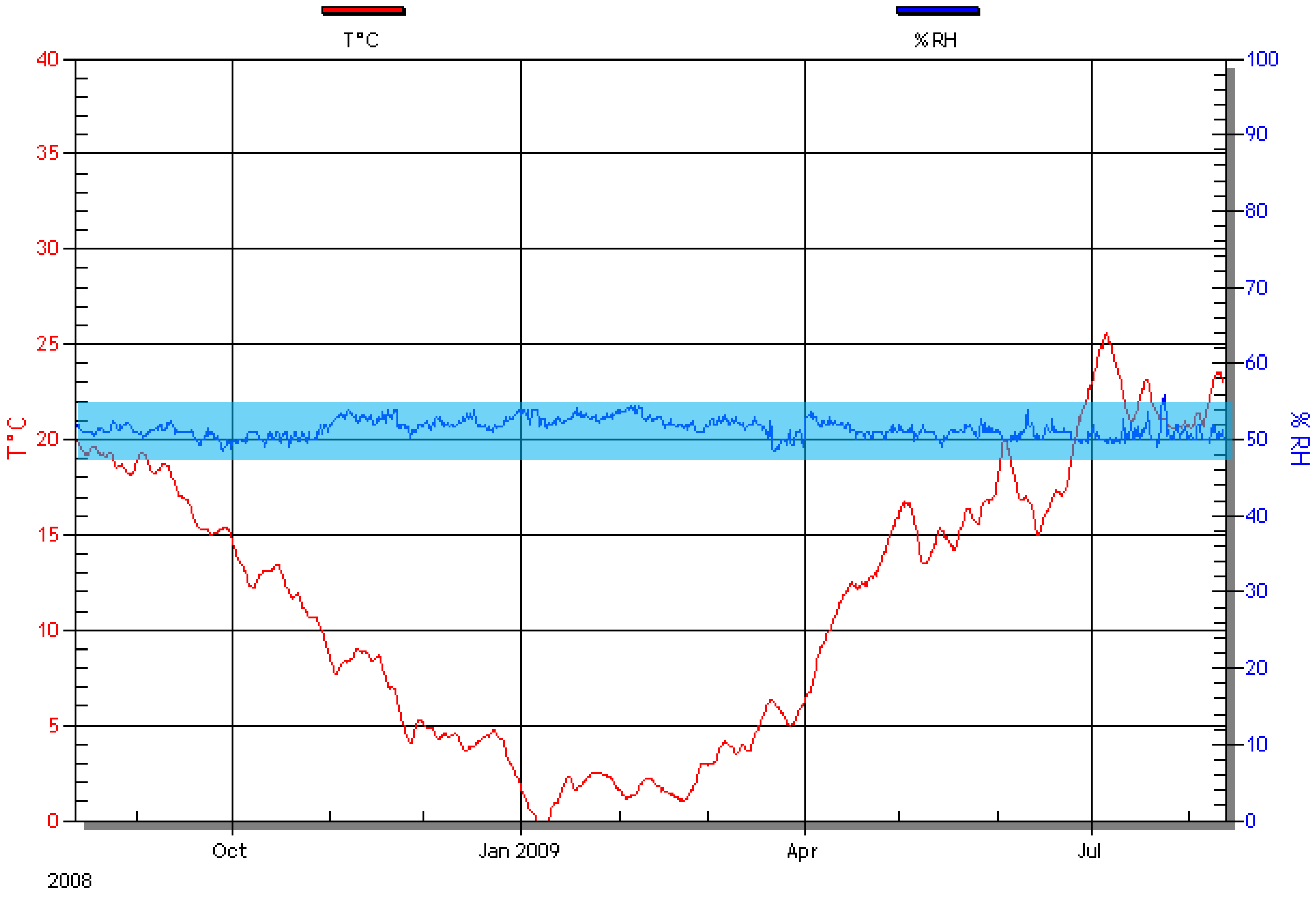
The interior climate over twelve months.



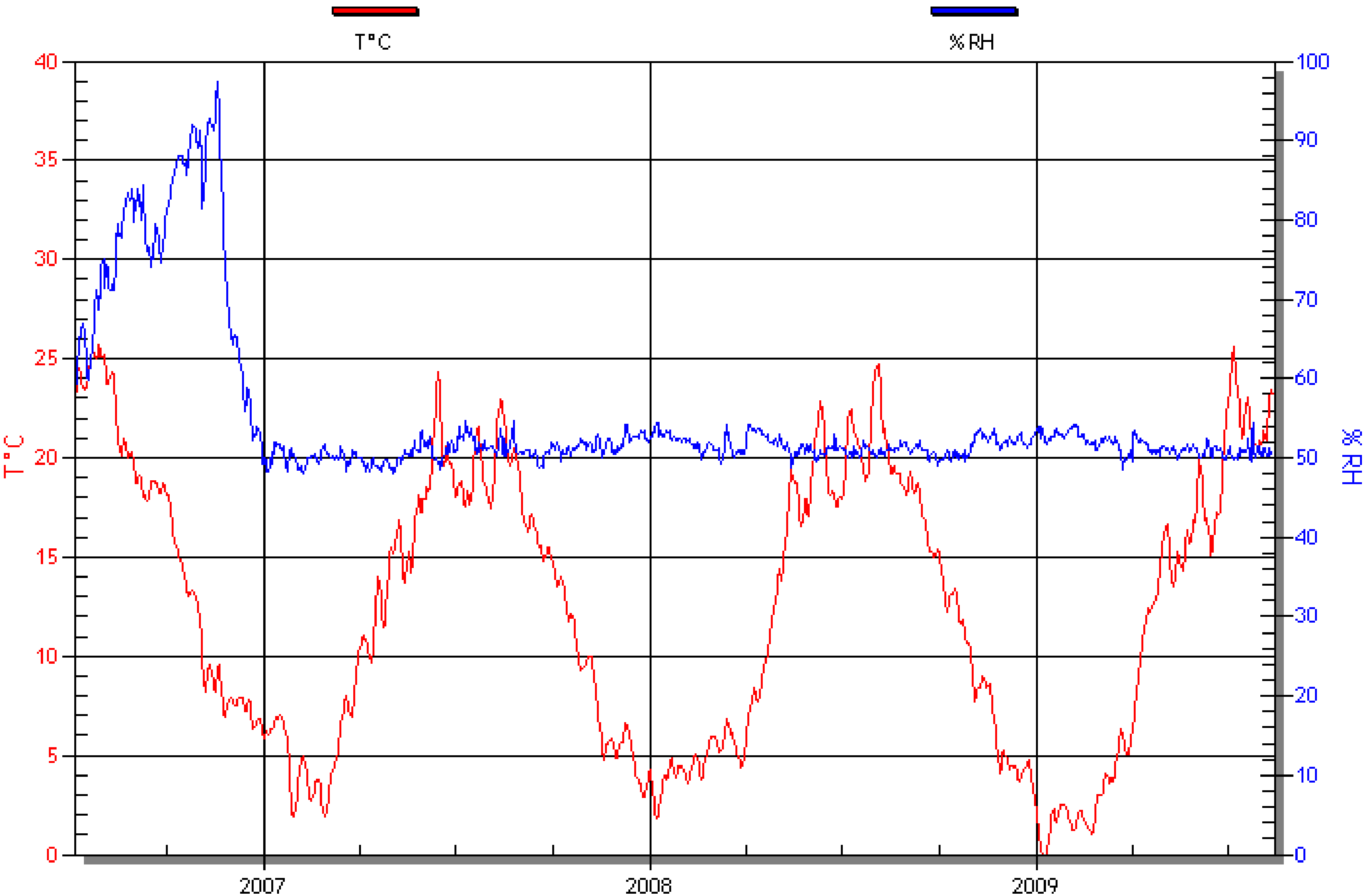
Inside temperature follows the outside



Relative humidity is contant due to dehumidification



The climate over three years. Dehumidification is always needed



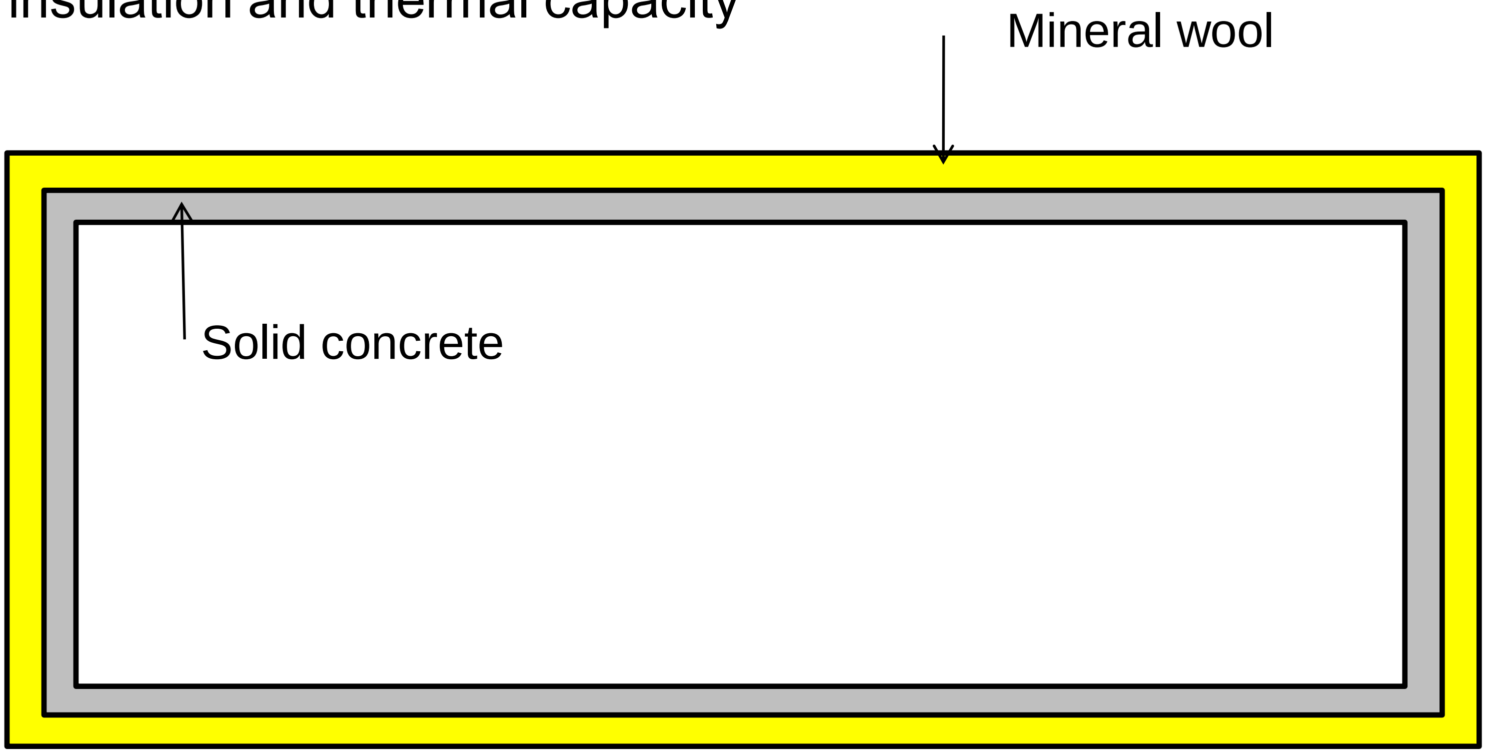
Store for historic music instruments in an old factory building

