# Textbook for solar air collectors

Here you get a quick overview of the most important things that cause formation of moisture in buildings - especially in basements and buildings that are not used in winter.

This description applies primarily to solar air heaters for dehumidification - not only for heating or for supplementing existing heating.

And you get an understanding of why a solar air collector is able to solve moisture problems. There are a number of different conditions that must be met in order for an installation to function properly.

**If you want to know more...**

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## The difference between heating and dehumidification of rooms

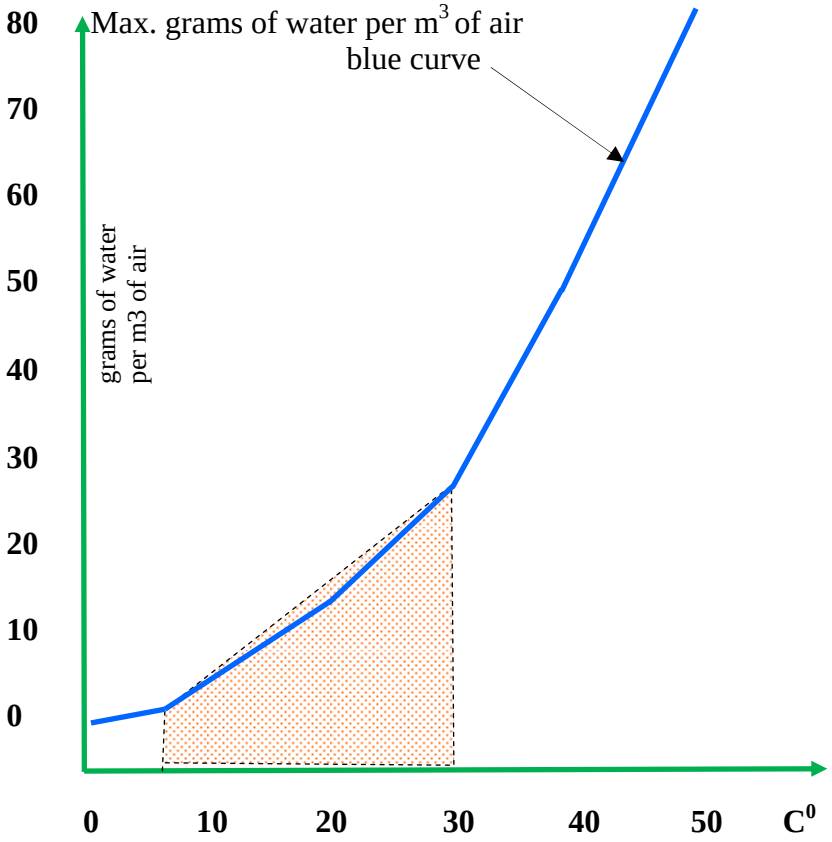
There are widely different issues to this, which will be understood in this text.
In heated houses there is not the same risk of creating unfortunate condensation as in cold houses. So this text is about the last.

## Why moisture in the houses?

This does not mean the understandable causes of leaks in the roof or foundation but the accumulation of moisture that comes almost out of nothing just because the rooms are unused and cold in the winter.
To fully understand this, it will be best to get a knowledge of how much moisture/water air can contain at different temperatures. There are some very specific physical laws for this - and if you understand them, you can much better calculate what it takes to avoid the moisture problems.

## Relative and absolute moisture - what is the difference?

This is very important to understand!
We know and measure almost always only the relative humidity (RM) which does not say anything about how much water is actually in the air.
If you measure 60% RF, but the temperature is only 5° C, then there is only about 3 grams of water in 1 $m^3$ of air.
If there was 30° C when you measured the 60% RH, there would have been 18 grams of water in the same air - that is a difference of 6 times.
So the 60% says nothing in itself - you must also know the temperature.
Air cannot contain e.g. 110% moisture, only max. 100% where you hit the so-called dew point.
But keep in mind that hot air can hold more moisture than cold air. The exact figures for this can be seen in a table: Appendix 1 at the end of this booklet.




## A nice and lucky coincidence:

The air cannot contain more water per $m^3$ than e.g. 30 grams at 30° C heat. It is at 100% relative humidity.
If there is more moisture, this will "fall down" like dew and be sucked into wood or brick.
**Note:** there is an important correlation between temperature and max. moisture content between 5 and 30° C. It is almost the same figure in this range - which is also the most typical temperature range both inside and out. It is therefore very easy to remember.
**Also of importance:** When the air temperature rises 11 degrees, the ability to carry moisture is doubled. If the temperature rises e.g. 22 degrees, this ability is quadrupled. If the air is only 50° C, it can suddenly contain about 83 grams of water. No wonder a hair dryer works well when it's hot.
So heat is essential to evaporate water from walls, etc.

Building experts and engineers typically warn against blowing hot summer air into e.g. a cold basement.
You can also see from the graph what will happen when 30 degrees of warm air with 60% moisture hits a cold wall of 10 degrees. The hot air contains approx. 18 grams water/$m^3$. When cooled to 10 degrees, it loses approx. ½ of the moisture, which will settle as condensation on the wall.

There is an important difference when we speak air collectors. Here the air is not just hot - but **extra heated,** and there is room for more moisture.

Under the section on dehumidifying cellars, you can see more precisely why avoiding the dangerous condensation can be done when doing the right thing regarding the air flow.

