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DIRECTORATE-GENERAL ENERGY AND TRANSPORT

New Energies & Demand Management
Promotion of Renewable Energy Sources & Demand Management

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THE EUROPEAN
MOTOR CHALLENGE PROGRAMME

Fan Systems Module

Contents

1.Introduction to the FAN Module document

This document is subsidiary to the Motor Challenge Programme (MCP) "Partner Guidelines". It defines what an MCP Partner Action Plan should cover, if the Partner company's commitment includes FAN Systems (FAN)[1]. In particular, it explains what a Partner does for each of the following steps of participation in the Motor Challenge:

- **Inventory** of FAN components and system functioning
- **Assessment** of the applicability of possible energy savings measures
- **Action Plan**, presented to the Commission, which defines what the Partner has decided to do to reduce operating costs by improving energy efficiency
- **Annual report** of progress on the Action Plan.

Note that documents relating to the Inventory and the Assessment are in house, confidential documents, while the Action Plan and Annual Report are reported to the Commission.

2.Inventory of FAN components and system functioning

As a first step towards identifying applicable energy savings measures, an MCP Partner should establish an **Inventory** of FAN system components and major system operating parameters. The Inventory is established in 3 phases.

A. Basic system description

This consists of consulting company records or carrying out simple measurements, in order to assemble the following (nameplate) data.

1. operation purpose (ventilation, material transport, smoke extraction, etc.)
2. fan type (axial, centrifugal, mixed flow, etc.),
3. air flow (in m^3/s)
4. motor power (in kW),
5. duty point,
6. operation hours,
7. control devices,
8. transmission type (V-belt, direct, etc.)

In many organisations, most or all of this data could be assembled by in-house staff.

B. Documentation and measurement of system operating parameters

As the number of fans in place can be very large, documenting or measuring the following elements is desirable for the 50 largest fans or 3 largest fan groups. Another approach might also be to focus on all fans for two different applications (e.g. HVAC or material transport).

[1] Refer to the "Partner Guidelines" for an explanation of terms such as "Partner", "Action Plan" and "commitment".

Collection of this data could be carried out by qualified in house engineering staff, or by a third party, such as an MCP endorser.

C. Global indicators of system performance

On the basis of the data collected, the following global indicators of system performance can be estimated.

Overall			
Electricity consumption for fans [kWh/a]		Total Electricity consumption [kWh/a]	
Share of fan electricity consumption [%]			
System specific (for each System)			
Electric Power of Fan System [kW]		Design Volume flow [m^3 /s]	
Specific Fan Power (SFP) [kW/(m3 /s)]			

Note that for many systems (particularly smaller ones under 20 kW) the potential savings would not justify the complex and costly data collection necessary to establish precise figures.

A second option will be to use not physical but economic indicators such as the specific cost in Euro/(m^3 /s). In such cases additional factors should be taken into account. In this case appropriate approximations such as

- annualised capital costs might be estimated at 7% of current replacement cost of entire system;
- maintenance might be 4% to 5% of current replacement cost;
- energy costs might be estimated from nominal power and operating hours

might be used. These are not relevant, if physical indicators will be used.

3.Assessment of energy saving technical measures

It is generally agreed that large energy savings could be obtained with a more careful use of available fans, in particular with a more accurate and rational design of the system (ducts, joints and regulation devices). While there are many examples of how efficiency can be improved, the following is a summary of the key opportunities. The difficulty for the energy efficient design of the system is the accurate prediction of the losses as without this, the system characteristic cannot be drawn. Regulation and control is needed to constantly match the system requirement to fan output. While a fan could be installed satisfying optimally the "design mean operating condition", it should also be capable of working well at other duties.

Energy saving measures can be either improvements of specific system components, or overall improvements of the system. However it should be noted, that the overall system efficiency is mainly determined by the component with the lowest efficiency. The application of some high efficiency components therefore does not guarantee good overall efficiency, as the overall efficiency of the fan system is derived by multiplying the efficiencies of the components of the system. Interactions between the fan unit and the system can be crucial for successful application from the point of view of required performance and energy saving. System related effects may account for a high percentage of the calculated losses in a given circuit, causing the fan to work away from its design point or even making the fan inappropriate for the application.

The efficient use of a fan can and has to be promoted through careful examination of all the sources of losses. It is true that the fan itself has to be correctly designed but all the effort in correctly designing a machine can be wasted if all the other steps of the choice/design procedure are not carefully examined. More specifically: Energy savings are possible in the careful fan selection, in adapting the operation schedule, improving the drive and drive system and the ducting system.

