RICE

MVD Fan Save User Guide

Advanced version

Authors: Prof. Ing. Zdeněk Peroutka, Ph.D.
Ing. Jan Michalík, Ph.D.
Ing. Miroslav Byrtus, Ph.D.
Ing. Martin Sirový

Pages: 31
Release: May 26, 2013
Submitter: ABB, Turgi, Switzerland

Report No.: 22190-036-2013

Abstract

This report is intended to be used as a user guide for developed software MVD Fan Save beta 3.2. The software tool has been developed in order to provide advanced comparison of operational and economical features under various operational conditions. It is able to compare a few currently in use control principles of fans. All considered controls are compared with variable speed drive (VSD) with frequency converter.

The software tool is oriented parametrically with respect to input data, i.e. it offers advanced user interface tools enabling the user to define and modify in detail all basic and advanced data of all components included in the chain – motor, fan, system and control element/method.

The software also includes basic economical evaluation features such as operational costs, payback period or lifetime savings calculations.

The software already includes default case study ready to be used for testing and learning purposes for fans. However, the basic parameters can be modified by user according to particular application and data.

University of West Bohemia

RICE, Regional Innovation Centre for Electrical Engineering

Univerzitní 26, 306 14 Plzeň

Czech Republic

The Authors	Contact
Prof. Ing. Zdeněk Peroutka, Ph.D.	pero@rice.zcu.cz
Ing. Jan Michalík, Ph.D.	jmichali@kev.zcu.cz
Ing. Jan Molnár, Ph.D.	jmolnar@rice.zcu.cz
Ing. Miroslav Byrtus, Ph.D.	mbyrtus@rice.zcu.cz
Ing. Martin Sirový	sirovy@rice.zcu.cz

Table of Contents

List of shortcuts

VSD ……. **V**ariable **S**peed **D**rive

FC …… **F**requency **C**onverter

HC …… **H**ydraulic **C**ouplings

NPV …….. **N**et **P**resent **V**alue

CFC …… **C**ompared **F**low **C**ontrol

VFC …….. **V**ariable-Speed **F**low **C**ontrol

MVD ……. **M**edium **V**oltage **D**rive

1 Introduction

This report has been written as a user guide for a software tool MVD Fan Save beta 3.1 which is an advanced version of previous release MVD Pump & Fan Save and it is focused in detail on fan application only. The software is introduced and the user is provided over the whole workflow.

MVD Fan Save tool has been developed in order to provide sophisticated comparison of operational and economical features (e.g. operational costs, payback period or lifetime savings calculations) under various operational conditions. It is able to compare a few currently employed control principles of fans. All considered controls are compared with VSD with frequency converter.

1.1 System requirements

- Operating system
  - Microsoft Windows XP with Service Pack (SP 3), Windows Server 2003 with SP1, or later operating system running Microsoft Office 2010 and higher.
- Microsoft Excel 2010.

1.2 MS Excel settings

The application MVD Fan Save is intended to be operated under the MS Excel 2010 software. Thus, following guide is demonstrated on this version.

First step - it is necessary to **enable macros immediately after application startup** according to Fig.1.

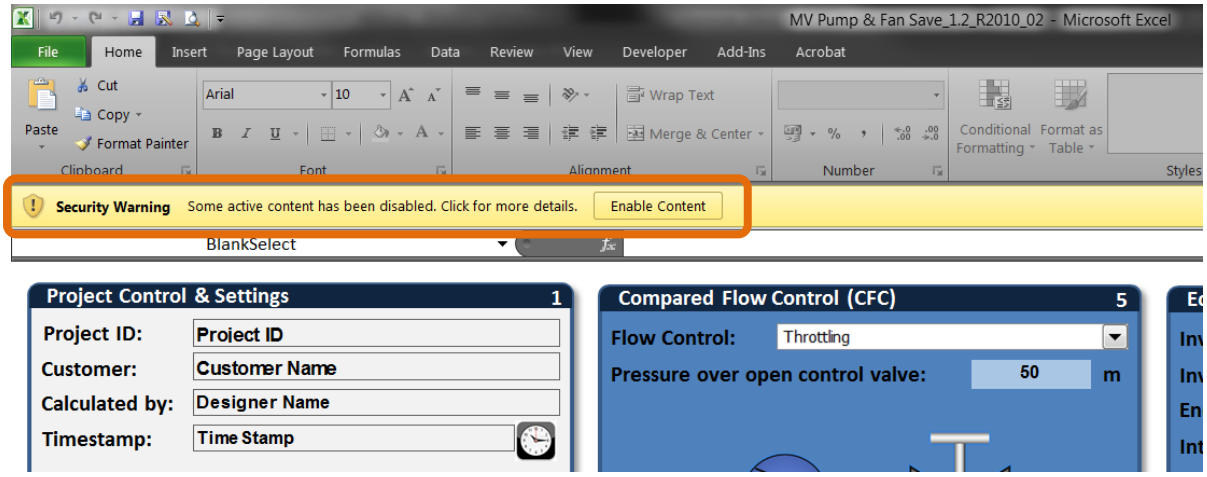


Fig.1 MS Excel - Security Warning

2 User Interface Description

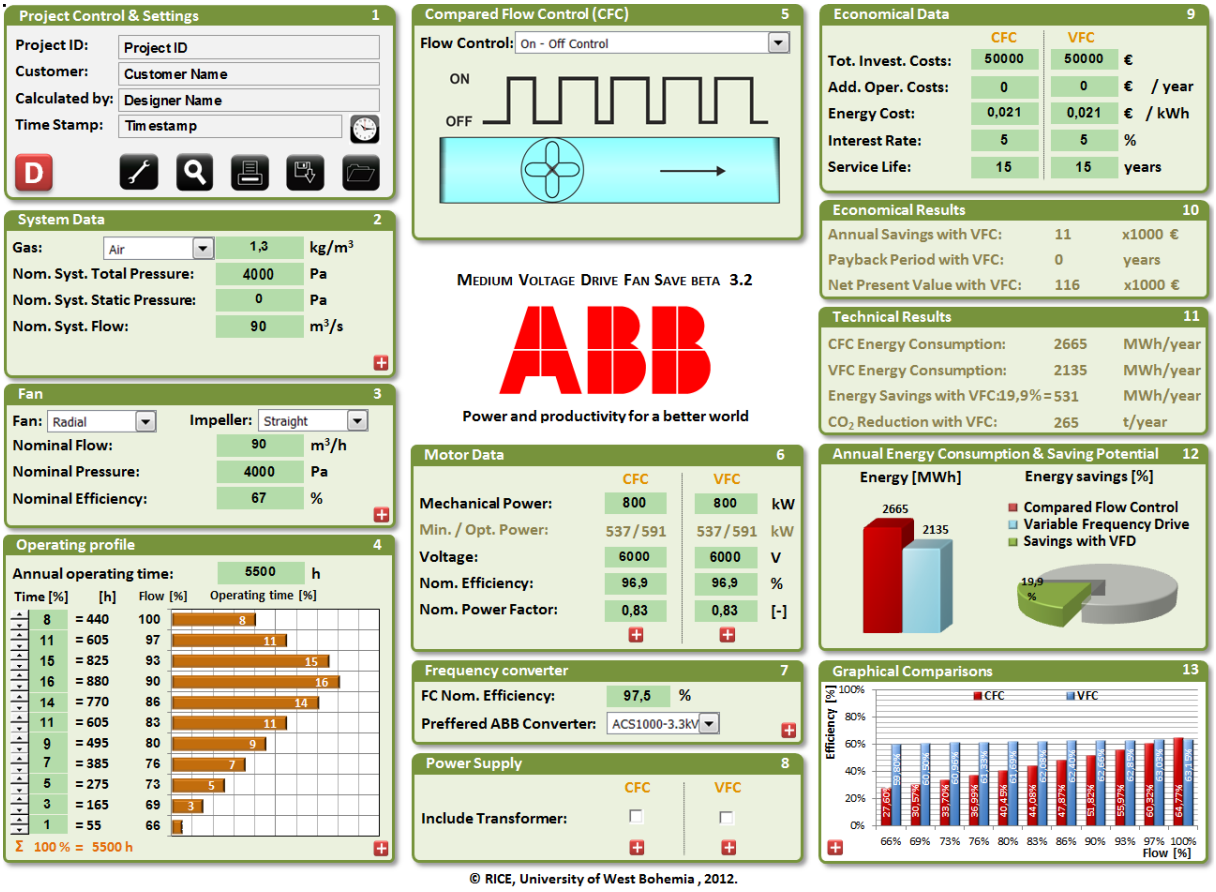


Fig.2 User Interface Controls

The user interface has two levels: Basic user interface and Enhanced user interface. Within the basic interface, user can set up basic operating data of system, fan, operating profile and flow control to be compared with VSD with frequency converter. This part of interface is displayed in Fig.2. The enhanced user interface enables the user to define in detail parameters of the system, fan, operating profile, CFC, motor data, frequency converter and power supply. The advanced interface is activated by pressing the "plus" button placed in the bottom of the tabs (see Fig.2).

3 User workflow

In this chapter, all blocks will be described according to their numbers placed into the top right corner.

3.1 Project Control & Settings

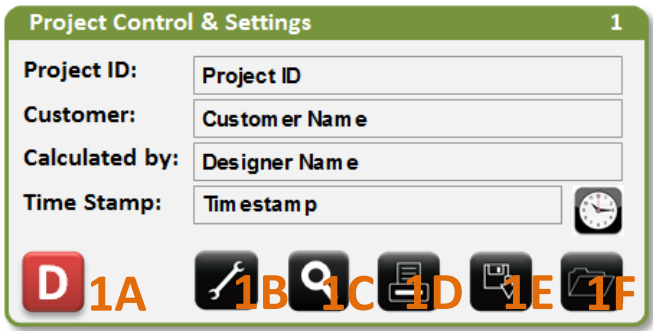


Fig.3 Project control & setting entry

In this entry, user can fill in following project data:

- Project ID
- Customer name
- Designer name (calculated by…)
- Date/time stamp – user defined
- Format or system time by pressing the clock button  .

1A. *Default case study.* By pressing this button user can anytime reset all values into default values – all entries will be reset and all values recalculated.

1B. *Settings button.* Selection of metric/imperial system and currency (including current exchange ratio).

1C. *Zoom button*. Auto adjusting the user screen according to current screen resolution.

1D. *Print*. Whole case study printing into the form of report.

1E. *Save button*. Save case study in unique format (*.vsd) into file able to be opened again with load button.

1F. *Load button*. Load a case study from *.vsd file.

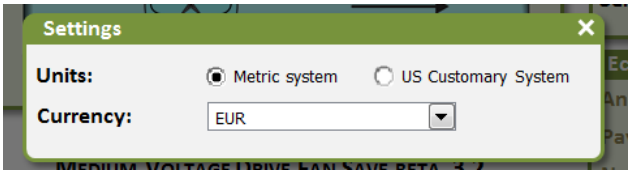


Fig.4 Selection of units and currency system

The *settings button* should be pointed out. After pressing this button, Fig.4 will appear where selection of metric/imperial system and currency (including current exchange) can be done. Default system is metric (SI), default currency is Euro.

