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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

Drives Module

Contents

1.Introduction to the Drives 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 Drive Systems[1]. In particular, it explains what a Partner does for each of the following steps of participation in the Motor Challenge:

- **Inventory** of Drive System 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 Drive Systems components and system functioning

As a first step towards identifying applicable energy savings measures, an MCP Partner should establish an **Inventory** of Drive 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 data:

1. General drive system design and layout.
2. Age and nameplate information of the motors (size, type, ...).
3. Type of end-use device, for each motor.
4. Type of speed control (if any), for each motor.
5. Type of transmission, for each motor.
6. Type and frequency of maintenance of motor, transmission and end use equipment.
7. How many times each motor was repaired.
8. Operating hours/year

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

In production sites with very large numbers of motors, data collection and measurement might be limited to the largest motors, accounting for a significant proportion (for instance 2/3) of motor system energy use.

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

B. Documentation and measurement of system operating parameters

Documenting or measuring items 1 to 4 is desirable for the whole plant. Data for items 5 to 7 for all the drive systems also deserves to be collected. This data collection is essential for medium and large systems (over 25 kW). Collection of this data will require a fair level of technical expertise, either from in house engineering staff or from a third party, such as an MCP endorser.

1. Total drive power consumption, for the whole plant.
2. Voltage unbalance, for the whole plant.
3. Total harmonic distortion, for the whole plant.
4. Power factor, for the whole plant.
5. Oversizing and load factor, for each motor.
6. Demand profile: estimated variation during day/week, for each motor
7. For large motors, a data logger and appropriate current and voltage sensors should be used (probably installed for the assessment period only). For smaller systems, use best available data.

C. Global indicators of system performance

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

Annual costs:	Capital		Maintenance		Energy	
Annual operating hours			Average Power of total drive system			
Electrical drive power use compared to goods produced (kWh/Q-Prod.) (1)						
Indicative overall unit drive system cost (Euros/mechanical kWh)						

(1) Q-Production is some relevant indicator of the volume of goods produced at the production site, expressed, for instance, in tonnes, meters, pieces, …

Note that for many systems (smaller than 25 kW) the potential savings would not justify the complex and costly data collection necessary to establish precise figures. In such cases, the assessment could be based on appropriate rules of thumb, for instance:

- annualised capital costs might be estimated at 10% of current replacement cost of entire system. Where drives are integrated into equipment, their cost could be estimated using catalogue data;
- maintenance might be 3% to 4% of current replacement cost;
- energy costs might be estimated from nominal power, load factor and operating hours.

3.Assessment of energy saving technical measures

Motor systems electricity consumption is influenced by many factors such as:

- motor efficiency;
- proper sizing;
- motor controls: stop/start and speed control;
- power supply quality;
- mechanical transmission system;
- maintenance practices;
- the efficiency of end-use device;

In order to benefit from the available savings potential, the users should try to optimise the whole motor system.

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 drive system service provider (who might be an MCP Endorser) or by qualified in-house engineering staff.

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.

The following table shows potentially significant energy savings measures which might be applicable to your system. Although the values in the table are typical, the applicability of the measures will depend on the specific characteristics of the installation.

Table 1: Drive power energy savings measures

Drive system energy savings measure	**Typical savings range**
System installation or renewal	
Energy Efficient Motors (EEM)	2-8%
Correct sizing	1-3%
Energy Efficient Motor Repair (EEMR)	0,5-2%
Variable speed drives (VSD)	10-50%
High-Efficiency Transmission/Reducers	2-10%
Power quality control	0,5-3%
System operation and maintenance	
Lubrication, adjustments, tuning	1-5%

The assessment should, for each of the measures in Table 1, evaluate applicability and profitability. This might take a form similar to the Table 2.

Table 2: Assessment Results.

Energy saving measures	Specific proposed action	(1)Estimated annual energy savings	Change in annual O&M costs (2)	Additional investment cost (2)	Estimated payback time (months)
System installation or renewal					
Energy Efficient Motors (EEM)					
Correct sizing					
Energy Efficient Motor Repair (EEMR)					
Variable speed drives (VSD)					
High Efficiency Transmission/Reducers					
Power quality control					
System operation and maintenance					
Lubrication, adjustments, tuning					

(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.

3.1Energy Efficient Motors (EEMs)

For an additional cost of 20%-30% Energy Efficient Motors (EEMs), also called High Efficiency Motors (HEMs), will offer 2%-6% better efficiency, representing significant energy savings.

