GREATER COMFORT WITH LESS ENERGY

Demand-Controlled Ventilation

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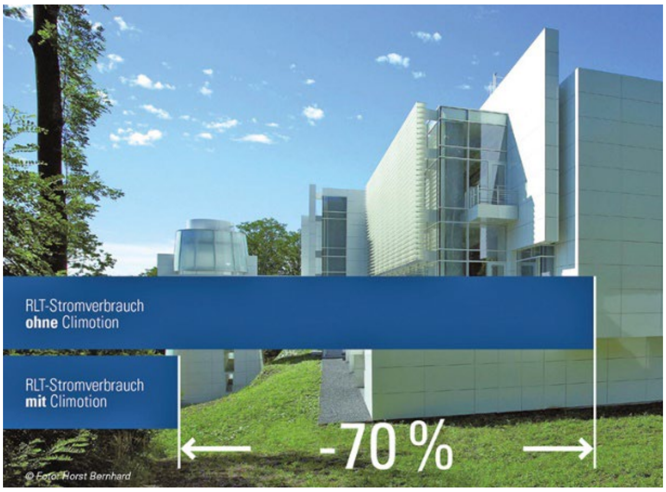
Converting a conventional ventilation system to demand-based control can drastically reduce the system's energy consumption. In most cases, building operators can save over 50% on electricity costs for powering the fans. Ventilation concepts with non-directional flow offer further savings while also providing added comfort for the building's users.



Climotion reference project at the Arp Museum in Remagen. Introducing demand-controlled ventilation with Climotion met the strict air requirements with significantly lower power consumption for the fans.

Information at a Glance

- In many commercial and public buildings, ventilation systems are not controlled according to actual demand. This leads to unnecessarily high energy consumption and room temperatures that are often unpleasant.
- In most cases, operators can easily reduce energy consumption by implementing demand-based control of the ventilation system—particularly the electricity needed to power the fans.
- The Climotion algorithm opens up possibilities for further savings and significantly improves comfort in the building.

You can't make an omelet without breaking a few eggs. That's true beyond the kitchen: Things get dirty wherever people and machines are at work. These impurities also get into the air, for example, dust and dirt particles or elevated concentrations of carbon dioxide and other gases. Ventilation systems are intended to reduce these impurities to a tolerable level so people feel comfortable and the machines can work properly.

But the question is: What constitutes good air—or at least acceptable air? And how must we design a ventilation system to achieve a certain air quality? For ventilation in non-residential buildings, the standard DIN EN 13 779[1]) provides a clear answer. It defines four quality classes for indoor air (IDA): IDA 1 is the highest quality, while IDA 4 is the lowest. Planners or system engineers therefore design their ventilation systems according to the IDA category required.

In non-residential buildings that are regularly occupied by people, planners must also take into account the number of people who work or live there. After all, it is usually the building users who pollute the air most—through breathing, smoking and other transpirations. The more people there are in a room, the more fresh air the system must supply. A recognized indicator of "stale air" is an elevated/rising concentration of CO_2 compared to outdoor air. DIN EN 13 779 specifies standard values for the amount of fresh air required per person in a given period.

IDA	Air quality	Outdoor air volume flow (non-smoking area) in $m^3/(h \cdot person)$
1	High	72
2	Medium	45
3	Moderate	28
4	Low	18

Air quality according to DIN EN 13 779

High-Power Ventilation Annoys Operators and Reduces Comfort

If it were only a matter of air quality, we would design systems to be as powerful as possible and constantly operated at full capacity. But building operators and users wouldn't like this very much. That's because a ventilation system that is too powerful for the majority of its service life leads to high operating costs without any gain in comfort. Quite the opposite, in fact: when ventilation is too strong, users often complain about drafts and associated issues such as dry eyes, tension and headaches. This unnecessary movement of air drives up power consumption for the fans in particular (see below). Furthermore, the system consumes thermal energy to bring the supplied outside air to the required room temperature.

Smart Control Increases Efficiency and Comfort

Demand-controlled ventilation is the smart alternative to constant ventilation. This solution provides only the amount of fresh air that is actually needed, which can be determined based on various criteria. As a general rule: The more intelligent the control functions are, the more satisfied everyone is. DIN EN 13 779 distinguishes between six categories of control: IDA – C1 represents a system that is not controlled at all, while IDA – C6 represents a smart, demand-controlled system that measures air quality using gas sensors.

Category	Description
IDA – C1	System runs constantly without control
IDA – C2	System is operated manually
IDA – C3	System is operated according to a schedule
IDA – C4	System runs when people are present
IDA – C5	System runs based on the number of people
IDA – C6	System runs based on room air parameters

Control classes according to DIN IN 13 779

Forecasting of Potential Savings

Smart ventilation offers particularly high savings in the electricity used to power fans: If you cut the volume flow by half ($\dot{V}$), you reduce the power consumed by the fans (P) to one-eighth. Based on the rules of proportionality, we can assume the following approximation:

$$P_2 = P_1 \cdot \left(\frac{\dot{V}_2}{\dot{V}_1} \right)^3$$

With this equation and a few additional assumptions, you can estimate how much electrical energy a demand-controlled system will save for operating the fans prior to a project. For example, the operator of a large auditorium can save almost 8,000 euros per year on electricity costs by converting to demand-based control. This conversion is inexpensive compared to many other energy saving measures, and the investment quickly pays for itself.

