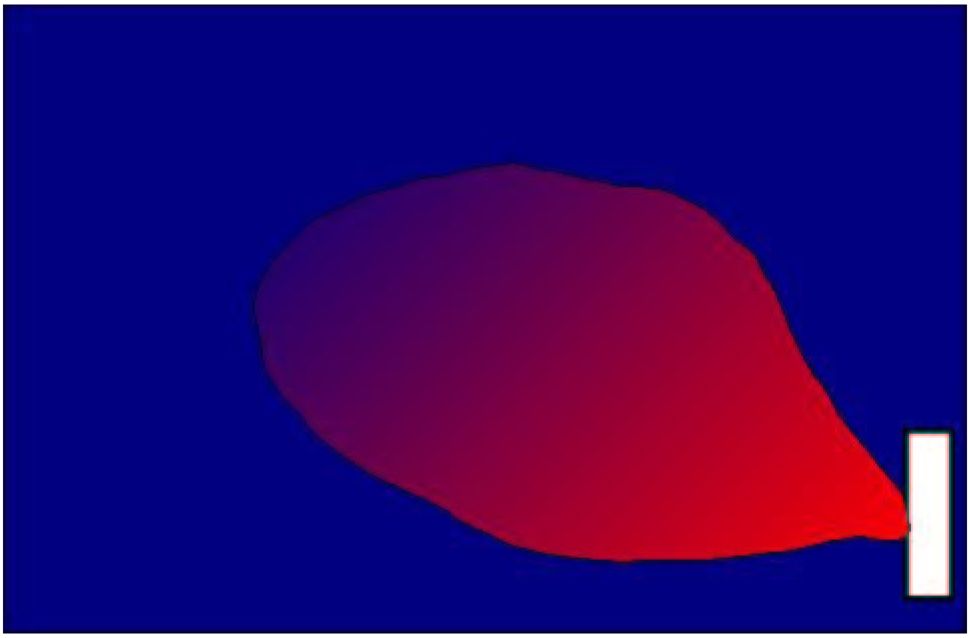

Heating-Turbo

A new kind of convection heater or an add-on component for existing heaters reduces the time to heat up a room or an office to 5...10 minutes.

Without increasing the heating-power.

Summary: Modern convection heaters are mounted very close to the wall in order to save precious space. After the room has reached a comfortable temperature, they easily keep this level. But during the heating-up-phase almost all of their heating-energy goes into the wall and the ceiling above the heater, which explains why we need 1...2h to heat up most rooms today. By adding a fan or a air-directing plate to the convector it is possible to blow the warm air out of the convector directly into the room during the heating-up phase. Thus, the air in the room reaches a comfortable temperature level after only 5...10 minutes. And to compensate for the initially cool wall-temperature, we increase the air-temperature in the beginning (comfort-temperature = average between air- and wall-temperature).

Proprietor of 12 patents and patent-application for the above technology:

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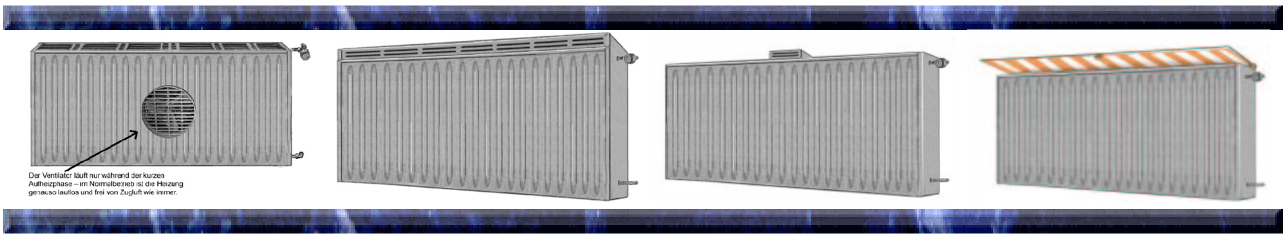
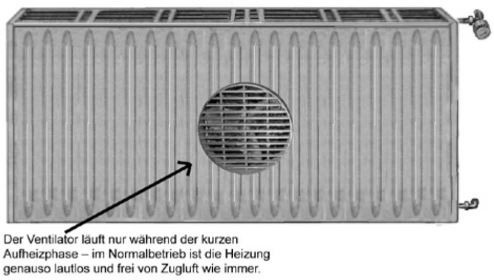
We are looking for a manufacturer to buy all rights or buy licenses.

