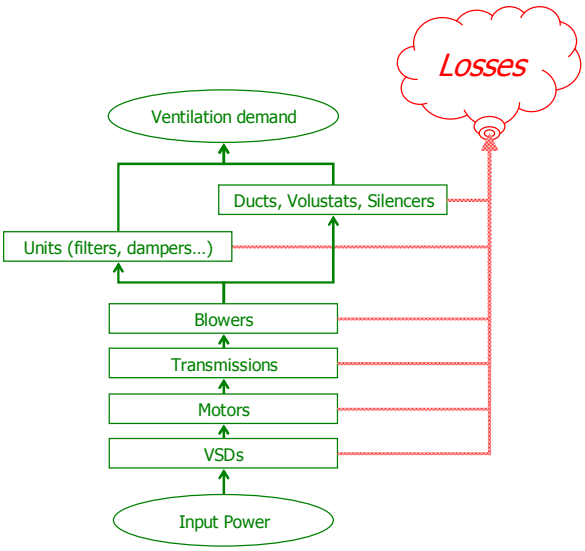
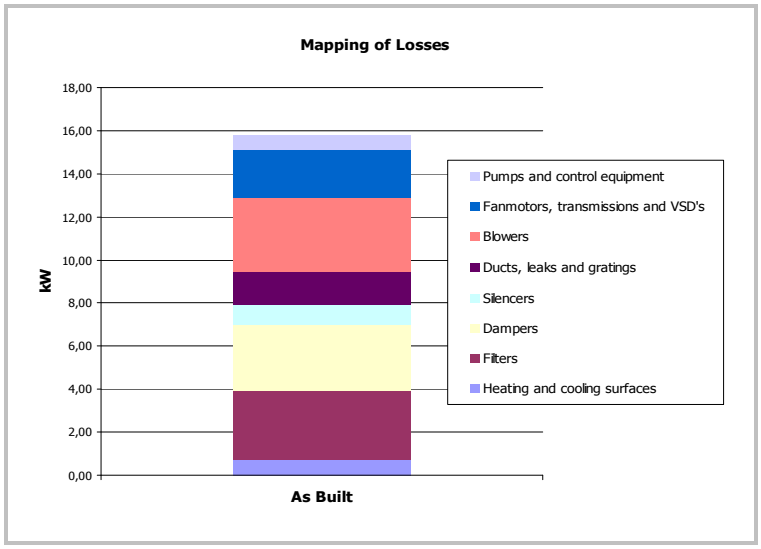
A tool for making air handling calculations in HVAC systems

I have developed a tool that I use for calculating savings in the air handling domain of an HVAC-system. Savings related to temperature and humidity control is calculated in another tool (see “Psychometrics Tool”), although I have linked them together for obvious reasons.

The main “new idea” of my tool is to calculate total system efficiency: Whenever any energy-savings-measure is calculated, the total amount of losses must be taken into account. This is important since the efficiency of e.g. VSD, motors, transmissions and fans varies with load factor. The illustration below shows the connection between these elements:

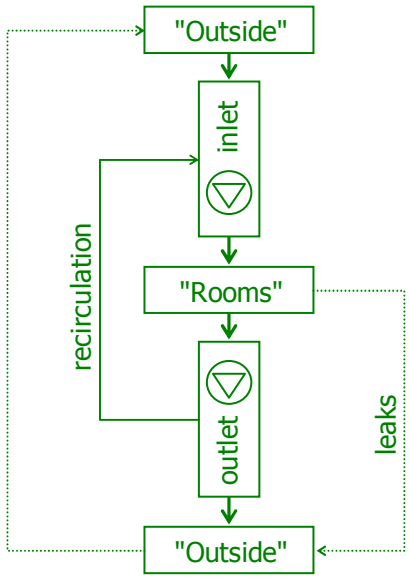


It is a good idea always to check the energy balance for the total system. All losses should equal the total input power, so of cause I also do that. Calculating the losses for each element for all the different operating conditions, calls for a systematic approach and I use a spreadsheet with the possibilities of scenario control. The relative and absolute size of all the losses are shown in a diagram so that any improvement can easily be seen and discussed:

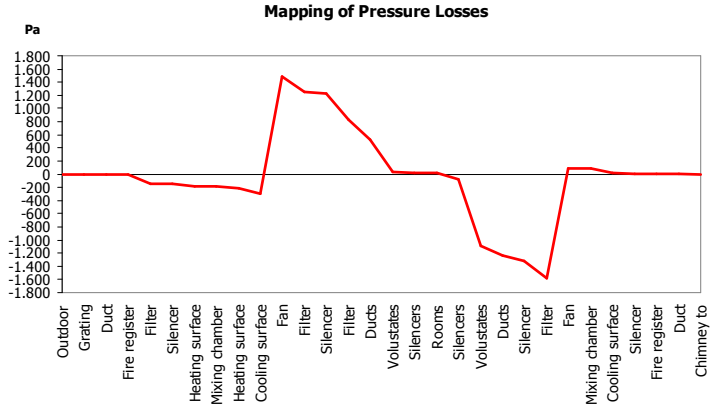


In order to calculate the input power, necessary to meet the demand for ventilation, it is a good idea to make an overview of all pressure-losses and -gains generated at the specified air-flows. All components are listed with their individual differential pressure and air-flow in the order of appearance, from the point where the outside air is drawn

into the HVAC and to the point where it is blown outside again. Any recirculation and leaks should of cause also be taken into account. The figure below shows the principle:



When the mapping is done, it is possible to calculate the Pressure losses for each component, as well as the static pressures throughout the entire system. These pressures and losses can later be recalculated in various scenarios, where components are changed or removed, or pressure and/or flow demands are altered. The static pressure values from the mapping, is shown in a diagram, in order to visualize where possible savings could be located:



Measurements and other “practicalities”

Prior to any calculation and analyses on a HVAC, the following data should be collected:

1. *Total system drawing of both inlet and outlet system, including all inlet- and outlet dampers, silencers, diffusers, etc.*
2. *Screen-dump from CTS of total system drawing, setting- and operating values.*
3. *Components list from manufacturer.*
4. *Motors and pumps list.*

5. *VSDs (frequency converters) and transmission documentation.*
6. *Drawings of physical dimensions and placing of units.*
7. *Fan diagrams showing relations between pressure, flow and efficiency.*
8. *Measurements of all static pressures throughout the entire system.*
9. *Measurements of all relevant air volume flows.*
10. *Measurements of power consumption for all motors.*
11. *All possible information and ideas from users and maintenance personnel, including the state of filters, operating hours, changes, etc.*

All measurements should be performed during a steady state period where all airflows are constant. Usually the measurements from the commissioning tests will be sufficient, but it is a good idea to make a few control measurements to see if changes have been made to the system. Data from CTS can also be used to check if the dataset from commissioning can be used.

It is essential that pressure drops/gains and air-flows are known for all components, together with total power consumptions for fan motors. If data are missing or not corresponding with check-measurements, new must be made.

In order to simplify calculations, it is sometimes necessary to calculate separate average pressure drops for the component types in the air-distribution system, that is: One for all ducts, one for all flow-regulation-dampers, one for all silencers/diffusers. This can be done by averaging all static pressure measurements before and after the flow-regulation-dampers, and from these two values calculate the average pressure drops across the other distribution components (ducts and silencers), knowing the average room pressure, and inlet and outlet pressures from the HVAC-units.

Power measurements can often be easily made by reading the VSD display, just make sure if it is the input or output power. If possible power measurements can supplemented with energy measurements over a period of time. This will give at better picture of the operating conditions, especially in VAV-systems.