Best in class

– a book about profitable indoor climate

Svensk Ventilation

– a book of facts from

VVS Tekniska föreningen

VVS Installatörerna

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Best in class

– a book about profitable indoor climate

Contents

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Preface

A good indoor climate both improves our health and helps us to work more efficiently, these are facts that are easily quantified. A good indoor climate also improves our overall sense of well-being though this may be more difficult to prove.

But what do we mean by a good indoor climate? What does it consist of? How do you measure it? And how can we profit from having a good indoor climate.

These questions, and many more, are answered in the book you are holding in your hand.

Our starting point is that everybody using a building wants the best possible indoor climate – the builder and owner/landlord also ought to want the same.

In the spring of 2006, the new revised edition of the R1 was released. R1 is a publication containing guidelines for demands which can be put on the indoor climate. R1 is a necessary foundation for specification and assessment of the indoor climate – and for estimating the quality of the indoor climate in existing buildings.

All measurement results used in this book come from R1, which in turn is based on European standards and the latest research findings

We have elected to take it a step further by issuing a classification score to a building's indoor climate. A hotel, as an example, could be given between one and five stars. It is of course possible to pass judgement in other ways on the indoor climate. The idea of issuing an indoor climate classification encourages all those involved in a building to rate its indoor climate and other environmental factors. If I as a filmgoer can choose between watching the same movie in a five star climate or a three star climate, I would of course choose the five star alternative.

Most of us already make certain choices like that. We would rather work out in a gym where we experience that the environment is clean and fresh, we would rather buy food in the shop where it does not smell of fish 20 yards from the counter. We often base our choices on how feel.

Sometimes the feeling can turn into a physical experience, a bad indoor environment can cause headache, breathing problems or just make us really tired.

Today we see a large increase in the number of people suffering from asthma and allergies. The exact reason for this increase is still not fully understood by researchers, but there is an almost total agreement that the indoor climate (mainly the air and its content of contaminating substances) has a significant impact.

One of the often-used arguments previously given for not investing in the plant required to ensure a good indoor climate of a new building was one of the extra cost involved, despite the fact that it is much easier to install at the construction stage. It is vital that we make the investment in the equipment needed from the ventilation plant to the attenuators, heat recovery to filtration.

Today's thinking in the construction of buildings has to be not only about keeping the costs down, but also what the building is going to be used for and what future activities might take place within it. It is at this stage the R1 is used to help us work within the correct guidelines.

At this point, based on the use to which the building is to be put, we can select the appropriate systems to ensure we meet the demands and needs and to attain the best possible indoor climate. It is important that the equipment selected is able to meet these demands without being oversized and that the energy requirement is kept as low as possible. This helps keep costs down and helps us meet our environmental obligations.

It is difficult to make an argument because of the equipment cost, i.e. a quality system is expensive to purchase and the running costs are high. Today's ventilation systems are in most cases energy efficient and when refurbishing an older system it is possible to drastically reduce the running costs and thereby achieve a short payback time on the investment.

This is one way of making the indoor climate profitable.

Another way, as already mentioned, is that you create an environment where people are less likely to fall ill and are able to work more efficiently.

Most of us are probably unaware of the indoor environment we live and work in. We take it for granted that the air we breathe is of a good quality.

We want to change this. Everybody profits from a good indoor environment. With help from this book and the R1, it will also be easy to create it.

Ingvar Ygberg

Managing Director, Svensk Ventilation

This is why we need to classify our indoor climate

– In my role I notice that my customers – large office tenants – more and more appreciate a good indoor climate. The users have a growing understanding of the importance of the premises for the welfare of the organisation. There is a growing trend that decisions about future location often deals with a number of weighted criteria, of which the indoor climate is one. Furthermore, the tenants/users are becoming more knowledgeable when it comes to identifying their needs as regards premises.

Conny Johansson
Senior manager at Tenant & Partner AB
– Sweden's leading advisors to commercial tenants

– When we talk about the importance of the environment for our health and well-being, the quality of the indoor climate should be of the greatest importance as we spend most of our time in such environments. This is particularly valid for infants who spend their first time in life almost exclusively indoors, where they are exposed to a large amount of chemicals and other pollution. There are today scientific studies showing a connection between poor indoor environment (chemical exposure) including poor ventilation and for instance asthma and allergies in children. Fresh air as a result of good ventilation and good indoor environment in general are important factors for our health, factors which should always be observed when building.

Carl-Gustaf Bornehag
Docent in public health science
SP Technical Research Institute of Sweden
Karlstad University, Technical University of Denmark

– One of the most important tasks for a Construction Client is to translate the customer's requirements and expectations on a building project into terms which can be understood and interpreted by the people involved in the building trade. R1 constitutes an important aid when it comes to formulating requirements for a good indoor climate.

Stefan Sandesten
CEO, The Swedish Construction Clients Forum

– Sigtunahem´s motto is "Living with consideration". By building extremely energy-saving dwellings with supply and extract air ventilation with energy recovery we give our tenants a very good indoor climate at the same time as we make a contribution for the environment. This is one part of our consideration – for people and for our common environment.

Anette Sand
CEO, Sigtunahem

– For human well-being, a good environment to live in and thereby a good indoor climate is needed. This suggests the need for an on demand ventilation system. Therefore, the various categories of the building trade must be involved at an early stage of the planning process so that the design of the buildings is adapted for the need for climate installations. These must in turn be designed with consideration for indoor environment, maintenance and energy usage.

Leif Gustafsson
CEO, YIT Sverige AB


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Chapter 1

Indoor climate – what is it?

Good indoor climate helps keep us healthy; it makes us more efficient in the work place. A good indoor climate can make cost savings for employers as well as householders and a building with good indoor climate increases in value.

The question most people ask themselves when deciding on how to create a good indoor climate is:

"What type of indoor climate system is the best?"

The answer is"It depends."

It depends on what the building is going to be used for. How it is constructed. What equipment and fittings are there? Who will be using it? And any number of other factors, which few of us even consider.

What one wants is a well adapted system, which is designed taking into consideration the building itself, the activities in the building and the various demands from the people living or working in the building. It must be correctly sized and designed considering servicing and maintenance. It must not cause disturbances such as draughts and noise. Finally it should be well managed and be properly functioning, in other words it should operate well over a long period of time.

A good indoor climate is a climate that one does not notice. We should not notice that all lamps are positioned correctly so we always have the correct light for the task we perform. We should not notice that it is silent (if silence is what we want). Nobody should think about the fact that the air in the room constantly is changed so that the air we breathe is clean and fresh. We should not freeze, or be too warm if we are normally dressed for the time of the year. The indoor temperature should be adjusted to the work and the time of the year.

A poor indoor climate is always felt, although it might be difficult to identify it as the source for the problems that occur.

Headache is a very common symptom of poor indoor conditions. Poor lighting, noise of various kinds or poor air quality can cause the headache.

It is often the case that a person suffering from headache is quite sure that the headache has a specific cause. However it is not unusual to find that the cause lies elsewhere and is often found when a careful examination of the working environment is made.

Despite the fact that we might have interpreted the reasons for the problems incorrectly, a person's own perception is one of the best gauges of the quality of the indoor climate. Therefore, a person complaining is an important signal – very few people complain for no reason.

In 1996 a report was issued from the Environmental Health Study. The report numbered SOU 1996:124 contains a proposal for a national action program for the indoor environment. The overall goal was formulated as follows:

"No one should fall ill or suffer negative effects due to a deficiency in the indoor environment".

Indoor climate, simply put, is the result from the building being exposed to various loads. The main loads are:

- **Outdoor climate and quality of the outdoor air which affect temperature, sound, light and air quality inside the building.**
- **Activities and indoor processes affecting the total indoor climate substantially. A little used interview room would have an entirely different load than a busy office with lots of computers and printers.**
- **The building itself. Choice of materials and the construction affect the indoor environment as do furniture and other interior fittings.**

Creating a good indoor climate – when and how

Many building loads must be compensated in order to arrive at the desired indoor environment. Various types of installations can accomplish this. Heating, cooling, transport of pollutants, lighting and sound attenuation are examples. A good indoor climate is created when these various systems are integrated where possible and work in conjunction with one another. The worst possible result is achieved when these installations and systems counter-act each other.

Bad planning often causes problems with the indoor environment. At the design stage, when there are discussions about the building's appearance, what its environmental impact will be and of course the cost.

These things are of course important but the following questions also should be asked:

1) **How is the building going to be used?**
2) **What requirements (desires and demands) do the people who will work or live in the building have?**
3) **What special problems will this building be exposed to? Intense solar radiation from one side, more or less constant shadow on the other side? Totally different activities with different needs?**

These are questions that need to be considered at an early stage of the planning process – which most people probably do. However too few use the information gained until it is too late. To ensure we create the correct environment in the building we need to bring together those parties who specialise in the different fields required in the construction and fitting out of the building. After all, many of the basic services and finishes will be influenced by one another.

A ventilation/air-handling plant installed to ensure the indoor air quality is of a high level is likely to have an effect on the noise level within the building. If an acoustics engineer is involved at the design stage we can avoid noise related problems once the building is occupied. Leaving such matters to chance could mean costly remedial work having to be carried out soon after occupation, causing embarrassment as well as disruption.

This way of working not only makes the building more expensive, it also creates frustration with both owner and user of the building.

