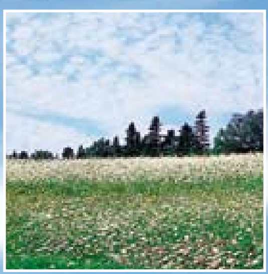
Energy Calculation and Life Cycle Cost



Saving Energy, Economy and Environment with Fläkt Woods.

FläktWoods

Energy calculation by Fläkt Woods

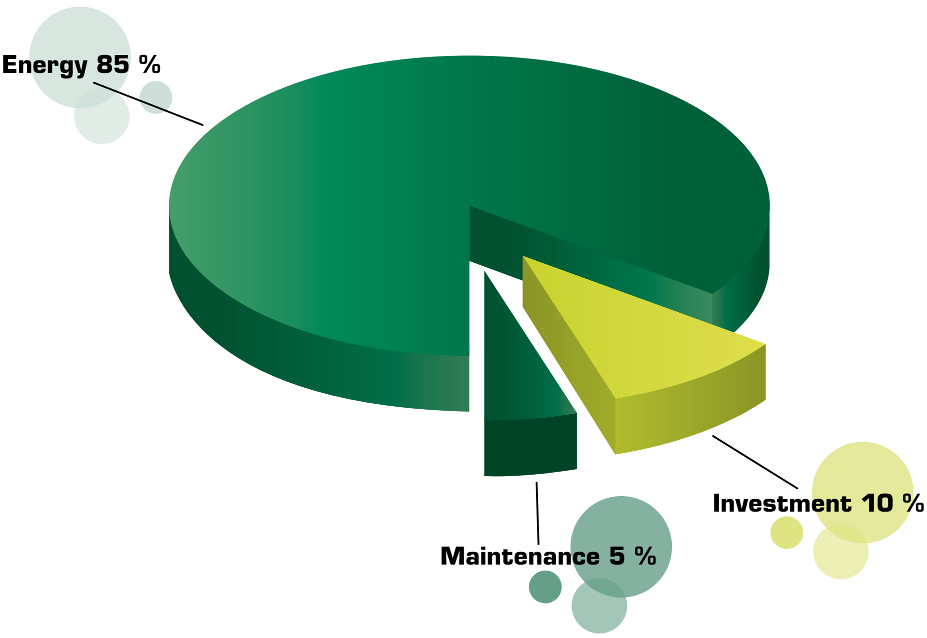
About 85 % of the lifetime cost for an air handling unit is energy cost, 10 % initial investment and 5 % maintenance. This fact and the Energy Performance of Buildings Directive (EPBD) from the European Union leads to a demand for accurate energy calculations and LCC-calculations for air handling products.

To address the needs created by the EPBD directive, Fläkt Woods has created a model for calculating both the annual energy consumption and the LCC. The calculation of LCC focuses on the energy cost, LCC_E. Fläkt Woods' selection tool Acon can calculate the annual energy cost and the LCC_E cost for the selected air handling unit. When calculating, Acon will consider all energy consumers (e.g. fans, pumps, drive equipment for heat exchangers, heaters and coolers) and also different kind of heat exchangers.

Climate Data

In order to calculate the correct heating and cooling loads, you need to know the behaviour of the outdoor climate at the selected site. Fläkt Woods' selection tool uses meteorological data from the Swiss database METEONORM©; which consists of climate data for a large number of locations worldwide. Due to the fact that the efficiency of heat exchangers, heaters and coolers differs with the temperature conditions, the calculations are done at several data points during the year. The resulting efficiency for each function can be described as a function of the outdoor temperature. The resulting heating and cooling demand will then be summed up for the specified annual running hours. In the selection tool it is possible to calculate the energy consumption for different airflows and temperatures at different times

Air handling unit calculations



(e.g. Comfort mode for day calculations and Economy mode with reduced air flow and lower temperature calculations at night). For VAV-systems, the airflow can be described as a function of the outdoor temperature. CO_2- emissions to the environment can also be calculated for different fuels.

