Energy efficient climate control in museum stores

A shelter for fighter airplanes protecting against a nuclear strike.

The roof is 50 cm solid concrete covered with plastic paint

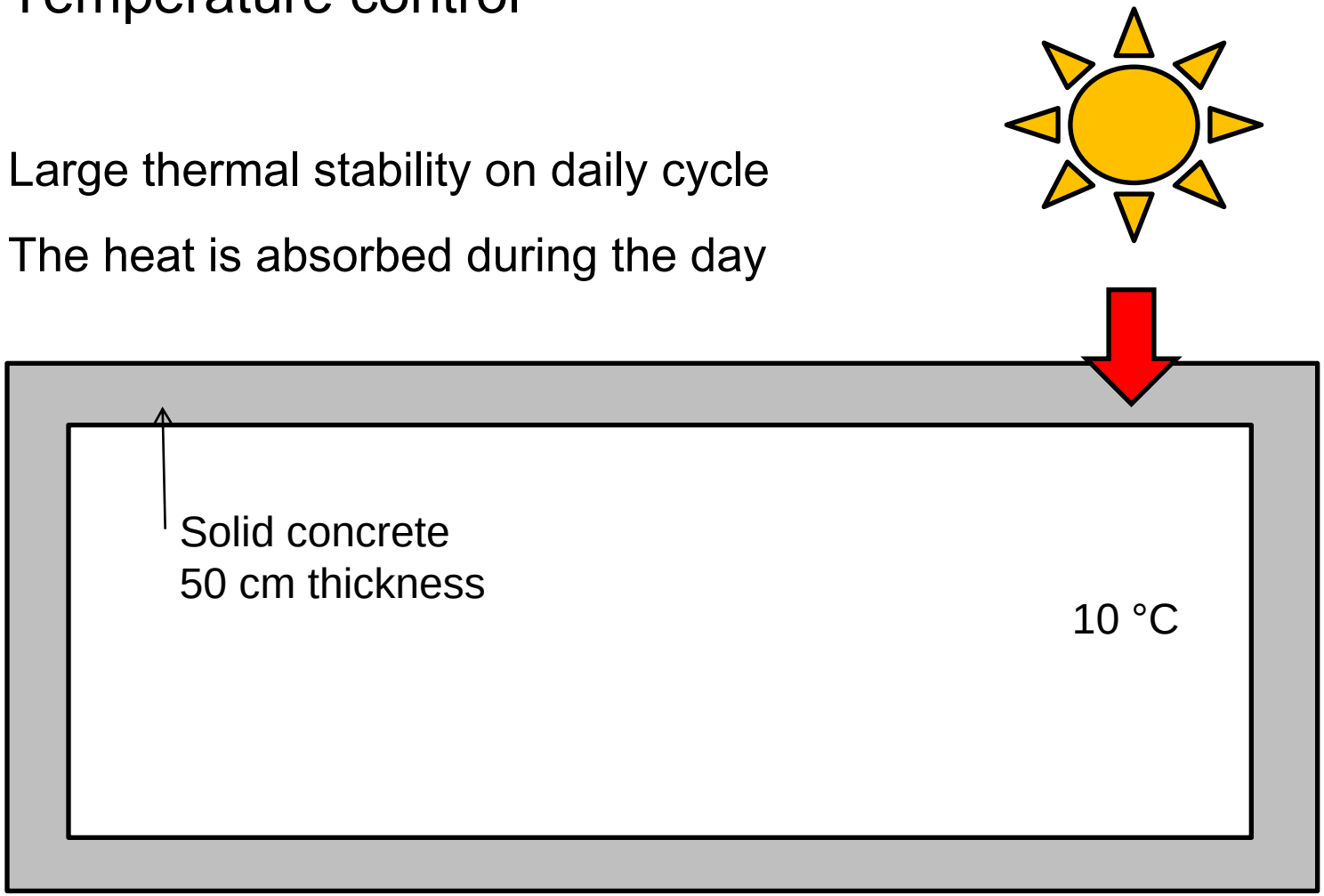
In use as temporary store for collection of furniture

The store is densly packed with moisture sensitive wooden objects

Temperature control

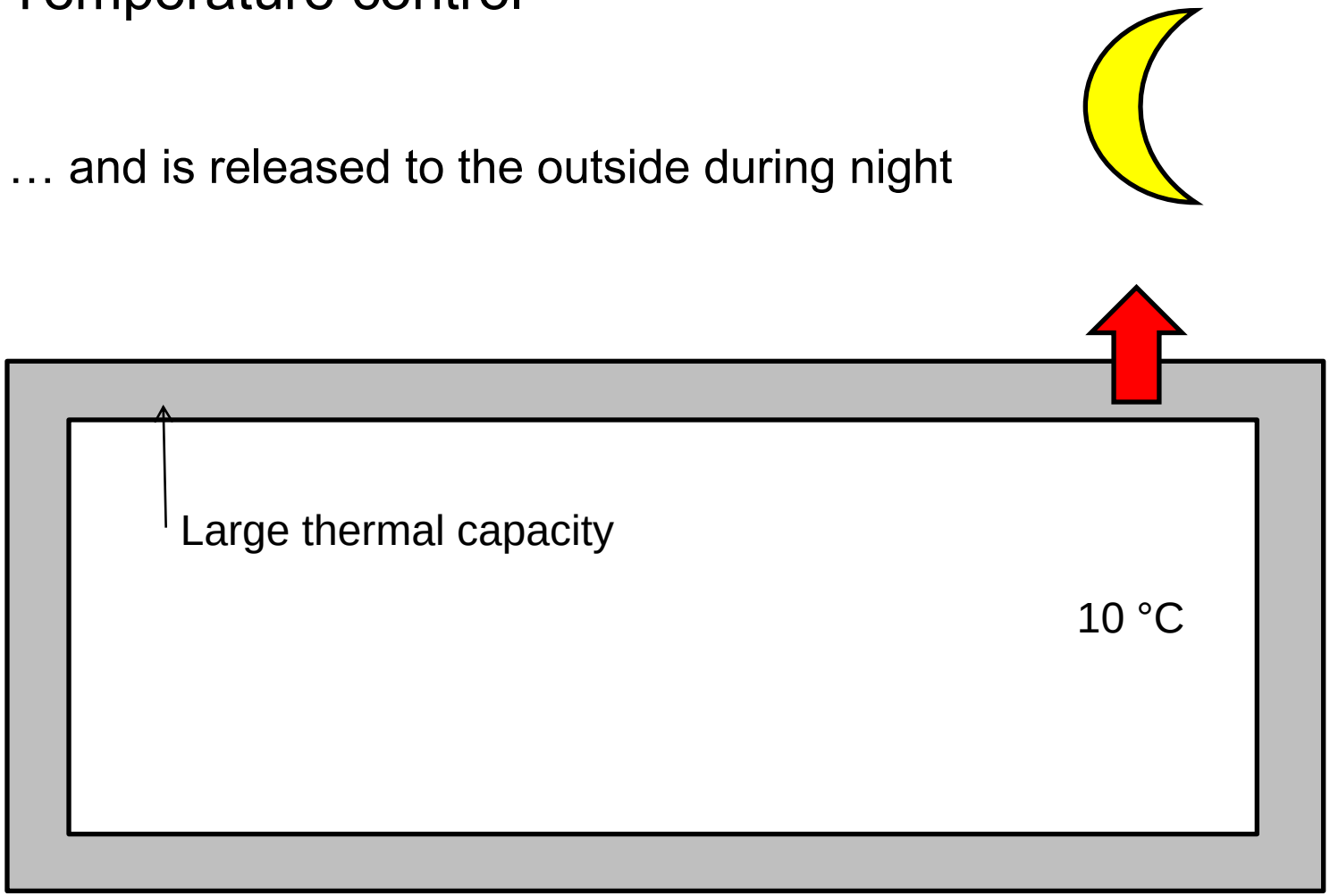
Large thermal stability on daily cycle

The heat is absorbed during the day



Temperature control

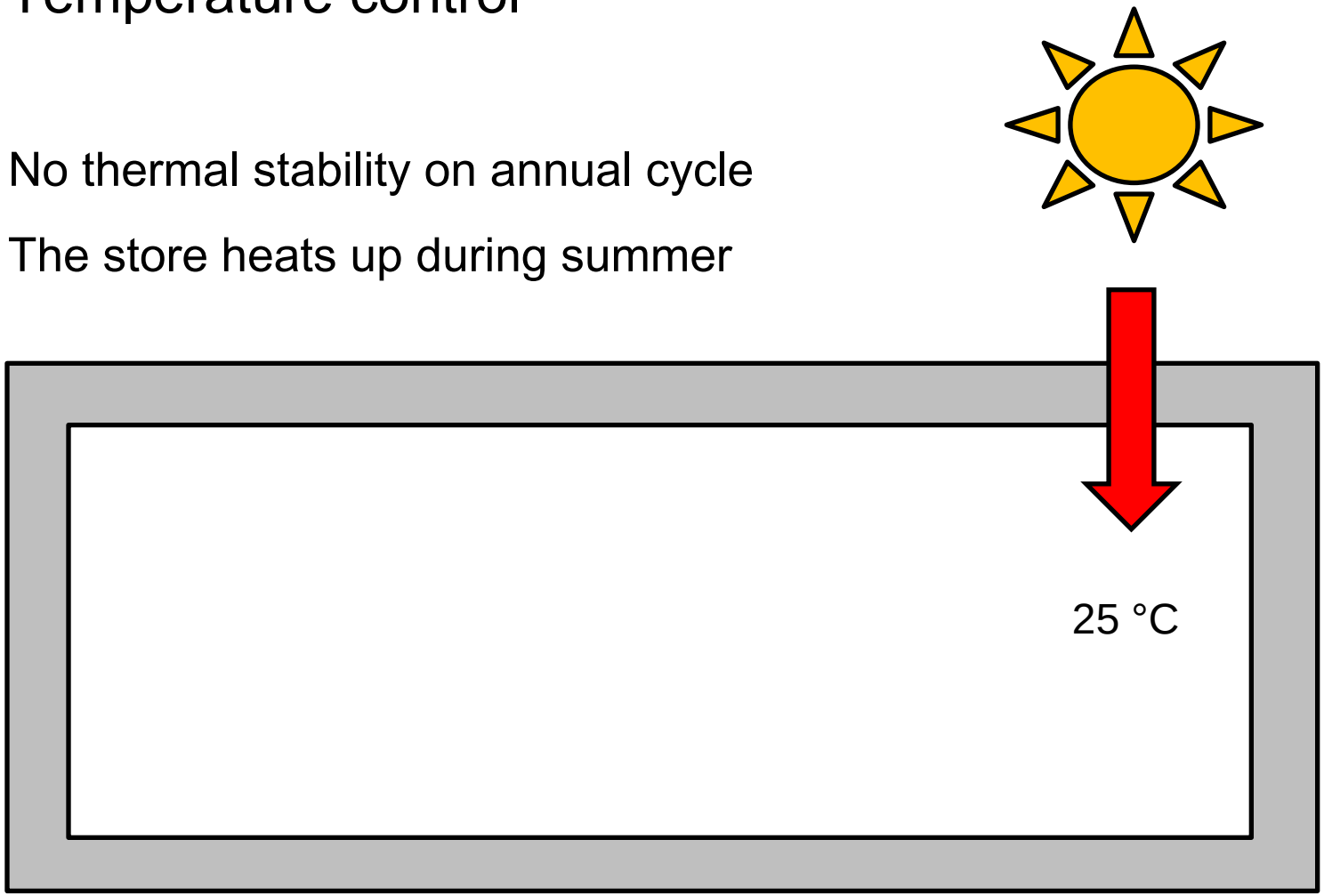
… and is released to the outside during night