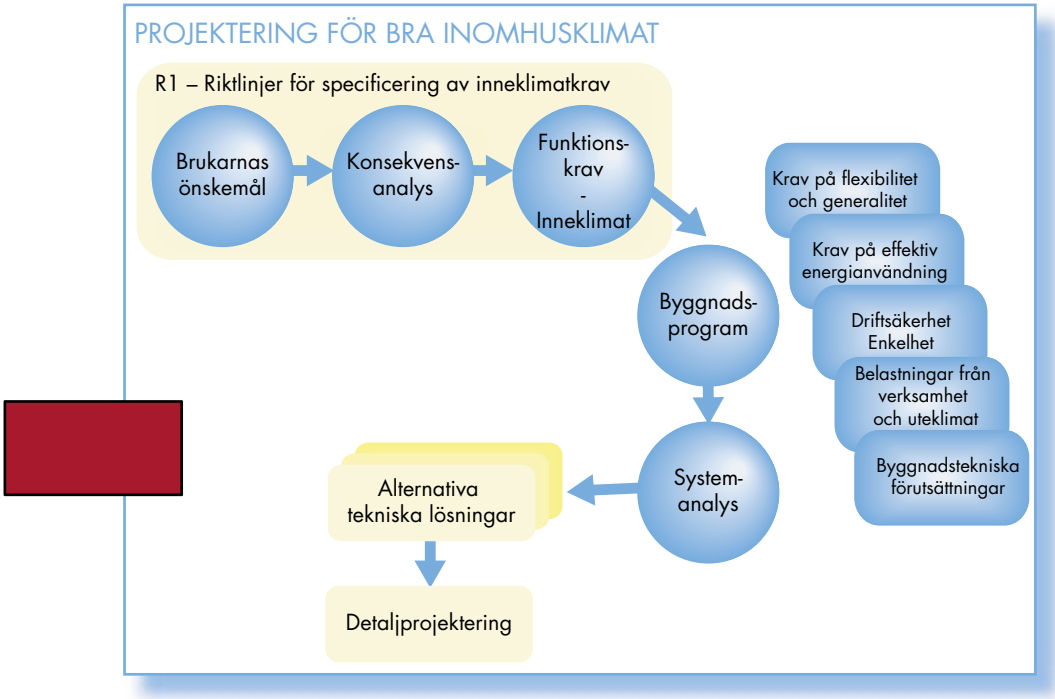
It is better to invest time and money in the entire indoor environment at as early a stage as possible. The initial cost of the building may be more expensive but will be found to be the most economical way in the long term. The fabric of the building can remain without the need for renovation to the ventilation system, lighting, temperature or acoustics.

Tenants are less likely to leave and of course the building owners are happy.

It is important that the right choices concerning the indoor environment be made as early as possible. We are able to predict the requirements based on both the technical specification of what is currently available and of course the cost implications of our choice. This is the best time to bring together those involved in the project planning and those who have

responsibility for the financing and purchasing for the project. This gives us the opportunity to make the best choice of system based on both technical and financial reasoning. This is where the R1 can be of great help.

Demand specification and follow-up



To create a good indoor environment, whether in a building under construction or in a refurbishment, it is wise to write a demand specification. It should contain measurable and verifiable values for all essential parts of the indoor environment, i.e. thermal climate, air quality, acoustics and lighting.

Of course we can consider other demands, such as tap water temperature (to avoid the growth of bacteria such as legionella), drinking water quality (radon) and even values for electromagnetic fields.

The purpose of the demand specification is not only to set measurable values on the indoor climate. Most important really is that it helps everybody involved in the project to ensure the quality assurance of all work – and to together strive for the same goal. It also makes it much easier for different

disciplines within the project to understand each other. A common problem in building projects (new building or renovation) is misunderstandings caused by poor communication. A clear and joint demand specification for the whole indoor climate reduces the risk for this, which makes it so much easier for everyone to do right from the beginning. This saves time and human energy and, in the end, also money.

If there is a demand specification available, which clearly shows the intended quality level of the indoor climate, the end result almost automatically will be better than it would have been without such a demand specification. In order for the demand specification to be really effective, it should include written routines for service and maintenance of the installations.

Another result of the demand specification is that the possibilities of maintaining a good indoor climate are much greater than without such a document. Once we have achieved completion and all the systems have been commissioned and have met the specifications, the building is occupied. From this point we should only need carry out a system assessment at regular intervals to ensure the systems are fully functional, any problems or regular maintenance work can be actioned at this time. It is important that these assessments are carried out in accordance with that outlined in the demand specification.

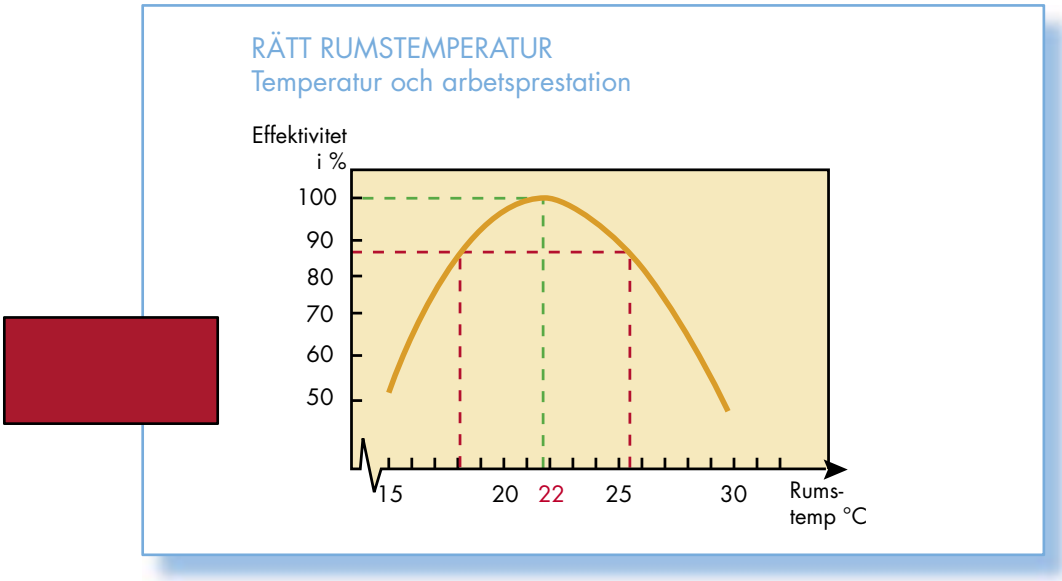
Providing we carry out these assessments as prescribed and take the correct action we will be able to avoid more complicated problems at a future date.

Exactly what is suitable to bring into the demand specification and values for various applications are listed in the R1 (read more on page 26). How to maintain a good indoor climate is discussed on page 25, later in this chapter.

What does a good indoor climate consist of?

A good indoor climate is a climate which does not affect people working or living within in a negative way – or rather, a climate which affects us positively. Swedish authorities have quite a few regulations for the indoor climate; both for residences and other premises, there are also what we might call general directions to follow. The indoor climate normally is divided into:

- **Thermal indoor climate**
- **Air quality**
- **Sound environment**
- **Light environment**



People's performance level at their place of work is to a large extent dependant on the temperature. Even a couple of degrees increase in temperature over the norm can affect our performance and this could be reduced by over ten percent. Source: *David Wyon*

THERMAL INDOOR CLIMATE

The thermal indoor climate (temperature, heat radiation, air movements and draught) in a room affects people in several ways. We can become tired and find it difficult to concentrate if the temperature is too high; if it is too cold we have difficulties in doing things physically. Furthermore, researchers have shown that most people react pretty much the same at various temperatures – provided that they perform similar activities and wear clothing suitable for said activity.

For offices and dwellings, a suitable temperature in the summer is 23 – 26°C; in winter 20 – 24°C. The reason why it should be warmer in the summer is that the temperature difference between outdoor and indoor temperature otherwise would be too great, our light summer clothes that are

comfortable outdoors would not necessarily be adequate to keep us comfortable indoors without the temperature increase.

Temperature is easy to measure. However, a common mistake is to measure in one point only. Large windows, exposed to the sun can mean very high temperature in the summer for those sitting close and for them it does not matter that the temperature at the door six meters away is perfect according to all regulations.

So, in other words it is equally important to control the peoples´ perception of the temperature as it is to measure the actual temperature.

In the cold climate of Sweden, it is natural to initially think about "heating" when discussing the thermal climate. Today, however, we have very well insulated buildings and almost every place of work (and many homes) is filled with machines producing heat. Computers, printers and copying machines are some of the things affecting the temperature and making it warmer. So, today cooling is at least as important as heating.

OBVIOUS CONSEQUENCES

The consequences of an incorrect temperature are well known for most of us. Only a few degrees too high or too low can reduce our capacity. Our efficiency is clearly reduced, but our safety is also detrimentally affected. Our ability to think suffers, as does the quality of our work and all because of the temperature conditions. A good example of a work place where the temperature is very

How the building is to be used will be decisive for the indoor climate. There are very different requirements between a gymnasium, a classroom or a residential home for the elderly.

important is an air traffic control tower. If an air-traffic controller works in excessively warm conditions his concentration is very likely to be impaired, which in this particular case can have devastating consequences for many people. A five degree increase from 22 to 27 degrees reduces the power of concentration by between 30 to 50 percent. The indoor temperature can easily be increased by five degrees just by strong sunshine on a hot summer's day.

Of course conditions where the temperature is too low can also have unwanted consequences. An ordinary example of the importance of temperature for our ability to work is the sensitivity and the fine motor ability of our fingers. Even at 20 degrees it is lower than at 22 degrees. The reason for this is that the body adapts to the temperature of the surrounding air – when it gets colder, the body's heat is concentrated to the most vital organs while the temperature of arms and legs goes down. At 16°C, the temperature of the fingers goes down to the extent that it will be very difficult to write.

Our perception of comfort is easily affected by the surrounding temperature whether we feel it is too hot or too cold. Most people have similar perceptions of temperature.

Therefore, it is an important part of the work of creating a good indoor climate to find out the "perception of the users". We can ask the simple question of the occupiers, is it too hot or too cold? The answers are a great first indicator of whether or not there are any problems that need attention or actioning.

RIGHT PLANNING

A prerequisite for a good indoor climate is to decide at the planning stage what type of temperature zone do we want to create. It is difficult and expensive to make changes afterwards. If there are exact temperature requirements (e.g. same indoor temperature regardless of time of the year) the heating and cooling plant must be designed accordingly.

