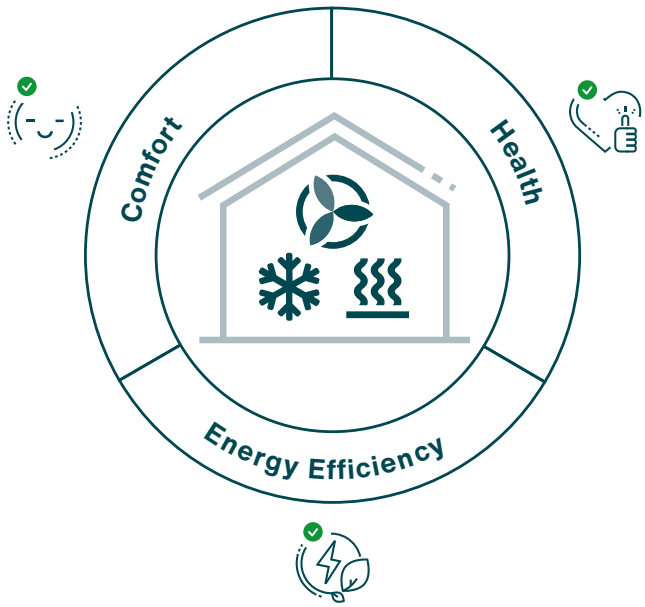
How innovative technologies balance health, energy-efficiency and comfort

# The future of sustainable homes

always the best climate

# The future of sustainable homes

Due to the changing climate, we must live with more extreme weather conditions. As a result, overheating is becoming an increasing problem within residential buildings. While energy prices are skyrocketing, architects, planners and designers are struggling to balance health, energy-efficiency and comfort to create sustainable homes. Balancing these aspects by designing dwellings with the best ventilation and air temperation systems, can be quite challenging. Legislation and end-user requirements add to the challenge.




**After reading this whitepaper, you will know:**

- what innovative technologies are the future of indoor climate solutions;
- how these technologies are combined into one solution for ventilation and air temperation;
- in what type of residential buildings this solution works best.

# What are we talking about when we think of good indoor climate?

A good indoor climate is always a balance between ‘health’, ‘energy-efficiency’ and ‘comfort.

- A **healthy** indoor climate: e.g., low $CO_2$ level, rapid reduction of (virus) particles, prevention of dust mites and moulds, less fine dust, and pollen.
- An **energy-efficient** indoor climate: e.g., optimal (re)use of energy to reduce the amount of electricity and/or fossil fuel that is needed to make a home healthy and comfortable.
- A **comfortable** indoor climate: e.g., proper temperature, rapid removal of odours, the right level of humidity, and no draughts.

**Picture of reference project:**
Passive house in Nonantola, near Modena (Italy)

# The challenge of combining ventilation and air temperation

**Ventilation and air temperation must be in tune with each other to design a healthy, energy-efficient, and comfortable home. When this is not the case, individual systems can work against each other. For example, when a ventilation system and a heating system are working independently, they might have temperature setpoints and/or measuring points that differ from each other. If this is the case, it may happen that the ventilation system is bringing cool outdoor air to the home to lower the temperature while simultaneously the heating system is running at full speed to increase the temperature. This results in unnecessary energy consumption.**

The example on the next page shows what happens in a well-insulated home when ventilation and air temperation are not in balance **(house 1-3)** and what happens when it is in balance with all three combined in one system **(house 4)**.

01

### A lot of air temperation, no ventilation

The air temperation will keep the temperature in the home comfortable. As the home is well insulated, energy consumption will be low. However, as there is no ventilation, the comfort will only be short-term. The indoor air might circulate in the home, but no fresh air will enter resulting in bad smells, high humidity, and $CO_2$ levels. This makes the home uncomfortable and unhealthy in the long run.

02

### Little air temperation, little ventilation

This example shows a home in which there is only a small amount of air temperation, with limited ventilation. This means low energy consumption by the system(s). However, the resident(s) will lose out on comfort (e.g., temperature, smell) and health because the amount of supplied fresh air is insufficient and not filtered.

