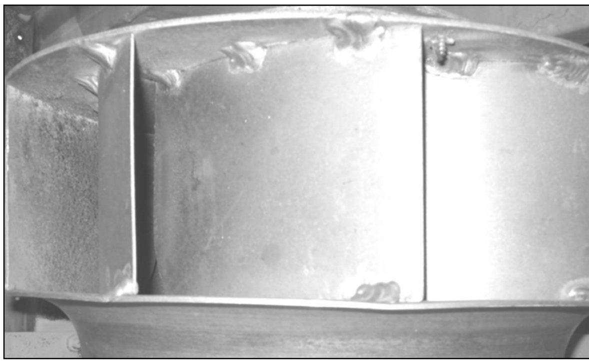
FanSave **User's Manual**

Energy Savings Calculator for Fan Drives

ACS55
ACS150
ACS310, ACS355
ACS550, ACH550, ACS580
ACS800, ACS880



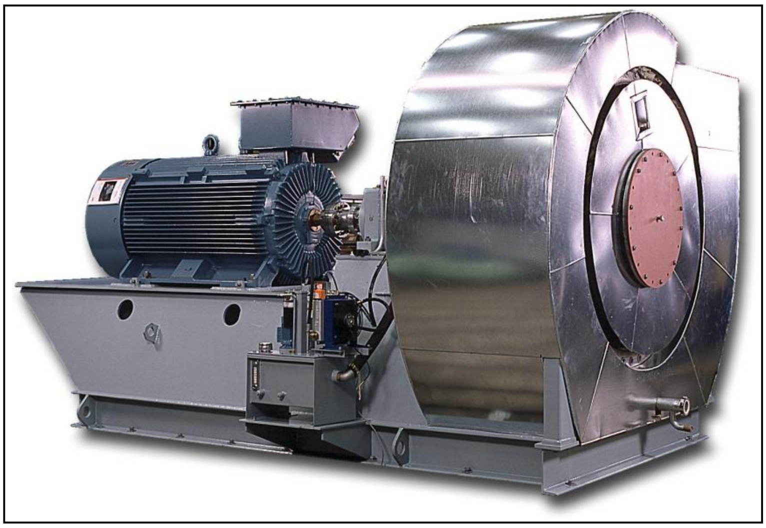


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ABB

1 — General

FanSave is a tool running on Microsoft Excel to calculate the energy savings available when using ABB variable speed AC drive instead of other fan control systems.

Comparisons can be made with damper control, pitch control, single speed vane control and 2-speed vane control.

Calculations are based on typical fan operating characteristics. Consequently, the accuracy of the results is limited. The accuracy of the results is also affected by the accuracy of the input data. The results of this program must not be used as the basis for guaranteed energy savings.
Results of calculations can be printed out.

Version 5.3

New general purpose drive ACS580 added.

Version 5.1

Added three languages and now supported languages are Chinese, Dutch, English, Finnish, French, German, Portuguese, Russian and Vietnamese.

Version 5.0

New industrial drive ACS880 added and the structure of worksheet changed from horizontal to vertical. The data inputs are on one page and following page is report. The vertical pages are supposed to be more user friendly supported by PageUp and PageDown of keyboard and scroll wheel of modern mouse.
Additionally the internal computing are made modern way. This anyway prevents the usage on older the 2007 Excels. The US style is supported later with US version.

2 — Starting and Running the Program

Software Required

Microsoft® Excel 2007 or later is required to run the energy calculation workbook. Also you shall enable the running of macros. The permanent settings for this are on Excel options/Trust center/Trust center settings/Marco settings.

Files Provided

The FanSave files for fan drive calculations are incorporated into Excel workbook named originally FanSave53.xls.