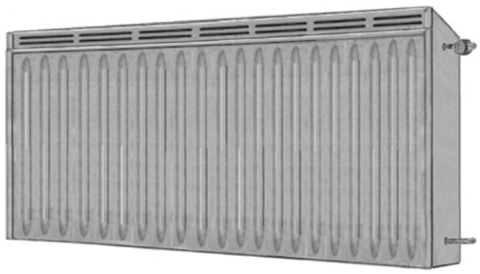


Construction-examples

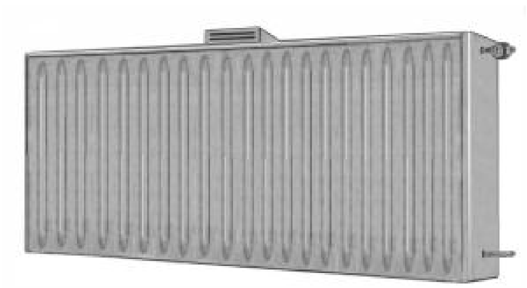
a) Heating-Turbo can be integrated into ready-made convectors:



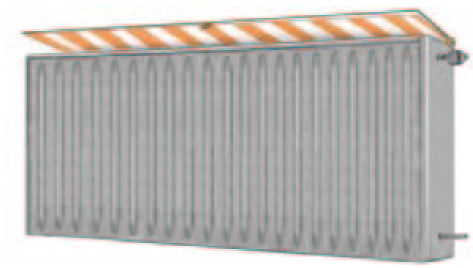
b) Heating-Turbo can be constructed as an add-on which is mounted on the top of existing convectors:



c) Heating-Turbo as a versatile add-on that fits to almost any popular 2-plate-convector (use more than one heating-turbos on very broad convectors):



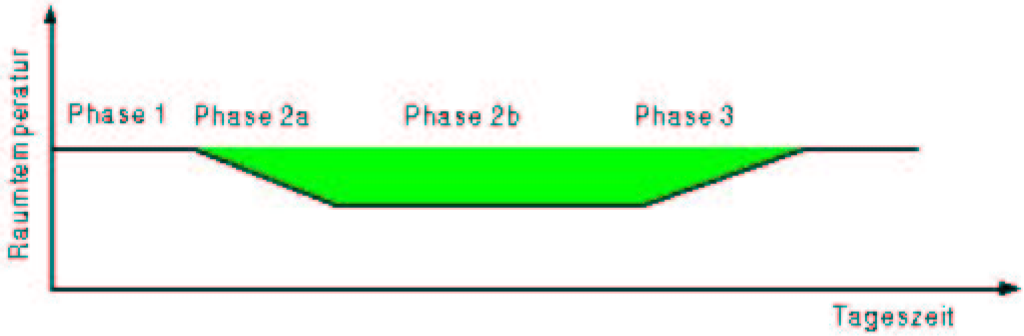
d) Alternative (no fan): An awning above the convector is rolled out only during the heating-up phase and keeps the warm air away from the wall:



The fan is active only during the heating-up phase. Afterwards, the heating works as quiet as always.

Why reducing the temperature saves energy

The convector in a room kept at a constant temperature provides exactly the same amount of heating-power that is lost through the walls, and this loss is proportional to the temperature difference between the inside and outside. Taking into account the storage capacity of the walls, the diagram below shows how the temperature falls in the room, with the green area representing the heating energy which is saved:



- In the diagram above, the room was first kept at a comfortable temperature (e.g., 23°C).

- Then the heater is turned off and the walls of the room gradually cool off (Phase 2a), giving up their stored thermal energy to the surroundings. In fact no heating power is fed to the room in this phase, and the energy savings would have to be 100%. But the thermal energy emitting from the walls has to be "recharged" into the walls later (in the heatup phase 3). Thus, the actual energy savings is only what is caused by the temperature difference between the inside and outside - the rest of the energy savings is simply "borrowed".

- As soon as the wall temperature has reached its reduced value, Phase 2b begins: The room heater comes on again in low to prevent further dropping of the temperature. A measure of the energy savings is here again the temperature difference between inside and outside.

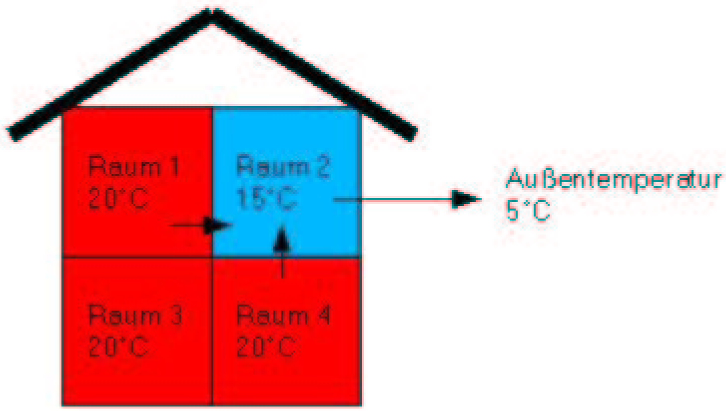
- Turning the heater on again begins Phase 3, the heatup phase. In fact the room heater operates at full power during this phase, compensating for the energy which was lost from the walls during Phase 2a. But since we have not considered the wall-losses as a saving in Phase 2a, we do not have to count the reheating energy in Phase 3 a second time.

  Another way of expaining this effect: When the heater is turned down, the difference between inside and outside temperature does not immediately reach its reduced level. Instead the original high temperature differential is maintained for some time because the walls only gradually cool down. During this time we have similar losses as for a normally heated room in spite of the reduced heating power, but these losses are not evident from the heating power at this point in time; they only become evident when we want to heat up the room later and require full heating power to do that.

