recair

Recair Enthalpy

saving energy in comfort

We need air, always and everywhere; in good quality! The air quality inside our buildings is not always what it should be.

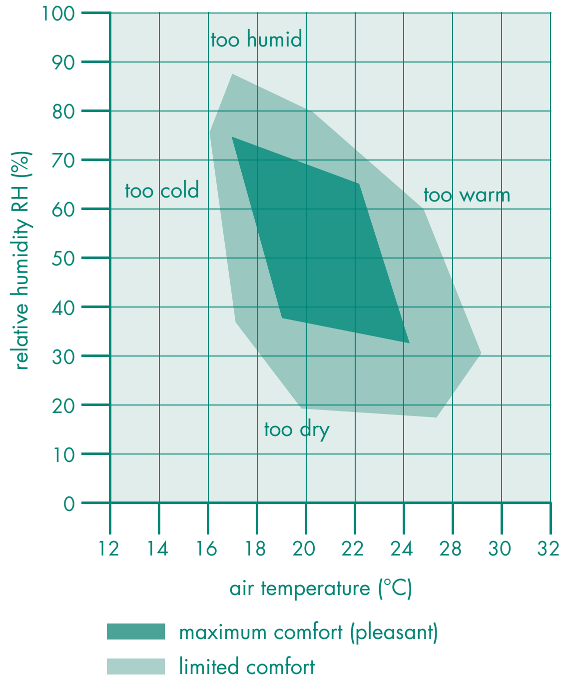
Comfortable clean air. Temperature, humidity and velocity… Always and everywhere! That is why we equip our buildings with air handling systems.

We assume air is healthy and of a comfortable temperature, with as little pollution as possible.

Out of this perception we developed the Recair Enthalpy. A recuperator which (more than any other available today):

- *brings fresh air to your office and home,*
- *provides a comfortable temperature and humidity. Wherever you are, regardless of the season.*

Figure 1: Comfort zone




Recair Enthalpy

Super-efficient

The Recair Enthalpy is a new unique heat recovery core for implementation in heat-recovery ventilation (HRV) units. It is the next step ahead in recuperation technology following the Recair Sensitive.

Where the Recair Sensitive is meant for recovery of sensible- or thermal heat from an air flow only, the Recair Enthalpy can also recover the latent energy (heat stored in the moisture of the air).

Based on its famous triangular duct counterflow design, Recair Sensitive heat exchanger cores excel in the highest heat recovery effectiveness (> 90%) at lowest pressure loss (low fan power consumption).

With the Recair Enthalpy, Recair again raises the standard in the market for heat recovery components. The Recair Enthalpy provides the user with not only effectiveness higher than 90% for both sensible and latent heat, but also, as first enthalpy heat exchanger core in the world, the Recair Enthalpy features control over the amount of sensible and/or latent heat recovered, from zero to maximum.

With the Recair Enthalpy, more than in the past, it is possible to recover and efficiently re-use energy generated for heating and cooling interior spaces, while optimising the indoor air quality which is crucial for a healthy indoor climate. It is ideal for use in balanced ventilation systems in homes, offices and many other applications. It also allows users to substantially reduce their basic energy costs and reduce their dependence on fossil fuels.
The Recair Enthalpy is the first enthalpy recuperator that enables you to regulate indoor humidity, so that your interior climate is never too dry or too humid.

Ideal for different climates

The Recair Enthalpy is an excellent choice for ventilation systems operating in a wide range of climates, including those areas which experience more extreme weather.
In cold climates the Recair Enthalpy offers:

- recovery of heat and moisture,
- prevention of a dry indoor climate
- prevention of blocked return air flow through the core because of freezing. In other words, it keeps the high performance, also under freezing conditions.

In warm humid climates the Recair Enthalpy features cooling and dehumidification of fresh ambient air.

Manufacturers of ventilation systems, architects and individual home owners in Europe, North America and Asia are showing increasing interest in the Recair Enthalpy. No wonder, since it creates the ideal indoor climate – with healthy fresh air, at the right temperature and the right humidity – in a way that is affordable, cost-effective, energy-efficient and environmentally conscious.

Benefits of the Recair Enthalpy:

- the most effective heat recovery (> 90% for both sensible and latent),
- cool, fresh supply air at night, during hot summers,
- no freezing of the exchanger, even in cold climates,
- prevents a too dry or humid indoor climate (controlled latent recovery),
- affordable and convenient,
- elimination of odours,
- preventing build-up of mould and mildew,
- significantly reduced energy costs,
- little maintenance.

Different areas of application

Recair Enthalpy products can be used at home, in offices, schools, and even in greenhouses!

Working principle Recair Enthalpy

The Recair Enthalpy is a follow-up development on the Recair Sensitive. In view of its possibilities, an entirely new innovative recuperator is created (patented).

