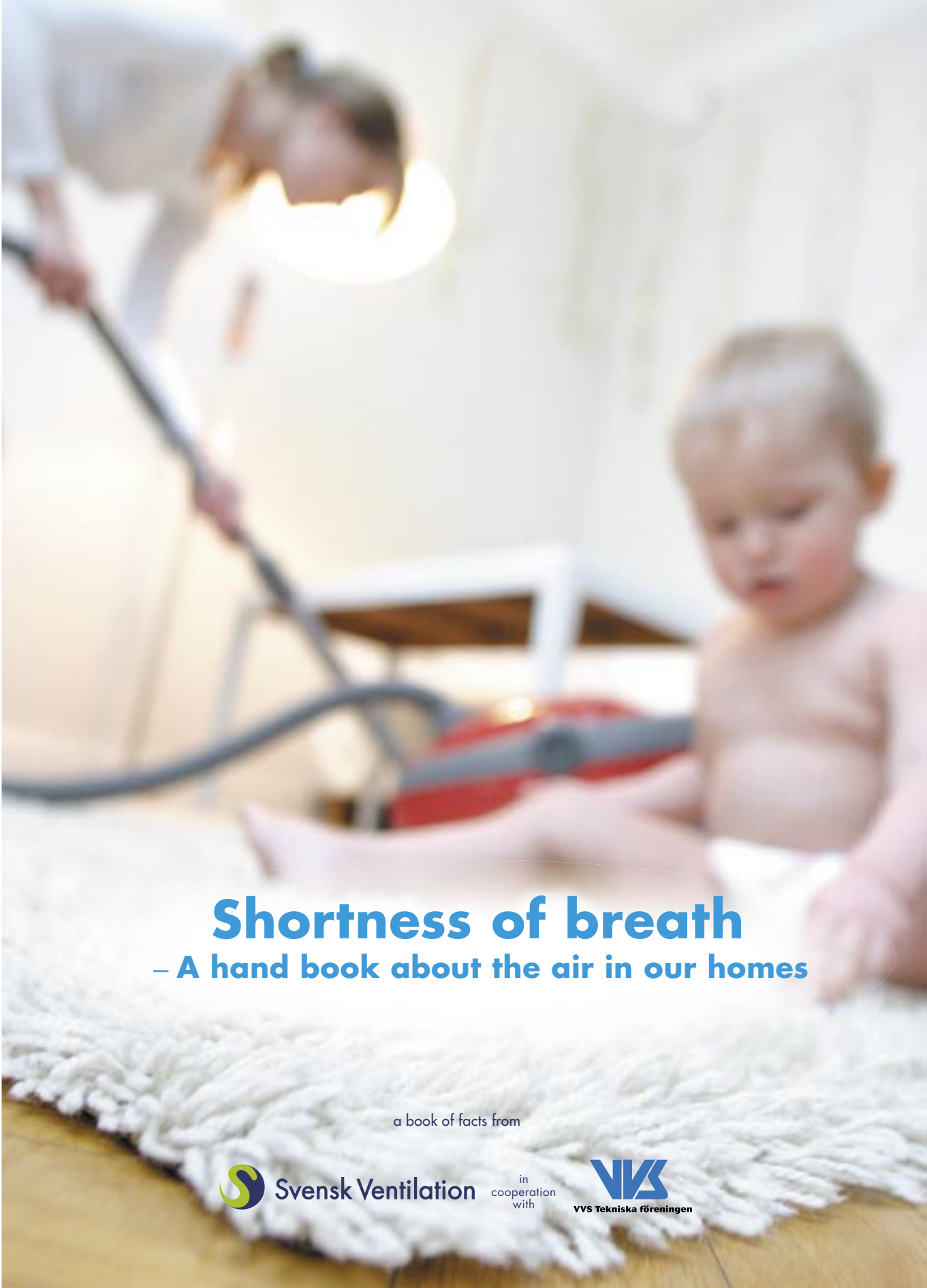

Shortness of breath

– A hand book about the air in our homes

a book of facts from

Svensk Ventilation

in cooperation with

VVS Tekniska föreningen

Shortness of breath

– A hand book about the air in our homes

Contents

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Foreword

This guide was originally written for Sweden but it is felt that what is relevant for Sweden is equally relevant for any country. You may feel that some of the studies do not apply but you will find it is quite easy to transfer situations to our own. This is a thought provoking work that warns us of the dangers of ignoring the air quality in our homes.
Good air makes us feel better. Most people spend a considerable part of their lives at home, children more than adults and infants almost all of the time.

For them, the quality of the air they breathe in the home is especially important, as diseases such as asthma and allergies are established in out childhood years. Today's research shows a clear connection between stale or contaminated indoor air and ill health. Good indoor air makes us healthier.

Swedish outdoor air is good, among the best in the world.
Indoors the situation is a different matter. Each year almost 500 people die from the air they breathe in their homes. The big villain of the piece is radon, which in combination with smoking (active or passive) is life threatening. Hundreds of thousands of dwellings in Sweden have radon readings that by far surpass valid limits. So, people die from the air in their home.

Others may only get ill from the air they breathe in their home. We notice an alarming increase in the number of asthma- and allergy patients in our hospitals. Today, approximately 40 percent of all children are asthmatic or suffer with allergies. Going back a couple of generations, these conditions were uncommon and few people had even heard of someone with asthma.

All of this is well known. Yet, very little is being done about the air in our homes. When air quality is on the agenda for discussion in the parliament, the topic is almost always pollution outdoors. Research being done in Sweden mainly deals with the outdoor environment.

The indoor environment, mainly our dwellings ought to be equally important, by rights more important. We spend considerably more time indoors than out-doors, here in the north we spend 90 percent of our time indoors. Indoor air consists of outdoor air becoming further polluted by everything that is inside the house and therefore per definition almost always is worse

than the outside air. Although something can be done about it, it rarely happens.
We all share the responsibility for the present situation. The information about the importance of indoor air quality and how bad it is at times has been insufficient for many years. Most people show a scant interest in these issues although it has to do with our health and well-being. Many of us worry about installation, energy costs and noise when we start thinking about ventilation – not health and well-being. In the building industry ventilation is often looked upon merely as an additional cost and there are consultants and architects who sometimes overlook ventilation when designing a house.

All of this is probably a result of the fact that air is something we take for granted. A bad, or even more evident, a sewer system not yet installed will undeniably be noted, it's the same thing with electricity. It is easy to detect and complain about a poor electrical system, but breathing is possible irrespective of a good or a bad ventilation system.
Another important aspect of ventilation is energy. Good ventilation needs energy to function but it can still be an energy saving measure. Through a ventilation system with heat recovery and on demand regulation, the total energy consumption of a building can be reduced. This is even more important now that the Swedish environment goals mean that we must decrease the energy consumption substantially.

Everybody who owns a house has a responsibility for the indoor environment of the dwelling to be suitable to live in. This includes a responsibility for the health and well being of the people and this is of course valid whether the house is a single home or a block of flats and whether the owner is a person, a company or a housing association.

We have written this guide, as we want to show the importance of good air at home. We also want to show that it can be a relatively simple installation, both in existing houses and when constructing new houses.

Ingvar Ygberg
Svensk Ventilation

Chapter 1

Good air at home – a necessity

Most of us take it for granted, whether at home, away, in or out, that the air just is there. Almost regardless of what is happening, we have air to breathe and we take for granted that it is good enough.

The question is, however, what "good enough air" really is.

Outdoors, the air in Sweden is on the whole adequate almost anywhere and any time. But what about indoors? In our homes?

We know that almost 500 people die every year on account of bad air. It is mainly radon that kills. The number comes from The Swedish Radiation Protection Agency.

Many of us spend at least half of the time at home in our houses and apartments. Radon that can come from the building itself or the ground beneath it or even a local water source is the most dangerous pollutant that can occur naturally in our homes. Its effects can be intensified if smoking takes place. However, there are many more substances that pollute our indoor air and that we –often with simple measures- can neutralise.

All air is polluted to some degree. Normally we think about car exhaust gases and various other types of emissions when we discuss these things. This type of pollution is always present in the out-door environment and gets into our homes with the air. Other sources of pollution are our furniture, electrical equipment, pets and of course, people. Untreated air coming into our home will carry any number of pollutants with it. After it has entered the building the pollution gradually grows worse. Due to the fact that our homes are normally well insulated and often have double-glazing the air tends to linger. It's an unfortunate fact, but the better our home is insulated the more likely it is that the air quality will be poor.

Good air at home not only means increased well-being, but also that we perform better. We work better and we manage more. For children, good

air is even more important. They avoid asthma and allergies, diseases that are being established early and which according to many researchers largely depend on the indoor environment.

In a dwelling that is being ventilated according to present Swedish regulations, half a room volume is being supplied per hour – the measurement being used is always – air change per hour (the demand is .5 air changes per hour). This is a low number, a higher rate is important, especially for people suffering from asthma and/or allergies. A study performed at the Harvard University in the USA shows that people working in premises ventilated in accordance with minimum air change requirements showed 50 % higher absence than those working in premises where the airflow rate was doubled.

The study concerned working places but there are good reasons to believe that we are also positively affected by higher airflow rates at home. The Värmland study (page 64) shows a clear relation between low air change rates and high frequency of asthma and allergies.

Good air at home can also be combined with low energy consumption as shown in the article about the new houses at Lindås (page 60). Ventilation has one main aim. It should take away all pollution generated in a building and replace the poor air with clean air. The demand we put on the ventilation is that it shall function regardless of weather and wind, it shall not use more energy than necessary. Instead it shall be energy efficient and economical to run.

Exempel

An old house becomes good as new

Torgny Wännström at Tullinge, south of Stockholm wanted fresh air at home. Now he has it.
– "The Investment was worth every krona, and we have added a permanent value to the house", he says.

The house was built in 1936 and was rebuilt ten years later. Torgny and his wife bought the house in 1976. Initially the house was heated by coal, thereafter an oil-fired boiler was installed and when Torgny and his

family moved in they added electric heating elements.

Extra insulation was added to the house, as well as double-glazing. The aim was to make the house more energy efficient but unfortunately no thought was given to the potential consequences to the air quality inside.

Many years passed before the next rebuilding project started. It was a mere chance that Torgny Wännström met an expert in the field of indoor air and happened to talk about his own house.

– "My wife had views on the indoor air and the decision was made that something should be done about it."

So a couple of years ago, the old natural ventilation system was no longer functioning properly as the house had been made almost draught proof. A fan-controlled supply- and exhaust air system with heat recovery was installed. The installation only took a week and the total cost was less than 60 000 SEK.

–" We hired a carpenter who did all joinery work needed for pipes, ducting and other installations.

– I am very satisfied with the result, we now have better and cleaner air in the house. Also the ventilation has added value to the house, it will still be here even when we do not live here anymore", he said, adding.

"The system is very easy to run, the only thing you do is to change filters once every six months.

Presently there is another building project going on in the house, a 40 square meter large room with walls constructed almost entirely from glass is being added and we will be able to add it to the ventilation system. The family also has replaced the old boiler with a more economical heat pump system.

– "The total energy consumption has come down considerably", Torgny said, further adding,

– "The cost for heating the house today corresponds to the cost for one cubic meter of oil. When the house was heated by oil, we used 3-4 cubic metres per year, so we are down to just a third now.

The ventilation system was not there when the house was heated by oil, so of course it will increase the energy usage.
But I think you can basically disregard that, we are down to such a low consumption and the gains with ventilation are great in other ways."

Poor air quality in the home – The consequences

Today in Sweden there is a huge increase in people suffering from asthma as well as all kinds of allergies. Two, three generations back there were few people that even knew someone suffering from allergies or asthma. Today, four out of ten children have some kind of allergy or intolerance.
Researchers are not sure of the reason for this big increase but most agree that the air we breathe is of great importance. Probably the air at home is most important as it is the young children who get ill as they spend a large part of their time at home.
Worse still are the health costs. The price is highest for the people and the families that are affected, to be allergic or asthmatic has many both difficult and trying consequences.
But the price is also high for Sweden as a country. Medical costs for all allergic and asthmatic children are high as are the costs for sick leave and loss of production for adults with these diseases.
The economic consequences for society and the personal consequences for the individual increase as long as we do not improve the air quality in our dwellings. With relatively simple means it is possible to drastically improve the air quality in our homes (see chapter 2, Ventilation solutions in dwellings). What it takes is increased knowledge about – and changed attitudes towards indoor air. We must stop taking it for granted.
Swedish outdoor air is cleaner than in many other places in the world. The air in our working places also has improved considerably in recent years. In order to get sufficiently good air quality in our homes, two things are called for:

1) **We must take the demand for clean, fresh air in our dwellings as seriously as the demand for clean outdoor air and clean air in our working environment.**
2) **We must make resources available for research about the importance of indoor air. It is not acceptable that Swedish researchers must move abroad to be able to perform their work within an area that is important for us all.**

With increased research and more wide spread knowledge about the importance of indoor air for our health, our well-being and our

performance, hopefully more of us will take a greater interest in what we are breathing in, regardless where we live.
It is however difficult to generate any interest for the issue of indoor air quality despite the fact that we spend 90 percent of our time indoors. As early as 1996 the environmental health study wrote in their report (SOU 1996:124) that:
"No one should fall ill or suffer negative effects due to a deficiency in the indoor environment".
The study also addresses one of the most common arguments against good ventilation – our wish to save energy. Ventilation can be energy demanding and therefore conflicts with one of our most important environmental goals, to decrease our energy use.
That has been the case. But now there are both simple and efficient solutions for heat recovery as well as controlling the ventilation. A well-built ventilation system therefore becomes an effective way of economizing on energy.








Chapter 2

Ventilation solutions for our homes

The purpose of ventilation is to enable us to breath clean air by removing the stale, polluted air from our homes whilst replacing it with good quality air.

The main task is of course to see to it that the indoor air is healthy to breathe. But ventilation today is also about energy, about saving energy costs by adding heat recovery to the ventilation system. Ventilation should also, in order to save even more energy be controlled by demand, we shall not use more air than necessary in any given moment.

Exactly how the ventilation should be designed depends on type of building. An old building in the countryside being rebuilt to suit a modern family needs a solution different from a new built block of flats with hundreds of apartments.

The design of the system also depends on how the dwelling will be used. A rather common situation today is that an older couple sell their house to a young family. The layout of the house is perfect also for the new owners, they re-decorate to make the house "theirs". What is often forgotten is that the house is now being used in a totally different way than before.

The volume of laundry in a family with children is at least double and sometimes even more than that of an older couple, due to the number of people in the family. Sporting kids or for that matter adults increase the volume of laundry even more. The problem starts when it is time to dry the laundry. The demand for effective ventilation decreases somewhat for those using a dehumidifier (to remove the excess moisture in the air), but how many homes have one?