  Thus, the energy-saving-potential in a given room can easily be recognized by watching how fast the room temperaturs cools down when the heating is turned off. The faster the temperature drops, the higher the energy-saving-potential through temperature-reduction in this room. In other words: If temperature-reduction in a room does not take place fast enough, then we cannot save any energy by reducing the temperature.

How adjacent rooms affect the savings

During the temperature drop (Phase 2b) it doesn't matter to the overall energy balance whether the reduced temperature is maintained by low heating power of the room's convector or whether the heat flow necessary for the reduced temperature comes from heated adjacent rooms:



In the above example there is a heat flow from the heated rooms 1 and 4 into room 2, and a balance is established with the losses from room 2 to the outside. The result (in this example) is that a temperature of 15°C exists in the internally unheated room 2 and at the outside temperature assumed here of 5°C a temperature drop of no greater than 5K can be reached. In spite of this effect, the exact same energy savings is always obtained corresponding to the respective drop. The heat flow from the adjacent rooms replaces only the heat flow which would actually have to be provided by the room's own convector in order to maintain the described balance with the respective outside temperature.

If a room's temperature can be reduced, we automatically save energy proportional to this reduction. However, in purely insulated appartment-houses reducing the energy-consumption of one appartment by for example 30% might result in 10% higher heating costs for the neighbor. Overall, we achieve a 20% energy saving! But we might also transfer part of the heating-costs to the neighbor.

Rapid room heating increases energy savings

One usually has to wait 1...2 hours until a cooled-off room is comfortably warm again. This is why most people leave the heater on at an unnecessarily high level and lose the energy savings possibilities that a temperature drop would mean. With our simple innovation rooms are brought to a cozy temperature in just 5...10 minutes. This has three effects:

1. The occupants will reduce the room temperature more often and lower when the room is not in use. The heating energy needs of many rooms can be reduced by percents in the two digits.

2. If rooms are used only by the hour, the walls don't have to be completely heated, which results in a significant savings.

3. The custom of turning the heat down at night can be extended until just before the demand time. By extending the nighttime reduction by 2 hours, the energy savings are increased by more than 50% because we extend the night-reduction exactly while it is at its lowest temperature (at 4am the rooms have cooled down to their lowest temperature, and if we manage to keep them at this level for 2 more hours, we save a lot!).

Comfort from rapidly heated rooms

Heating turbo increases the air-temperature almost immediately and the walls as well get warm faster and more evenly. The room can be used even while the walls are still cool. It is not unusual, that the walls are cooler than the air. Anytime we supply heating power to a room (this is: 75% of the year!) the wall temperature is lower than the air temperature:

$$T_{air} = T_{wall} + P * R_{lw}$$

The temperature differential between air and wall varies with the need for heat output P. In a typical room (R_{lw} = 1.1 K/kW) there is in the transition period for example P = 0.5kW of heating demand and the walls are 0.6K colder than the air. In winter, with say 1.5kW heating demand, the walls are 1.7K colder than the air. The temperature subjectively felt by people corresponds here to the average of room and air temperature:

$$T_M = 0.5 * (T_{air} + T_{wall})$$

If air temperature and supplied heat output P are known, then we can determine the wall temperature from:

$$T_{wall} = T_{air} - P * R_{lw}$$

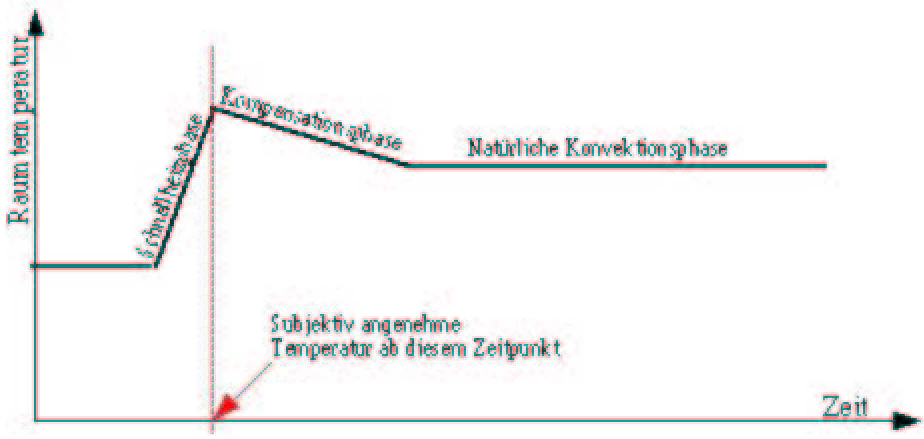
And the subjectively felt temperature is calculated by:

$$T_M = 0.5 * (T_{air} + T_{wall}) = 0.5 * (2 * T_{air} - P * R_{lw}) = T_{air} - 0.5 * P * R_{lw}$$