Very humidity sensitive artifacts. Very little density of stored objects

The store is surrounded by workshops which are heated in winter

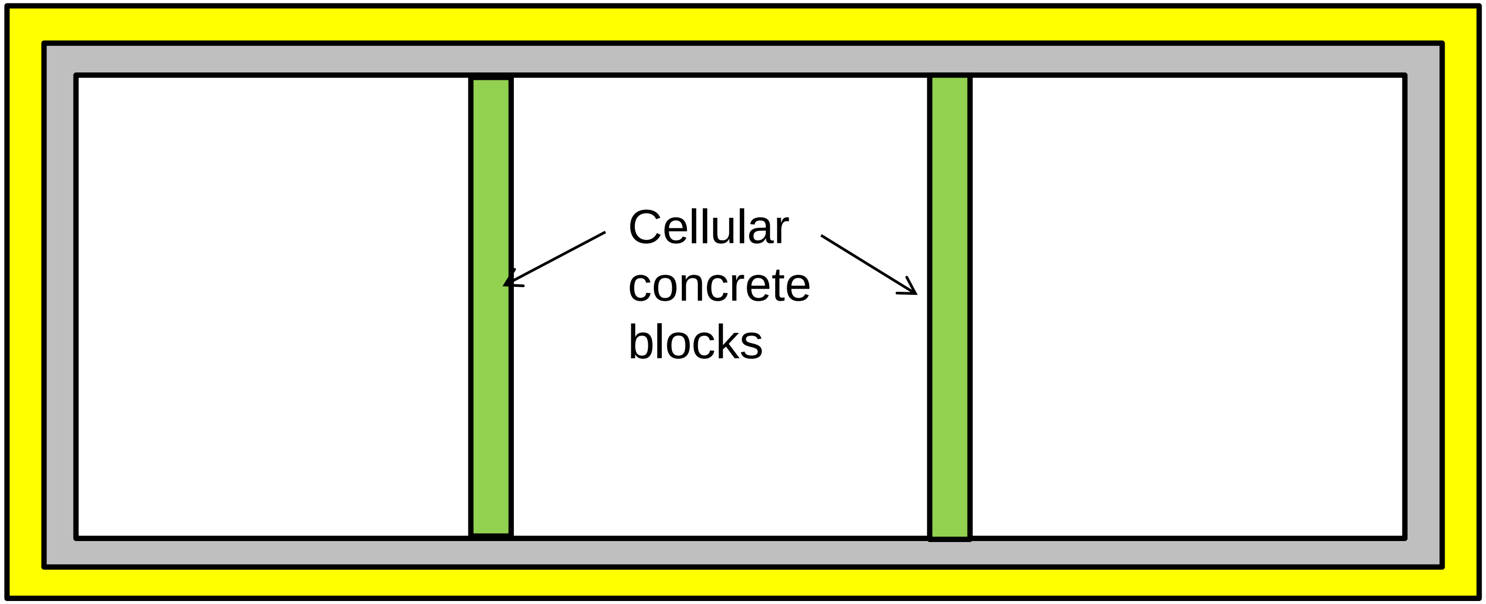
Temperature stability

Combination of thermal insulation and thermal capacity



Humidity stability

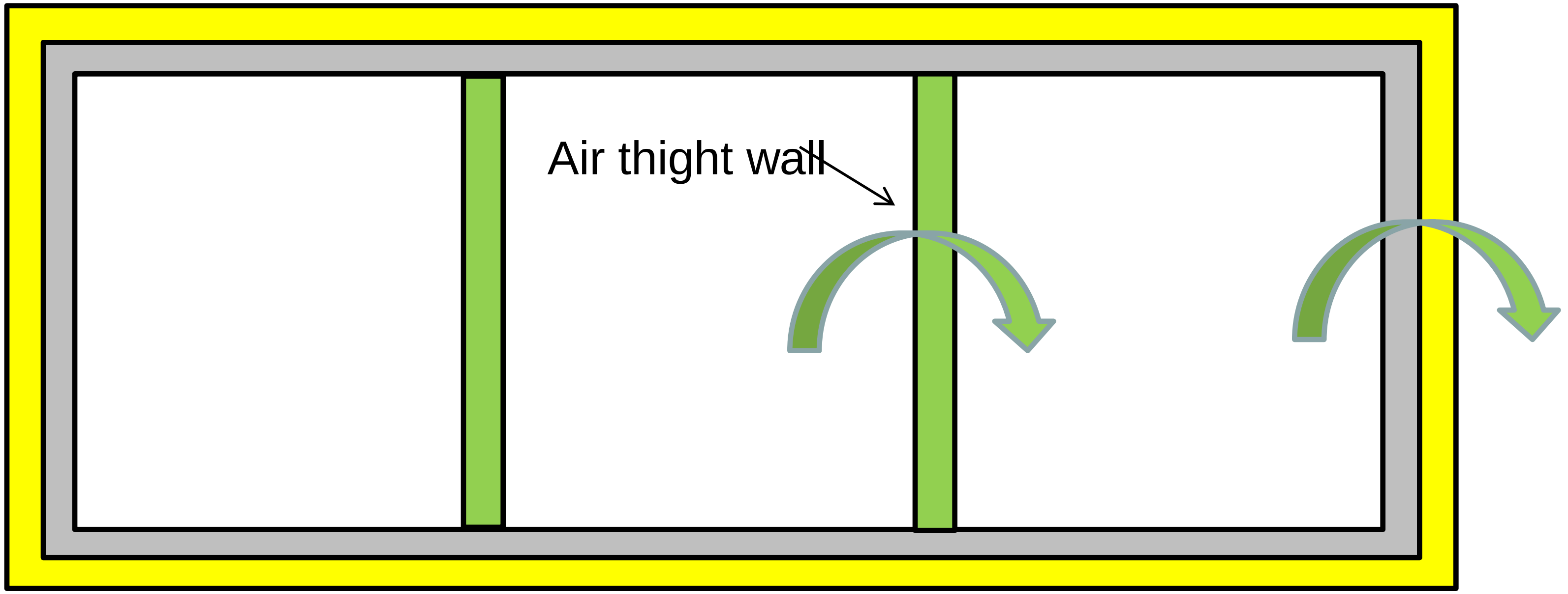
Interior walls are made of cellular concrete to act as a humidity buffer