The following paragraphs show the potentially significant energy savings measures which might be applicable to your system. The measures are presented beginning with those that have a large potential impact and are the easiest to implement.

The opportunities for reducing fan energy consumption are considered under the following four categories:

a) **The design of the ventilation system for minimum losses** for a given required duty, including length and position of ducts, change in direction or cross-section.

b) **Choice of the best fan for given duty**: this presumes knowledge not only of the peak performances needed but also of the amplitude and time variation of the required duty. System related effects also play an important role in this.

c) **Choice of type of regulation of fan's working point**: this includes throttling, variable speed, variable geometry etc

d) **Fan's efficiency**: different fan types have different peak efficiencies, with axial airfoil bladed fans with the highest values. However even fans of the same type have sometimes largely different peak efficiencies. Selection should favour always the most efficient fan.

In the following we present a list of those measures that are often the most important options that should be considered in order to improve fan system performance. This list is of course only a guide, and depending on specific system needs, other measures might be pertinent.

(1) **Control and motor drive system**

The control system (including demand control and operation schedule) is very important when it comes to energy saving.

Operation schedule

In order to minimise the operation it is important to analyse the need for ventilation during different parts of the year, month and day. Using this analysis to set up an optimised timer schedule could dramatically reduce energy demand. An example of the large saving potential is the need for ventilation outside of working hours in commercial buildings and industry.

Demand control

There are a lot of demand control systems available in the market. By monitoring the demand the airflow rate can be adjusted to the demand. There are airflow controls of many kinds. One of the most used is the adjustable speed drive with frequency converter[2]. For larger axial fans, adjusting the pitch of the blades is a common method of adjusting the airflow.

(2) Motor

a) Selecting the right type and size of motor. A too large safety margin would give too large a motor, which will cause extra losses. Modern motors give good performance from 80 % to about 100 % of rated load, making selection easier. However the selection of the right size of a motor is very important.

b) Apart from very low duty applications, it is always worth looking for eff2 or eff1 motors, that reduce motor losses and hence running costs. (For further information see the drives module.)

(3) Transmission

a) Avoid gearboxes whenever possible

b) Change from V-belt drive to direct drive

c) Change from V-belt drive to flat belt drive

d) Change from flat belt drive to direct drive

Whenever possible try to avoid the inclusion of a transmission between motor and fan. The most efficient coupling is the direct coupling of motor and fan on one axis.

(4) Ducting

a) The Ducting system is typically installed in buildings or industrial installations after the main structures are built. This sometimes makes it necessary to have many bends and diameter changes. Also mostly rectangular ducts are installed, whereas tubular ones are better for energy consumption.

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[2] It should be noted, that frequency converters add additional losses (typically about 5 %) which can be neglected if the fan is operating often under part load. However if there is no need or possibility to adjust the airflow rate, the use of frequency converters should be avoided.

b) In addition after installation a ventilation system has to be balanced to assure that all places will receive the ventilation required. This balancing means nothing else, than putting dampers in some ducting lines, which is adding additional pressure losses and therefore wasting energy. To avoid these losses, correct planning of the ventilation system is necessary.

(5) Fan Selection and Maintenance

Additional saving can be very often realised by choosing the right fan. The right selection of fans is today made easier due to the fan selection programs of the manufacturers. Savings can also be achieved by regular maintenance of fans and systems components.

The saving potential for the measures given are summarised in **Table** 3 together with some application on their applicability on new systems, major overhaul and system retrofit. Of course, the applicability of particular measures, and the extent to which they might save money, depend upon the size and specific nature of your operation. Only an assessment of the system and of your company's needs can determine which measures are both applicable and profitable. This could be done by a qualified engineering company (who might be an MCP Endorser) or by qualified in-house engineering staff.

Table 3: Energy saving potential for fan systems and typical applicability of the measures proposed

saving measures	**saving range**	**Applicability to systems**		
	[%]	**new**	**major overhaul**	**retrofit**
(1) Control system				
a) Operation schedule	10 to 50			☺
b) Demand control	-5 to 50		☺	☺
(2) Motor				
a) Selecting the right type and size of motor	5 to 20	☺	☺	
b) Select an HEM (EFF1)	2 to 10	☺	☺	
(3) Transmission				
a) Changing from V-belt drive to direct drive.	5 (larger fans) to 15 (smaller fans).	☺	☺	
b) Changing from V-belt to flat belt drive.	5-10		☺	☺
(4) Ducting	about 15	☺	☺	
(5) Fan Selection and maintenance	5 to 15	☺	☺	

This document only gives an overview of energy saving measures in fan systems. For further information, please refer to the MCP Tool Box, which contains guides on technical measures and on Life Cycle Evaluation of fan operating costs. It should be kept in mind that savings on factors such as maintenance, unplanned outage, installation and commissioning are often greater than from reduced energy costs. (In **Table 4** space is left to include these factors where they can be easily estimated.)