Temperature and Humidity

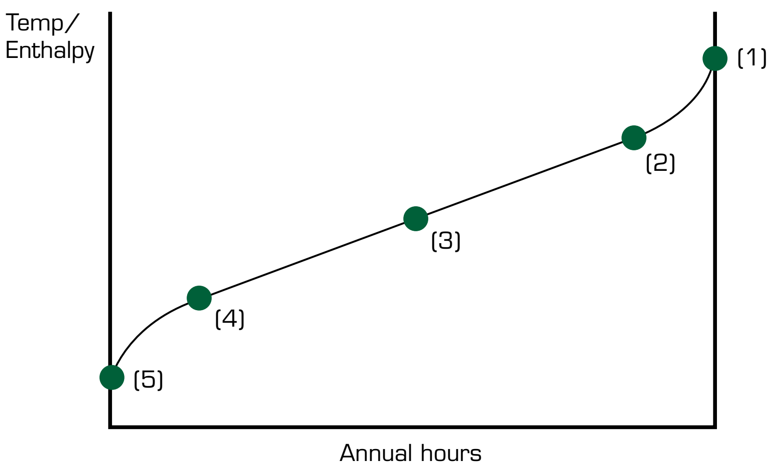
The outdoor temperature and humidity are tabled hour by hour for the whole year at a specific location. A calculation of heat- and cooling demand for the annual 8 760 hours would be very time consuming, and therefore Fläkt Woods has created a degree- and enthalpy-hour curve that is based on five points for each specific case.

1. The highest annual temperature and humidity.
2. The lowest temperature of the 100 hottest hours of the year.
3. The annual mean value for temperature and humidity.
4. The highest temperature of the 100 coldest hours of the year.
5. The lowest annual temperature and humidity

To draw the temperature curve according to these five points, we have compared it to a well-known curve, which also corresponds to DIN 4710. After that, the curve equation after the measured curve has been generated.

These five temperature values and three humidity values can be found in Acon for a large number of cities around the world. For cities not included in Acon, there is a possibility to add climate data. The temperature/enthalpy diagram describes the mean value of temperature and enthalpy for an air handling unit that is operational 24 hours per day. If the running time is limited to daytime operation, the curve will have an offset by 0.12° Celsius upwards for every hour less than 24 hours.

Degree- and enthalpy-hour curve



Calculation model

To achieve a high accuracy on the energy calculation, the following important factors must be considered:

- The heat transfer of every heater, cooler and heat exchanger differs a lot depending on the conditions of the entering fluid. This means that the conditions of the air must be calculated so when it enters a new function, we will know exactly the temperature, enthalpy, velocity and pressure.
- The calculation of the air through a cooling coil with condensing water droplets is quite complex, the pressure drop over the coil will increase, and adia batic cooling must be considered.
- When there is a heat recovery wheel in the air handling unit, the leakage flow and the balancing pressure must be considered. The extra pressure and airflow influences the exhaust fan considerably.
- The pressure drop over filters is calculated as the mean value of the start pressure and the final pressure drop.
- All power consumers must be included, even pumps and various control motors.