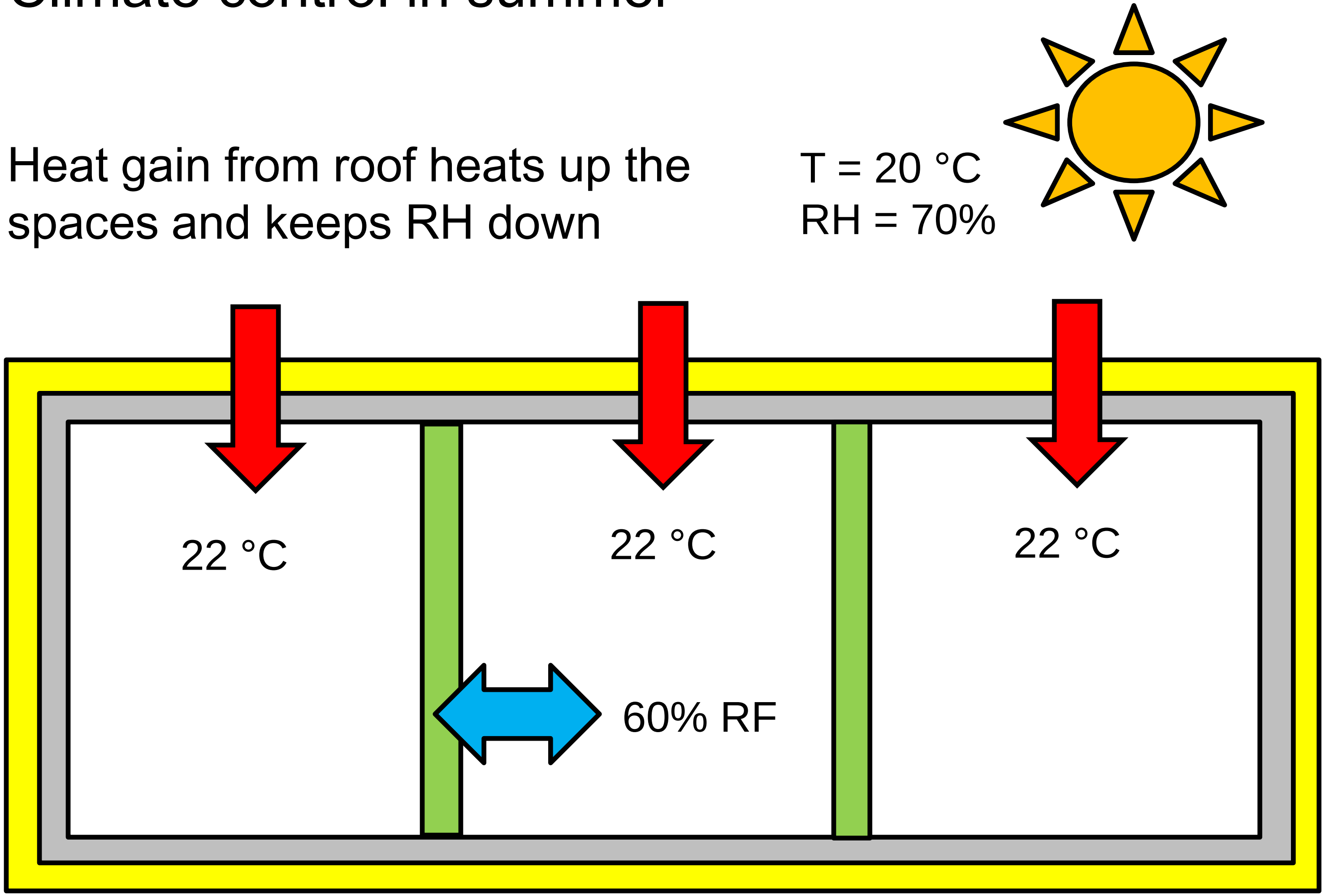
Climate control

The is no mechanical ventilation

The air exchange rate is 0,04 h^{-1}

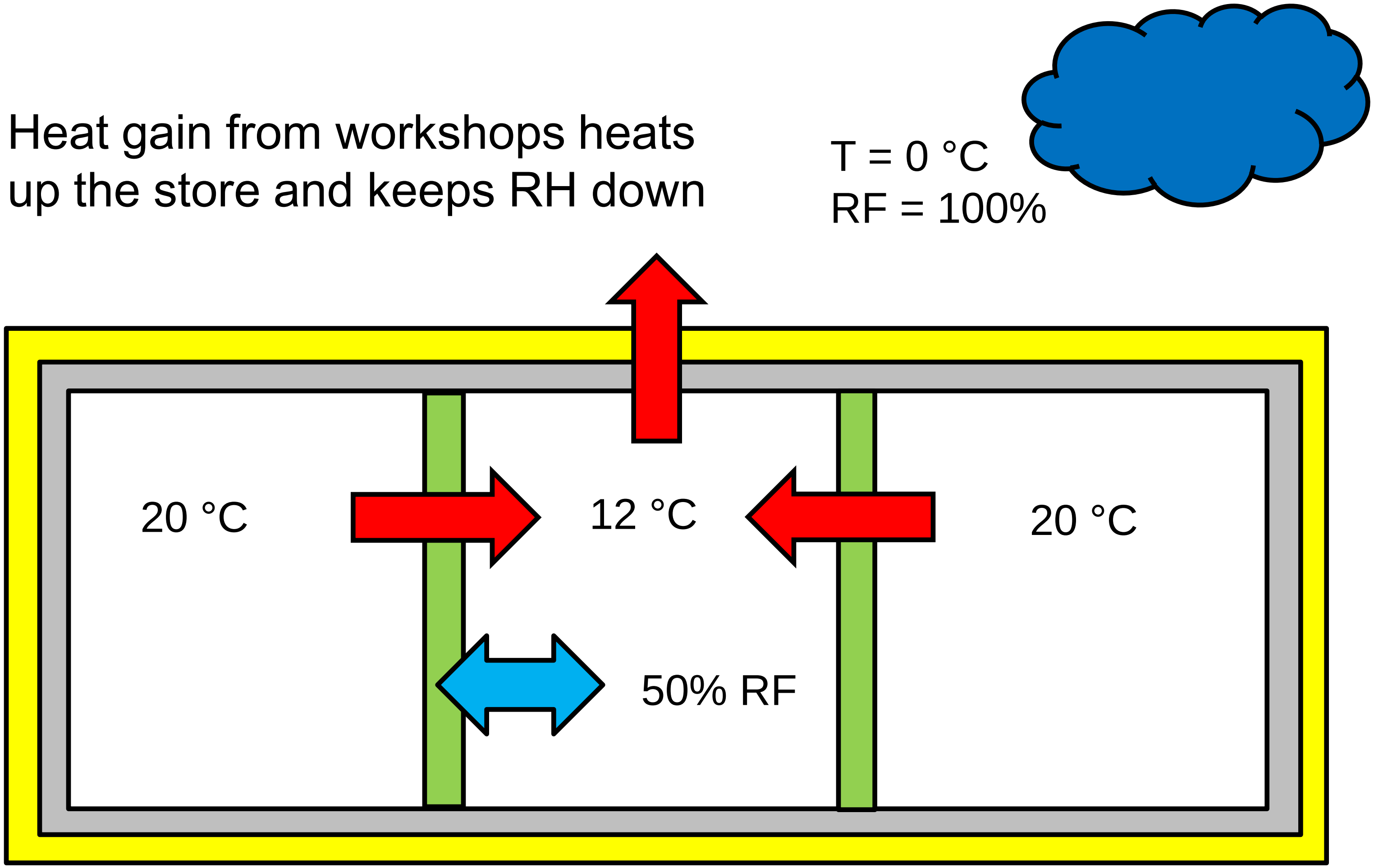


Climate control in summer

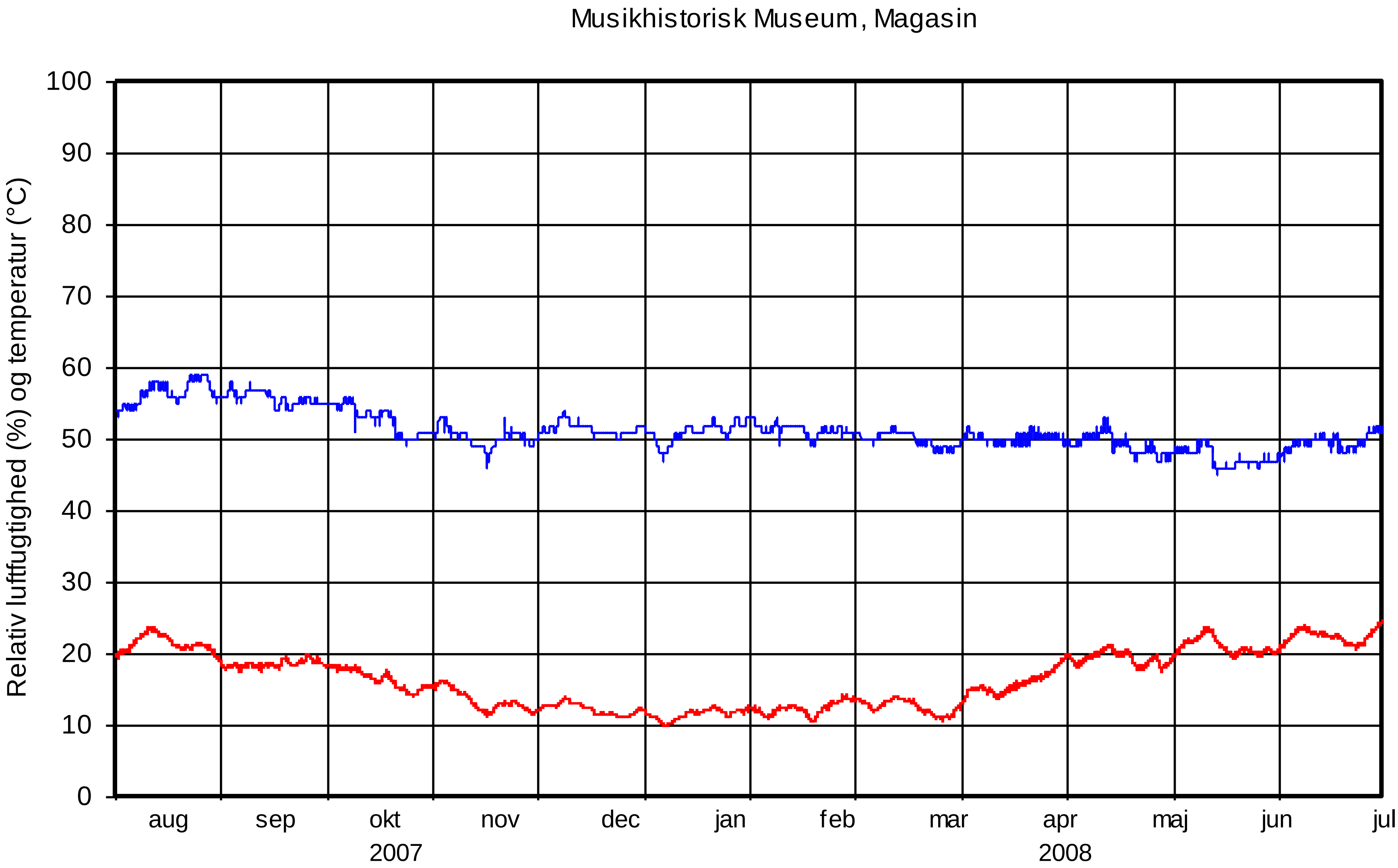


Climate control in winter

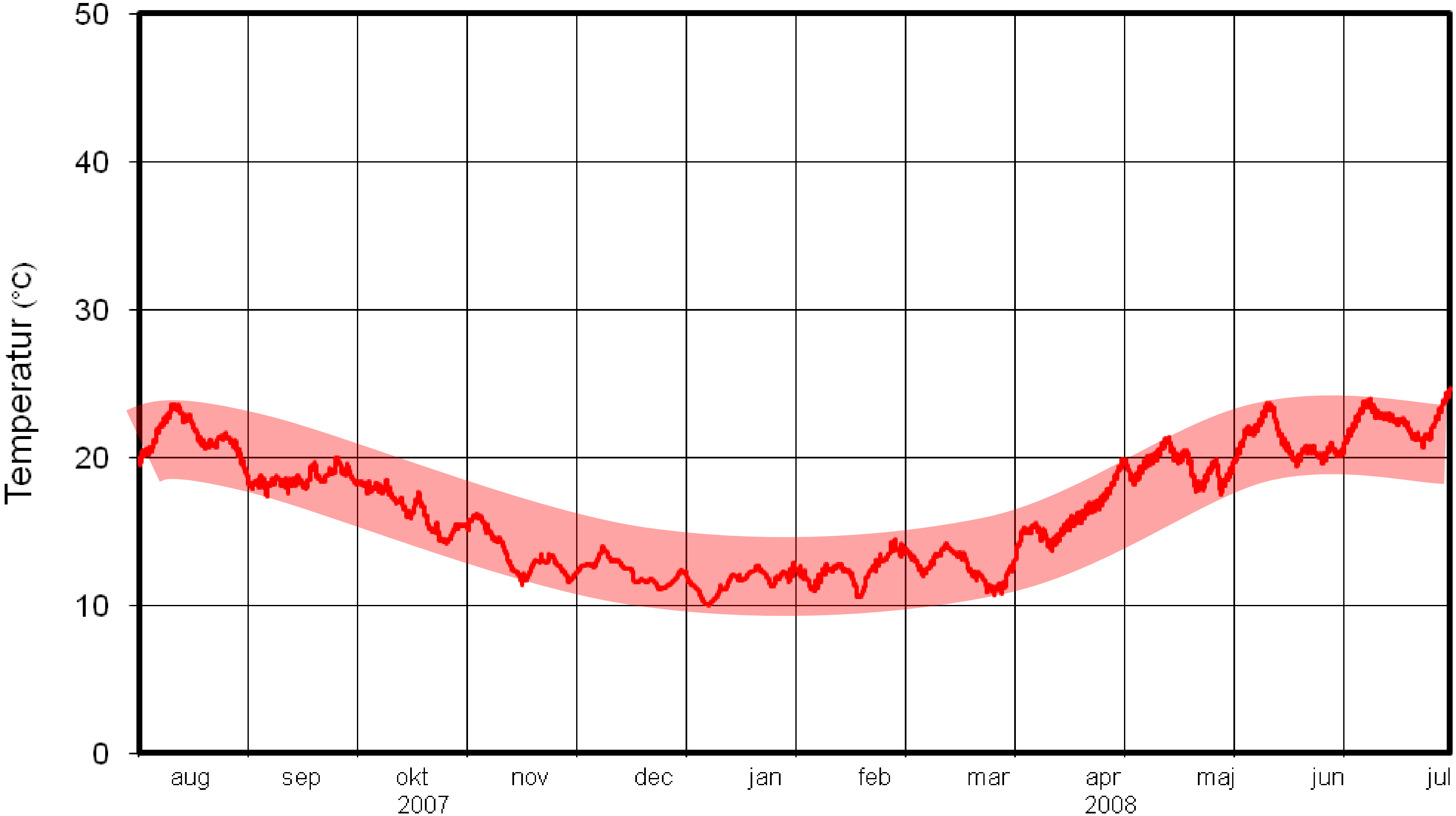
Heat gain from workshops heats
up the store and keeps RH down