***Important:* Change of units and/or currency will cause recalculation of actual values in the whole document!**

3.2 System Data

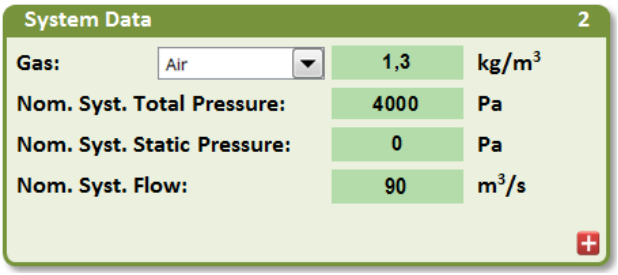


Fig.5 Basic system data entry

User can select type of gas from the list of typical ones or to define his/her own gas by entering desired gas density (Fig.5). Further user can enter values of *Nominal System Total Pressure*, *Nominal System Static Pressure* and *Nominal System Flow*.

By pressing the "plus" button, Enhanced System Data window appears (see Fig.6). The left hand side enables entering system parameters and define system curve. At the right hand side the system curves are plotted in relation to fan nominal curve (top) and sum of static and dynamics head. The default values correspond to default system values and are plotted in Fig.6. All pressure quantities are given in meters of current liquid.

2A. *Nominal Flow*. User can enter nominal flow value. Units used here are m^3/s.

2B. *Op. Limits of Nominal*. User can define operational control range of the fan.

2C. *Nom. Total/Dynamic*. Changing total head causes corresponding change in dynamic head only.

2D. *Nominal Static Head*. Nominal static head is given by nominal value in table **2I**.

2E. *Static Head Curve Type*. User can switch between constant static head curve and linear static head which increases linearly with respect to flow.

2F. *CO_2*. Entering weight of CO_2 emissions produced within 1 kW of fan output power.

2G. *Temperature*. Entering temperature of pumped liquid.

2H. *Real Nominal Operating Point Values (Calculated).* Real nominal operating point is calculated as an intersection of system curve and fan nominal curve. This block is useful especially in case when the user enters his/her system curve.

2I. *User System Curves – Input Data Source*. User can choose either the curve calculated from nominal values or the curve calculated from table entry. Choosing the table entry, areas **2D** and **2E** become inactive.

2J. *User System Curves – Table Entry*. User can define his/her own system curve which is given as a sum of dynamic H_D and static part H_S. There are some restrictions on the system curve given by the table entry

- The system curve has to be increasing.

- The system curve has to lie in the operational area whose border are defined by dashed lines (Fig.6, right, top – Fan VSD Flow Restriction)

If user crosses the restrictions, blocks 2 and 3 get red after closing the Enhanced System Data Window and user is forced to correct his/her data entry.

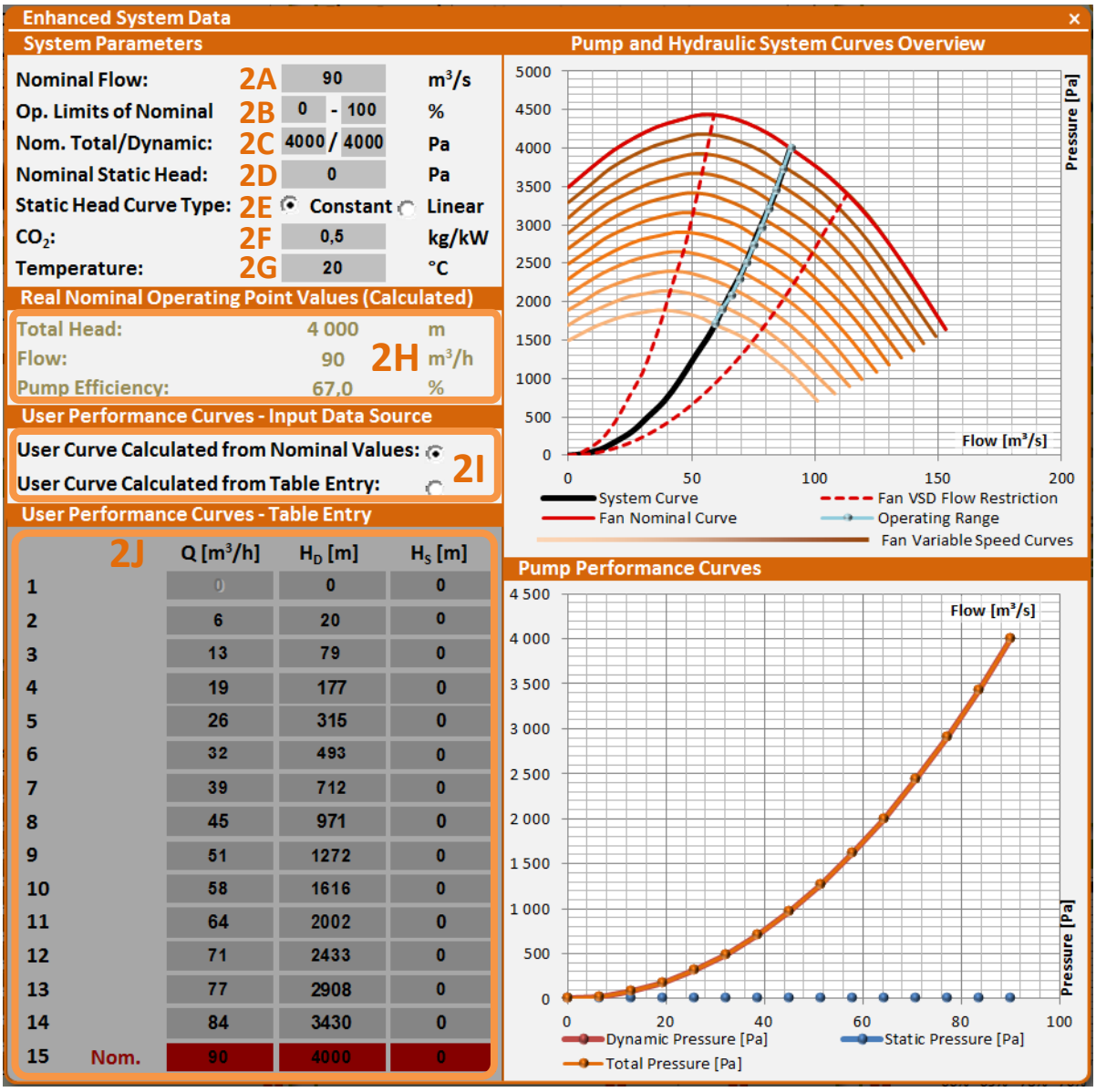


Fig.6 Enhanced system data entry

3.3 Fan Data

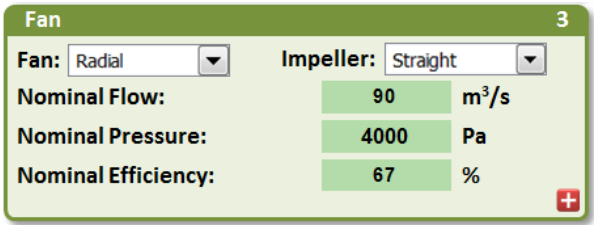


Fig.7 Fan data entry

This entry (Fig.7) serves for choosing fan (*Radial/Axial*) impeller (*Straight/ Forward/ Backward*) type. Within this entry user can specify values of *Nominal Flow*, *Nominal Pressure* and *Nominal Efficiency* of the fan. Similarly to System data (chapter 3.2), by pressing the "plus" button, Enhanced Fan Data window appears (see Fig.8). The upper and left hand sides enable entering fan parameters and define fan performance and efficiency curves. At the right hand side the system curves are plotted in relation to fan nominal curve (top) and fan performance and efficiency curves (bottom). The default values correspond to default system and fan values and are plotted also in Fig.8. All plotted pressure quantities are given in Pascals.

3A. *Choosing fan type.* Radial fan with blade orientation (Straight, Forward, Backward). Axial fan.

3B. *Nominal Flow.* User can enter nominal flow value. Units used here are m^3/s.

3C. *Op. Limits of Nominal Flow.* User can enter range of flow in percent with respect to the value of nominal flow. The operational range is indicated by dashed lines in the upper plot in Fig.8.

3D. *Nom. Total Pressure.* User can enter value of nominal total head of the fan.

3E. *Nominal Efficiency.* User can define nominal fan efficiency.

3F. *Nominal Speed.* Entering nominal fan speed.

3G. *Include Gearbox.* By ticking, user can select whether the gearbox is included into CFC and VFC. If the gearbox is selected, user can define *User Ratio* and *Efficiency* of the gearbox.

3H. *User ratio.* The value is the ratio of fan and motor speed.

3I. *Efficiency.* The value gives gearbox efficiency.

3J. *Real Nominal Operating Values (Calculated).* This block summarized final nominal operating values.

3K. *User Performance Curves – Input Data Sources.* User can choose either the curves are calculated from nominal values or the curves are calculated from table entry. Choosing the table entry, areas **3B**, **3D** and **3E** become inactive.

3L. *User Performance Curves – Table Entry.* User can define his/her own fan performance and efficiency curves. Moreover, the nominal operating values can be changed by choosing one of the rows in the table entry by clicking proper radio button.