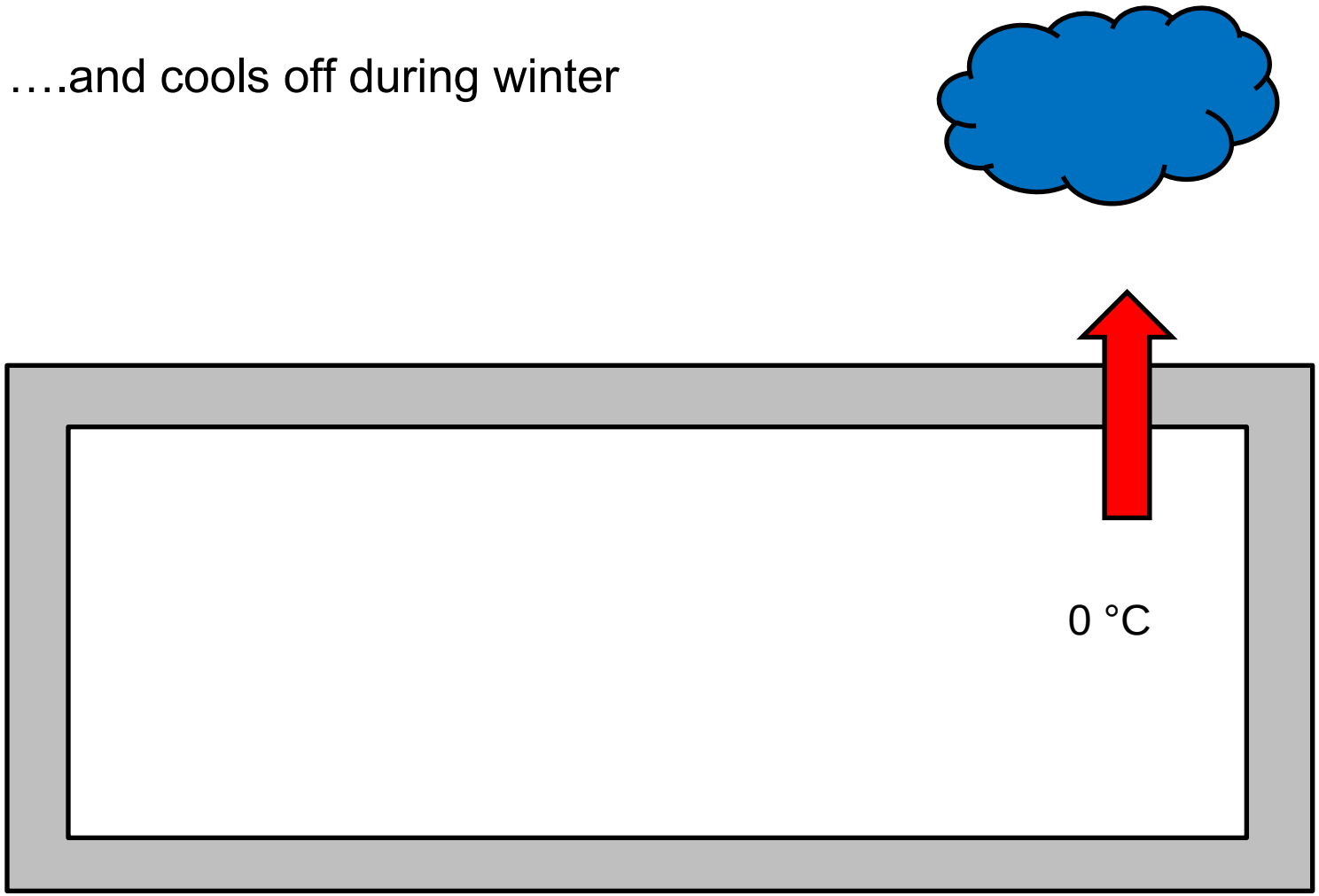
Temperature control

No thermal stability on annual cycle

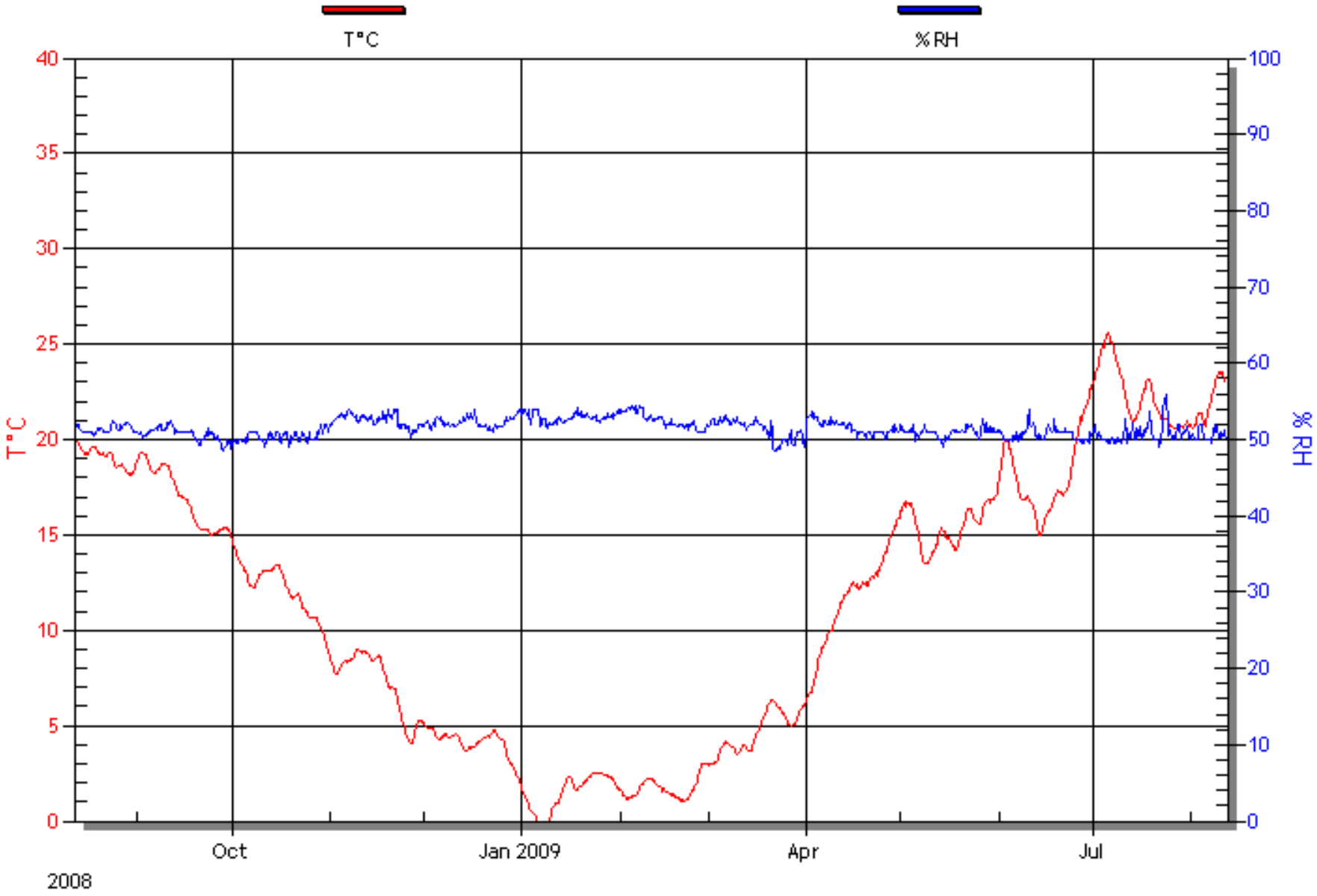
The store heats up during summer



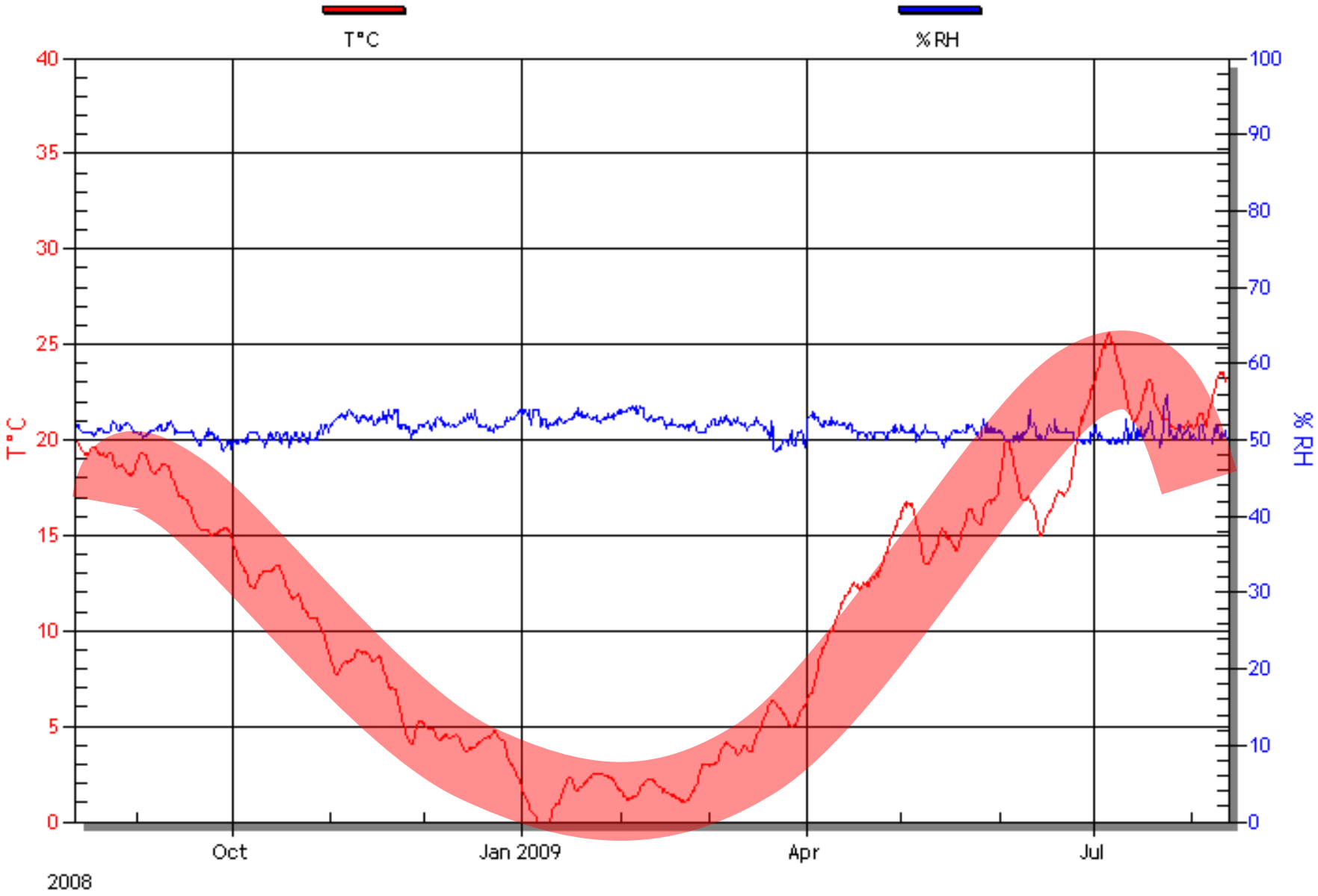
….and cools off during winter



The interior climate over twelve months.



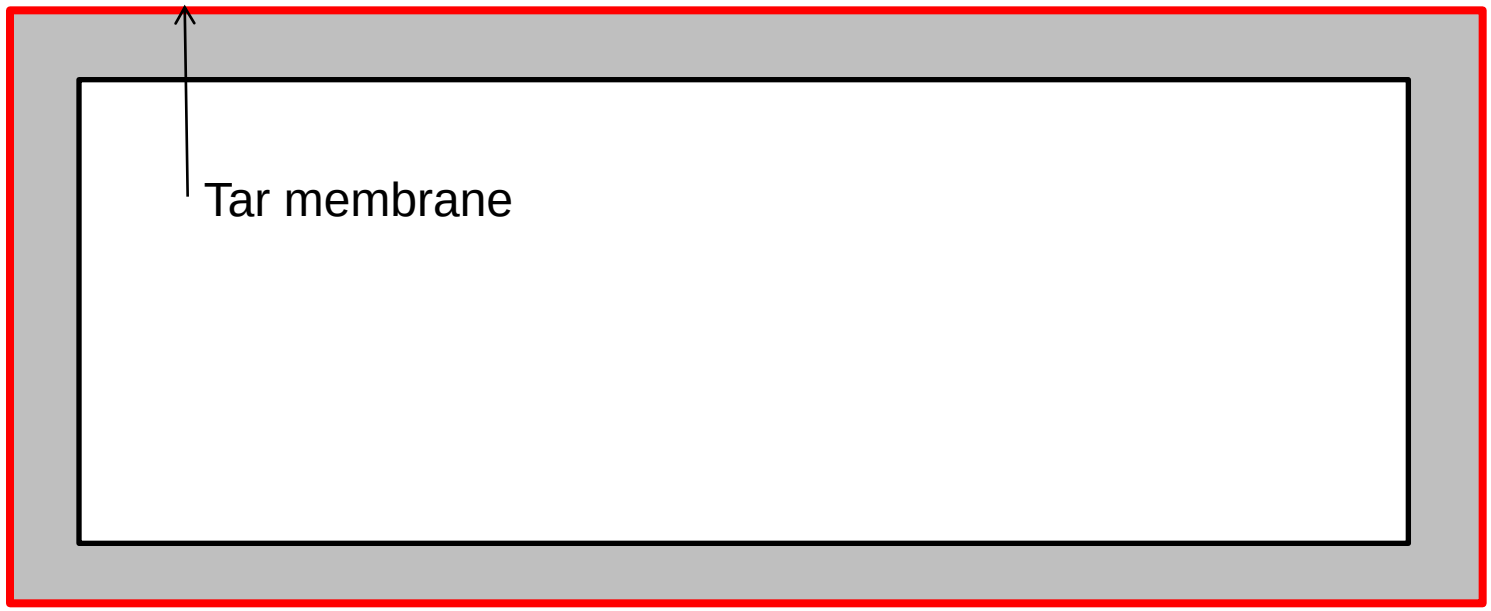
Inside temperature follows the outside



Humidity control

The structure is water tight

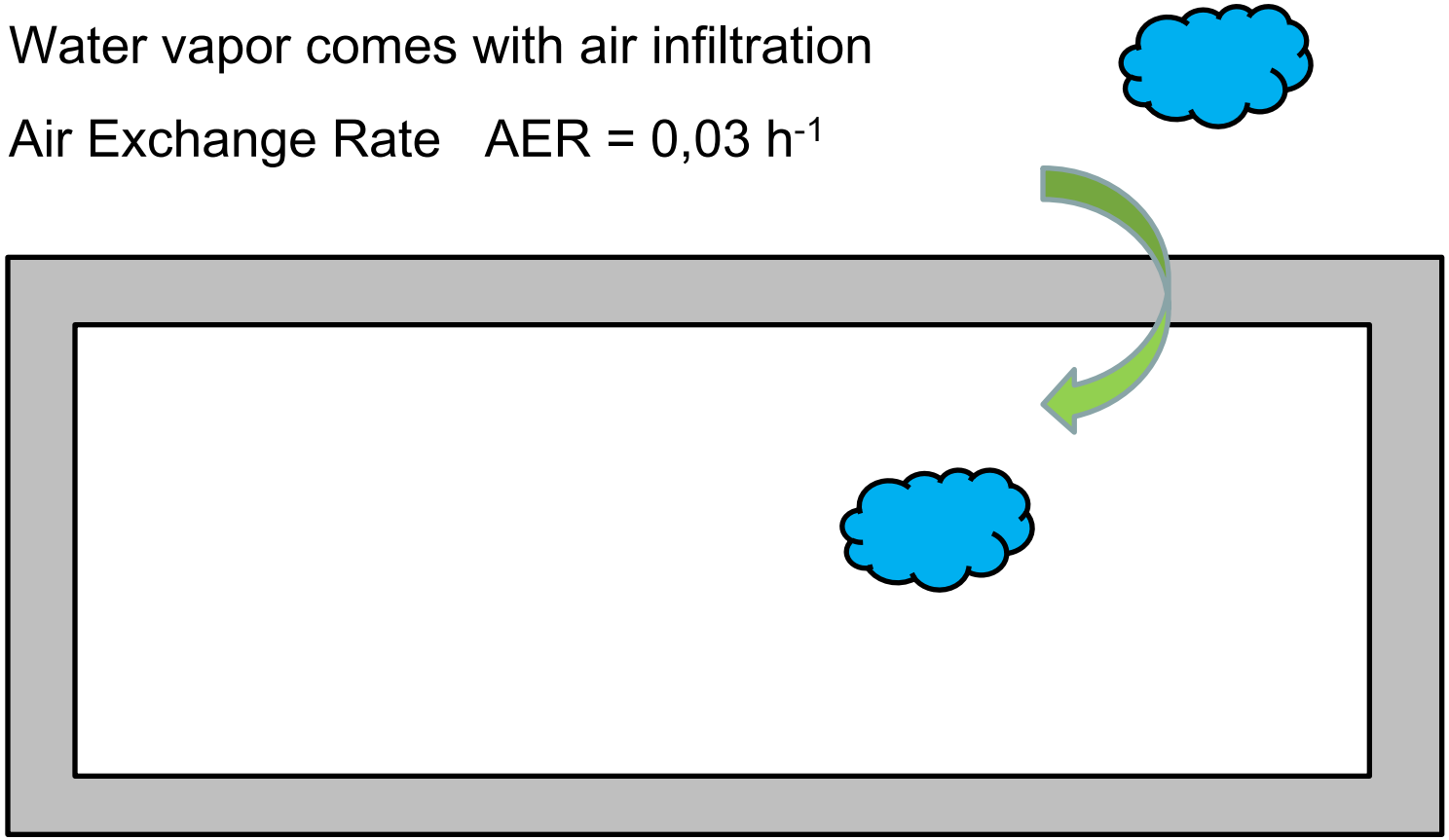
The only source of humidity is the outside air