A quality aspect on the thermal climate is that it should be easy to control in the individual room, preferably also the individual working station. A person should be able to have it a little warmer or colder than his or her colleague in the room next door. To be able to control our local environment is important. The less a person needs to adjust to demands and desires of others regarding the thermal climate, the better it is.

Checklist for the thermal climate:

- ✔ Correct temperature interval – a level that is normally considered comfortable
- ✔ Individual control in separate rooms or smaller zones in larger rooms
- ✔ Small risk for disturbances in form of draughts, heat radiation etc

AIR QUALITY

The air is the part of the indoor climate which often is most difficult to attach a value to – and to discuss. Good air is taken for granted. It is easy to detect bad lighting and to do something about it. But how do we know that there is something wrong with the air? And do we know what effect the air will have on us?

Researchers agree that bad indoor air affects people negatively. Our performance is impaired, as is our health; we have, over the last few years witnessed a huge increase in asthma and allergies among children. The exact cause for this increase is not known, but it is quite clear that the indoor air has a major impact in this case.

There is a lot of research going on about the outdoor air. We know that car exhaust fumes and industry emissions must be reduced; most people know that the quality of the outdoor air is vital to our health. Even more important to our health is the quality of the air we breathe indoors and yet the research into this area is very much limited.

There are two reasons why indoor air is at least as important as the outdoor air:

1) **Scandinavian people spend on average 90 % of their time indoors or in transit. We are at home, at work or in any number of premises.**
2) **Indoor air equals outdoor air plus all contamination impurities which are added indoors. These pollutants come from people, our activities (e.g. cooking), materials used in furniture, and other things in the house, machines, animals etc. Also construction materials and detergents pollute the indoor air.**

There are a lot of airborne pollutants to take into consideration as far as indoor air is concerned. For some of them there are established limit values,

but research has not come especially far in this area. The most important materials with health effects which are known enough to establish limit values for highest acceptable concentration are formaldehyde, radon, carbon monoxide, nitrogen dioxide, ozone and particles.

The air quality is decided also by the air exchange in the premises. An absolute minimum demand, which many people consider low, is that a room should be ventilated with .5 air changes per hour.

The simplest way of removing pollutants, and to ensure a good air change rate, is to install a modern ventilation system. A good ventilation system will give a sufficient airflow, without creating disturbing noise, vibrations or draughts. It has a good filtration system and it is easy to control the supply air temperature and airflow. The system should also be easy to maintain and service. Modern systems are energy efficient, and today many systems have heat recovery. Both of these factors will lower the operation cost and the investment cost can be recovered in a relatively short time.

A common problem with ventilation is that the supplied air is not sufficiently clean. This can be rectified by good filtration of the supply air. The higher filter quality, the better cleaning of the air. This is providing that the filter is changed often enough. An old and dirty filter will not clean the air; instead it can make bad air worse as it will release pollutants which the filter has caught earlier.

Another aspect is that many materials emit large amounts of pollutants inside the premises. Therefore, one should as far as possible choose so called low-emission materials – in other words materials which emit small amounts of pollutants. This is important for building materials, walls and floors as well as furniture and textile fabrics. The less emissions, the better the air quality.

As detergents pollute the air, it is important that instructions are in place for types of detergents to be used and how to use them.

The consequences of bad air are quite obvious to most of us. We become tired, we lose concentration, our performance suffers and we are easily irritated. Anyone who has been in an assembly room with bad ventilation for a long time knows that what is said, and thought, towards the end of the session does not quite keep the same level as in the beginning.
Our thinking suffers in circumstances where there is insufficient fresh, clean air.

THE DEADLY RADON

Radon and tobacco smoke, especially in combination, are among the most dangerous we have in our indoor environment. The problem is at its worse in our homes. In July 2004 the National Board of Health and Welfare in Sweden lowered the threshold value for radon to 200 Becquerel per cubic meter of air. Almost half a million homes in Sweden have a value exceeding the new threshold value. Almost 500 Swedes get lung cancer caused by radon every year.

Radon comes from three different sources. The largest source is the ground, the second largest is Alum Shale Concrete and the third is water.

The air in the ground always contains radon, sometimes as much as two million Becquerel per cubic meter. The ground air comes in to the house through the foundation and as the air pressure in the house is often lower than the outside pressure, the air is sucked in.

If a building is built on ground with very high radon values it is important to take care of the problems. Good ventilation is important, in most cases a system with fan controlled supply and extract air is needed to avoid negative pressure in the house. If this is not sufficient the radon values can be reduced by installing a radon extract fan or a radon well.

Most local authorities have very good knowledge about where it is inexpedient to build due to ground radon, the problem seldom occurs in new building projects nowadays.

FAKTA

En radonsug skapar ett undertryck under huset så att luften aldrig sugs in i byggnaden. En radonbrunn fungerar ofta bra om huset är byggt på grus eller grovsand. Radonbrunnen ligger en bit från huset och suger där bort luften från jorden. En enda radonbrunn kan hjälpa flera hus.

Checklist for air quality:

- ✔ Low concentration of air pollutants, the most important being formaldehyde, radon, carbon monoxide, nitrogen dioxide, ozone and particles.
- ✔ Choice of low-emission materials for both building and fittings.
- ✔ Filtration of the supply air.
- ✔ Sufficiently high air exchange in the premises.

SOUND ENVIRONMENT

Many studies performed about what is most disturbing in the indoor environment say that noise is very annoying for many people. This, somewhat surprisingly, also applies to premises which easily fulfil all regulations for noise that the authorities have established. The reason is that the requirements have been set too low.

People are finding themselves more easily disturbed by noise at values lower than those set as the threshold limits set by the relevant authorities.

There is any number of sources for noise disturbance and various ways it can spread. It would be advisable to involve an acoustics engineer at the earliest possible stage, whether it is a new build or a renovation project. Noise problems can prove difficult to rectify once the project is complete and yet very easy to avoid.

Noise can come from:

- **The outdoor environment, traffic noise is most common (often a big problem in buildings with natural draft ventilation).**
- **Installations such as ventilation-, heating and cooling systems.**
- **Activities on the premises, talking, music and even the sound of steps in a corridor.**

It is difficult to eliminate the noise from the outside environment but we can limit it's effect by the means of various forms of insulation as well as double or triple glazed windows and in some cases acoustic barriers.

Noise from installed equipment is an unnecessary and preventable problem nowadays. We have the means and the technology to eliminate it but we still don't always use it. The ventilation system is often the source of the most complaints when it comes to noise and yet there are many ways we can prevent them.

- **Fans with anti-vibration mounts**
- **Correctly-selected silencers**
- **Sufficiently large ducts for air transport in order to create low air speeds and low pressure drop, which will reduce noise.**
- **The correct grilles and diffusers for each room**

Sound is transmitted both through the air and through the building. The sound environment also contains sounds which we cannot hear – so called

Large ducts reduces noise. *Photo: Fläkt Woods*

infra sound. Some installation can in certain cases produce infra sound. Infra sound is a very low-frequency sound (below 20 Hertz) which if not damped can spread over a very large area. As humans do not hear it, we do not realize that we are being affected by it. It is however possible to measure, which is important, as researchers are convinced that infra sound can have a detrimental effect on people.

Another danger with infrasound is just that we do not realize that we are being affected, which we often do with normal noise. Noise can affect our energy levels and make us tired as well as lowering our concentration, leading to our performance suffering.

The simplest way of reducing noise (and infra sound) is by the use of the correct materials and equipment in the building. Triple-glazed windows, sound barriers/shields and damping for the ventilation have already been mentioned but there are more things to consider. Noise-damping materials in the building are good, as is a space division that makes sound transmission more difficult. Sound absorbing panels make big difference in larger

Checklist for the sound environment:

- ✔ Anti-vibration mounts for all machinery.
- ✔ Noise insulation for installations, grilles and diffusers.
- ✔ Control and handle noise from outer environments.
- ✔ Use noise-damping materials and fittings.

premises; textiles and fabrics can also have an astonishing effect on the sound level.

LIGHTING ENVIRONMENT

Lighting is the only one of the factors affecting the indoor climate that does not need to be discussed when building homes. Lighting in homes is not as fixed an installation as for instance the heating or the ventilation system is, and most of us also want to create our own personal lighting environment which we like and feel comfortable with.

The requirements are however much higher for the lighting environment in the work place or other commercial/industrial premises.

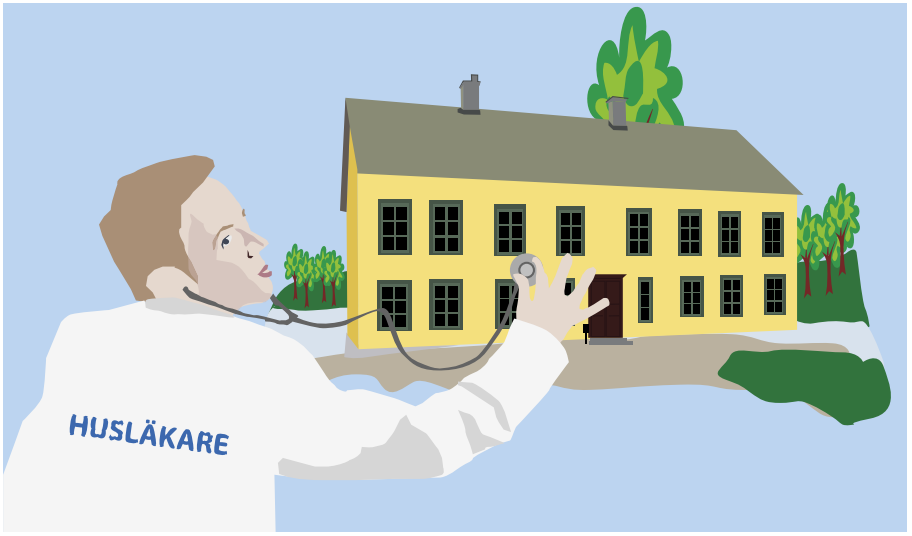
Bad lighting in the workplace is likely to make us tired as we have to concentrate harder on seeing what we are doing; headaches are also very likely as the strain on our eyes begins to have an adverse affect on us. Thankfully bad lighting tends to be relatively easy to correct and is often not too expensive to put right.