The heart of every Recair Enthalpy is a Recair Sensitive. The plastic heat exchanger, with all its strong characteristics arising from the dense packaging of small stable triangular ducts, ensures the necessary uniform heat flow over the core (see brochure Recair Sensitive) to warrant the highest effectiveness. This also means that the working principle of the Recair Enthalpy – as far as the moisture transfer is concerned – is not based on the use of membrane technology. For reason of moisture transfer control, the Recair Enthalpy works on the principle of alternation of the air flow direction through the small inner ducts of the heat exchanger core.

The Recair Enthalpy achieves this by the air tight mounting of 4 sliding valves to a Recair Sensitive (every core handles two air flows; every flow has an intake- and outlet opening. leading to 4-valves). A valve system consists of a frame in which a sliding valve is mounted. A labyrinth on the valve assures an air tight sliding seal. Every valve is equipped with its own motorized drive. An electronic motion controller belonging to the Recair Enthalpy sees to it that valves act as instructed by the controls of the Heat Recovery Ventilator Unit.

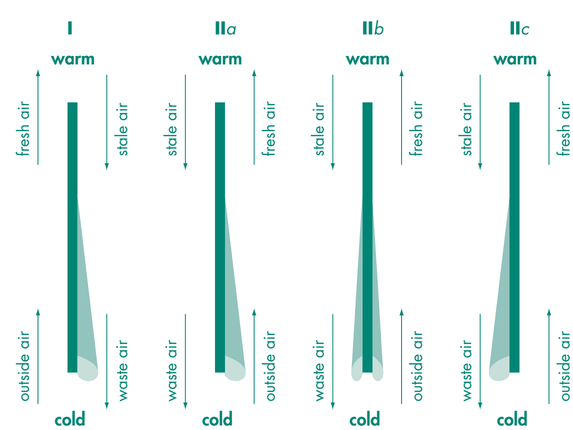
Every valve operation causes an inter-change of the air flowing through a duct, with the air flowing through the neighbouring duct. In other words, a primary air duct will become a secondary air duct (with movement of the valves also the flow direction in the ducts reverses), and the secondary air duct will be primary air duct.

In this way, moisture deposited at the duct wall as condensate or even ice during a waste air period of the duct (colder climates) will sublimate cq. evaporate again in the next (fresh air) period of the duct. This process is driven by the vapour pressure difference of water, causing transport of water only, no particles are moved to or from the duct walls. This implies no transfer of contamination, only water.

During times of non condensing conditions, inside the Recair Enthalpy, moisture transfer cannot take place, thus no reason for valve movement. At times of non-condensation the Recair Enthalpy performs equal to a Recair Sensitive. However when air conditions cause condensation in the Recair Enthalpy, moisture can be recovered by operating the valves. Switching intervals vary from long periods (only a couple of switches a day during moderate condensing conditions) to short periods (a switch every 10 minutes in severe conditions). Under these circumstances the Recair Enthalpy will prove itself most worthwhile, as than the heat recovery is at maximum.

The working principle is –more graphically– explained below. First for cold climate conditions and second for a warm-humid climate in which the heat exchanger is used to (pre-)cool and dehumidify the fresh air before entering the building.

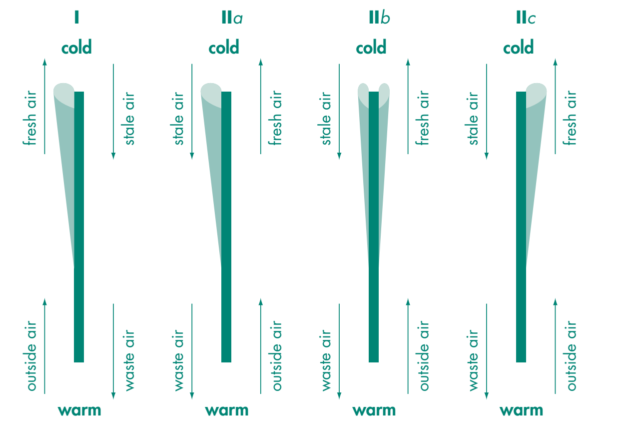
Figure 2.1: cold climate



At the initial state (phase I), fresh air passes through the left hand duct and waste air through the right-hand duct, with moisture condensing/freezing towards the outside end of the waste duct. Then the valve will operate and the flow alternation takes place (phase II). The fresh air – now passing through the right-hand duct – starts to evaporate the condensate (phase IIa), while moisture in the waste air – now passing through the left-hand duct – begins to condense at the same relative position in the duct as the evaporation takes place in the adjacent duct (phase IIb).

The same holds for ice, which is sublimated at the same position, as where the moisture freezes in the adjacent duct. Finally, (phase IIc), all water will be evaporated in the fresh air flow. Simultaneously the maximum level of condensation has been achieved in the waste air duct. At this point, the mirror-image of the situation as shown in phase I is reached. Now the direction of the air flows is normally reversed to repeat the whole process. If humidity production indoors is too high, periods of valve movement can be controlled at different intervals, causing excess humidity to be removed from the Recair Enthalpy as condensate. Also the sensible heat transfer can be controlled. By using the valves to direct one of the flows through both duct types of the core (primary and secondary), leading the other flow over a bypass round the recuperator.