To achieve a room temperature which is perceived as even, we have to compensate for the fluctuating heat output by adjusting the air temperature (this is also the reason why we feel cold in winter in spite of the fact that we haven't changed the thermostat setting). If the required heat output P changes by ΔP, then the air temperature has to be adjusted by

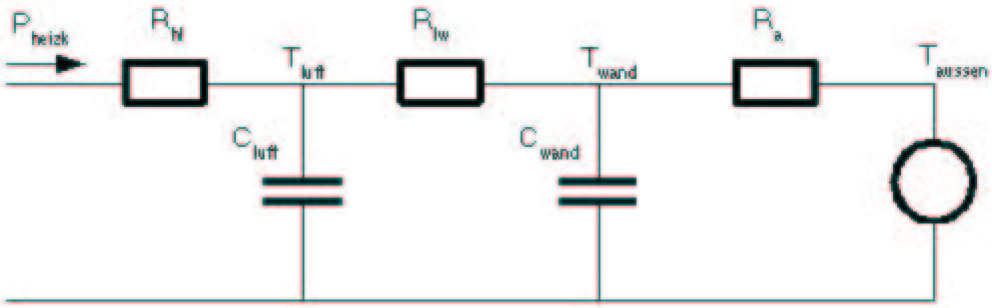
$$\Delta T_{air} = 0.5 * \Delta P * R_{lw}$$

For our imagined 25 sq. metro room with R_{lw} = 1.1 K/kW it follows that the air temperature needs to be raised by 0.6K per kW of introduced heat output. In this way we can always achieve the desired subjective comfort temperature even with colder walls. The following diagram shows how the air temperature needs to be adjusted so that the room has reached a comfortable temperature just a few minutes after turning on the heater:



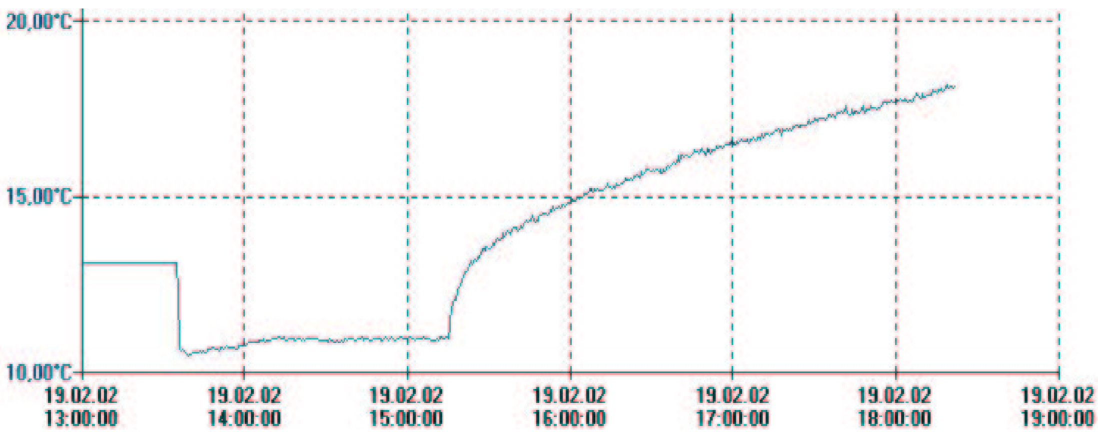
Rapid room heating is possible

Let us consider the equivalent circuit diagram of a heated room:



The heating power P_{heizk} warms the air mass C_{luft} through the surface heat transfer resistance heater/air R_{hl} . It continues to flow over the surface heat transfer resistance air/wall R_{lw} into the wall capacity C_{wand} (the material mass of the wall) and over the insulation resistance R_a to the exterior, whose temperature is assumed to be constant at T_{aussen} .

For the purposes of determining the parameters of the components by way of example, we have used an electric heating fan to warm a 25 square meter, modern light-construction room. The heating fan feeds 1.75kW of heating power into the room air, with the room temperature increase recorded as follows:



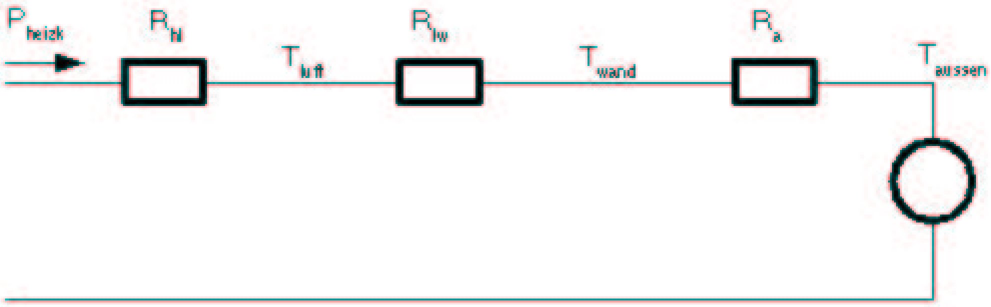
One can distinguish two phases of room heating:

> <u>1st phase:</u> Initially a very rapid heating up by approx. 2K in about 5 minutes
> <u>2nd phase:</u> A significantly flatter curve of about 0.03K/minute = 1.8K/h.