There are several things to consider in order ensuring a good lighting installation. The lighting should be adapted to the activities that will take place in the premises. For most working places it means a good, comfortable main lighting and also a correctly placed concentrated light. A common mistake is to place the concentrated lighting in a way that it shadows instead of illuminating; this tends to happen when more consideration has been given to the looks rather than the function when choosing where to locate the lights.

At the same time, the lighting system is an installation where great consideration should be taken to the shaping of the room. The lighting design is a part

Checklist for the lighting environment:

- ✔ Suitable intensity of illumination
- ✔ No glare or reflexes from sources of light or glossy surfaces
- ✔ Flicker-free lighting
- ✔ Good colour reproduction
- ✔ Well balanced light, i.e. comfortable contrasts (luminance distribution)
- ✔ Access to daylight and possibility to outside view



An annual "health check-up" ensures that the indoor climate keeps the same quality even after a number of years.

of the architecture in many premises. Therefore, lighting experts almost always have competence both on design and function; they know how the lighting can be used as a decorative feature as well as an essential function of the building.

MAINTAINING A GOOD INDOOR CLIMATE

It is wise to specify clearly how the indoor climate should be controlled and a valid set of values for the building is in place when writing the demand specification. The goal is to maintain the building's original quality, and to make sure that this will be the case, the measurements must be made in the same way every time. It is also advisable to specify in the demand specification how often measurements should be taken. If they are made every year it is easy to discover deviations early, when it will be easier and less expensive to correct.

In order for the climate to stay on the same level as when the building was new, all installations must be well maintained.

The ventilation system must be serviced correctly, filters must be changed regularly and the complete system should be cleaned every so often. No technical systems will last without servicing and maintenance, no matter how robust they are.

Service and maintenance is however often a neglected area, which can have several reasons.

A common reason is that nobody thinks about what it is that keeps the indoor climate good – as long as nobody complains. It just works and there is no need to worry. This is an attitude that exists so long as the system works. It is also an attitude that can be very expensive in the long run. Deterioration of the indoor climate often occurs gradually, the air gets worse or the noise level increases. People staying in the premises get used to the deterioration and do not react until it has gone far – often to the extent that the problem will be expensive to correct.

Another reason for neglected maintenance is that it can be difficult to maintain the systems practically. They are built in a way that they are difficult to reach once the building is ready. This is important for the architect to consider at the design stage – how can the ventilation equipment and ducting be reached for cleaning

A third reason is that the service manuals for many systems are unclear and difficult to understand. In the past, knowledge about servicing and maintenance has always been in the back of the head of those working with this. Now, the systems become more and more complex, and the demands on documentation consequently increase.

The importance of well-documented routines for servicing and maintenance can hardly be over-emphasised. Without them, the work will most probably not be performed correctly which in turn means that the system will not last as long as it should.

Servicing and maintenance of houses have many common denominators with servicing and maintenance of cars. Most cars perform well, at least for a while, even if we do not hand them in for service. Still, we choose to visit the garage at regular intervals. We know that it otherwise probably would be more expensive in the long run. The same applies to our houses.

They are probably OK without service and maintenance. But over time the performance worsens and becomes less effective and the life is considerably reduced. A building, of which its technical installations are not properly maintained risks becoming a poor investment for the owner, just like a car without a properly filled-in service book is a bad investment for its owner. The second-hand value is much lower – not to mention the possible repair costs that might fall upon oneself if keeping the car.

R1 – HERE IS EVERYTHING ABOUT INDOOR CLIMATE

R1, which is a book of about 60 pages, has the subtitle "Guidelines and specifications of requirements on indoor climate" which well describes what R1 contains. It is a rewritten and updated version of the original version, which was released previously in 1990. Using the R1 as an aid when planning a new building or a renovation project will mean great opportunities to create a very good indoor climate.

The purpose of the R1 is that everyone involved in a building project should have a foundation for specifying and evaluating the quality of the indoor climate. It is intended to function as a model (template) when it comes to the indoor climate and as such it simplifies the discussion between purchasers, tenants, architects, consultants, contractors, and building managers – in chapter 3 it says "The guidelines provide a framework for establishing the correct requirements for the quality of the indoor climate."

In order for the R1 to function as intended it must be introduced early in the process. It is an aid to be used before the system selection stage, i.e. before all decisions about installations are taken.

In the R1, all limit values are listed and explanations for these.

The publication is published by the Swedish Society of HVAC and has been produced by a committee consisting of a large number of representatives for the trade. Head author is Lars Ekberg from CIT Energy Management AB (a company within Chalmers Industriteknik in Gothenburg).

Chapter 2

Indoor climate economy

Today there are a number of research reports which show that a good indoor climate is not only good for people's health and well-being – it is also good for the economy. People who live or work in a good indoor climate quite simply are more profitable than people working in lesser environments. If the indoor climate is very poor the consequences can be serious with people's health suffering with the financial cost being met by the employer as well as the taxpayer.

This depends largely on the physical factors outlined in chapter 1, but another significant factor that should be considered is the psychological effect, though this is more difficult to measure. If we stay in an environment where we are happy and feel good, we work more efficiently. Few of us would argue that sound, light, air quality and temperature are important to our well being.

When designing a building, there are normally two topics on the agenda. The first is the building itself. The second is the budget.

With unlimited resources it is easy to build a house with a fantastic indoor climate, innovative design and perfectly adapted to the activities that the building will be used for.

However, the reality very seldom looks like that. All building projects have a fixed budget. This applies to the single-family house, which may have limit of 1.9 MSEK as well as the new university hospital with a budget over half a billion SEK. From the first brick to the last drop of paint we need to be sure we have budgeted for these costs.

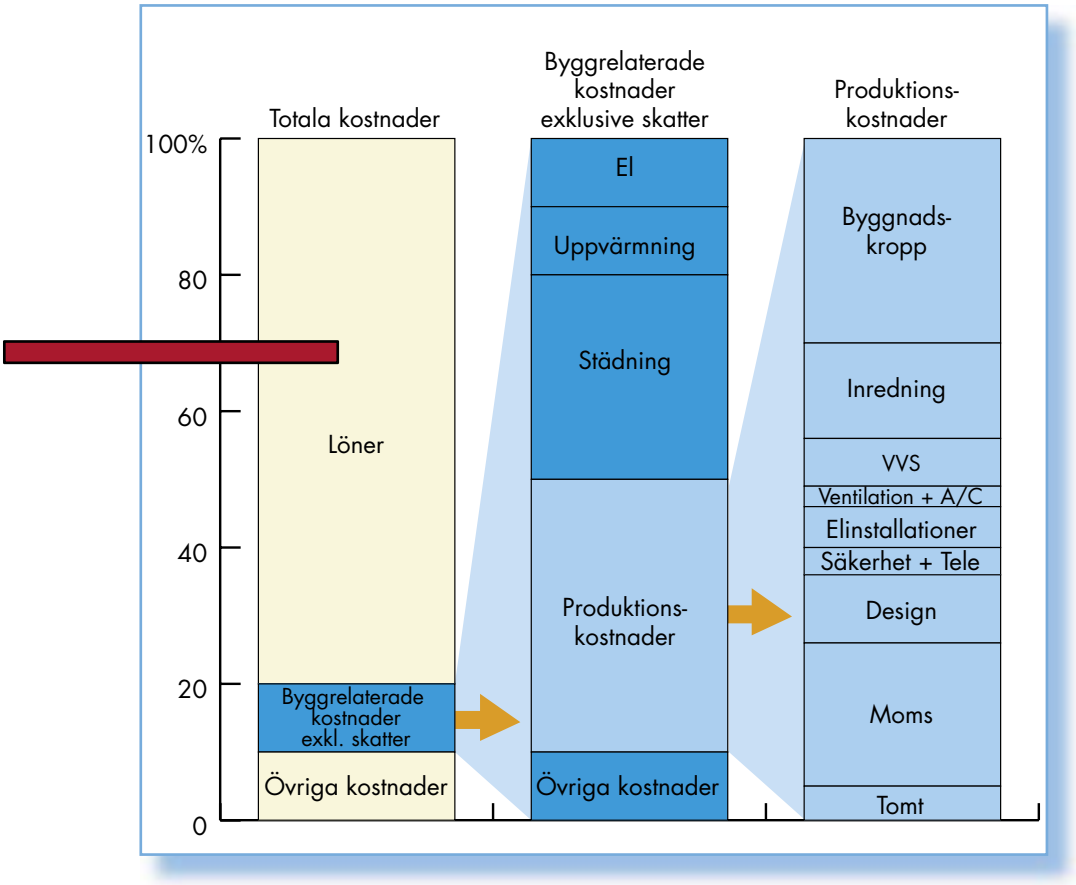
When you build a new property or refurbish an existing property in a way that you the indoor climate adds value you will have done well. But how do we add to a property's value by ensuring a good indoor climate?

Well, the following can be included:

- **A good indoor climate increases the productivity of the people working in the premises.**
- **A good indoor climate reduces the number of sick-days, which means lower costs for everyone – the enterprise, the individual and society.**

The number of sick-days will quickly reduce when the indoor climate in a room is improved. Research shows that a small increase of the ventilation in a room reduces the number of sick-days by one day per year and employee. The value of this extra working day per employee by far exceeds the cost involved with the improvement.

There is research showing that by investing in improved indoor climate, an increase in productivity of 6 percent is achieved easily. However, in order for the investment to become profitable, we only need an increase of 2 percent, the balance is pure profit.



The figure shows the relation between various costs for an office. Salaries represent 80% of the total cost while the installations are a very minor part. Source: Olli Seppänen

Profits increase with better indoor climate

Increased productivity – no matter how you define the word productivity – is good for the individual, the business and society – provided it is not achieved at the expense of something else. Increased productivity created by a better indoor climate cost nothing but an investment, which is recovered in a relatively short period of time. Such a productivity increase is consequently only positive.