Figure 2.2: warm-humid climate



Phase 1; fresh air passes through the left hand duct, now cooling down with moisture condensing towards the end of the fresh air duct, while waste air is gaining heat on its way through the right-hand duct leaving the building. After alternating the flows (phase IIa), the waste air will leave the building through the left-hand duct evaporating the condensate, while moisture starts to condense from the fresh air at exactly the opposite point in the duct of the evaporation. When operating the valves periodically, fresh air is de-humified. The end of the cycle occurs when all condensate has been evaporated in the used air flow, and the maximum level of condensation has been reached in the opposite air duct; the mirror-image of phase 1.

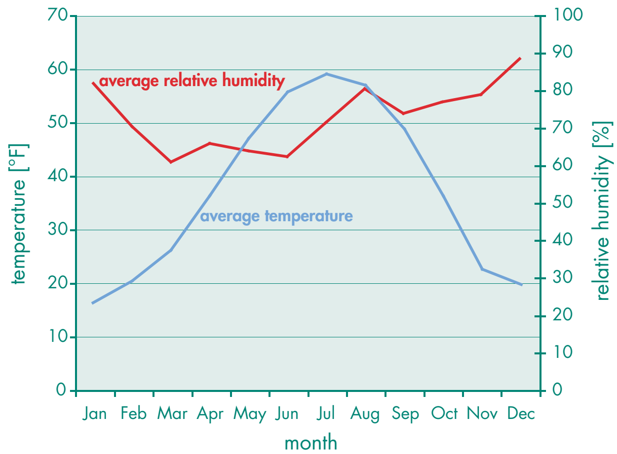
The next step could be another flow alternation. Depending on the decision, whether or not, to operate the valves synchronous or a-synchronous, the Recair Enthalpy can act as a full enthalpy heat exchanger or as a controllable partly enthalpy recuperator.
And with one switching interval going to infinity, as a sensible heat exchanger. Having the possibility of choice to recover moisture or not, realizes the right level of comfort.

Anchorage - Alaska

Climate of Anchorage, Alaska

The climate of Anchorage, Alaska (see fig. 3.1) is sub-arctic with short, cool summers. Average daytime summer temperatures range from approximately 55 to 68 °F (13 to 26 °C); average daytime winter temperatures are about 5 to 30 °F (-15 to -1 °C). Anchorage has a frost-free growing season that averages slightly over 100 days. Average January low and high temperatures are 9 /22 °F (-13 /-5 °C).

Figure 3.1: Climate Anchorage, Alaska



The Recair Enthalpy is charged with two air flows; at one side stale air enters with a temperature of 70 °F (21 °C) and a relative humidity of 50%, while, at the same time, outside air, flows in from the opposite side, at 18 °F (-8 °C) and 85% relative humidity.

Inside the heat exchanger stale air immediately starts to transfer heat to the fresh air flow. This drop in temperature causes the relative humidity to increase to 100% (at this point the air is 50 °F and saturated). From this moment on moisture will condense at the duct walls inside the Recair Enthalpy until temperature drops below 32 °F, than moisture will even freeze. Waste air leaves the Recair Enthalpy and exhausts to outside at a temperature of 21 °F (-6 °C) with 100% relative humidity. At the same time, the cold outside air entering the Recair Enthalpy from the opposite side increases in temperature and humidity (sublimation of ice and evaporation of condensate from the duct walls deposited during the former cycle). This sublimation/evaporation is driven by the difference in vapour pressure.

Remarkable here is, that due to the fact that the air flow is gaining temperature, it is able to evaporate the condensate from the walls all the way through the heat exchanger until all ice and moisture is sublimated/evaporated and the heat exchanger interior becomes dry. In this case at a temperature of 46 °F (8 °C). From this moment on the air (still inside the heat exchanger) will only increase in temperature until it leaves the Recair Enthalpy into the building as fresh comfortable air with a temperature of just over 64 °F (18 °C) and 53% relative humidity. True, a sensible heat exchanger would offer the same temperature, but with a much lower relative humidity (less than 20%)! And also the Recair Enthalpy will not freeze under circumstances described here above. Table 1.1 shows the savings belonging to this example.

Table 1.1: gain from Recair Enthalpy to described example. Calculations based on 150 [m3/h], 21[°C], RH 50 % (Imperial: 90 [SCFM], [70 °F], RH 50%).

example	inside	outside	fresh air
T [°F] ([°C])	70 (21)	18 (-8)	64 (18)
RH	50	85	53
	gain [W]		
total	1987		
sensible	1349		
latent	638		

Figure 3.2: psychromatic chart in case of a condensation and freezing in a Recair Enthalpy (dots represent hourly temperatures and humidities for a representative year).