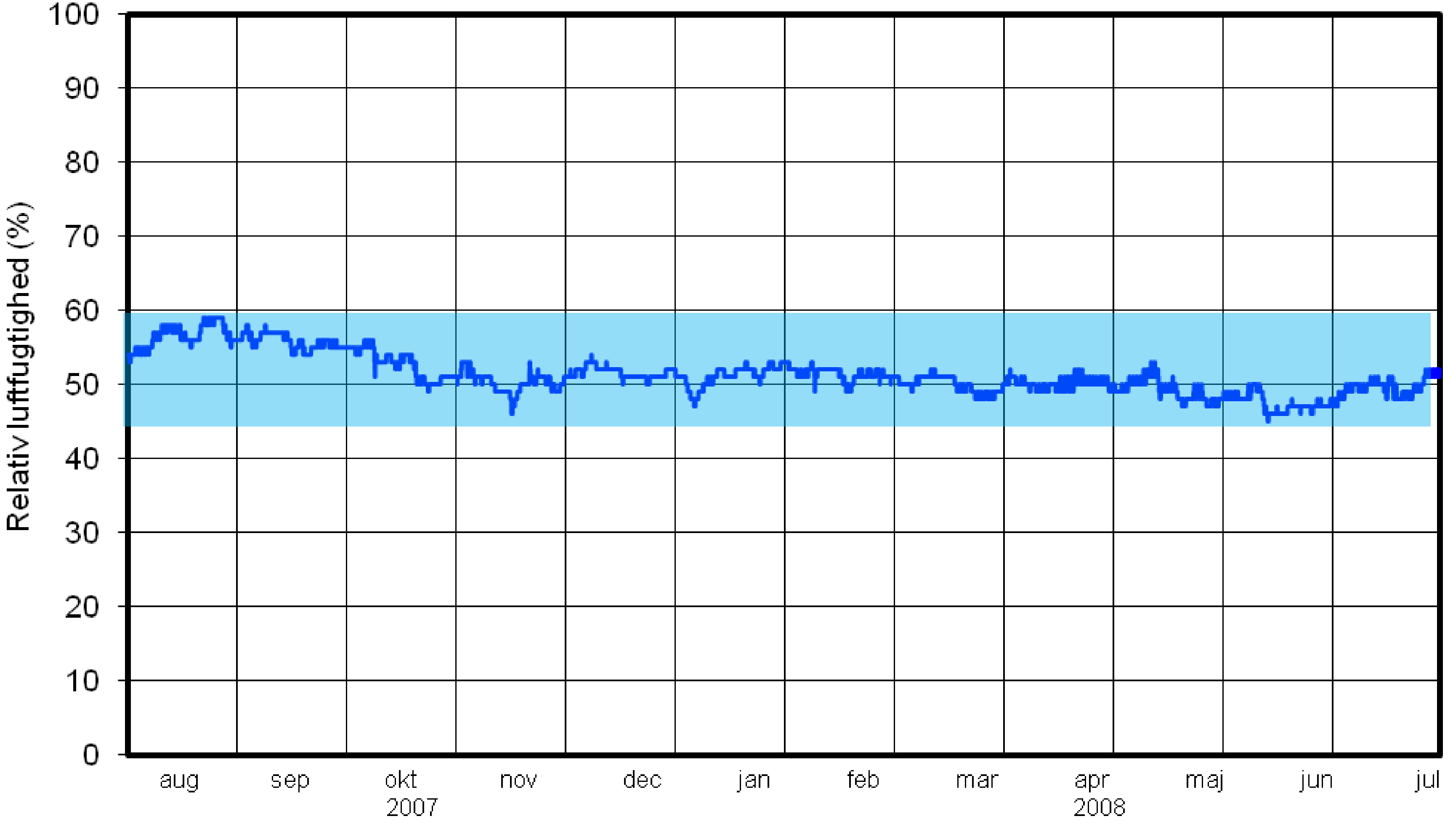
Climate records for the interior over one year.



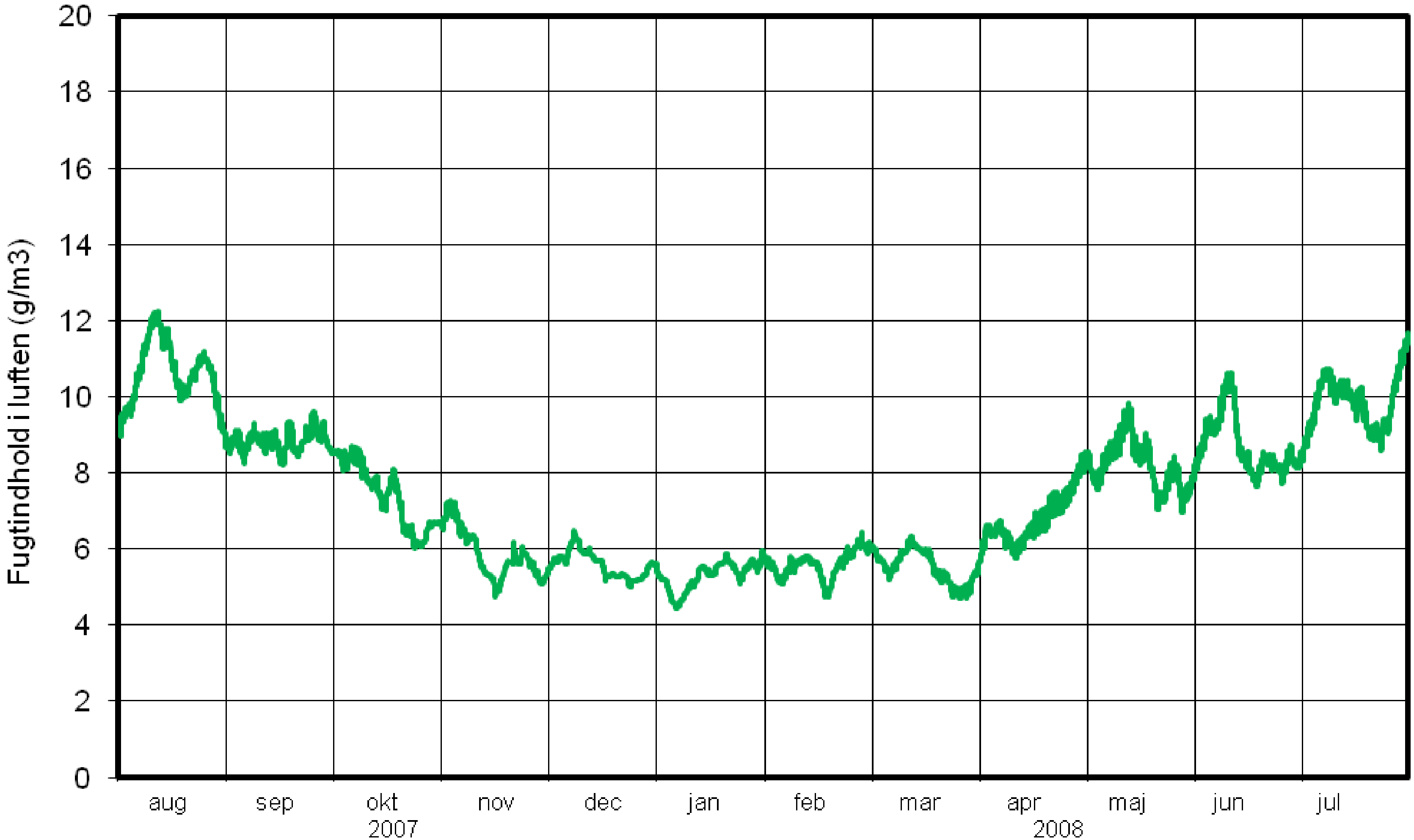
The temperature is controlled by heat flow from workshops in winter



The RH is controlled by only by temperature and humidity buffer of the walls

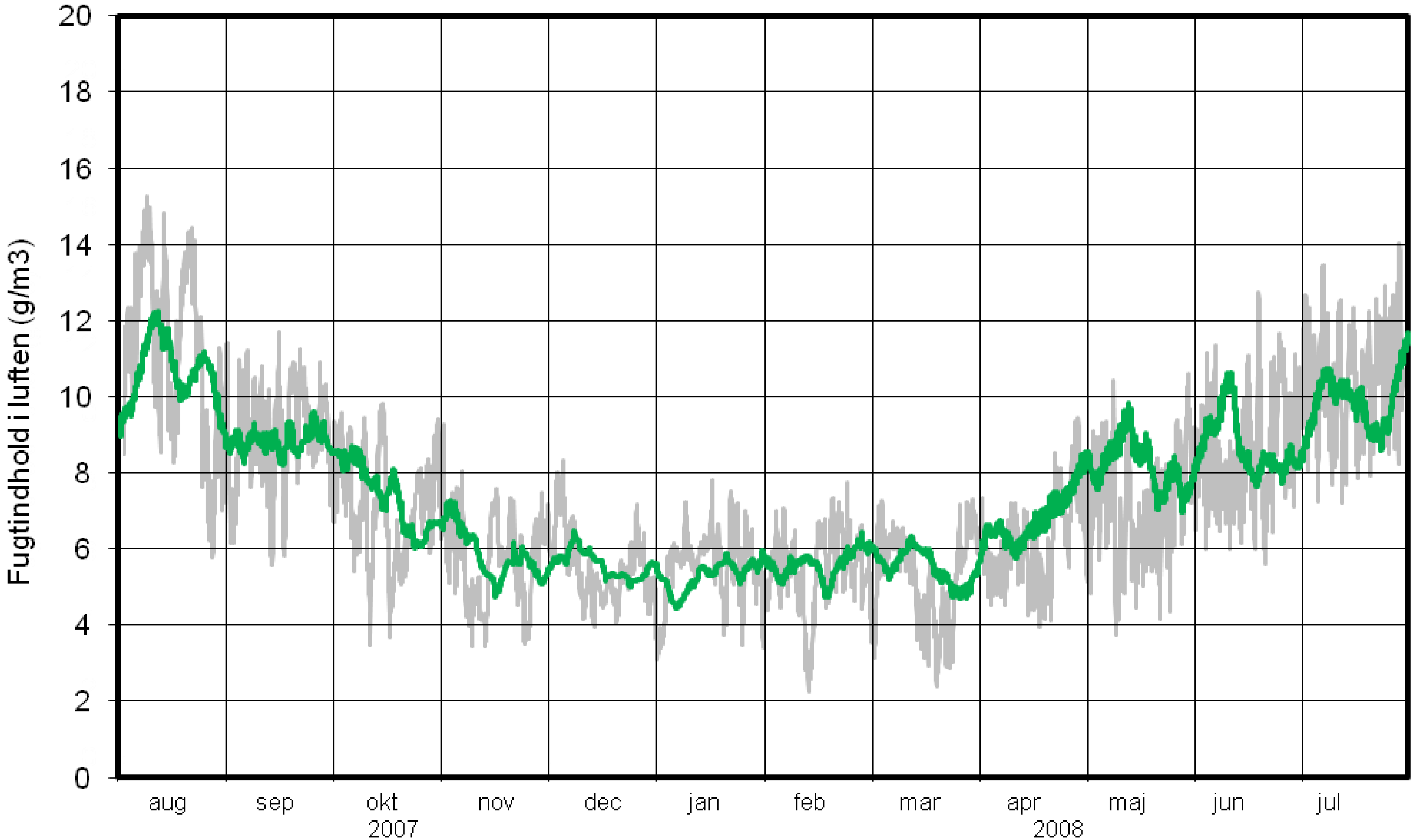


Moisture content in inside air calculated from temperature and humidity records



Moisture content in outside air (grey) and inside air (green)