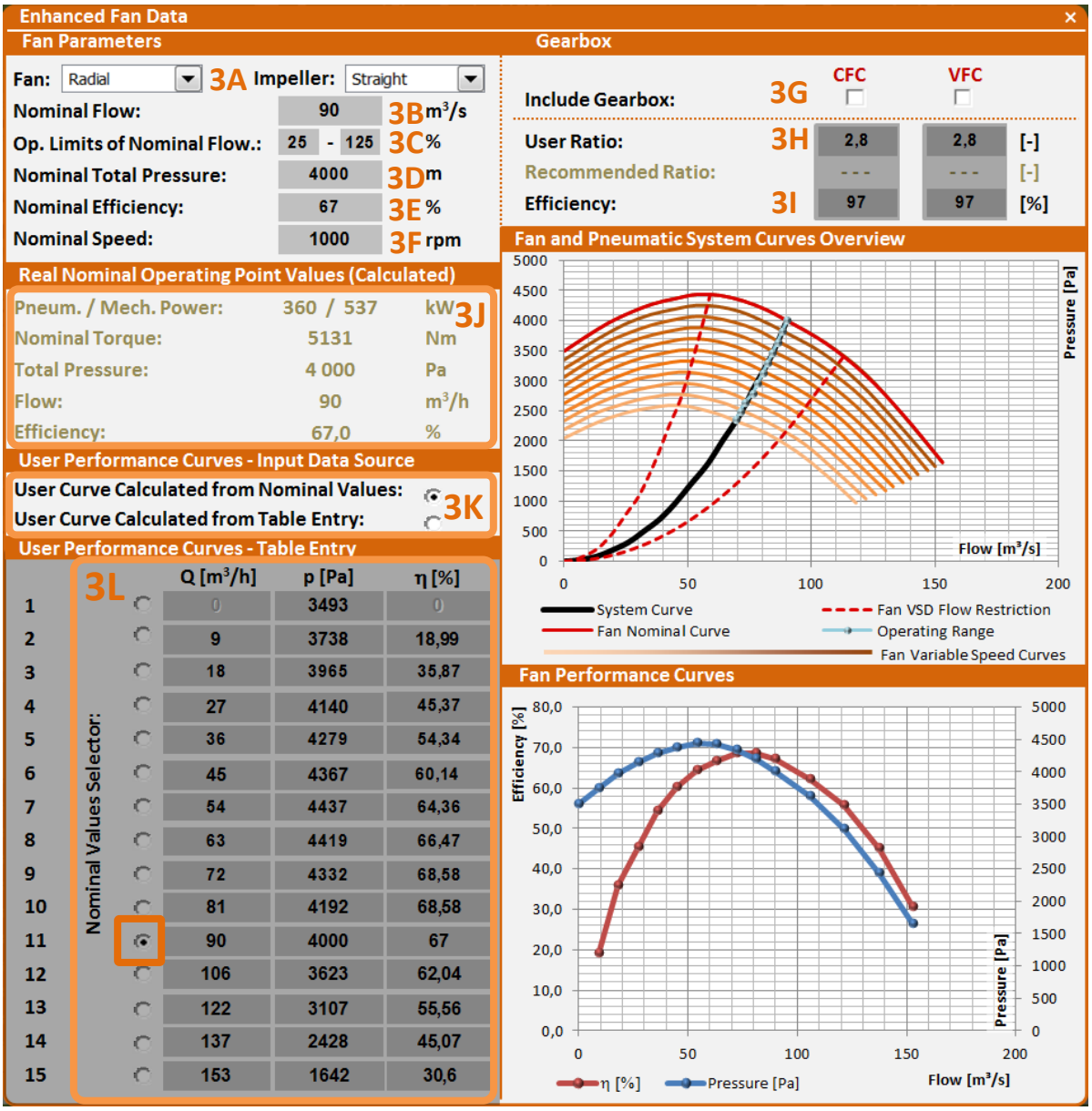


Fig.8 Enhanced Fan Data

3.4 Operating Profile

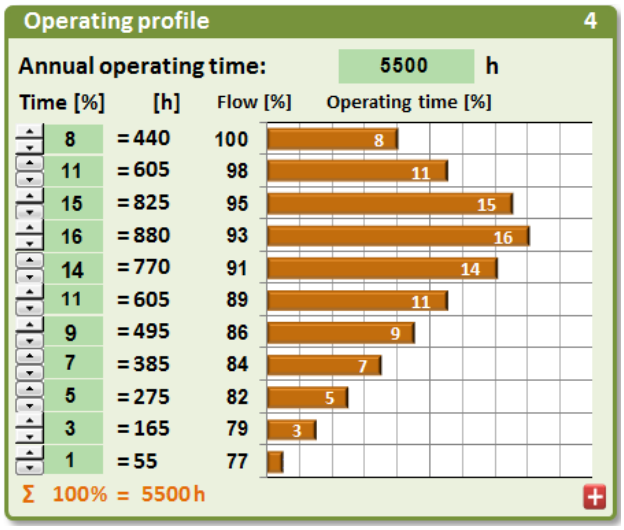


Fig.9 Operating profile entry

With this entry, user can set operating profile of the controlled drive with resolution of 10% of defined flow operating range. (In Fig.9, there is the operating range defined from 77% to 100% of flow. The operating range from 0% to 76% is not used.) Sum of the entered values of operating time is continuously calculated in order to secure 100%. If the sum does not equal to 100%, user will be warned. The important entry is also *Annual operating time* because it is used for economical calculations and, thus, should not be avoided.

By pressing the "plus" button, window Enhanced Fan Data appears (see Fig.10). Using the window, user can enter

4A. *Operating Range (Min-Max).* User can enter operating range of the operating profile.

4B. *Operating Limits (Min-Max).* This table summarizes basic fan and system parameters which are presented both in percent and in corresponding SI units.

- *System.*
- *Fan Fixed Speed.* The range of fan flow is indicated for fixed speed control.
- *Fan Variable Speed.* The range of fan flow is indicated for variable speed control.
- *Fan Curve Shape.* The range defines maximum possible fan flow range by respecting the system curve.
- *Total Limits.* Minimum and maximum fan flows, which can be used for fan control, are introduced.

4C. The limits presented in **4B** are viewed graphically.

The value of 100% flow corresponds to real nominal system flow (intersection of fan and system curve).

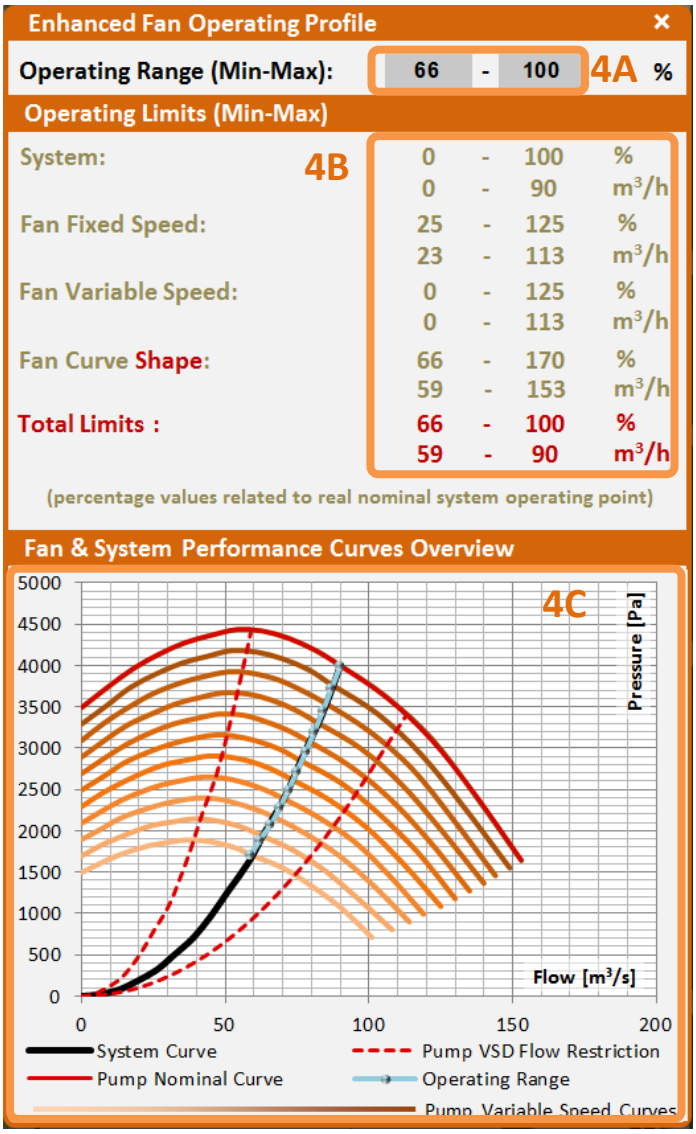


Fig.10 Enhanced Fan Operating Profile entry

3.5 Compared Flow Control (CFC)

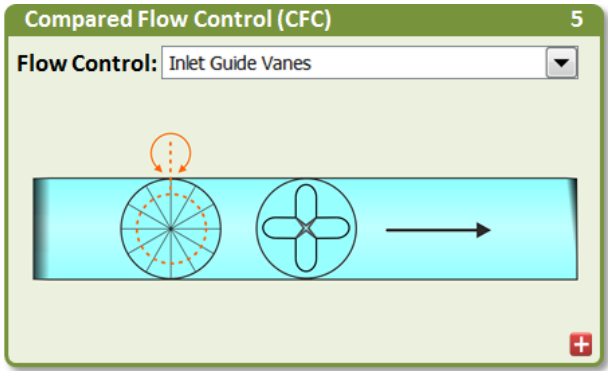


Fig.11 Compared flow control entry (CFC)

In this entry, user selects flow control to be compared with VFD. The list of compared flow control methods differs according to fan type.

- *Radial fan type* is compared with following flow controls*: Inlet Guide Vanes, Inlet Damper, Outlet Damper, Variable Speed Control – Hydrodynamic Coupling* and *On – Off Control.*

- *Axial fan type* is compared with these flow controls: *Inlet Guide Vanes*, *Inlet Damper*, *Outlet Damper*, *Pitch Control*, *Variable Speed Control – Hydrodynamic Coupling* and *On – Off Control.*

In the next, parameters, which can be set up within each flow control, are summarized.

3.5.1 Inlet Guide Vanes, Inlet Damper, Outlet Damper

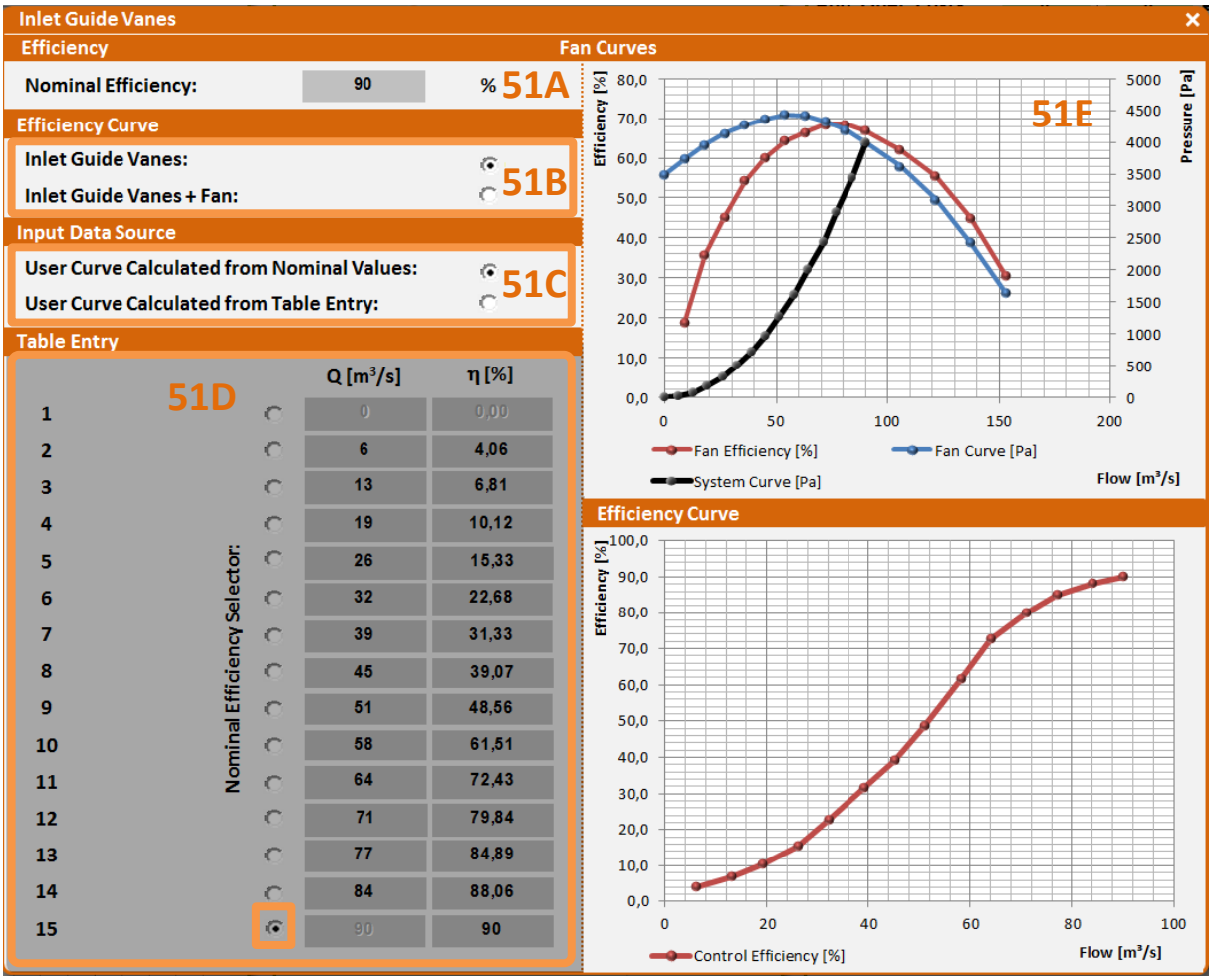


Fig.12 Enhanced entry for Inlet Guide Vanes

Inlet Guide Vanes, Inlet Damper and Outlet Damper controls can be used for both radial and axial fans and following data can be controlled (Fig.12 illustrates the enhanced entry tab for Inlet Guide Vanes Control)

51A. *Nominal Efficiency.* User can enter nominal efficiency of the control element, i.e. Inlet Guide Vanes.

