Demand-controlled heating and ventilation improves comfort in schools and offices.

Season and demand adapted heating and ventilation not only provides schools and offices with good comfort but also substantially reduces energy consumption. This has been shown in several buildings in which the company, DELTAte, has been involved.

"A cynical experiment with children!" This is how the V society chairman of the day, Hans Johansson, expressed himself in a local newspaper in Kungälv in 1992.

The V society had learnt that a new school had been built in Kungälv, the Waldorf School, in which the classrooms were ventilated naturally, i.e. without the use of fans.

The background to this was that the pupils' parents wanted a new school with a climate control installation designed to address the indoor climate problems that newly built schools throughout the country were suffering from. There was, moreover, a general desire for a school with reduced energy consumption. A quiet system, without the noise of fans was also requested.

Demand and season controlled ventilation.

Instead of planning the school conventionally with constant air flow and high inflow air temperatures, which results in a poor indoor climate and high energy consumption despite the use of heat exchangers, DELTAte decided upon an alternative solution.

A ventilation system in which the air flow was controlled by the current need - room air-temperature control - was adopted. In addition, the supply air temperature was reduced to agree with decreasing outdoor temperatures, which resulted in demand controlled, seasonally adapted air flow.

We chose a low-flow-rate radiator heating system as this would entail efficient, quiet operation with accurate thermostat control.

Yes, it was an experiment, but it was based on past experiences and the results of investigations.

It stands to reason

It should come as no surprise that the measure of supplying air to meet demand in a school results in an energy cost reduction of about 60 %, as compared to the cost of providing constant air flow. The air flow is controlled by the room temperature. Lowering supply air temperature in line with reduction in outdoor air temperature improves the cooling effect of the air and thus automatically further reduces the air flow on extra cold winter days. This seasonal adaptation of air flow and reduction in supply air temperature decreases the need for heating it by about a further 20 %.

Conventional heat exchange is then no longer advantageous, which opens the way for interesting economical operating solutions where the extract air does not need to be reintroduced for exchange with the supply air. Furthermore, the quality of the air deteriorates less since it does not pass through as much equipment.

The air flow reduction and the capacity of the cooler air to maintain a more consistent room temperature of 20-21 °C during the winter months also contributes to maintaining a higher relative humidity during the winter than in conventionally ventilated schools and offices. Users consider this a big improvement, and it is beneficial from a medical and physiological standpoint also.

In the case of the Waldorf School, there was a request to install a climate system with no mechanical ventilation if this were possible. The solution was a design with somewhat larger room volumes than usual and a skylight turret with windows on opposite sides in the ceiling in each room. The wind and thermally driven air change rate is controlled manually through the degree of window opening. The window that is downwind at the time is opened to the extent needed to obtain the desired climate in the room. The supply air is admitted via an underground duct; the ground warms up the air in the winter and cools it in the summer.

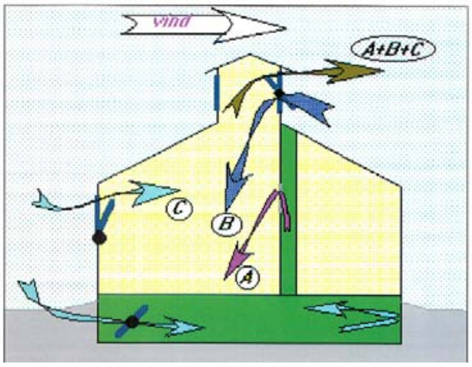

Fig. A = Air change via foundations or ducts.
B = Turret airing (Single sided principle). C = Facade airing

This type of climate installation is known as a **wind and thermally operated variable ventilation installation with passive ground heating and cooling.**

The new school was a success with satisfied users and low energy consumption, to the extent that many interested parties visited the school to see it for themselves and talk to the teachers.

This resulted in the company receiving a considerable number of orders to design similar climate installations in schools throughout the country. The supply ducts in many of the buildings were equipped with axial fans which were activated in the summer when the outside temperature increased and thermal forces decreased. The term "assisted natural ventilation" originated. In situations where auxiliary fans were not installed, facade window airing was used during the summer.

Fig. 2. The Rudolf Steiner School in Göteborg is an example of a three story building that employs this relatively simple ventilation system. Energy consumption for heating and electricity usually amounts to between 80-120 kWh/m² in buildings with the basic type of climate system.

Many schools with similar installations were also built in Norway. In contrast to Sweden, Norsk Byggforsk and universities in Norway showed a keen interest in this type of climate system. This interest was caused by the user's appreciation of the good indoor climate in combination with the low energy consumption.

Complex buildings.

The concept has undergone successive development over the years, which has entailed an increase in electronic control. Today the heating valves and ventilation baffles for individual rooms are electronically, sequentially controlled on the basis of a room’s temperature.

The supply air units needed to be developed to address problems that arose in more complex buildings. A significant step in this direction occurred when DELTAte designed a self regulating supply air unit for variable flow. After a year of prototype testing in a classroom, Acticon AB introduced a series of variable flow units, which were named "Flipper, the smart air unit", at the 2002 Nordbygg exhibition. Using this roof placed, pressure controlled unit, fresh air could be supplied without a draft and significantly under tempered across the entire range from 0 –100 % air flow, which was then something completely new on the market.