But what is productivity in reality?

In 2000 researchers Leaman and Bordass defined the concept of productivity "the ability in people to increase their performance through an increase of the quantity or the quality of the product or service they deliver".

To increase productivity means either that a larger number of products are produced, or that fewer people are needed to do the work, in comparison with the fixed cost at hand. Increased productivity means that one gets more output without investing more.

The indoor climate has a great impact on several of the factors that affect productivity the most. A few examples of factors which should be considered

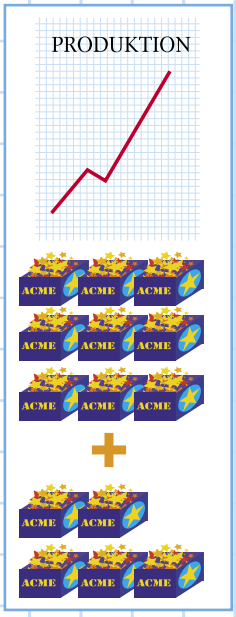
EXAMPLE

The company Acme Production manufactures the article "article".

Short term absence due to illness in the company is 2 percent, so as an average 8 people out of the 400 employees are absent every day. This costs the company (gross) almost four MSEK in a year.

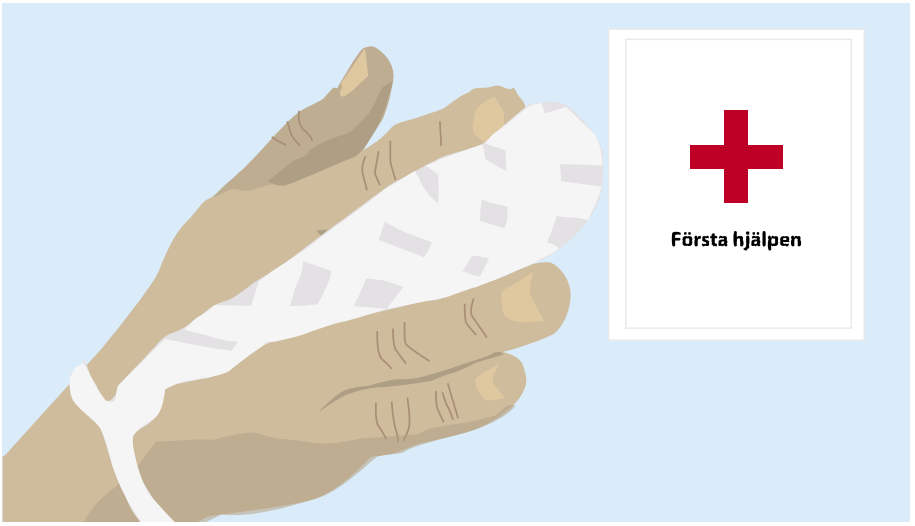
Acme rebuilds the factory premises and improves the indoor climate, a reasonable cost for this in a factory for 400 people is about 500 KSEK

As a result of the rebuilding, the absence goes down from eight to seven people per day, which reduces the costs for them from 4 MSEK to 3.6 MSEK in a year. The investment of 500 KSEK is in other words paid-off in just over a year, purely by reducing employees sick days. As a bonus, everybody's well-being improves as does the productivity that increases the profitability for the company.



to measure the relation between indoor climate and productivity are:

- **Sick leave.**
- **Number of injuries and accidents.**
- **Rate of work and interruptions.**
- **Accuracy and attention to detail.**
- **Cost per produced unit.**



Who gains from better indoor climate?

The simple answer is everybody.

The owner gains as it is possible to charge higher rent for a building in which the indoor climate demonstrably is very good.

Companies renting premises gain as their employees are more efficient and not sick as often as others.

People living in the property also gain, as the risk of being subjected to asthma and allergies is considerably lower.

Below a summary of a number of calculation examples published by Professor Olli Seppänen at Helsinki University of Technology in the book Indoor Climate and Productivity in Offices. The examples are intended to

show how long it takes to pay off an investment for a better indoor climate. The investment is paid off by increased productivity with those working in the premises, reduced number of sick days and people who work more efficiently among other things. Professor Seppänen´s calculations show that the pay-off time for the investment is between four months and a couple of years, depending on how costly the investment is and how big the improvement is.

EXAMPLE 1 – TEMPERATURE

Many offices have too high a temperature as sun is not being properly screened off. Furthermore, there are often many sources of heat such as computers, copying machines and printers in the premises. People also heat the air merely by being present. The ventilation and the cooling system in place is not enough to keep the temperature down. Those who invest in a system for reducing the temperature can recover the investment in 12 months only through the resulting productivity increase. The investment is then paid off; however, the profit from the increased productivity remains. So, one year after the refurbishment, the investment gives an actual profit.

EXAMPLE 2 – VENTILATION

In a building situated in a climate like the one we have in the South of Sweden, an investment in a ventilation system that improves the indoor climate will be paid off in between four months and two years. The conditions include that the premises have "unacceptable indoor climate". The cost for the investment is much lower than the value of the increased productivity and in most cases the pay-off time for the investment **will be very short.**

EXAMPLE 3 – FREE COOLING

One of the fastest ways to pay back an investment is to use the cold night air to cool down premises. Especially in the summertime, when the daytime temperature can be high both inside and outside, this "free of charge" cooling becomes very effective. The value of the productivity increase is according to performed measurements at least 20 times higher than the cost incurred by the increased energy consumption. The increased energy costs depend on the fact that the plant is run during a longer period every day. Investment in new equipment is not necessary, which means that the measures will have a very short payback time.

EXAMPLE 4 – AIRFLOW

When increasing the airflow from 6.5 litre/second and person to 10 or 20 litre/second and person in an office, the profits in form of increased productivity is almost 10 times higher than the cost for the increase. The cost consisted of investments, maintenance and energy. Pay back time for the investment was 2-3 months.

The following figures were used as basic data for the calculation of pay off times above:

Value per worked hour/person: 30 Euro

Floor area per person: 25 square metres

Investment cost: Up to 272 Euro/square metre

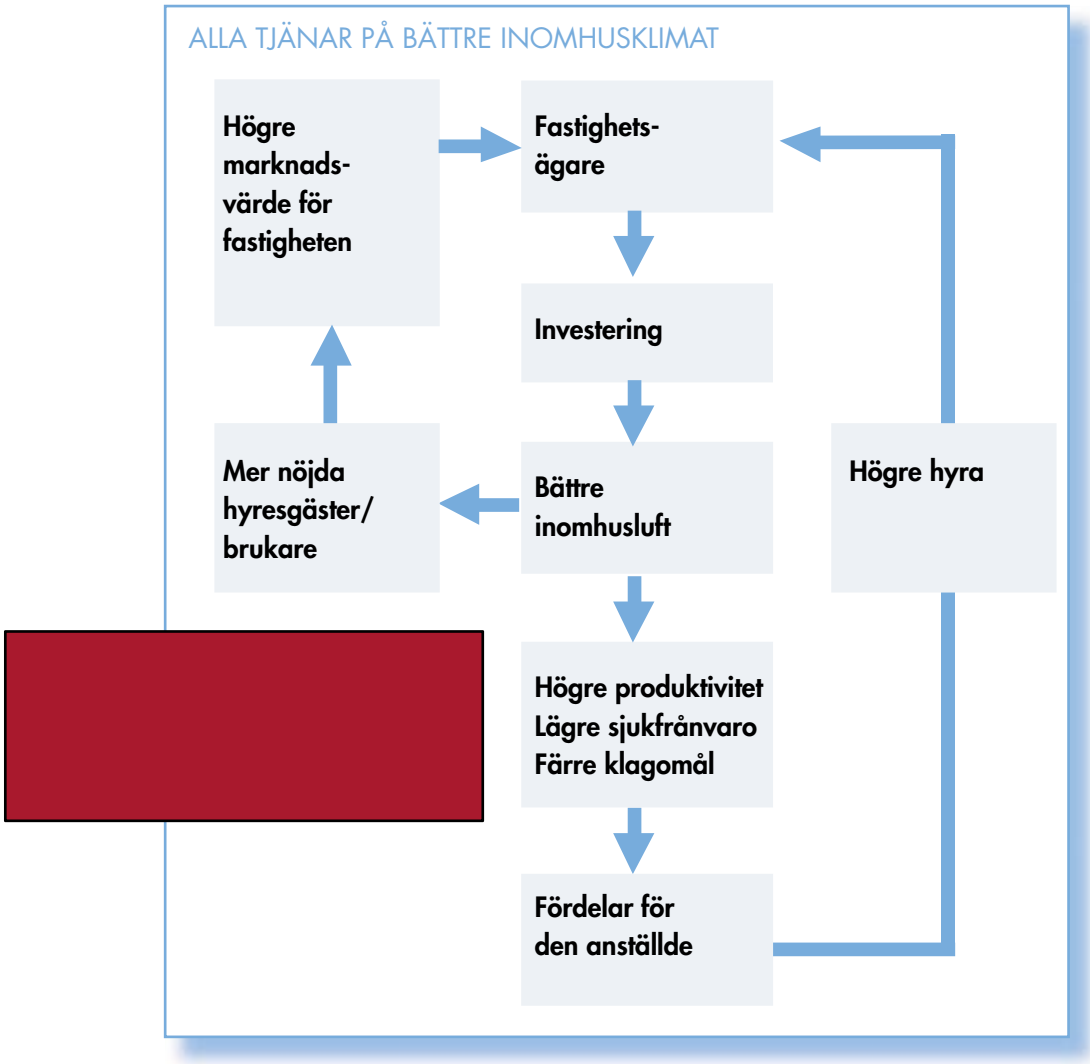
LCC – the true cost

The cost for a technical system is nowadays calculated according to LCC (Life Cycle Cost) – consequently the cost of a system over its entire life cycle. Previously only the purchase price was considered.