51B. *Efficiency Curve.* User can choose whether the efficiency curve is defined for control element only (e.g. Inlet Guide Vanes) or it is resulting efficiency curve covering the efficiency of fan and control element (e.g. Inlet Guide Vanes).

51C. *Input Data Source.* The efficiency of control element or both control element and fan can be calculated either from nominal values or it can be entered by user. Choosing the table entry, area **51A** becomes inactive and the table entry **51D** becomes active and user can define the efficiency characteristic.

51D. *Table Entry.* Besides the efficiency characteristic entering, user can choose the nominal efficiency point by clicking on the proper radio button. Default nominal point is the last operational point.

51E. *Fan Curves, Efficiency Curves.* The right hand side of the tabs displays corresponding performance curves.

3.5.2 Variable Speed Control – Hydrodynamic Coupling

Variable speed control by Hydrodynamic Coupling can be used for both radial and axial fans as the previously mentioned controls but this one differs from the previous by parameters to be entered. Fig.13 illustrates the enhanced entry tab hydrodynamic Coupling.

52A. *Auxiliary losses.* User specifies possible auxiliary losses of hydrodynamic coupling. The losses are given by constant loss power in *kW* (e.g. oil pump for journal bearings).

52B. *Output parameters.* Here, minimal and maximal speed with corresponding efficiency of the hydrodynamic coupling is summarized.

52C. *HC User Performance Curve – Nominal Values Entry.* User defines nominal speed and corresponding efficiency. Further, zero offset can be entered which defines the shift of the hydrodynamic coupling efficiency at the zero speed. The efficiency then linearly increases up to the nominal operating point.

52D. *HC Performance Curve – Input Data Source.* User selects whether HC performance curve is given by nominal values or by table entry. Choosing the table entry, area **52C** becomes inactive and the table entry **52F** becomes active and user can define the efficiency characteristic.

52E. *Gearbox.* User can specify whether the gearbox efficiency is included in HC efficiency or not.

52F. *Table Entry*. Besides the efficiency characteristic entering, user can choose the nominal efficiency point by clicking on the proper radio button. Default nominal point is the last operational point.

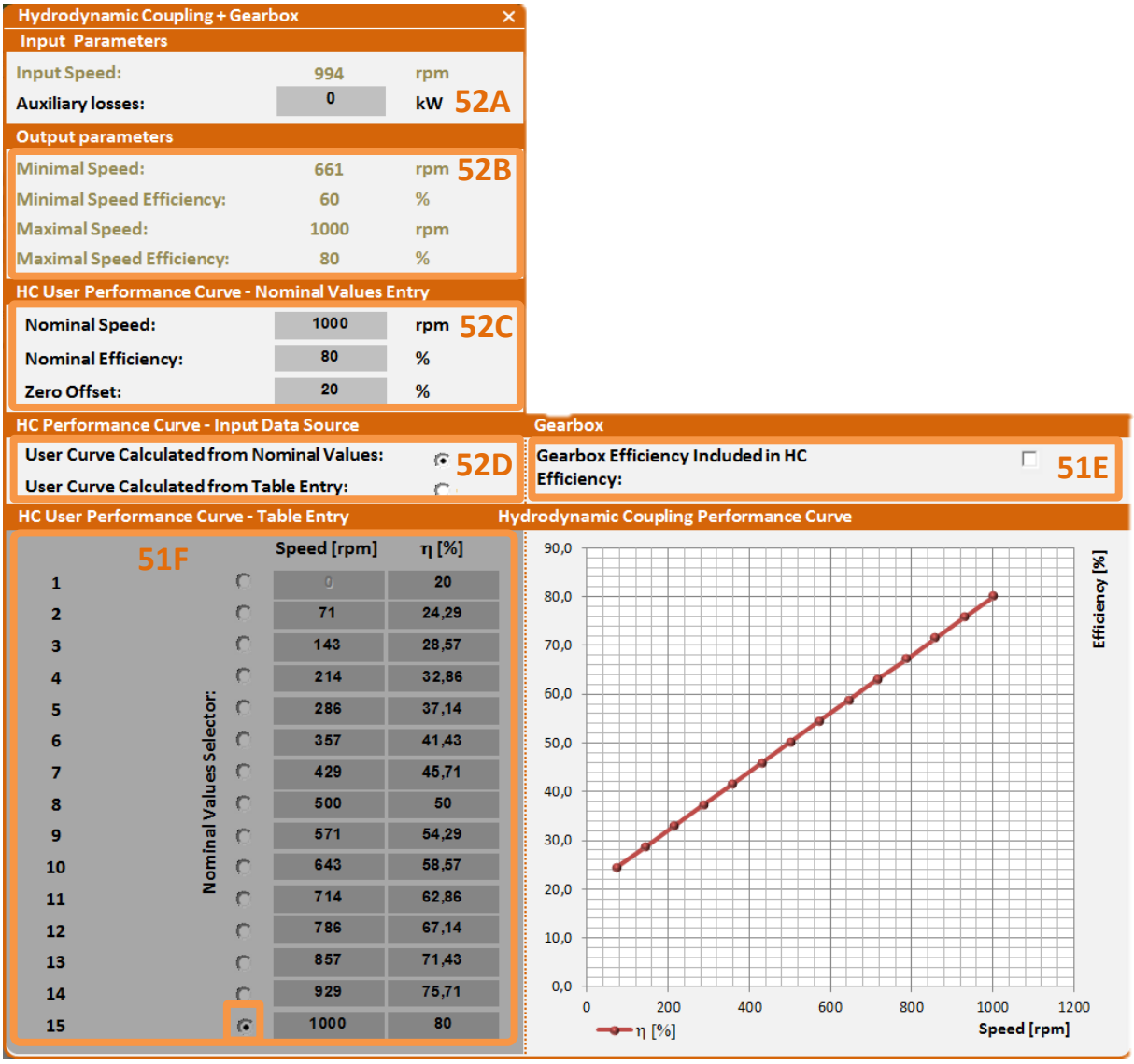


Fig.13 Enhanced Variable Speed Control – Hydrodynamic Coupling entry

3.5.3 On – Off Control

The on-off control method does not need any additional input parameters. The efficiency of the on-off control is proportional to the flow.

3.5.4 Pitch Control

The default efficiency of the pitch control is determined according to typical pitch control efficiency [2].

54A. *Nominal Efficiency.* User can enter nominal efficiency of the control element, i.e. Pitch Control.

54B. *Input Data Source.* User selects whether Pitch Control performance curve is given by nominal values or by table entry. Choosing the table entry, area **54A** becomes inactive and the table entry **54C** becomes active and user can define the efficiency characteristic.

54C. *System Curve/Fan Efficiency with Pitch Control.* User can specify whether the pitch control gearbox efficiency in dependence on gas flow.

54D. *Iso-lines of pitch control efficiency.* The figure displays efficiency iso-lines across the whole operational area given by gas flow rate and gas pressure. The iso-lines correspond to the surface plotted in **54E.**

54E. *Efficiency surface.* The plotted surface is given by efficiency values across the whole operational area given by gas flow rate and gas pressure. It is parametrized via control nominal efficiency (54A) and Fan Efficiency (3L)

54F. *Efficiency curve.* There is plotted pitch control efficiency which corresponds to (54E). This curve is used for final control efficiency comparison.

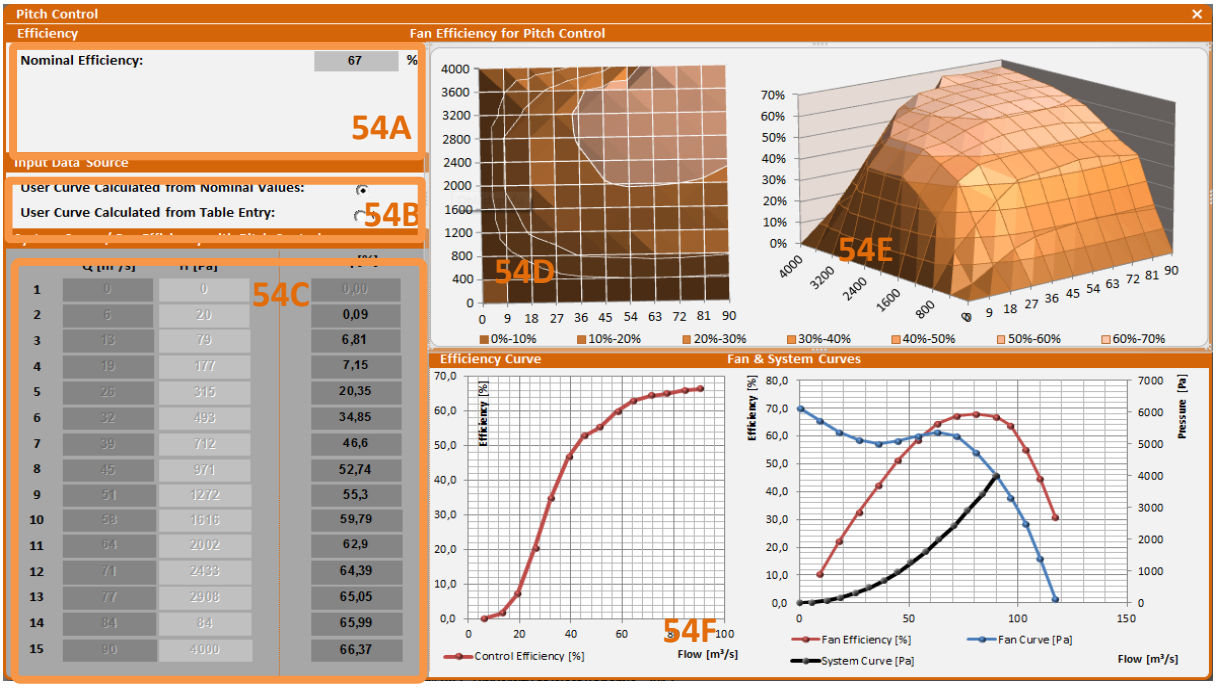


Fig.14 Enhanced Pitch Control entry

3.6 Motor Data

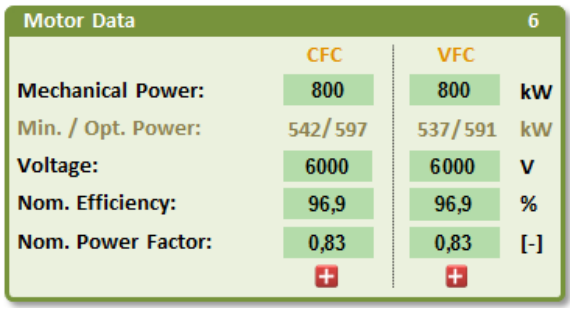


Fig.15 Motor data entry

Electrical motor data entry – user can set own values of motor power, voltage, nominal efficiency and nominal power factor for both compared flow controlled drive and variable flow controlled drive. This window also offers precalculated value of power – minimum/optimal calculated from preset system and pump data. Minimum value is minimum motor power able to run the system, optimal value is minimum value increased with 10% of security reserve. If user put in lower value than minimum, it will be automatically corrected by software into the minimum one. There are two "plus" buttons in Fig.15 who enable to modify motor data for compared flow controlled drive and variable controlled flow drive, respectively. Using the first one, i.e. for compared flow controlled drive, screen displayed in Fig.16 appears. User can specify following values:

6A. *Nominal Mechanical Power.* User can enter motor mechanical output power corresponding to nominal operating point.