After a year in the house you start noticing the moisture. The airflow rate that was quite sufficient for the older couple is insufficient for the new family. Another thing to consider when designing the ventilation system is where in you live. Many countries have hugely differing climates dependant on which part of the country you live. Also the location of the house (noisy environment, closeness to heavy industry, etc) should be considered

In a dwelling the air should be supplied to the rooms where people stay regularly and for longer times (like the bedroom and living-room) while the air can flow through spaces where limited time is being spent from other rooms. Air is extracted from the rooms where pollution is highest, kitchen, bathroom and other wet areas.

This chapter describes what solutions there are when it comes to ventilation. There are also tips and advice on how to handle your own ventilation, both in houses and blocks of flats and something to think about when refurbishing or building a new house to avoid problems with the indoor climate in the future.

The ventilation in a dwelling should be designed to:

- **Create a healthy and comfortable indoor environment by supplying the volume of air that circumstances demand. Supplied air shall be clean and pollution produced indoors shall not be spread to other rooms. The air might need to be cleaned through filters.**
- **Air flows shall easily be possible to control by demand. They shall be stable and not be dependant on exterior temperature or number of open windows.**
- **Give an air exchange rate of minimum 0.5 per hour, or more, without creating draught. If the air exchange rate can be increased to higher levels it is good. 0.5 is the demand from Boverket, The National Board of Housing, Building and Planning. Few Swedish houses reach this demand.**
- **Heat recovery.**

Ventilation in dwellings – Technical solutions

Usually, we say that there are three types of technical system solutions for ventilation. Within these there are of course variants but the three main types are:

- **Natural ventilation (S-system)**
- **Fan controlled extract air systems (F-system)**
- **Balanced ventilation systems (FT-system) which consist of supply as well as exhaust fans, these are also called supply and exhaust air systems.** The latter two are often combined with some type of heat recovery.

In order for the system to function, it needs, apart from natural ventilation, a good control system, detailed below.

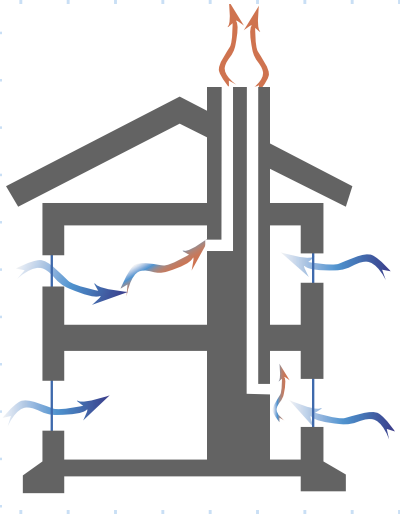
Natural ventilation (S-system)

The principle for natural ventilation is simple. The warm air indoors will rise and disappear via ducts, which creates a negative pressure in the building. Due to the negative pressure, new air is being sucked in from outside, the new air comes in via gaps in the house. No fans or other mechanical devices are needed, which sounds like the ideal ventilation for all types of dwellings. A simple thing like insulating tape in the windows can ruin a complete natural ventilation system and make the ventilation insufficient. The larger temperature difference between indoor and outdoor air, the larger volumes of air are being replaced. In the summer when the difference is small or none, there will be no ventilation. Natural ventilation is therefore always complemented by opening windows, especially during the warm part of the year when the natural driving forces are non-existent.

Early natural ventilation systems worked well enough as houses were not well insulated and rooms tended to be larger. The chimney was always warm as it was necessary to have a fire lit to provide hot water and a means to cook.

This is how natural ventilation works

The warm air indoors rises and disappears from the house via air ducts, which creates a negative pressure in the building. Due to the negative pressure, new air is being sucked in from the outside via grilles, open windows and gaps in the building.



Even a natural ventilation system that works from a ventilation point of view involves some undesired effects. If the airflows are sufficient for creating good air indoors you will waste energy as the warmed air will go straight out and its energy lost. If you solve this by reducing airflow, the indoor environment becomes unhealthy as the air quality deteriorates.

Another problem with natural ventilation is that one cannot control the ventilation, we are at the mercy of elements. The air will not be cleaned as you can't put a filter over every source of incoming air. Filtering air is an obvious solution when we live in cities or where there are known pollutants in the atmosphere, or if we live near busy roads. But consideration should also be given to filtering air in areas where it is perceived to be unpolluted, as a good quality filter can remove pollens that can often trigger an allergic reaction.

All air leaving the building will be replaced with unheated air from the outside. The new air must be heated, which costs energy. The incoming air can also cause draught, a common reason for putting insulation tape around windows and doors. Draught is not a problem during the warm part of the year but can become a nuisance during the winter when the incoming air has a temperature below 0 degrees (C)

Natural draft ventilation in short

FUNCTION	YES	NO	COMMENT
CONTROLLABLE		X	HIGHEST VENTILATION WHEN INCOMING AIR IS COLD
LOW ENERGY CONSUMPTION		X	NO ELECTRICITY USED BUT HIGH COST FOR MAINTAINING A COMFORTABLE TEMPERATURE AS WARM AIR IS CONSTANTLY LOST
VENTILATION ON DEMAND		X	
INCOMING AIR IS FILTERED		X	
GOOD COMFORT		X	THE COLD AIR CAN CAUSE DRAUGHT PROBLEMS
POSSIBLE NOISE PROBLEM COMINGFROM OUTSIDE	X		SUPPLY VENTS CAN CAUSE PROBLEMS WITH NOISE TRANSFER
GOOD AIR QUALITY		X	THE INCOMING AIRFLOW IS NORMALLY TOO LOW

Fan controlled extract air (F-system)

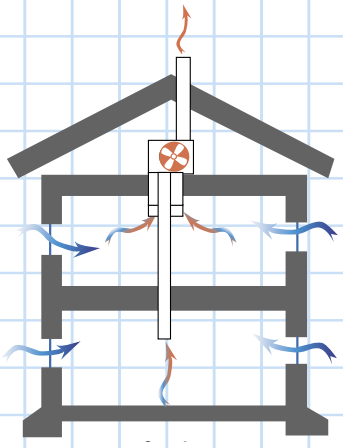
Mechanical extract is when we use fans to control the airflow rate in the home. The fans extract the air from the dwelling by means of a motor & impeller mounted in some kind of casing. The air is normally extracted from the kitchen, bathroom and laundry room. These are the rooms where moisture & unwanted odours are most likely to occur. In the same way as natural ventilation happens the air is replaced via gaps under doors, round window frames and if fitted, return air grilles.

It is important not to remove the air via bedrooms and the living room as the air will flow in the wrong direction with the consequence that smell of cooking and moisture will spread throughout the dwelling.

Fan controlled extract systems are popular as it is an inexpensive and easy to install method of ventilating the home. However, F-systems have the same disadvantage as natural ventilation in that the incoming air is untreated and will be cold in the winter and is almost certain to be contaminated with pollutants. Therefore it is common for return air grilles to be closed in winter & any gaps under doors or round window frames to be sealed. The result is less cold draughts but the air quality suffers with the reduced volume of air able to get in. The air stays longer in the room and we breathe the same air over and over again. Nowadays grilles can be supplied with filters that take care of the coarse pollutants. By proper sizing and placing of diffusers, draughts can be avoided.

This is how a fan controlled extract system works

The air is extracted from the dwelling with help of fans. The air is extracted from the kitchen, from toilets/ bathroom and from laundry room and is replaced in the same way as in houses with natural ventilation, i.e. through grilles, airing windows and leaks in the building.



Fan controlled exhaust air in short

FUNCTION	YES	NO	COMMENT
CONTROLLABLE	X		
LOW ENERGY CONSUMPTION		X	IT IS POSSIBLE TO HAVE HEAT RECOVERY IN MODERN SYSTEMS
VENTILATION ON DEMAND		X	
INCOMING AIR IS FILTERED		X	AIR INLETS CAN BE FITTED WITH FILTERS IN MODERN SYSTEMS.
GOOD COMFORT		X	THERE IS A RISK OF NOISE PROBLEMS AND DRAUGHT
POSSIBLE NOISE PROBLEM COMING FROM OUTSIDE	X		SUPPLY VENTS CAN CAUSE PROBLEMS WITH NOISE TRANSFER
GOOD AIR QUALITY		X	ON CONDITION THAT THE GROUND DOES NOT CONTAIN RADON AND THAT THE INCOMING AIR IS NOT POLLUTED.

Exempel

Draught problems in newly built homes

In a recent study carried out in Sweden by Maria Nordberg concerning draught problems in newly built homes it was found that the supply air diffusers had contributed to the problem. In some cases the diffusers had been placed incorrectly. The problem was worsened by the fact that most people do not think about how the air streams change when furniture is put in place.

Balanced ventilation system (FT-system)

The most complete form of ventilation system is said to be the so-called balanced system, FT-system. Fans control both supply and exhaust air, which means that one has full control over the volume of fresh air, which is not the case in the other systems. In fairly well insulated houses one can claim that practically all supply air comes through the supply air diffusers, as the system is not based on negative pressure. It also means that it is easy to clean the air. You put filters at the air intake.

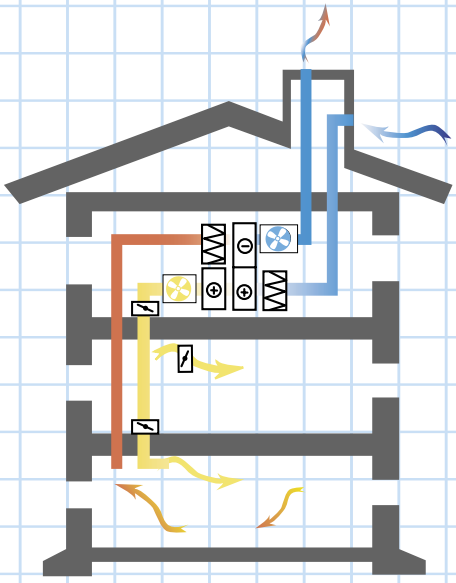
Balanced systems are nothing new but have struggled to find a demand for use in our homes. On the downside the system is more expensive to purchase than the others but in its favour is the opportunity for energy savings and creating a more comfortable environment. Today the systems are both effective and quiet and there is lots of research showing that if you want an installation with both low energy consumption and good indoor climate you need a balanced system. Low usage of energy implies heat recovery and energy efficient products like fans, filters and heat exchangers.

A good FT-system is both stable and flexible. Stability means that the system should function as intended almost regardless of what is being done in the house. Flexibility means that one should be able to control the

This is how a FTX-system works

The most complete form of ventilation system is the balanced system, FT-system. FT-system with heat recovery has the designation FTX. X stands for heat exchange.

Fans control both supply and exhaust air. The used, and warm indoor air is led through a heat recovery unit where the exhaust air heats the cold fresh air taken in.



Fan controlled supply and exhaust air with heat recovery in short

FUNCTION	YES	NO	COMMENT
CONTROLLABLE	X		EASY TO CONTROL AIRFLOW IN BOTH SUPPLY AND EXTRACT SYSTEM
LOW ENERGY CONSUMPTION	X		HEAT RECOVERY AND VENTILATION ONLY WHEN NEEDED SAVES ENERGY.
VENTILATION ON DEMAND	X		PROVIDES REQUIRED VENTILATION LEVEL AT ANY TIME DEPENDANT ON RELEVANT FACTORS
INCOMING AIR IS FILTERED	X		FILTERS SHOULD BE CHECKED REGULARLY AND CHANGED TWICE A YEAR
GOOD COMFORT	X		COLD DRAUGHTS ARE AVOIDED AS THE INCOMING AIR IS PREWARMED
POSSIBLE NOISE PROBLEM COMING FROM OUTSIDE		X	SILENCER MAY BE REQUIRED TO BE ADDED TO THE SYSTEM
GOOD AIR QUALITY	X		MADE POSSIBLE BY THE USE OF VENTILATION ON DEMAND

ventilation on demand, more ventilation is needed when many people are in the house than when the house is empty. Such ventilation control by demand becomes more and more common and in combination with heat recovery, the energy requirement decreases and the operating costs go down.

An FT-system with heat recovery is called FTX-system, where the X indicates heat exchange, this is the ideal system. Instead of sending the used and warmed air straight out, it is led through a heat recovery unit where the exhaust air heats up the cold fresh air taken in. In recent systems, heat recovery is almost a matter of course.

Controlling and regulating ventilation systems

Controlling and regulating a ventilation system has a decisive effect on the functioning of the installation and thereby the air quality indoors. A good control system ensures the optimum air quality is achieved with the minimum of energy consumption. There are many ways of controlling and regulating a ventilation system. Below some common systems are described and also some comments about what to think about when using them.

In **apartment houses** with fan controlled exhaust air (F-systems) or fan controlled exhaust and supply air (FT-systems), these are some common forms of airflow control:

1. Two different fixed air flows are used, one higher airflow used in the daytime and one lower during the night. A common problem is that the lower airflow often is set too low, it is important to have sufficient enough air exchange at night. Switching times are controlled with a timer.
2. Two different fixed airflows are used, but switching to the lower airflow is controlled by a temperature sensor, e.g. below –7 or 8 degrees. From an air quality point of view this is less suitable as the lower airflow normally is set below set demands. The reasons for using this system are lower energy consumption and less problems with draught. One big problem with temperature regulation is that the fan controlled ventilation can go down to such an extent that the thermal forces will be dominating, ruining the complete flow balance in the system.
3. Control according to alternatives 1 and 2 in combination with a speed controlled kitchen fan. The kitchen fan is normally controlled in 3 steps. One disadvantage with speed controlled kitchen fan in well-insulated houses is that the negative pressure can drastically increase when the fan is running at full speed. This will create draught problems from the supply air grilles
4. Control according to alternative 3 in combination with a boost function in the bathroom. This device can be manually activated in order to increase the airflow during a limited time, e.g. when taking a shower. The boost function is normally adjusted to a position corresponding to standard airflow.

Single house with F-system:

5. A suitable system in a single house without heat recovery is to have a speed controlled exhaust air fan controlled by a centrally placed speed controller (called thyristor). This makes it easy to manually control the fan to reach required airflow. One must be careful that the device is reset to standard when the house is used in the normal fashion, This type of exhaust air system can be suitable when one wants to upgrade

a natural ventilation system after insulating the building. It is normally rather simple to install ducts to the various rooms from a centrally placed fan in the roof space. From an energy point of view it is recommended to supplement with some form of heat recovery.

6. In single homes with exhaust air heat pump there is a preset normal fan speed giving required air exchange. This is the recommended normal position. In periods with increased activity in the house a higher speed can be chosen and when the house is empty, a lower speed can be chosen. The kitchen fan is controlled according to point 3 above.

Single homes with FTX-system:(balanced system with heat recovery)

7. Regulating possibilities are basically regulating the kitchen fan speed in various steps. The steps can be normal flow, boost flow and half normal flow. Half normal flow to be used when nobody stays in the house. One alternative system solution is to separate the kitchen fan from the rest of the system and only regulate it according to demands arising from cooking. The airflow in the ventilations system can then be arranged in steps as described above.

We require that the air in our homes is of a sufficient quality to ensure the comfort and well being of those who live there. We must then also have system solutions that secure that these requirements are always met. A reduction in fan speed that decreases airflow below the norm should not be allowed regardless whether the reduction is made via timer or temperature sensor.