It is easy to fool oneself if we only calculate with the purchase price and installation cost. A system that is cheap to buy is often extremely energy-intensive to run. Energy-intensive systems are expensive to own. To get a better idea of how much a system costs, the following items are included in LCC:

- **Purchase price.**
- **Installation cost.**
- **Service- and other running costs.**
- **Life time expectancy.**
- **Dismantling cost, sometimes even disposal costs.**

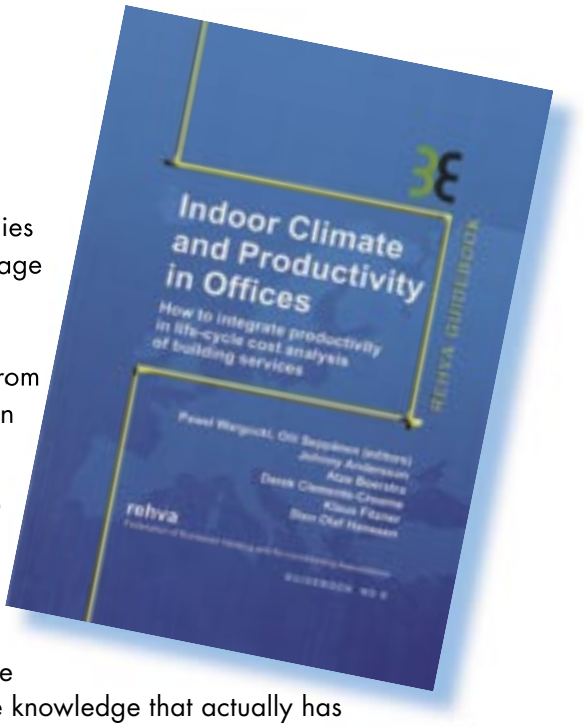
A normal ratio between purchase price and LCC is 10-90; the purchase price is in other words only one tenth of the total cost for the system.



One example showing that the gains from the investment in the indoor climate not only goes to the building owner but is shared with the tenants. Source: Olli Seppänen

Research reports

There have been a number of research studies made around the world concerning the linkage between indoor climate and both people's health and productivity. A few of them are described below. The examples are taken from the book "Indoor Climate and Productivity in Offices".



IMPROVED INDOOR CLIMATE MEANS INCREASED PRODUCTIVITY AND BETTER HEALTH

A number of researchers have over the last years studied the effect of the indoor climate on office workers. They confirm much of the knowledge that actually has been available for a considerable time - but which has had no support from research as the area till now has been relatively unexplored. There is also some new information, principally in form of figures supporting the thesis that it pays to invest in good indoor climate. There are often small improvements being made, the measurable result is none the less greater. Below some examples:

- **Nurses working with telephone counselling wrote their reports 16% slower when the temperature was above 26°C. (Federspiel et al, 2002)**
- **Staff efficiency in a call centre increased by six percent when the supply air was increased from 2.5 l/s per person to 25 l/s per person. (Wargocki et al 2004)**
- **Short term sick leave was 35 percent lower in an office building in which 24 litres of air per second and person was supplied compared to a similar building where 12 l/s was supplied. (Milton et al, 2000)**
- **The typing speed increased by 6.5% and the number of typing errors was reduced by 18% in a group of people who were working with text typing when a 20 year old wall-to-wall carpet was removed from their office. The complaints about bad air in the room decreased from 70% to 25% of people entering the room. This study has been repeated in another country with similar result. (Wargocki et al, 2006b) and the conclusion can be drawn that the perception of really bad air quality in**

office environments is an indication that also the work efficiency is markedly lowered.

- **Increased indoor temperature, reduced ventilation and bad air quality can be linked to the presence of SBS-related (SBS, Sick Building Syndrome) symptoms as headache and mucous membrane problems. (As shown by among others Mendell 1993, Mendell et al 2002, Seppänen et al 1999, Seppänen and Fisk 2002, Wargocki et al 2002b, Wyon and Wargocki 2006a and b).**
- **The flickering from fluorescent strip light reduces the comfort with those working in the premises and it also has negative health effects (Veitch and Newsham, 1998).**
- **To be able to control ones local environment, in other words change ventilation, sound, light and temperature, reduces symptoms that can be linked to sick buildings (SBS) considerably. In a Dutch study SBS-related sick leave reduced considerably (with up to on third) when the possibility of individual control increased. (Preller et al, 1990).**
- **In a study performed in a laboratory environment, researchers showed that same people performed considerably better when they could control the ventilation at their work place than when this was not possible. They made fewer typing errors, they suffered less headaches and they thought that their capacity for thinking was improved (Kaczmarczyk et al, 2004).**

THE MASSACHUSETTS STUDY – ABOUT SICK LEAVE AND AIR

The Massachusetts study is one of the studies which most distinctly shows the connection between indoor climate and productivity. The researcher Don Milton at Harvard University had led a large field study on how much people were affected by, among other things, varying degrees of ventilation.

Those who worked in areas where only the minimum requirements on airflow were met had fifty percent higher illness-related absenteeism than those working in areas where the airflow was twice as high.

The annual loss in productivity for those working in the premises with lower airflow was in year 2000 estimated at USD 400 per person.

A very common reason for lowering the airflow is to save energy and thereby lowering the costs. The direct cost is also lowered, but the costs for sick leave and reduced productivity increase. Don Milton´s study shows that the costs for sick leave and loss in productivity are far greater than the savings made on energy.

SIMULATION ABOUT INVESTMENT PAYING OFF

Researchers P Wargocki and R Djukanovic at the Technical University of Denmark north of Copenhagen showed in 2005 that the profits from increased productivity with people working in an office equipped for improving the indoor air by far exceed the cost for the measures taken. The profit in productivity was many times higher than the increased running costs. Even if one takes the initial investments into consideration and the Life Cycle Cost, the profits are still considerably higher than the cost. The measures that were simulated were increased air exchange and choice of low-emission building materials (in other words materials with lower emission of volatile organic compounds to the air).

STUDY OF NIGHT COOLING

An old and well-tried way of cooling buildings is to use the cold night air. Before, it was done by simply opening a large number of windows, today few people would put into their heads the thought of leaving the windows open for intruders. But we want to use the cold air. The gain from this is that refrigerating plants will not be needed to cool the air, the cooling is free.

A number of researchers, among them Dr Maria Kolokotroni, Brunel University, England and Olli Seppänen at Helsinki University of Technology, Finland have studied the result from night cooling. To keep the ventilation running during night time costs in the example of the researchers between 0.09 and 0.37 Euro per person and day (depending on the energy price).

This cost is however very quickly compensated by the fact that the people working in the building become more productive when the ventilation has been running during the night. Without night ventilation, working time is lost – on average 17.2 minutes per person. These 17.2 minutes are converted to money 7.15 Euro per person and day – or 1 573 Euro per person and year. In theory, pure profit for the business. With 100 employees the productivity increase will be in the million class per year, a very easy way for a business to make more money.

STUDY OF ALTERNATIVE TEMPERATURE CONTROL

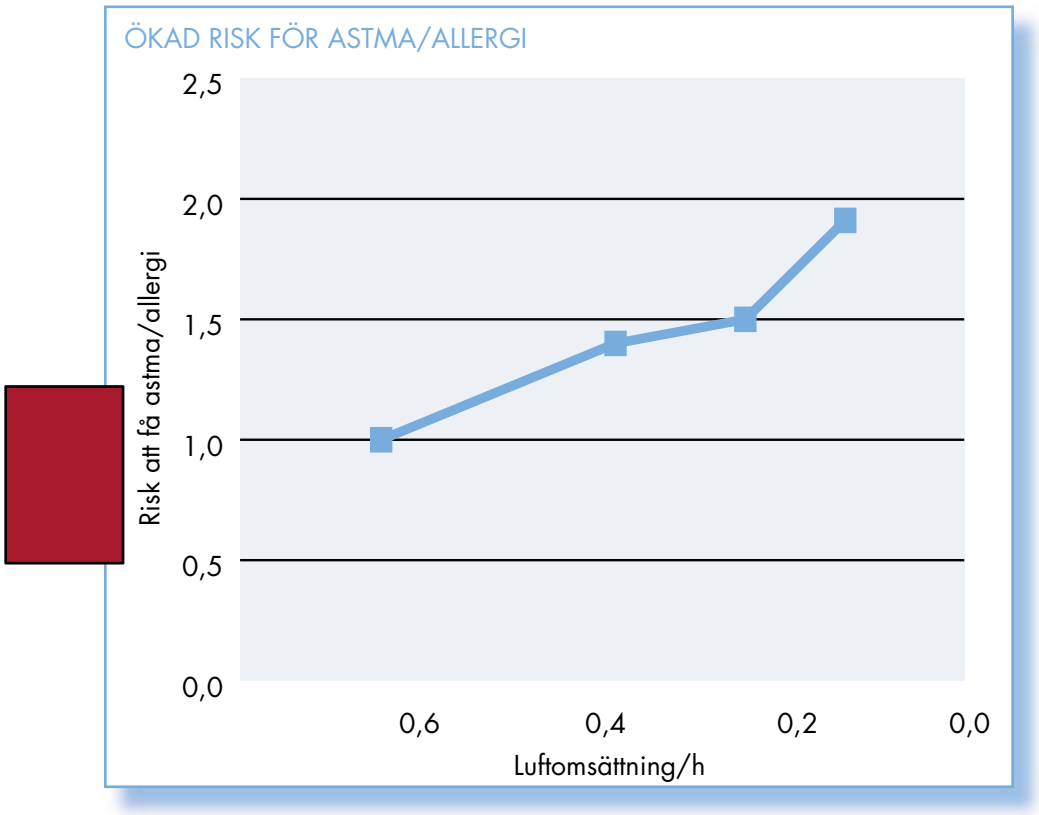
The researchers M Vuolle and Olli Seppänen at Helsinki University of Technology, Finland have studied various ways of cooling office premises, and what effect this has on productivity. The researchers used one floor with 50 small offices. The building had always had a simple fan controlled ventilation system.