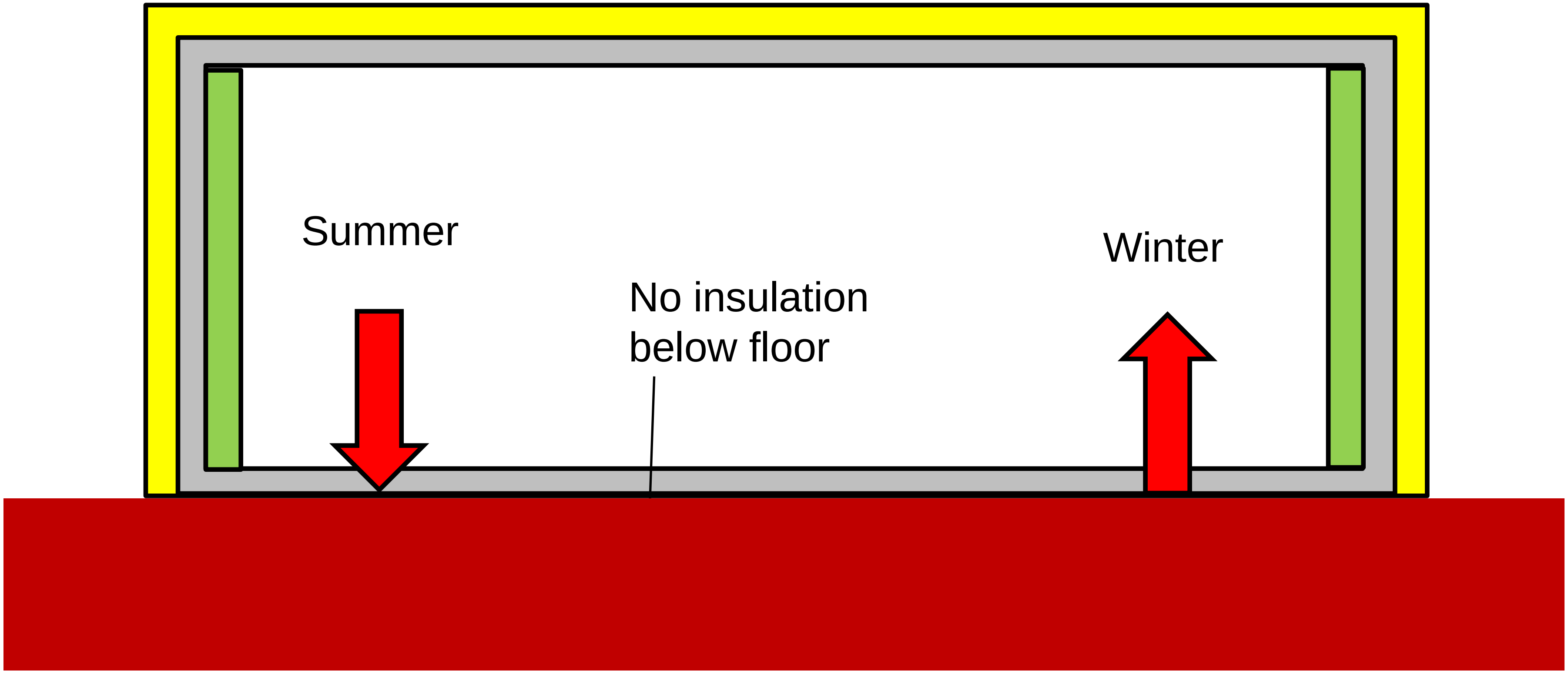
There is a considerable moisture buffer on weekly cycles



New store for the Museum of cultural history in Ribe

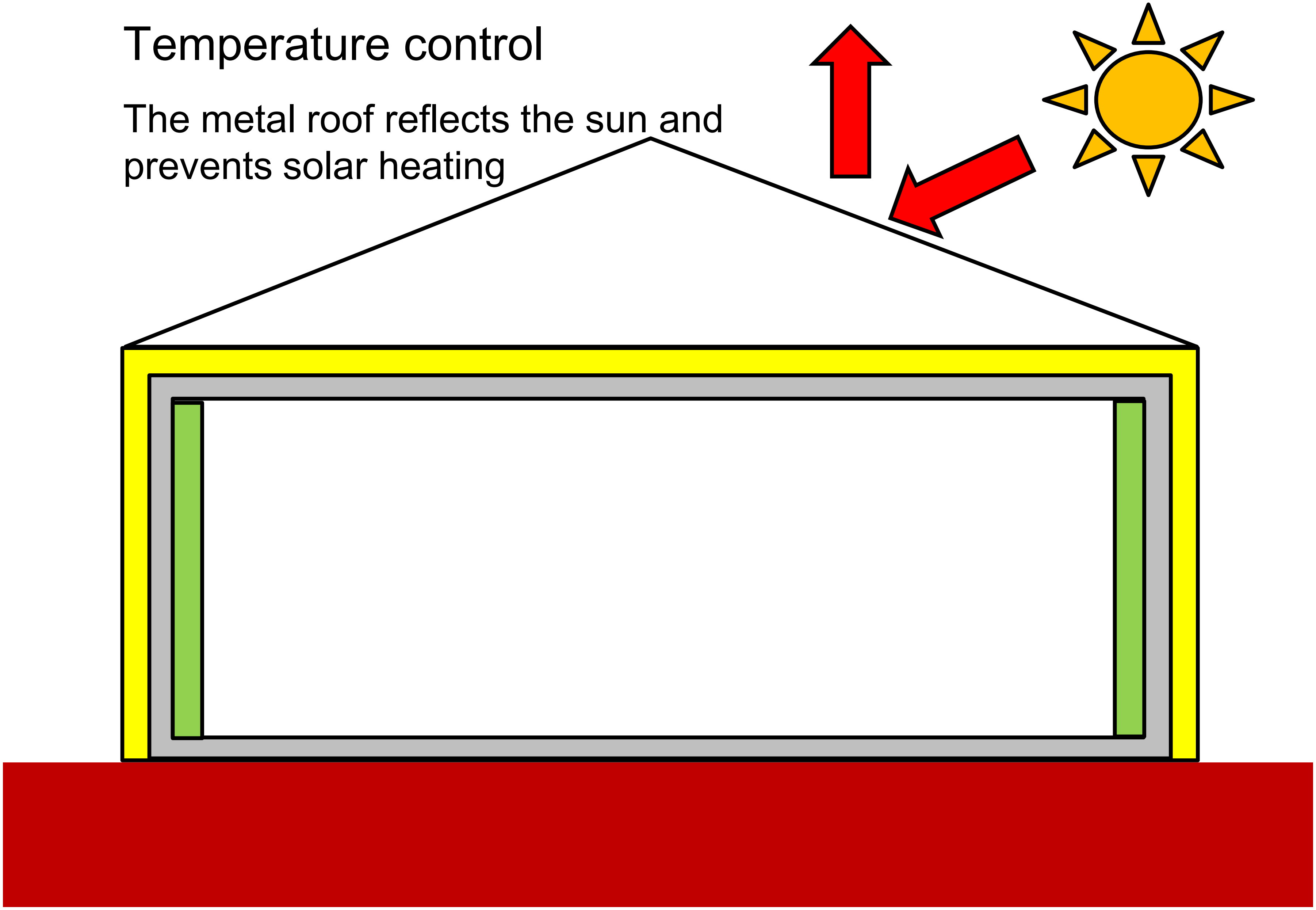
Temperature control

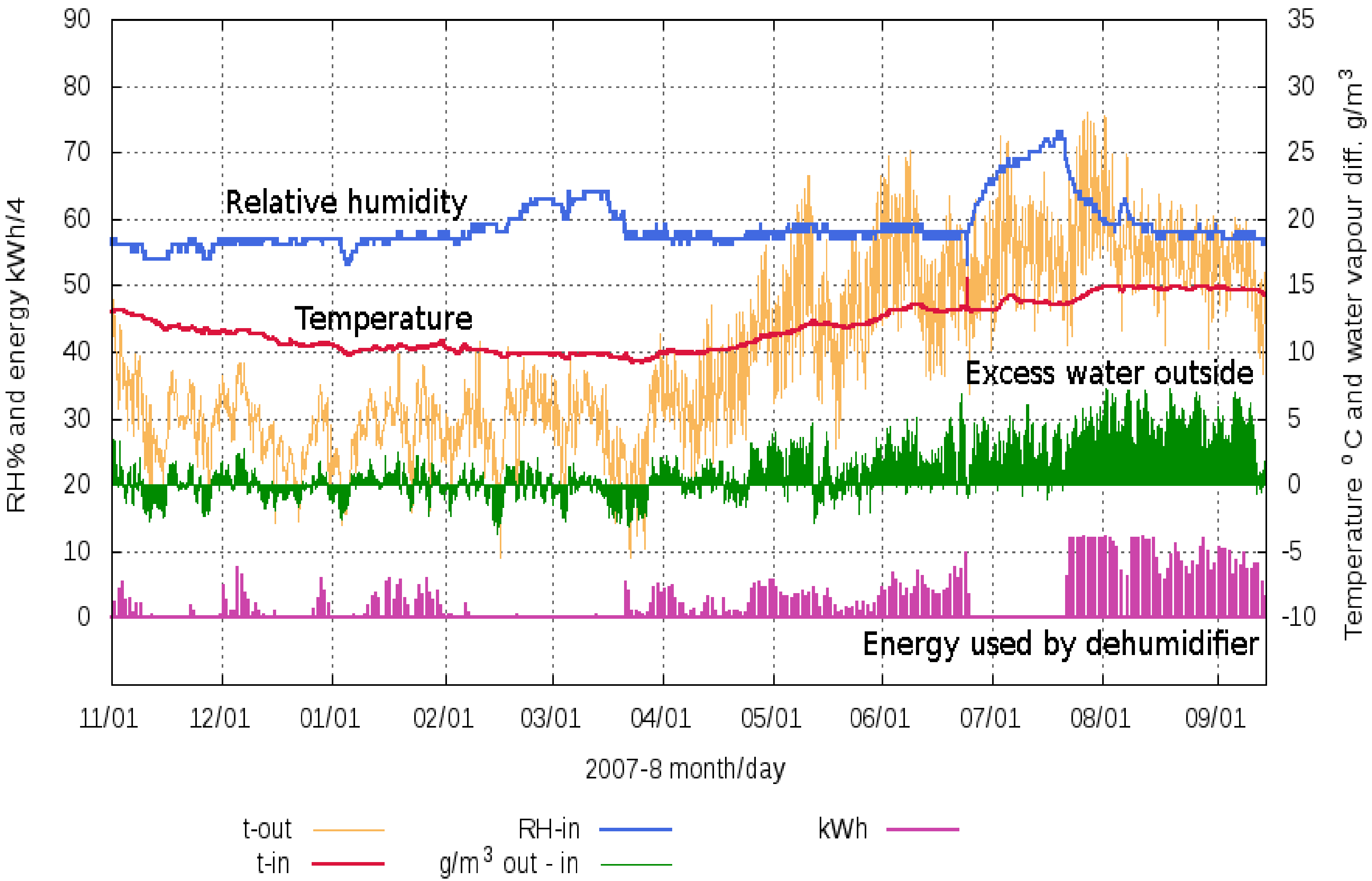
The floor in without insulation so the ground below gives temperature stability on an annual cycle