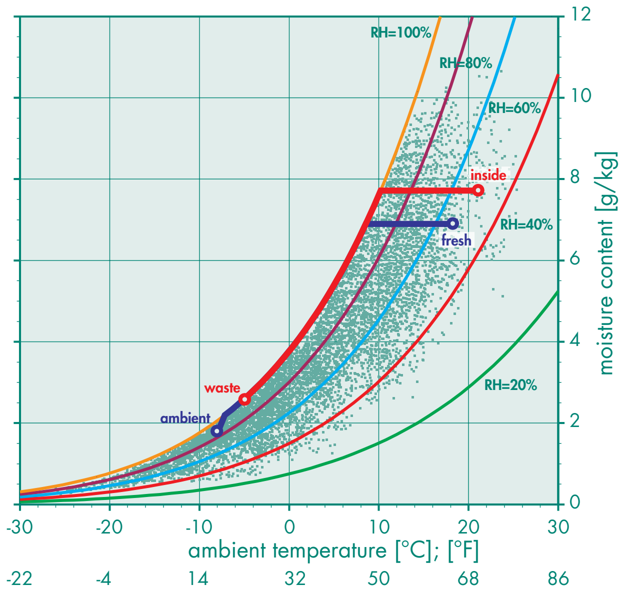


Table 1.2: savings Recair Enthalpy on yearly basis for Anchorage. Calculations based on 150 [m3/h], 21[°C], RH 50 % (Imperial: 90 [SCFM], [70 °F], RH 50%).

Recair enthalpy	**RE400**	
Anchorage	**yearly gain [GJ]**	**[kWh]**
heating total	37	10278
sensible	27	7417
latent	10	2861
cooling total	0	11
sensible	0	11
latent	0	0

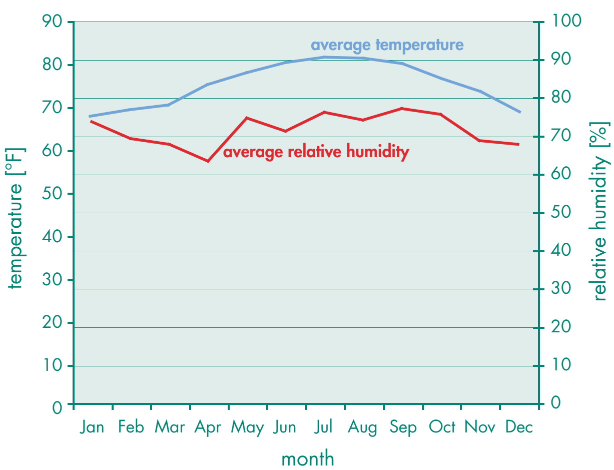
Miami - USA

Climate of Miami, Florida

Miami has a tropical climate with hot, humid summers, and warm, dry winters. However, the average monthly temperature for any month has never been recorded as being under 64 °F (18 °C) (January averages 67 °F – 19 °C). Most of the year is warm and humid, and the summers are almost identical to the climate of the Caribbean tropics. In addition, the city gets most of its rain in summer (wet season) and is relatively dry and cool in winter (dry season).

A typical summer day does not have temperatures below 75 °F (24 °C). Temperatures in the high 80's to low 90's (30-35 °C) accompanied by high humidity are often relieved by afternoon thunderstorms or a sea breeze that develops off the Atlantic Ocean. During winter, humidity is significantly lower, allowing for cooler weather to develop. Minimum temperatures during that time are around 60 °F (15 °C), and the equivalent maxima usually range between 70 and 77 °F (19-24 °C).

Figure 4.1: Climate Miami, Florida

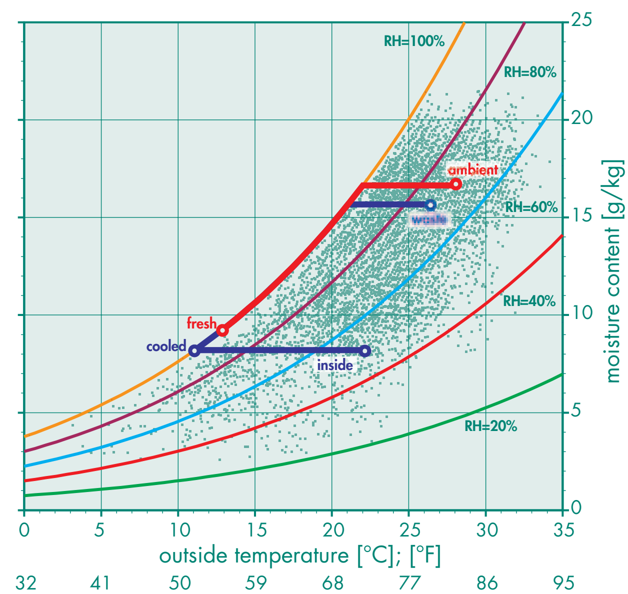


Recair Enthalpy cooling and dehumidifying warm humid outside air

(Products operating according to the working principle here described are subjected to patent rights)

Stale air of 72 °F (22 °C) is cooled by means of an air conditioner to 52 °F (11 °C). In this case air may be cooled for 555 W just to avoid condensation. Stale air of 52 °F (11 °C) will then enter the Recair Enthalpy.