The majority of the measures taken to change airflows in apartment houses, apart from controlling the kitchen fan, have aimed at periodically reducing the airflows below the norm.

A variable airflow is however a good method to lower the energy consumption. The airflow must be controlled by the demand, not by temperature or point of time.

Ventilation on demand

Today we take for granted that we can, for example, let water in to the bath, more or less, cold or hot, according to our need. We would never accept to just have a tiny, constantly running, luke warm jet of water in the bathroom.

But this is what we mostly must do with our ventilation, we accept a constant, fair amount of air not considering the actual activities in the dwelling. It is obvious that shower and laundry, party or absence demand different volumes of air.

Ventilation on demand means an individual regulation of the airflow in every apartment, either manually or via some form of automation. Regardless of what airflows that are supplied or extracted, there must be a balance between the fan controlled supply and exhaust airflows. This is important, among other things in order to utilise the heat exchanger in an optimal way and thereby minimise the energy consumption. This is a more energy efficient method than to let the fans run all the time with constant speed. The reason for this is that one does not use more air than necessary to get a good air quality and that one during periods when nobody stays in the dwelling only uses as much air as is needed to air out the emissions from the building. So there are two great advantages with ventilation on demand, lower energy consumption and better air quality.

Ventilation on demand means that the design of the system changes as compared with traditional system solutions. The fan speed control must be based on the principle of electronic speed control with signal from a pressure sensor placed in the duct system. The diffusers in the apartments must also be designed so that a change in airflow is possible. Thanks to the fact that a demand regulated system builds on a constant pressure being possible to maintain, we also get a third great advantage. It also helps us to avoid noise problems. Regardless of the adjustment of supply and exhaust diffusers, the pressure drop will not change and thereby we eliminate one of the prerequisites for the occurrence of sound problems.

To control the ventilation so we get the right air volume at any given moment will improve the comfort considerably. At the same time energy will be saved as the ventilation goes down when it is not needed.
If it is the case that ventilation is also used for the purpose of reducing the radon content it is important to know that the ventilation flow necessary in an empty house is considerably higher that in an empty houses without radon. Demand regulation is good anyway but minimum levels are higher that for other houses.

Choosing the right ventilation system

When choosing a ventilation system, whether for a refurbishment project or in the construction of new houses, one must think through a number of issues. One important aspect of the choice is that it will influence the heating system, when changing ventilation system in an existing house it might be a good idea also to go through the heating system.

When constructing a new house there are a number of Laws and regulations. One important thing to consider is to involve a ventilation expert early in the process. Indoor air is an important base in a house and it will be easier and less expensive to install the right type of ventilation from the beginning.

Modern ventilation installations cost some money to install, but can, if properly used, become inexpensive in the long run. Quite contrary to old systems they do not waste energy, they save energy instead. The installation cost is then compensated by a lower running cost. The extra cost is normally paid back within a few years.

Probably the most common question put by a person or company that is going to build a house is "what does it cost". When choosing a ventilation system that question must be extended and read, "What does it cost in the long run?" Life Cycle Cost (LCC) is the best method of calculating installations. LCC does not only include purchase price but also what the installation costs to run, to maintain and in many cases even dismantling. LCC for a ventilation system also takes in consideration the potential energy saving.

Irrespective of what system one has or will install, it is recommended to first go over the function and the products in the existing system. Try also to estimate running costs for the system.

Renovation of ventilation system in apartment buildings

There is a big difference between renovating and to build new. When renovating one must always make the best out of the situation, there is already a building to start from and it is a question of finding a solution suitable for that particular building.

What is limiting the possibilities is partly practical obstacles for renovation, partly economy.

The important issue is to find a solution that is acceptable for both the owner and the tenants. To arrive at such a solution demands a good portion of common sense and creativity combined with great knowledge about indoor air. Under certain circumstances, it is possible to reduce airflow during the winter to avoid problems with draught. This must not happen in a way that the air quality is diminishes significantly. Below follows a listing based on what system is installed in the building today.

NATURAL VENTILATION SYSTEM

As mentioned earlier, natural ventilation systems often do not function well. To improve on this, it should be re-built to a fan powered exhaust air system. The design depends largely on the existing duct system. After reconstruction, cooker hood and grilles with filter as in common F-systems can be installed. When re-building to a fan driven system one should always think about not creating unnecessary noise. The fresh air must be supplied through grilles in the outer wall, placed in such a way that draught problems to the greatest possible extent are avoided.

FAN POWERED EXTRACT SYSTEM

Before starting renovation of a F-system one must find out how the system works today. Otherwise there is a risk that the renovation becomes unnecessarily costly. One must form an idea of:

- Supply air diffusers
- Exhaust air diffusers
- Duct system
- Fans
- Air flows and directions
- Cooker hoods

SUPPLY AIR GRILLES AND DIFFUSERS

Many types of supply air grilles & diffusers have been installed in homes over the years. The supply air devices will bring fresh air into the dwelling and should, in order to operate well, be adjustable. In the past, window

vents were installed as fresh air devices. The problem with this is that there is no airflow at all when they are shut. Many houses have been additionally insulated over the years in a way that the ventilation flow has been drastically reduced. In these cases, new or alternatively more supply air grilles must be installed to enable sufficient make up air. When installing supply air grilles, it is important to adjust the number of grilles so as to avoid too high air velocities that create problems with draught and noise. At the same time one has to see to it that one does not have more than what creates a suitable negative pressure indoors (5-10 Pascal).

EXTRACT AIR GRILLES AND VALVES

There are many various types of exhaust air devices installed in homes, the earliest were just cast iron grilles. The demand one ought to put on an exhaust air device when renovating a f-system is that it shall be adjustable, create low sound and that the pressure drop corresponds to the pressure drop in the duct system and chosen fan. It is important that the pressure drop over the devices is kept on a level as low as possible in order to avoid noise.

DUCT SYSTEM

Duct systems made from sheet metal are often in relatively good condition, access doors and some joints can however be leaking which has an effect on the system performance. Duct systems made from building materials can leak to such an extent that the performance of the ventilation system is insufficient. The duct systems must be cleaned at regular intervals.

FANS

Fans in exhaust air systems are very different in condition. Some are fully functional while others are totally worn out. The worn out fans must of course be replaced or renovated, but it might be worth considering replacement of fans that are not yet worn out as well. The advantages with replacing old fans are among other things decreased need for service and reduced energy consumption due to the fact that new fans normally have a better efficiency than old ones. Reduced service need is achieved when replacing a belt driven fan with a direct driven fan. Today it is common to choose a speed controlled fan with backward curved blades that increases the efficiency and simplifies commissioning.

The demand for ventilation in a house is not constant, it varies with time of year, the activities of the people staying in the house and how many that live

in the house.

It is important that the fans are not over-sized, which makes the fan ineffective. Under-sized fans on the other hand can create noise problems.

Exhaust air systems have been used in dwellings in Sweden since the thirties. Up to the middle of the forties mainly slow rotating axial fans were used, pressure drops in the systems were often low and the air devices were not possible to adjust. When fans in such systems are going to be replaced, it is best to dismantle the axial fan and replace it with a roof fan. Also here it is important to take into consideration potential problems with noise.

INSULATED BOX FANS

More common in low-rise developments Insulated boxed fans are normally placed in the attic and connected to the ducting or on occasions placed in a purpose built plenum chamber. There have been many variants over the years. From the beginning of the sixties to the middle of the eighties, prefabricated insulated sheet metal boxes with double inlet belt driven fans were used. This type of fan could provide ventilation for up to three staircases. A good way of renovating these units is to replace the belt driven fan with a direct driven equivalent whilst utilising the original insulated box. In some cases it may be impossible to gain access to the original fan due to work carried out in the preceding years, in this case a new system will need to be installed.

PLENUM CHAMBERS

In very tall buildings fans are often installed in a large, purpose built plenum chamber, often at the top of the building. These are most likely to be walk in and with a large surface area made up of external weather louvers to allow the stale air to escape. Again this would be suitable for a large double inlet fan preferably speed controllable. (picture 4).

Picture 1

Picture 2

Picture 3

Picture 4

DUCTED COOKER HOODS

Cooker hoods especially those with a boost function are good for removing odours, moisture and grease associated with the cooking process. Many have grease filters to prevent the ingress of potentially dangerous and flammable contaminants in the ducting. Installing a cooker hood is a positive step.

ENERGY

The SFP (specific fan power) value for fans installed when the houses were built is 0,7-2 kW/m³/s. For new fans, the figure is 0,3-0,6 kW/m³/s. One can expect to reduce the operating energy cost to half after installation of a new fan. The heating requirement will also decrease with demand adjusted ventilation, possible due to speed control. (More about energy in Chapter 3, Energy and Ventilation.)

BALANCED VENTILATION SYSTEMS (WITH HEAT RECOVERY)

In cases where the house is equipped with FT(X)-ventilation it is of course best to keep that system. If the unit is worn out, the whole unit can be replaced or just the worn parts (heat exchanger, shutter, fans, etc.). In cases where it is easy to replace the unit, this is a good alternative if the condition is poor. In many cases it is however rather complicated as the walls have been built after the unit has been put in place

Today there are plenty of energy efficient products to choose from for those renovating an old system or installing a new one.

Renovating ventilation systems in non communal houses

Also in self-contained houses it is important to study the existing system and decide what type of improvements one wants to make. To go through the weak points of the existing system is a good first step.

A common situation when it comes to old houses is that the house has been built with a natural ventilation system and then the heating system has been replaced and the house has been insulated – without changing the ventilation system. This normally means that the ventilation system no longer functions. To re-install a natural ventilation is seldom possible as natural ventilation needs un-insulated houses.

Many houses built with fan-controlled ventilation also have ventilations systems that do not function properly. Many house owners do not think about the fact that the ventilation system at home must be maintained, kept clean and filters changed. If that is not done, the system will deteriorate and finally it will have no effect at all.

What system to choose depends on what you have and what the house looks like. The checklist on page 37 gives some guidance about what is important to think about. Ask a person knowledgeable in ventilation matters for advice at an early stage

Exempel

The Million Program ready for renovation

At present in the UK the government have ambitious plans to build hundreds of thousands of affordable dwellings to meet the ever-growing need for housing. This housing needs to come in at an economical cost whilst meeting the demands for energy conservation as well as good indoor air quality.

In Sweden between 1964 & 1975 an equally ambitious project was undertaken, “The Million Program”, it called for the construction of a million homes to meet the countries needs.

One group Signalister of which Solnabostäder is a part, have thousands of flats, most of them constructed during the “Million Program. Most of the dwellings were equipped with fan controlled supply & extract systems.

It is high time for many systems to be replaced, not least in order to reduce the energy costs. The cases where systems have already been replaced show that it is possible to reduce costs substantially.

During the eighties it was common to add heat recovery to the existing ventilation systems. The results were however mixed.

Operations Manager at Solnabostäder is Lars Löfstedt. The project of renovating the ventilation systems started a few years ago. At the beginning, a survey of the HVAC-system was conducted, where every single part was scrutinized. The problems with the existing units had been noticed also by the residents, as odours from the extract air had been mixed into the supply air.

– “These things cause problems and if the extract air comes into the system as supply air, something must be done about it”, says Lars Löfstedt.

For Lars Löfstedt, and others in the same situation, there are many decisions to be taken in connection with replacement of a ventilation system. Must everything be replaced? If not, what can be kept? What do we want to achieve? How do we improve the comfort for the residents? What disadvantages can occur in the system? And what do we do in practice?

The last question is often more difficult than you might think. To remove an old system for scrapping is possible, it can be a lot more difficult to move in the new system. Many ventilation systems contain large parts that cannot be transported through normal doorways and many houses also have narrow passages, difficult to pass. Plant rooms are also small and cast-in-situ and built after installation of the system.

– “It can be problematic to replace a ventilation unit in dwellings like these. Often the units are so big that you must lift them up with a crane and make a hole in the roof to lower them into the building. The type of unit we now have chosen can be brought up in an ordinary lift and fixed together on the spot”. says Lars Löfstedt.

With this we gain two things, we save more than 100 000 crowns (SEK) per system and the stoppage is short, in this case less than a week.

The new ventilation systems that Solnabostäder have installed contain heat exchangers with double efficiency compared with the old ones. The airflows have increased with the new renovated systems without causing problems with draughts.

The need for additional heating (district heating) has disappeared due to the heat recovery and can now be removed from the accounts.

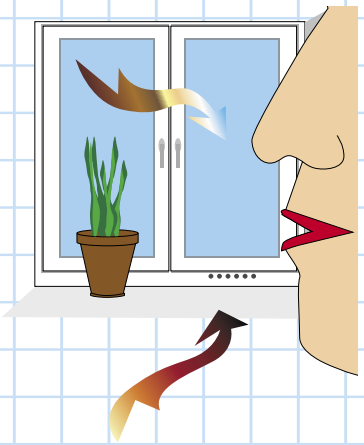
Lars Löfstedt estimates a rebuilding cost of approx. 200 000 crowns per unit room. With the increased energy recovery, it will finance the rebuilding within four years.

–”This type of renovation pays off quickly. It is important to choose energy efficient products and systems. Ventilation in our dwelling-houses represents a larger and larger part of the operation costs, why choice of technique and recovery systems is very important so operation costs can be reduced at the same time as the functionality is improved”, says Lars Löfstedt.

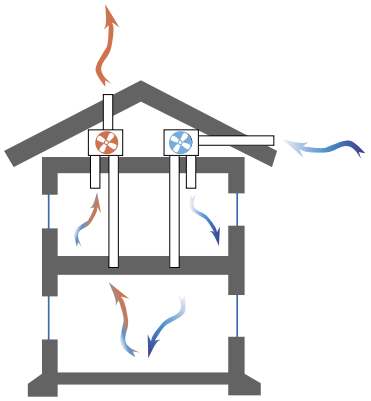
Check list for renovation

These questions are important to go through before a renovation. All questions are not relevant in each case, questions that need an answer depend on what type of building and what type of system that is at hand.

- ✔ **What needs to be done?**
  - Drag[illegible]as
  - Draughts
  - Does it take long for the misted over bathroom mirror to clear?
  - Does the air smell stuffy when the house has been empty for a day? A week?
  - Does the air smell stuffy in the bedroom in the morning?
  - Does the air smell stuffy when the children have been playing in their room with their friends?
  - Does the smell of food spread to other rooms?



- ✔ **Is there radon in the air? How much?**
- ✔ **Does someone in the house suffer from asthma or an allergy?**
- ✔ **What can be achieved (energy saving, better health, improved comfort?)?**
- ✔ **Financial constraints, how much will our budget allow?**
- ✔ **What type of system is the existing one?**



- Is it practical to carry out remedial works to the system or do we need to replace it?
- If the heating system has been altered after the house was built, it might have affected the ventilation.
- What other measures should or could be taken in connection with the renovation of the ventilation system (windows/insulation etc)?