6B. *Nominal Voltage.* User specifies nominal voltage of the motor.

6C. *Nominal Frequency.* User can specify the frequency corresponding to nominal operating point.

6D. *Nominal Speed.* Nominal speed of the motor can be defined.

6E. *Number of Poles.* Number of poles of the motor can be defined.

6F. *Nominal Efficiency.* Nominal efficiency of the motor can be specified.

6G. *Nominal Power Factor.* Nominal power factor is defined by this field.

6H. *Auxiliary Losses.* Moreover, user can enter power which corresponds to auxiliary losses given by motor operation.

6I. *User Performance Curves – Input Data Source.* User can choose either the curves are calculated from nominal values or the curves are calculated from table entry. Choosing the table entry, areas **6A**, **6F**, **6G** and **6H** become inactive together with fields corresponding to CFC in Fig.15.

6J. *User Performance Curves – Table Entry.* User can define own motor performance and efficiency curves. Moreover, the nominal operating values can be changed by choosing one of the rows in the table entry by clicking proper radio button.

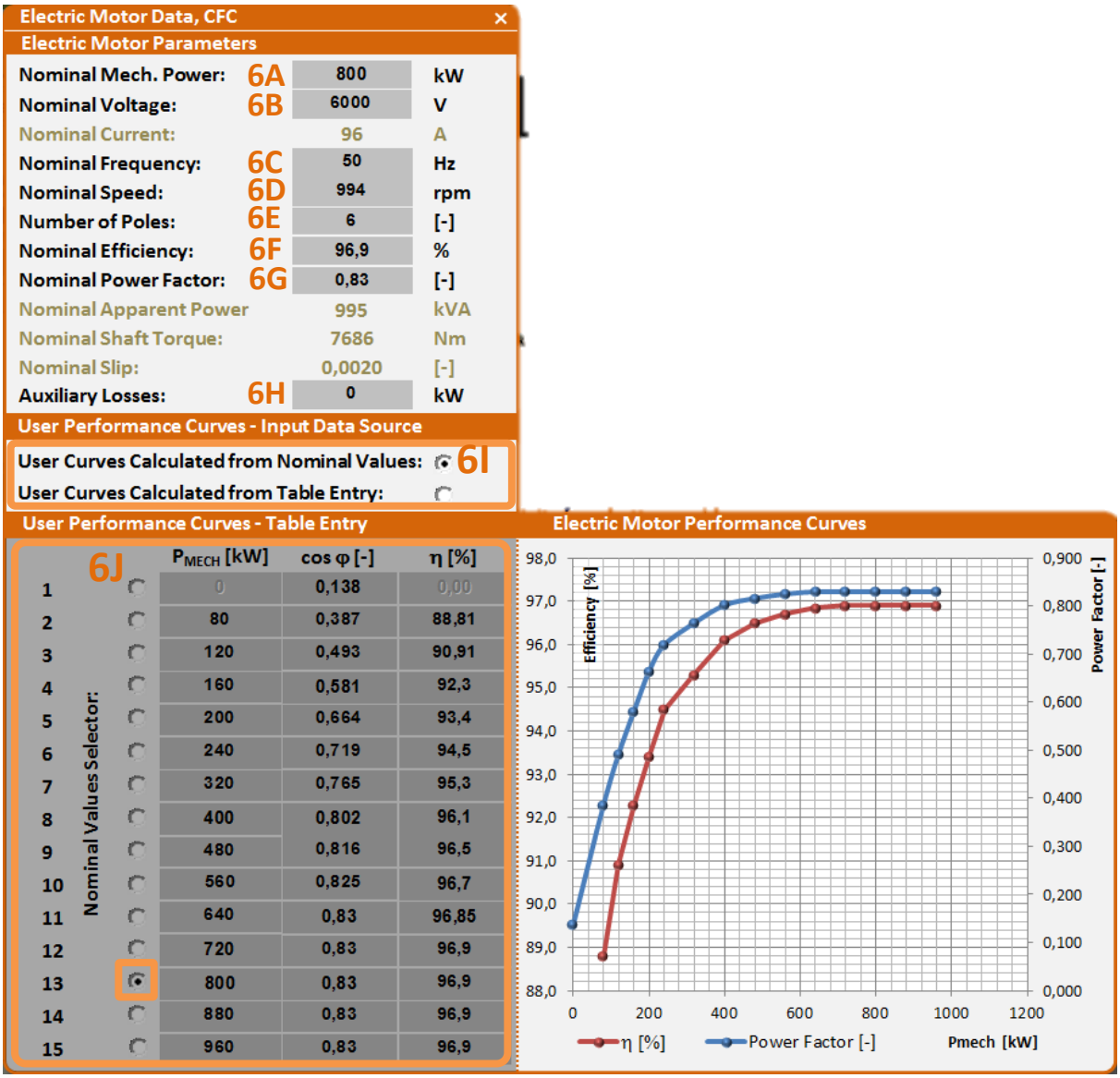


Fig.16 Enhanced motor data entry

The right bottom side of Fig.16 displays electric motor efficiency curve and power factor in dependence on motor mechanical power.

Using the second "plus" button (i.e. for variable controlled flow drive), the same screen as in Fig.16 appears but it enables to enter the same motor data for VFC.

3.7 Frequency Converter

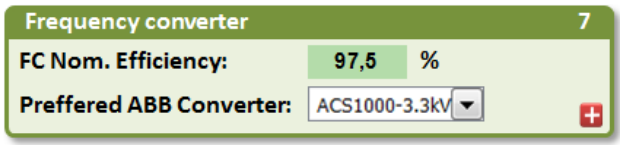


Fig.17 Selection of preselected ABB drive entry

According to the motor data (chapter 0), the software offers the list of suitable ABB drives sufficient for entered power and voltage range. Selection of the drive has only informative character and it is also listed in the final report. Using enhanced button, user can specify more parameters on the frequency converter by entries displayed in Fig.18

7A. *FC Input Voltage.* User can define FC input voltage.

7B. *Power Supply Frequency.* User can enter power supply frequency of the frequency converter.

7C. *Nominal Efficiency.* Nominal efficiency of the frequency converter can be specified.

7D. *Nominal Power Factor.* User can enter nominal power factor of the frequency converter.

7E. *Auxiliary Losses.* Moreover, user can enter power which corresponds to auxiliary losses given by frequency converter operation.

7F. *Nominal Cont. Apparent Power.* User can specify nominal cont. apparent power of the frequency converter.

7G. *Output Frequency Range.* User can specify the frequency range of the frequency converter.

7H. *User Performance Curves – Input Data Source.* User can choose either the curves are calculated from nominal values or the curves are calculated from table entry. Choosing the table entry, areas **7C**, **7D** and **7F** become inactive together with the field corresponding to FC Nom. Efficiency in Fig.17.

7I. *User Performance Curves – Table Entry.* User can define his/her own frequency converter curves. Moreover, the nominal operating values can be changed by choosing one of the rows in the table entry by clicking proper radio button.

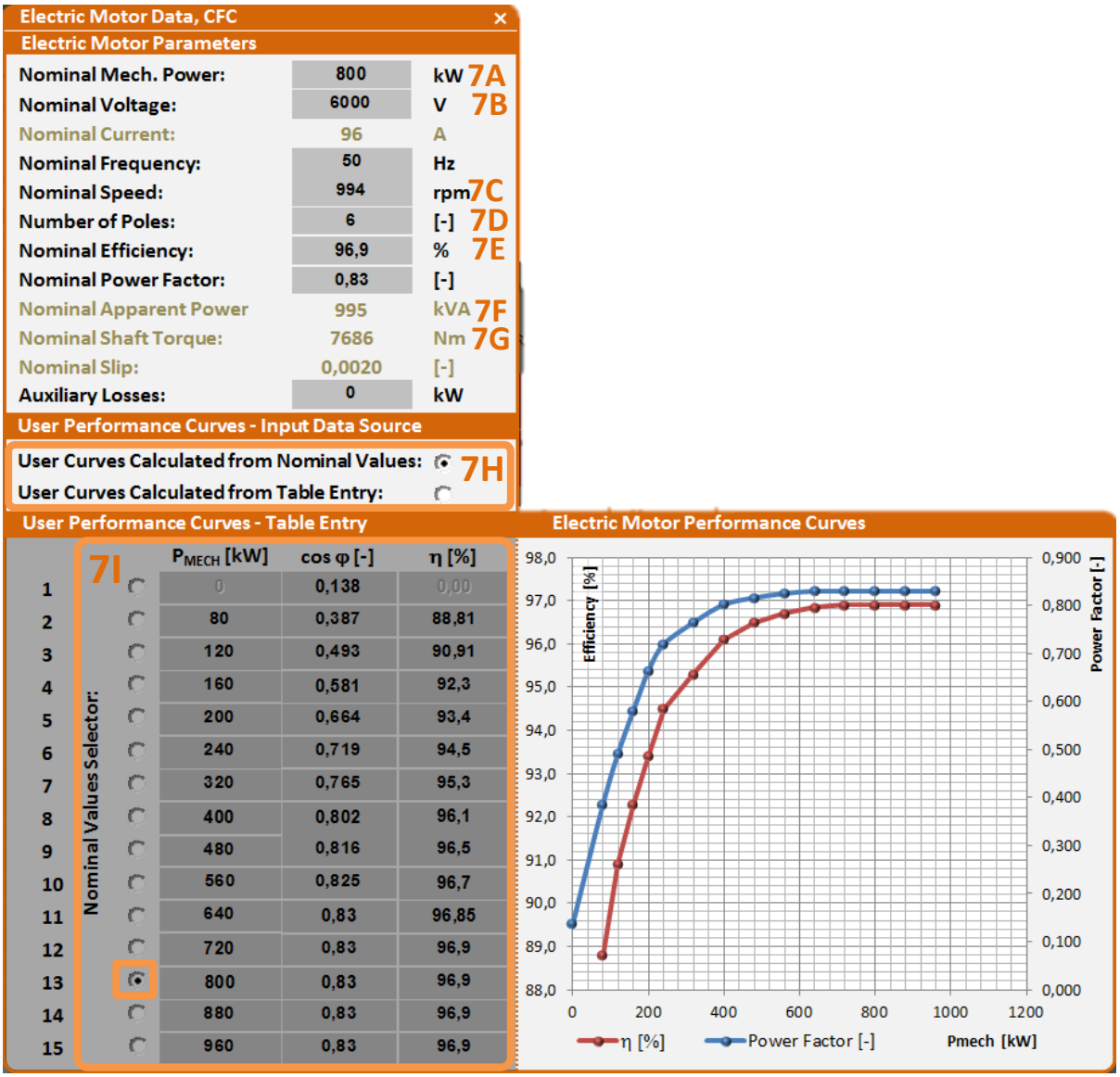


Fig.18 Frequency converter enhanced data entry

3.8 Power Supply

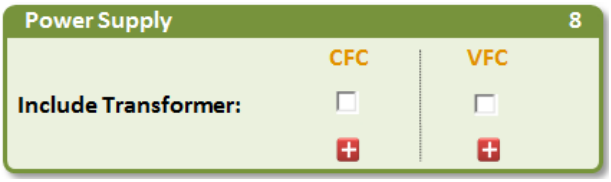


Fig.19 Transformer/no transformer selection

Selection of the field "*Include transformer*" affects only the overall efficiency calculation. The transformer can be included for both drives separately. Using "plus" buttons, power supply parameters can be specified according to Fig.20 in following order (i.e. for CFC)

8A. *Nominal Apparent Power.* User can enter nominal apparent power of the transformer.