Humidity control

Water vapor comes with air infiltration

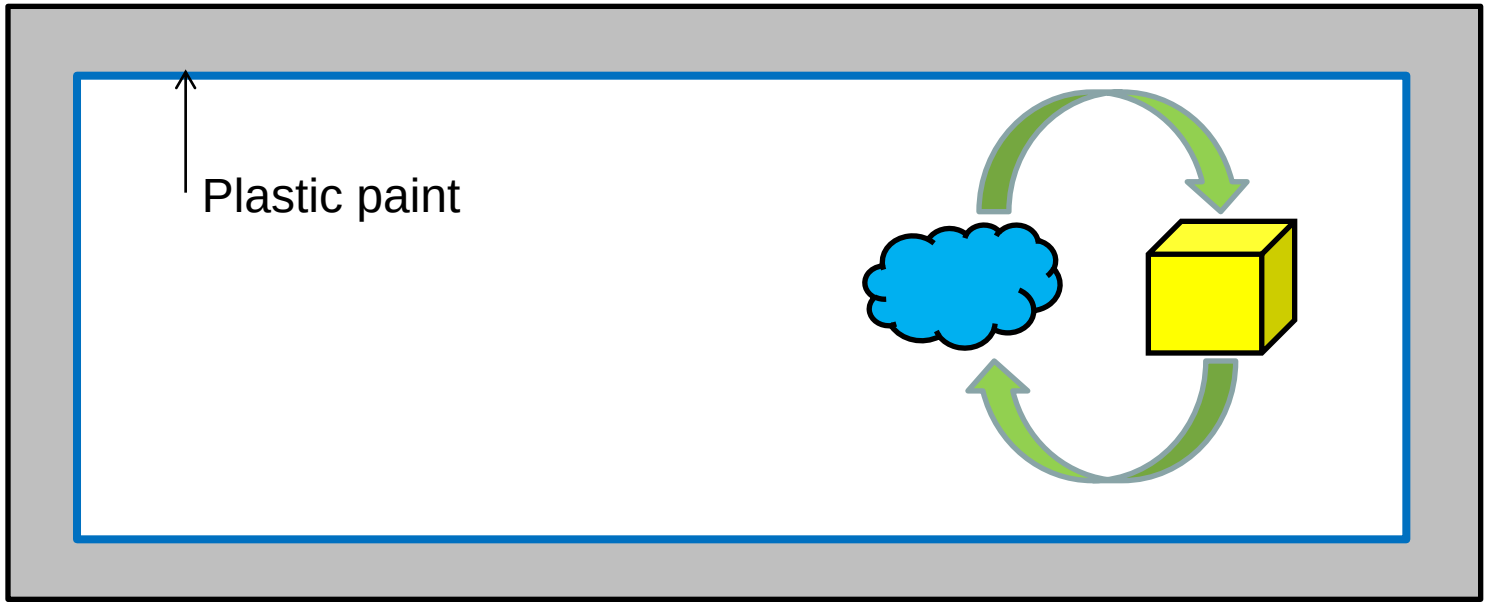
Air Exchange Rate AER = 0,03 h^{-1}



Humidity control

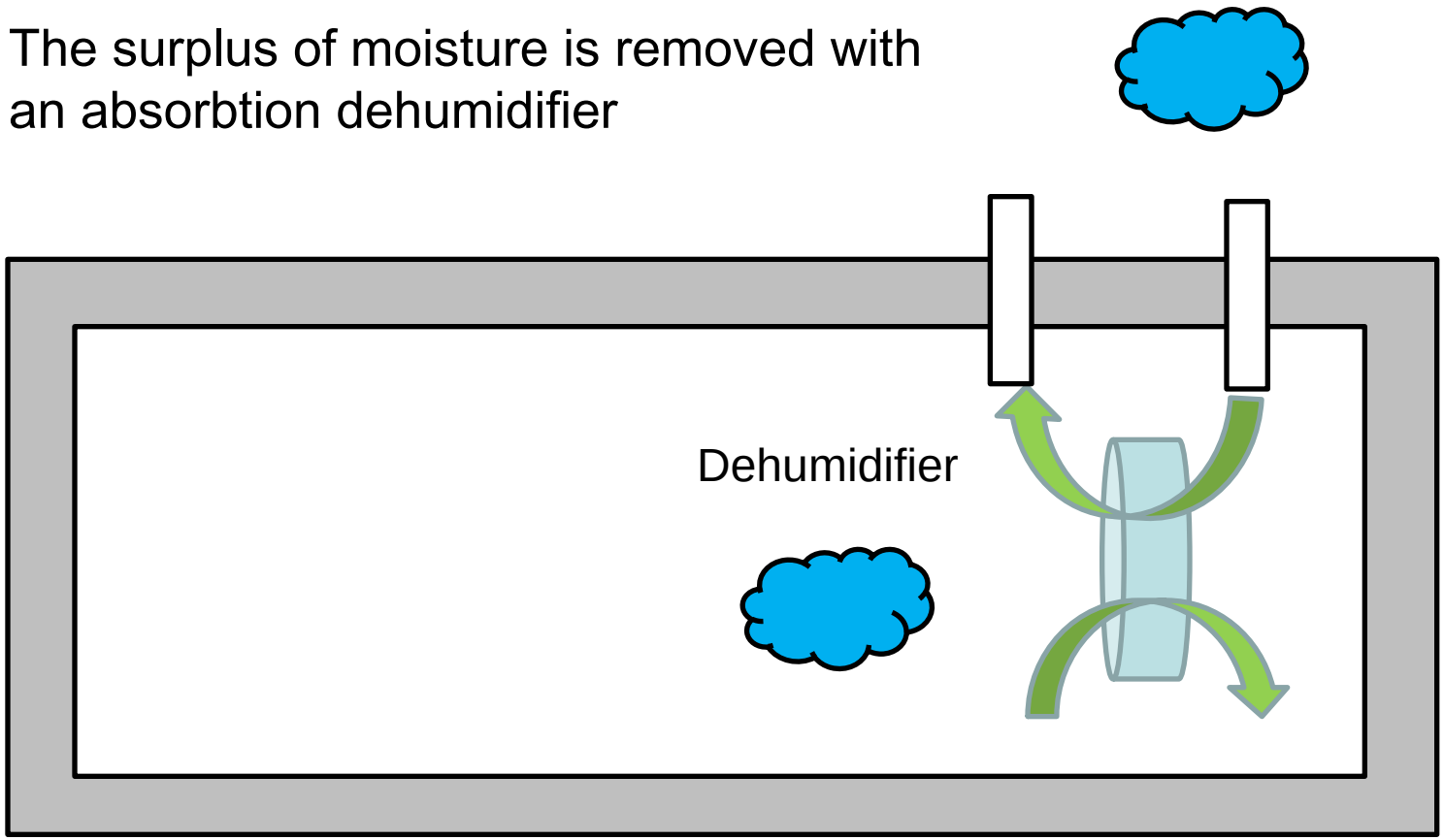
The inside is impermable to water vapor

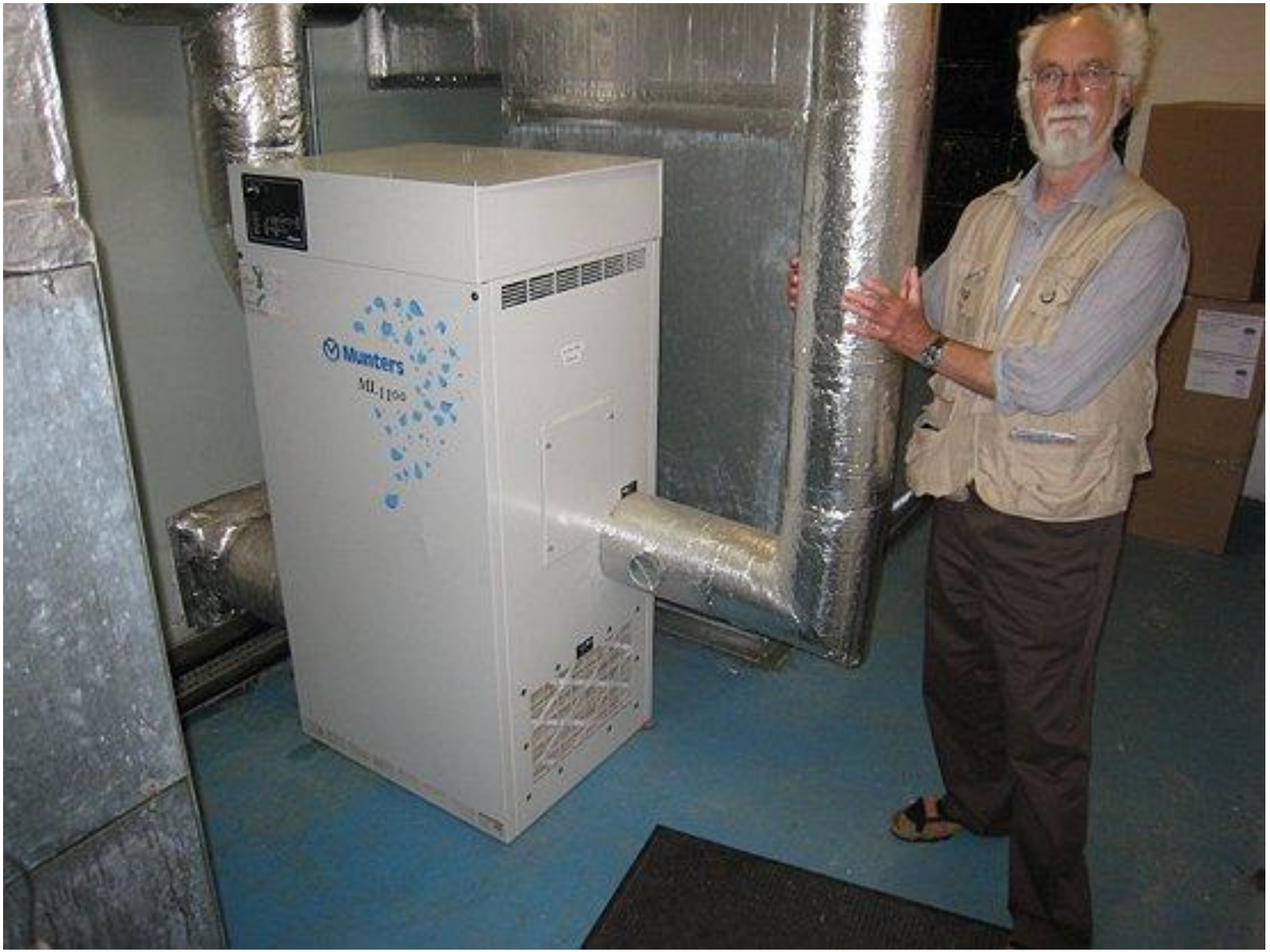
The wooden objects provide humidity buffer



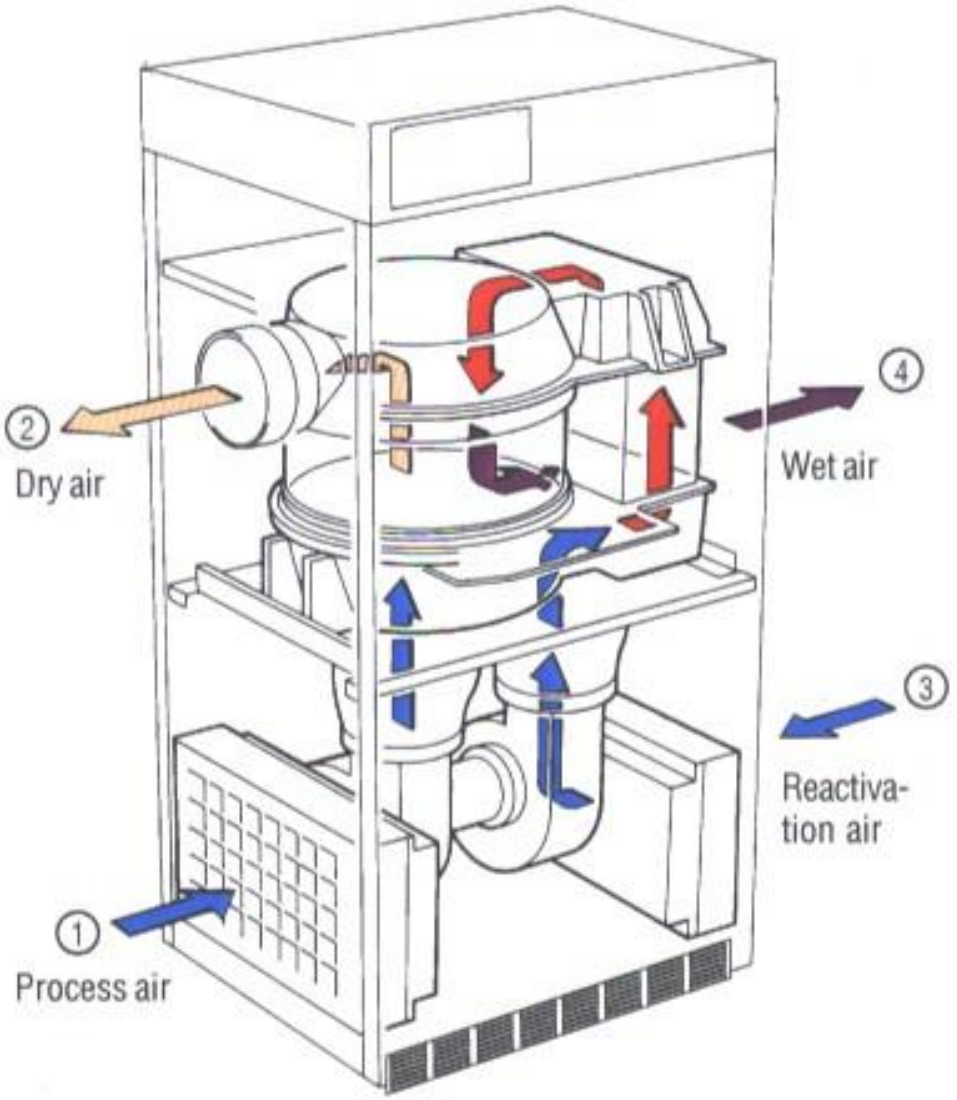
Humidity control

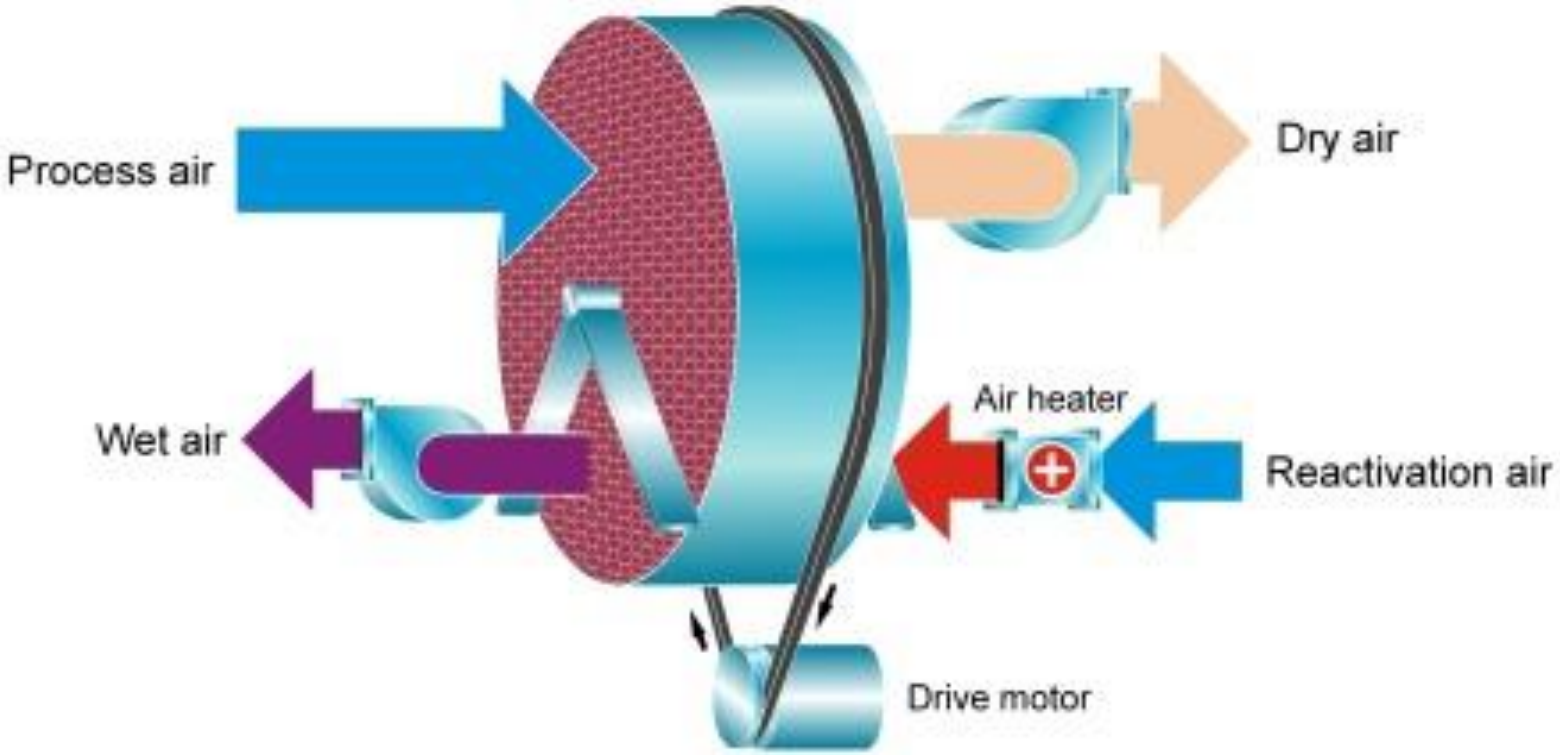
The surplus of moisture is removed with an absorbtion dehumidifier