During the steep 1st phase it is mostly the air which is heated, and we can ignore the temperature rise of the walls. During the 2nd phase air and wall are warmed and due to the greatly differing heating capacities of air and wall we can assume that the heating power introduced flows into the wall. It follows that at the transition from the 1st to the 2nd phase the resulting temperature jump (2K in our measurement) drops almost exclusively at the surface heat transfer resistance air/wall R_{lw} (because the walls were hardly heated before) and at the same time nearly the entire heating power flows over this surface heat transfer resistance R_{lw} (because the air capacity is filled). We can therefore calculate R_{lw} as follows:

$$R_{lw} = 2K / 1.75kW = 1.1 \text{ K/kW} \quad (1)$$

A further measurement showed that at approx. 11°C outside temperature and an unchanged 1.75kW heating power, a balance between heating power and losses through the walls was not established until 36°C room temperature was reached. In this state of equilibrium the capacities of air and wall are no longer relevant and we can simplify the equivalent circuit diagram as follows:



In this state of equilibrium the temperature differential between room air (T_{luft} = 36°C) and outside temperature (T_{aussen} = 11°C) drops only at the series circuit of the surface heat transfer resistance air/wall R_{lw} and the loss resistance to the exterior R_a. It follows that:

$$R_{lw} + R_a = (36\text{-}11)\ K / 1.75\ kW = 14.3\ K/kW\ (2)$$

And with (1) it follows that:

$$R_a = 14.3\ K/kW - R_{lw} = 13.2\ K/kW\ (3)$$

In the 2nd phase the 1.75kW heating power introduced at first creates an air temperature increase of approx. 1.8K/h. The greatest part of this heating power heats up the walls, since the air capacity in comparison to the wall capacity is quite small. Since in addition the surface heat transfer resistance air/wall R_{lw} is constant during the entire measurement, the temperature drop at R_{lw} must also be constant (as the heating power through it is constant). It follows that the measured air temperature rise in the 2nd phase corresponds exactly to the rise in wall temperature.

At the beginning of this 2nd phase the wall is not yet significantly warmed, i.e., it does still have the same temperature as the outside world. For this reason we can at first ignore the loss resistance to the outside world R_a . Inititially in the 2nd phase the entire heating power of 1.75kW is thus available for warming the wall, and heats up the later at around 1.8K/h. As a first approximation therefore:

$$C_{wand} = 1.75kW / 1.8K/h = 0.97\ kWh/K\ (4)$$

(Checking plausibility: The specific heat capacity of concrete is 0.244 Wh/kgK.
Thus, we are heating up about 4 tons of material. This is realistic.)

We can calculate C_{luft} for the air volume of our room (around 75 m^3) using the specific heating capacity of the air (1.3kJ/m3K), whereby:

$$C_{luft} = 75\ m^3 * 1.3kJ/m^3K = 97.5kJ/K = 0.03kWh/K\ (5)$$

And for the heatup speed V_l of the air we obtain:

$$V_l = P/kW * 33\ K/h \text{ or } V_l = P/kW * 0{,}5\ K/minute\ (6)$$

Now let's apply these results to a typical convection heater in a room: The Kermi Model 22 (1400mmx900mm) in our test room puts out around 2kW of heating power (75/65/20) a few minutes after it is turned on:

According to (6) the air temperature would therefore
have to rise by 10 K within 10 minutes. In fact however this takes 1 hour.

Rapid roomheating using traditional heating-convectors

Neither the limited heating power nor the mass of the heater explains why rooms take so long to heat up. The same convector that needs only 10 minutes to heat up a room when placed further away from the wall needs 1h to do so when placed close to the wall:

The heating power introduced into the room is used for a long time to heat the wall to which the heater is attached and the ceiling above the heater.

Economy of space does not allow to place convectors 1m or more away from the wall. So, through the design of new heaters or constructing a small add-on to existing heaters we solve this problem:

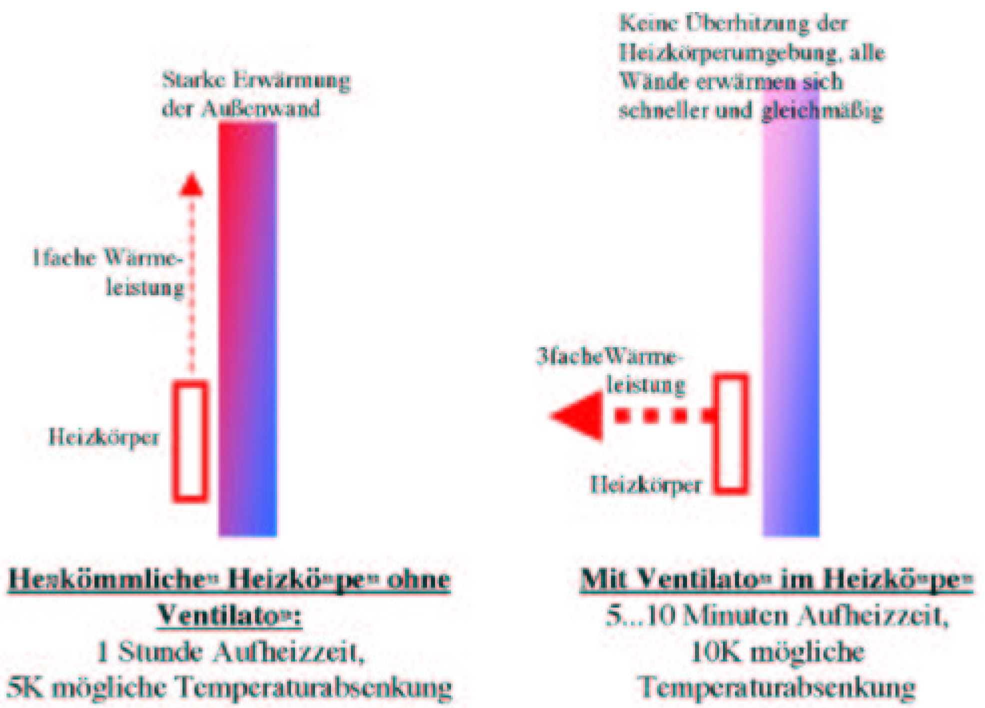
1. Only during the heatup phase we operate a fan that draws the warm air out of the convector and blows it horizontally into the room. If natural convection is poor it has the side-effect of increasing the heating power of the convector.

2. As soon as the comfort temperature is reached (or initially the increased temperature – see the chapter "Comfort..."), the heater continues to operate unrestricted but the fan is throttled back.

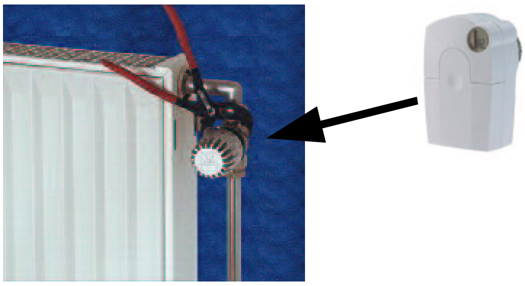
3. Only when the fan is completely shut off is the comfort temperature maintained by means of traditional control of the convection-heater.

<u>Result:</u> Short heatup times, the fan noise is audible only at first and only for a short time, rooms are noiseless and draft-free, and there is significant energy savings.

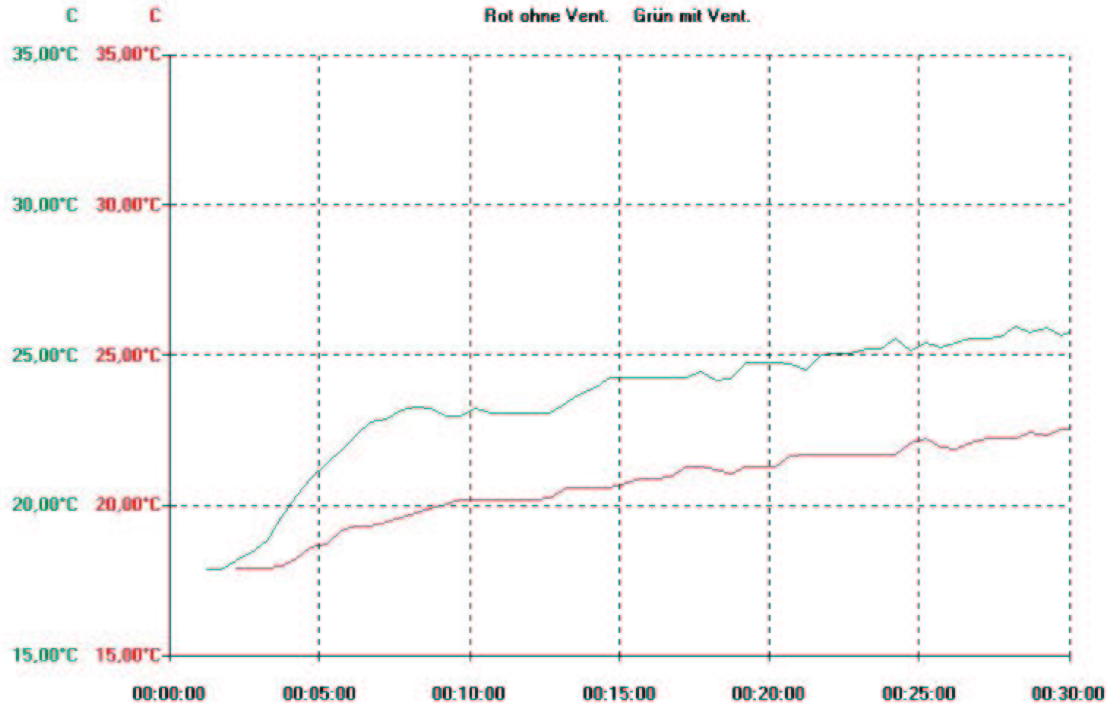
<u>Difference to existing fan-convectors:</u> In conventionally sized or existing convectors we hardly increase the heating power. But we switch the air going through the convector to be blown horizontally out of the convector during the heating-up-phase and take the normal route (bottom to top) afterwards. Also, we operate the fan only during the heating-up-phase and turn in off during normal operation.