Installation

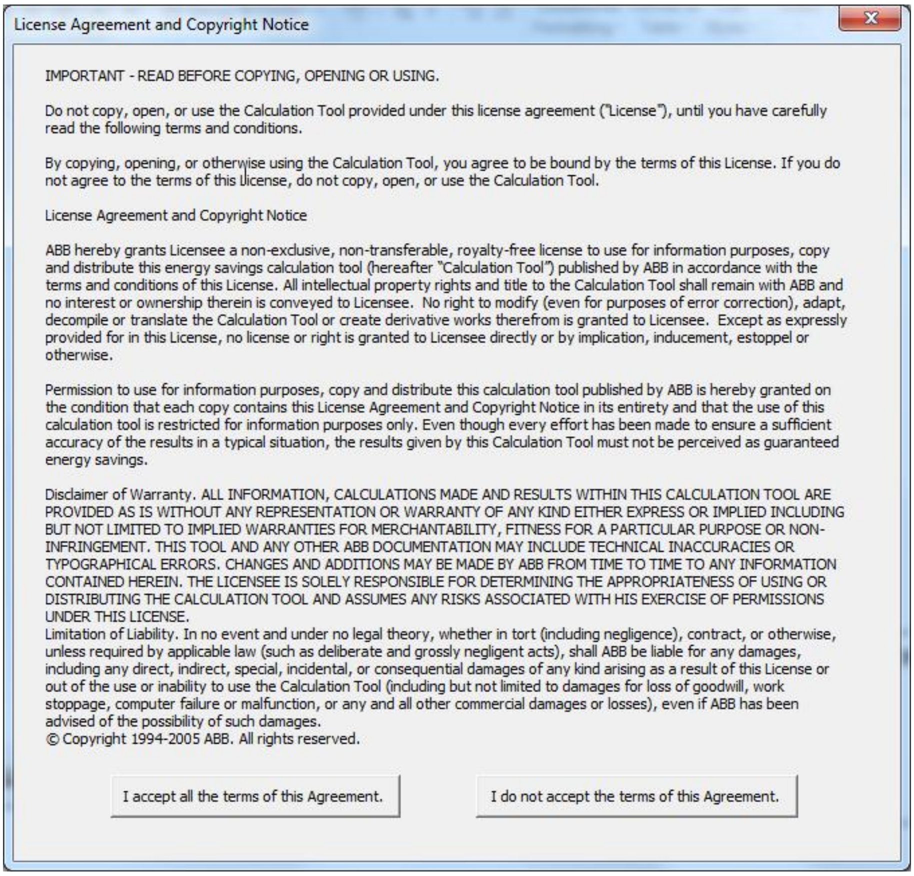
No installation is required but the workbook is can be copied to a hard disk and short-cut arranged to desktop.

Opening the Workbook

Start Excel as usual. For fan calculations open FanSave53.xls.
You may adjust the Ribbon etc settings of Excel to get more space.
FanSave will open with zoom setting 100% to get overview of input page, but you may zoom later on according to your preferences.

Disclaimer

At the end worksheet is the important disclaimer statement.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Worksheet

The language setting is on top right corner. The translated words and help texts are taken from Language sheet based on English keywords. This manual explains the English ones.

The Worksheet print will print a two page report by default.

3 — FanSave worksheet inputs and results

General

All white fields on the sheet are for entering information and data Figure 1. The sheet is filled in by default values to help users to right away find the idea of worksheet.

The Results are displayed on second page Figure 2.