## The condensation problem

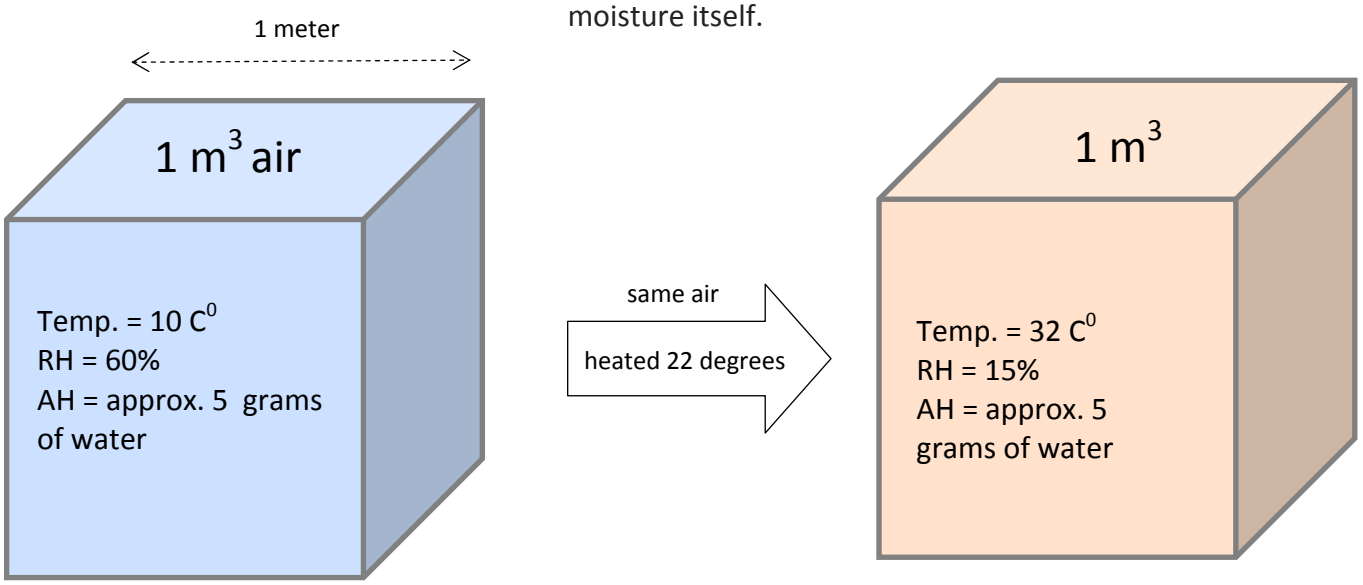
is very important to understand. Everyone knows it e.g. from the dew on the grass when the sun goes down and it gets cooler.
What is going on?

For example, when air is 25° C, it can easily contain 20 grams of water per $m^3$. But when it cools down to 5° C, it can only hold approx. 5 grams of water. So where are the extra 15 grams? They may for instance be found here

## If you only let hot summer air into a cold basement, something similar will happen

so you cannot usually recommend this. It should only be a little warmer outside than in the basement (about 5 degrees) to prevent condensation.
But here the solar air collector makes its entrance, as it warms the air further - so that it can suddenly absorb much more moisture itself.

# Therefore, you must be on guard




## A typical situation with the operation of a solar air collector

One day in spring or autumn with a little sun.
Outdoor temp. = 10° C
The solar air collector does not draw any moisture out of the air, but heats it with e.g. 22 degrees.
It causes the relative humidity (RH) to fall from 60% to 15% due to the heating.
This means that the air inblown air is so dry that it can absorb some moisture before it gets cooled and reaches the dew point again.
That is to say that enough speed is needed out of the house before the air touches too much on cold walls. See page 6.

The air still contains the same amount of moisture, but it now has much greater possibility of absorbing more new moisture

## Exact figures for moisture in air

If you want to see exactly how much moisture is in the air at any temperature and relative humidity, see Appendix 1. Here are exact figures

## Solar air collectors for summer houses

If the house is completely unheated throughout the winter, there is a rule of thumb that says: The solar collector should be able to change all the air in less than 1½ hours.

Thus a house of 70 $m^2$ with 2.30 m height to ceiling contains 160 $m^3$ of air.
The collector should be able to send in approx. 100 - 110 $m^3$ air per hour to be on the safe side.

Solar air collector placed on wall


Humid air comes out at bumps or valves in windows or in bath and kitchen.

Leave doors between the rooms open. If possible, close damper to the chimney if there is a wood burning stove near the inflow.

***Solar air collector on wall or roof***

## Where is the moisture?

How much moisture can there be in a house of 60 $m^2$ if it is only 5° C?
The house has approx. 150 $m^3$ air.

Each $m^3$ air can contain approx. 5 grams of water, giving a total of 5 x 150 g = 0.75 liters of water in all. The rest has settled in the wood or wall etc. of the house, and it may be several hundred times more.

Woodwork should not contain much more than approx. 14% of its weight as water. When over 20%, there is a high risk of mold and rot. If the house has 5 tons of wood in the walls and fixtures, the water will soon exceed 500 kg of this. That is where the moisture is.

## Documentation for real air flow is important

If an advertisement says that a fan can provide e.g. 105 $m^3$ in a small system, there is reason for skepticism. It may have nothing to do with the real flow, but just the amount of air that the fan can provide when it has no resistance.
Perhaps it only provides 1/5 in the system.
And then it may go awfully wrong.
SolarVenti has had its SV14 solar air collector tested under a scheme called ETV, which assesses whether our statements regarding dehumidification are real. See report in appendix 4.
With the air flow provided by the system, the report proves that we can keep a house of approx. 70 $m^2$ free of harmful moisture throughout the year.
However, if you significantly reduce the air flow, what will happen is that in many cases the moisture does not get out of the house before it settles again. Simply because the air will again be cooled - typically in the rear bedrooms - where moisture accumulation occurs with a later risk of mildew and dangerous mold formation.

## Solar air collectors for basements

In case of an unheated basement, the solar air collector should be able to change all the air in less than 1 hour.