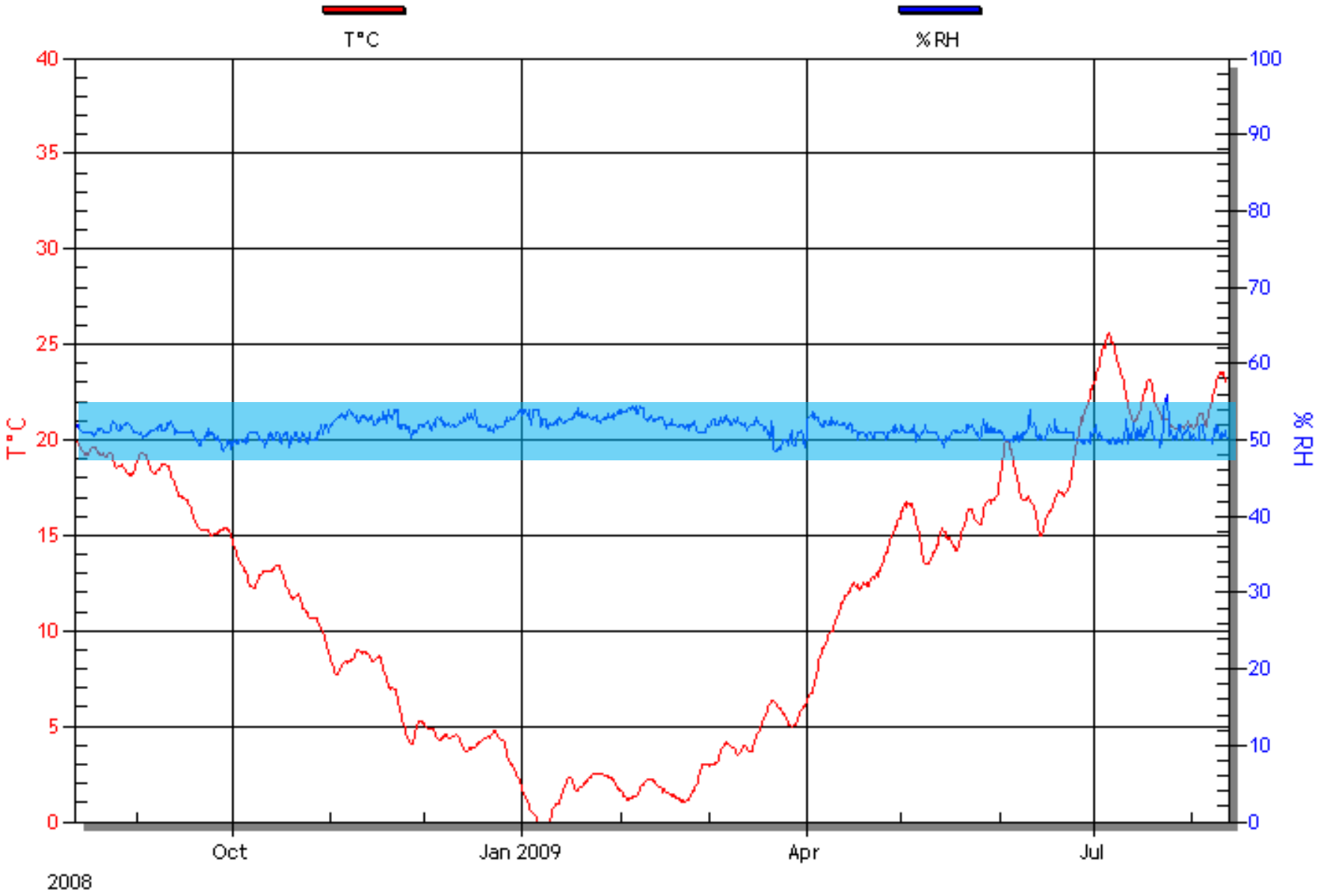

Munters


Munters
MI-1100

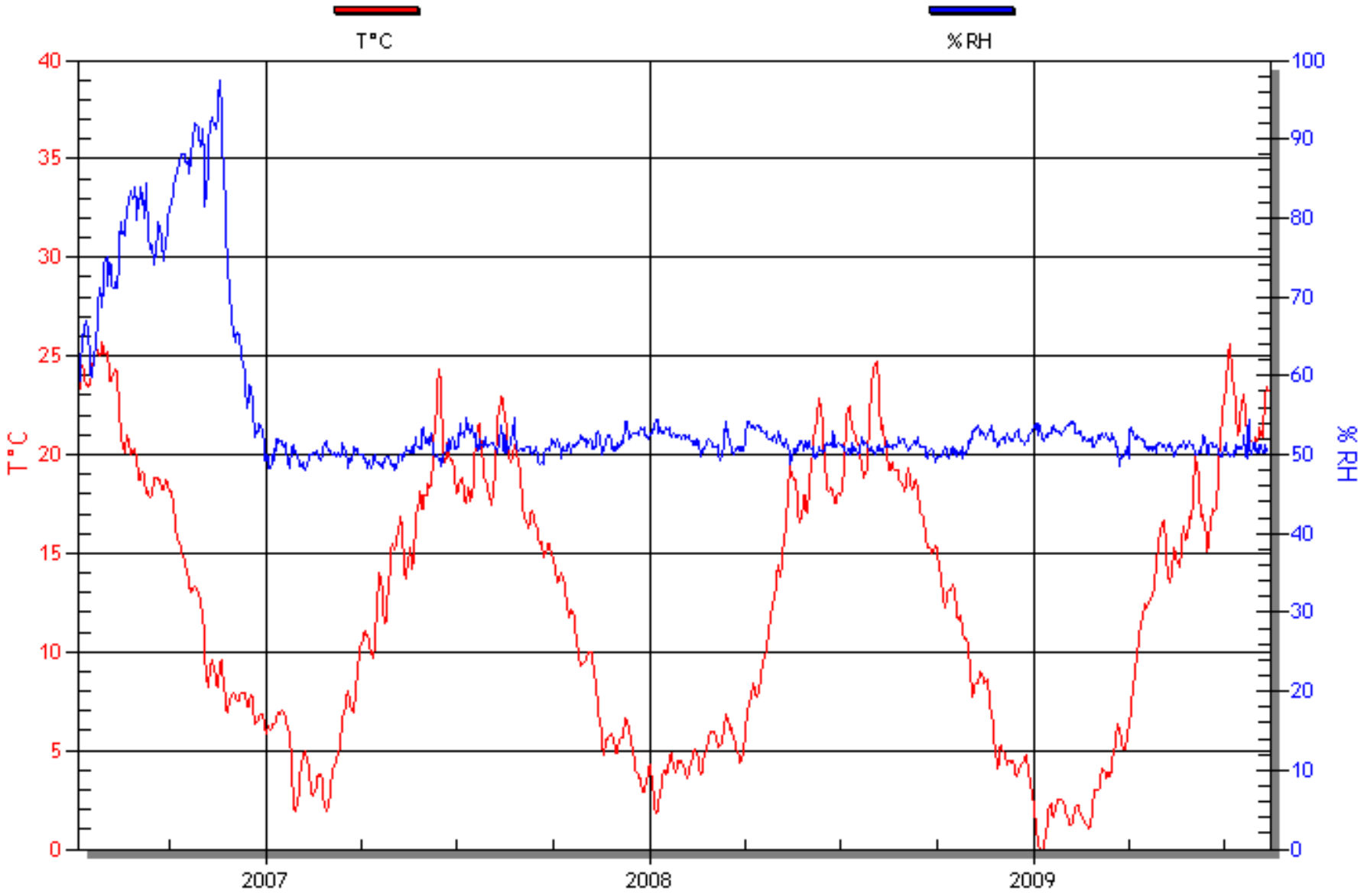

2
Dry air
4
Wet air
3
Reactiva-
tion air
1
Process air


Process air
Dry air
Wet air
Air heater
Reactivation air
Drive motor

Relative humidity is constant due to dehumidification



The climate over three years. Dehumidification is always needed



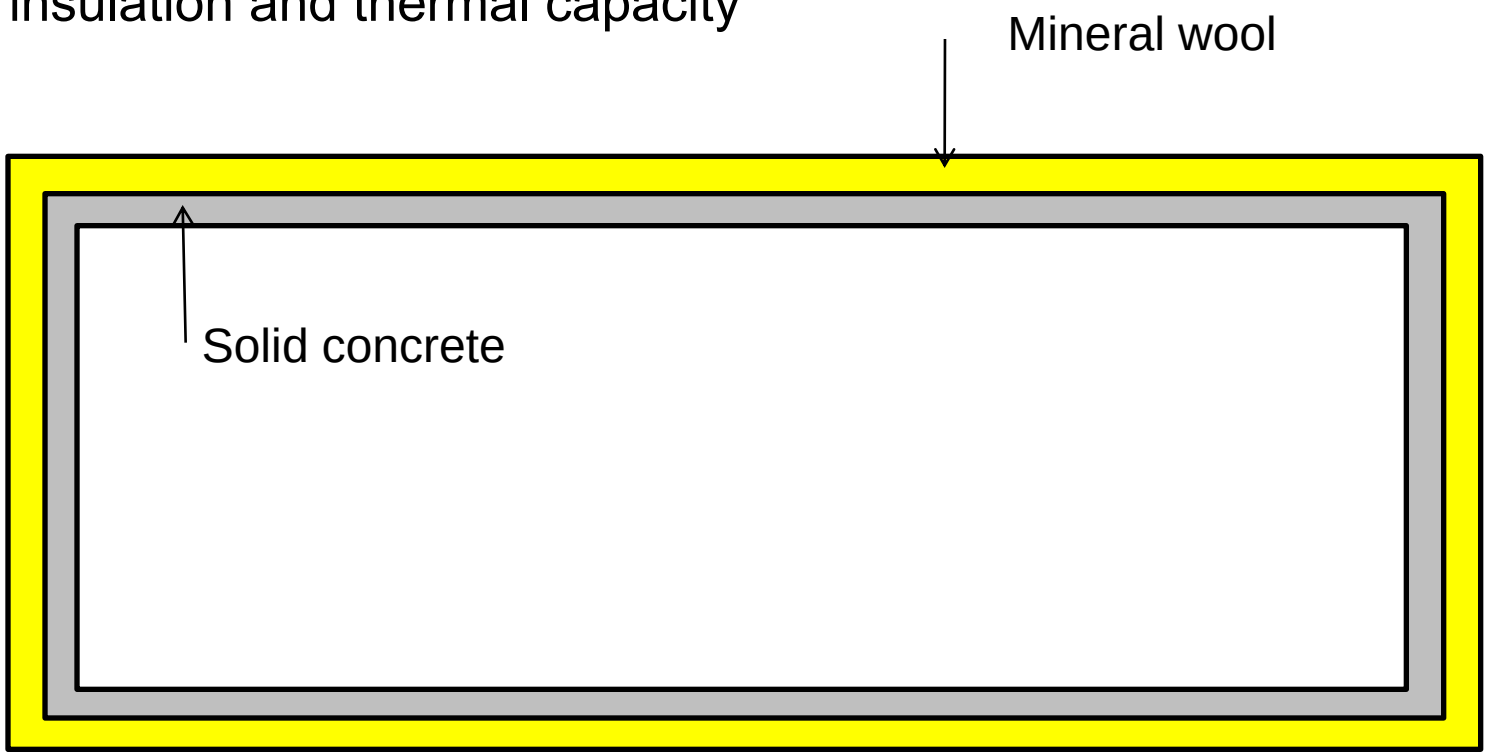
Store for historic music instruments in an old factory building

Very humidity sensitive artifacts. Very little density of stored objects

The store is surrounded by workshops which are heated in winter

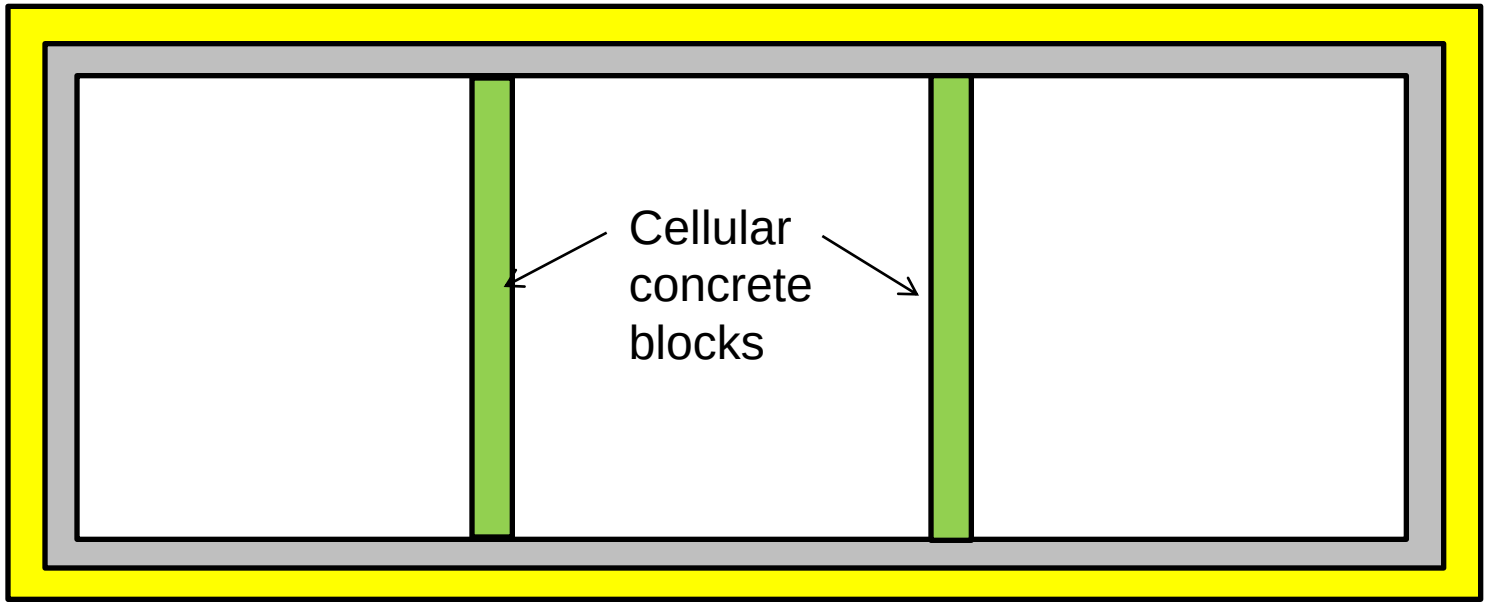
Temperature stability

Combination of thermal
insulation and thermal capacity



Humidity stability

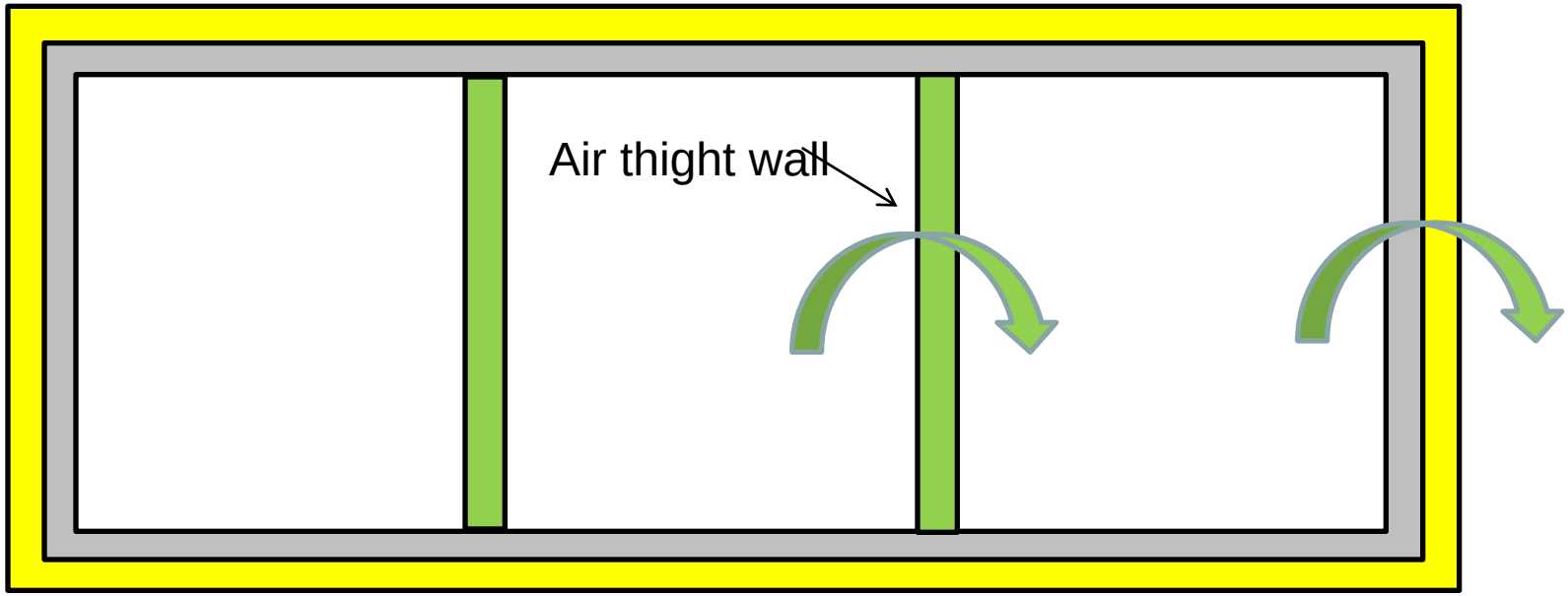
Interior walls are made of cellular concrete to act as a humidity buffer