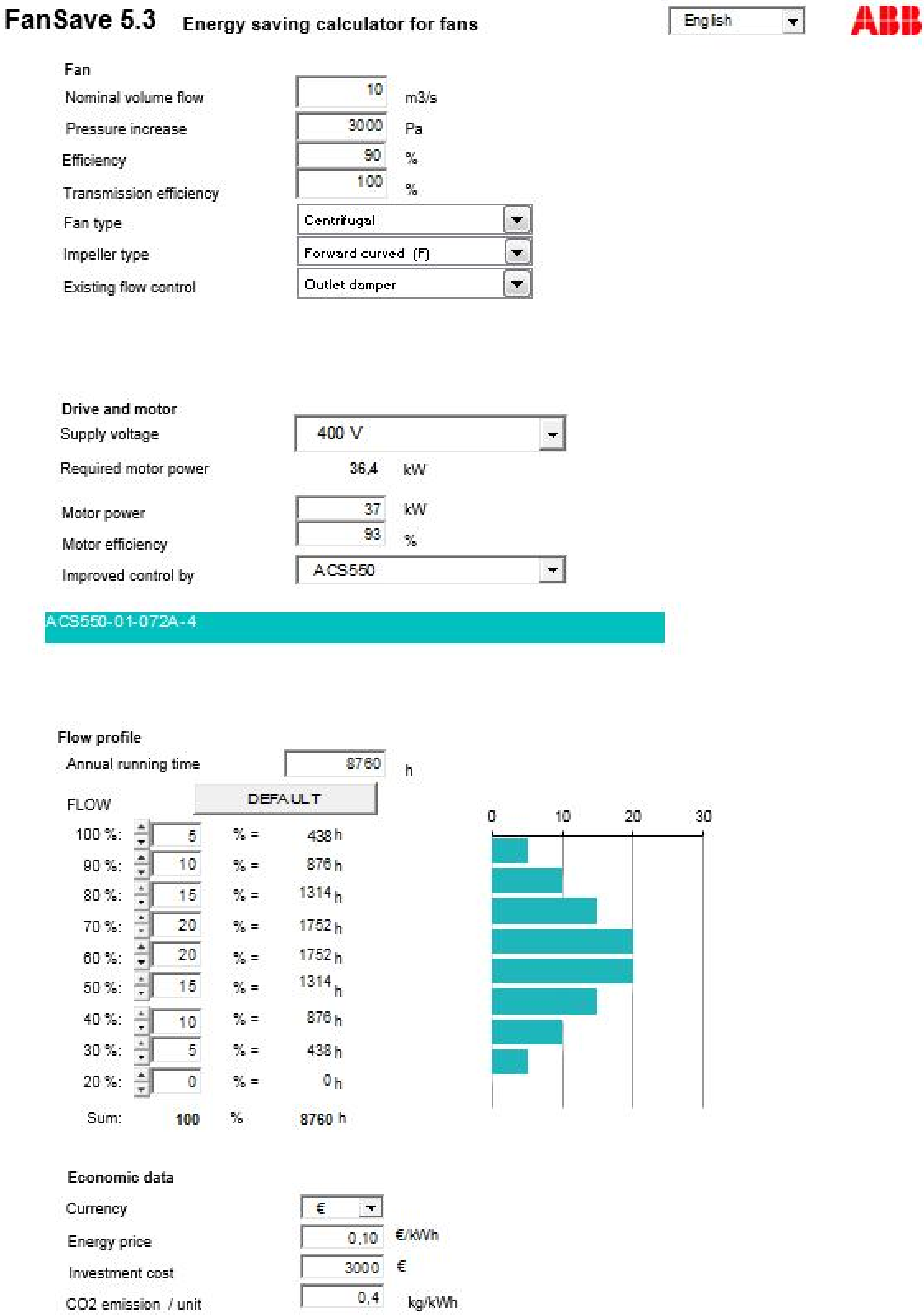


Figure 1 FanSave input page

Input data

The input data includes information about fan, transmission, existing control method, motor, operating profile.

Economic data such as energy price and investment cost is required in order to get figures for investment appraisal.

Fan data

Nominal Volume Flow, Q_{vn} (m^3/s)
Enter the maximum system volume flow in cubic meters per second, which the existing system will deliver and fan must reach with existing control. FanSave will assume that exactly the same flow has to be delivered also with AC Drive. The energy saving calculations will be based on flow rates that are equal to or less than Qvn.

Pressure Increase, p_{tF} (Pa)
Required pressure increase of the fan for the given nominal volume flow Q_{vn}.
Value is determined from the fan curves and system curve intersection.
If pressure is more than 5000 Pa FanSave will indicate this by red color and It is better to compute these cases manually. The computing of high pressure fans does not come correct because the compression of the gas cannot be simply modeled.

Efficiency, η (%)
Enter the nominal efficiency of the fan at nominal volume flow.

Transmission Efficiency, η (%)
Efficiency of the transmission method e.g. belt transmission. If the fan has been connected directly to the motor, use 100%.