03

### Little air temperation, a lot of ventilation

Plenty of ventilation ensures healthy indoor air quality. Fresh air will keep $CO_2$ levels low and when the air is too humid, it will be replaced with dryer air preventing mould growth. However, when there is no heat/cold recovery, the limited amount of heated or cooled indoor air will simply leave through the window. With opened windows nuisances such as draughts, noise, and insects arise. In short, less comfort and not energy efficient.

04

### One system that provides sufficient ventilation and air temperation

One integrated system that combines air temperation and ventilation will find the ultimate balance between health, comfort, and energy-efficiency. At any time, the system brings fresh, filtered air into the house while re-using heat or cold from the extract air. At the same time, it will filter out unhealthy particles, ensure perfect humidity levels and energy-efficient additional air temperation when desired.

# 3 reasons to equip a house with 1 system for ventilation and air temperation

**Let the climate system do the work for you**

**Are you trying to balance health, energy-efficiency and comfort? Let a combined system for ventilation and air temperation do the work for you. Such system consists of a heat recovery ventilation unit, an air-to-air heat pump, and an insulated air distribution system.* In this chapter you'll find three reasons to equip a home with such a climate system in it.**

01

## It improves the health of the resident

A balanced ventilation system guarantees the right amount of ventilation. Fresh, filtered air offers multiple health benefits such as better sleep, less hypersensitivity, and reduction of harmful substances for the residents. The innovative technology in which a renewed model on thermal comfort is implemented makes the combination of balanced ventilation with air temperation unique: *the Adaptive Comfort Model*.

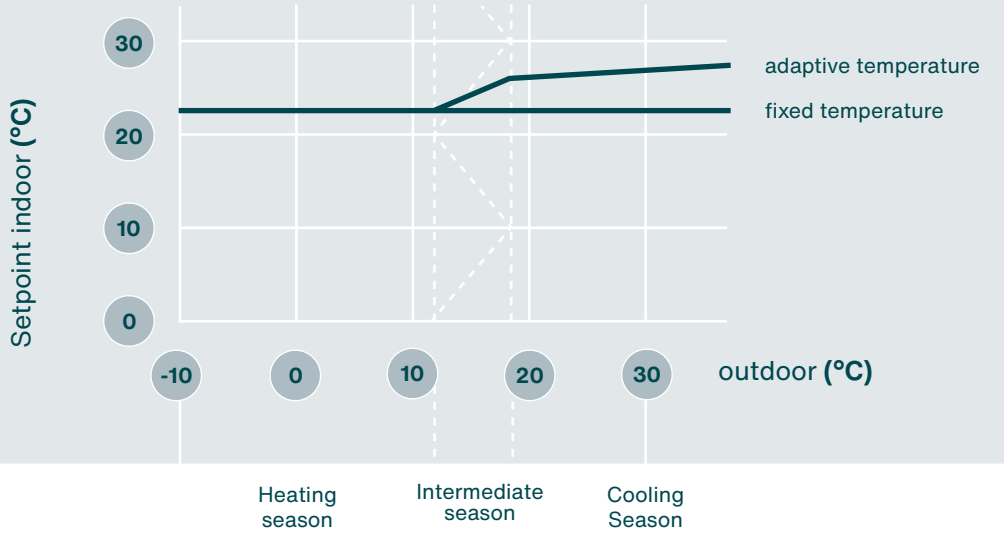
### Adaptive Comfort Model

For a long time, it was thought that whether an indoor climate was perceived as comfortable or not, depends on the parameters

'temperature', 'air velocity' and 'humidity values'. This model, known as the Fanger model, assumed people's preference for constant values of these parameters, regardless of the season. Since the early 2000's an alternative model emerged that claims that people perceived a building as equally comfortable when the indoor temperatures increases as the outdoor temperature is also increasing. Energy saving was pointed out as the biggest advantage of this finding.