For owners of larger buildings there are further issues to consider:

- Is it possible to place a unit centrally? If it is not possible to install ducts, would one unit per flat be a solution.
- Who is going to manage the system? Caretaker or tenants? Important that the system is user friendly.
- Is remote monitoring or control necessary?
- Different levels of ventilation? Freedom of choice for the tenants?
- How will this affect the market price for the house when selling??

Heat pumps

There are many different types of heat pumps in the market. What they have in common is that they deliver heating in an energy efficient way. Some variants are ground source heat pumps/geothermal heat pumps, exhaust air heat pumps and outdoor air heat pumps.

With the exception of the extract air heat pump, the products mentioned above have nothing to do with ventilation, which means that ventilation must be solved separately in these cases.

Heat pumps take via a so called heat carrier heat from for instance the outdoor air or the bed-rock. Electric energy is supplied to the pump which then "gives back" more energy than what was supplied in form of purchased energy. To handle heat pumps and their heat carriers, certified personnel is needed both for installation, service and maintenance.

The exhaust air heat pump extracts heat from the indoor air via the exhaust air ventilation. From a ventilation perspective, this type of heat pump is comparable with a conventional exhaust air system.

Kitchen fans

A kitchen fan with evacuation is simply a fan controlled exhaust air unit. It is supposed to remove foul air – just as a ventilation fan does. A kitchen fan can, if installed when the house was built, be a part of the ventilation and therefore, no changes should be made when it comes to it's function before finding out how this change will influence the rest of the ventilation.

To install a kitchen fan in an old house might be risky just because of the fact that the fan will change the airflow both in the kitchen and in the rest of the house. If it is a powerful fan the pressure can change to the extent that the air goes in the wrong direction in the duct system. If for instance a stove is in use when the kitchen fan is turned on there is a risk that smoke is sucked into the dwelling. This is both unpleasant and dangerous. Too powerful suction of air from the kitchen fan will create negative pressure in the kitchen and air from adjacent rooms or air from the outside will be sucked into the kitchen.

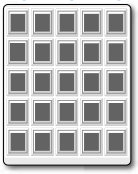
Kitchen fans are often discussed in terms of motor power and air flow, high power means high airflow, which many people believe is the same as high efficiency. This is not the case. One does not need especially high airflow in a kitchen fan in a home in order for it to work satisfactorily. High airflow also means more noise than necessary. Most important when installing a new fan is that it works together with the rest of the ventilation without causing new problems, such as back draughts or noise issues.

If there is uncertainty whether it is possible to install a kitchen fan that extracts air, one alternative would be a carbon filter fan, which cleans and circulates the air.

What kind of ventilation do I have?

- ✔ Is there a users manual or perhaps operating and maintenance instructions, most systems will have been supplied with some form of technical information, which will often have been saved.
- ✔ Find out the age of the house. If the house was built before the mid sixties it is most probably natural ventilation. The air is probably coming in through natural leakages around doors and windows, etc. Check if doors and windows have new sealing strips and if the house has new insulation in the walls. If that is the case, the ventilation has probably deteriorated

Look for exhaust air grilles in the kitchen, in wet areas and in the bedroom. If these grilles are still there, it is probably natural ventilation. In the late sixties it was common to install fans to increase the natural draft, at the same time many grilles were replaced for devices that could adjust the airflow.



- ✔ Look for air intakes in the outer walls. It can be drilled holes or vents in window-frames or mouldings. This indicates that one has tried to create some form of airflow and it is likely that the house either has natural ventilation or fan controlled extract air ventilation. The best way to find out if there are fans is to climb up on the roof (or the attic) and check.

- ✔ If there is a hood over the kitchen range, connected to the wall with duct or hose, there is fan controlled extract air.
- ✔ Check with a paper if you have both supply- and extract air (see next paragraph)

How do you know what kind of ventilation there is? The owner of a block of flats most probably knows and it is easy for someone living in such a house to ask the owner or the caretaker. Anyone who wants to find out on his own can follow the check list above and can be relatively sure of the result.

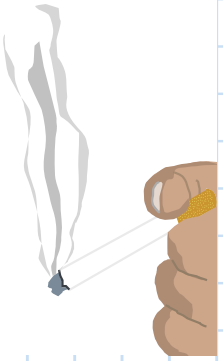
Does the ventilation work?

All houses have some kind of ventilation, natural if nothing else. All ventilation can cease to function. Some common reasons are, poor commissioning, bad maintenance and changed conditions (for example insulating the house).

Here are some simple ways of checking that the ventilation works.

- ✔ Hold a paper against the vents, a crepe paper should stick, a normal A4 sheet of paper shall also almost stick. Alternatively be blown out from the diffuser if it happens to be a supply diffuser that is being checked.

- ✔ Check the bathroom mirror after using the shower. If the mirror is misted over more than half an hour (the mist should preferably disappear faster) the ventilation in the bathroom is too poor.
- ✔ Can you smell food in other rooms than the kitchen? That can mean that the air flows in the wrong direction.
- ✔ Can you smell the odour of smoking where nobody has smoked? This also indicates that the ventilation does not work properly.
- ✔ Condensate on the inside of the windows is also a warning signal (see page 64, The Värmland study).
- ✔ Does it whistle through the letterbox? The reason could be that the exhaust air grilles are not sized for the actual exhaust airflow or that they are shut.



Simple measures for better air

If the ventilation does not work for some reason there are some simple measures to take for better air quality. None of these is good long term, the best thing to do is to improve the existing system or install a more effective system. In the meantime one can do the following:

- **Open the windows to allow the premises to air through.**
- **Check that fresh air valves and window vents are open and clean.**
- **Remove sealing strips around doors and windows. If you do not want to take away all of it, at least remove at the top of the doors and windows.**
- **When you cook, open a window in an adjacent room, not in the kitchen.**

Service and maintenance

One of the most common reasons for poor air quality is ventilation systems that are not looked after properly. Our interest for servicing technical installations at home is often low, which affects both the performance and lifetime of the systems. Compare that with our cars that we leave at the garage to be serviced at regular intervals. We are also careful with the air quality, not many cars are sold without an air conditioning system, which in most cases also contains filters, thus cleaning the air. If the air conditioning stops working, the car goes back to the garage. At home, on the other hand, where we spend a lot more time than in the car, we do not think much about air quality.

A badly maintained ventilation system can in itself be a problem for the air quality, the air can in fact be worse than it would have been without ventilation.

The commissioning, the setting of parameters in connection with the installation is also very important for the effective function of the system. Common problem areas are:

- **Filters that are dirty and/or old give higher pressure drop and consequently higher energy consumption and they deliver polluted, not clean, air. Therefore, filters must be replaced at least twice a year to be effective. To change a filter is easy, pretty much like changing a bag in a vacuum cleaner.**
- **Filters with low separation can make dirt and micro organisms gather inside supply air ducts and allow them to spread from there.**

- **Dirt gathering in the ventilation system can also, in the longer run, decrease the airflow to an unreasonable level, so it is very important to keep the ventilation system clean.**
- **Shutting off fans at night can also result in pollutants being spread via the duct system.**
- **Problems with dampness can be the result of inadequate weather protection at outdoor air inlets or condensation in the ducting caused by bad insulation.**

It is of course best never to let these types of problems to occur at all. As with most problems they are difficult to correct once they have occurred. The best way of preventing these things is to take care of the ventilation system as well and as regularly as the rest of the house

In order for the equipment to be handled correctly, all instructions for service and maintenance must be updated regularly.

Pitfalls

It is often equally simple to get it wrong rather than right. Knowledge and experience increase the chance of doing right. Below follow some common pitfalls.

DESIGNING

A well-managed construction, whether a new construction or a refurbishment, often makes for a good building in the end. When designing it is important to have access to knowledge in different areas, it is equally important to have access to a person who knows ventilation as someone who knows about electric matters. If all basic installations needed (electricity, ventilation, water and heating) are involved from the beginning, the result will always be better than if one chooses to ignore any of these. It does not have to be harder or more expensive to build a house with good technical systems than with not-so-good ones.

The future proprietor is responsible for the result of the building project. In Sweden, the Planning and Building Act and the construction regulations from the National Board of Housing, Building and Planning map out what the formal requirements are to ensure that building quality is achieved.

With a badly installed plant you risk anything from inadequate (or in the worst case no) performance) to noise issues.

The adjustment should also be performed by a ventilation specialist as an incorrect or poorly made adjustment will influence the performance of the system. If the result is not as intended, it may not necessarily be the fault of the equipment – it could be installed incorrectly.

SOUND

A common complaint on fan-controlled ventilation plants is noise pollution. In many plants, noise is a problem as serious as draughts, stale air or incorrect indoor temperatures. Older plants can be refitted to reduce the noise levels substantially. There are regulations about maximum noise levels in dwellings.

Modern ventilation systems are usually very quiet and not disturbing at all. It is of importance to keep low air speed in the ducts, which reduces the noise level considerably. Two common reasons for noise from modern plants are incorrect installation and narrow ducts.

Noise problems can be difficult to overcome as there can be any number of causes. In such cases it is best to consult someone experienced in acoustics to identify and ultimately resolve the problem

AIR INTAKE

The air that is taken into the house comes in through the so called air intake. How this is placed has a large impact on the air coming in.

A common problem is that they are not protected against rain and dampness, a simple weather protector prevents moisture entering the system.

Another detail to consider is to place the grilles facing away from the traffic when it concerns blocks of flats and towards the garden or other houses when we talk about villas. One should not place the air intake close to the street. The placing is important in order to minimize both pollution and noise from the outside.

Chapter 3

Energy and ventilation

In February 2005 the Kyoto Protocol came in force. The signatories, among them Sweden, committed themselves to reduce greenhouse gas emissions to eight percent below the 1990 levels by 2012. The only way to meet this commitment is to reduce our total energy use.

Although a change-over to greater use of domestic renewable sources of energy will help to reduce emissions, a significant effort also needs to be made by all energy consumers to reduce their energy use and to use the energy that after all is needed in a more clever way.

In 2002 EU passed a directive, which will be incorporated into Swedish Law in January 2006. Three years later the law shall be fully implemented. In the directive there are four points that the member states must introduce:

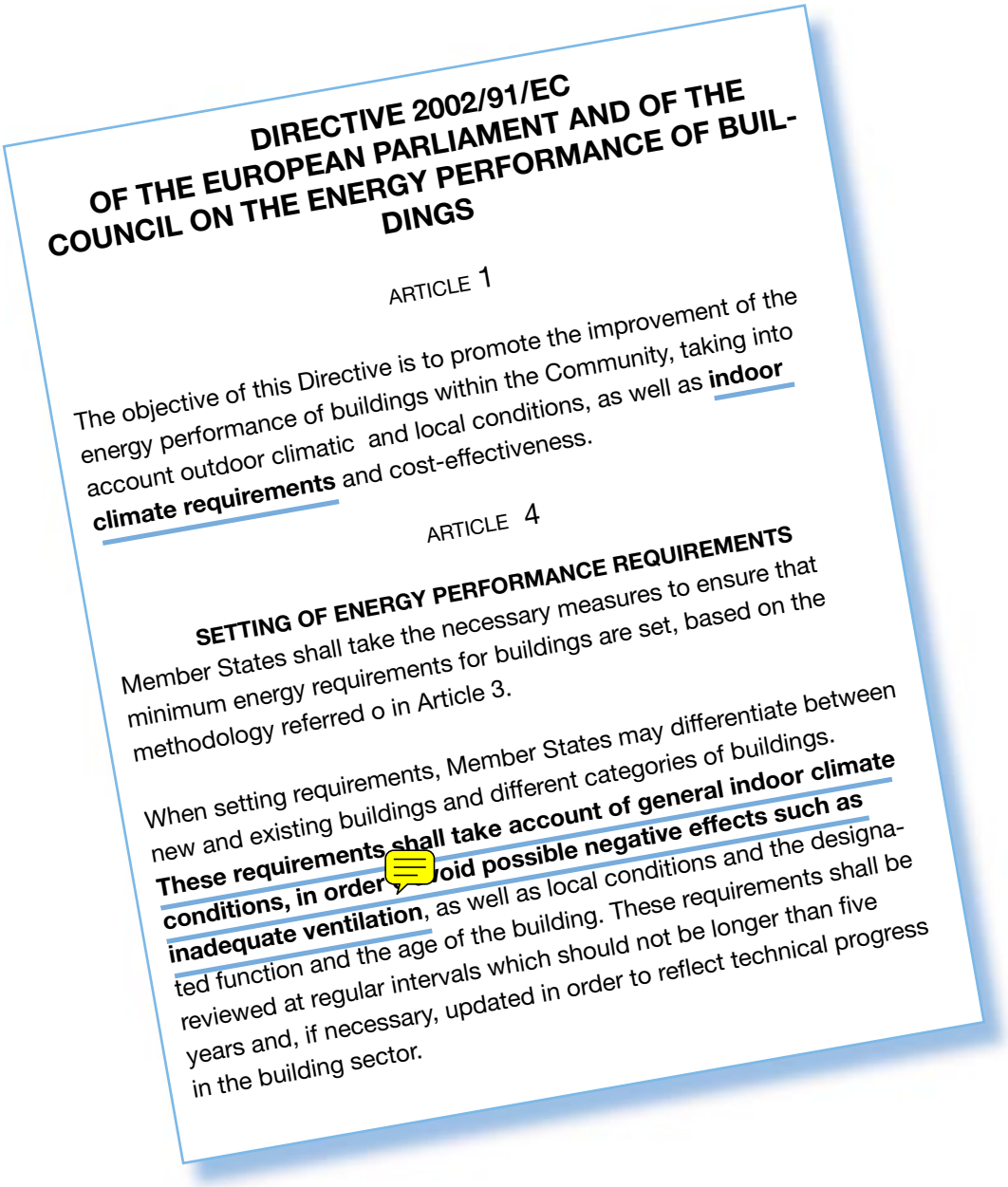
- **A common methodology for calculating energy performance of buildings (i.e. how much energy a building is using)**
- **Minimum standards for energy performance will be determined by Member States and applied both to new buildings and to major refurbishments of existing large buildings.**
- **A system of building certification will make energy consumption levels more visible to owners, tenants and users.**
- **Boilers and air conditioning systems in buildings will be inspected regularly to verify their energy efficiency and greenhouse gas emissions and assessment of the heating plant (if older than 15 years).**

The purpose of this Directive is to reduce the energy use within EU (firstly imported energy) and to reduce the carbon dioxide emissions to meet the Kyoto Protocol commitments.

The requirement of reducing the energy use may however not affect the indoor climate. Article 4 of the Directive says that the requirements ”shall take account of general indoor climate conditions, in order to avoid possible negative effects such as inadequate ventilation”.

The Swedish environment goals say the same thing as the EU Directive, we must reduce the energy use.

The Kyoto Protocol and the EU Directive have put focus on an issue that has been on the agenda for several years. The energy crisis in the seventies



DIRECTIVE 2002/91/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL ON THE ENERGY PERFORMANCE OF BUILDINGS

ARTICLE 1

The objective of this Directive is to promote the improvement of the energy performance of buildings within the Community, taking into account outdoor climatic and local conditions, as well as **indoor climate requirements** and cost-effectiveness.