Table 4: Fan system assessment results

Fan reference/description	Specific proposed action	(1)Estimated annual energy savings	Change in annual O&M costs (2)	Additional investment cost (2)	Estimated payback time (months)

Legend

(1) When energy savings cannot be precisely measured (as is often the case), they can be estimated from the assessment results and generally accepted technical coefficients.

(2) Investment and O&M costs are estimates of changes in costs, with respect to what would have been spent without Partner commitment to the Motor Challenge. This may be, for instance: additional investment for higher performance equipment; increase/decrease in maintenance costs; associated savings from better quality or reliability, etc.

The assessment conclusions will identify the measures which are applicable to your system, and will include an estimate of the savings, the cost of the measure, as well as the payback time. Assessment results are confidential in house data, not reported to the Commission.

4.Action Plan

Your company's Action Plan, as proposed in the form below, should indicate:

- the measures you have decided to implement, and the time scale for implementation;
- the reasons for excluding the other measures.

The Action Plan is presented to the Commission. After approval, your organisation will be recognised as an MCP Partner.

Energy Savings Measures	Feasibility (1)	Specific Actions (2)	% Covered (3)	Time table (4)	(MWh/year)Expected savings (5)

Legend:

(1) **Feasibility.** Indicate obstacles to application by one or more of the following codes:

NA Not applicable for technical reasons

NP Not profitable

NC Not considered, because evaluation would be too expensive

If this field is left blank, the measure is considered to be both applicable and profitable.

(2) **Specific Actions.** Several specific actions may be adopted to implement one energy saving measure. For instance, buying a leak detector, and replacing low quality quick disconnects might be actions corresponding to the "Reduce air leaks" measure.

(3) **% Covered.** If the Partner's proposed commitment covers several fan systems, this column should be used to indicate the proportion of the systems for which the specific actions will be implemented. This can be evaluated according to the most convenient indicator: number of systems; power; energy consumption. Specify the indicator used, as by: "%"; "%kW", %kWh"

(4) **Time table.** The time scale at which the action will be implemented. This might be a specific period or date, or might depend on some other action, for instance "When compressor is replaced", or "When paint shop is refurbished".

(5) **Expected savings** in MWh/year. This will often be an estimate, based on generally accepted practice.

5.Annual Report

The Annual Report to the Commission specifies progress made in carrying out the Action Plan, and will comment on any new or amended initiatives. The following reporting form should be used with progressive updating on an annual basis. The two left hand columns are copied from the Partner's Action Plan as approved by the Commission.

Approved Action Plan		Annual report for year 20xx
Actions decided upon to implement energy savings measures, by fan system	Agreed upon time scale for action	Progress on action, as percentage achieved, and comments where appropriate(1)
Action 1		
Action 2		

(1) The percentage achieved could refer to an indicator such as the proportion of systems in the scope of the Action Plan for which the specific action has been completed.

Partners may find it useful to produce parts of the following Synthesis of the results of commitment to the Motor Challenge. They are invited (but not required) to submit the Synthesis to the Commission.

Annual report synthesis		
	Since commitment	This year
Percentage of actions in Action Plan completed		
Estimated total investment for Plan (000 EUR) (1)		
Estimated change in non energy O&M costs (000 EUR) (1)		
Estimated energy savings (MWh) (2)		
Share of fan electricity consumption (3)		
Indicative overall unit compressed air cost (Euros/000 Nm^3)		

(1) Investment and O&M costs are estimates of changes in costs, with respect to what would have been spent without Partner commitment to the Motor Challenge. This may be, for instance, additional investment for higher performance equipment, or increase/decrease in maintenance costs.
(2) Energy savings are generally difficult to measure precisely. They will usually be calculated using pro-rata estimates based on the assessment results and on generally accepted industry technical coefficients.
(3) Electricity consumption of all fans installed divided by total electricity consumption of the site.

Appendix 1: Fan System Inventory

No.	motor power[3] [kW]	operation hours [h/a]	fan type (axial, centrifugal, mixed flow, etc.),	control devices	air flow [m^3/s]	transmission type (V-belt, direct, etc.)	operating point, [% of full load]	operation purpose (ventilation, material transport, smoke extraction, etc.)

[3] Fans with drives under 1 kW should be excluded from the inventory