Figure 4.2: psychromatic chart in case of a condensation in a Recair Enthalpy (dots represent hourly temperatures and humidities for a representative year).



Cooled stale air will cause condensation of moisture from the fresh air flow inside the heat exchanger. The process of evaporation in the waste air flow needs energy. This energy is supplied by the condensation taking place in the opposite flow. The psychromatic chart (figure 4.2) shows a schematic representation of the condensation and evaporation in the Recair Enthalpy.

Table 2.1: gain from Recair Enthalpy to described example. Calculations based on 150 [m3/h], 22 [°C], RH 50 % (Imperial: 90 [SCFM], [72 °F], RH 50%).

example	inside	outside	fresh air
T [°F] ([°C])	72 (22)	82 (28)	55 (13)
RH	50	70	100
	gain [W]		
total	1769		
sensible	816		
latent	953		

Table 2.2: the performance realized by the Recair Enthalpy.

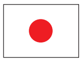
		waste	fresh
temperature	[°F] ([°C])	79 (26,5)	54 (13)
relative humidity	[%]	73	100
flow	[SCFM]	90	90
	([m3h-1])	150	150
Vapour flow	[Pounds]	6.4	3,6
	([kgh-1])	2,9	1,62
Transferred sensible power	[BTU/h]	2787	-2787
	([W])	(816)	
Transferred latent power	[BTU/h]	3255	-3255
	([W])	(953)	
Transferred moisture	[Pounds]	3.1	-3.1
	([kgh-1])	1,40	-1,40

By first “investing” 1895 BTU/h (555 W) the Recair Enthalpy offers 6042 BTU/h (1769 W) cooling power (2787 BTUh sensible + 3255 BTUh de-humidification).

A sensible heat exchanger core would definitely show a lower performance. As there will be no evaporation in the waste air flow. As a result, there is no possibility to transfer the energy-surplus coming free from the condensation taking place in the fresh air flow. In this way less energy transfer means less cooling of the outside air temperature and so a higher fresh air temperature entering the building.

Table 2.3: savings Recair Enthalpy on yearly basis for Miami. Calculations based on 150 [m3/h], 22[°C], RH 50 % (Imperial: 90 [SCFM], [72 °F], RH 50%).

Recair enthalpy	RE400	
Miami	**yearly gain [GJ]**	**[kWh]**
heating total	1	364
sensible	1	358
latent	0	6
cooling total	42	11583
sensible	20	5500
latent	22	6083



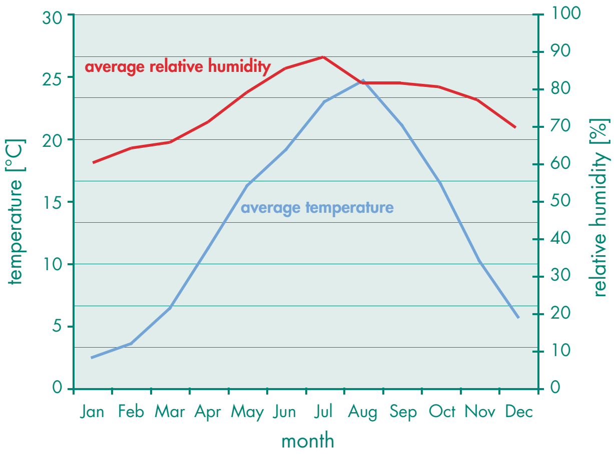
Tokyo - Japan

Climate of Tokyo, Japan

The climate at Tokyo is moderate and comfortable throughout the year. It is hot and humid with typhoons in summer where as the winter is long and dry. Tokyo enjoys 4 seasons:

- Spring: March to May. The initial days of spring are cold but by the month of May, the weather gets warm.
- Summer: June to August. After rainy season, the temperature soars to 30 °C along with humidity.
- Autumn: September to November. In the initial days of autumn, summer temperature prevails. But in general, the temperature in autumn is pleasant and soothing.
- Winter: December to February. Temperature falls to around 2 °C (36 °F).

Figure 5.1: Climate Tokyo



Recair Enthalpy cooling and dehumidifying warm humid outside air

(Products operating according to the working principle here described are subjected to patent rights)

Stale air from the building of 21 °C (70 °F) will first be cooled (by means of an air conditioner) to 10 °C (50 °F). In this case air may be cooled for 552 W just before condensation starts. Stale air of 10 °C will then enter the Recair Enthalpy.

Stale air will cause condensation of moisture from the fresh air flow inside the heat exchanger. The process of evaporation in the waste air flow will need energy. This energy is supplied by the condensation taking place in the opposite flow.