8B. *Primary Voltage.* Primary voltage of the transformer can be defined.

8C. *Short Circuit Voltage.* User can enter short circuit voltage of the transformer.

8D. *No Load Current.* User can enter no load current of the transformer.

8E. *No Load Losses.* User can enter no load losses of the transformer.

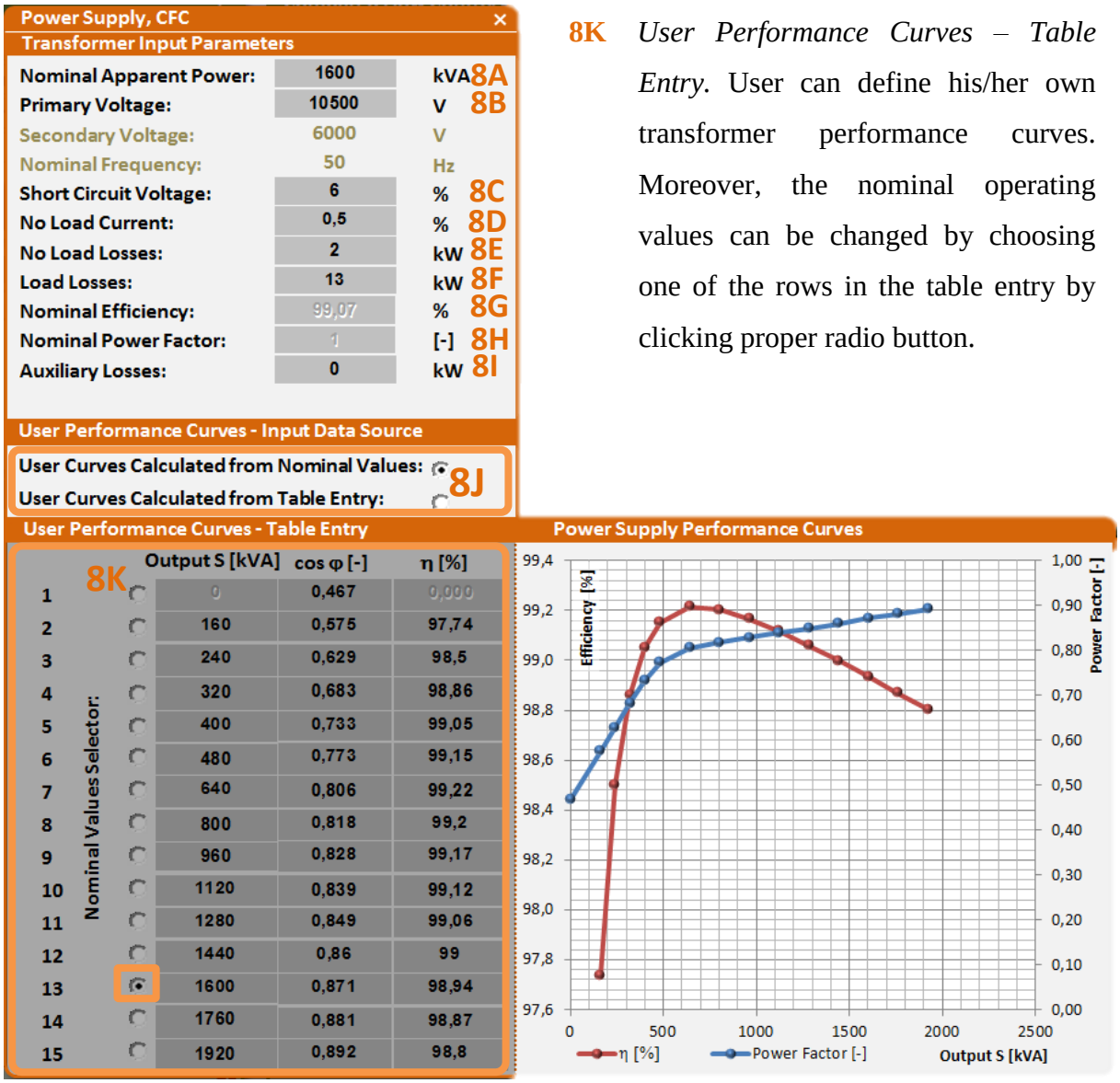
8F. *Load Losses.* User can enter load losses of the transformer.

8G. *Nominal Efficiency.* User can enter nominal efficiency of the transformer.

8H. *Nominal Power Factor.* User can enter nominal power factor of the transformer.

8I. *Auxiliary Losses.* Here, user can enter power which corresponds to auxiliary losses given by transformer operation.

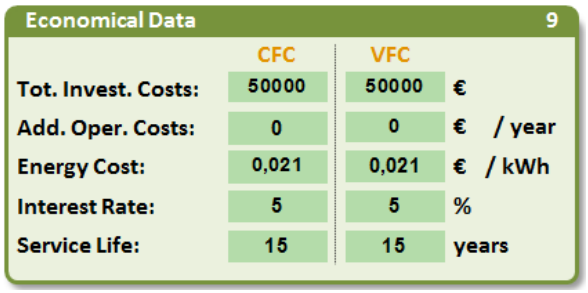
8J. *User Performance Curves – Input Data Source.* User can choose either the curves are calculated from nominal values or the curves are calculated from table entry. Choosing the table entry, areas **8A**, **8E**, **8F**, **8G** and **8H** become.



8K *User Performance Curves – Table Entry.* User can define his/her own transformer performance curves. Moreover, the nominal operating values can be changed by choosing one of the rows in the table entry by clicking proper radio button.

Fig.20 Power supply data enhanced entry

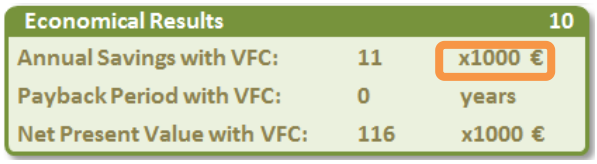
3.9 Economic Data



In this entry, user can set basic economic and operational data needed for final economical results provided in tabs 10 and 12.

Fig.21 Economic data comparison

3.10 Results



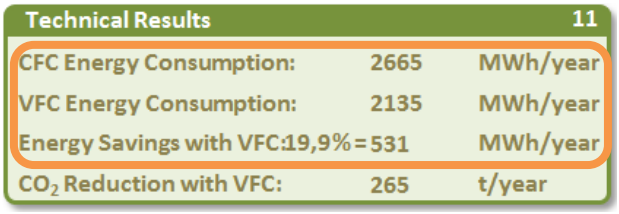


Fig.22 List of a) economic results, b) technical results

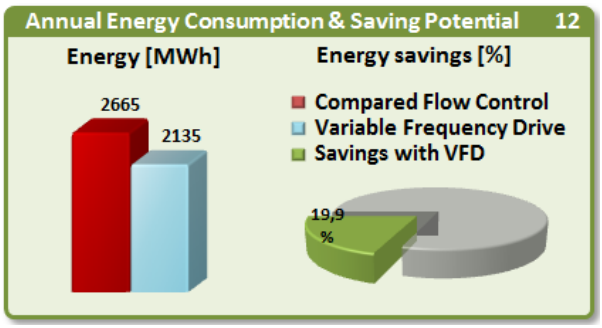


Fig.23 Annual energy consumption & saving potential comparison

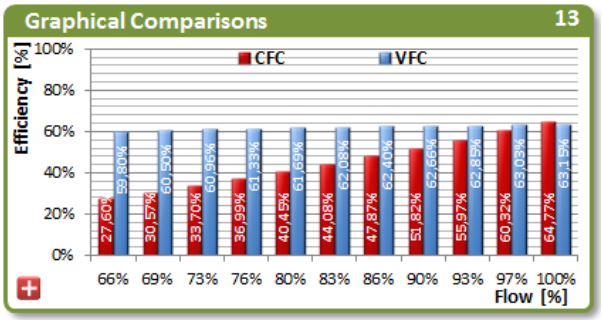


Fig.24 Efficiency comparison

In these four tabs (Fig.22 - Fig.24), final economic and technical results are provided according to defined system parameters and operating profile.

In Fig.22a), economic evaluation is provided – user can discover, what annual savings, payback period and net present value are going to be with VFD in comparison to selected CFC. In the highlighted frame, there is a multiplier of corresponding value in the line. This system has been employed due to various values of currencies.

In Fig.22b), comparison of energy consumptions of VFD solution (improved energy consumption) with an original one

(present energy consumption) is provided. Energy savings are also considered for the solutions with VFD – how much energy will be saved with VFD in comparison to CFC. The highlighted part is also graphically displayed in Fig.23 in the same meaning.

The last Fig.24 introduces calculations of VFD and CFC efficiencies for the selected/defined power range with resolution of 10% of this range. The calculations are based on mathematical models of each type of employed control and include efficiencies of the whole drive chain, e.g. *"fan-gearbox-electrical motor-frequency converter-transformer"* for VFD.

Clicking on the "plus" button, Enhanced Graphical Comparison Tab appears (see Fig.25).