Only in recent years was it discovered that an adaptive indoor temperature not only benefits energy-efficiency but also health. A dynamic temperature range of 17-25 stays within our comfort zone. By allowing the indoor temperature to gradually move along with the increasing outdoor temperature, the body is prevented from "thermal boredom". This means the indoor climate allows the body to get used to differences in temperature. This has a positive effect on health (blood pressure, heart rate and glucose metabolism) and makes residents more resistant to heat waves (increased sweat production and decreased body temperature).[4]

## Adaptive and fixed temperature



Bart Cremers, Knowledge Consultant Indoor Climate, explains how the adaptive comfort model is implemented in Zehnder's Climate systems:

*"As manufacturers of indoor climate systems and designers of homes, we have a responsibility to reduce energy consumption and improve the health of residents. Adaptive comfort contributes to this.*
*The Zehnder ComfoClime algorithm looks at the past period but weighs the temperature on the most recent days more than those before. This makes the indoor temperature adaptive but prevents large fluctuations."*

# „A year has three seasons."

**Bart Cremers**

02

# It improves a home's energy-efficiency

15% of all energy consumption worldwide, and 40–60% of energy usage in buildings, is spent on air temperation. Research has shown that even though global warming has a positive effect on heating requirements, the negative effect on cooling requirements is much higher. [5]

Consequently, the energy demand keeps increasing and legislations on energy consumption are getting stricter. These facts demonstrate the importance of finding sustainable solutions to provide a comfortable and healthy indoor climate for residents while reducing energy consumption and costs. [7, 8]

One single system for ventilation and air temperation is such a solution. Being a smart energy management system, it can reduce residential energy consumption.[5] This is done with the implementation of the adaptive comfort model that was mentioned earlier, but moreover, by making use of *Trias Energetica*.[9]