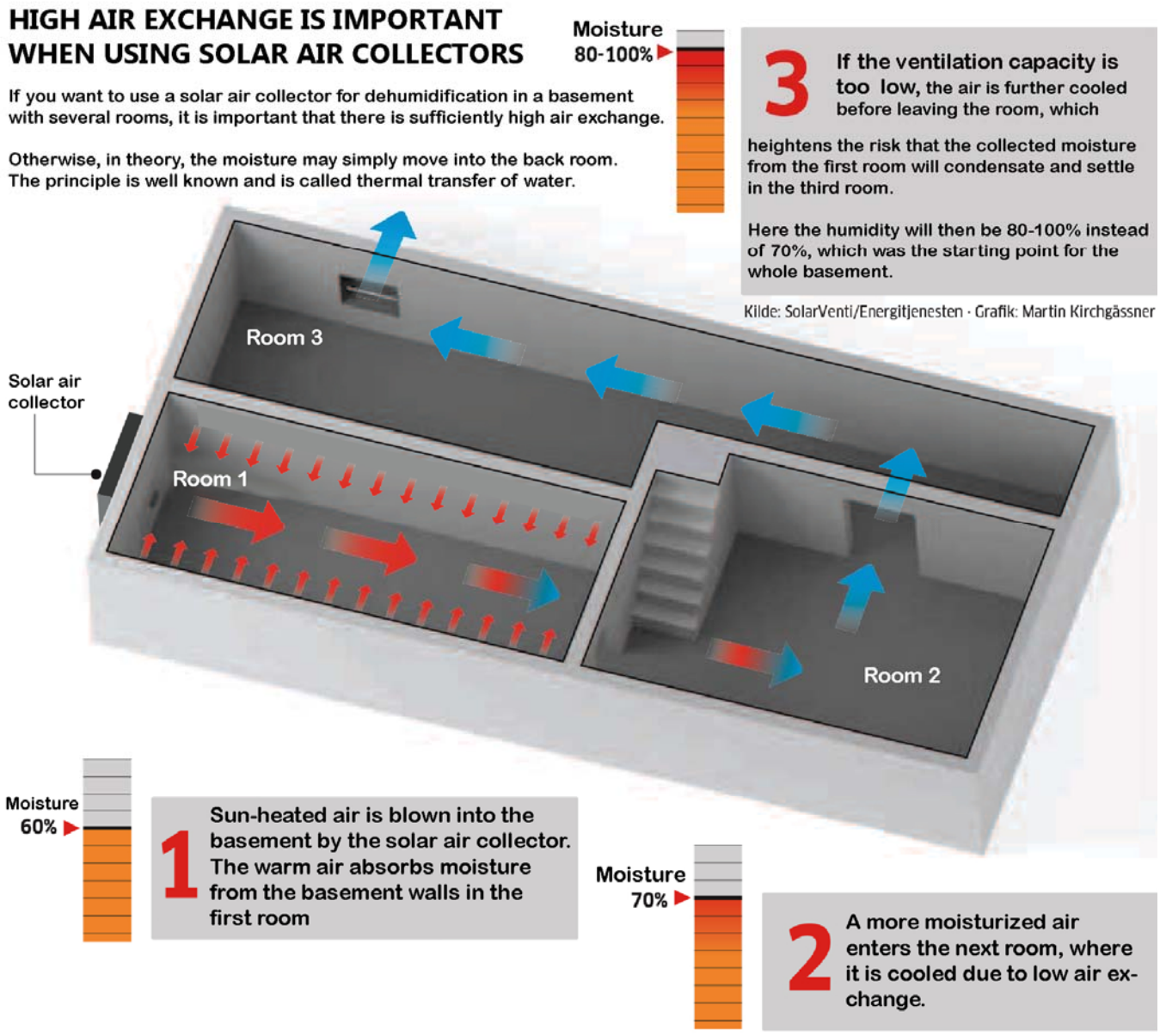
A basement of 50 $m^2$ with 2.20 m height to ceiling contains 110 $m^3$ of air. The collector should be able to provide approx. 110 $m^3$ air per hour to be on the safe side.

## Why faster air change:

There are several reasons: The thick cold concrete walls present a particular risk of condensation. We cannot heat them fully with just a few hours of sunshine.

There is usually no help to get from the sun through windows in a basement. Therefore, it requires special technology and management to solve the problem.

## What happens with too little air flow?



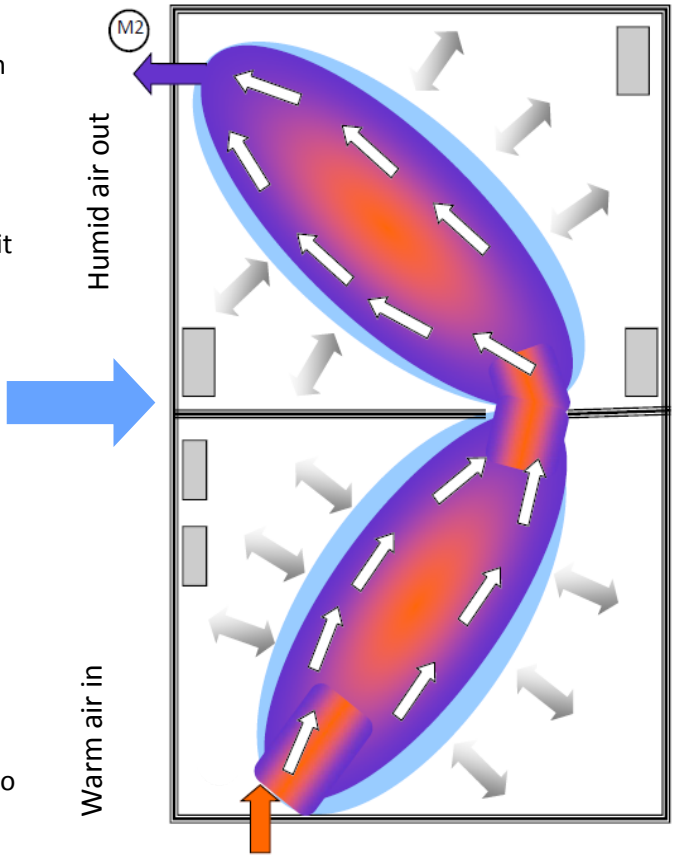

This is quite clear from the explanation which was brought in the Danish magazine: "Ingeniøren" august 2015.

# Important points:

- Basement systems should always be combined with a corresponding extractor, distributed to one or several fans, so the air enters the main rooms.
- Always exhaust in the most humid rooms.
- On hot summers it is advisable to exhaust from the ceiling in the basement - and just not from the floor level.
- **In unheated basements** you should not use heat recovery as it actually increases the risk of condensation.

## How to avoid rapid cooling of the air

The almost ice-cold walls in a basement are a big challenge when it is warm outside with a high absolute humidity content in the air.
Normally condensation will happen instantly by just opening a window.
We recommend a change of air of max. one hour - but in reality it happens differently in order to be successful.
We rather exchange 1/3 of the air approx. 3 times an hour.
Thus, the air movement is more like in the picture right.
Touching the walls more than needed simply is not ”affordable”.
This way, too rapid cooling and dew formation is avoided.
The figure shows that you only dehumidify part of the basement in the first place - and avoid most walls. When the system is not running, there will be a leveling of the moisture in the room, so everything will be dried down. In very difficult cases, additional heat may be required during certain periods.
A system should be able to run at intervals at night, where the absolute humidity content in the air is lowest during summer.
The combination of heat supply during the day and periodically running of the system at night has proved very effective.
SolarVenti's controller (SControl) can interrupt the operation if no real dehumidification occurs. In addition, it has several features that ensure optimal dehumidification




## Solar air collectors for garages

Closed garages differ from both summer houses and basements on important points.