Fig.

Hybrid ventilation.

A new generation of climate units took shape at the beginning of the 2000s which enabled the same principle to be applied to conventionally designed buildings. As before supply air enters via underground ducts where passive heating and cooling is taken advantage of.

A new feature was a pressure controlled axial fan (low pressure fan) which maintains a variable pressure in the supply air duct all year round. The supply air pressure varies steplessly between 20-30 Pa on cold winter days and up to 80-90 Pa on hot summer days. The air flow in the rooms is varied using a damper and variable flow unit to between about 4-15 l/s per person depending on demand and season. Through transferred air, the extract air is collected in the corridors and is evacuated from there via natural ventilation outlets on the roof. This type of climate installation is commonly known as hybrid ventilation, which entails a good indoor climate together with still further reduction in energy consumption. In recent years some new passive house concept buildings, i.e. a very well sealed and insulated building, have been installed with a hybrid system.

Vargbro School in Storfors.

Architect: Björn Johansson K-Konsult Arkitekter Karlstad

Fig. 4 Vargbro School with the air intake building in the foreground.

Vargbro School is an example of a building with extremely good sealing and insulation in combination with a hybrid ventilation system. This school, which lies in climate zone 2, has been carefully followed-up and evaluated by Jens Beiron at Karlstad University, who has recently presented his work in a report "Operational observations of an energy efficient school".

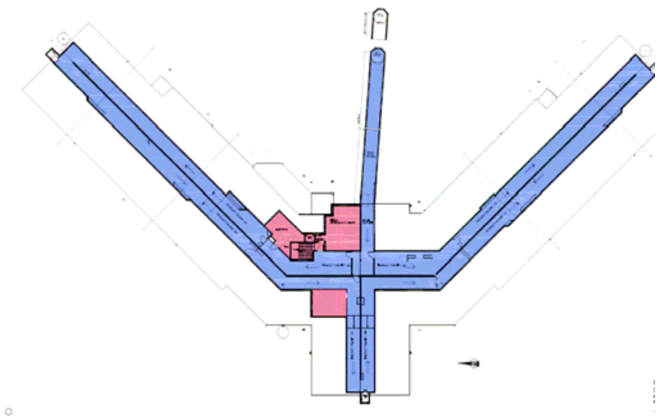

Fig. 5 Supply air ducting under the school.

Fig. 6 Supply air dampers and heating valves in supply air ducting. Easily accessible for inspection and adjustment while being out of harms way.

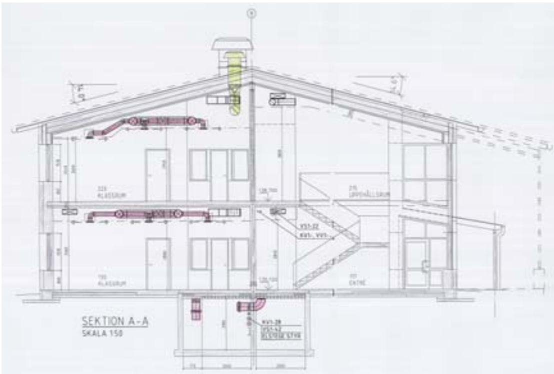

Fig. 7 The supply air is taken from the "warm" part of the ducting system and from there passes via the vertical shafts to the variable flow units in the classroom ceilings.
Through transference to corridors and stairwells, the air is extracted via natural draught outlets on the roof.

The report shows, among other things, that the school has a total weighed energy consumption which is 30 % lower than the PH09 criteria (new criteria for passive house standards) and as much as 70 % lower than the new BBR requirements. The fact that it also has a fully functional climate system with "passive" cooling must make it one of the most energy efficient buildings in Sweden that has comfort cooling.

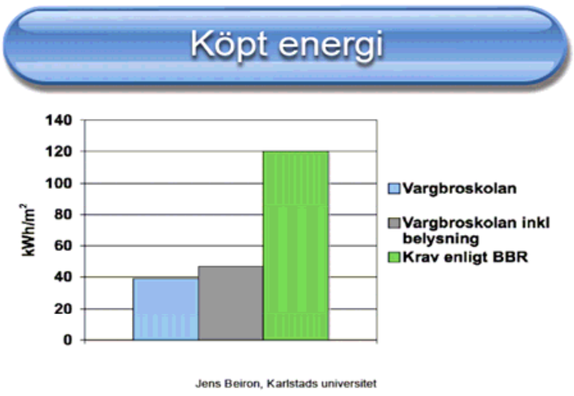

Fig. 8 Vargbro School energy consumption.