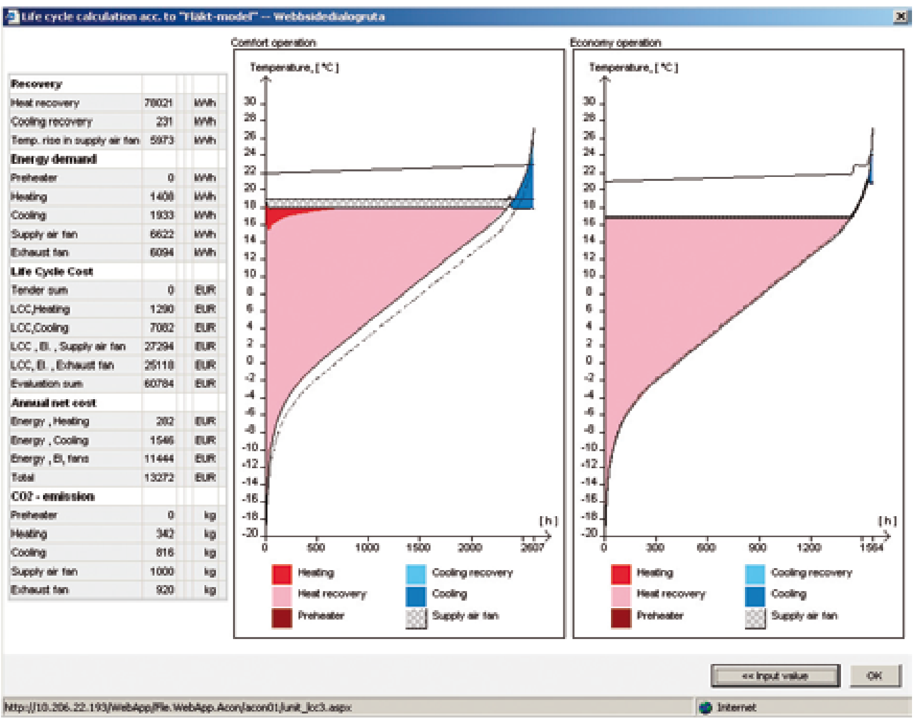
When calculating the heat- and cooling demand, the enthalpy differences between the outdoor air and supply air are added for every 100 hours. The differences between hour per hour calculation and this method is less than 2-3 % of the estimated total energy consumption.

All this together gives us high accuracy and a trustworthy energy calculation. No simplifications, or generalisations have been made.

Temperature calculation

The supply and exhaust air temperatures must be given for the designed winter and summer cases.

Acon selection tool



Both the supply air temperature and the exhaust air temperature are supposed to be linear in the degree-hour diagram between the input value for winter and the input value for summer. Calculated heating and cooling capacities account for the heat gain in the fan. When cooling the air to the right temperature and humidity, both the targeted temperature and humidity must be given.

There are two options regarding cooling calculations:

- Calculate to reach the right temperature.
- Calculate to reach both the right temperature and the right humidity

When there is need for controlling both temperature and humidity to an exact operating point, we need an air treatment function consisting of a heater, a cooler and a reheater. This procedure has a large impact on the energy consumption.

The diagrams below show the differences between the two control functions. In diagram 1, the air is cooled to the desired temperature, and in diagram 2, the air is controlled to both the right temperature and humidity.

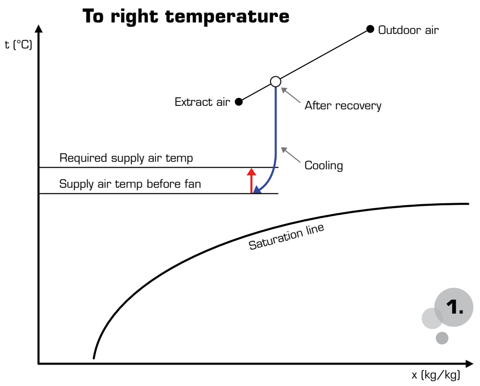
Outdoor temperature compensation

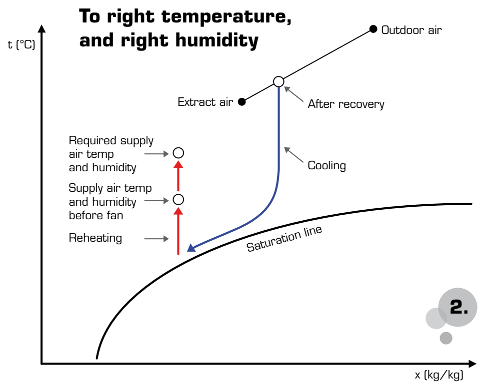
To be able to calculate the correct energy consumption when the supply air temperature is varying during the year, we are using the function outdoor temperature compensation. It describes the supply air temperature as a function of the outdoor air temperature. The conditions are stated as the actual value of the supply air at four different outdoor temperatures. The temperature is supposed to be linear between these points.