The convection heater is controlled by little regulators which any do-it-yourself person can exchange against existing thermostats (price about € 37.50):



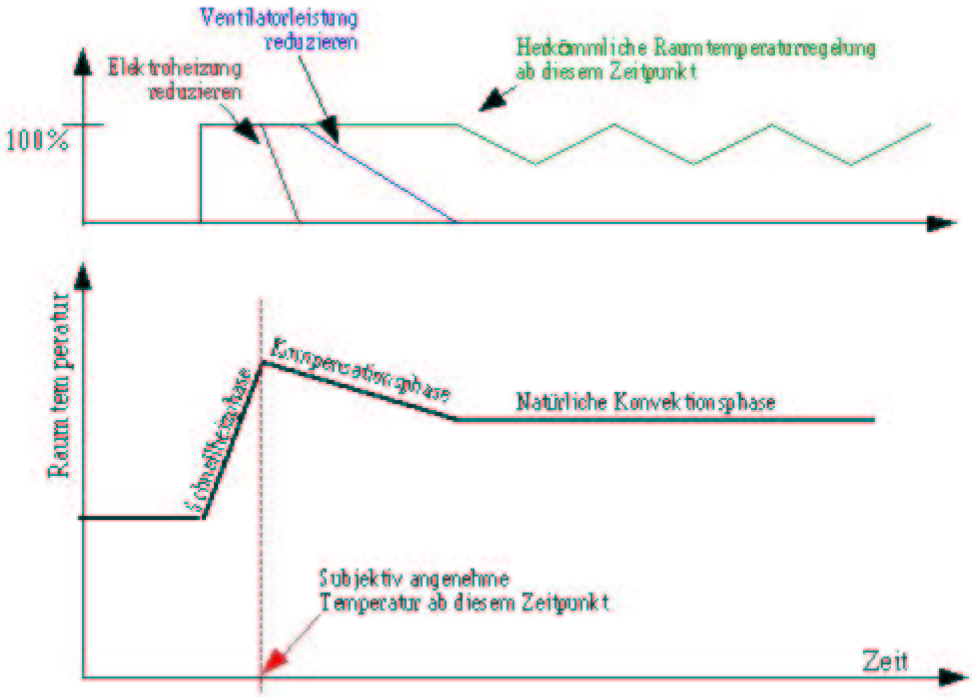
The following diagram shows the heating-up of a room with heating turbo (green curve) and without (red curve):



Combining Heating-Turbo and electrical heater

The heating-turbo effect can be increased by adding an electrical heating element to the fan. Thus, the heating-turbo ensures that the convector's heating-power is blown horizontally into the room PLUS it adds the electrical heating-power. The “electrical-heater-increase” in the speed at which the room is heated is not that important. But adding an electrical heating element does allow to reduce the room-temperature to a lower level, thus increasing the energy-savings drastically. (The rise in temperature within the first 10 minutes of heating-up the room is proportional to the heating-power put into the room).

In this application the electrical supplementary heater, fan and radiator are full on during the heatup phase. As soon as the increased temperature is reached, it is maintained by diminishing the electrical heat component. If the electrical heating is throttled down to zero, the fan output is reduced by the degree necessary for maintaining the respective temperature. And if the fan output is turned down to zero, then the room temperature is maintained by traditional control of the radiator output:



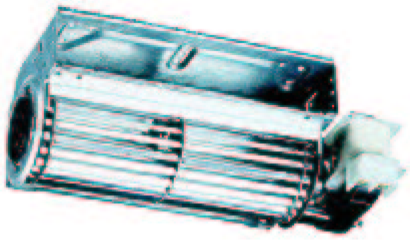
Dimensioning the ventilator

The airflow through the ventilator has to be calculated such, that all of the heated air, which is necessary to introduce the required heating power, passes the ventilator.

Measurements showed that hot air from a traditional convection heater has up to 50°C temperature. If the room-air is at a 20°C level, then the heated air out of the convection heater introduces 30K temperature-differential into the room. With a specific energy of 0.36 Wh/m^3K in the air, we bring about 0.01 kWh/m^3 into the room. Thus, per kW heating power the ventilator has to transport

$$1 \text{ kW m}^3 / 0.01 \text{ kWh} = 100 \text{ m}^3\text{/h air.}$$

Small axialfans are rated at 100...300m^3/h. Radialfans reach up to 1000 m^3/h. Popular tangential fans with 180mm width are rated at 80 m^3/h. Thus, it is necessary to use a tangential fan with a broader mechanical width:



If there is an additional electrical heating element, then we reach higher air-temperaturs (up to the legal limit) and can use a smaller airflow.

Market estimation

In Germany (80 million people) there might be a total of 80 million living-, hotel- or office-rooms, of which maybe 50 million rooms are heated by traditional convection heaters which operate in day/night-mode.