Fan type
Fan type can be selected. The options are centrifugal and axial flow.

Impeller type
Centrifugal fans of different blade shapes behave differently. The options for impeller type are forward curved, backward curved, and radial blades.

Existing Flow Control
Pick the existing control method that you want to compare with ABB AC Drive control. The control method is selected from the drop-down list on the upper left part of the sheet. The control options are: Outlet damper, Slip coupling, Voltage,Two-speed motor, Cyclic (on/off), Inlet box damper, Inlet vanes, (1-speed vane, 2-speed vane and Pitch control).

The smaller energy usage of frequency converter is compared to a large energy required by:
Outlet damper control which control the volume flow by throttling it with a damper.
Slip coupling which control the fan speed with slippage by hydraulic/eddy current technology.
Voltage control which will make the motor voltage lower and make the induction motor to have larger slip. Note! Voltage control is applicable only for fans with lower unit powers (< 3kW)
Two speed motor (two sets of windings 1:2/Dahlander connection) which means larger motor compared to one speed motor.

Cyclic (on/off) which means ON/OFF duty is adjusted according to flow requirements and it is acceptable from application point of view. The control can't be as good as with speed control. When motor and fan are running they run at full speed.
Inlet box damper is based on damper control.
Pitch adjustment for axial fans / **Inlet vanes** for centrifugal fans
Vane control is done by inlet vane installed at the fan inlet.
Pitch control is by adjusting the pitch angle of axial-flow fan.

Drive and motor data

Supply voltage

Enter the reference supply voltage to be used. The value should be between 115 (1-ph) to 690 V (3-ph). This is used to screen out drive types.

Required motor power

FanSave is computing from fan data the required motor output power including 10% thermal margin. Based on this number you shall enter the Motor power.

Motor power (kW)

Enter the nameplate power rating of the motor. This is used to select the proper drive rating. The program uses calculated power demand to determine energy savings.

Motor efficiency, η_m (%)

Enter the motor efficiency from the motor nameplate or from other data supplied by the motor manufacturer. Use the efficiency for full load operation on fixed frequency utility power. The program will adjust the efficiency for operation at reduced speeds and loads. If the motor is oversized for the application, enter the efficiency for operation at the maximum applied load.

Improved control by

User should select the drive family from drop down box. FanSave will pick the drive rating based on motor power and voltage.

Flow profile

Annual running time

In other words, this is the total operating time per year. Enter the estimated number of hours that the fan is expected to run during a year's time. For 24 hour, 365-day operation, enter 8760 hours.

Operating Time at Different Flow Rates (%)

Enter the estimated time as a percentage of the total operating time for operation at each of the listed flow rates from 100% to 20%. Enter zero for flow rates that are not used. The sum of the entered percentages shall be 100%. A figure under the white cells show the sum. If it is not 100, a comment "Sums must equal 100%" is shown.

Economic Data

Currency unit

Specify here the currency to be used in calculations.

Energy price (per kWh)

Enter the price of energy per kilowatt-hour (kWh). The FanSave program does not have provisions for calculating demand charges. To estimate energy cost including demand charges, enter the average cost of energy per kWh including average demand charges. Please consider the rising energy prices.

Investment Cost

Enter the estimated additional cost of purchasing and installing a variable speed AC drive as compared to the alternative method of flow control used in the comparison. Use the same currency units as entered for energy cost. This entry will be used to calculate the direct payback time. If the existing system needs costly maintenance cost compute the net present value of those and deduct from investment amount.

CO2 emission (kg/kWh)

This value shall reflect the local conditions: the emission per kWh.

Results

The results of the calculations include the estimated annual energy consumption for the existing control method and for AC drive control, the difference of these two, which equals the annual energy saving.
FanSave also estimates the reduction in carbon dioxide (CO_2) emissions due to the reduced electricity consumption.
Payback period is calculated for the investment in the drive as compared to the alternative method of flow control.