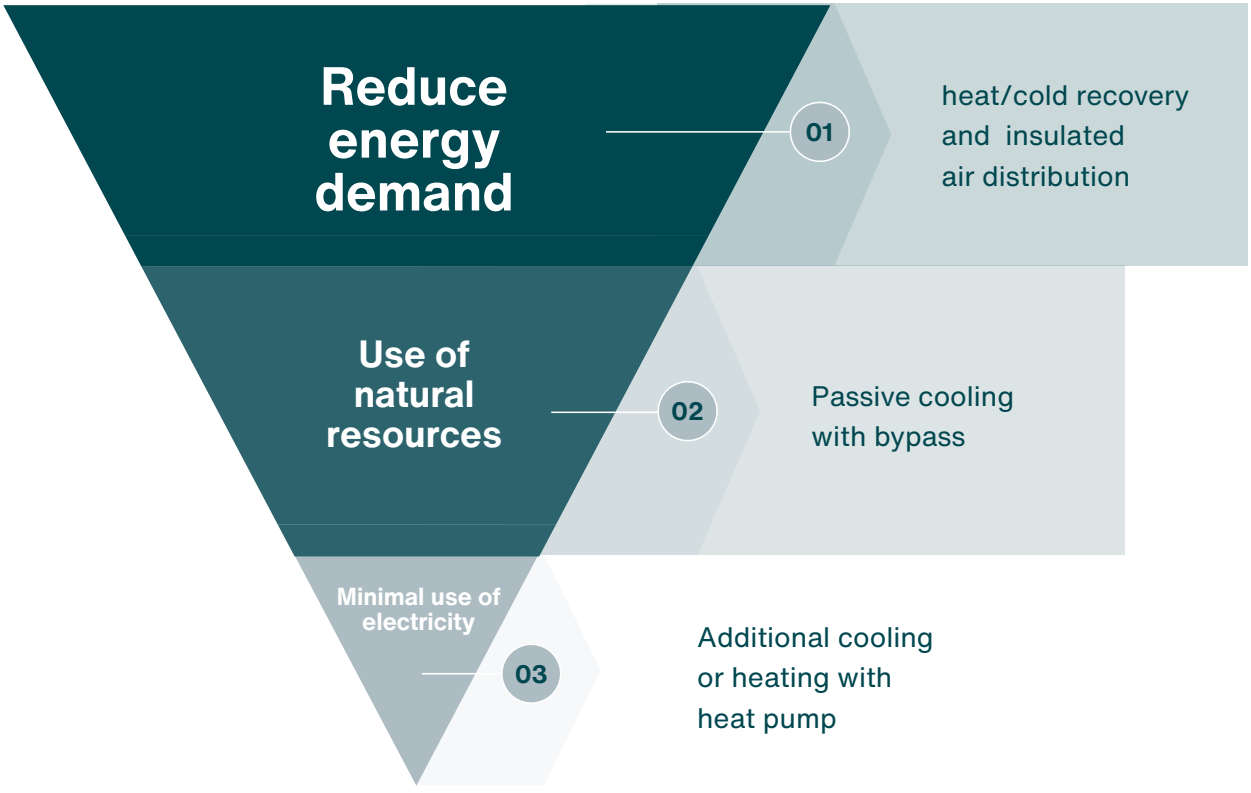
## Trias Energetica

Trias Energetica is a strategy developed to cope with the climate effects of fossil fuel use. It is the major guide for designing passive and low energy homes: First realise the highest possible energy saving, then make use of sustainable/ renewable energy, and lastly use fossil fuels in the most efficient way to cover the remaining energy demand. [6, 9]

Zehnder has implemented the strategy of Trias Energetica into its systems for ventilation and air temperation. It follows these three steps:

1. First, the system will reduce energy consumption with heat or cold recovery. The heat or cold that is already present in the home, will be transmitted on the incoming outdoor air before it enters the living areas. An insulated air distribution system makes sure temperature change in the distribution system is limited to the absolute minimum.
2. Second, the system will use natural energy resources. For example, it is cooler outdoors than it is indoors but the home is too warm, the system will use passive cooling: A bypass will be activated that brings cool outdoor air directly into the home, without exchange of heat.
3. Finally, electricity will be used by an air-to-air heat pump to provide additional heating or cooling when natural energy resources are low or unavailable.

## Trias energetica applied to one system for ventilation and air temperation



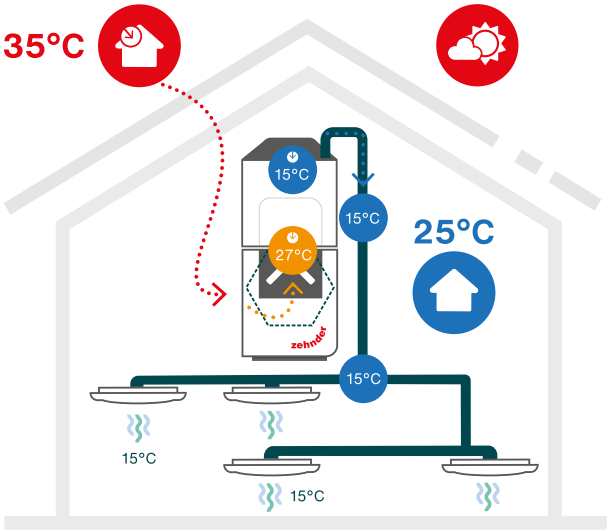
The visuals below give an example of how one system for ventilation and air temperation can improve the indoor temperature while taking both Trias Energetica and Adaptive Comfort into acount.

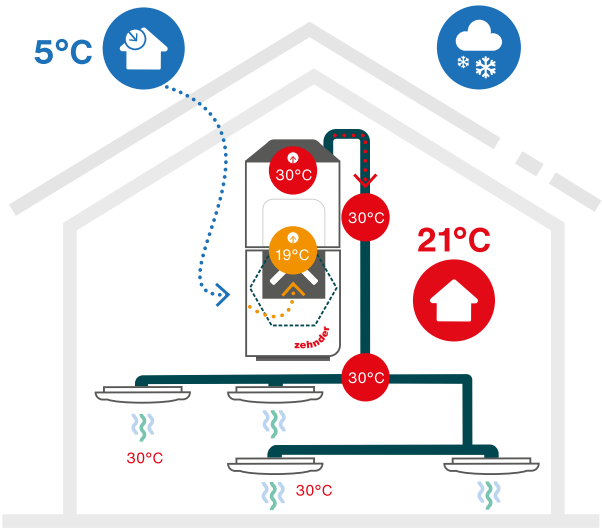
### Summer situation:

In this example the outdoor temperature is 35 °C. When it enters the home, it will first pass the ventilation unit. The heat exchanger in the unit will use the current indoor temperature to lower the temperature of the incoming air to 27 °C. Then the air will pass through the air-to-air heat pump. This heat pump dehumidifies the air and cools it down to 15 °C. The fully insulated air distribution system makes sure the air temperature remains almost the same until it is supplied to the living space. It also prevents condensation and thus moisture problems. The supply air cools down the indoor temperature to 25 °C.*

### Winter situation:

In this example the outdoor air enters the ventilation unit at a temperature of 5 °C. When the indoor temperature is already quite warm, the heat exchanger can reuse this heat to warm up the air to 19 °C. Then the air passes through the air-to-air heat pump. This heat pump heats up the air to 30 °C. The fully insulated air distribution system makes sure the air temperature remains almost the same until it is supplied to the living space. The supply air mixes with the air already present and heats up the room to 21 °C.*






* Visuals state example temperatures, actual temperatures depend on the indoor and outdoor conditions.

03

# It makes a home more comfortable

In terms of comfort, heat recovery ventilation provides many benefits for residents compared to window ventilation. Examples are no draughts, insects and pollution being filtered out, less noise and pollution odours and more comfortable indoor temperatures. When the heat recovery ventilation unit is combined with an air-to-air heat pump and an insulated air distribution system, it can provide (extra) heating and cooling faster than surface cooling or heating (e.g., underfloor heating). This results in more comfort, especially when temperatures fluctuate, and it is desirable for a system to react quickly.

However, research has shown that it can be quite hard for end-users to determine correct settings of a ventilation system. This often results in the residents wrongly using conventional systems[10], and with that selling themselves short in terms of comfort, health, and energy-efficiency. Therefore, a growing number of people are searching for smart solutions to live more comfortably in their houses.[11]

## Automation

If a resident doesn't manually operate the combined system for ventilation and air temperation this smart solution will automatically find the best balance between comfort, health, and energy-efficiency. However, automation from smart technology is equivalent to the removal of a certain amount of control from the resident. If this is experienced as a loss of freedom, it may lead to resistance towards the system, also known as psychological reactance.[5]

Furthermore, technology is always developed around standard users. This makes the 'automatic' function of the system suitable for most users and situations, but there are exceptions.[12] Lives of residents in homes are not always predictive and repetitive. People and their domestic environments vary and daily home life and activities are dynamic and thus so are the residents' needs and expectations in terms of indoor climate.[11]

For that reason, an indoor climate system should be designed in such way that technology and people reach the preferred situation together.[10] How is this done? By designing an automatically operating indoor climate system with *scenarios*.

## Scenario's instead of settings

Who knows exactly what the setpoint for indoor temperature should be, or the air volume that needs to be ventilated, when throwing a party? The most preferred system that integrates ventilation and air temperation, is therefore equipped with scenarios that can temporarily overwrite the automated function of the system.

A scenario is a combination of variable settings that can be manually activated for a limited amount of time. Examples of such scenarios are 'on a holiday', 'throwing a party' or 'cooking'. When the resident selects a certain scenario using the app, the system will find the perfect settings to match their needs in terms of fresh air and temperature. While doing this, the system considers whether it is the heating, cooling or intermediate season.

For example, when cooking on a cold winter day, the scenario will adapt to the current need. This could mean boosting the ventilation for a while to remove smell, excess moisture, and possibly particulate matter from the air. At the same time, it will determine whether to hold back on additional heating as cooking often produces extra warmth.

If the residents decide to throw a party on a hot summer night, they don't have to worry about $CO_2$ levels or increasing temperatures. By selecting the 'party' scenario, the system will increase ventilation and, likely, make use of (passive) cooling. In other words, the system will provide the most optimal indoor climate for that specific user case. In this way, it is easy for a resident to influence their indoor climate without having to know what settings would get the job done nor having to adjust settings on separate systems.