Here a wet or snowy car often enters in the evening, when there is absolutely no sun for a collector.

In addition, garages can be made of either wood, brick or concrete, which absorb moisture more or less effectively.

## Requires a special solution

If the garage is made of wood with a moisture absorbing surface, this can be utilized to equalize the moisture in a short period of time. On the other hand, hard concrete with a moisture-proof surface can be a bigger challenge.
A combination of solar air collector and a controller that can utilize the car's engine heat is ideal.
This is possible with SolarVenti's SControl.

## What happens in a garage?

There can be several liters of water on a wet car. This water will evaporate into the room in a short period of time.
The first times in autumn may work fine, but gradually walls, floors and ceilings cannot handle more moisture, and mold and mildew will appear.
A solar air collector will continuously reduce the moisture level, but if the walls are hard and e.g. painted with a waterproof surface, you will soon exceed the dangerous 75% moisture.
SolarVenti has solved this by letting the system run as soon as there is a sudden increase in the moisture - even if the sun does not shine. Instead of the heat of the sun, the heat from the car's engine is used, which can typically be 3-4 kWh during the cooling.
The system requires a little power from a battery or the grid. About 5 £’s worth a year.


## Solar air collectors for containers

Here you should note the following differences:

- Is the container insulated?
- Is it covered with wood or metal inside?
- What does it contain?
- Is it sunbathing or placed in shadow?
- Where is it geographically?
- How often is it opened? and much more…

All this has an influence on how powerful the system should be to keep it dry.

## Generally about containers

There are good experiences in regard to keeping containers dry throughout the year. Much less rust on metals, and moisture and odor usually disappears - completely free of charge.
If containers are covered with wood inside, this helps to balance the moisture over a longer period of time, so that you can control the level more easily.
If the container is heated by the sun, you can use a smaller sized system.
Typically, you choose between an SV3 and a SV7 for a 20"container.
Make sure that the air can get out again - at the opposite end of the inblow.
If new moist things get in (like in sports clubs), you should go up in size - e.g. an SV14 or an SV20, as it requires more capacity.

## Solar air collectors for warehouses or museums

Principally, there is no upper limit to how large rooms can be kept dry and fresh with a properly dimensioned solar air collector system.

If you consider an electric dehumidifier as an alternative, you should know that this usually requires a fairly high temperature in the room to function (about 15$^{o}$).
This can in itself be rather costly. This, in combination with the fact that items are best kept in cool rooms, makes it particularly advantageous to use solar air collectors. Then there is no demand for a certain room temperature - and you can keep things cooler.

Dimensioning follows the same rules as for other systems for summer houses or basements if the storage is underground. This means one air change in the room for every 1 to 1½ hour according to circumstances.

If the system is larger than approx. 12 m$^{2}$, one can consider using a special professional version from

## Solar air collectors for club houses

Typically, these are dimensioned as for summer houses but may require a larger system if humid items are often let in.
For example, a rowing club or a saddle area in a riding club require more drying capacity than generally calculated due to the amount of moisture you add daily. Thus, closer to 1-2 times air change per hour with solar heated air.

## Solar air collectors against radon

You can remove up to approx. 75% of radon in the house, while you are solving a moisture problem in a basement or the like.

As a rule, the solar air collector needs to run at some extra intervals during day and night to remove most radon. In appendix 3 you can see the connection between the air change and the reduction of radon. These figures are formed on the basis of a number of measurements in relevant houses.

In addition to the ventilation itself, it is important that the fresh inblown air is cleared of dust particles, as dust itself holds on to radon.

If you remove approx. 70% radon in a basement, it will affect radon level on the ground floor, reducing this too. One must be careful not to create negative pressure in the house as it may promote the penetration of radon.

A big advantage by using solar air collectors to remove radon is that other problems can be solved at the same time.

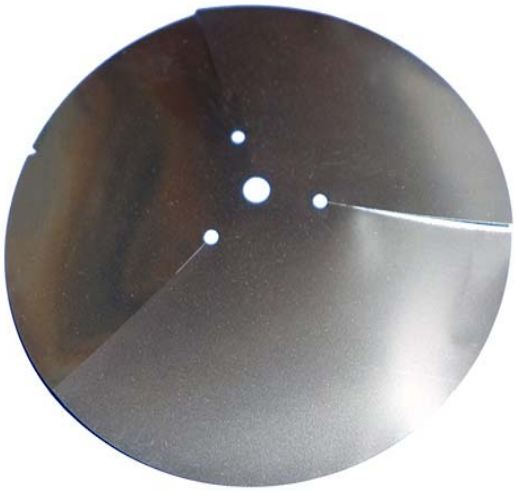
## Air collectors for drying crops

The list of possibilities for the use is very long.
SolarVenti has for several years been working on the problem and has developed a series of solutions.
Some crops can withstand full heat from the collector, while others prefer a lowered temperature of e.g. 40$^{o}$ C.
Dried crops can be stored for almost 2 years without further delay, where the alternative is often quick deterioration.
If you have a specific wish, ask SolarVenti about the possibilities.

## Other important features

There are a number of other factors that should be noted when purchasing a solar air collector.
This includes:

1. Filter - is the air cleaned - should it be changed, etc.
2. Is there a counter valve that prevents backflow of the air?
3. How long piping is possible?
4. Can solar air collector be placed on the roof?



## Filter means a lot

for several reasons:

- Cleaner air without dust particles or pollen is blown in.
- Insects cannot enter - nor into the collector, which may otherwise be filled with spider webs.
- Expected shelf life over 15 years.

SolarVenti's construction always contains filters that do not even need to be cleaned. The sun takes care of this, with heavy heating. The filter also holds back pollen and smoke particles.