Climate control

The is no mechanical ventilation

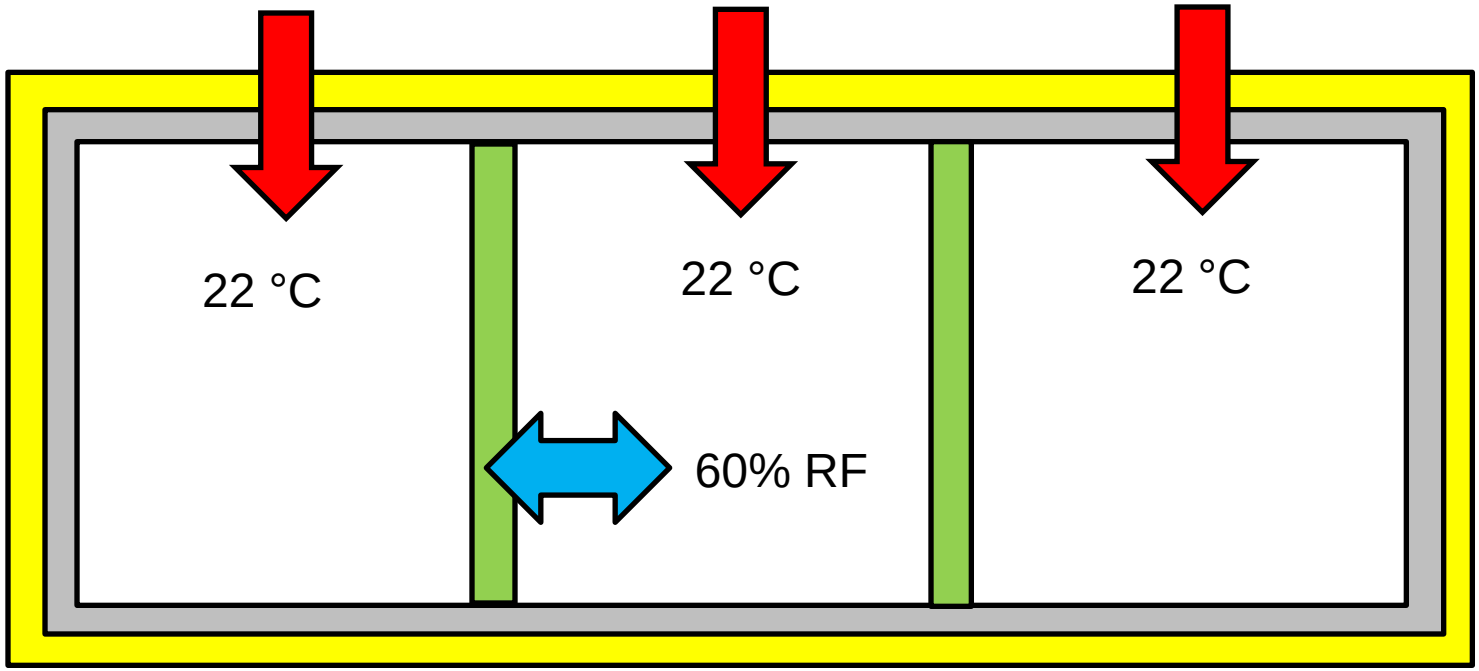
The air exchange rate is 0,04 h^{-1}



Climate control in summer

Heat gain from roof heats up the spaces and keeps RH down

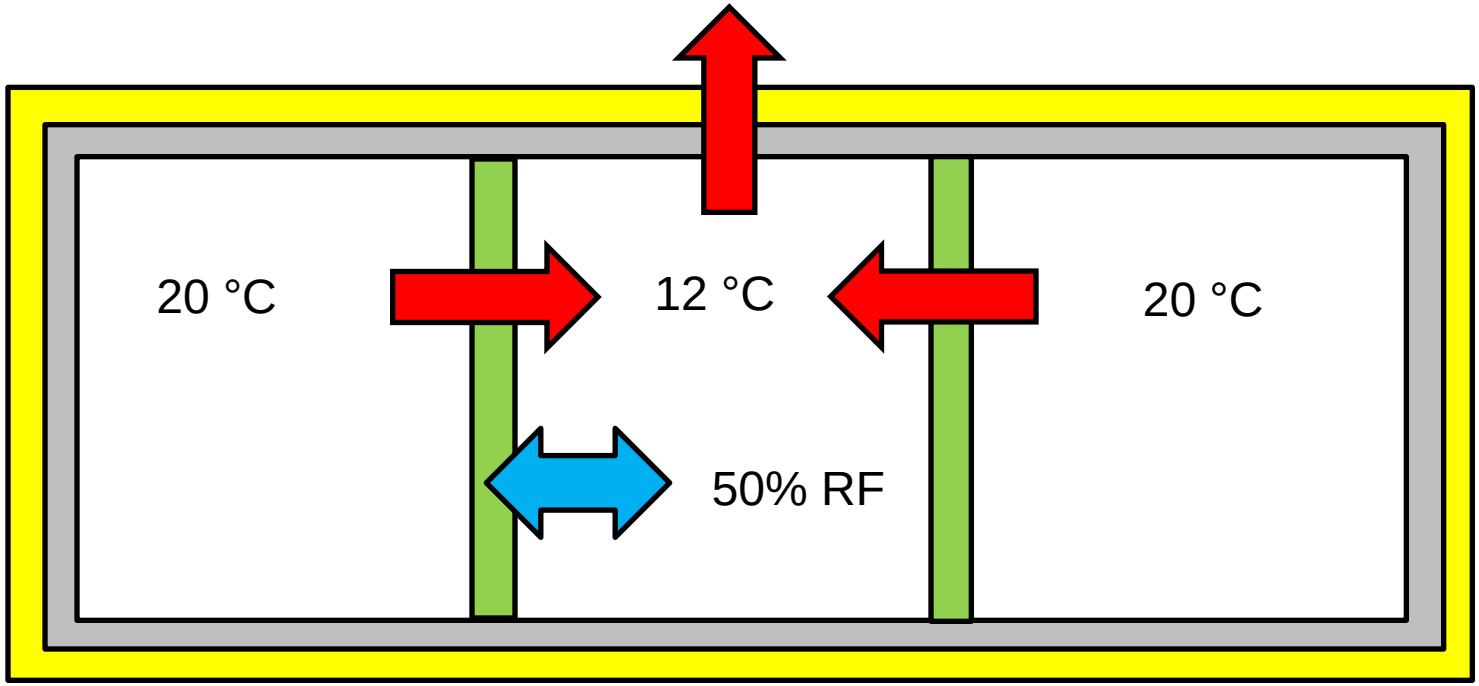
T = 20 °C
RH = 70%



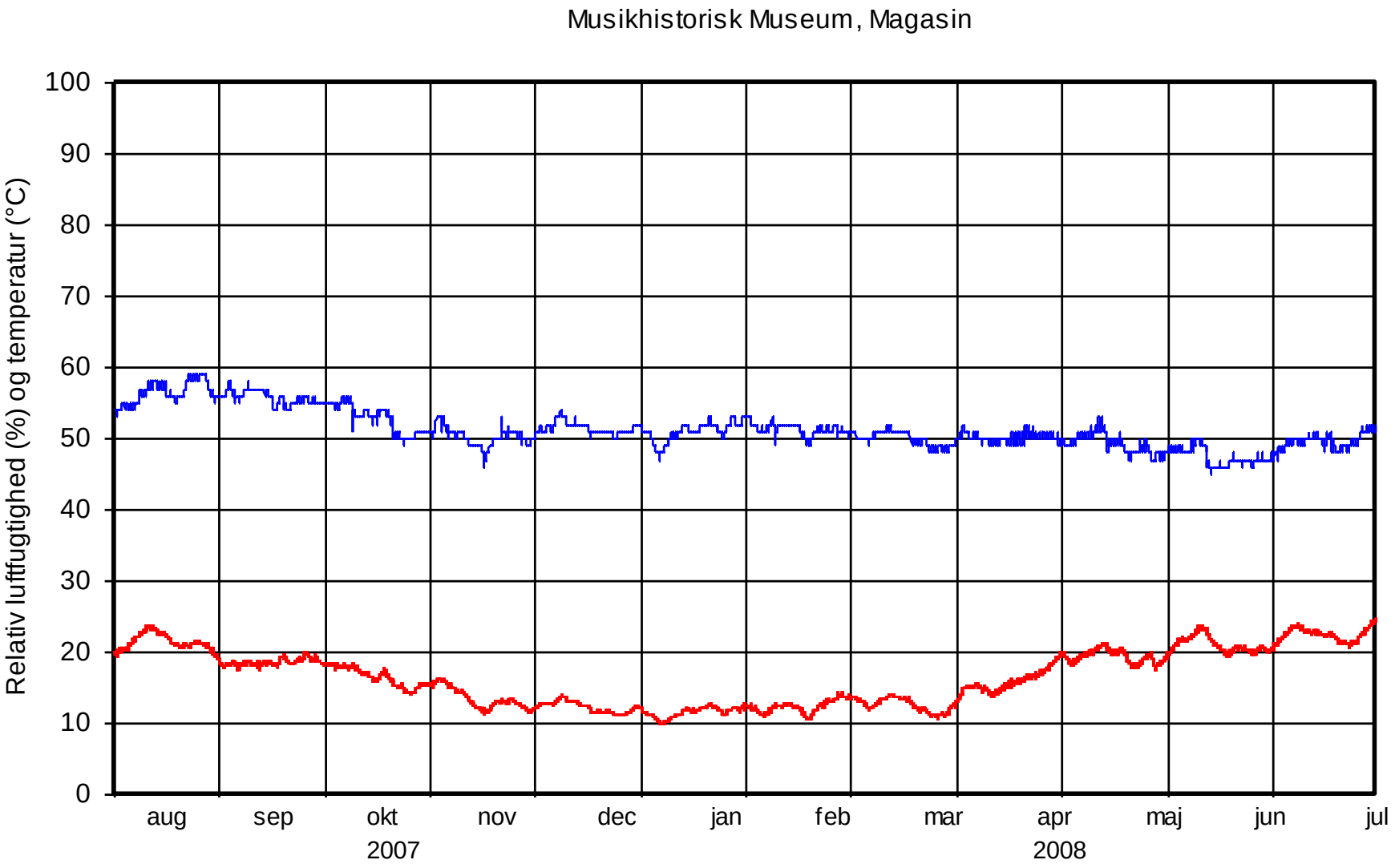
Climate control in winter

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

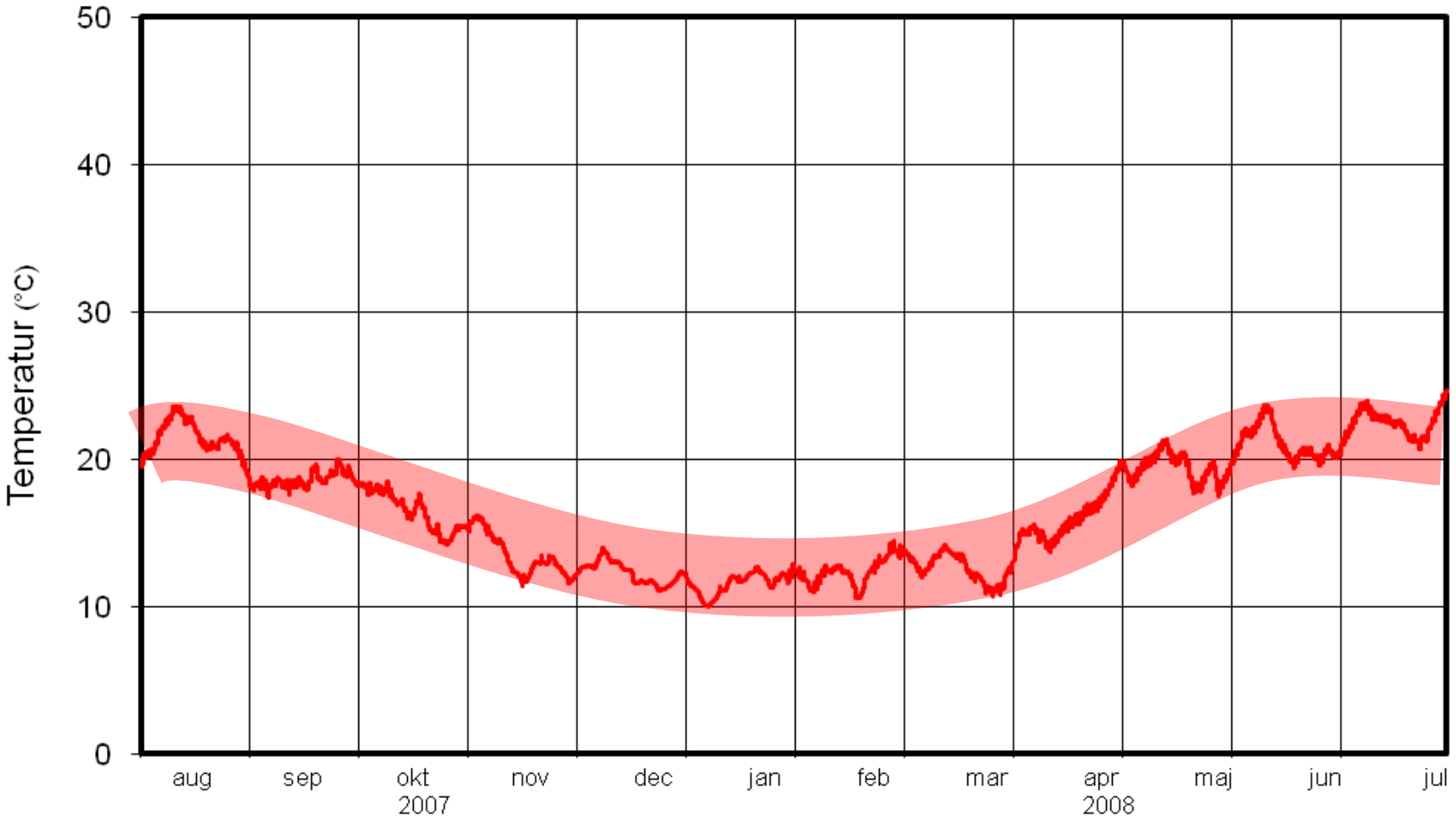
T = 0 °C
RF = 100%



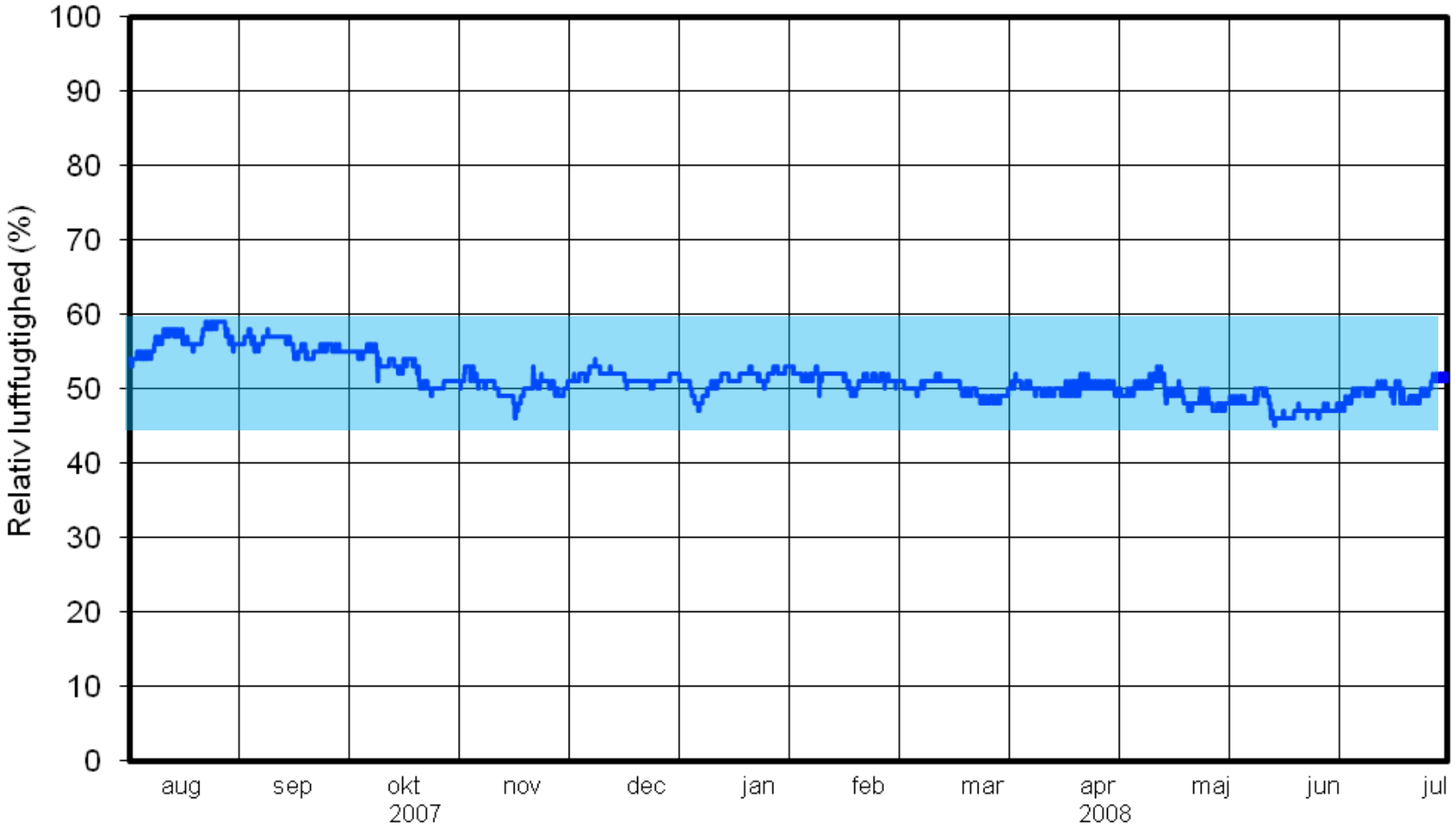
Climate records for the interior over one year.



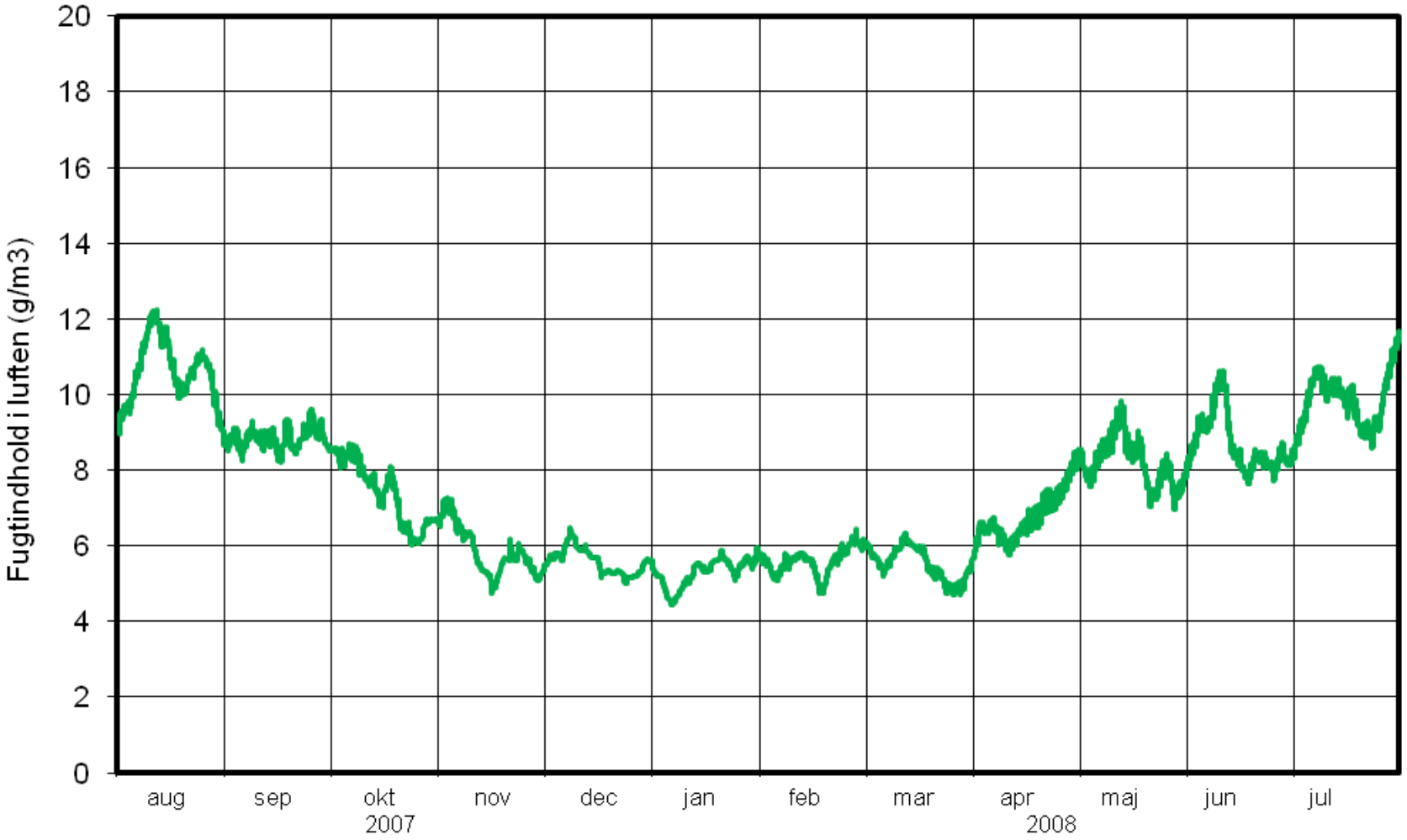
The temperature is controlled by heat flow from workshops in winter



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

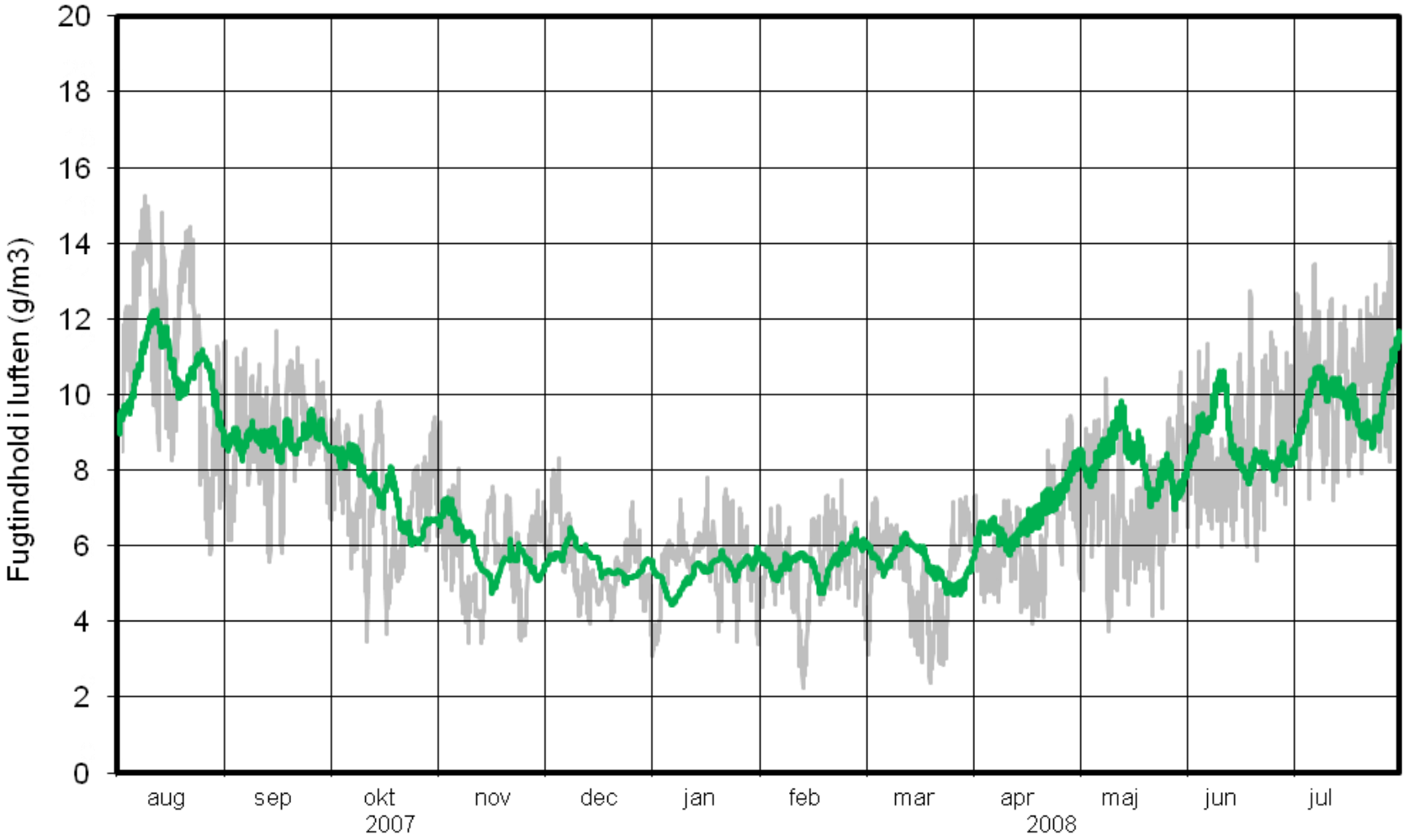


Moisture content in inside air calculated from temperature and humidity records



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

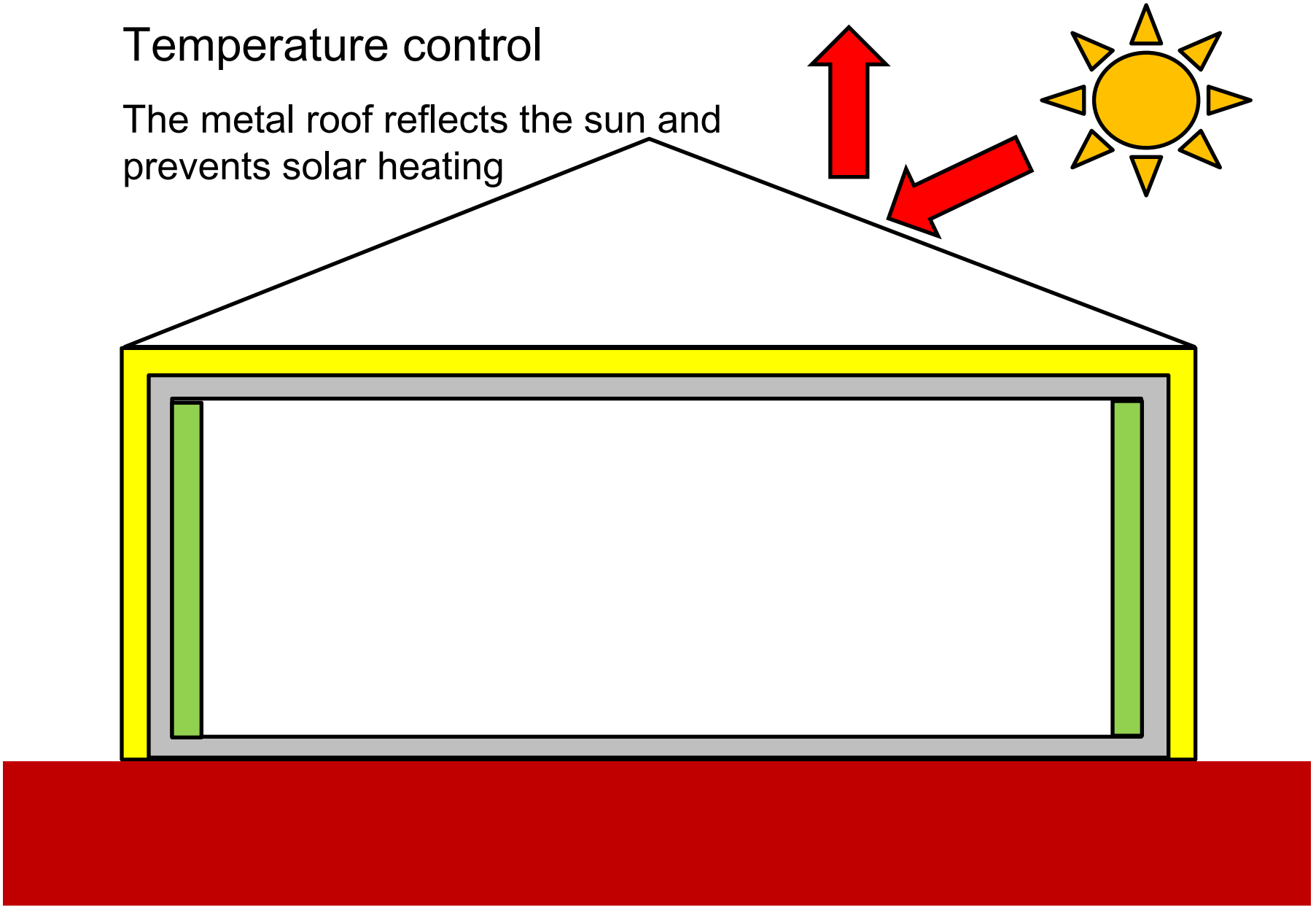
There is a considerable moisture buffer on weekly cycles