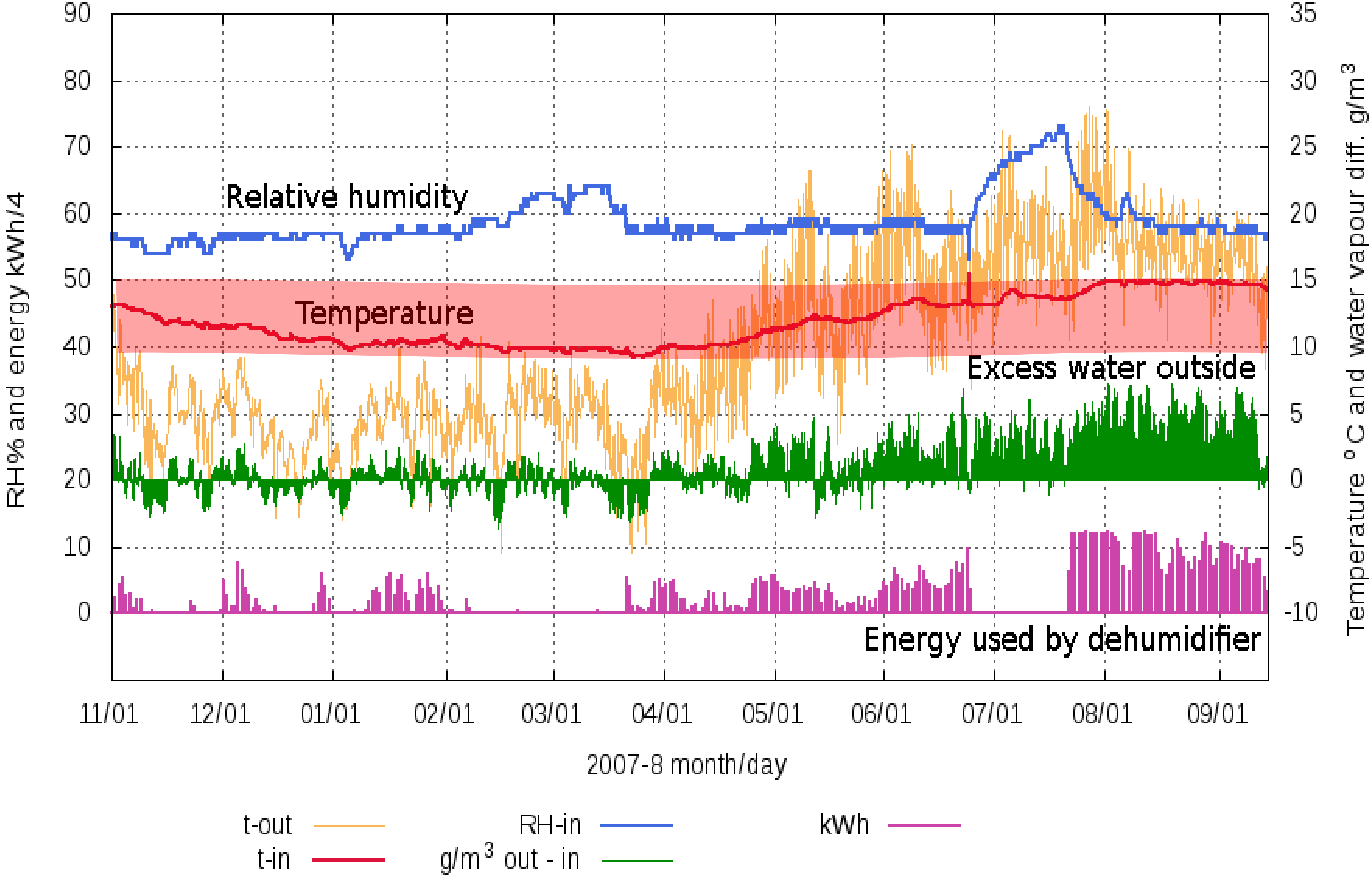
Temperature control

The metal roof reflects the sun and prevents solar heating

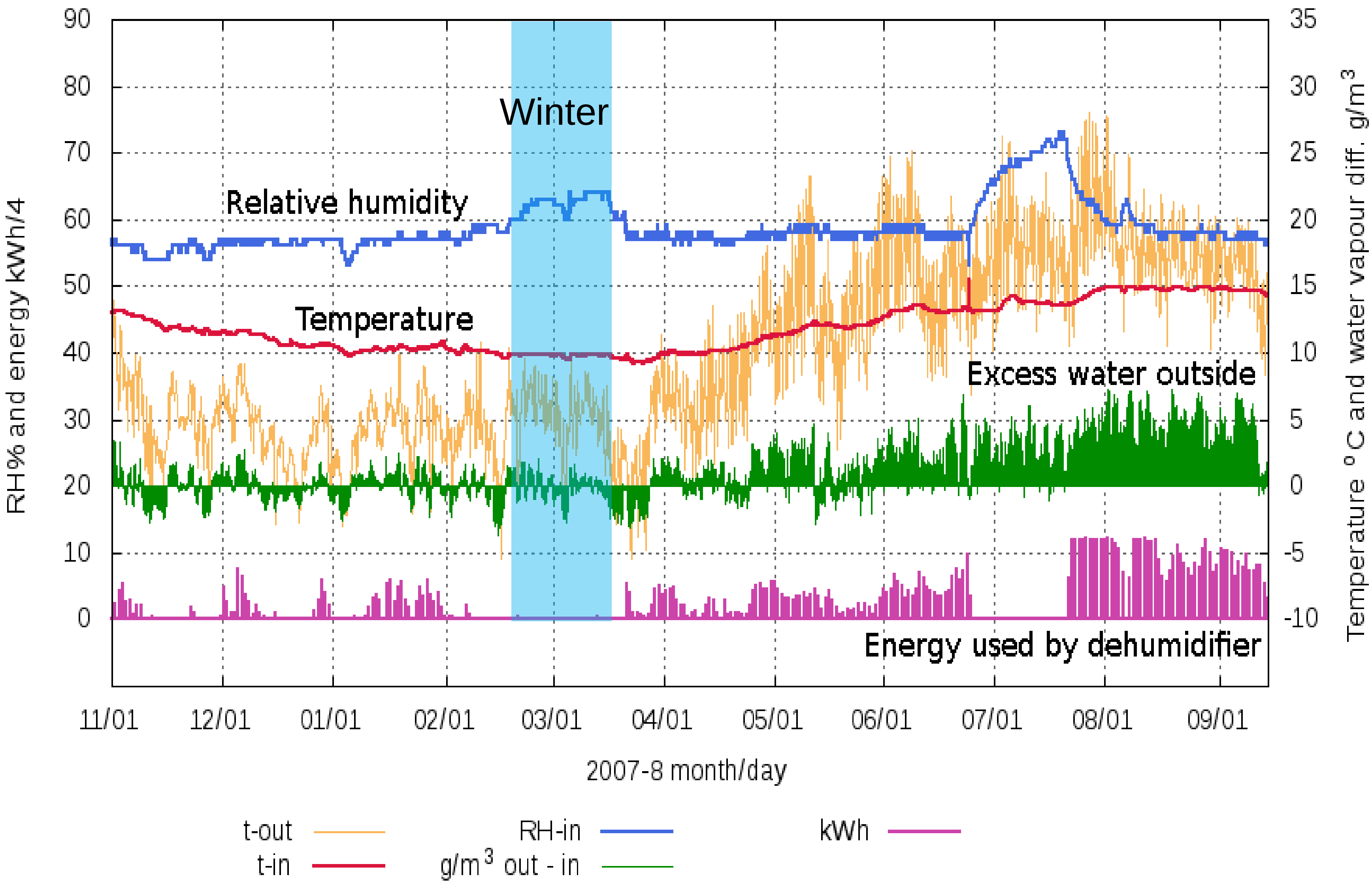




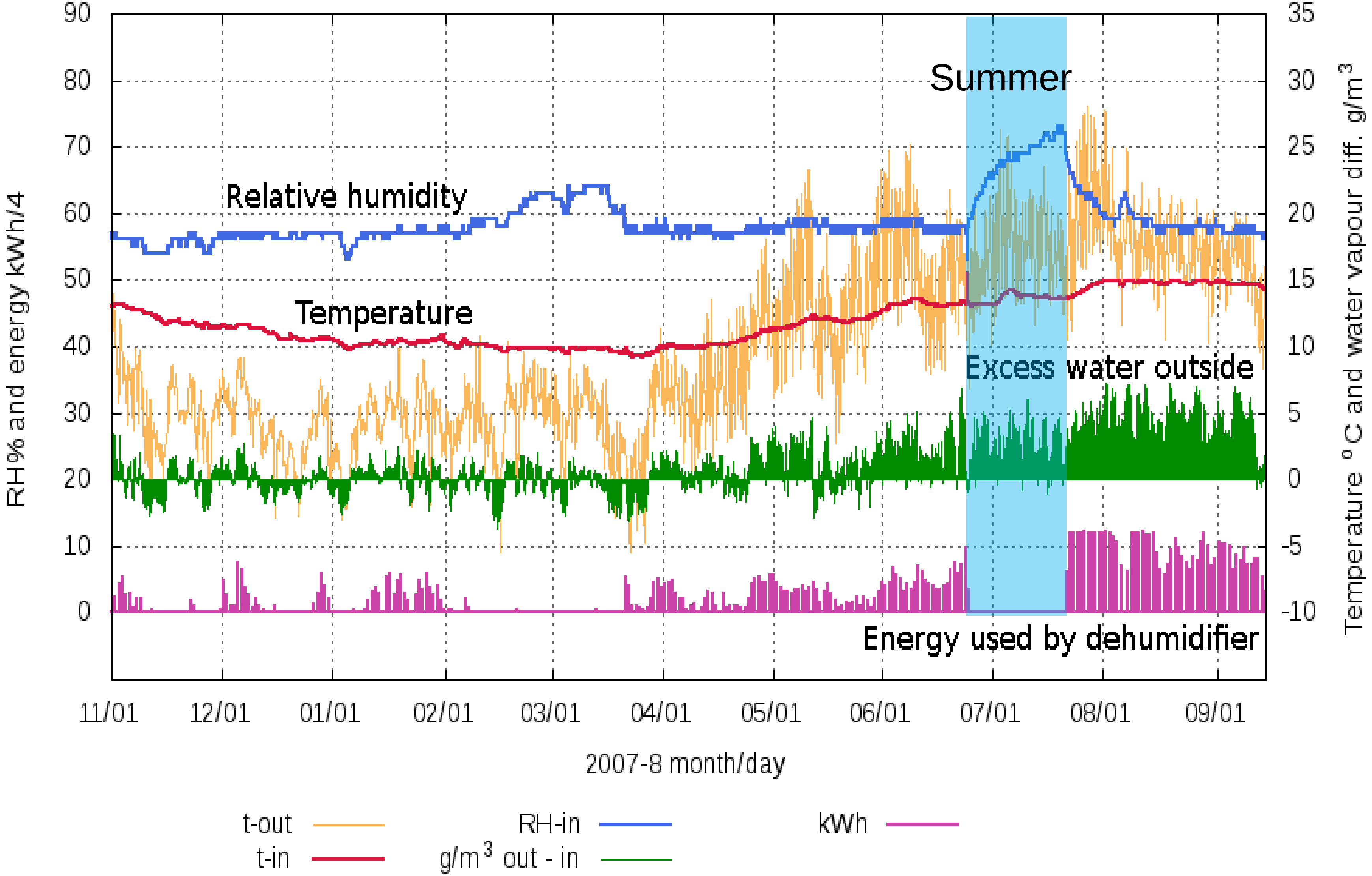
Relative humidity
Temperature
Excess water outside
Energy used by dehumidifier
RH% and energy kWh/4
Temperature °C and water vapour diff. g/m3
90
80
70
60
50
40
30
20
10
0
35
30
25
20
15
10
5
0
-5
-10
11/01
12/01
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
09/01
2007-8 month/day
t-out
t-in
RH-in
g/m3 out - in
kWh



Relative humidity
Temperature
Excess water outside