## Counter valve obligatory

Without this, it polluted air from the house is likely to enter the collector. Especially if this sits high, it can act as a hot air hood in the house.

Without this valve insects may also crawl into the collector from within the house.

All SolarVenti solar collectors have such a valve.


## Can the solar air collector provide air pressure enough?

If you need a piping little over 1 meter, it is important that the fan can provide the required pressure.
The hardest thing is to press warm air downwards as it is counteracted by the chimney effect.
A SolarVenti can usually push a good flow of air in up to 3 meters of pipe. Even more with an in-line fan (8 meters)

# How much moisture can air contain at different temperatures?

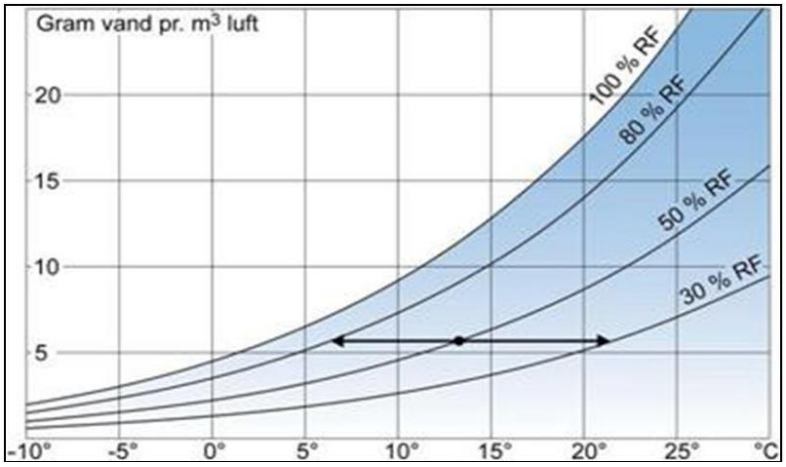
| Temp. | Relative humidity | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ° C | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
| + 50° | 8,30 g + 10° | 16,60 g + 21° | 24,89 g + 28° | 33,19 g + 33° | 41,49 g +37° | 49,79 g + 40° | 58,08 g + 43° | 66,38 g + 45° | 74,68 g + 48° | 82,98 g + 50° |
| + 45° | 6,54 g + 6° | 13,09 g + 17° | 19,63 g + 23° | 26,18 g + 28° | 32,72 g + 32° | 39,50 g + 35° | 45,81 g + 38° | 52,35 g + 41° | 58,9 g + 43° | 65,44 g + 45° |
| + 40° | 5,11 g + 3° | 10,23 g + 13° | 15,34 g + 19° | 20,46 g + 24° | 25,57 g + 28° | 30,68 g + 31° | 35,80 g + 33° | 40,91 g + 36° | 46,03 g + 38° | 51,14 g + 40° |
| + 35° | 3,96 g - 1° | 7,92 g + 9° | 11,88 g + 15° | 15,84 g + 19° | 19,80 g + 23° | 23,76 g + 26° | 27,72 g + 29° | 31,68 g + 31° | 35,64 g + 33° | 39,50 g + 35° |
| + 30° | 3,04 g - 4° | 6,07 g + 5° | 9,11 g + 11° | 12,14 g + 15° | 15,18 g + 19° | 18,22 g + 21° | 21,25 g + 24° | 24,29 g + 26° | 27,32 g + 28° | 30,36 g + 30° |
| + 25° | 2,30 g - 8° | 4,61 g 0° | 6,91 g + 6° | 9,22 g + 11° | 11,52 g + 14° | 13,82 g + 18° | 16,13 g + 19° | 18,43 g + 21° | 20,74 g + 23° | 23,04 g + 25° |
| + 20° | 1,73 g - 11° | 3,46 g - 3° | 5,19 g + 2° | 6,92 g + 6° | 8,65 g + 9° | 10,37 g + 12° | 12,10 g + 14° | 13,83 g + 16° | 15,56 g + 18° | 17,29 g + 20° |
| + 15° | 1,28 g - 15° | 2,56 g - 7° | 3,85 g - 2° | 5,13 g + 1° | 6,41 g + 5° | 7,69 g + 7° | 8,97 g + 9° | 10,26 g + 10° | 11,54 g + 12° | 12,82 g + 15° |
| + 10° | 0,94 g - 18° | 1,88 g - 11° | 2,82 g - 6° | 3,76 g - 3° | 4,70 g 0° | 5,64 g + 1° | 6,58 g + 3° | 7,52 g + 5° | 8,46 g + 7° | 9,10 g + 10° |
| + 5° | 0,68 g - 22° | 1,36 g - 14° | 2,04 g - 10° | 2,72 g - 7° | 3,40 g - 4° | 4,08 g - 2° | 4,76 g 0° | 5,44 g + 2° | 6,12 g +3 ° | 6,80 g + 5° |
| 0° | 0,48 g | 0,97 g | 1,45 g | 1,94 g | 2,42 g | 2,90 g | 3,39 g | 3,87 g | 4,36 g | 4,84 g |

**Note:** The ability to absorb moisture rises extra much when the temperature is above 25 degrees.

If unheated air during the summer is blown into a cold basement, the moisture will condense on the walls.

If 25 degrees of summer air with e.g. 60% moisture is heated to 50 degrees, it can contain significantly more moisture, from approx. 14 grams to approx. 83 grams (blue markings).

Important is that the air is rapidly leaving the room before condensation.




**Molières diagram**
This is the normal way to show the relationship between moisture and temperature. But many probably prefer a diagram with figures

# General tips and advice before purchasing solar air collector systems

**Appendix 2.1**

## Dimensioning of SV systems for houses and basements.

**Generally:**
In principle, a solar air collector cannot get too big as nothing can boil and you can turn off the system. It is impossible to state exactly the exact size of these plants as conditions vary a lot, but if it is possible (architecture, economy) one should not under-, but rather overdimension. This also prevents back-condensation.

## For unheated and damp houses, garages etc.

Standard notes and sizes on brochures are followed:

**The size of the system increases if:**

- The house is extra loaded with moisture.
- If the ceiling goes right to the roof, check that you get a change of air per 1½ hours as minimum with the system.
- The house is in the shade.
- Damp cars are regularly driven into e.g. garage.
- One wishes a definite contribution to the heat (not just dehumidification).