New store for the Museum of cultural history in Ribe

Temperature control

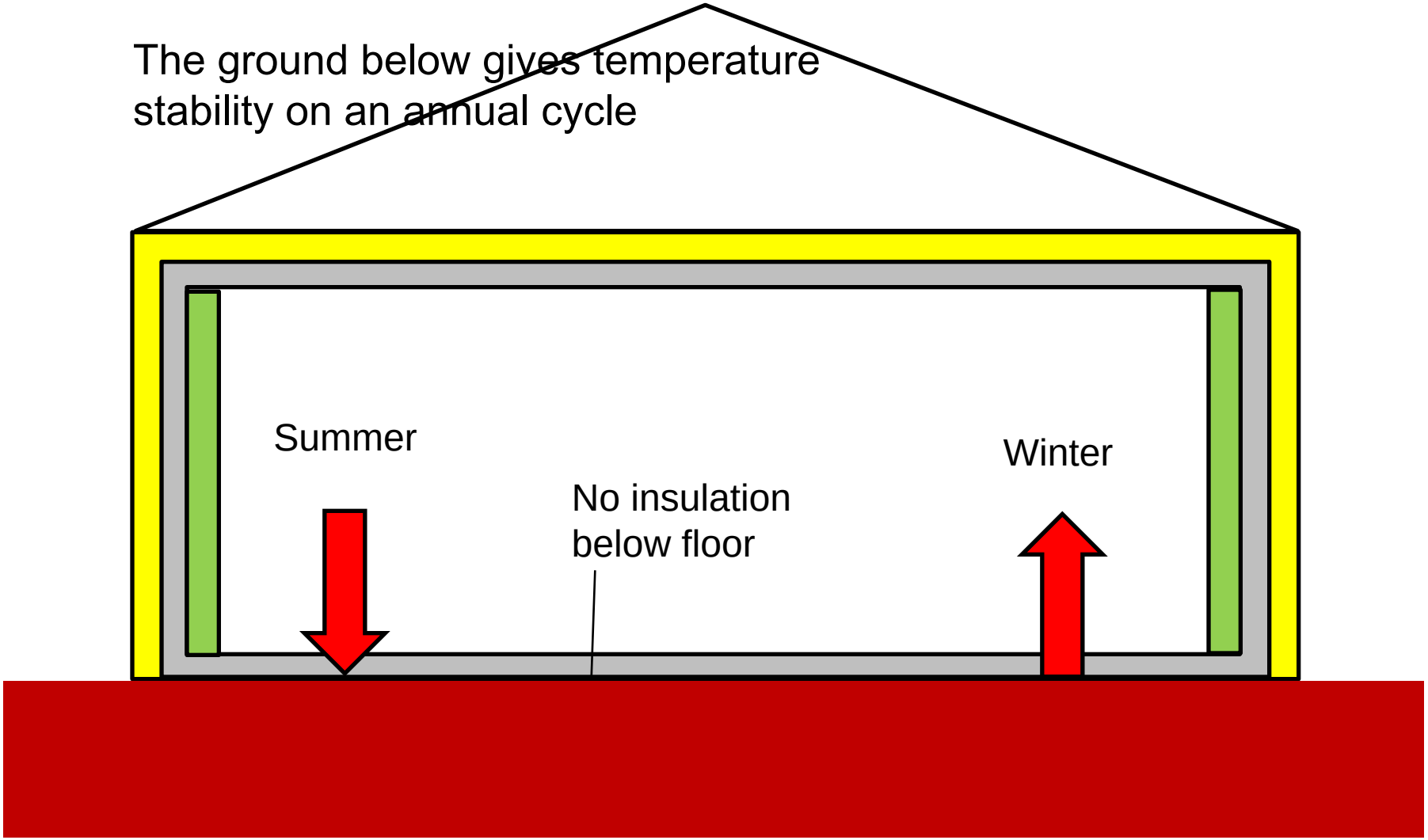
The metal roof reflects the sun and prevents solar heating



Temperature control

The floor has no insulation

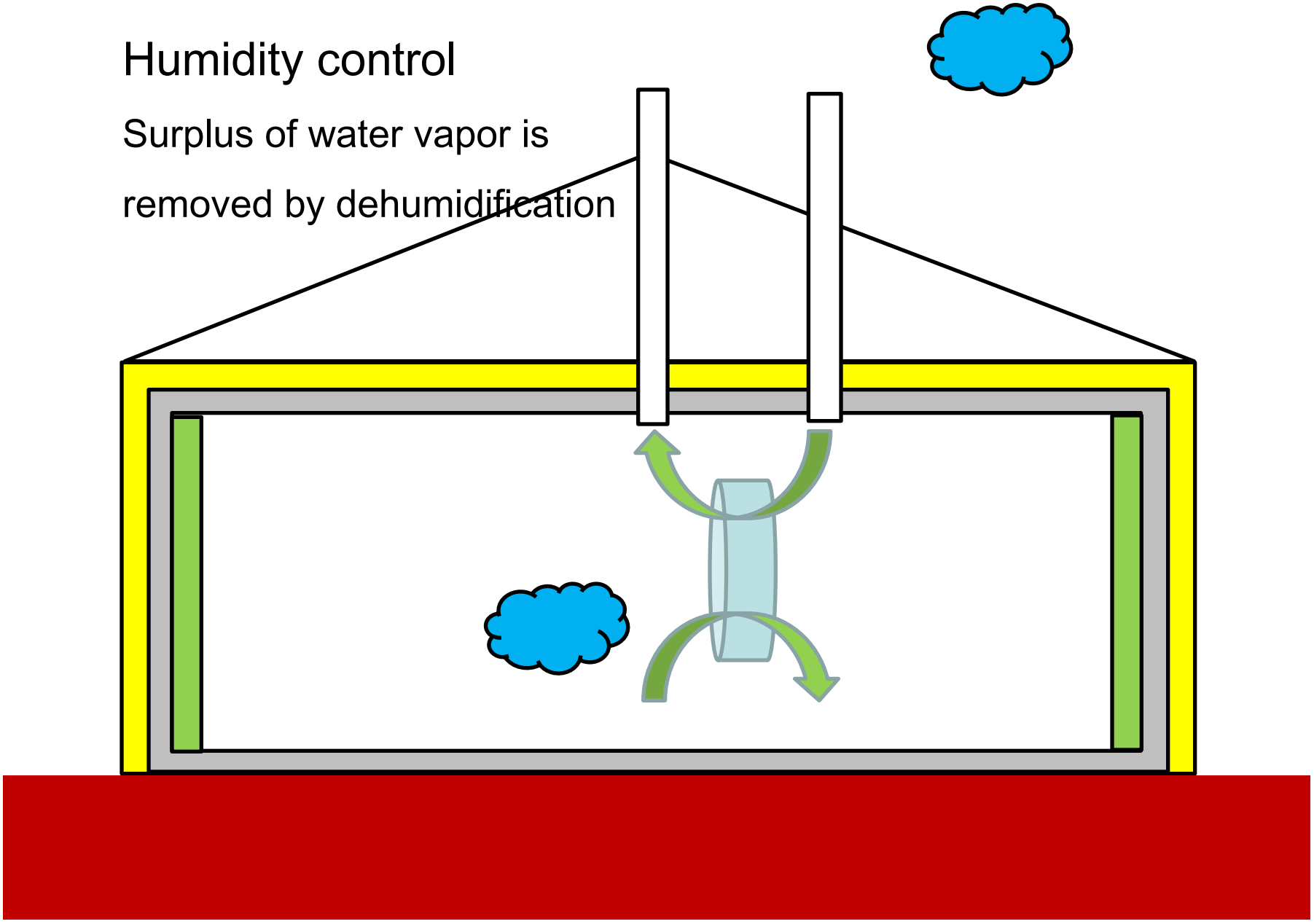
The ground below gives temperature stability on an annual cycle



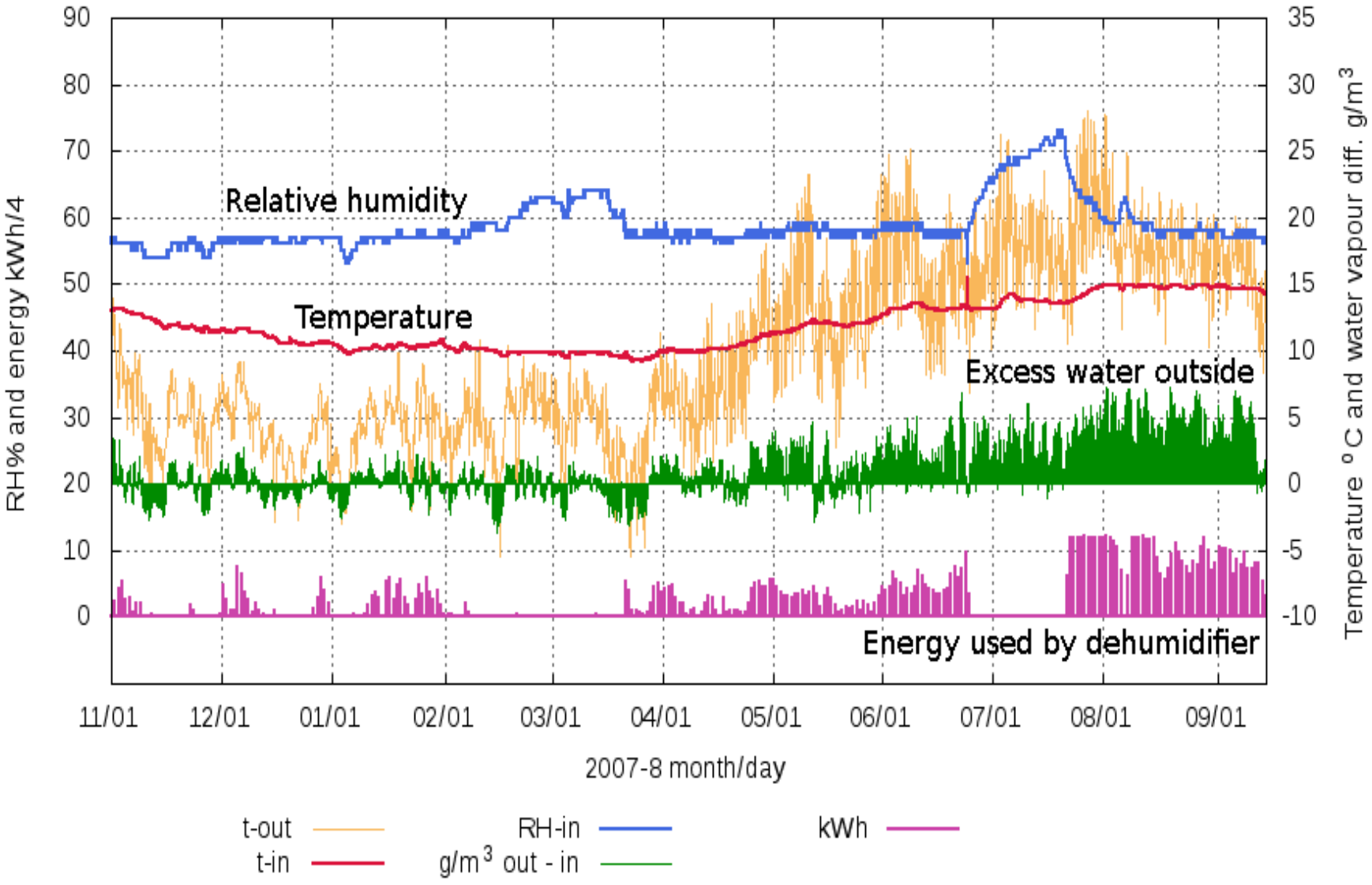
Humidity control

Surplus of water vapor is

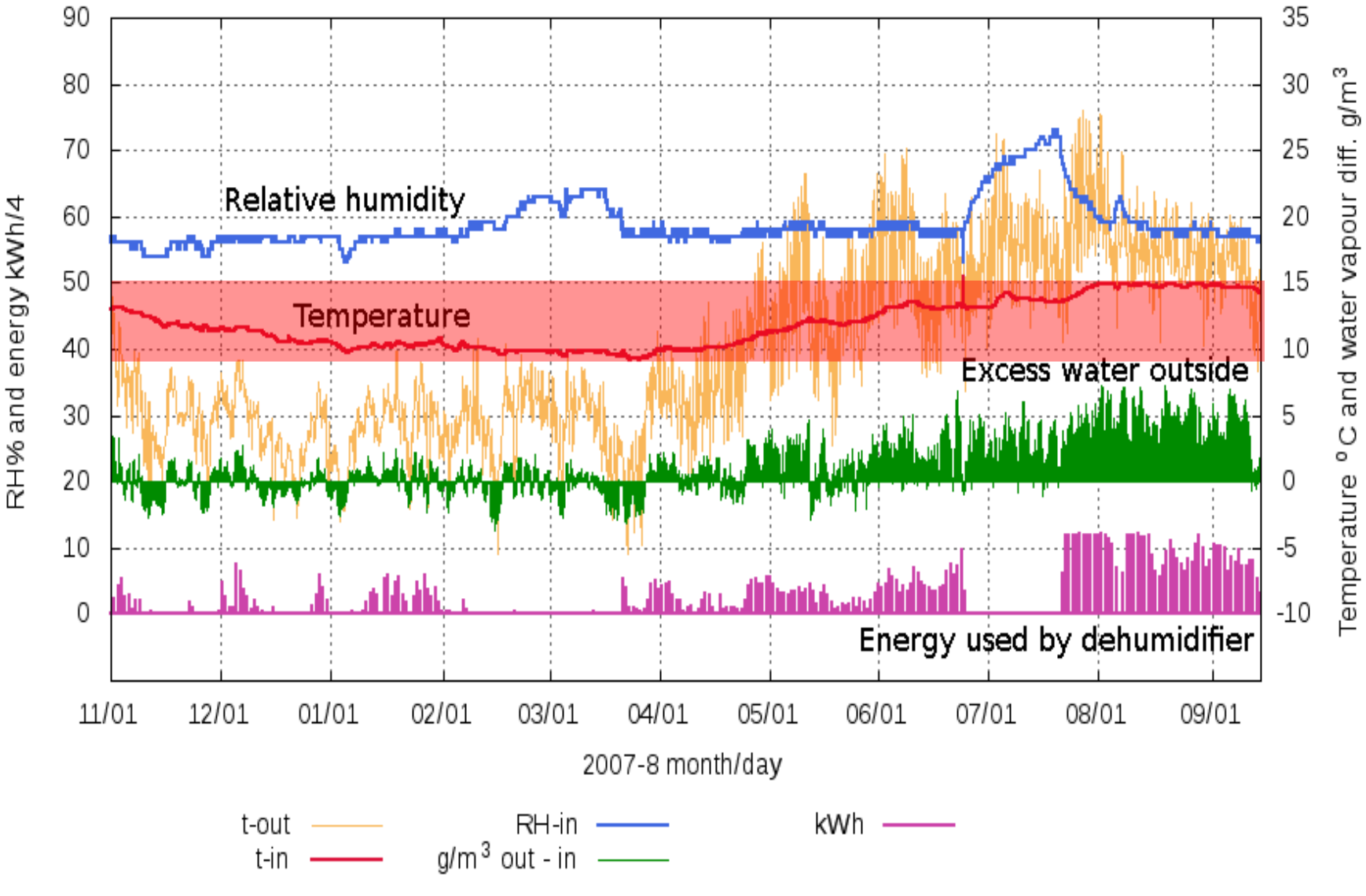
removed by dehumidification



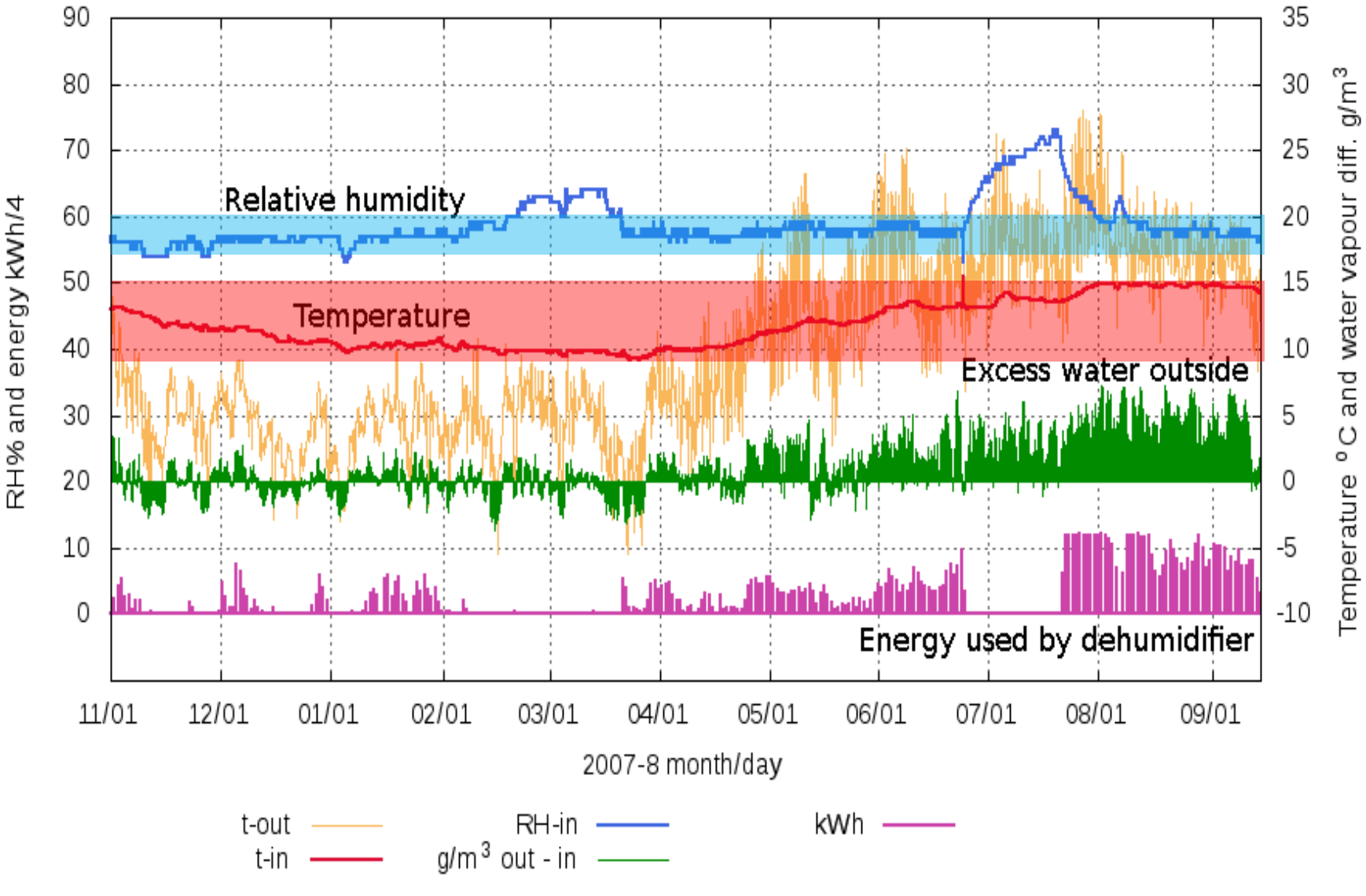
The climate records for one year in the Ribe store