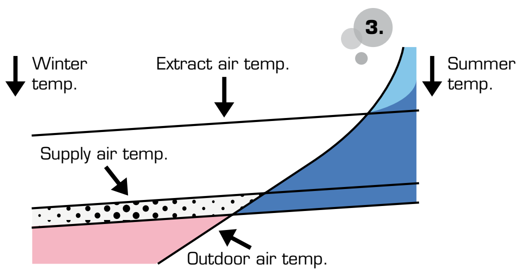
The exhaust air should be linear between the input value for winter and the input value for summer.

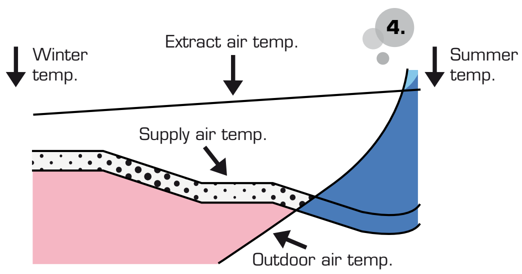
The illustrations 3 and 4 show the differences between a simple model with no outdoor compensation to the left and to the right with a supply air temperature behaviour as it would be with room temperature controls.

Examples









Operation and variable airflow

Operation

The running hours have huge impact on the energy consumptions, e.g. if the air-handling unit would run 24-7 then it would be 8 760 hours per year, but for most comfort applications, 3-4 000 hours is probably more typical.

We divide the operational mode in two categories; Comfort mode and Economy mode. Each mode can have it's own settings regarding airflow and temperature set point. The comfort mode is assumed to occur during daytime, and economy mode during the night. This can be seen as an offset of the temperature curve in the duration chart. The temperature is naturally a little colder during the night compared to the day.

If return air will be used, the amount of return air in percent of total supply airflow must be noted. It is presumed that the return air, i.e. exhaust air, will be mixed with the outdoor air before the heat exchanger and air treatment function.

The example below shows a constant air volume system with comfort mode, with 100% airflow, and economy mode with reduced airflow to 40%.

The comfort mode is blocked when outdoor temperature is below -15° C.

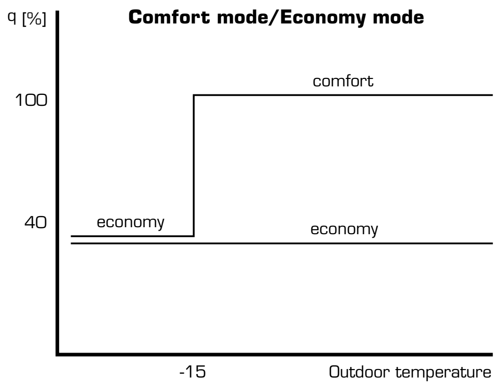
Variabel Air Volume

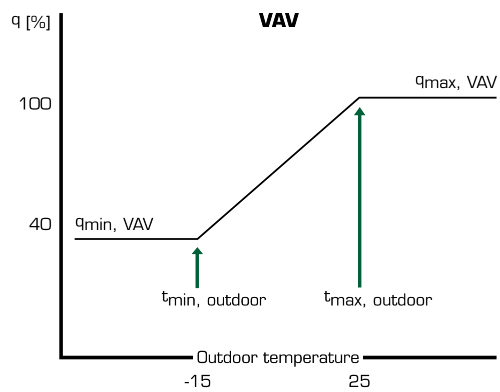
When calculating the energy consumption of a VAV-system, the airflow rate at both minimum outdoor temperature setpoint, and the outdoor temperature maximum setpoint, shall be noted. At temperatures below the minimum temperature setpoint, the airflow is assumed to be constant. The same thing applies for the airflow above the maximum setpoint. Between the two points the curve is assumed to be linear.

Example:

Maximum airflow, 100 % of the rated airflow, from 25° C and above. Minimum airflow, 40 % of the rated airflow from -15° C and below. The minimum external pressure in the supply duct must not go below 150 Pa.