## For unheated basements etc.

Standard notes and sizes on brochures are followed:

**The size of the system increases if:**

- Basement is extra loaded with moisture.
- Clothes, for example, are washed in the basement
- Direct water is coming in (which cannot be drained away)
- One wishes a definite contribution to the heat (not just dehumidification)
- Extra drive of fan drive at e.g. radon (timer)
- Air change is checked to be at least once per hour (recommended as to back condensation)

## Combination with heat pump

A solar air collector can very well be combined with a heat pump. Normally, a heat pump system has no change of air in the house. Not even an air to air heat pump. So a change of air with a solar air collector is most welcome.

In summer houses you can reduce the operation of the heat pump a lot and, for example, limit its operation to pure frost protection or turn it off completely when you are not in the house.

# Heated houses and basements

The larger the system, the more heat saving and ventilation.
In order to get a heat contribution besides the fresh air, you should at least double the collector area in relation to the general dimensioning for recreational houses. The air velocity is reduced correspondingly in the collectors, so the inblow temperature rises.

As you often see advertisements with solar air collectors that heat the old air in the house, this is completely unsuitable if the purpose is to dehumidify. It is very hard to find a good reason to do this, apart from (maybe) you may save a very small amount of heat by doing so. Everything else speaks against it - especially the health factor.

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# 12 good reasons not to recycle air:

1. At any rate the fresh air is needed - should not be reduced
2. With fresh air an optimal humidity inside the house is achieved all year round.
3. The filter in the SolarVenti will keep itself clean with solar energy for 15-20 years as long as only fresh air is used. In several non-SolarVenti discount models the air is drawn past electronic devices without filtering = short life expectancy.
4. Heat savings at recirculation are minimal, as the efficiency of the solar collector is reduced.
5. - and because a big part of the heat savings comes from dehumidification of the building with fresh air.
6. Recirculation does not create dehumidification, but generates harmful substances in rooms with poor amount of oxygen.
7. Recirculation is unhealthy for house and its people (or: fresh air is healthy).
8. The solar collector produces more watts without recirculation.
9. Mold and mildew love recirculation, but hate fresh air.
10. Asthma etc. loves mold and mildew, since it thrives at it.
11. Two holes in the wall are needed if you recirculate – only one hole with a SolarVenti.
12. A SolarVenti can be roof mounted – this possibility is not exactly an option with recirculation

# About Radon Gas and SolarVenti®

**Appendix 3**

It is generally recognized, that ventilation can reduce radon concentration.

Radon level rises when there is low-pressure weather. So it is important that you do not create under-pressure while ventilating.

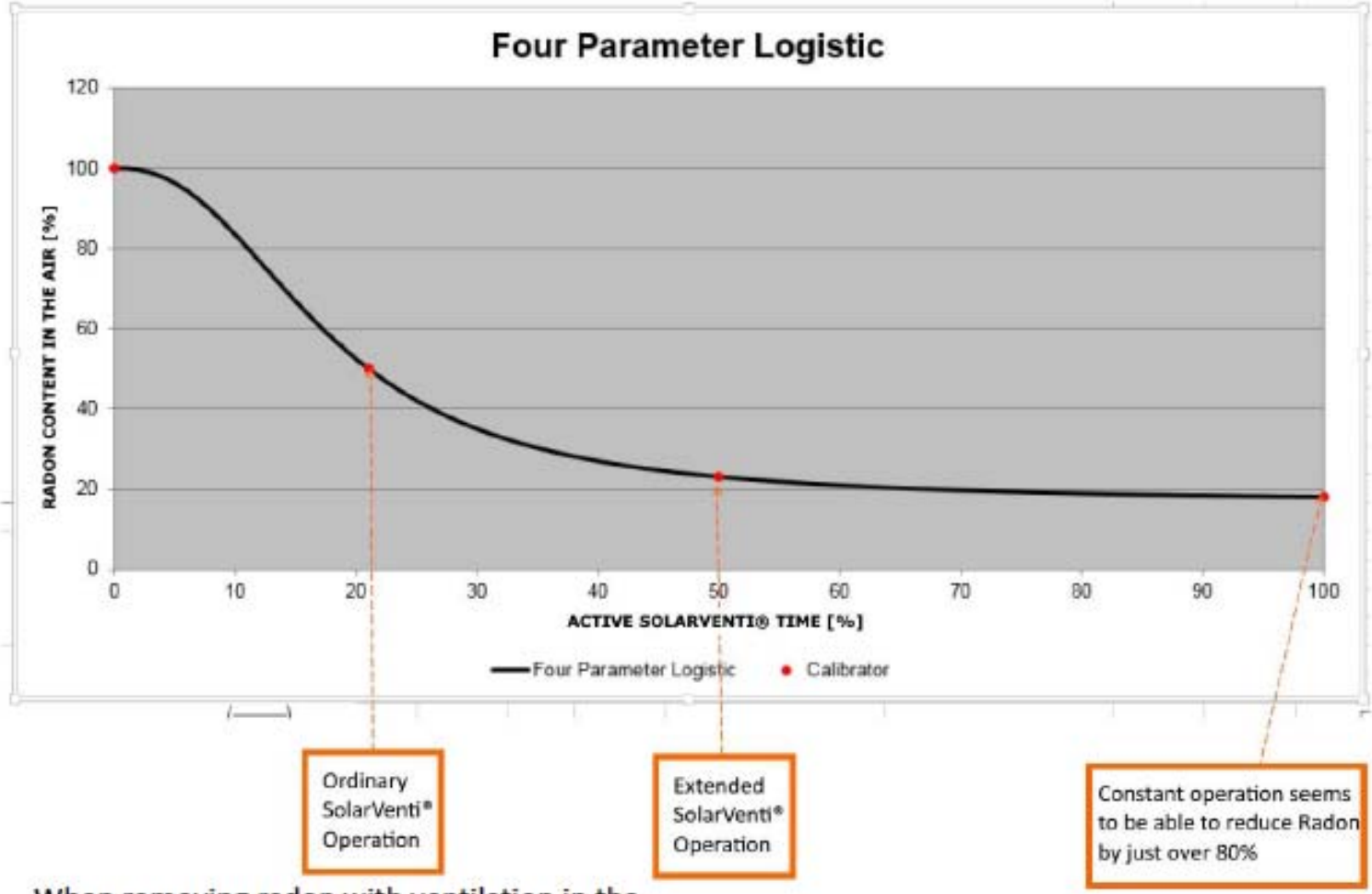
Ventilation costs money and heat, but with SolarVenti® you get the heat and fresh air at very low costs.