Table 3.1 gain from Recair Enthalpy to described example. Calculations based on 150 [m3/h], 21[°C], RH 50 % (Imperial: 90 [SCFM], 70 [°F], RH 50%).

example summer	inside	outside	fresh air
T [°F] ([°C])	70 (21)	82 (28)	54 (12)
RH	50	80	100
	gain [W]		
total	2164		
sensible	857		
latent	1307		

The psychromatric chart (figure 5.2) shows a schematic representation of the condensation and evaporation in the Recair Enthalpy.

Figure 5.2: psychromatic chart in case of a condensation in a Recair Enthalpy.

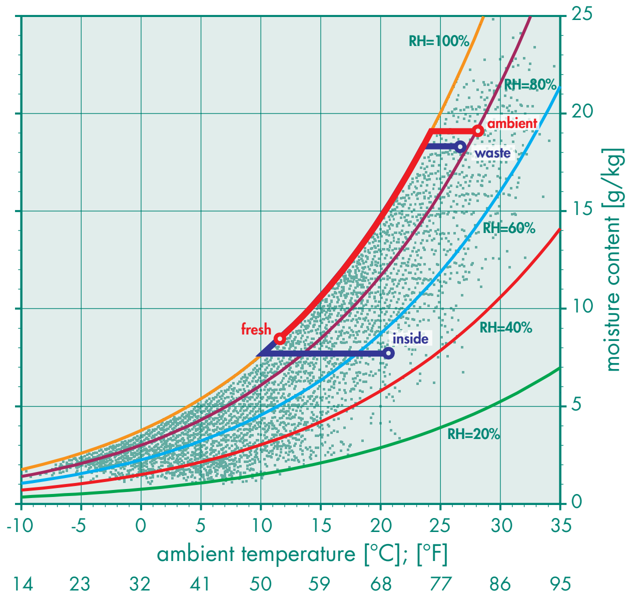


Table 3.2 savings Recair Enthalpy on yearly basis for Tokyo. Calculations based on 150 [m3/h], 21 [°C], RH 50 % (Imperial: 90 [SCFM], [70 °F], RH 50%).

Recair Enthalpy	**RE400**	
Tokyo	**yearly gain [GJ]**	**[kWh]**
heating total	16	4383
sensible	13	3508
latent	3	875
cooling total	18	4931
sensible	8	2239
latent	10	2694

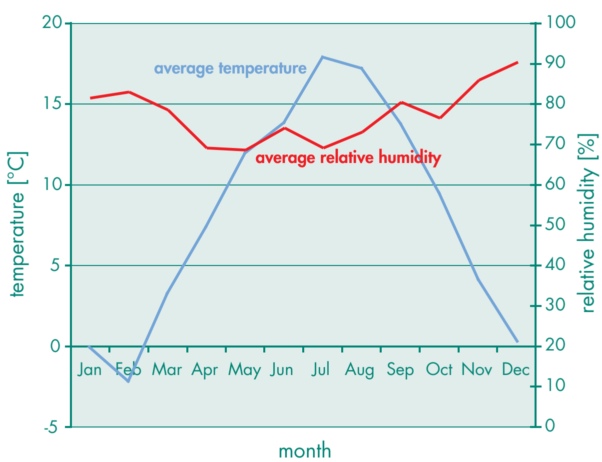
Munich - Germany

Climate of Munich, Germany

Munich lies on the elevated plains of upper Bavaria, some 50 km north of the northern edge of the Alps. It has a modified continental type of climate. Winters are rather cold (January mean: 0.5 °C [33 °F]). Summers are fairly warm (July mean: 19 °C [66 °F]), and temperatures throughout the year are somewhat reduced relative to lower-lying parts of Germany due to the altitude.

The climate of Munich is strongly influenced by the proximity of the Alps. Winds from the SW to SE lose their moisture on crossing the Alps, resulting in Föhn conditions in Munich. The Föhn invariably brings warm, dry weather at all seasons. Temperatures as high as almost 20 °C (68 °F) in winter, or 35 °C (95 °F) in summer can occur with Föhn support.

Figure 6.1: Climate Munich



Simultaneously the Recair Enthalpy is charged with two air flows; at one side stale air enters with a temperature of 21 °C (70 °F) and a relative humidity of 60%, while, at the same time from the opposite side, outside air comes in at -5 °C (23 °F) and 85% relative humidity.

Inside the heat exchanger, stale air immediately starts to lose heat to the fresh air flow, causing an increasing relative humidity up until 100%. At this point the saturated stale air is 11,5 °C (53 °F), moisture will start to condense. Further downstream in the heat exchanger freezing will occur on the duct walls of the Recair Enthalpy.

This condensation/freezing goes on over the remaining length of the trajectory through the heat exchanger. Waste air leaves the Recair Enthalpy at a temperature of -3,5 °C (26 °F) with 100% relative humidity.