ARTICLE 4

SETTING OF ENERGY PERFORMANCE REQUIREMENTS

Member States shall take the necessary measures to ensure that minimum energy requirements for buildings are set, based on the methodology referred o in Article 3.

When setting requirements, Member States may differentiate between new and existing buildings and different categories of buildings. **These requirements shall take account of general indoor climate conditions, in order to avoid possible negative effects such as inadequate ventilation**, as well as local conditions and the designated function and the age of the building. These requirements shall be reviewed at regular intervals which should not be longer than five years and, if necessary, updated in order to reflect technical progress in the building sector.

brought a benefit in that we became aware of the limited resources of the earth. We began to save and tried in all ways to reduce the energy we use. Almost all consequences were positive. However, one negative consequence followed from this new awareness: We made our houses airtight to the extent that the air stopped leaking through walls, doors and windows. As we did not follow up the improved insulation with improved ventilation, these measures led to a substantial deterioration in the air quality in our homes. Our indoor environment that has led to health problems for many people. Poor air and dampness became big problems in both new and old houses.

In Norway there is a present project (2005) where homes will be allotted a maximum energy consumption. To come down to proposed levels (150/130 kWh/m2) it is necessary to use balanced ventilation with heat recovery. Similar discussions are taking place in Sweden and in many other countries.

The one who uses less energy saves money – and protects the environment.

When we talk so much about about saving energy it is only natural that we question the various functions in our homes and their impact on our environment as well as the resultant energy usage. One of the arguments put forward by advocates of natural ventilation is that it does not involve the use of energy.

That is in itself correct, but it does not mean that natural ventilation does not use energy. On the contrary as cold outdoor air first is warmed up and then let out. As nothing of the energy carried by the indoor air is utilised you just keep the birds on your roof warm.

All fan controlled ventilation uses energy to function as the fans are driven by motors. There are a lot of things one can do to utilise maximum effect of the energy that still is being used by a ventilation system. If you build a house, whether it is a detached house or an apartment building, it is today natural for many people to choose a system that gives the possibility for heat recovery. Another important part for the purpose of improving the energy efficiency is ventilation on demand. Ventilation when needed or on demand will reduce the volume of air when the need goes down, e.g. when the home is unoccupied. Heat recovery and ventilation on demand are two ways we can make a huge impact on the energy efficiency of our ventilation systems. Whilst ensuring we benefit from good air quality in our homes.

Heat recovery

The heat inside the home, regardless where it comes from should not be let straight out. It should be recovered. A heat exchanger with high efficiency can reduce the energy costs considerably. Heat recovery means that the heated air helps to warm up the cold supply air from the outside. This saves a lot of energy. Today there are a number of different types of systems for heat recovery from the exhaust air. Here are a few:

PLATE HEAT EXCHANGER

Cross flow heat exchanger and counter flow heat exchanger, or as they are normally called, plate heat exchangers are the most common of the types available in the market. It is most common in detached houses and in apartment buildings with separate ventilation plants in each apartment. The technique is simple, where supply and extract air pass each other in a set of pleated aluminium plates. The warm extract air heats the aluminium plates and the cold supply air takes up the heat.

The cross flow heat exchanger has an efficiency of 40-55 %. The counterflow heat exchanger can in the best case achieve 80 %. Both types can be considered difficult to clean due to the construction.

ROTATING HEAT EXCHANGER

The rotating heat exchanger is built up around a rotating wheel consisting of pleated aluminium profiles where the warm extract air heats the rotor, which in turn heats up the cold supply air. This system has many advantages over other solutions. Despite that fact it is less common than the cross flow heat exchanger. The reason for this is the risk of leakage of contaminated extract air to the units supply-air side. The rotating heat exchanger is characterised by low pressure drops, which leads to low fan effects and thereby low energy use for the fan operation. It is comparatively easy to clean and has a high efficiency 60-75 %.

LIQUID COUPLED HEAT RECOVERY

The liquid coupled system builds on that a freeze protected liquid (brine) is circulated between cooling and heating batteries placed in the supply and

extract air systems. The warm extract air warms up the liquid which in turn warms up the cold supply air.

The system allows supply and extract air units to be placed independently from each other, e.g. when the supply air unit is placed in the basement while the extract air unit is placed in the attic. The system is flexible and makes it possible to install several recovery batteries in different extract air systems and put them together to one supply air battery. The efficiency is comparatively high (50–70 %). The system is normally being used in apartment buildings and may well be used in connection with refurbishing or new buildings

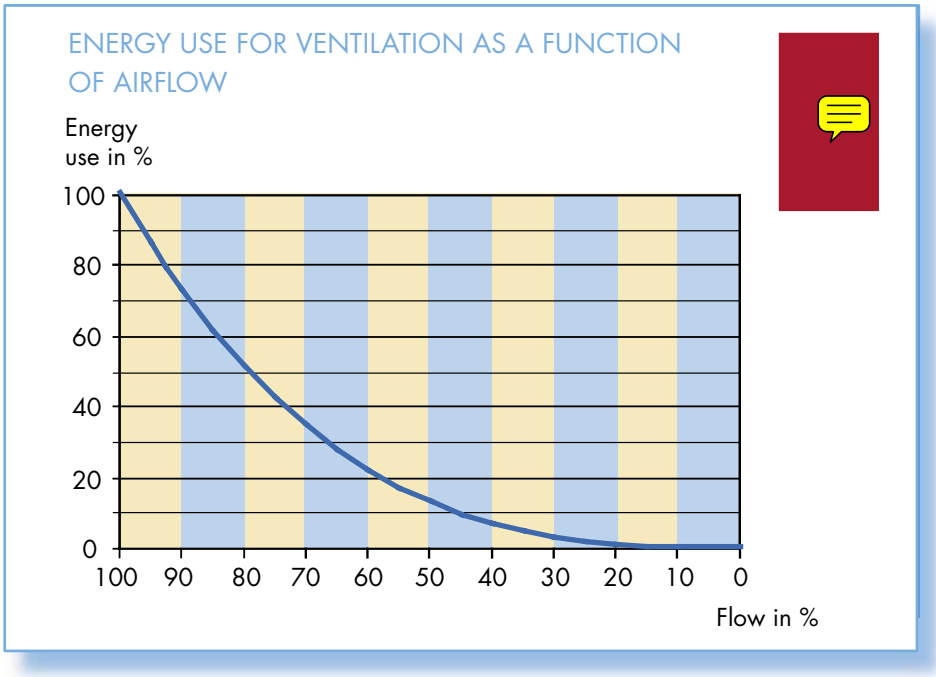
Ventilation on demand saves energy

Today we would never consider leaving our radiators on 24 hours a day 365 days a year, using the same energy cost per day regardless of season. Would we have our heating on full whilst we were on vacation? No, we only use what heat we need, when we need it.

If we do the same thing with the ventilation we can save a lot of energy. Instead of full ventilation 365 days a year we use a system similar to the radiator thermostats to regulate how much air that needs to be taken away and supplied. Such systems can be automatic or manual, they can also in many cases be installed in existing ventilation systems. However, here one must calculate whether the investment in such a system is higher than the saving that can be achieved by using less energy. In a new system it is always profitable to install a fully controllable system.

What you control is the airflow, how much air that is supplied to the room. The minimum requirement for Swedish homes is 4 litres per second per person. With ventilation on demand it can be decreased to maybe 1 litre per second when nobody is in the house, and substantially increased when there are many people in the room. Thereby you use as much energy for ventilation as is required, never more.

Ventilation on demand leads to lower energy consumption than in a constant airflow system, as the annual average airflow often is lower.



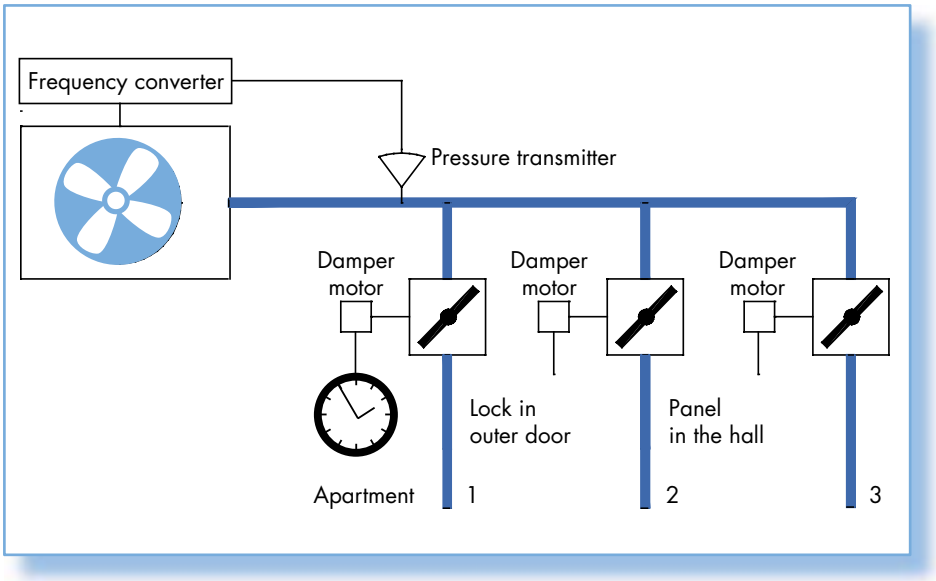
The energy use varies substantially with the airflow. Lowering the airflow to half when nobody is at home means that the energy use is reduced to a fifth.

Control of the airflow to the apartment can be done via a control device and sensors. This can be done easily by using an automatic speed controller that manages the various control situations

The ambition is always to achieve as low operation costs as possible. For ventilation and heating of homes it is possible to control various demands and usage times from one and the same air handling unit. In order to limit the distribution of ventilation air in both time and amount a so called demand controlled ventilation unit is installed. This means installation of a motorised damper in the ventilation duct. The damper opens and closes via a timer or for instance via the lock in the outer door. When one of these dampers closes, the pressure in the duct will increase and the fan slows down, which gives a decreased airflow.

The consequences are:

- **Every apartment gets the proper amount of air, regardless of how other apartments are controlled**
- **Substantially increased efficiency**
- **Minimised electricity consumption for fan and pump operation**
- **Lowered sound level in the ventilation system**



Example of an on demand ventilation system.

Correct building technology

An incorrectly built ventilation system (e.g. ducts with a tight bend close to the fan) will increase the energy costs as the air must overcome a larger resistance. Simply put, we should make it as easy as possible to transport the air through the system, any restrictions increases the resistance, which in turn has an adverse effect on the fan. By keeping a low pressure drop there is also a chance of substantial cost savings.

Commissioning & servicing of the system

It does not matter how good a system is if it is not properly commissioned and serviced regularly.

The commissioning is important from many aspects, not just the energy consumption. A poorly installed or commissioned system may well fail to match the design performance and could very likely increase the energy demand on the system. Commissioning should always be carried out by a professional.

Also servicing the system is important from an energy point of view. It is best to perform planned and regular services, the unplanned service tends to become fire-fighting operations. These are often costly. A system that is being serviced regularly will in the long run become a lot more economical than a system that is being repaired only when it breaks down. Good servicing is prerequisite for controlling and keeping the energy consumption on a low level.

When it comes to commissioning and service, user friendly is the key word, the easier it is to use and service the system the more likely it will be used correctly.

Energy efficient components

The development of energy efficient components has been ongoing for several years. The most important component is the fan that can be driven in several ways. To size the fan and the rest of the system correctly is important from an energy point of view. A slightly smaller fan would perhaps be able to keep a sufficiently high airflow but the energy efficiency in the smaller fan will be low as it must work harder to move the air. A slightly larger fan is more expensive to purchase but has a higher efficiency and therefore does not need to use so much energy to do the same job

Clean systems

Today most input systems contain some type of filter to ensure we prevent the ingress of contaminants into the supply air. It is important that the filters are changed on a regular basis both from the hygiene point as well as to enable the system to operate at it's optimum level.

AIR FILTERS

Air filters are tested and approved according to the European standard EN 779:2002 and are delivered with test protocol. In Sweden there is also a P-marking, carried out by SP, Sveriges Provnings- och forskningsinstitut. The P-marking guarantees that the product meets the functional requirements during its entire lifetime.

Filters are available in different classes, for home ventilation normally filter classes F (fine filter) and G (coarse filter). The letters always appear in combination with a number, the higher number, the higher separation. A filter used in home ventilation should be of filter class F7 or higher in order to make the air sufficiently clean.

Cost over time – or just a purchase price?

When investing in a technical system of some kind, there are a number of costs to consider. The most obvious is the purchase price. There are however a lot more things to consider to find out how much the system really will cost. Some of them being:

- **Installation cost**
- **Energy cost**
- **Service- and other operation cost**
- **Dismantling cost, sometimes even destruction cost**

The established definition for this discussion is Life Cycle Cost, LCC. Today many enterprises choose to calculate LCC of a product rather than looking at the purchase price. A normal ratio between purchase price and other costs is 10-90, the purchase price is in other words only approx. 10 % of LCC.

A system that is inexpensive to buy can be very expensive to operate while a system that costs more to buy and install can be a lot more cost effective in the long run as it requires less energy to deliver the same result.

When it comes to, for instance refrigerators that we buy for our homes, almost everyone (both private people and developers) looks at how much energy it will require to function. When we buy a car, fuel consumption is an

ÖVERSÄTTNING SAKNAS

SYSTEM	A till- and extract air	B till- and extract air	C extract air
✔ Heat recovery efficiency	70%	40%	0%
✔ Investment:	300	200	120
✔ Life cycle cost energy:	300	600	950
✔ Life cycle cost service:	100	100	50
✔ Life cycle cost dismantling and destruction:	50	40	10
TOTAL SUM:	750	940	1130

important issue. The same thing is equally valid for a ventilation system. When choosing a system it is not only about purchase price and what you get for that – it is also about what it will cost in energy, service and maintenance to operate the system for many years ahead.

The total figure one arrives at, whether it is for a single house or for a huge block of flats, is never the "correct" figure of how the big the cost will be. It depends on a number of factors, like price of electricity and inflation, it must be a matter of more or less exact guesses.

The total amount is very useful as a comparative figure, if you compare three systems and use the same fixed parameters (for price for electricity and other estimations), it is possible to form an opinion of what system will turn out most economical in the long run.

Exempel

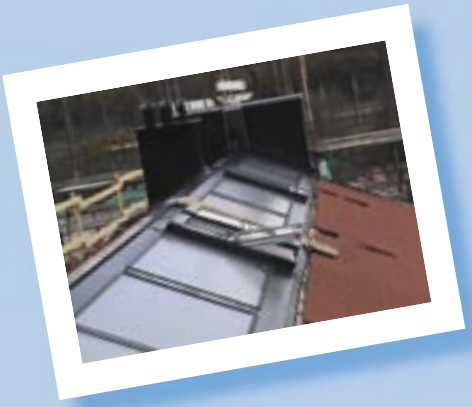
Warm houses without conventional heating system

At Lindås outside Gothenburg there are 20 terraced houses without traditional heating system. The houses are therefore called ”passive houses”. Compared to normal houses, these houses only use a third of electricity for heating. The reason for this is that they are very well insulated.