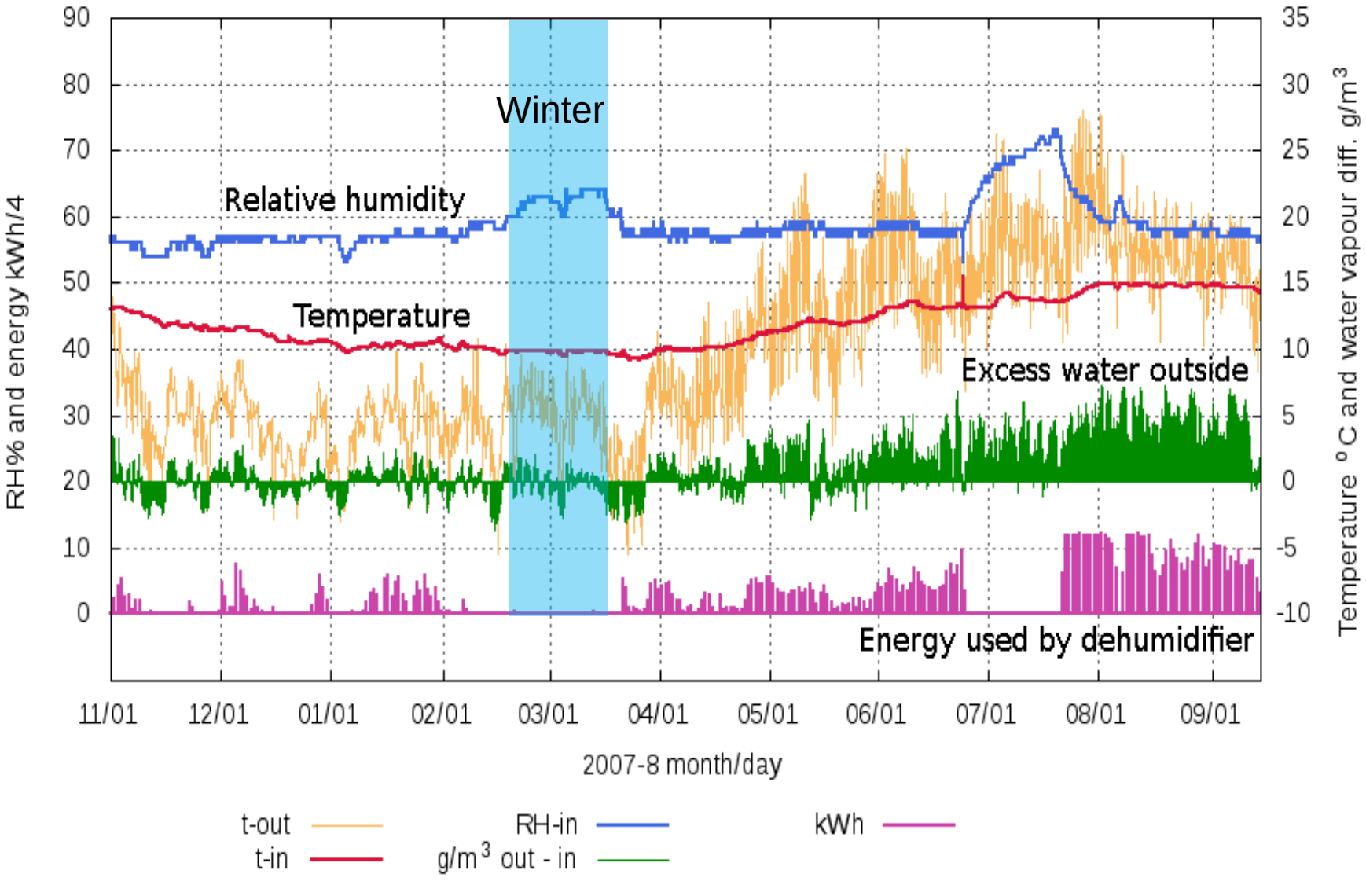
The temperature is 8 – 16 °C



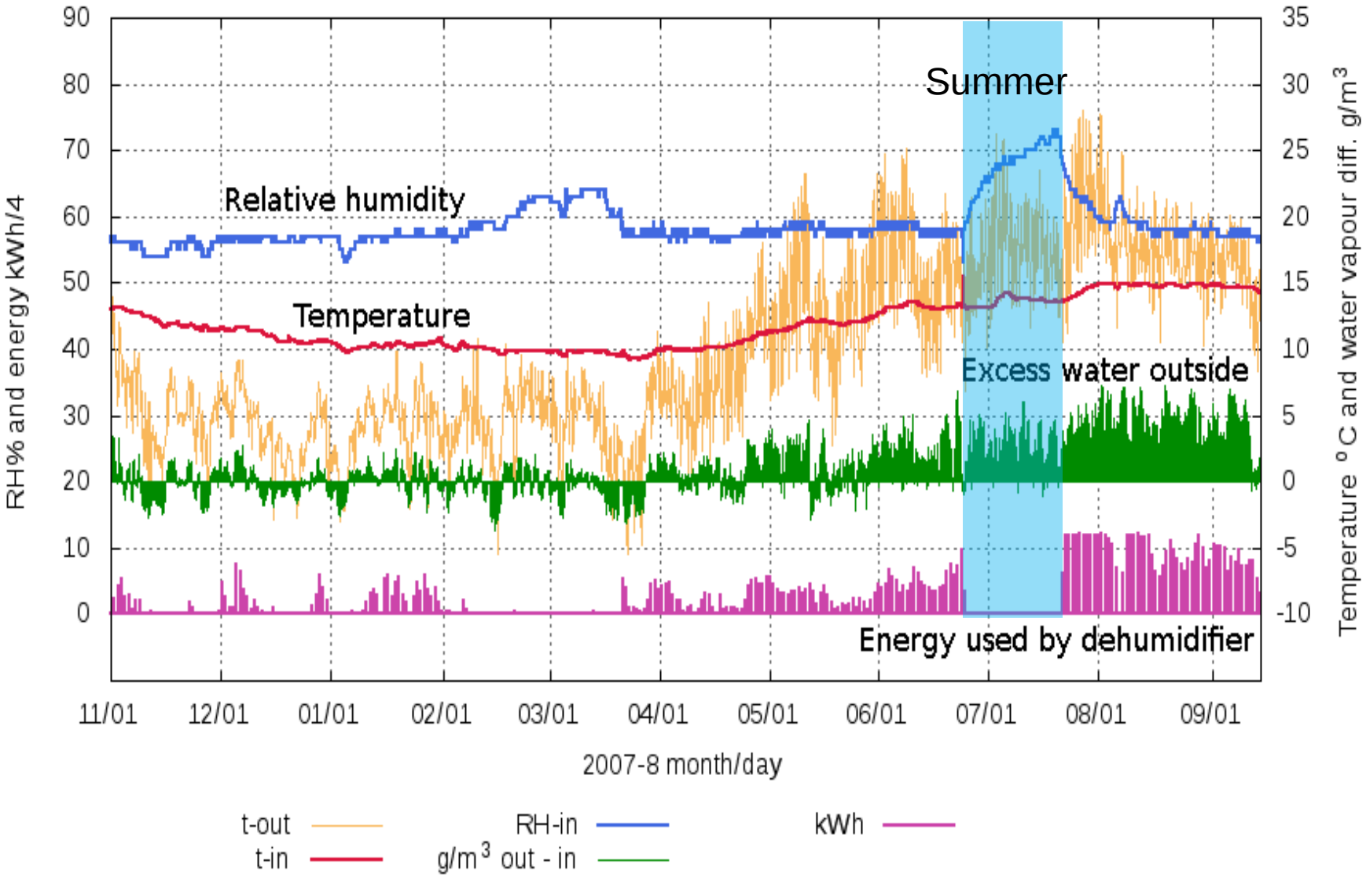
The temperature is 10 – 16 °C and the RH is 55 – 60%



...except when the dehumidifier was turned off

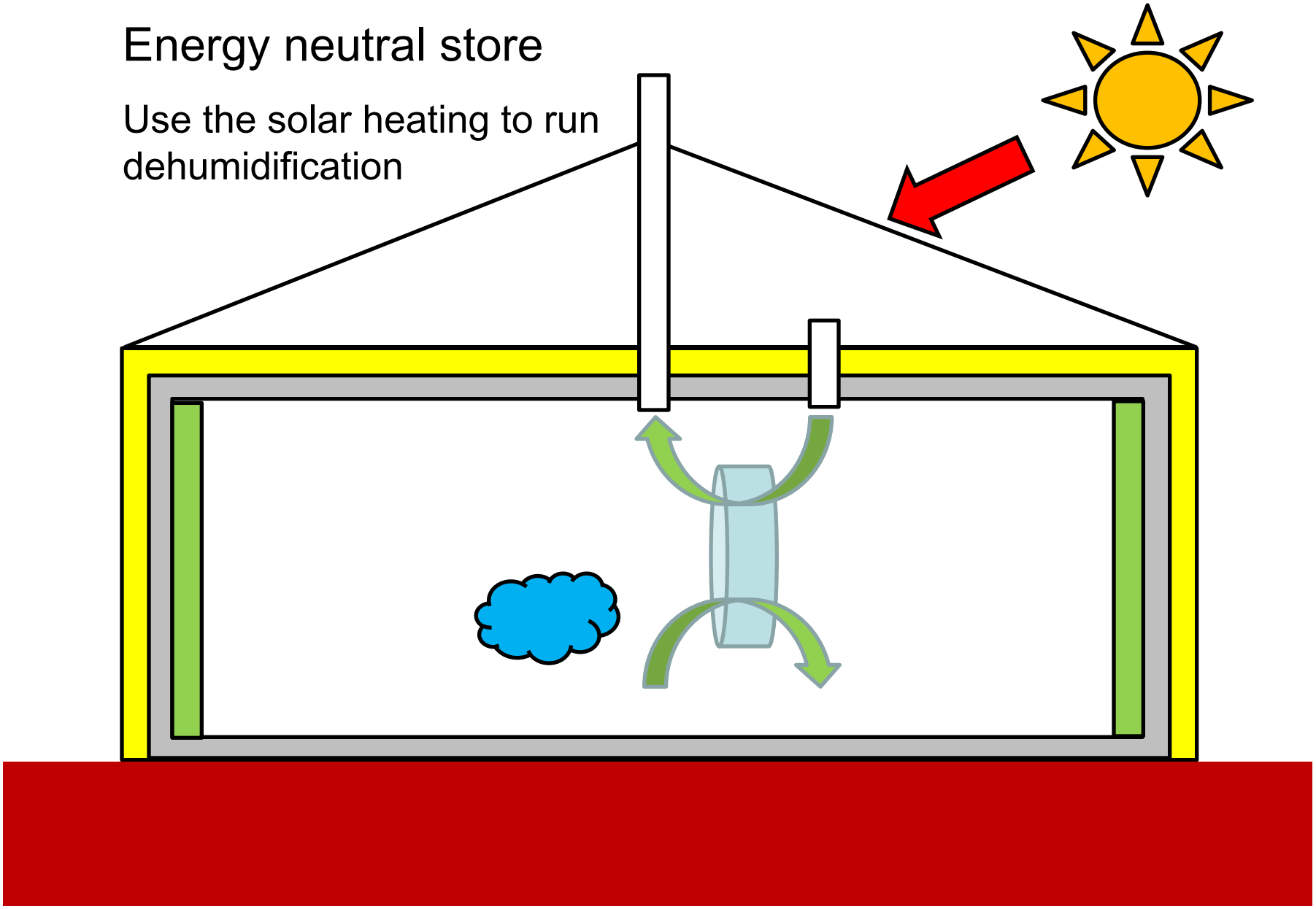


Dehumidification is always needed in summer



Energy neutral store

Use the solar heating to run dehumidification



	Climate control	Energy consumpt (pr. year)	Tempera ture	Relative humidity
Royal library, CPH	Full AC	30 kWh/m^3	18-20°C	45-55%
Music museum	Heating	10 kWh/m^3	10-25°C	40-60%
Værløse shelter	Dehumidi fication	5 kWh/m^3	0-25°C	45-55%
Ribe store	Dehumidi fication	2 kWh/m^3	7-15°C	45-55 %

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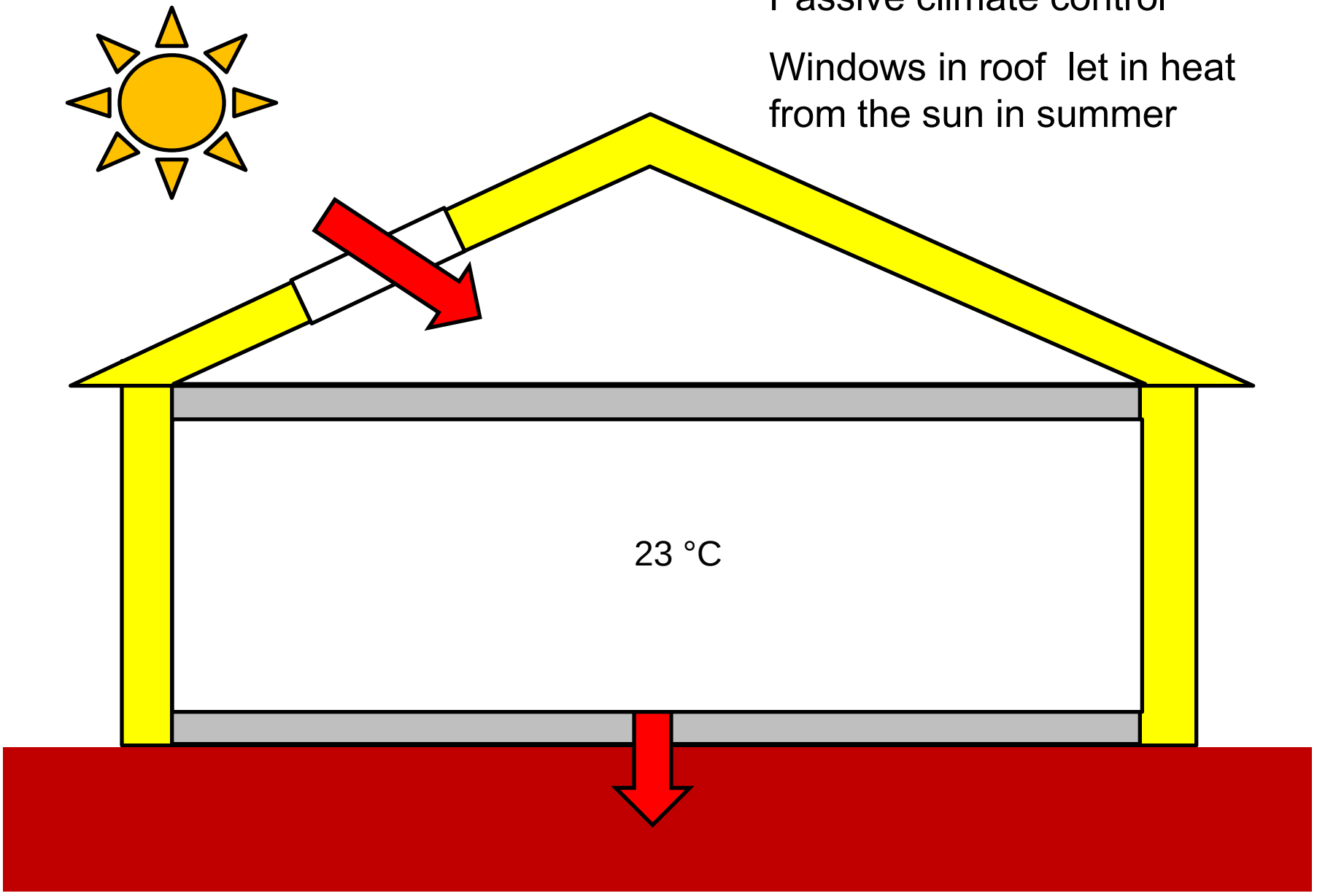
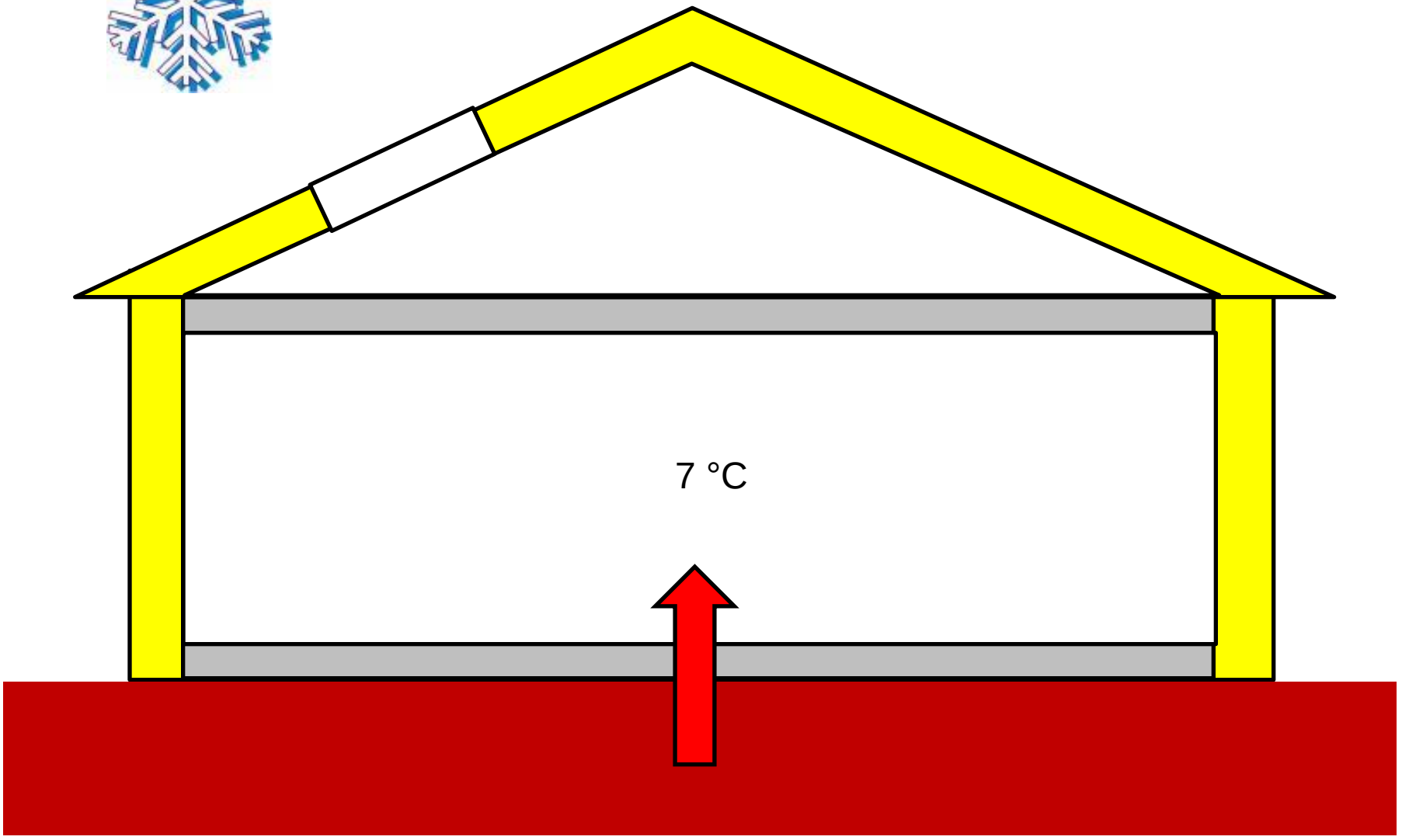
Værløse shelter	Dehumidi fication	5 kWh/m^3	0-25°C	45-55%
Ribe store	Dehumidi fication	2 kWh/m^3	7-15°C	45-55 %