The nighttime-reduction of the room-temperature can have a two-digit percentage increase of its energy savings if it is extended for another 1...2h every night.

50% of these maybe 50 million rooms are used only at certain times (living-rooms, kitchens, working-rooms, offices, hotel-rooms,...). In these estimated 25 million rooms, the heating-turbo can also increase energy-savings by two-digit percents.

Overview of our patents and patent applications

The above explanations refer only to the principle for which we are pursuing a growing number of patents or patent applications, the content of which was not covered here in detail and for which we refer you to the patent documents:

File Number **Internal No.** **Priority Date** **Status**	**Brief Description (Patent Claim 1)**
DE 100 16 098 internal: 000127 31.3.2000 under examination	Space heating apparatus comprising at least one heating apparatus in conjunction with a control apparatus whereby the control apparatus includes operating elements, characterised in that the space heating apparatus includes additional heating elements for supplementary heating of the rooms during the heatup phase and means for activating/deactivating these additional heating elements.
DE 101 51 346.1-34 internal: 010810 22.10.2001 Grant decision	Space heating apparatus, comprising at least one heating apparatus, at least one heating element which includes a fan and at least one control apparatus whereby the at least one control apparatus includes means for activating the at least one additional heating element at the beginning of a heatup phase and for deactivating the at least one additional heating element, characterised in that the at least one control apparatus also includes means for regulating the output of the at least one additional heating element and/or the at least one heating apparatus during a heatup phase such that the at least one heating apparatus maintains a heat output set at the beginning of the heatup phase until an essentially full deactivation of the at least one additional heating element.
DE 101 51 351.8-16 internal: 011017 22.10.2001 under examination	Space heating apparatus comprising a convection-based heating apparatus with a heater and at least one electrical heating ventilator, whereby the at least one electrical heating ventilator includes a fan and at least one heating element characterised in that the at least one electric heating fan is arranged relative to the radiator of the heating apparatus such that an air current generated by the at least one fan of the at least one electrical heating ventilator assists the convection on the radiator of the heating apparatus, and that the space heating apparatus includes at least one regulating apparatus for separate regulation of the at least one fan of the at least one electrical heating ventilator.
DE 100 09 365.5-34 internal: 000131 29.2.2000 under examination	Space heating apparatus with at least one single room heating apparatus each having a single room temperature regulating apparatus and with a central heating sysgem having overall regulation, and means for temperature and/or time measurement for regulation of the set temperature in the central heating system, characterised in that the respective single room temperature regulation apparatus of the at least one single room heating apparatus for regulating the set temperature in the central heating system is coupled with its overall regulation.
DE 101 43 162.7-16 internal: 010761X 4.9.2001 under examination	Radiator for a building heating system with a heater surface, whereby the radiator surface serves to transfer the thermal energy of the heating system to the ambient air, characterised in that the radiator surface is at least partly matched to a forced flow with ambient air so as to increase the heat transmission per unit of time.
DE 101 40 189.2-16 internal: 010781X 22.8.2001 under examination	Space heating apparatus including a radiator which generates a warm air current by means of convection for warming a room, as well as at least one fan which when running diverts the warm air current generated by the radiator into a particular direction, which includes at least one component deviating from the flow direction resulting only from the radiator, characterised by a regulating apparatus which activates the at least one fan using means for activation/deactivation associated with at least one fan only during the heatup phase, so that during the heatup phase a warm air current is generated in a different direction than during a subsequent temperature maintenance phase during which only the radiator is in operation.
DE 101 40 190.6-16 intern: 010809 22.8.2001 under examination	Space heating apparatus with a radiataor which generates a warm air current for heating a space and with at least one air directing unit which diverts the warm air current genreated by the radiator in a particular direction which is different from a resulting air current direction outside of the heatup phase, characterised in that the at least one air directing unit is adjustable with respect to the direction in which it deflects the generated warm air current during the heatup phase.
DE 101 49 994.9 internal: 010991 11.10.2001 under examination	Space heating apparatus for heating a space which comprises at least one radiator and at least one fan, whereby by means of the at least one radiator an air duct is formed and whereby the at least one fan is arranged such that the air current generated on one side by the at least one fan flows through the at least one air duct, characterised by adjustable mechanical means which in a first setting fully close an opening of the at least one air duct on the side facing the air current of the at least one fan and which in a second setting opens this opening of the at least one air duct.
DE 102 15 596.8 internal: 020251 10.4.2002 under examination	Space heating apparatus for heating a space, comprising at least one convection radiator, whereby a first air duct is formed by means of the at least one convection radiator, characterised by at least a second air duct essentially within the at least one first air duct which is closed off at the side, which has a smaller cross-section and a smaller length than the at least one first air duct, whreby the at least one second air duct has at least two openings of which a first opening is located near an opening of the at least one first air duct which opening faces the room and of which a second opening is located inside the at least one first air duct.
and others	(will be described later)

(Subject to errors and modifications, effective 05/03)