– When we designed the houses we had some simple principles in mind, we wanted them to function well, which means everything from room planning to air quality, says Hans Eek, architect SAR.

EFEM architect´s office, where Hans Eek worked, is the company behind the houses at Lindås. And Hans is satisfied.

– When talking to the people living in these houses, everybody says the same thing, they are very satisfied with the indoor air. It is simply good air to breathe, he says.



Passive houses are very well insulated and tight, which means there are small heat losses through walls, ceilings and floors. The tightness also makes it necessary to have a very efficient ventilation with fan controlled supply and extract air. The heat in the extract air is taken care of in a heat exchanger that heats up the cold fresh air. It is almost enough, but not quite.

The extra heat that is needed to heat the air completely and to cover the losses through walls, floors and ceiling comes from people and machines in the house. Very little extra energy is needed to warm the houses. Eek has worked with development of energy efficient houses since 1974. The first project, however, was a failure, an older woman had reacted against the waste of energy and ordered a house to be heated with solar panels. Hans Eek still describes that house as a ”engineer´s Christmas tree where nothing was working”. The woman who paid took the failure well and was of the opinion that she had contributed to science – at least one had found out what did not work. Since then the projects have been a lot more successful.

– The houses at Lindås were the result of a long process, they are one of many steps towards energy efficient houses. To heat a house with help of the ventilation is a good way to use the already existing heat in the house.

A decreased use of energy is of course good for several reasons, it costs less money to heat the house and it is good for the environment. It is also not more complicated to live in these houses than in others, even if some details differ. Some people have complained about not enough hot water, others that the heat sometimes is a little uneven. These problems are however outweighed by the saving of energy and the feeling of living in a very environmentally friendly house.

The terraced houses at Lindås are among the most well insulated houses in Sweden. The fresh air is taken from outdoors, the air passes through a fresh air filter. The cold incoming air is heated in a heat exchanger to which the extract air from toilets and bathroom is led. The system has a very high efficiency of 85 per cent. The kitchen extract air is led straight out through an ordinary kitchen fan.

– We do not want food smell and pollutants from the kitchen to reach the heat exchanger, it is enough with the air from bathroom and toilets to reach the desired effect, says Hans Eek.

The air exchange rate in the houses is according to the building norm BBR, i.e. 0.5 air exchanges per hour. The supply air, which then is heated before entering the rooms, is brought into the living rooms and bedrooms. The unit is placed in the kitchen, which would cause a certain noise, as ventilation systems are known to make noise.

– Only badly designed systems make noise, and of course they exist and that is obviously one of the reasons why many architects are very sceptical against mechanical ventilation. These systems do not make noise, their sound level is lower than that of a refrigerator, says Hans Eek.

He thinks that the indoor air is one of the absolute most important functions in a house. Good indoor air is as important as a well thought-out room planning and a good daylight let in.

– People are going to live in the houses and then there must be good air. The fact that the houses are very energy efficient is also important. That is what I have worked for the last 30 years, he says.

In 2003, Hans Eek together with the building physicist Dr Wolfgang Feist from Germany received the City of Gothenburg´s International Environment Prize. Eek was earlier project leader for the visionary project ”GÖTEBORG 2050” dealing with a durable city in a durable world. At present he has the mission for the Energy authority and the region of Västra Götaland to develop and spread the knowledge and to contribute towards building more areas with “passive houses” in our country

Chapter 4

Indoor environment at home and health

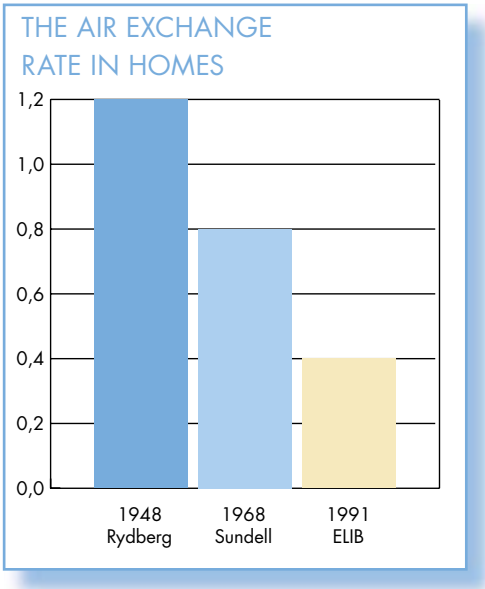
It goes without saying that it should not be dangerous to live in your house. The worlds largest research project on indoor air, the so called Värmland Study, however, shows that this is many times the case.

Our living has changed dramatically over the years. Our houses become more and more airtight and as few of us have thought of improving the ventilation at the corresponding rate, the indoor air stands still. Not many Swedish homes meet the requirements of the authorities of 0.5 air exchanges per hour.

Over the years, Swedish researchers have studied just the air exchange rate in Swedish homes. Professor Rydberg studied the air exchange in homes in 1948 and he found that the average figure was 1.2 per hour. In 1968 Professor Sundell made a corresponding study, the air exchange in our homes had gone down to 0.8. 1991, ELIB (a Swedish study by Norlén and Andersson) showed that the air exchange rate had gone down to 0.4 per hour.

We have over a long period lowered the air exchange rate in our homes – at the same time the number of cases of asthma and allergies has increased substantially.

Professor Sundell shows in the Värmland Study that there is a clear connection between low air exchange rate in the home and asthma and allergies in children.



The air exchange rate has decreased drastically.

Exempel

The Värmland Study

The Värmland Study asked many of the questions currently being debated throughout the world. Are children more allergic if there are pets in the home? What effect does the air quality in our homes have on our children? Do we clean too much? Or too little?

At this point researchers can see that the risk for illness increases if the ventilation is poor in the house. In the 25 % of the detached houses with the lowest air exchange rate, the risk for asthma, eczema and hay-fever was double as compared with the 25 % of the houses that were ventilated in accordance with recommended rates.

The overall objective with the study is to find out why people are more pone to sickness in houses affected by damp.

One of the most important points with this study is that it includes both medical and technical questions, it is carried through by doctors, chemists, microbiologists and engineers. The goal is to see what connections there are between the indoor air and the health of the children.

The Study was started in the year 2000 by Professor Jan Sundell at Denmarks Technical University and Dr Carl-Gustaf Bornehag at the University of Karlstad and The Swedish National Testing and Research Institute, SP. All families in Värmland who had children between the ages of one and six received a survey in the mail, a total of 14 000 were sent out. Almost 9 000 of these families responded to the questions asked by the researchers. The questions ranged from food and cleaning habits to pets. There were also questions about how the children were feeling and where they normally spent the daytime.

In the 9 000 families there were 11 000 children, making this survey by far the biggest study in the world on how the indoor environment affects the health of children.

In order to get more exact results, four hundred children (200 healthy, 200 with severe allergies or asthma) were selected for an in-depth study regarding the connection between indoor environment and illness.

These children were given an extensive medical check-up. Then their home environments were studied in depth through on-site surveys and measurements. What pollutants were present? What did the ventilation look like? What else has an impact on the children?

So far, the researchers have concluded that ventilation has a significant impact on children's health. A good air exchange rate does not remove the risk for asthma or allergies but children living in well-ventilated homes have a better chance of staying healthy. It was also concluded that the majority of the houses are insufficiently ventilated. 60 % of all apartments and 80 % of all single homes did not meet the official Swedish requirements.

One obvious warning signal that was found is condensation. The researchers simply measured the condensation on the bedroom windows in the morning – and could see a clear correlation. Too much condensation increases the risk of becoming asthmatic or allergic. "Too much condensation" in this case is more than two inches on a double-glazed window.

Condensation appears when the ventilation is insufficient.

The families themselves brought up a number of things that they thought had an impact on the health problems of their children. It was smoking, living in a city, short breast-feeding period, the

child is in the crèche and various types of eating habits. In homes where the family itself could establish that there existed a problem with dampness, the risk for allergy and asthma symptoms was doubled. A combination of floors made from PVC and dampness in the house, further increased the risk.

The Värmland Study also shows that children living on a farm have fewer allergic or asthmatic problems than other children.

During 2005, everybody that answered the first inquiry will be answering the same questions again. The researchers will be able to draw a number of conclusions about how the indoor environment affects children's health. The study will probably go on for decades to come. It is financed by FORMAS, Swedish Asthma and Allergy Association, The County Council of Värmland, The Vårdal Foundation, Denmarks Technical University and several others in a cooperation between SP and the University of Karlstad and some twenty other institutions in Denmark, Sweden, Norway, Holland and USA. The official name of the study is "Dampness in Buildings and Health".

What causes pollution in our home?

A home should be a place for relaxation, playing, meeting friends, family life, seclusion and for everything people want it to be. For many people the home is also a place of work.

There are a number of things that make the air at home worse than the air outdoors or at our work place. We mix people, pets, various activities with chemicals and materials without considering what it means for the air.

Should we be worried? Surely you can have both a dog and a hamster, it does not even smell if you put a scent box or two where the pets eat and sleep.

Yes, we should be worried.

Many things, some of them necessary, others less necessary, have an effect on the air in our homes. In order to minimise this effect, the air must be exchanged often, preferably the incoming air should also be cleaned. If the supply air is clean, the pollutants added indoors will have a lesser effect.

Building materials

Earlier houses were built in a different way than today, we built houses weather permitting, preferably when it was warm and dry outside, construction was also allowed to take time. The houses were built more ”in their own pace” than with a fixed dead line for someone to move in. Traditional materials were used, wood and stone.

Today, we build all year around and must therefore use materials that can withstand both moisture and cold weather. Construction must be fast, not only to save money but as often because the person moving in wants his/her home as soon as possible.

Many of the new interior materials are badly analysed, we simply do not know what the consequences will be long term. Today we know well the results of radon, which exists in Alum Shale Concrete, which was used as building material for many years. At that time nobody realised how dangerous the radon was, today we know.

Exempel

The Bamse Study

Another Swedish study pointing in the same direction as the Värmland Study is the Bamse Study. It is a study on childrens allergies carried out in Stockholm. More than 4000 children from Stockholm born between 1994 and 1996 were followed from birth. The purpose was to obtain more knowledge of how different factors, the indoor environment in particular, impacted on the risk to children getting different forms of allergies. The incidence of allergies is on the rise; whether this is because certain protective factors have been removed, or if harmful factors have been added to the indoor air, is not known. In the Bamse Study the researchers concluded, among other things, the following:

- A poor indoor climate (mould/ dampness/condensation) in the home increases the risk of asthma
- Smoking during pregnancy leads to an increased risk that children develop asthma
- Breast feeding decreases the risk of children developing asthma
- Among children exposed to two or three risk factors (tobacco smoke, poor indoor climate, prematurely interrupted breast feeding) the risk of developing asthma was more than twice that of children exposed to one, or none, of these risks. Similar tendencies existed for allergic rhinitis (hay fever)

The Bamse Study is a co-operation between The Department of Occupational and Environment Health, The Astrid Lindgren´s Children´s Hospital and the Institute for Environmental Medicine at Karolinska Institute (one of Europe´s largest medical Universities). The children, and their living environment, were checked regularly. At the age of four, 40 percent of the children had some form of allergic problem, i.e. asthma, skin rashes, hay fever or food allergies.

Furniture and home electronics

Furniture and textiles can also contaminate the air. Many pieces of furniture are today impregnated with various substances to be all from fireproof to dirt repelling. All these substances have an effect on the air.

Older types of computer screens emit substances that contaminate the air. Various types of printers, mainly laser printers, do the same, as do copiers. A good rule for this type of equipment is to not keep it in the bedroom or in rooms where you spend a lot of time.

Two substances that are frequently discussed are brominated flame retardants and pfthalates, that can be included in a number of products that we keep at home.

Brominated flame retardants are various chemical compounds that contain the element bromine. Today there are some seventy such substances used to make a number of products less flammable. They are used in electronic equipment, in cables and cases for computers and printers, they are used in building materials and a lot of textiles, such as in furnishing fabric.

These substances are hazardous and in many cases unnecessary. They are emitted into the air in our homes, we then breathe this air and as a result our bodies store the contaminants. There are good alternatives to the bromine addition and many companies have removed it from their production.

Pfthalates are one of the most commonly used industrial chemicals. They are used as softeners in PVC-plastic but also as solvents and aroma enhancers in perfume and cosmetics. In our homes the pfthalates mostly come from the floors, where they emit and spread in the air. The pfthalates reduce the fertility in people and can cause fatal injury and affect hormones. Danish and Swedish researchers have shown a clear relation between pfthalates and children´s asthma/allergies.

People

People contaminate the air just by being, but also through our activities. The first thing that comes to mind is probably the carbon dioxide we all emit and that is mixed with the air, which then deteriorates. Carbon dioxide in itself is

not poisonous. However, a high concentration of carbon dioxide means a lower concentration of oxygen – which makes us tired. We can also get headaches, feel dizzy and nauseous due to too high a level of carbon dioxide. This is most obvious in rooms where many people stay and the ventilation is not sufficient, the air quality worsens and we are less able.

Carbon dioxide is however not the most important contamination from people, that is dampness. We emit moisture both via exhalation and through our bodies. This moisture must be removed from the building as moisture creates a lot of problems. Dampness can cause mould, damp environments are perfect for several kinds of mites. Damp home environments attract house dust mites. The mites settle primarily in beds as they feed on dead skin. This specific type of mite leaves behind particles that are strongly allergenic and can cause asthma and hay fever. The connection between too much moisture in bedrooms, mites and allergies have been established. The remedy is an adequate volume of fresh air.

By keeping the humidity at the right level we can avoid these problems. Installing a humidifier in homes is almost never a good idea, the moisture people emit is already too much for a normal home. To add even more moisture will create larger problems with mites and mould.

Animals

Sometimes there is a discussion whether it is good or bad to keep animals in the home. All pets, with the possible exception of certain reptiles and fish, contaminate the air. Many people are also allergic to furry animals.

Is it possible, someone might ask, to protect oneself against becoming allergic to animals by exposing oneself to just animals?

The answer is no. It is a popular myth that this would be the case. This myth is built on the following facts that are, in fact, correct:

1) **People who have furry animals at home are very seldom allergic.**
2) **People who do not have furry animals at home are more often allergic**

So, one concludes that the sheer presence of a furry animal will protect against allergy.

However, that is not a correct conclusion; the explanation is much simpler than that.

People who are allergic, or who know that there are allergies in their family, express self-preservation instincts: they do not keep furry animals in their home. People who are not allergic do not have to think about these things and therefore are more likely to live with a furry animal
Statistics show, therefore, that people without allergies more often have furry animals than people with allergies. From this you can draw the conclusion that people are sensible. But you cannot accurately draw the conclusion that furry animals protect against allergy.