Three different methods of lowering the temperature were used: increased ventilation (i.e. ventilation during a greater part of the day), increased airflow without mechanical cooling and system with mechanical cooling.

The result was that all improvement of the cooling gave increased productivity. The conclusion drawn was that the cost increase of the investment and the increased energy use was very quickly recovered as the productivity increased.

THE VÄRMLAND STUDY

The biggest study in the world on how the indoor climate affects the health of children right now proceeds in Värmland, Sweden. The Technical University of Denmark in cooperation with SP Technical Research Institute of Sweden and Karlstad University, Sweden and some 20 other institutions in In



Children living in well ventilated homess are more likely to avoid asthma and allergies.

2000, researchers Jan Sundell and Carl-Gustaf Bornehag contacted all the families in Värmland, Sweden who had children between the ages of one and six, in total 14 000 families. 8 000 families with 11 000 children responded to the survey they had received.

Of the 11 000 children, 400 were selected for an in-depth study. Half of these 400 children are healthy, half of them with severe allergies or asthma. Through careful studies of the children´s health and their home environment it has been possible to establish that ventilation has an impact on how well the children feel.

A good air exchange rate does not remove the risk for asthma or allergies but children living in well ventilated homes have better chances to stay healthy. It has also been established that the majority of dwellings are too poorly ventilated. 60 percent of all apartments and 80 percent of all single-family houses do not fulfil the Swedish requirements for air exchange.

Safety and indoor climate

It is quite obvious that a poor indoor climate will make the people staying there feel worse and perform worse, but their impaired performance and health can also mean a direct danger to other people.

A person working in a warm room gets a reduced ability to concentrate. He or she gets tired easily and the headache is normally not far away. For most people this only means that our work suffers, the result is not as good as it could have been, but it is not dangerous.

The situation becomes a little bit different if the person in question is an air-traffic controller and has responsibility for directing a number of airplanes to and from an airport. No one on board these planes even wants to think the thought that the control officer who controls the air space around them has a headache and is tired because the ventilation is inadequate or the light from the ceiling lamps is flickering. The mere thought that so simple things can mean so enormous consequences is horrifying.

There are many other professional categories whose actions can have very serious consequences for others – solely due to a poor indoor environment.

Doctors and other nursing staff must not lose concentration, one of the most common consequences of bad indoor air.

The same is valid for drivers and engine drivers. Drivers however have an advantage over many others, the air handling systems of most cars today are much more advanced than the systems we have in normal offices and dwellings. Most of us, in other word, care more about how we feel when we drive the car than when we are at home or work.

Cars nowadays often have individual control of the climate; the driver might have temperature preferences different from the passengers.

A good indoor climate also reduces the risk for working site accidents. When one is tired and has a headache it is easy to be careless about the safety or not to see a slippery and wet spot on the floor.

A good indoor climate costs – but is profitable

The most common reason for a building not having a perfect indoor climate is that one has wanted to reduce the building costs, or that one has underestimated the costs of running it.

It is correct that the building costs will be lower with fewer or inferior technical installations for air quality, sound, light and temperature.

It is also correct that some of these installations cost money to keep in operation, especially ventilation that consumes energy and with todaý´s high energy prices the running costs quickly become noticeable.

Still, we are only cheating ourselves by cutting back, thinking we are saving costs.

On the contrary, it will be more expensive in the long run with poor indoor air.

1) **A good indoor climate increases people's productivity and improves their health; sick-related absenteeism is reduced and people work better. This means direct profits for the companies that have fully realized the connection.**

2) **Modern installations reduce the energy costs. The systems can be demand controlled, they have heat recovery and all components as well as the systems as a whole become energy effective if properly designed and planned. Those who invest in such a system pay off their investment within a few years due to the fact that the energy costs will be greatly reduced.**

SAVE THROUGH MODERN INSTALLATION TECHNOLOGY

Historically, the buildings technical systems have been big energy users. This is not the case anymore; on the contrary, the development has made it possible to reduce the building's total energy use with these installations. Below some examples on how to achieve this:

- **SYSTEM SOLUTIONS** Modern systems are energy effective. Here it is important to think about choosing correctly, an unnecessary large system will consume extra energy without creating increased value. Heat recovery and demand control also helps towards keeping down the energy use.
- **HEAT RECOVERY** can be arranged in all types of systems, for example ventilation, heating and cooling systems. For effective recovery, the equipment must have high efficiency.
- **DEMAND CONTROL** means that the installations are used only when needed. This is for many people a matter of course as far as lighting is concerned, but also heating, cooling and ventilation can be demand controlled. The control can be automatic or manual and can often be installed in an existing system.
- **COMPONENTS** Energy effective components should be chosen to greatest possible extent. Here one should choose the best quality products possible, for example energy effective light fittings and air handling components with low static pressure. As far as the installation of the system into the building is concerned, it is crucial how the various components are combined into the system.
- **COMMISSIONING** A poorly commissioned system can have an almost nonexistent function, at the same time as it uses a lot of energy – totally the opposite situation from the one intended when the system was built.
- **SERVICE AND MAINTENANCE** Today it is obvious that servicing is important, all technical systems must be maintained in order not to lose any functionality or effectiveness.

Chapter 3

Indoor climate classification

Most people agree that the indoor climate is important, but how do we know what kind of indoor climate a building has? Are we expected - as an intending buyer – to find out for ourselves? Or is it the responsibility of the owner of the building to know? Indeed, does anyone have the responsibility to know? If so, who?

It is a given that it is in the owners and the managements interest to convey the knowledge that a building has a very good indoor climate, but how should they do if the indoor climate is not the best?

The hotel world has for many years worked with a system which is simple to understand and has been accepted by almost everybody. The hotel owners use it, as do the travel companies and the consumers. Of course we talk about the marking scale from 1-5 stars.

Those of us who stay at a five-star hotel is prepared to pay more, but expect everything from excellent service to high quality of equipment and food.

Those who choose to stay in a one-star hotel pay considerably less – but do not expect the same quality offered in a five-star establishment.

The thought behind the system is that we have the choice to accept or reject a hotel based on its classification.

A similar system can be used for indoor climate. A five-star indoor climate is a selling point, and something which many people surely would pay a little extra for. A five-star indoor climate makes us feel better, we perform better, and our well-being improves.

As with the marking scale of hotels, of course there is a problem with the fixing of boundaries. Where exactly is the dividing line between a good three-star and a half decent four-star hotel? Is it the glazed tile in the bathroom, the beautifully folded towels or is it the quality of the breakfast buffet?

Marking is always a combination of subjective and objective factors. In order to get highest mark when it comes to indoor climate, however, the

highest measurable requirements specified in the R1 must be fulfilled. The lowest mark corresponds to the requirements from the authorities. Light cannot vary and consequently only has one class. In the star system we take for granted that the lighting installation meets the requirements of the authorities.

The R1 contains all definitions of different values and descriptions of what the values mean in practice.

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5-star indoor climate 

The 5-star indoor climate meets with the highest requirements specified in R1. A 5-star indoor climate is a climate which is not noticeable. The sound is pleasant to the extent that it exists. The lighting is well thought-out and functional. The air is clean and is changed frequently. The temperature is perfect.

Decisive for whether the indoor climate gets 4 or 5 stars is if the individual can influence the indoor climate. Can I, at my work space get higher or lower temperature? Can I change the lighting? Ventilation? Only premises where the indoor climate can be individually influenced can get a 5-star rating.

A 5-star indoor climate is the best possible basis for feeling good in the premises. In a work place this means higher productivity and increased comfort, at home it means increased comfort and well-being. In all places it means better health and consequently lower absence due to illness.

4-star indoor climate 

The 4-star indoor climate has the same requirements as the 5-star indoor climate. The difference is that the users cannot control the climate individually, so in a 4-star indoor climate it is not possible to have a higher or lower temperature in a separate room or to control smaller zones in larger rooms.

For those working in the premises it means slightly lower comfort and well-being, the number of those dissatisfied will increase. However, the number of those dissatisfied is limited; the indoor climate is adjusted to suit the great majority of people.

The difference between the 5-star indoor climate and the 4-star indoor climate can be compared with a car with an individual climate system and a car without it. In the 5-star environment every person can adjust the temperature of their choice where they sit, the front seat passenger might want a slightly higher temperature than the driver prefers.

3-star indoor climate 

In the 3-star indoor climate, deviations from the strictest requirements for maximum one of the three parameters (noise, air quality and thermal

climate) are accepted. The deviations must never be greater than 10 percent except for temperature which must never be less than 20°C.

During summer-time one must accept room temperatures slightly above those normally considered as comfortable (comfort limit normally max. 24°C.

The risk of disturbances in the form of noise, draughts and heat radiation is minor.

This is still a good indoor climate even though it varies more than the higher classes. It puts higher demands on those staying there to adjust their activities and clothing according to existing circumstances

If we continue to compare with vehicles, one could say that the 3-star indoor climate compares to a motor coach. It is a good climate but it is the same for everybody and it varies a great deal depending on loads (for instance direct sunlight and number of passengers).

2-star indoor climate 

In the 2-star indoor climate, deviations from the highest values of two of the three parameters (noise, air quality and thermal climate) are accepted. The deviations must not be greater than ten percent except for the temperature which must never be less than 20°C.

During summer-time one must accept room temperatures slightly above those normally considered as comfortable (comfort limit normally max. 24°C.

The risk of disturbances in the form of noise, draughts and heat radiation is minor.

1-star indoor climate 

In the 1-star indoor climate, deviations from the highest values of all three parameters (noise, air quality and thermal climate) are accepted. The deviations must not be greater than ten percent except for the temperature which must never be less than 20°C.

During summer-time one must accept room temperatures slightly above those normally considered as comfortable (comfort limit normally max. 24°C.