## This much Radon is removed:

Below are some results we have studied on reducing the radon level at different runs with our built-in fan.

When the SolarVenti® panel runs during the sunny hours, measurements has shown that the radon gasses is cut down with 50%.

If you leave the SolarVenti® panel running for some extra hours, ie ½ of the time, you will be able to remove approx. 75% of radon.
Then it's hard to remove more, but it's possible.




When removing radon with ventilation in the basement, it is important not to create a moisture problem at the same time.
It is precisely SolarVenti's ® brand case, to be able to remove moisture from basements while contributing to heat.

To eliminate the most moisture and radon at the same time, SolarVenti is therefore an ideal solution.

The measurements are made in a smaller number of cases, and the conditions can vary widely from house to house.

Therefore, you cannot be sure that it applies in other situations - and you should always make extra measurements, knowing the effect in each case.

## ENVIRONMENTAL TECHNOLOGY VERIFICATION

DANETV

DANISH TECHNOLOGICAL INSTITUTE

# ETV Verification Statement

| | | |
|---|---|---|
| **Technology type** | Solar air heater | |
| **Application** | Ventilation, heating, dehumidification of indoor air | |
| **Product name** | SolarVenti SV14 | |
| **Company (vendor)** | SolarVenti A/S | |
| **Website** | www.solarventi.dk | **Phone** +45 86 96 67 00 |
| **E-mail** | hjc@solarventi.dk | |

DANETV, The Danish Centre for Verification of Climate and Environmental Technologies, undertakes independent tests of environmental technologies and monitoring equipment.

DANETV is a co-operation between the following five technological service institutes: DHI, Danish Technological Institute, FORCE Technology, Delta, and AgroTech. DANETV was established with the financial support of the Danish Agency of Science, Technology and Innovation. Information and DANETV documents are available at www.etv-denmark.com.

Verification and tests are planned and conducted in accordance with the guidelines for the ETV Scheme which is currently being established by the European Union.

This verification statement summarizes the results of the ETV test of the SolarVenti SV14 solar air heater.

**Technology Descriptions**

Open loop solar air heaters are characterized by simple devices which require very little or no maintenance. They usually consist of three major parts: 1) solar air collector, 2) solar cell panel and 3) ventilator with or without a temperature regulated controller.

When the solar cell panel powers the ventilator, cold outdoor air is driven through the solar air collector and thereby heated. Heated air is supplied to a summer house or a garage through a duct whereby the summer house or garage is ventilated, heated, dried or a combination of these (see figure 1).

# ENVIRONMENTAL TECHNOLOGY VERIFICATION

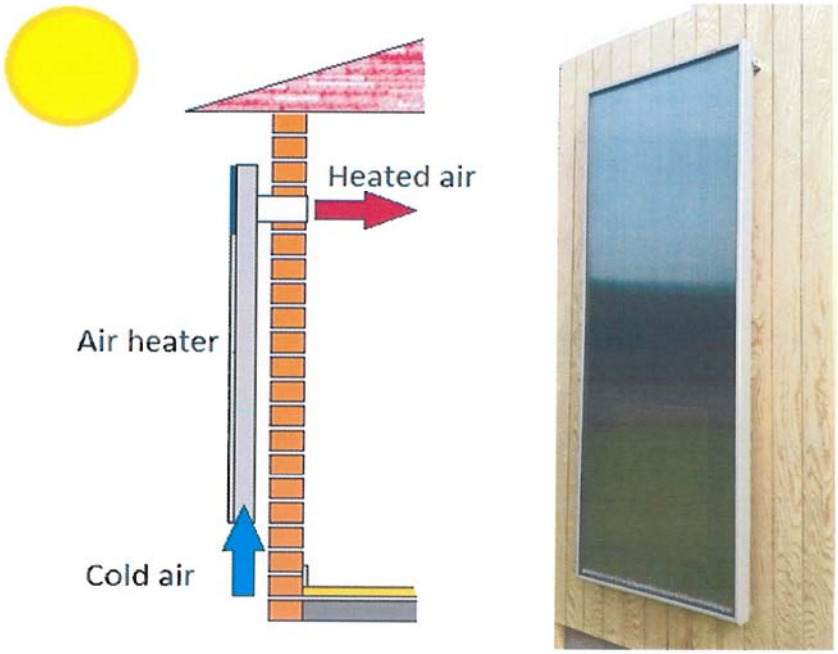



*Figure 1: Drawing depicting the function of a solar air heater (left) and the SV14 solar air heater (right).*

## Application of Technology

The intended application of the tested product is defined in terms of the matrix, the targets and the effects of the product. The matrix is the type of application which the product is intended for, the targets are the measurable properties which are affected by the product, and the effects describe how the targets are affected.

| | |
|---|---|
| **Matrix** | Residential houses, summer houses, garages, etc., up to 70 $m^2$ |
| **Targets** | Supplementary heating and ventilation |
| **Effects** | Improved indoor climate in unheated humid buildings |
| **Exclusions** | None |

## Description of Test

The ETV solar air heater test has been designed to quantify and verify the vendor's claims and to provide an indication of how the solar air heater will perform in an actual application. A test rig was built to simulate real operational conditions comparable to those present when the air heater is mounted vertically on the wall of a house or a garage. A simulation model has been developed to describe the seasonal performance. Establishing the actual performance characteristics of the air heater has a great advantage over laboratory tests with forced ventilation through the solar air heater as the fans are known to be very sensitive to pressure losses, both related to the heater itself and to the downstream hot air channel. Tests of different systems (manufactures and models) are comparable by means of seasonal performance calculations based on data from the test rig and on regional climate data (design reference year data).

# ENVIRONMENTAL TECHNOLOGY VERIFICATION

**Verification Results**

This section summarizes the results of the test and verification as described in the test report and the verification report, respectively. It is important to note that the results were reached under certain conditions. The test matrix is designed to reflect the conditions in a typical Danish summer house without heating and with moisture problems. Therefore, the results are only valid in relation with installations with no heating from October 15th to April 15th. The effect of the product will vary according to the different applications, settings, environments, locations etc. It will not be possible to achieve the target which has been verified during this process in all installations.