Energy used by dehumidifier
RH% and energy kWh/4
Temperature °C and water vapour diff. g/m3
2007-8 month/day
11/01
12/01
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
09/01
t-out
t-in
RH-in
g/m3 out - in
kWh

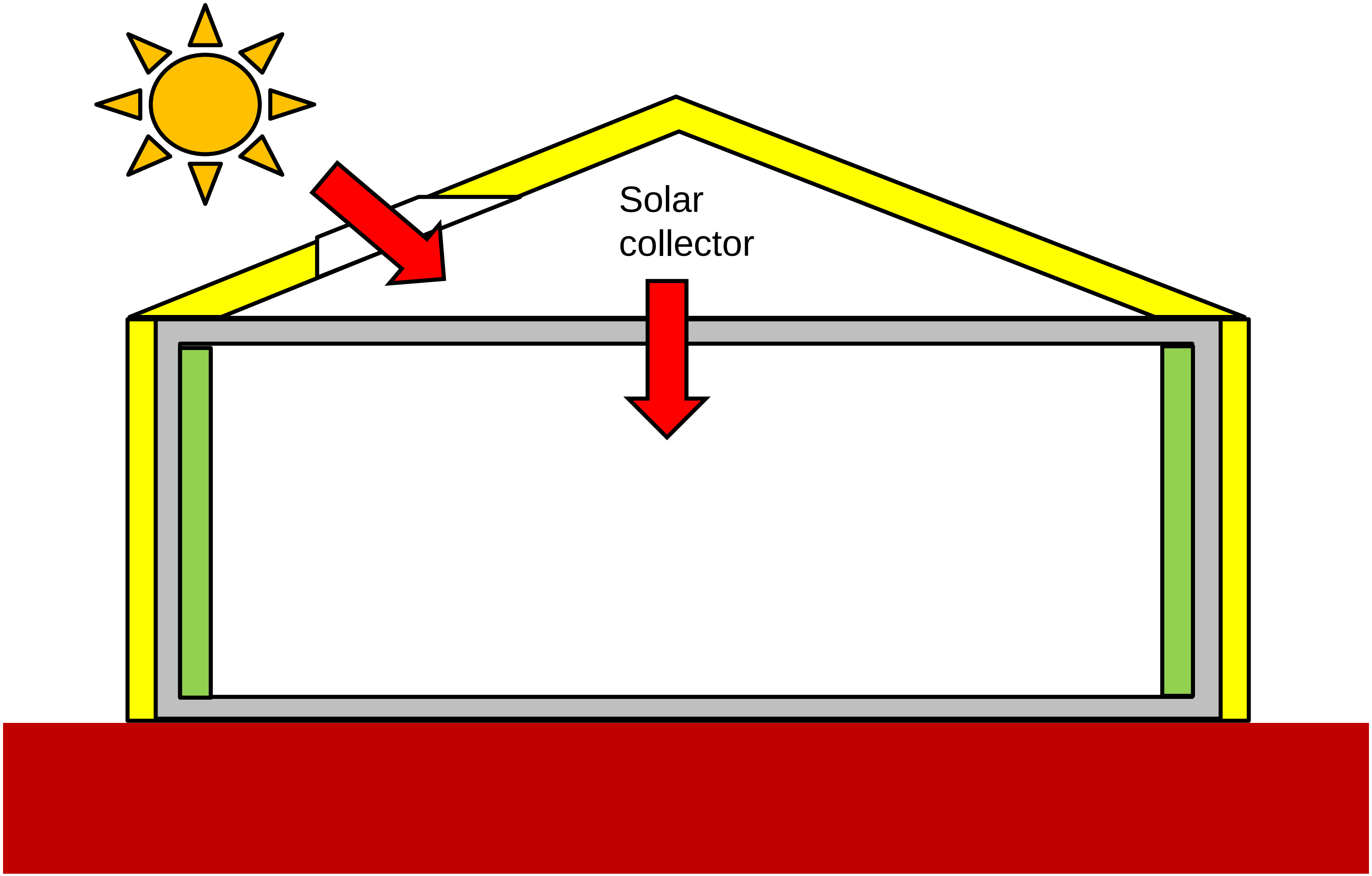


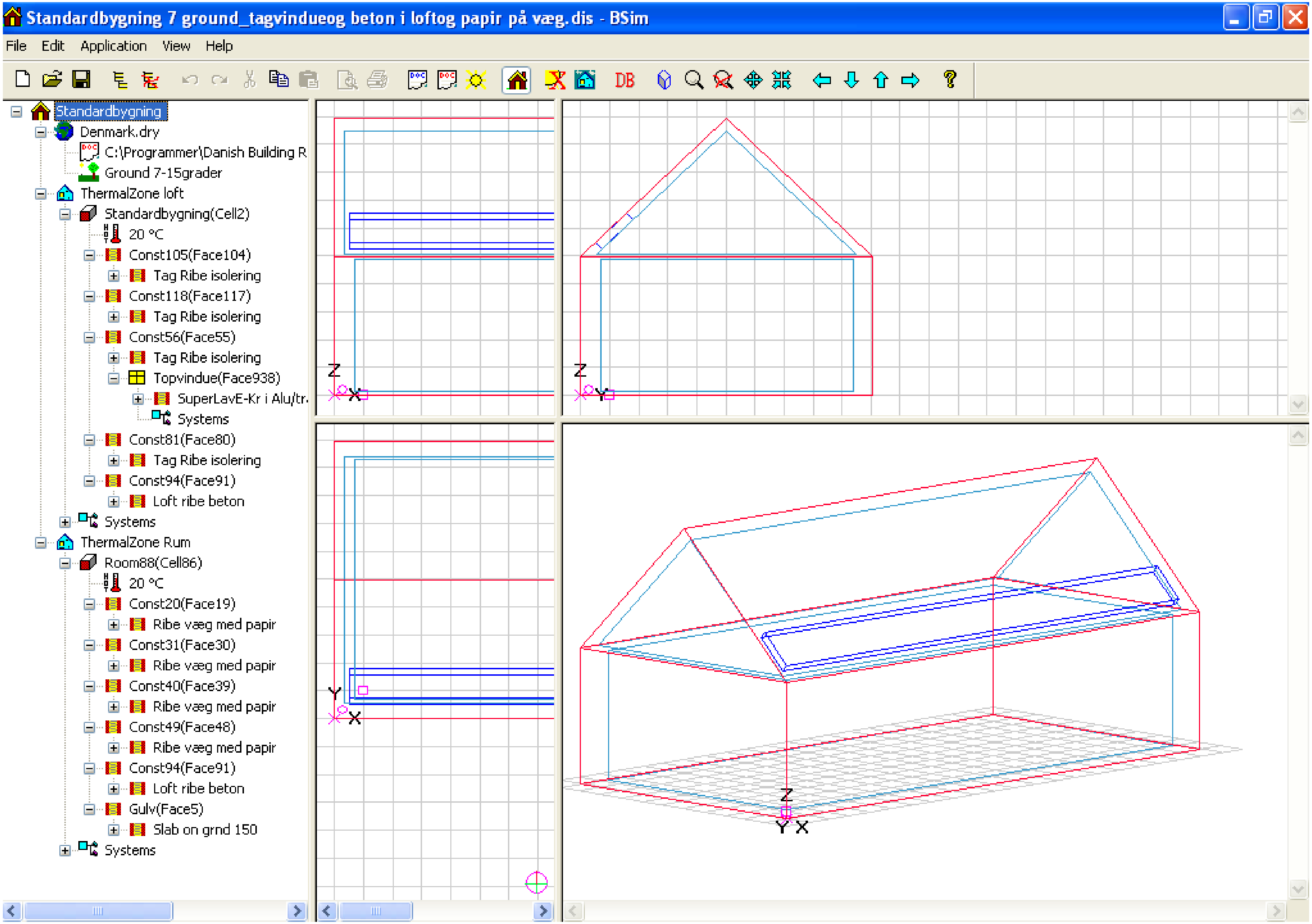
Winter
Relative humidity
Temperature
Excess water outside
Energy used by dehumidifier
RH% and energy kWh/4
Temperature °C and water vapour diff. g/m3
2007-8 month/day
11/01
12/01
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
09/01
t-out
t-in
RH-in
g/m3 out - in
kWh