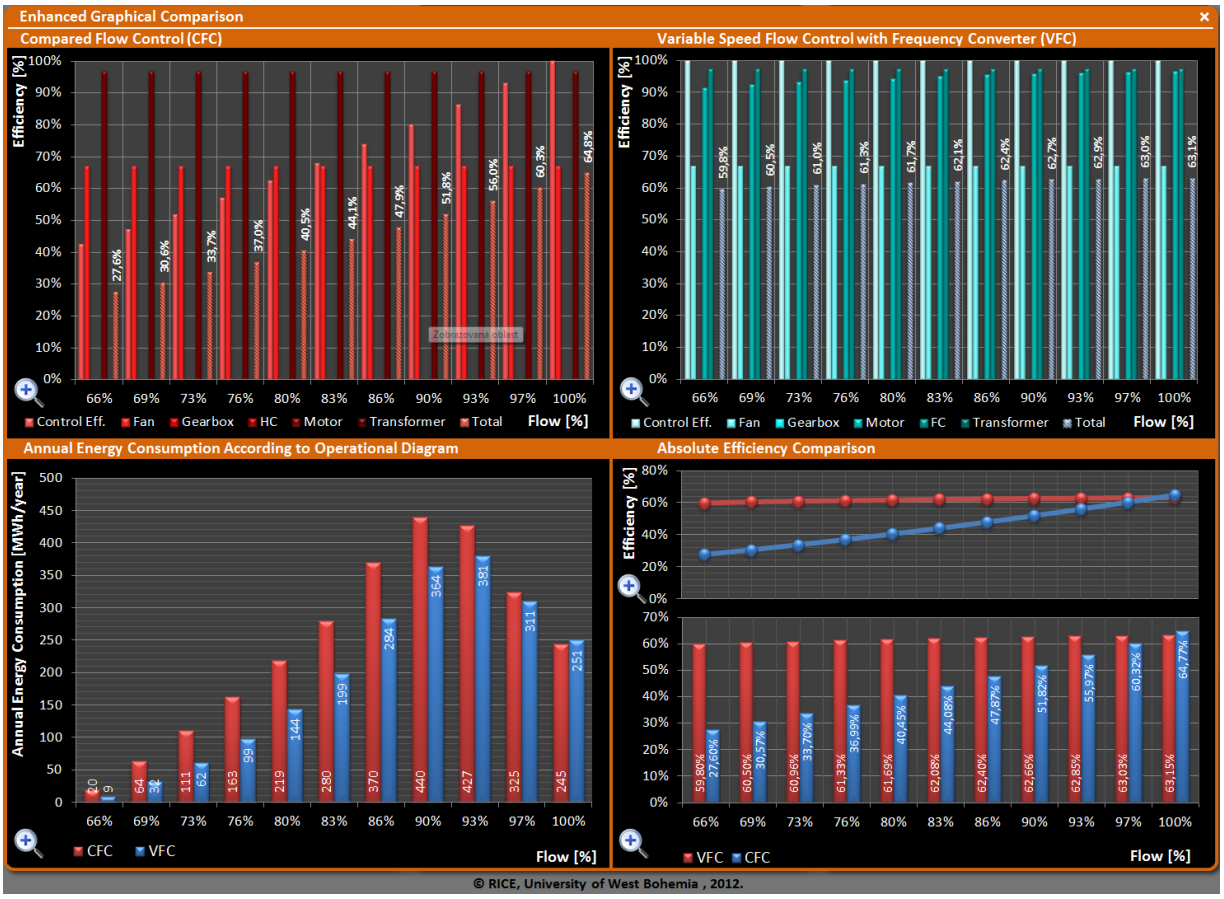
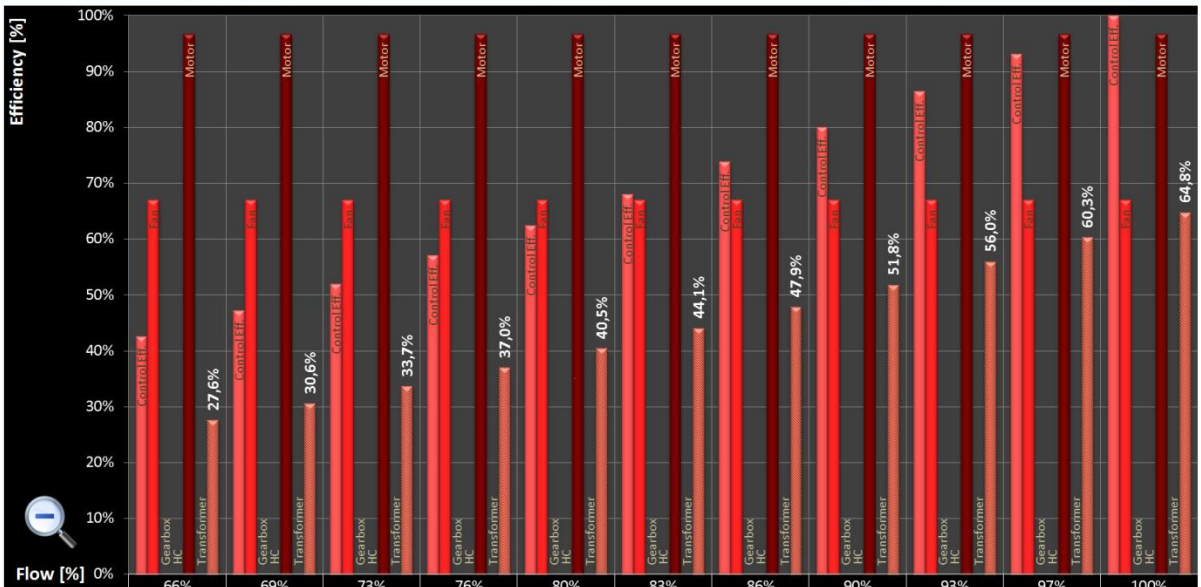


Fig.25 Enhanced Graphical Comparison

The tab is divided into four parts. The parts reveal detail data of efficiencies and energy consumption of compared flow controls. Every part can be zoomed by clicking on the zoom button  . By zooming the first part titled as *Compared Flow Control (CFC)*, screen displayed in Fig.26 appears.



Flow [%]	66%	69%	73%	76%	80%	83%	86%	90%	93%	97%	100%
Control Eff.	42,61%	47,20%	52,03%	57,12%	62,46%	68,06%	73,91%	80,01%	86,42%	93,13%	100,00%
Fan	67,00%	67,00%	67,00%	67,00%	67,00%	67,00%	67,00%	67,00%	67,00%	67,00%	67,00%
Gearbox	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
HC	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Motor	96,67%	96,67%	96,67%	96,67%	96,67%	96,67%	96,67%	96,67%	96,67%	96,67%	96,67%
Transformer	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Total	27,60%	30,57%	33,70%	36,99%	40,45%	44,08%	47,87%	51,82%	55,97%	60,32%	64,77%

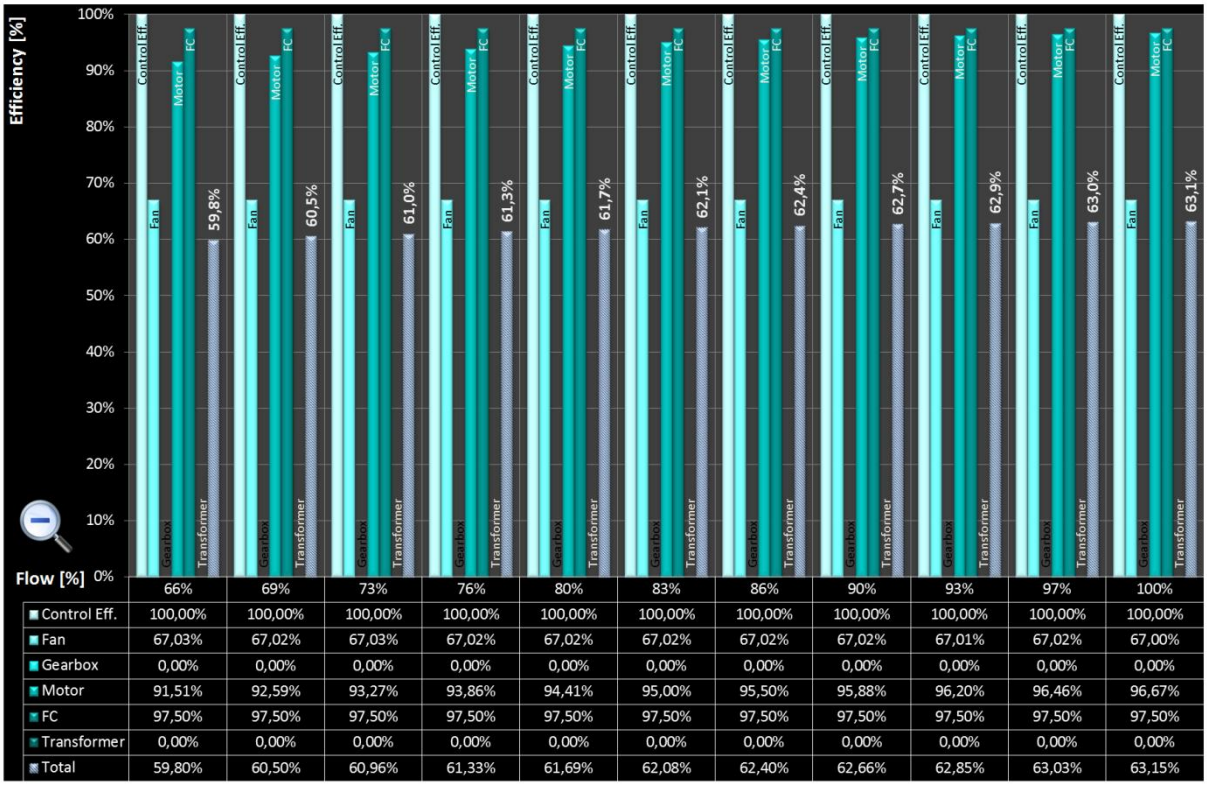
Fig.26 Enhanced Graphical Comparison - Compared Flow Control (CFC)

The CFC zoomed tab displays in detail efficiencies of all elements in the drive-fan control chain in dependence on flow for defined operational range (e.g. from 50% to 100% of flow). For every given flow, following efficiency data is displayed both in values and bar graphs:

- *Control Efficiency* – efficiency of all control methods except for hydrodynamic coupling. If hydrodynamic coupling (HC) is chosen to be compared, then Control Efficiency is set up to be 100% and efficiency of HC appears in the middle row titled HC.
- *Fan* – fan efficiency is stated.
- *Gearbox* – gearbox efficiency is stated. If there is zero efficiency, the gearbox is not included in the drive-control chain.
- *HC* – efficiency of hydrodynamic coupling is stated in case, when HC control method is to be compared. If the HC control is not employed, the efficiency is set to be zero and its efficiency is not included in the calculation.
- *Motor* – motor efficiency is stated.
- *Transformer* – transformer efficiency is stated. If there is zero efficiency, the transformer is not included in the drive-control chain.

- *Total* – total efficiency is stated as a product of all non-zero efficiencies within each column.

The second part placed in right bottom corner titled as *Variable Speed Control with Frequency Converter (VFC)* gives detail efficiency overview of control using frequency converter (see Fig.27).



Flow [%]

	66%	69%	73%	76%	80%	83%	86%	90%	93%	97%	100%
Control Eff.	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
Fan	67,03%	67,02%	67,03%	67,02%	67,02%	67,02%	67,02%	67,02%	67,01%	67,02%	67,00%
Gearbox	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Motor	91,51%	92,59%	93,27%	93,86%	94,41%	95,00%	95,50%	95,88%	96,20%	96,46%	96,67%
FC	97,50%	97,50%	97,50%	97,50%	97,50%	97,50%	97,50%	97,50%	97,50%	97,50%	97,50%
Transformer	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Total	59,80%	60,50%	60,96%	61,33%	61,69%	62,08%	62,40%	62,66%	62,85%	63,03%	63,15%

Fig.27 Enhanced Graphical Comparison - Variable Speed Control with Frequency Converter (VFC)

The data in Fig.27 are organized in the same manner like in Fig.26.

Annual energy consumption is given for VFC and CFC in detail in the third part (bottom left corner). It compares used energy in dependence on flow (see Fig.28).