Examples





Result

The energy cost consists of two main parts. – the electrical energy required for running the fans and the thermal energy. Heating is generally the larger part of the energy requirement in northern Europe and Scandinavia, but the cost is normally reduced by the usage of heat recovery equipment. The cost for providing cooling is also a significant factor and may need to be considered in many cases.

Degree-hour diagram:
For the calculated air handling unit, the diagram shows the annual supply- and extract air temperatures. For the winter case, the diagram shows the recovered heat (pink area), additional heating (red area) and heat gain from the fan (dashed area).

For the summer case, the diagram shows recovered cooling energy (light blue area), needed cooling energy (blue area), and heat gain from the fan (dashed area).

When cooling to the right temperature and right humidity, the needed reheat energy is also shown.

Note that the area for cooling only shows the sensible part of the cooling energy.

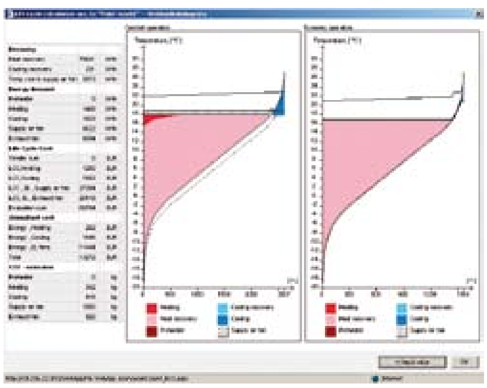
Life Cycle Cost:
The Life Cycle Cost is the cost for heating, cooling, and electricity during the air handling units stated lifetime. The evaluation sum is the sum of tender sum and the total energy cost.

The LCC-calculation is based on the NPV-cost model, and to be able to calculate the total life Cycle cost for the air handling unit, energy price and interest rate are needed.

- The energy cost per kWh for different energy fuels must include all fees and costs, which are paid to the energy producer.
- The expected price increase per year, should be noted as the actual price increase above the inflation
- The tender sum is the total cost for the investment including product and installation cost.
- Discount rate should be noted as the actual price increase above the inflation
- The operating time of the air handling unit must also be considered

Annual net cost:
This is the annual energy cost during the first year.

CO_2:
To calculate the Air Handling Units CO_2 footprint, the amount of CO_2 emission for producing energy to heating, cooling and electricity must be given.



We Bring Air to Life

FläktWoods is a global leader in air management. We specialise in the design and manufacture of a wide range of air climate and air movement solutions. And our collective experience is unrivalled.

Our constant aim is to provide systems that precisely deliver required function and performance, as well as maximise energy efficiency.

Solutions for all your air climate and air movement needs

FläktWoods is providing solutions for ventilation and air climate for buildings as well as fan solutions for Industry and Infrastructure.

Air Handling Units (AHUs)

Modular, compact and small AHU units. Designed to ensure optimisation of indoor air quality, operational performance and service life.

Air Terminal Devices and Ducts

Supply and exhaust diffusers and valves for installation onwalls, ceiling or floor are all included in our large range and fit all types of applications.

Chilled Beams

Active induction beams for ventilation, cooling and heating, and passive convection beams for cooling. For suspended or flush-mounted ceiling installation – and multi-service configuration. With unique Comfort Control and Flow Pattern Control features.

Residential ventilation

A complete range of products for residential ventilation. Consists of ventilation units, exhaust air fans and cooker hoods designed to optimise indoor comfort and save energy.

Energy recovery

Dessicant-based product and systems that recover energy, increase ventilation and control humidity.

Fans

Advanced axial, centrifugal and boxed fans for general and specialist applications. Comprehensive range including high temperature and ATEX compliant options. Engineered for energy efficiency and minimised life cycle cost.

Chillers

Air-cooled and water-cooled chillers with cooling capacity up to 1800kW. Designed to minimised annual energy consumption in all types of buildings.

Controls and drives

Variable speed drives and control systems, all tested to ensure total compatibility with our products. Specialist team can advise on energy saving and overall system integration.

Acoustical products

A complete line of sound attenuating products, including rectangular and round silencers. Media Free silencers, custom silencers and acoustic enclosure panels.

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