# In what type of homes does this solution work best?

**The earlier described innovative technologies do not provide the same results in every type of home. Zehnder's experts Jerôme Corba (The Netherlands) and Giuseppe Dalpasso (Italy), both Technical Consultants, describe in what types of W a single solution for ventilation and air temperation works best.**

Jerôme Corba

**Jerôme Corba:** *"The number of homes connected to a district heating or waste heat network is rapidly growing across Europe. Especially for multifamily homes that are connected to such a network, it is very useful to have a system that combines heat recovery ventilation with an air-to-air heat pump.*

*District heating or waste heat networks only provide heating, the cooling demand remains unanswered. An air-to-air heat pump, like the Zehnder ComfoClime, is the perfect solution for this. It is an easy to install, standalone solution without an external unit. It provides just enough cooling to give the resident extra comfort in a sustainable way.*

*When it comes to single-family homes, this system works for nearly zero-energy buildings and Passive House buildings. When insulation is still limited, additional heating and/or cooling may be required during peaks in the cooling or heating demand."*

**A success story of the application of this system to a single-family home is one of the first projects in which the Zehnder ComfoClime air-to-air heat pump was implemented. Giuseppe Dalpasso, worked closely with and advised the designer and builders of the project concerning ventilation and air temperation, tells about the need for these type of indoor climate solutions:**

*"With its warm and humid summers, Italy has always been a forerunner in the field of the combination of ventilation with air temperation. There is a demand for solutions that provide comfort, but also keep the energy bills low."*

The project for the Cerchiari family in the surroundings of Modena, was the perfect field test for the Zehnder ComfoClime air-to-air heat pump as in the North-East of Italy it is very hot and humid in summer. Even though applied to a passive house that was well planned, designed and built, the challenge for the cooling system was tough.

The residents are very happy with the results. Giuseppe Dalpasso explains why:

"It has been about one year since the climate system was installed.

Since then, the residents told me they experienced a perfect indoor climate on all three floors of the home. They were especially astonished by the results during summer: they stated that their indoor climate was very comfortable. One of them even joked that on a hot summer day, he preferred staying inside over going to the pool in the backyard!"

Giuseppe Dalpasso sees systems that combine ventilation with air temperation as the solution for the growing shortage in fossil sources:

*"These systems are literally the future of sustainable homes. In about five years' time, the classical installations based on fossil sources will be replaced. Traditional climatic systems can't compete with the general feeling that a modern system provides in a passive house: the quality of the air, the temperature, the humidity levels, and the low noise level at which it operates. Furthermore, it's also convenient in terms of money, especially when combined with photovoltaic installations."*

**Giuseppe Dalpasso**

# Summary

There is a growing demand for more sustainable homes. Insulation helps to keep cold and heat outside. The difficulty lays in keeping the indoor air fresh. Finding the perfect balance between health, energy-efficiency and comfort can be quite challenging.
This whitepaper promotes to integrate single systems for ventilation and air temperation based on three reasons:

01 **It improves the health of the resident:** Fresh air that is combined with the implementation of the Adaptive Comfort Model has a positive effect on health

02 **It improves a house's energy-efficiency:** By making use of Trias Energetica, the energy demand is reduced.

03 **It makes a home more comfortable:** To make daily lives of residents more comfortable, avoid psychological reactance, and guarantee a perfect indoor climate in every situation, automatic operation is combined with manually activated, temporary scenarios.

One integrated system for ventilation and air temperation works best in homes that are connected to a district heating or waste heat network, or as a standalone solution in homes with a low heating or cooling demand (e.g., nearly zero-energy house or passive house).

# Products

01

**The Zehnder ComfoAir Q ventilation unit provides fresh air, while recovering heat or cold from the extract air.**

More about this product

02

**The Zehnder ComfoClime air-to-air heat pump provides additional air temperation when needed.**

More about this product

03

**The insulated ThermalShield air distribution system prevents loss of heat or cold in the ductwork.**

More about this product

## Could you use advice for your building project?

Ask your question to a Zehnder expert

# References

* Footnote: Example of heat recovery ventilation unit: “Zehnder ComfoAir Q”; example of air-to-air heat pump: “Zehnder ComfoClime”; example of insulated air distribution system: “ThermalShield”

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