The last part (right bottom corner) of the tab contains two graphs. The upper one summarizes total efficiency of VFC and compared flow control (see Fig.29). The lower one provides the same data displayed in bar graph (see Fig.30).

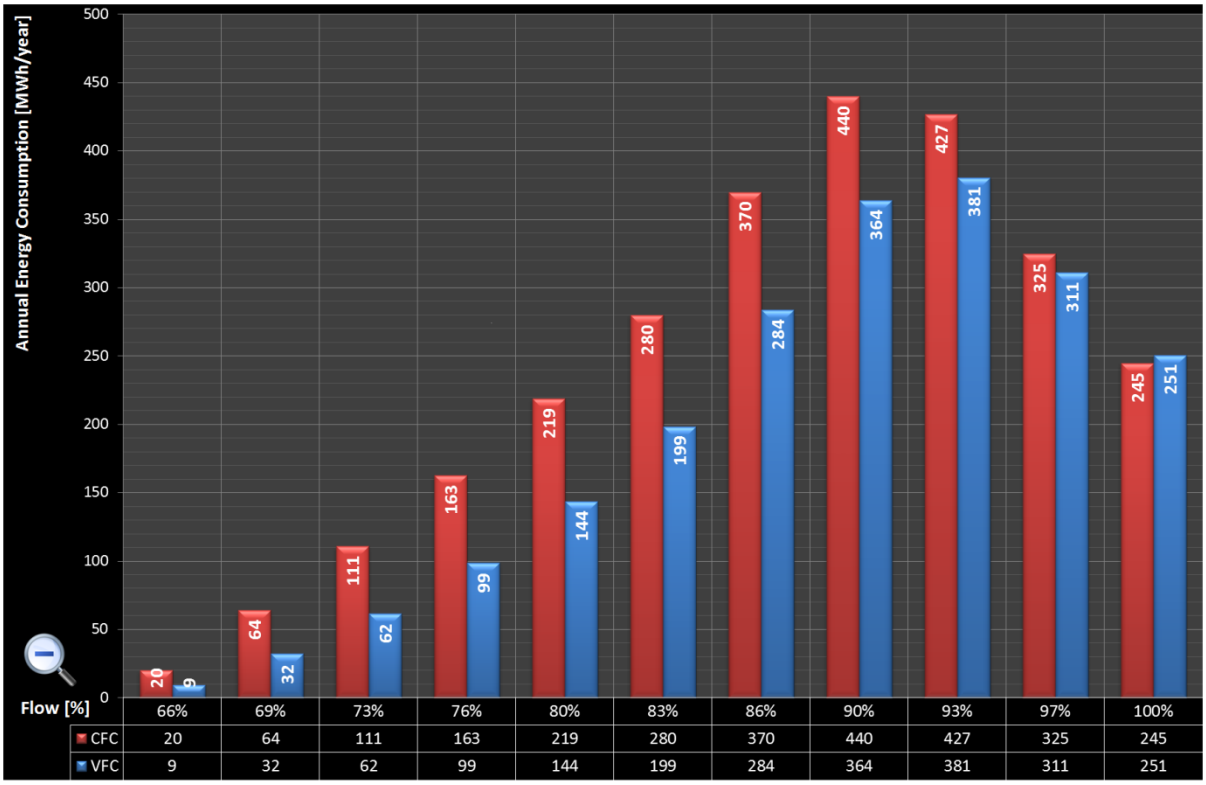


Fig.28 Enhanced Graphical Comparison – Annual Energy Consumption

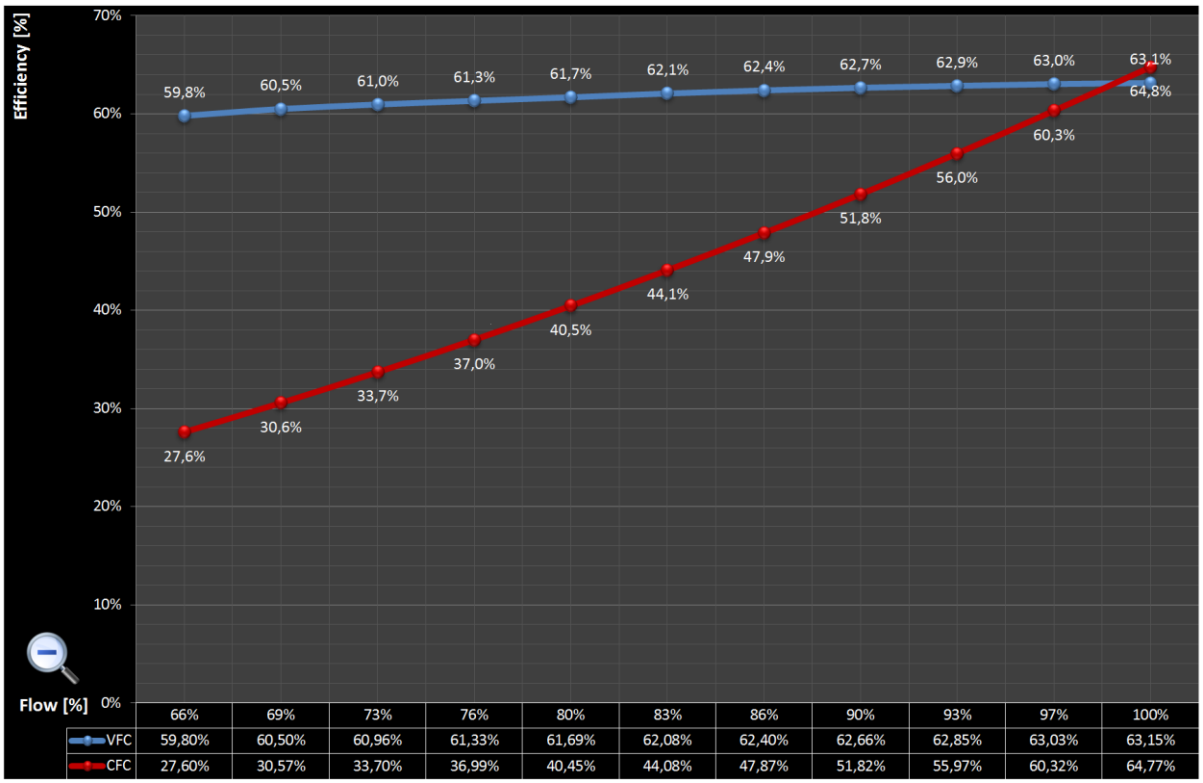


Fig.29 Enhanced Graphical Comparison – Absolute Efficiency Comparison (line graph)

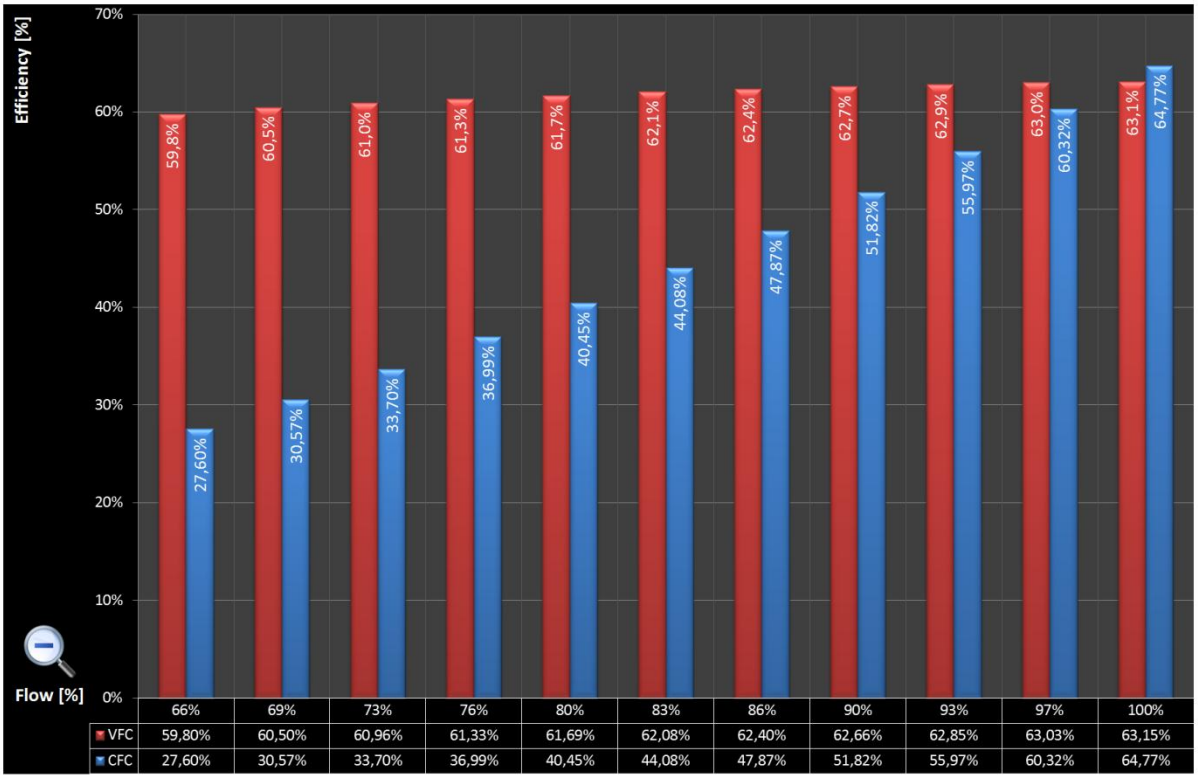


Fig.30 Enhanced Graphical Comparison – Absolute Efficiency Comparison (bar graph)

4 Conclusion

This document is intended to be used as a user guide for developed software MVD Fan Save beta 3.2 enhanced version. It introduces the software and guides the user over the whole workflow.

MVD Fan Save beta 3.2 tool has been developed in order to provide comparison of operational and economical features (e.g. operational costs, payback period or lifetime savings calculations) under various operational conditions. Presented tool offers enhanced data entering and enhanced efficiency calculation. It is able to compare a few currently employed control principles fans. All considered controls are compared with VFD.

The software already includes default case study ready to be used for testing and learning purposes for fans. However, the basic parameters can be modified by user according to particular application and data.

References

[1] Erns E. Ludwig, *Applied Process Design for Chemical and Petrochemical Plants, Vol. 3*, Gulf Professional Publishing, 2001.

[2] H. P. Bloch, C. Soares, *Process Plant Machinery (Second Edition)*, Elsevier Science & Technology Books, 1998.

[3] M. J. McPherson. *Subsurface Ventilation Engineering*, www.mvsengineering.com, [Online]

[4] M. Sirový, Z. Peroutka, J. Molnár, J. Michalík, M. Byrtus, *Flow control methods in thermal power plants: Energy efficiency evaluation*, in *17th International Conference on ELECTRICAL DRIVES and POWER ELECTRONICS*, Košice, 2011, pp. 238-242.

[5] S. T. Bailie, *Effects of inlet guide vane flow control on forced response of a transonic fan*, Dissertation Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 2003.

[6] P. S. Georgilakis, *Spotlight on modern transformer design*, Springer London, 2009.

[7] www.voith.com

[8] www.vacunair.com

[9] www.engineeringtoolbox.com

List of Figures

Revision History

Rev.	Chapter	Description	Date Name / Dept.
1	All	Document release	May 26, 2012 MB, JM, MS / RICE