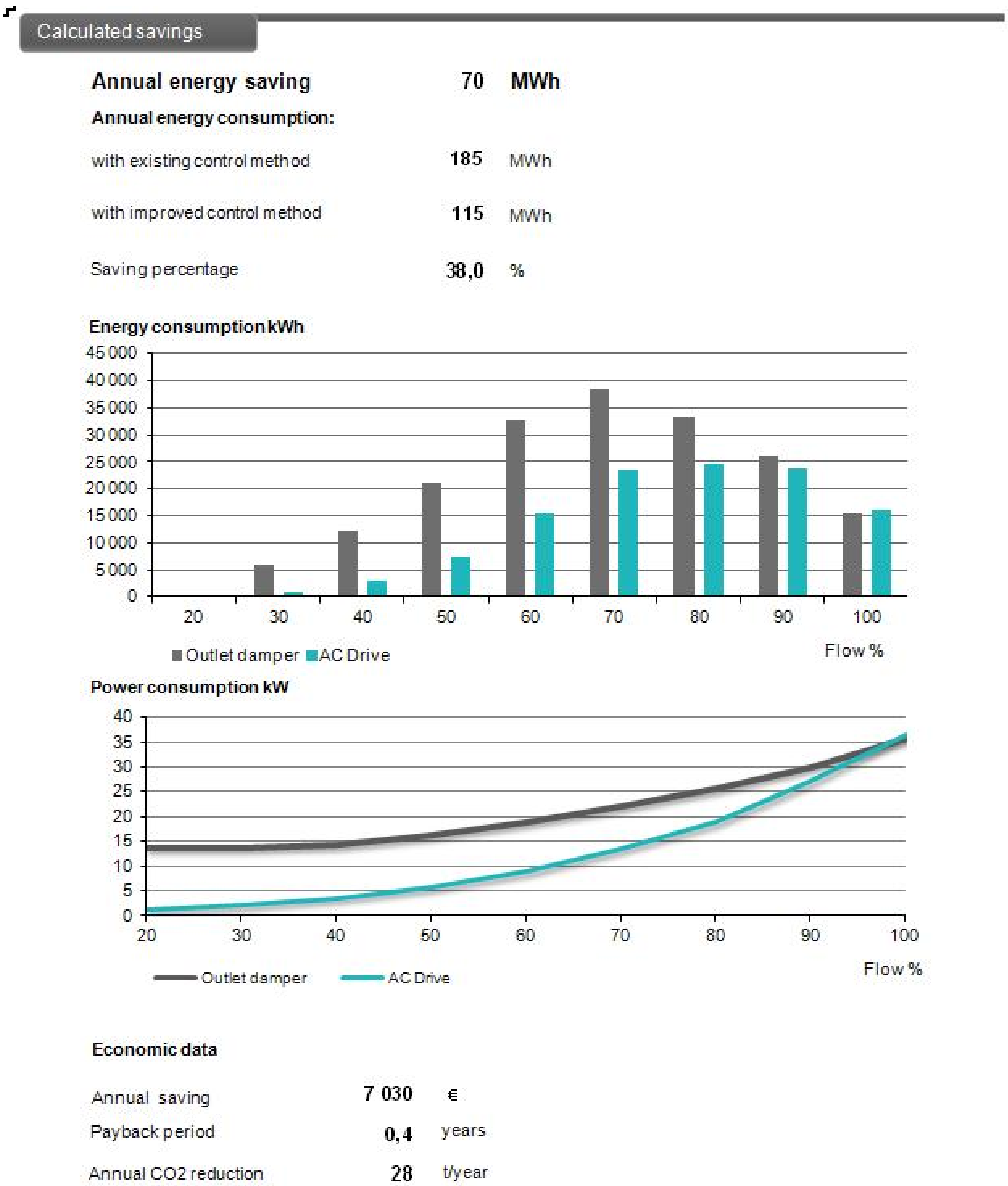


Figure 2 FanSave results page

Calculated savings

Annual energy saving (MWh)
This is the energy difference in favor of frequency converter control.

Energy consumption (MWh)
These are shown for both with existing control method and new control methods.

Saving percentage
The reduction in electricity costs in percents. This is also, of course, the energy saving in percents.

Energy consumption – graph (kWh)
The calculated energy used annually with the two control methods are shown as function of flow.