Summer
Relative humidity
Temperature
Excess water outside
Energy used by dehumidifier
RH% and energy kWh/4
Temperature °C and water vapour diff. g/m3
2007-8 month/day
11/01
12/01
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
09/01
90
80
70
60
50
40
30
20
10
0
35
30
25
20
15
10
5
0
-5
-10
t-out
t-in
RH-in
g/m3 out - in
kWh

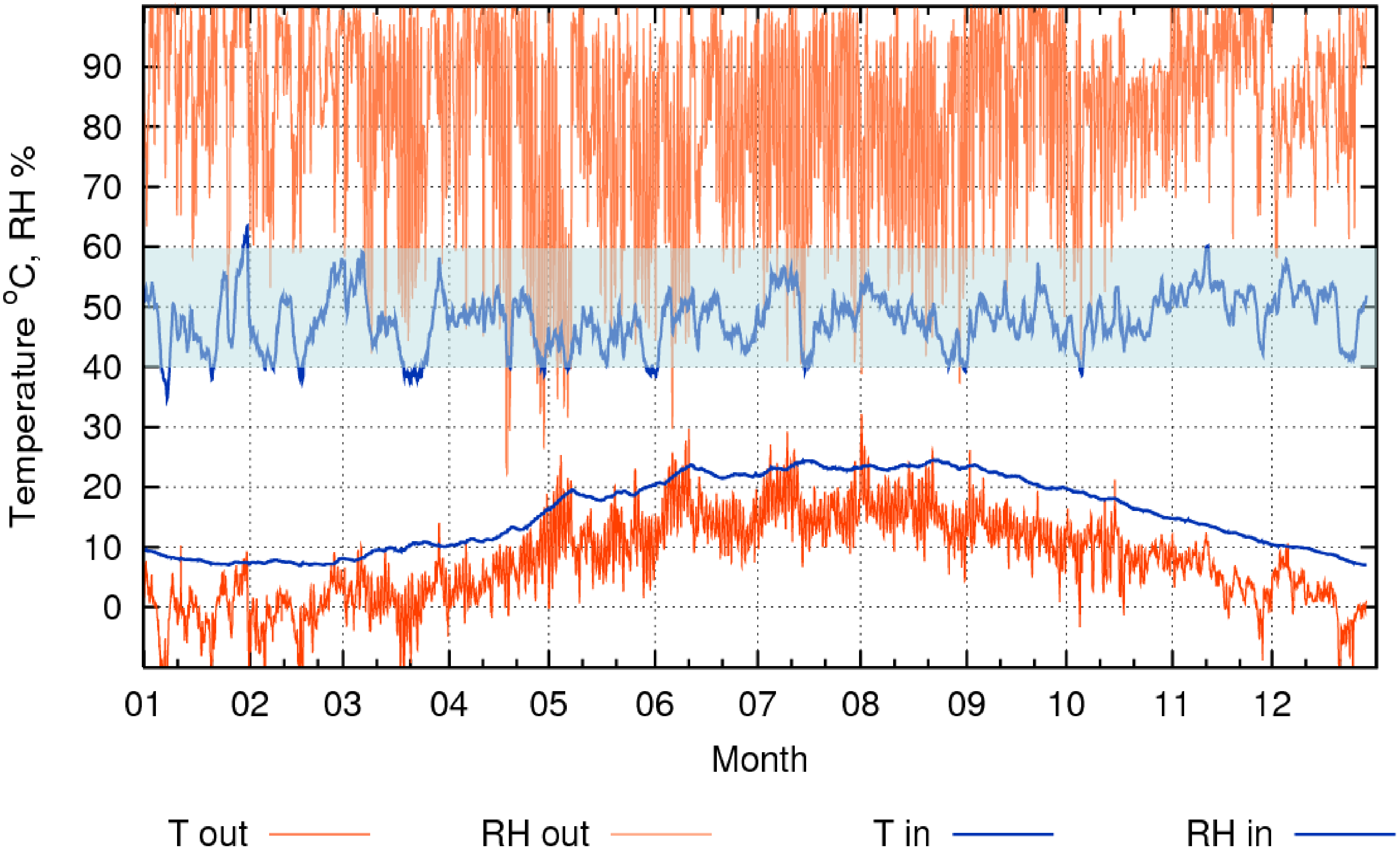
An attic with windows in roof to take in heat from the sun



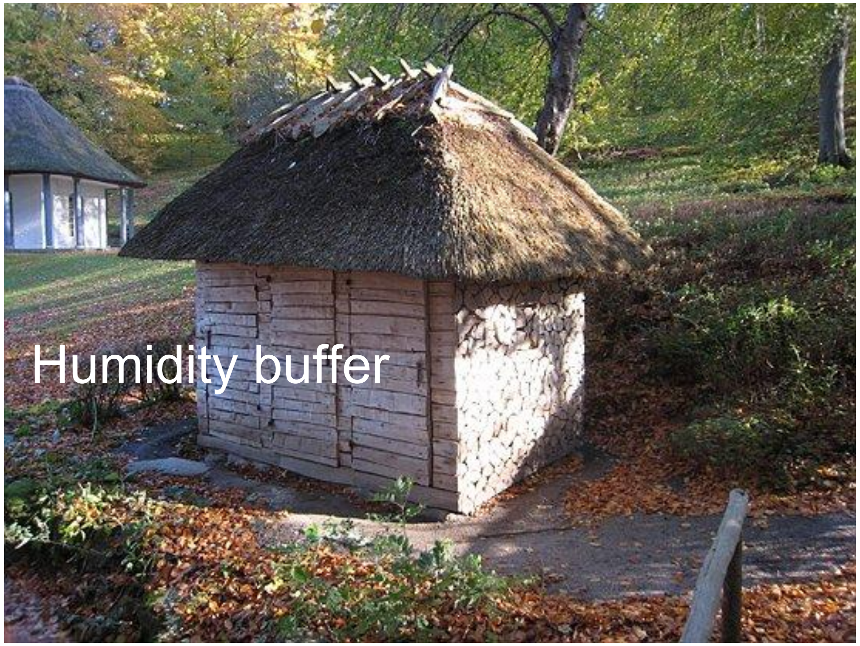


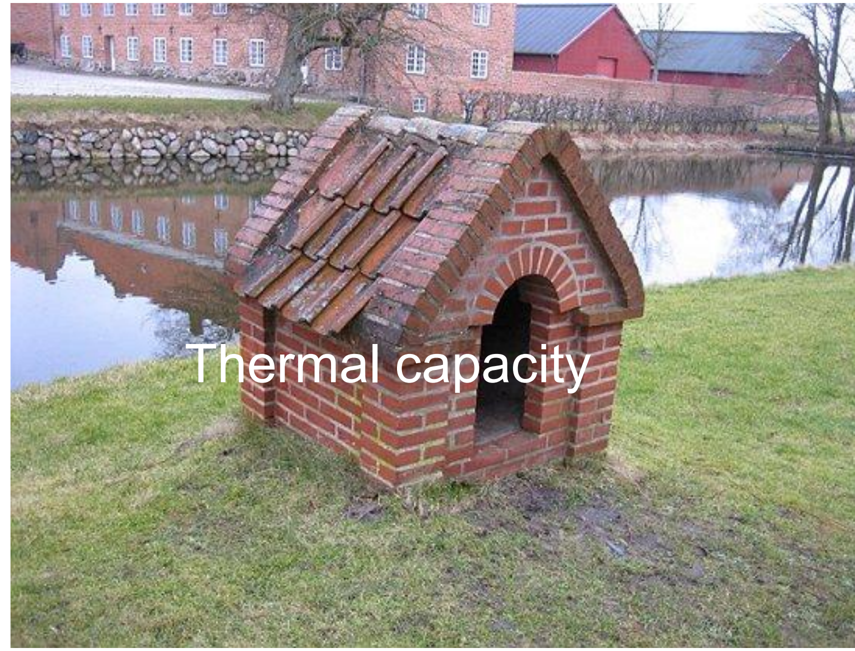
Standardbygning 7 ground_tagvindueog beton i loftog papir på væg.dis - BSim
File Edit Application View Help
DB
Standardbygning
Denmark.dry
C:\Programmer\Danish Building R
Ground 7-15grader
ThermalZone loft
Standardbygning(Cell2)
20 °C
Const105(Face104)
Tag Ribe isolering
Const118(Face117)
Tag Ribe isolering
Const56(Face55)
Tag Ribe isolering
Topvindue(Face938)
SuperLavE-Kr i Alu/tr.
Systems
Const81(Face80)
Tag Ribe isolering
Const94(Face91)
Loft ribe beton
Systems
ThermalZone Rum
Room88(Cell86)
20 °C
Const20(Face19)
Ribe væg med papir
Const31(Face30)
Ribe væg med papir
Const40(Face39)
Ribe væg med papir
Const49(Face48)
Ribe væg med papir
Const94(Face91)
Loft ribe beton
Gulv(Face5)
Slab on grnd 150
Systems
Z
X
Y

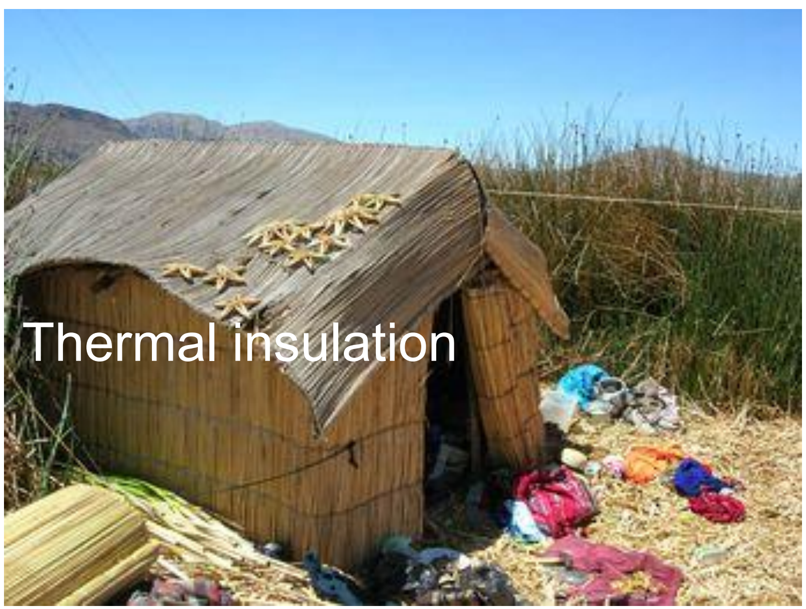
Computer simulation of the T and RH in (empty) passive store



	Climate control	Energy consumpt (pr. year)	T	RF
	Full AC	30 kWh/m^3	18-20°C	45-55%
Music store	Heating	5 kWh/m^3	12-23°C	50-60%
Værløse shelter	Dehumidification	2 kWh/m^3	0-23°C	50-55%
Ribe store	Dehumidification	1 kWh/m^3	8-16°C	50-55%
NN	Passive	0,1 kWh/m^3	8-24°C	40-60%


Humidity buffer


Thermal capacity


Thermal insulation


FATHER