Healthy Heating

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Those in the Eco-building community are familiar with the idea of efficient heating systems. With space heating the major drain on fossil fuels, this makes sense, but we are overlooking the effects heating systems have on our health. **Chris Morgan** argues that if we continue to do so, we run the risk of solving some problems only to create others...

Introduction

In our drive to reduce energy use, and fossil fuel use in particular, we risk creating new problems for ourselves. We shake our heads sagely at the poor decisions which led to sick building syndrome in buildings of the seventies and eighties, but we may find we are creating similar problems with the increasingly airtight and efficient eco-homes of the 'noughties'.

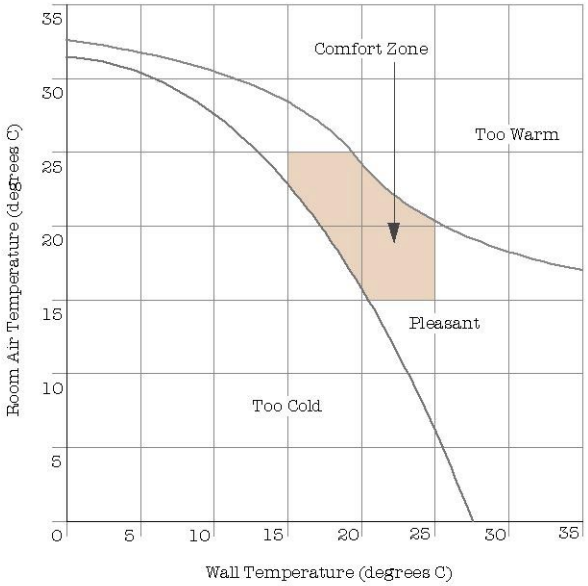
Let's take a step back and think of our biological heritage. The two heat sources with which we have evolved for millenia are the sun, and fire. Both deliver light, and heat in the form of infra-red radiation. In terms of our evolutionary make-up, it is probably fair to say we react well to a source of radiating heat, warm surfaces, cool air and a little air movement.

It is no surprise therefore to read that our biological needs for thermal comfort go far beyond the number "20oC" on a dial, and in fact are influenced by a complex matrix of:

- surrounding surface temperatures
- surrounding air temperatures
- air movement
- moisture in the air and objects nearby
- and the type of heat emitter

In addition we know that certain parts of our body are more susceptible to heat loss (or gain) than the rest. We know that a cool head (speaking in strictly thermal terms!) aids concentration, while cold feet are particularly uncomfortable, and that in general, we require a cool head and warm feet (and to a lesser extent hands) to be comfortable and function well.

All of these aspects and more need to be considered when deciding on the heating regime of a building and its occupants, bearing in mind too that occupants' needs change with the days, the seasons, with age, and from person to person.



Characteristics of a Healthy Heating System

Warm Surface Temperatures
This is possibly the most important aspect of thermal comfort, yet it hardly registers in discussions about heating. We gain and lose a significant percentage of our heat through radiation heat exchange. What we need are surfaces which are a few degrees warmer than the ambient air temperature. Within certain tolerances (see diagram) the warmer the surfaces, the cooler the air can be whilst still maintaining comfort. The subsequent potential to save energy through lower air temperatures whilst improving health has yet to be fully appreciated in the eco-building community.

The way to achieve warm surfaces, generally, is to use radiant heating, either from a point source, like a stove or fireplace, or from a large surface area, as in underfloor heating. (see image, following page) This tends to heat the surfaces and the objects in a room without heating the air in between – just like the sun. Some heating of air takes place of course, but it is minimal.

Air Temperature.
Air temperature dominates the common understanding of temperature, yet it is only one constituent part, and unfortunately, the most problematic. In trying to keep warm, many people simply increase the air temperature which in addition to being only partly successful (and partly counter-productive, see below) tends to exacerbate health problems.
Excessively warm air temperatures reduce concentration and performance, increase pulse rates, skin moisture and likelihood of fatigue. Warm air heating and air conditioning

systems have also been associated with common colds, dried mucous membranes, headaches, irritability and weakened circulation. Cool air, on the other hand, tends to have the opposite effect, and aids deeper breathing which is particularly important when sleeping.

Warm air is lighter than cold air so rises and collects below ceilings. This can be very helpful in summer where high level windows and vents readily exhaust warm air and aid comfort, but in winter, it means that most of the warmth is where people aren't! This means more heat has to be generated to 'swell' the warmth down to where people are operating, which leads to excessive heat input and, significantly, excessive warmth to the head, whilst feet remain too cold. This is exactly the wrong way around for human comfort and health.

Since we have to maintain fresh air levels at all times ventilation is critical, but in exhausting air for freshness, we are also exhausting heat. Heat exchange ventilators are now common, but it remains the case that by heating the one thing that we need to get rid of, we are to an extent making a rod for our own backs. With warm air heating, lobbies become crucial to stop heat escaping each time we come in or go out, and if windows or trickle vents are left open, we are simply heating the sky. When the building fabric itself is warm and the air is cool, as it should be, such drafts are much less of a worry.

View of a Light Earth building incorporating heating pipes in the floor and walls. This creates a large surface of low level heating which has been monitored and proven successful in creating high levels of comfort. Design: Gaia Architects.

So all in all, warm air heating makes for a sorry tale, and since all heating systems will heat the air to some extent it is unavoidable. Clearly though, we can seek to minimise this, whilst optimising the benefits of cooler air in the process.

Air Movement

Moving air, however warm, will tend to cool the body by evaporation. Thus there is something strangely counter-productive of first heating, and then moving something which by moving it, serves to cool things!