Power consumption – graph (kW)
The calculated power demand with the two control methods are shown as function of flow.

Economic results

Annual Saving
This is how much money you save thanks to the variable speed control by AC drive annually. Money saving comes in the form of smaller electricity bill.

Payback period
This direct payback time shows how soon the savings cover the investment cost.

Annual CO_2 reduction (t/year)
This is the reduction in tons per year, which results from the reduced energy consumption due to variable speed control.

5 — Explanation of Calculations

Fan performance curves

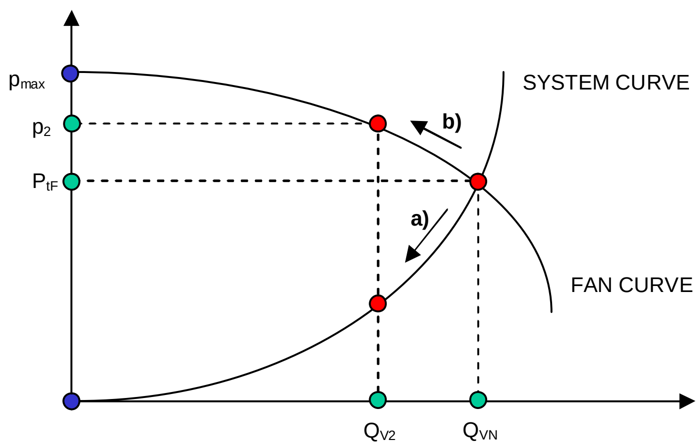
Fan performance can be defined from its performance curves i.e. *pressure curve* (Qv/ptF-curve) and *power curve* (Qv/P_R-curve). Different fan types have different shaped performance curves. Additionally, the position of the curves depends on gas density and rotation speed. For these reasons, the performance curves are often presented as sets of curves with different parameters. The manufacturer of the fan provides these performance diagrams.

The *pressure curve* of the fan can also be referred to as the fan curve. The suitability of a fan to a certain duct system depends partly on the form of the fan curve. All the calculations of FanSave are based on parabolic fan curve.

The useful mechanical power transferred into the volume flow is called air power $P_{F.}$ It is proportional to the gas volume flow, compression factor and total fan pressure. For low pressure fans the compression factor ≈ 1.

The impeller power P_R (also called shaft power), i.e. the mechanical power necessary for rotating the fan is then obtained by taking the fan efficiency into account. For all centrifugal fans the impeller power increases as the volume increases. This connection is presented in the *power curve* of the fan.

Further on, the electric fan power is calculated by taking the motor and drive efficiencies into account.



Graph.1. An example of typical fan and system curves.

System curve

All the duct systems have their special performance curve, *system curve*, dependent on the resistances in the duct. In a turbulent flow, all the resistances caused either by friction or various duct elements are proportional to the square of the volume flow. From this follows that the resistance of the duct system, i.e. system curve, often complies with the same rule.

Especially in industrial processes it is likely to encounter also system curves with an additional constant pressure and previously mentioned changing pressure. The calculations of FanSave are based and valid on the basic system curve without any constant pressure.

When adjusting the fan speed to control the volume flow, the process moves via system curve (a). Respectively, when throttling the duct the fan operates continuously at the same speed, and the movement of the process is via fan curve (b).

Control methods

For FanSave calculations the most important control methods to control the fans during operation have been selected. Fig.4 below shows the relationship of the electric fan power compared to the volume flow in connection with these control methods. The control method presentations are average examples used in calculations.