In the mean time, the cold outside air entering the Recair Enthalpy from the other side, increases in temperature and humidity (sublimation of ice and evaporation of condensate from the duct walls deposited during the former cycle). This sublimation/evaporation is driven by the difference in vapour pressure. Remarkable here is, that thanks to the fact that the air flow is gaining temperature, it is able to sublimate/evaporate the condensate from the walls all the way through the heat exchanger until all the moisture is evaporated and the heat exchanger interior is dry. In this case at a temperature of 11 °C (52 °F). From that moment the air will only increase in temperature until it leaves the Recair Enthalpy into the building as fresh comfortable air with a temperature of just over 19,5 °C (67 °F) and a relative humidity of just over 60%.

Table 4.1: gain from Recair Enthalpy to described example. Calculations based on 150 [m3/h], 21[°C], RH 60 % (Imperial: 90 [SCFM], 70 [°F], RH 60%).

example	inside	outside	fresh air
T [°F] ([°C])	70 (21)	23 (-5)	66 (19)
RH	60	90	63
		gain [W]	
total	1968		
sensible	1210		
latent	757		

True, a sensible heat exchanger would offer the same temperature, but with a much lower relative humidity of just under 20%! The Recair Enthalpy will not freeze under circumstances described here above.

Figure 6.2: psychromatic chart in case of a condensatio-nand freezing in a Recair Enthalpy (dots represent hourly temperatures and humidities for a representative year).

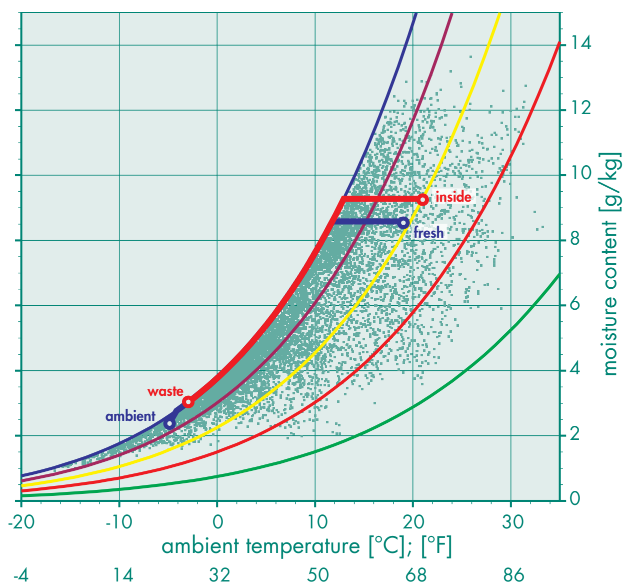


Table 4.2: savings Recair Enthalpy on yearly basis for Munich. Calculations based on 150 [m3/h], 21[°C], RH 60 % (Imperial: 90 [SCFM], 70 [°F], RH 60%).

Recair Enthalpy	RE400	
Munich	**yearly gain [GJ]**	**[kWh]**
heating total	29	8006
sensible	19	5342
latent	10	2667
cooling total	0	86
sensible	0	86
latent	0	0

Specifications

This document only intends to show the relevant functional specifications like effectiveness, pressure loss and dimensions of the Recair Enthalpy. When designing your Heat Recovery Ventilator, of course more specific details are needed. For the system engineer Recair summarized all relevant data in a separate document called Recair Enthalpy fact sheet. Please contact us to obtain this document.

Effectiveness

In the Recair Enthalpy moisture will condense (and freeze) and water (and ice) will evaporate (sublimate) simultaneously. The thermal effectiveness is approximately the same as for a dry recuperator (see data of the Recair Sensitive). Additional to the sensible heat, the latent heat is transferred. If the effectiveness is defined as (1), the effectiveness will exceed 100 %.

$$\textbf{Total effectiveness} = \frac{\text{total exchanged heat}}{\text{maximum exchangable sensible heat}} \qquad (1)$$

The switching interval of the flows hardly influences the effectiveness. The indoor temperature and indoor RH will have influence on the total effectiveness, the more condensation the higher the total effectiveness and the evaporation rate.

Figure 7.1 shows the effectiveness, thermal effectiveness and evaporation rate as a function of the outside temperature for the RE400. Other conditions are:

Table 5.1: conditions used for Fig. 7.1.

heat exchanger	RE400
outside RH [%]	80
inside temperature [°C]	20
inside RH [%]	60
flow [m3h-1]	150
changing interval [s]	300

Figure 7.1: effectiveness and evaporation as a function of the outside temperature.