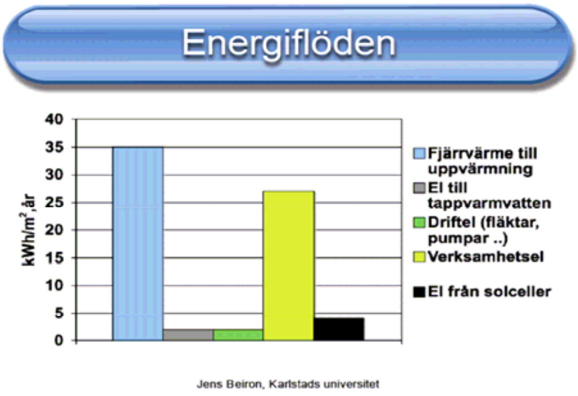

Fig. 9 Vargbro School energy flow.

Energy consumption for fan and pump operation (incl. passive cooling) is about 2 kWh/m². The SFP value for the fans is about 0.4 kW/(m³/s).

Hot water consumption is low since it is only used in toilet wash basins, one shower and the school kitchen. Since the hot water consumption is low, the installation of individual, electric water heaters was decided upon in order to avoid heat loss in the plumbing system. In this particular case, the heat loss would have been greater than the energy requirement for heating the water. The energy consumption for water heaters at the school has been estimated at about 2 kWh/m².

The total annual energy consumption for heating, hot water and electricity (incl. corridor lighting) is about 42 kWh/m².

Solar cell installation.

In addition, Vargbro School has a small solar panel installation and a small wind power plant, primarily for educational purposes, with a solar cell installation of 131 m².

During the first year this installation has provided about 4 kWh/m².

Fig. 10 Solar cell installation at Vargbro School.

On a yearly basis, the solar cell installation at Vargbro School produces sufficient energy to run the school's fans, pumps and water heaters. It also covers the electricity requirement for the comfort cooling installation in the form of the ground installed ventilation duct. During the summer when the fans are running at high speed, the ventilation ducts have a cooling effect that is perfectly adequate for providing cool, comfortable rooms when the outside temperature is at about 30 °C. It is an effective comfort installation that requires very little electricity and is totally free of environmentally damaging refrigerants.

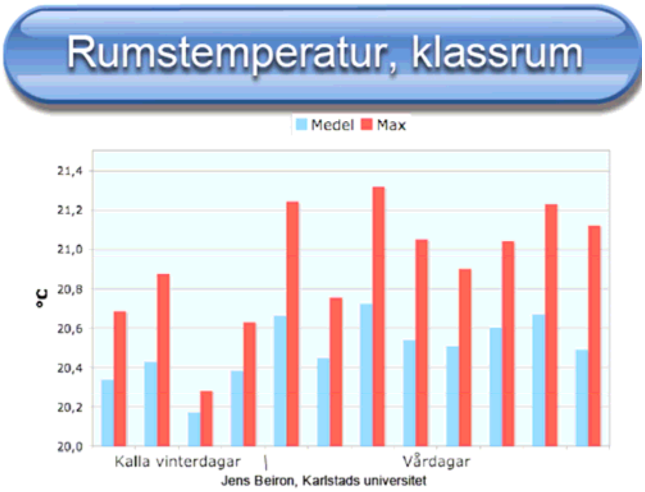

Fig. 11 Room temperature logs for classrooms at Vargbro School.
Demand and season adapted ventilation and sequential control of heating and ventilation ducts provide good room climate conditions all year round.

New products and solutions

As the need for climatic measures and the threat of serious environmental problems place ever higher demands on energy efficient buildings, it is high time our conservative industry started taking the problem seriously. Maximum profit and faith in standard Swedish HVAC technology, which was once internationally respected, should not be the only consideration.

The industry and universities should be widening their horizons and looking around at home and abroad for solutions that increase energy use efficiency and raise the standard of indoor climates, and should then quickly adapt their HVAC technology to suit.

An absolute minimal requirement for energy efficient operation and a good indoor climate is that the air flow is controlled according to demand and in relation to the premises' heating system. Furthermore, it is important that the air flow in room's with different heat requirements is controlled by the room temperature, which also enables the air flow to be season adapted.

Energy efficient installations can, naturally, also be created without ventilation ducts but then without the benefit of passive cooling during the summer and with an increase in the need for fan operation. Equipment such as adjustment dampers, regulation dampers and control valves with their damper actuators can also be housed in the ventilation ducts making it easily accessible for service and maintenance as well as being out of harms way. See fig. 6.

Ducting should not be a deterrent cost-wise either since it removes the need for fan rooms and comfort cooling installations while creating more space higher up in the building since much of the equipment can be placed in the ducting. The cost of the installation in Vargbro School, which was contracted during a period of economic growth, amounted to 17 400 kr/m². This included costs for planning and construction loans.

Should the BBR energy requirements be stricter?

All new and existing buildings with DELTAte installed demand and season adapted ventilation easily meet the current BBR requirements for energy consumption. Most of them would also be categorised as a "Green Building" had that qualification been applied for.

The knowledge and technology required for creating energy-efficient buildings with a good indoor climate exists but it is not applied to the extent it should be. By strengthening BBR requirements, the Swedish National Board of Housing, Building and Planning would force the industry to use more efficient solutions and thus contribute to the construction of buildings with greater energy efficiency and a better indoor climate than is presently the case.

Torkel Andersson
DELTAte