Chemicals

Most of us keep a lot of chemicals at home. Everything from the bottles in the cleaning cupboard to hairspray counts, as do air cleaners of various kinds. There are two types of products called air cleaners. We have the machine which filters the air and which can be useful in dirty environments, especially if you suffer from asthma or allergy. The machine is put in a room, the air circulates through the filter and the room air is cleaned.

There is also so called air cleaners in the form of small boxes or hangers, which pushes away smells of various kinds (or maybe more correctly, spreads its own stronger scents). These should really be called something entirely different than air cleaners. They have a certain effect on the air but do not clean the air. We do not know much about how they influence people but a study carried through in 2004 showed that they can be hazardous. The study was carried out by the European consumer organisation BEUC, which tested 76 chemical scent products. In a press release dated December 2004 BEUC wrote "These products represent a substantial health risk, not only for people with asthma or allergies, pregnant women and children, but for everyone using them continuously."

A Danish survey made earlier showed that vacuum cleaner fresheners often contain dangerous substances.
On the whole it is wise to be careful with products which single purpose is to spread scents. Good air is clean and odourless, if there is a smell and an air cleaner is called for it is better to try to remove the contamination source to simply remove the problem. If that cannot be done, one should make an effort to clean the air – using filtration.

Radon

Radon is one of the most dangerous pollutants in our homes, therefore it is covered in a separate chapter, chapter 5 on page 7

Radon originates from three main sources, from stone materials like Alum Shale Concrete, which is a building material used up to 1975, from the ground and from the water. The problem with radon can, however, be reduced.

To make it comfortable at home

Much of what pollutes the air and that we have previously covered cannot really be noticed, we breathe in radon or phthalates but don't notice when we do. When people want to "create a good indoor climate" we tend not to concentrate on high air exchange and good cleaning in form of high-class filters. Not due to reluctance, it is often ignorance or that it feels more necessary to do things that will be noticed.

One example is to cool or heat, i.e. to create the correct temperature. Another is to stop draughts, or to remove what we perceive as dry air.

Often our actions in these situations can lead to a worsening air quality.

A draught is a good example of this. Air that does not move gets stale quickly. The air in a room, must, in order to keep the lowest acceptable quality, be changed with 0.5 air exchanges per hour. The only way to do this is to remove the used air and supply fresh air. If that is done by opening a window and create a draught, it will soon be uncomfortable for the people in the room, especially if it is cold outside. Others bring in a fan to create "air movement" – something that has the same effect as a whisk in a bowl. The air certainly moves around in the room, but it will not be exchanged. It might feel good, but the air quality does not improve.

A cold draft can feel very unpleasant. It develops on cold window surfaces or where cold air is let in without warming it. The cold air is heavier than the warm indoor air and falls down towards the floor, where a cold draught can create a problem during wintertime, in old as well as new houses.

Another important comfort issue is the room temperature. We want it nice and warm in the winter, except maybe in the bedroom, which may very well

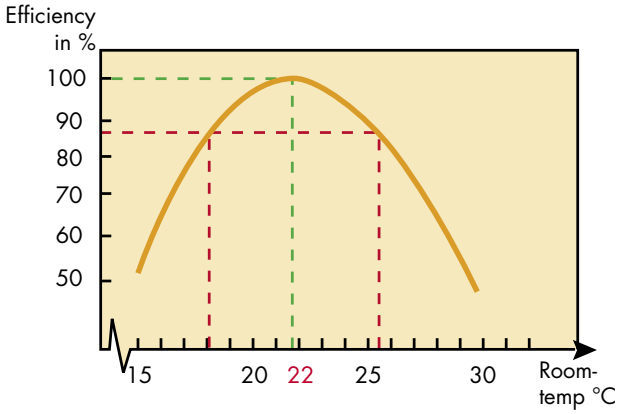
be cooler. In the summertime it can be a little cooler than outside, at least if the summer is warm. To control the temperature is important, especially as the temperature affects us substantially, only a couple of degrees too high or too low can have an impact on our abilities. At 18 degrees C the sensibility of the fingers is hampered, if the environment is too warm we lose our concentration instead. At 27 degrees C the ability to think clearly is diminished by 30-50 percent. Older people, who are less active need a slightly higher temperature than younger, more active people.

What we interpret as "too dry air" often has to do with the temperature. The sensation of "dry air" is common, but normally does not depend on dry air. In fact, it is very difficult for humans to determine, with our senses alone if the air is dry or not. The problems that are usually interpreted as signs of dry air, i.e. that the mucous membranes in the eyes, lips and in the mouth and nose dry up, often depend on dust or other pollutants.

Most common, however, is that it is too warm. Lower the temperature one degree or two and the air will feel less dry.

To install a humidifier, which has become increasingly common, is often a mistake. High humidity causes lots of problems, the risk of mould increases and house dust mites love moisture and multiply fast in such environments.

CORRECT ROOM TEMPERATURE
Temperature and work performance



SOURCE: DAVID WYON

This is what you can do

There are several things to do, which quickly and easily improves the quality of the indoor environment at home. Some of these measures will increase the energy use but in certain cases we have gone so far in our wish to save energy that the indoor air has become unhealthy. We need to ensure we have an adequate airflow rate to improve air quality.

- **Remove sealing strips from windows and doors – or parts of the strips. This will increase the air exchange rate and with a constant increased airflow the home will normally not be too cold even if it is cold outside. It the sofa or armchairs are placed close to a window, do not remove the sealing strip just there. If we have fitted draught excluders to our doors and window we can remove some of these to increase the airflow rate. Of course we should avoid causing draughts where people may be sitting. It should be remembered that bringing in cold air in the winter will increase energy use as additional heating will be required.**
- **During periods with comfortable outdoor temperature it is a good idea to air the home, especially if there is no ventilation or if the ventilation does not work properly.**
- **Keep the home clean and fairly dust free.**
- **Give the quilts and pillows an airing at regular intervals (reduces the risk for house dust mites).**
- **Avoid products used purely to mask smells such as air fresheners and scented candles.**

Chapter 5

Radon in our dwellings

Radon and tobacco smoke, especially in combination is among the most dangerous in our dwellings. Unlike tobacco smoke, you do not see or feel radon. Radon is very common in Swedish homes. In July 2004 the National Board of Health and Welfare lowered the threshold value for radon to 200 Becquerel per cubic meter air. By the year 2020, at the latest, all dwellings in Sweden shall be below this value. This change is an adjustment to the goal set by the Parliament.

Almost half a million homes in Sweden have a value exceeding the new threshold value. SSI, The Swedish Radiation Protection Agency, and estimates that there are around 150,000 homes with a radon level higher than 400 Becquerel or more, i.e. more than double what is allowed according to the threshold value.

These high radon levels kill almost 500 Swedes in a year. Radon causes lung cancer.

It is seldom possible to completely remove radon from a building but the radon level can be drastically reduced. Grants are available for that purpose.

Considering this danger very little is done.

Few people apply for grants. Few people do something about the radon problem.

Few people try to find out if the house they are living in contains radon.

Why is this?

The Government´s program for radon decontamination of small houses had 33 Million SEK to distribute for the year 2003 and the same amount for 2004. The number of applications is however constantly small and only a small part of the money has been used. Nobody expects that the interest will grow in the coming years.

The goal that was set in 1996 was that all houses should have been decontaminated before 2020. With the present pace it will take several hundred years.

In a press release from the Department of Environment in connection with the final report from the radon commission a few years back we find one part of the explanation for our unwillingness to find out the facts.

"Many people are afraid of analysing the radon level in their houses. One does not want to believe that the own house could be unhealthy."

It is a frightening but probably correct conclusion.

Radon is today such a well-known problem that house buyers cannot claim that a high radon level being discovered after the purchase is a hidden fault. So, a house buyer must measure in advance or stipulate in the contract that the radon level will be measured after the purchase. It is also important to specify how costs for a potential decontamination will be split between buyer and seller.

Before building a house, always ask the local authorities about the radon situation where the house will be erected. To avoid future problems with ground radon it is also a good idea to discuss this with the building contractor so that the house is built in a way that a minimum of radon leaks in.

Sources of radon

Radon comes mainly from three sources. The first thing that comes to mind when talking radon in homes is probably Alum Shale Concrete. The biggest source, however, is the ground and finally water.

GROUND RADON

The air in the ground always contains a lot of 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 often is lower than the outside pressure, the air is sucked in

Most of the local authorities have measured ground radon and know rather well which houses risk too high radon levels due to ground radon. It is a good idea to measure the radon value in all homes with ground contact.

It is not dangerous to stay outside in places with high ground radon value, outside air dilutes it very quickly and the radon value goes down to a safe level.

ALUM SHALE CONCRETE

It is not only Alum Shale Concrete among our building materials that emits radon but it is by far the most discussed source of radon. All building materials containing stone emit radon, normally in very small amounts. Alum Shale Concrete was introduced in 1920 and was used as late as 1980 (even if production was stopped 1975.

The Alum Shale Concrete is light, it is also very practical as it can be cut with a saw and it has good insulation properties. In fact an ideal building material, if it was not for the radon. The Alum Shale Concrete of course contains alum-shale, a material that has a high uranium content.

As early as 1972, SSI warned of the dangers with Alum Shale Concrete, three years later production was discontinued but the material was used until 1980, Light concrete produced after 1975 is made from sand, cement and lime. Its uranium content is very low and therefore both radioactivity and radon emissions are low

Approx. 400 000 homes were built with Alum Shale Concrete in Sweden. To create a high radon value in the house, a large part of the walls must be built from this material. If all outer walls are built from Alum Shale Concrete there is a risk that the radon value will exceed 200 Bq/cubic metre, which is the threshold value. Too low an air exchange rate will also increase the radon value. Houses with both outer and inner walls made from Alum Shale Concrete will quickly reach radon values exceeding 400 Becquerel per cubic metre. If also the beams are made from Alum Shale Concrete, there is a risk that the value will exceed 800 Becquerel per cubic metre.

WATER

Lakes and streams around Sweden contain almost no radon – contrary to the water in the soil and in the bed-rock. People risking high radon values in their drinking water are those with their own wells, drilled in bed-rock, and excavated wells where the water comes from cracks in the bed-rock. Water provided by utility companies normally does not contain high radon values as the water is cleaned before being distributed to the household.

Water, just as Alum Shale Concrete, emits radon, which will mix with the air and stay inside. To drink the water with radon is not dangerous, what is dangerous is the emitted radon, mixed with air.

To find out whether the water contains radon, it has to be analysed. There are laboratories which are accredited to perform such an analysis.

To detect and do something about radon

There is no other way to detect radon but to measure. This is however easy. The most common method is to use so called tracking film that you get from a measurement laboratory. The environmental office of every municipality knows where to go; Many municipalities also carry out measurements free of charge

The tracking film is placed is placed in several spots throughout the home and is left there for a couple of months. It is then sent to the measurement laboratory, which calculates the result.

If it turns out that there is too high a level of radon in the home there are several options for how to lower it. What should be done depends on from where the radon originates and how the building looks.
Some common ways of decontaminating homes are:

- **Increase the air exchange by ventilation, In simple cases it can be sufficient to install an exhaust air system. In many cases a combined supply and exhaust system is needed to avoid negative pressure in the house. Increased ventilation is especially effective if the radon problem comes from Alum Shale Concrete.**
- **Replace contaminated building materials**
- **If the radon comes from the ground it is advisable to pack around floor lids like cleaning wells, at water pipes and cracks in the building. It is however difficult to achieve good results purely through these measures.**
- **Install a radon extract fan, which creates a negative pressure under the house so that the air is never sucked into the building. In this case the house should not have negative pressure, The best in this case is balanced ventilation.**
- **A radon well function is a good solution if the house is built on gravel or**

coarse sand. The radon well is placed on a distance from the house and sucks the air from the soil. One radon well can assist several houses.

- **Water containing radon can be cleaned through a radon separator. What size and efficiency depends on how much radon there is in the water**
- **See to it that there is no negative pressure, which makes it easier for radon to be sucked into the house. A balanced ventilation system can ensure that there is no negative pressure.**

Money and radon

To measure radon in a house generally does not cost a lot. Many municipalities also measure free of charge.

If it is necessary to make radon decontamination it will cost money. Grants are available for single houses, but a precondition is that the person both owns the house and lives in it. The grant is maximum 15 000 SEK (or if the decontamination costs under 30 000 SEK, half of the cost).

To install a simple exhaust air system costs from approx. 20 000 (of which 10 000 is paid by grants), a fan controlled supply and exhaust air system is more than double that cost.

Tracking film for measuring of radon comes in a small box.

If the radon comes from the ground, the decontamination cost will often be less costly. A radon suction fan system will cost between 10 000 and 30 000 SEK, a radon well between 15 000 and 25 000 SEK. The latter can be used for several houses.

(Prices above are valid 2005)

Main source for this chapter: The Swedish Radiation Protection Agency SSI

Exempel

Radon house becomes good as new

Three years ago, the air in Carola Johansson´s and her partner's house in Uppsala had a radon level of between 700 and 800 Bequerel. Way above acceptable levels. Today the level is 120 Becquerel.

– It feels very good to know that we have done what we can to make the indoor air healthy. And that we have succeeded, she says.

Carola Johansson and Per Andersson moved in to the house in 1999. At that time the family consisted of two adults and five children. When Carola and Per bought the house they did not even consider whether there could be radon in it despite the fact that it was built in 1963 when many houses were built with Alum Shale Concrete.

– We never even thought of asking that question. We attended many house shows but never heard anybody mentioning radon. Nothing was being written about it at that time, says Carola Johansson.

Another reason why the question was never asked was that according to the house broker´s documentation the building material was something called Ytong.

– If it had mentioned Alum Shale Concrete, we should surely have reacted, but here we thought that we had been informed that it was not Alum Shale Concrete.

Ytong is a brand name for light concrete products, among other things Alum Shale Concrete. A couple of years after moving in, Carola saw an ad about radon measuring and she took accepted the offer.

– We did it because we wanted to know that we did not have radon in the house, we thought it could be a good thing to have such a document. There was no discussion about what we would do if it turned out that there was radon, such a thought did not exist. Today, three years after that measurement, she laughs when relating it, but when the result of the measuring came in May 2002 it was not funny. On the first page of the radon report, it says in black and white that the living room has 800 Becquerel per cubic meter, the upstairs hall 700.

At that time the threshold value was 400 Becquerel per cubic meter, today it has been lowered to 200.

– The only thing we knew about radon was that it was dangerous and that it can cause lung cancer. Both my parents had smoked for many years, Per and I have also been smokers and on top of that we had bought a radon house, I felt terrible.

They realised that they must do something about the situation, not least for the sake of the children.

– We did not know much about what to do, we had seen someone install a radon extract fan on a TV-program, but that was all. Radon extract fan never was an option for us because the main part of the radon in our house came from Alum Shale Concrete and then it is a matter of installing efficient ventilation, says Carola Johansson.