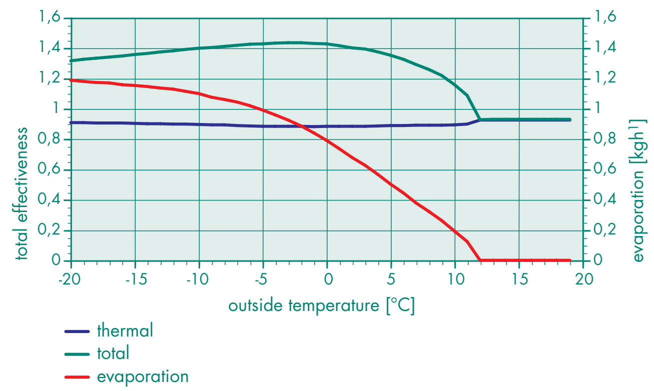


Figure 7.2 shows the effectiveness of the RE400 in warm humid climates, the conditions are:

Table 5.2: conditions used for Fig. 7.2.

heat exchanger	RE400
outside RH [%]	80
inside temperature [°C]	22
inside RH [%]	50
flow [m3h-1]	150
changing interval [s]	300

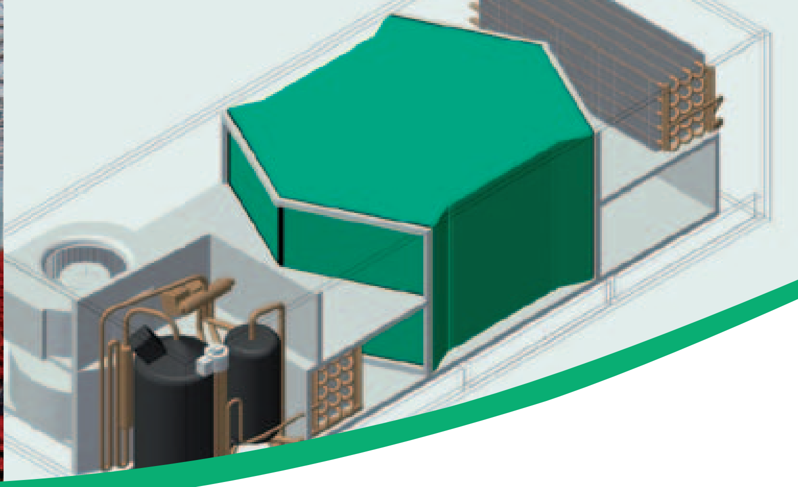
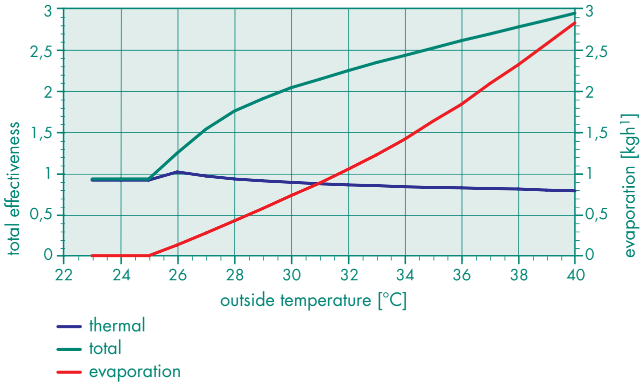


Figure 7.2: effectiveness and evaporation as a function of the outside temperature.

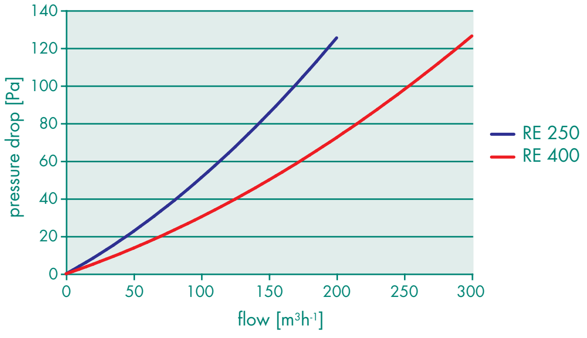


The switching interval hardly has influence on the effectiveness as long as the valves are changed before the water drops off. For longer changing intervals the water layer on the walls will get thicker. The chance of water dropping off is larger.

Pressure loss

Fig. 8 shows the pressure loss for both recuperators (RE250 and RE400) as a function of the flow.

Figure 8: pressure loss as a function of the flow



Operates in a wide range of temperatures

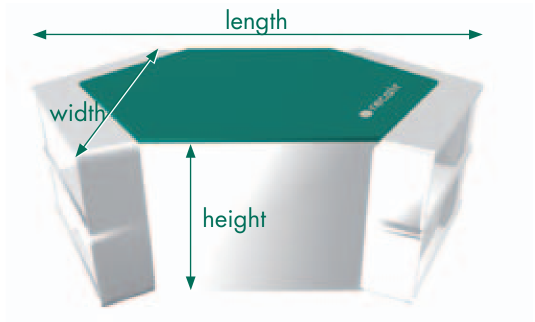
The Recair Enthalpy range operates effectively in air temperatures from -20 to +50 °C (-4 – 122 °F).

Available in two sizes

The Recair Enthalpy comes in two standard sizes.

Dimensions

	RE 250	RE 400
height [mm]	250	400
width [mm]	360	360
length [mm]	550	550
weight [kg]	6,41	9



Recair bv
Vijzelweg 16
NL-5145 NK Waalwijk
P.O. Box 721
NL-5140 AS Waalwijk
Tel. +31 (0)416 347 110
Fax +31 (0)416 348 926
info@recair.com
www.recair.com

EN 14-10-2011