In the 1-star indoor climate, certain disturbances in the form of odours can occur directly after the entering of the premises.

A 1-star indoor climate meets with the minimum requirements for indoor climate put forward by the authorities. A building must have a minimum rating of One Star.

Planning is everything for a successful result

A common language and guidelines, easy to understand and follow. This is what many people consider most important with the new R1. Here we have the views of three people on how they think the R1 should be used.

– The strength of R1 is that you find a common language which is very useful for discussing and reaching an objective level for various solutions in a comprehensive way.

This is what Martin Erlandsson member of management of the department for environment performance at IVL Swedish Environmental Research Institute Ltd., concludes. The various classifications make it, according to him, easier for construction clients and suppliers to keep a dialogue through the complete process - a simple and robust support for the communication.

It should be natural for the Construction Client to bring the R1 into the process already from the outset but as everybody concerned will benefit from a good and easy to understand communication tool, also the suppliers should be anxious to use the R1 from the start as well. For the Construction Client, who is not necessarily familiar with all details of the various technical solutions for noise, air and light, the tool offers a common language that makes it easier to make the requirement levels clear.

Should be supplemented

Martin Erlandsson is satisfied with R1 but means that it should be added to in the long run.

– R1 offers a language for the dialogue, so one can clearly define the ambition level as functional requirements but when it comes to concrete contract signing we also need a tool for getting verifi-

Martin Erlandsson

able performance measurements linked to the functional requirements. If one can verify a level, one can also specify it in the contract and follow up that the desired level has been reached.

If one has used the advice from R1 as a basis for the discussion, it will lead to concrete measurements for the project leader but the technique of measuring for how one should establish whether measurements have been reached also needs to be formulated.

Erik Westin

Erik Westin is responsible for project management and administrative support within Akademiska Hus in Stockholm and has taken the initiative and also ran a project for developing a form for parallel assignments with installation solutions.

Parallel assignment is a process where several consultants are commissioned to present their technical solutions based on the same given conditions. The difference from a traditional process; as for instance architecture competitions; is that the Construction Client is involved in the process

Important prerequisite

The objectives are among other things to arrive at more creative solutions, solutions that can be integrated into the building as a whole and contribute towards the goals set.

One prerequisite for reaching those solutions is that we have to adequately describe what functional requirements are put on the building. The R1 contains instructions for how functional requirements can be set up and be measured for thermal climate, indoor air quality, acoustics and lighting. In the parallel assignment, R1 becomes an important tool for the Construction Client when making clear the levels that will later be balanced with building costs and future operation costs.

– The idea is that we should give better possibilities for creative suggestions to come forward, but above all that we more effectively reach the goals we have set for the building. One part of that objective is to give scope for the participants to

question the prerequisites and offer other ideas, says Erik Westin.

Test project carried out

R1 is a good tool for these discussions and in an actual project a process schedule was produced where energy calculation and indoor climate requirements existed in the earliest stage. To test the ideas in practice, a pilot project concerning a potential new building on the KTH grounds was carried out at Akademiska Hus during spring 2006. The pilot project which is a parallel assignment including both installation solutions and formation exceeded beyond expectations according to Erik Westin:

– We have had three creative and good proposals for evaluation, all of which manage to balance between the indoor requirements and low energy consumption and which also contain very exciting architecture.

Lars Ekberg, Ph.D and a project manager at Chalmers Industriteknik.

– One cannot use the same old formula for all buildings, he points out.

He means that the old R1 used number crunching and absolute values instead of looking at the architecture, function and operation of the building as a whole.

Both easier and more difficult

– One could say that whilst the new R1 is a support for the construction client, it has made life more complicated as it demands knowledge about the building as a whole and how we achieve our ambition level for the buildings use, says Lars Ekberg and points at a substantial difference:

– In the old booklet there was a page with tables of thermal indoor climate, i.e. room temperature with various values and various levels which were desirable.

What then might have been missed was that all these figures assume that the premises would be used as an office, i.e. with sitting people with for office work normal clothing. Now it is necessary to reconsider matters and based on what the premises are going to be used for decide on those temperature limits. This invites a more purposeful way of working, says Lars Ekberg.

Lars Ekberg

– Now there is also a considerably more complete reference list as the R1 is a compilation of the established knowledge available. If one wants to, it is easy to track all information and go further if need be. It also gives a good overview of norms, standards and guidelines, that helps lead us through the handling of indoor climate issues.

Several large buyers have already introduced R1 as a part of the process and the prospects are that more and more will realize the benefits of using it.

– A buyer can use R1 as a basis and then add his own demands and guidelines towards his suppliers.

– In a similar way the HVAC consultant can benefit from the R1 when motivating and explaining to the buyer why a certain solution has been recommended.

Used correctly, the R1 results in measurable levels for the planned building and those levels have been set according to how the building is going to be used.

– What is perhaps missing is a handbook showing how to measure how these levels have been reached - quite simply, about techniques of measurement, explains Lars Ekberg. It became too extensive to include in the R1, but hopefully such a handbook can be produced at a later date.

Flexibility and adaptation of resources become key words as one goes from directly specifying general absolute requirements to giving guidelines for how one in the earliest stage through discussions shall set requirement levels for the building in question.

– Of course there are still regulations about highest or lowest target values for the indoor climate, but what is important is to start a dialogue between the construction client and those who will design the technical solutions so that the result will become as user friendly and functional as possible within the financial framework. With the help of the R1 we can perform a consequence analysis both for the users and those managing the building before even starting the planning process for design and installations.

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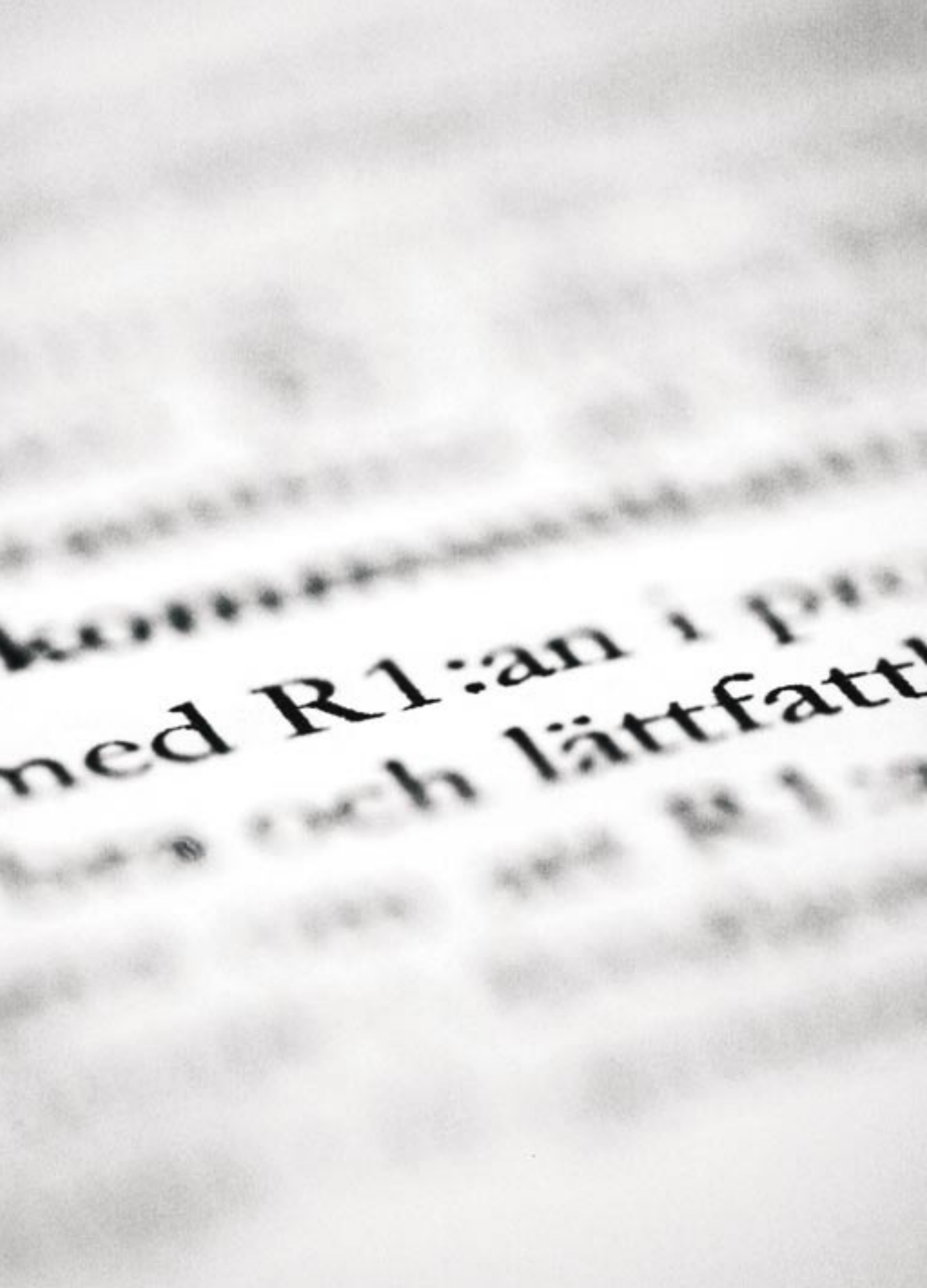
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For the individual, a good indoor climate means that we feel better and work more efficiently.

For the company it means fewer sick days taken and higher productivity.

For society it means lowered costs as there will be fewer people taken ill, resulting in a strain on the health service and the welfare state.

Everybody gains from a good indoor climate.

This book shows how to create a good and profitable indoor climate.

The knowledge is there, the technology is there and from springtime 2006 there have been comprehensive guidelines in place. The guidelines can be found in the book R1 which is a set of rules and regulations for the indoor climate. The book you are holding in your hand is a guide – here we will show you, with the help of R1, how to create a fantastic indoor climate.

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