Passive climate control

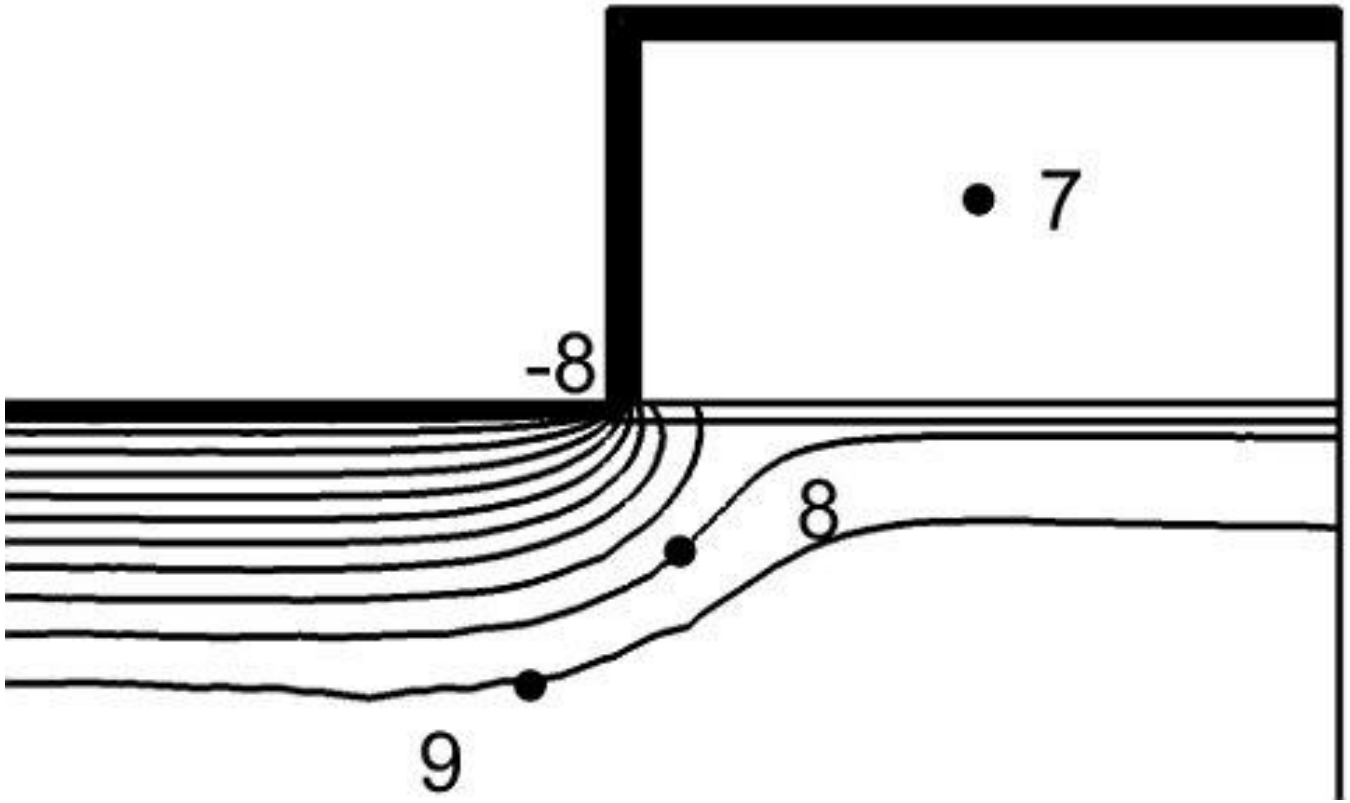
Windows in roof let in heat from the sun in summer



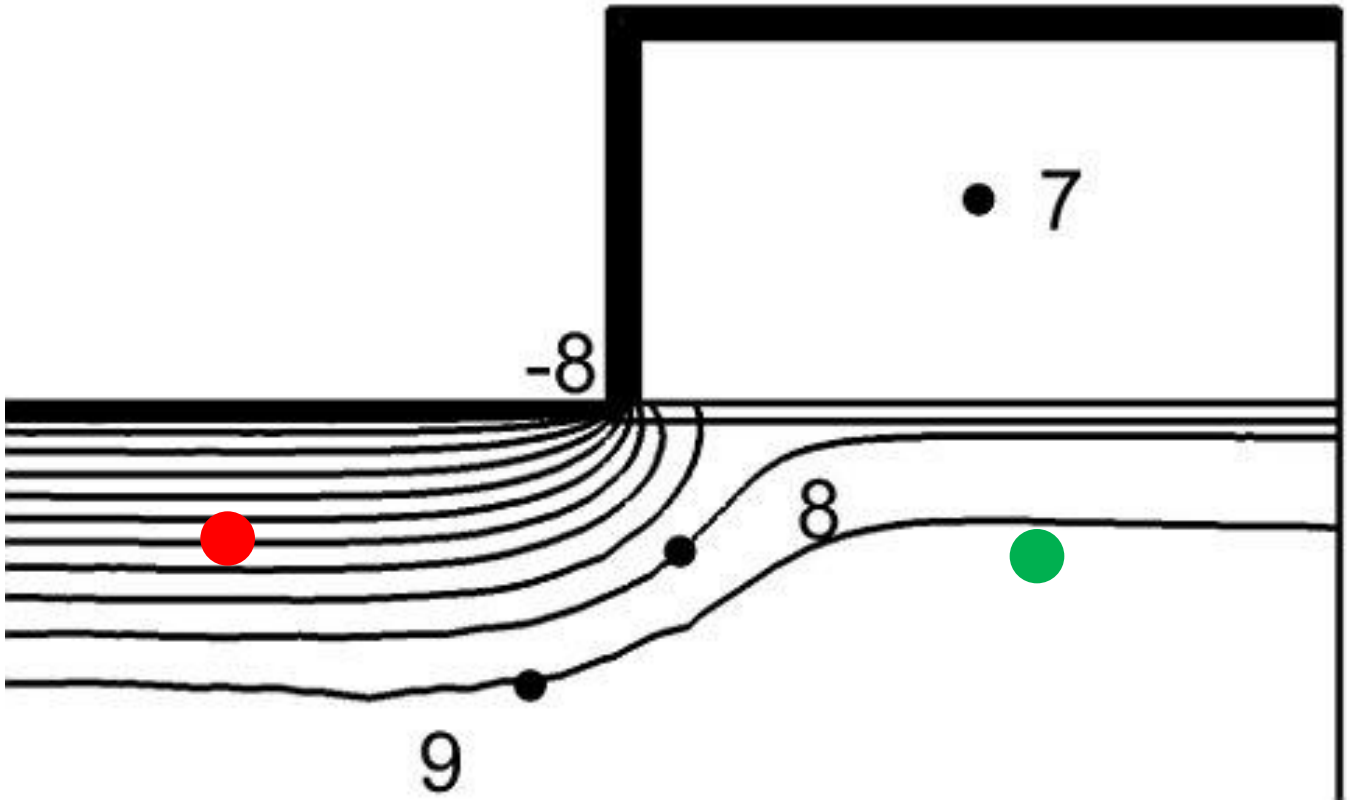
The heat is released from the ground in winter



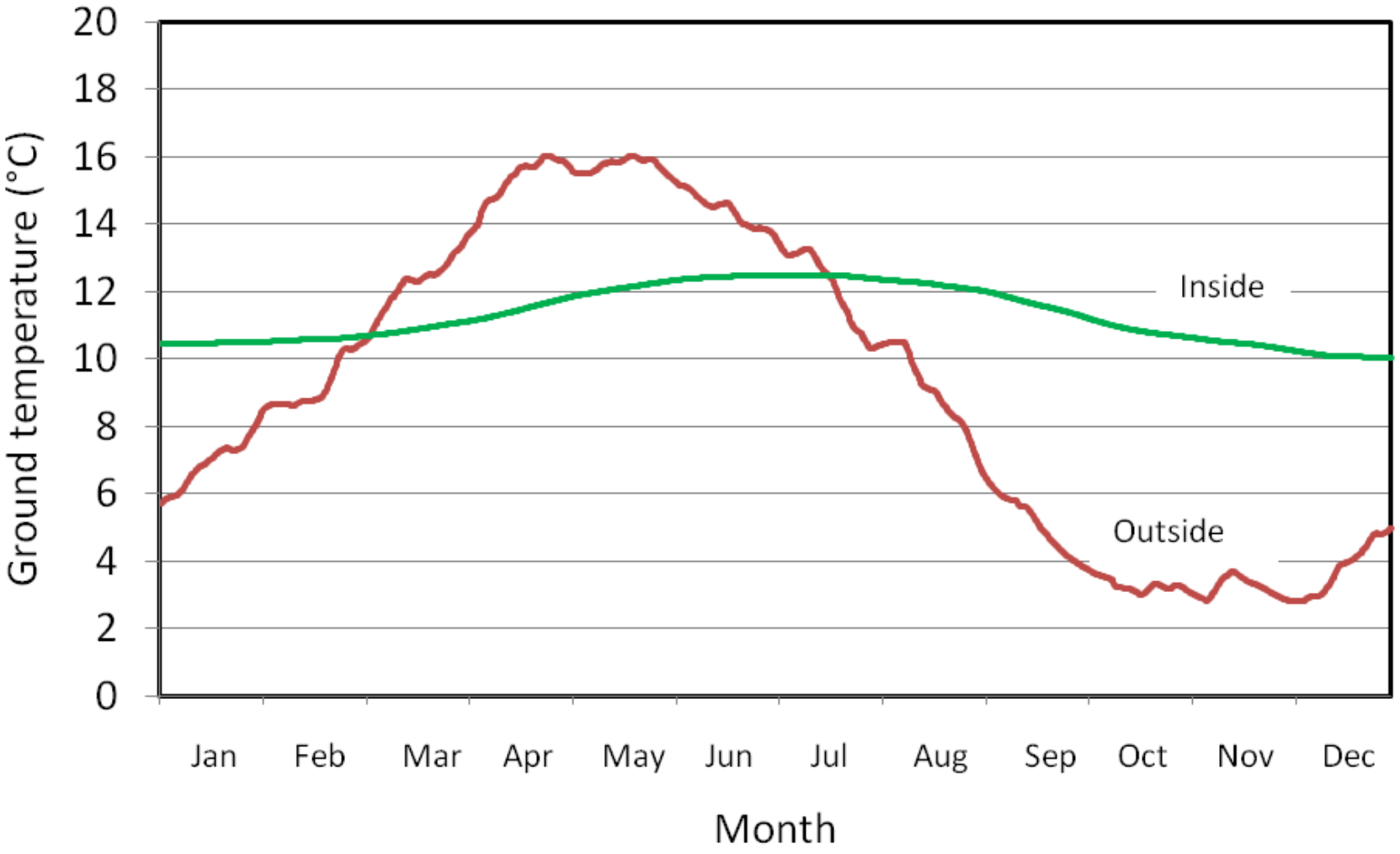
Temperature gradient in February



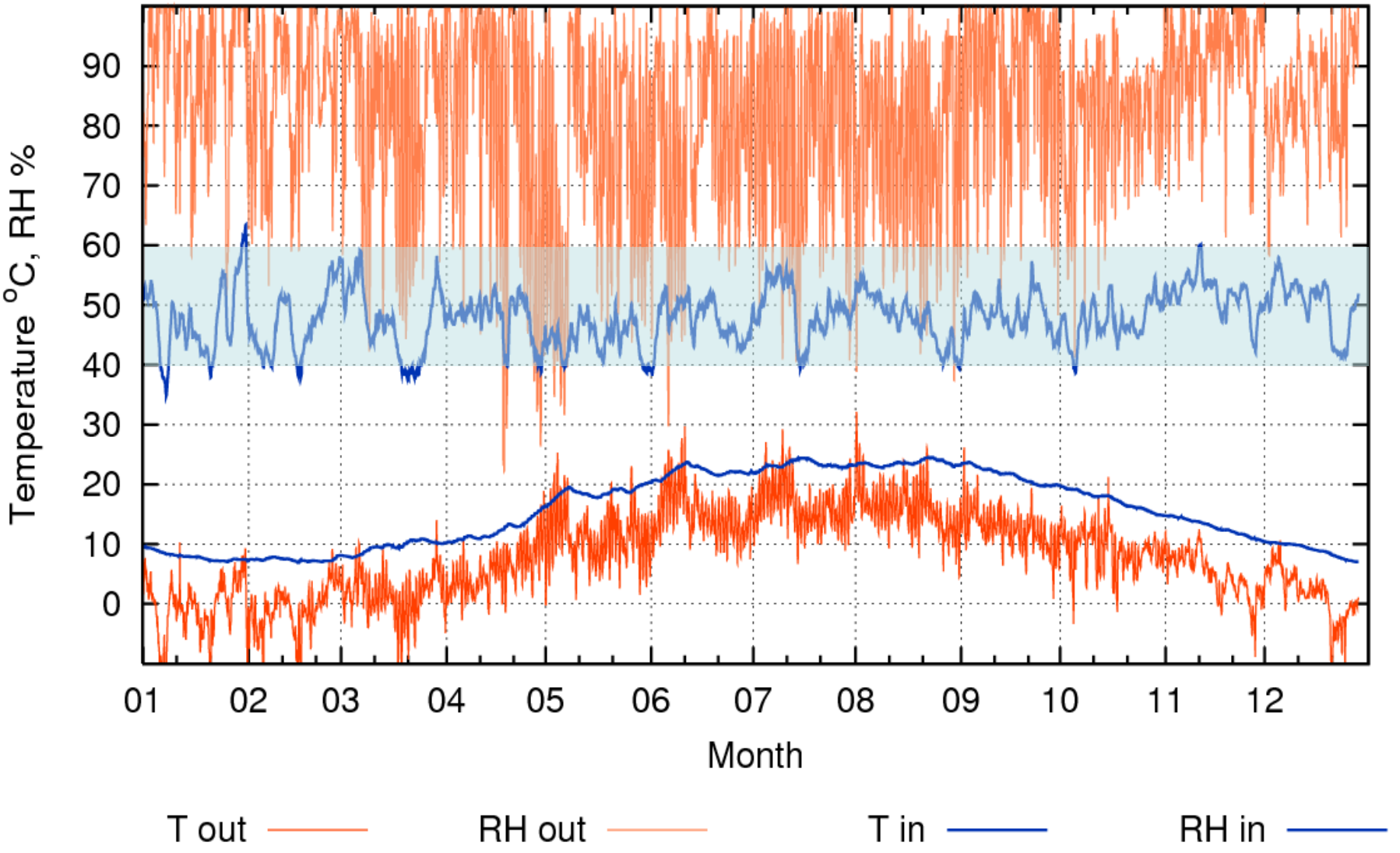
Measured temperatures inside and outside



Ground temperature measured 2 m below surface



Computer simulation of empty store, AER = 0,1 h^{-1}



Unfired perforated clay bricks used for humidity buffer