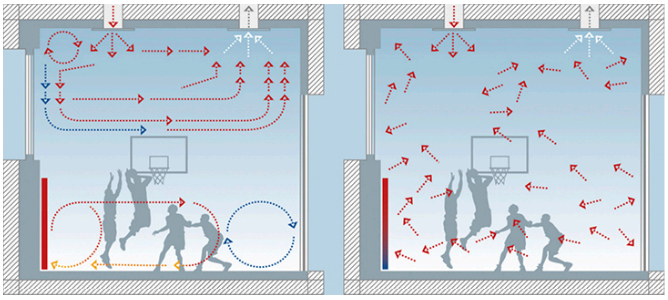
Sample calculation: Large auditorium	
Capacity	1200 people
Operating time	2,000 h/a
Occupancy	Full: 200 h/a Half: 1,800 h/a
Design (DIN, EnEV) Volume flow Fan power consumption	IDA 3, SFP 4 36,000 m³/h 20 kW
Potential savings Fan power Electricity costs CO_2 emissions	79% 31,500 kWh/a 7,875 euro/a 17.92 t/a

Potential savings with demand-controlled ventilation of the auditorium

In theory, the calculation is quite simple: If you require moderate air quality for the auditorium according to IDA 3, the ventilation system must supply around 36,000 m3/h of fresh air at full occupancy. You can calculate the power consumption using the SFP value (specific fan power), which is the ratio of the electrical fan power consumed to the air flow delivered. This value indicates the efficiency of a fan system. The SFP categories are also defined in DIN EN 13 779: SFP 1 is the maximum efficiency and SFP 7 is the minimum.

According to the German Energy Conservation Ordinance (EnEV), new or renovated buildings and systems that use more than 4,000 m3/h require at least SFP 4 (1,250 to 2,000 Ws/m3). For our example, that means the fan has a maximum output of 20 kW. If the auditorium and ventilation system are in use about 2,000 h per year, the electricity consumption is 40,000 kWh/a. At an electricity price of 0.25 euro/kWh, electricity costs for the fan amount to 10,000 euro/a.

However, an auditorium of this size is rarely fully occupied. To really demonstrate the difference between unregulated and demand-controlled ventilation, we can use the following simplifying assumption: the lecture hall is used to its maximum capacity only 10% of the time, while it is half full for the remaining 90%. Half the number of people need only half as much outside air, i.e. 18,000 m³/h. This reduces the power consumption of the fan by a factor of 8. For 90% of the operating time, the fan output drops from 20 to 2.5 kW.



Directed air flow without Climotion (left) and undirected air flow with Climotion (right)

Converting to a demand-controlled system will reduce electricity consumption from 40,000 kWh/a to 8,500 kWh/a, and reduce electricity costs by 7,875 euro/a. This is only a rough estimate based on simplifying assumptions. For serious forecasts, you have to consider numerous other factors and exact system values. You must also make sure that the ventilation system will continue to function with the reduced volume flow.

Practical Experience with Smart Ventilation and Energy Monitoring

Kieback&Peter has several decades of experience in overseeing ventilation control projects. We take a holistic approach that focuses on both the professional implementation of the project as well as the real-world success of the measures taken. Because in the end, customers are satisfied only if they get the results they are expecting. To ensure this, we advise setting up an energy monitoring system to enable a before/after comparison and enable further optimization of the systems.

In practice, we have found one solution to be particularly effective for demand-controlled ventilation: the DDC4000 automation system from Kieback&Peter combined with the patented Climotion control algorithm from Bosch (formerly Baopt from Bauer Optimierungstechnik).

This combination goes beyond the benefits of conventional demand-based control. First, it improves efficiency by a further 10 to 30%. Second, users of conference rooms, concert halls, gymnasiums and similar buildings report a noticeable increase in comfort thanks to Climotion. The experts at Kieback&Peter have proven these results in more than 200 Climotion projects—notwithstanding a few outliers in either direction.

One exciting real-life example is the Arp Museum in Remagen. Because of the museum's valuable paintings and sculptures, its control system must always keep the temperature and humidity precisely constant—which can be a challenge with constantly changing visitor traffic. In July 2014, Kieback&Peter converted the museum's automation system to DDC4200 while simultaneously introducing demand-controlled ventilation with Climotion. After the conversion, the VAC system consumed significantly less electricity—from an average of 320 kWh/d to 100 kWh/d.

The cafeteria at the University of Applied Sciences Darmstadt provides an interesting example of thermal energy conservation. In the winter of 2014, the university called Kieback&Peter in to solve an acute comfort problem: drafts in the cafeteria were so unpleasant that many students kept their jackets on while eating. The university sought a new ventilation system to put an end to this problem—without the need for expensive construction. We solved the problem by converting three ventilation systems to DDC4200 and Climotion. Although comfort was the main focus of the project, climate-corrected evaluations showed that the project also reduced demand for heating energy by around 49%.

Undirected Flow Avoids Problems Caused by Short Circuits

The secret to Climotion is the slow, undirected flow and the separate control of supply and exhaust air. The patented system ensures that fresh air is evenly mixed with existing air throughout the entire room. This prevents ventilation short circuits in which the supply air flows more or less directly from the inlet to the outlet.

A short circuit can cause serious problems: for one, ventilation occurs only in the area between the inlet and the outlet. This is the area where unpleasant drafts arise. Outside this area, there is hardly any air movement at all. This results in “islands” of temperature and pollutants that cause discomfort for occupants. Furthermore, sensors installed within these islands constantly report poor air quality, and the conventional control system responds by increasing air supply. This drives up energy consumption unnecessarily and increases drafts.

Smoke tests illustrate the difference Climotion makes.

Smoke test 1: Without Climotion, air stratification occurs above the occupied zone.

The figure shows a gymnasium with simple ventilation control and directional flow. The undesirable air stratification is clearly visible.

The next figure shows how evenly Climotion distributes air in the same gym.

Smoke test 2: With Climotion, the system distributes the air evenly throughout the gym.