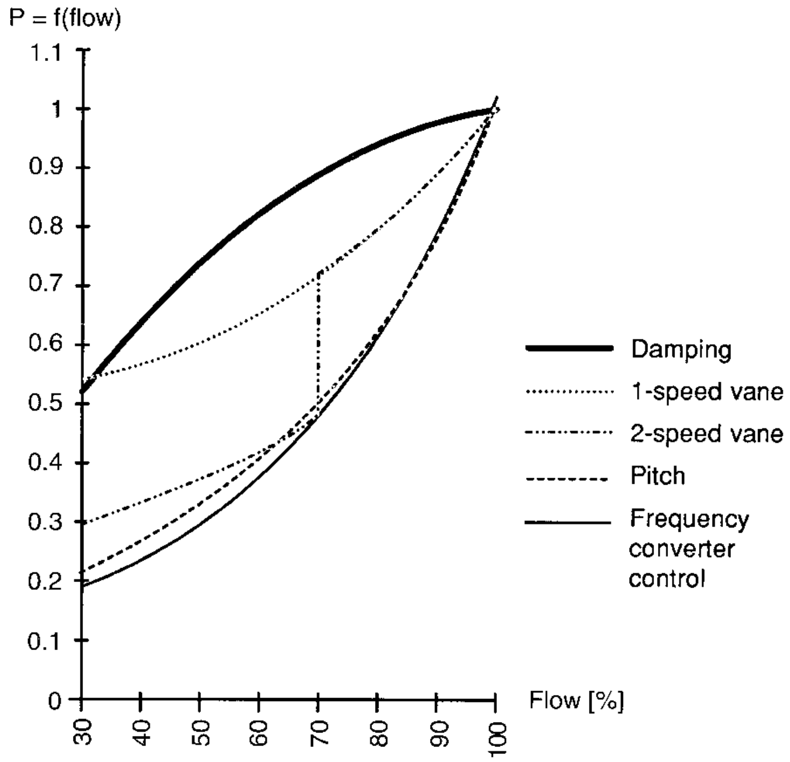


Figure 1 The power curves of flow control methods.

Efficiencies

The given values are used in the formulas. Further, as shown in the formulas, the efficiency of the system depends on the given efficiencies of fan, mechanical transmission, motor and drive, and on the adjustment method specific correcting factor. These correcting factors have been derived empirically.

FanSave calculations

The following formulas are used for power calculations:

The impeller power i.e. nominal shaft power of a fan is calculated from the formula

$$Pf = kp \cdot Qvn \cdot ptF$$

where kp is compression factor

$$kp = [1 - 0.35 \cdot ptF \cdot nk / pta]$$

The electrical power for different control methods, and for different flow rates is calculated as follows.

Frequency converter control nominal power

$$Pvs100 = \frac{Pf}{nk \cdot nt \cdot nm \cdot nd}$$, where

where nk =fan efficiency
nt = transmission efficiency
nm= motor efficiency
nd=drive efficiency

The power consumption on lower flow levels are tabulated

Flow	Multiplier
0.2	0.035
0.3	0.055
0.4	0.095
0.5	0.155
0.6	0.24
0.7	0.37
0.8	0.515
0.9	0.74

Other control types

$$Pd100 = \frac{Pf}{(nk \cdot nt \cdot nm)}$$

where nk =fan efficiency
nt = transmission efficiency
nm= motor efficiency

The power consumption on lower flow levels are tabulated with following multipliers.

Flow	Slip	Voltage	Two speed	Cyclic	Inlet damper	Pitch	Inlet vanes
0.2	0.146	0.094	0.225	0.2	0.47	0.339	0.339
0.3	0.163	0.156	0.225	0.3	0.5	0.36	0.36
0.4	0.22	0.223	0.225	0.4	0.54	0.394	0.394
0.5	0.297	0.331	0.225	0.5	0.58	0.446	0.446
0.6	0.386	0.44	0.225	0.6	0.62	0.483	0.483
0.7	0.505	0.563	1	0.7	0.67	0.559	0.559
0.8	0.626	0.703	1	0.8	0.75	0.636	0.636
0.9	0.773	0.846	1	0.9	0.84	0.763	0.763

Flow	Outlet damper F	Outlet damper B	Outlet damper R
0.2	0.38	0.49	0.49
0.3	0.38	0.57	0.57
0.4	0.395	0.655	0.655
0.5	0.45	0.723	0.723
0.6	0.525	0.79	0.79
0.7	0.615	0.855	0.855
0.8	0.715	0.91	0.91
0.9	0.84	0.96	0.96

Unit Conversions

Please use the conversion tools found on Web to work with local non SI -units.