**Heating**

| | |
|---|---|
| Energy output (Oct.15 – Apr. 15) | 205 kWh |

**Dehumidification and Ventilation**

| | |
|---|---|
| Avg. ventilation with SV14 (Oct.15 – Apr. 15) | 20.4 m³/hr |
| Avg. ventilation without solar air heater Oct.15 – Apr. 15) | 7.0 m³/hr |

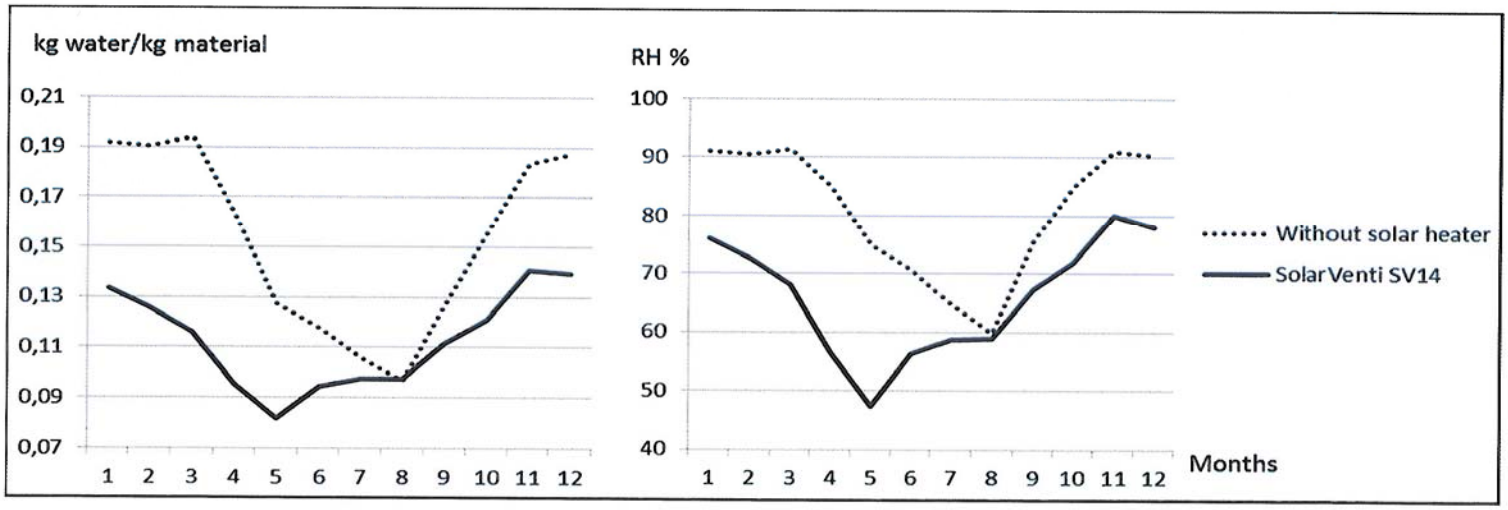



*Figure 2: Simulation results showing the hourly variations in temperature and indoor relative humidity in a design reference year with (solid line) and without (dotted line) a DSB2 solar air heater.*

It is concluded that the panel increases the average annual ventilation and provides extra heating of the house. This combined lowers the relative humidity of the air in the house and results in lower water content in the wooden material in the house.

The high relative humidity observed during wintertime > 80 % and the high water content in the wooden material of the house >18 % increase the risk of mold growth. Based on the calculated values, the unventilated house has an average to high risk of mold growth. The installation of the solar heater lowers the water content of the wooden materials to values lower than 15 % (0.15 kg/kg). This reduces the risk of mold growth. Based on the classification in *"By og Byg Anvisning 204 – Undersøgelse og vurdering af fugt og skimmelsvampe i bygninger (Investigation and Assessment of humidity and mold in Buildings)"*, the risk of mold is now to be considered a minor risk. This leads to the conclusion that the solar panel improves the indoor climate of the specific model house.

It is important to acknowledge that this is an overall consideration and that the risk of mold growth to a great extent depends on the specific construction, e.g. local thermal bridges may lead to high condensation which may increase the risk locally. It is also important to acknowledge that the model house has to be considered as a humid house with a high moisture load. The solar panel has the potential to lower the humidity, but whether the moisture is lowered enough to give a significant indoor climate improvement may differ in a

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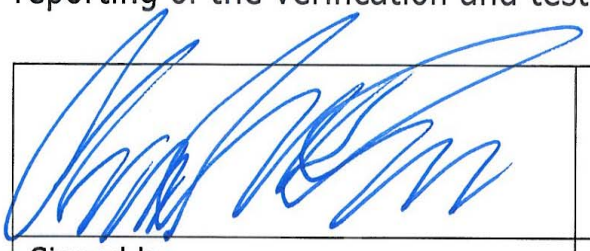
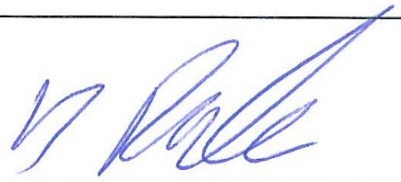
particular house. However, the present model house is dimensioned to represent an average summer house with respect to Danish building habits but with moisture problems.

## Quality Assurance

Tests and verification have been performed according to the DANETV Quality Manual. As part of the quality assurance, two technical experts have reviewed the planning, conducting and reporting of the verification and tests. There have been no deviations from the test plan.

| | | | |
|---|---|---|---|
|  | 12/11-2013 |  | 12/11-2013 |
| Signed by<br>Claus S. Poulsen<br>Test Centre Management Representative | Date | Signed by<br>Bjarke Paaske<br>Verification Responsible | Date |

**NOTICE:** ETV verifications are based on an evaluation of technology performance under specific, predetermined operational conditions and parameters and the appropriate quality assurance procedures. DANETV and DTI make no expressed or implied warranties as to the performance of the technology and do not certify that a technology will always operate as verified. The end-user is solely responsible for complying with any and all applicable regulatory requirements.