What is needed for health is a small degree of air movement. Think of a warm day and a light breeze and the truth of this is apparent. Too little air movement and we cannot get rid of our moisture (sweat) or odours through evaporation, respiration is impaired, we get warm and tired; too much air movement of course and we will get cold. Bear in mind however that occupants sitting for long periods will appreciate less air movement while those working manually will need more. Air movement is also related to the airtightness of the building and to the ventilation strategy.

Excessive air movement tends to lift and circulate dust which creates further health problems. In forced air systems, the movement of air also creates friction in the ducts and positive ions in the process. In (overly) simple terms positive ions are relatively bad for respiratory health, whilst negative ions are relatively good. Think of yourself by the side of a mountain stream with fresh, gurgling running water for an image of an environment with higher negative ions and you can get a sense of this. This positive ionisation of the air also creates problems for the respiratory system.

Humidity Levels

Whilst humidity levels do not directly affect the heating regime, the interactions between air, temperature and moisture levels are subtle and complex. Low humidity levels, for example, will increase respiratory problems associated with higher air temperatures, greater air movement, dust scorching and circulation, electrostatic charges and positive ionisation, while higher humidity levels will mitigate against them. On the other hand high humidity levels are associated with condensation and mould, which themselves lead to other health problems.

In general, relative humidity levels should remain between 40 and 60%. (See my other article about healthy interiors generally) This is harder to achieve with warm air heating since the heating of the air itself dries out the air.

Heat Emitter Surface Temperature

Fires and hot surfaces on stoves and radiators etc. have the effect of scorching dust, which is unhelpful for health, but more significantly they stir up air movement creating convection currents which then move all that scorched dust around.

Low surface temperature emitters which reduce this problem have become more common, largely due to quite separate health and safety concerns surrounding children and other vulnerable people burning themselves. However,

radiation is more effective with a higher temperature, so to achieve the same heat input, these heat emitters need to be larger to make up for the lower temperatures which can sometimes be a problem.

Temperature Gradients
We have already mentioned the problem of hot heads and cold feet created by warm air systems. But since most systems contain a large percentage of convection (air) heating, temperature gradients are common. Radiators, for example, hopelessly misnamed, produce the more of their heat output through convection than radiation. Place your hand beside, and then above a radiator to see for yourself.

Fans can be used to disturb the heat pockets which develop at ceiling levels, but again these have the effect of moving the air and thus cooling occupants at the same time. Reducing temperature gradients can only really be done at the design stage. One of the major advantages of underfloor heating is that heat is delivered in arguably the best place – the floor – and at low temperatures which reduce the air movement such that you strategically reduce stratification.

Temperature Monotony
Most of us are familiar with the welcome cooling effect of moving into a cold stone building on a hot day, or of entering a warm room after a snowball fight! Passing between areas of different temperature is invigorating. Conversely, experience suggests that having all rooms the same temperature has a deadening effect on the body as an organism. It is important therefore to zone areas of the building with this in mind; some rooms warmer and some cooler.

Controls
Heating systems which cannot easily be controlled can be both wasteful and uncomfortable in equal measure. Controllability (along with low installation costs) was often the rallying cry of the warm air heating brigade, and it is true that in general, air heating is easier to control than radiant heating, especially the large surface, thermally massive systems (like underfloor heating) which in most other respects are preferable. In practice though, controllability is not just about the controls of the heating system itself, but about the way the system interacts with the thermal mass of the house (or lack of it) and the lifestyle of the occupants. Care needs to be taken at the design stage.

Summary

Hopefully it is clear that a healthy heating system is relatively easy to create if you use mostly radiant heating, whilst it is relatively difficult to create using convective, or air heating.

You are looking for a system which creates warm surfaces, but relatively cool air, but a system where the heat emitter itself is not too hot. You are looking for a system which does not create excessive air movement, avoids excessive gradients but allows for different temperatures in different rooms. It needs to be quiet and easy to control, working well with the ventilation system and with the control of humidity.

Heating Options at a Glance

Underfloor heating, and wall heating (almost unheard of in the UK, but more common in Europe) are close to being ideal.

Kachelofens and other massive masonry stoves are also close to ideal.

Forced warm air heating is really to be avoided. Systems such as radiators, electric convectors are really mostly warm air systems and are not ideal.

Open fires are wonderful, but so wasteful of fuel that they need to be seen as 'mood' heating, rather than the main source of heat these days. Individual room stoves are often OK because they emit heat largely through radiation.

Ceiling radiant heaters are often useful in large open spaces, but creating hot heads is never a good idea. Ceiling panel heating is to be avoided.

It is important to stress, that, quite apart from the times when the 'ideal' approach isn't possible, there will always be circumstances where the following does not apply.

Looking to the Future

The issue is likely to become more compelling as we tighten up our homes and start to see heat transfer from exhaust ventilation as the main heat source in very low energy homes. Such heat exchange makes perfect sense in energy efficiency terms, but it is really just convective heating and as such needs to be looked at cautiously for those concerned about health.

Heat can also be stored passively, along with moisture. My own view of the future of low energy housing is that it is the capacity of buildings to absorb and desorb heat and moisture ('Thermal Mass' and 'Moisture Mass') which is the key to super-efficient energy use, rather than the warm air heat exchange technology. It is the buildings themselves, a holistic approach and the laws of nature, rather than applied technology that will help us out.

As we make our homes more airtight, the quality of the air and the warmth becomes more important still. Energy efficiency and healthy buildings can be mutually exclusive, but with good design they can also be mutually supportive. Let's get this right for our own, as well as our planet's health!

Resources

The author is not aware of any significant literature on this subject except that noted below. If you do know of other (English Language) sources of information, these would be gratefully received by the author! *(The article then listed a few resources)*