Initially the house was built with natural ventilation but that had not operated properly for many years due to various tightening measures, the house was basically not ventilated at all. So a fan controlled supply and exhaust air system with heat recovery was installed. The rebuilding took a week, the total cost for the radon investigation, material and installation became 85 000 SEK. 15 000, which is the maximum grant for radon decontamination measures was paid by the authorities.

– There is an enormous difference in the air before and after the refurbishment, says Carola Johansson.

– It was probably rather bad air quality before, when we fried hamburgers there was a smell of food a whole day afterwards. Now it disappears quickly and we have no mist on the bathroom mirror when we take a shower unless we shower for a long time and very hot, then there is just a little mist.

She thinks that the ventilation system at large has worked as it should from the beginning. They have to change filters twice a year, and the system, though quiet, can be heard. They also have a few ducts in the rooms as it was not possible to hide the complete system. The unit itself also takes up some space in the laundry room, where there already was little space.

- But one gets used to things quickly. It looks a little bit different, and the sound is not a problem. The most important thing is that we live in a house with good air. That is worth a lot, says Carola Johansson.

Chapter 6

Tomorrow's demands

Exactly what demands that are going to be put on indoor air in the future is of course difficult to predict. We know, however, what issues that are important both for the debate and for the demands that authorities will raise.

- **Research, for instance in Sweden, shows a clear connection between poor indoor air and illnesses like asthma and other allergies.**
- **International agreements and national demands on energy saving will have great impact on the way we look upon both how much energy we use and what this energy is used for. Examples of this are the Kyoto Protocol, which stipulates reduced emission of carbon dioxide and the environment goal of the Parliament, which clearly stipulates reduced energy use.**
- **A greater awareness that people need fresh air in all places, not least in our homes. Not only for keeping healthy, but also for our well-being. Fresh air means higher quality of life. This means that, among other things, there are economic reasons to build houses with a good indoor environment. More people want to live there.**

Two good examples of the last point are the department store Gekås at Ullared and the newly built homes like the Turning Torso in Malmö and Järla Sjö in Stockholm. Gekås at Ullared is a marked low price department store where one of the business ideas is that it shall be so attractive to shop there that people gladly stand in line for quite some time before entering the premises.

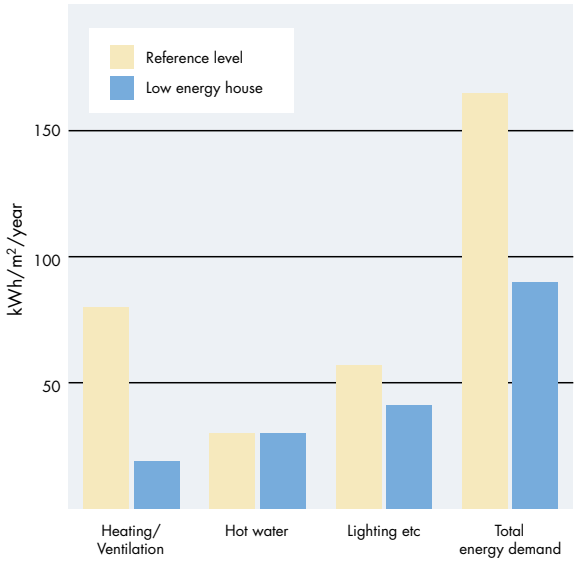
The most important reason for shopping there is the low prices.
But the management of Gekås also concentrate on other things, for example a very good ventilation system, this as they are convinced that people who feel good while they are in the premises also shop more. If the air is poor, the customers might loose both their temper and the desire to shop.

Exactly the same reasoning is valid in many new home projects. People who move in to the Turning Torso in Malmö or Järla Sjö in Stockholm move into homes where indoor environment has been considered, even if the indoor environment still has lower priority as a sales argument than room planning and outdoor environment on the home page of housing company

Much of the discussion about indoor environment in homes is about how to save energy. In Norway a work on how much energy a home can be allowed to use is now (2005) being carried through. The so-called Sintef report suggests a maximum energy consumption for single homes and apartments of 150/130 kWh/cubic metre. The figure was arrived at by using the assumption that the house has heat recovery and balanced ventilation. It is not necessary for the house owner to have the technical installations on which the calculations are based, but the amount of energy used cannot exceed the stipulated level.

The conflict between energy and good indoor environment lies in the fact that good ventilation is necessary to create a good indoor environment and good ventilation needs energy to function. As shown in other places in this book it is however possible by (amongst other things) heat recovery and on

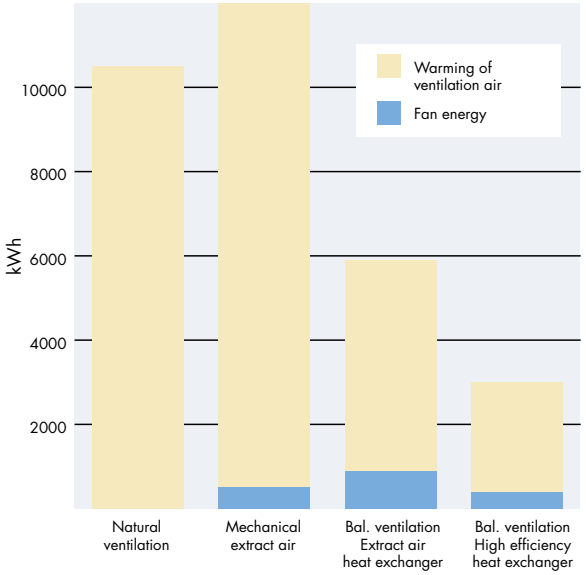
ENERGY USE IN SINGLE HOMES – 1



Comparison between energy use in a normal house and a low energy house with balanced ventilation and heat recovery.

demand ventilation reduce the energy consumption with help of the ventilation. Energy efficient equipment, as for example fans with high efficiency will also reduce the consumption.

ENERGY USE IN SINGLE HOMES – 2



Energy use for ventilation in single homes 160 m² with various ventilation systems

The Swedish environment goals also say that we shall reduce the energy use in our homes and discussions about setting limits for how much energy a house may use are ongoing. Everybody agrees that we must decrease the use of energy, not least because we have signed the Kyoto Protocol. The energy used in homes goes largely to heating and ventilation. The key issue is how the energy use can be reduced at the same time as the indoor air is improved

One subject for discussion in several Nordic countries is ventilation on demand. A ventilation system, which is running constantly will use energy also when the house is completely empty. A system, which is used only when needed and which can have different effect depending on the actual need, is the most economic from all aspects.

All Nordic countries have clear regulations for the indoor air in our homes. The laws and regulations cover everything from that the air shall be good to breathe to how the ventilation system shall be built. In the Finnish building regulation it is said ”ventilation systems shall be built … so that they contribute to creating conditions for a healthy, secure and pleasant indoor climate”.

Norway, Sweden, Finland and Denmark have the same minimum standards where air exchange is concerned, 0.5 air changes per hour. Finland and Norway have taken a step further than Sweden when talking about fresh air supply. 4 litres per 50 % extra, i.e. 6 litres. The Norwegian regulations say ” Fresh air supply due to pollution from people, shall for persons with light activity be 7 l/s person.” These rules apply both for public buildings and homes, The demand in Norway is in other words almost double compared to Sweden.

At the Harvard University in Massachusetts in USA, the researcher Don Milston has conducted a large study on how much people were affected by, among other things, varying degrees of ventilation at work. The results show that those who worked in areas where only the minimum requirements on airflow were met had fifty percent higher illness-related absenteeism than those in areas where the airflow was twice as high. The study was carried out at identical workplaces in two separate buildings, the only thing that differed was the ventilation. Nothing says that this result cannot be applied on our homes, quite simply, we feel much better when we stay in premises with high airflow.

Exempel

Quality assurance of the Indoor environment

How can I know that the house I live in has a good indoor environment?

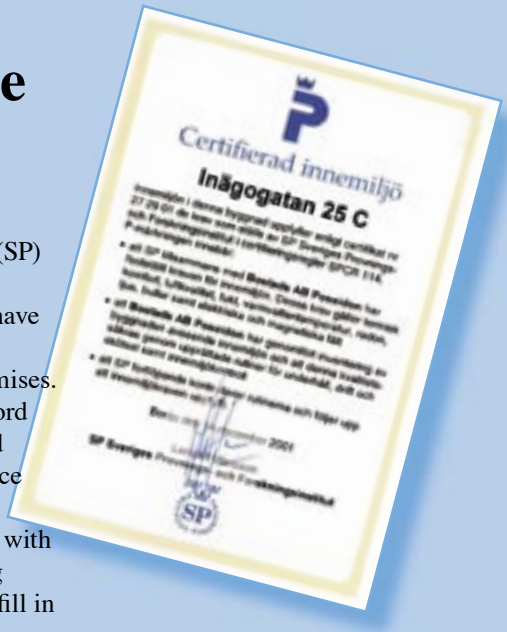
The Swedish National Testing and Research Institute (SP) and the
Housing Companies Poseidon and Svenska Bostäder have developed a system for certification and so called P-marking of the indoor environment in homes and premises. A P-marked indoor environment means that the landlord every year certifies that the building meets established functional demands and that there is a quality assurance system in place for the building.

When a building is about to be P-marked it begins with a careful investigation to find out whether the building meets with the set demands. The tenants are asked to fill in a questionnaire with questions about everything from room temperature to annoying smell of food. What is being controlled is among other things ventilation, moisture, electric and magnetic fields and radon

Thereafter, all deficiencies are corrected and everybody involved in the managing of the building receives training. The tenants are also informed about what P-marking involves and how they can contribute to a better indoor environment themselves. The buildings that are P-marked get a certificate which shall hang on the wall of every stairwell. When the P-marking is carried out the house owner must maintain and quality control all functions regularly. A renewed questionnaire on the living environment must be done every fifth year.

SP make regular random checks to secure that all routines are being followed.

In 2005 Poseidon had certified 4 000 apartments. A further 7 000 apartments are in the process of being certified. Poseidon have 23 000 apartments in total and plan to have all of them certified by 2010.



An example of a certificate that the landlord gets

Chapter 7

Everything You REALLY Need to Know

This chapter contains different facts that are important to know for those who want to create a good indoor climate. What is said here is in most cases covered in more detail in previous chapters.

1) Research has shown that the air quality is important for how we feel. The air flow in our homes are often lower than the minimum recommended, which is .5 air changes per hour. The first goal is to reach this minimum level. The next step is to increase the air exchange so that the volume of fresh air is better adjusted to our needs.

2) There are a number of research projects that have addressed natural draught systems in schools. Many of the findings in these projects also apply to our homes. Some important experiences are that one must be careful when choosing materials, one must create large rooms in order to get better air quality. It is not possible for a natural ventilation system to function so that the air exchange demand will be met during all times of the year.

3) The problems with the indoor climate often starts at the planning stage – as it is seldom considered at that point. Therefore, the issue is brought to the agenda too late. If the goals for the indoor climate were discussed at an early stage it would be so much easier to meet them.

4) The starting point for the planning can not be low energy use at any price. People's need of sufficiently good air quality must be a central interest for the future proprietor and the planner.

5) Keywords for all technical solutions are suited for the purpose, reliability and economical on resources. This means for example that flexibility should be built in to the ventilation system so that flows can be altered when needed.

6) The demand for airflow and other functional demands must be met for a foreseeable future. This means that the systems must be maintained (serviced).

7) Low pressure in the system is an important condition for reducing the risk of noise.

Checklist for a good system

Whether renovating or building a new house and regardless if the ventilation system is installed in a small house or a huge block of flats for hundreds of people, the system must manage the following points.

A good system

- ✔ **Good indoor climate is synonymous with:**
  - Draught free
  - Low sound level
  - Correct temperature
  - Good air quality
- ✔ **Low energy use**
- ✔ **Easy to adjust**
- ✔ **Great flexibility**
- ✔ **Low life cycle cost (total cost)**
- ✔ **Easy to manage and maintain and with simple but detailed instructions**

If these points are met by a natural ventilation system, an exhaust air system or a balanced system does not matter. The important thing is that they are met. The Comfort part, i.e. the four points under "Good indoor climate", are the ones that means the most for the daily life. The five last points are important for both the owner and the tenants. A system which cannot manage these points is not good enough and does not fulfil its purpose.

Chapter 8

Word list and links

Word list

Air exchange – Gives air flow in cubic metres per hour in relation to the volume of the room, in cubic metres.
Airflow – How much air is flowing per amount of time. The units often used are litres per second or cubic metre per hour.
Balanced ventilation system – Means that both the exhaust air and the supply air is controlled by fans. För short FT-system. A development of this system is the addition of heat recovery.
Carbon dioxide – The gas produced when human beings and animals breathe out of when carbon is being burnt. A very common gas. When human beings breathe out, the air consists of approximately 18 % oxygen and 4 % carbon dioxide. Carbon dioxide is believed to cause global warming.
Dry air – Air with a relatively low humidity.
Exhaust air – Air that is taken away from a room.
F-system – System where the exhaust air is controlled by fans.
FT-system – System where both exhaust- and supply air is controlled by fans, often called balanced ventilation system
FTX-system – System where both exhaust- and supply air is controlled by fans and containing heat exchanger for heat recovery
Heat pump – A very efficient heating system.
Heat recovery – To make use of the heat in, for example, the exhaust air.
Hybrid ventilation – A natural draught system enhanced with exhaust fans.
Mechanic ventilation – Ventilation with fan controlled air flow.
ppm – Part per million.
Radon – A gas that is formed when the radioactive element radium falls apart. When we breathe air with radon in it, the radon will harm the cells in our respiratory system. Radon is a carcinogen.

Relative humidity – Moisture content in the air in percent of the maximum quantity of moisture that the air can hold at a certain temperature
S-system – Natural draft ventilation, means that the ventilation is controlled by thermal forces.
Thermal – Air movements caused by differences in temperature.
Supply air – Incoming air that is brought to a room.
Ventilation – From Latin "Ventilo" or "Ventilare" which means "to air" or "to expose to the wind". Now understood as the transportation and the exchange of air in a building or in a room.

Sources: Nationalencyklopedin and Ditt Klimat Inomhus

Links

www.aaaai.org (American Academy of Allergy. Asthma and Immunology)
www.asthma.org.co.uk (Asthma UK)
www.epa.gov (US Environmental Protection Agency)
www.healthhouse.org (Lung Association's Health House Program)
www.le.ac.uk/ieh/ukieg/ukieg.html (UK Indoor Environments Group)
www.lunguk.org (British Lung Foundation)
www.lungusa.org (American Ling Association)

We should all be entitled to breathe air in our homes which is not contaminated. This is not the case. We give little thought to air quality when we buy a property and yet most of us would insist on climate control if we were buying a new car even though we spend much more of our lives in our home. Good air quality is important for our health and especially that of our children. The number of cases of asthma and allergies has increased substantially over the last twenty years. The quality of the air in our homes has worsened not improved.

This book is written for anyone who is concerned about the air quality in our homes, homeowners as well as specialists, It provides information and techniques for improving the air quality around us as well as research results and details of ongoing studies. Read the book, use the knowledge and the insight it gives, and demand clean air indoors.

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