As the reduced losses result in a lower temperature rise in the motor, the lifetime of the motor winding insulation, and of the bearings increases. Therefore, in many cases:

- reliability increases;
- down time and maintenance costs are reduced;
- tolerance to thermal stresses increases;
- ability to handle overload conditions improves;
- resistance to abnormal operating conditions - under and over voltage, phase unbalance, poorer voltage and current wave shapes (e.g. harmonics), etc – improves;
- power factor improves;

- noise is reduced.

A recent European-wide agreement ensures that the efficiency levels - EFFI (higher efficiency), EFFII and EFFIII - of most electric motors manufactured in Europe are clearly displayed. It basically establishes three efficiency classes, giving motor manufacturers an incentive to introduce higher efficiency models. These efficiency levels apply to 2 and 4 pole three phase squirrel cage induction motors, rated for 400 V, 50Hz, with S1 duty class, with output 1.1 to 90 kW, which account for the largest sales volume in the market.

Appropriate motor solutions may be selected by use of the EURODEEM database[2], which collates the efficiency of more than 3500 types from 24 manufacturers. The current release of EURODEEM may be downloaded free of charge from the web site:
http://iamest.jrc.it/projects/eem/eurodeem.htm

Appropriate motor choice can be greatly aided through the use of adequate computer software, such as **Motor Master Plus**[3], and **EURODEEM**[4].

3.2Proper Motor Sizing

Motors rarely operate at their full-load point. In the European Union, field tests indicate that, on average, the motors operate at around 60% of their rated load [1]. The induction motor efficiency typically peaks near 75% of full load and is relatively flat down to the 50% load point. Motors in the larger size ranges can operate with reasonably high efficiency at loads down to 30% of rated load.

Proper sizing;
- improves energy efficiency, by allowing motors to operate at peak efficiency;
- may reduces line losses due to low power factor;
- may slightly reduce operating speed, and thus power consumption, of fans and pumps.

3.3Motor Repair

When motors above 5 kW fail, they are often repaired several times during their lifetime. Laboratory testing studies confirm that poor motor repair practices reduce motor efficiency typically between 0.5 and 1%, and sometimes up to 4% or even more for old motors.

To choose between repair and replacement, electricity cost/kWh, motor power, average load factor and the number of operating hours per year will have to be taken into account.

Typicaly, replacement of a failed motor through the purchase of a new EEM can be a good option in motors with a large number of operating hours. For example, in a

[2] Published by the European Commission
[3] Sponsored by US Department of Energy
[4] Promoted by the European Commission - DG TREN

facility with 4000 hours per year of operation, an electricity cost of 0.06 Euro/kWh, for motors between 20 kW and 130 kW, replacement with an EEM will have a payback time of less than 3 years.

3.4Variable Speed Drives

The adjustment of the motor speed through the use of Variable Speed Drives (VSDs) can lead to better process control, less wear in the mechanical equipment, less acoustical noise, and significant energy savings. When loads vary, VSDs can reduce electrical energy consumption particularly in centrifugal pump, compressor and fan applications - typically in the range of 20-50%. Materials processing applications like centrifugal machines, mills and machine tools, as well as materials handling applications such as winders, conveyors and elevators, can also benefit both in terms of energy consumption and overall performance through the use of VSDs.

Use of VSDs can also lead to other benefits:
- extend the useful operating range of the driven equipment;
- isolate motors from the line, which can reduce motor stress and inefficiency;
- accurately synchronise multiple motors;
- improve speed and reliability of response to changing operating conditions.

4.Action Plan

Your company's Action Plan, as proposed in the form below, you 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)
System installation or renewal					
Energy Efficient Motors (EEM)					
Correct sizing					
Energy Efficient Motor Repair (EEMR)					

Variable speed drives (VSD)					
High Efficiency Transmission/Reducers					
Power quality control					
System operation and maintenance					
Lubrication, adjustments, tuning					

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, proper sizing may be achieved by installing a correctly sized EEM.

(3) **% Covered.** If the Partner's proposed commitment covers several Drive 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 motor is replaced".

(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	Agreed upon time scale for action	Progress on action, as percentage achieved, and comments where appropriate (1)
Drive system installation or renewal		
Action 1		
Action 2		
…		
Drive system operation and maintenance		
…		
…		

(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 (000 EUR) (1)		
Estimated change in O&M costs (000 EUR) (1)		
Estimated energy savings (MWh) (2)		
Drive power energy use compared to goods produced (kWh/Q-Prod.) (3)		
Indicative overall unit mechanical energy cost (Euros/kWh)		

(1) Investment and O&M costs are estimates of costs that are additional to (or perhaps less than) what would have been spent without Partner commitment to the Motor Challenge.

(2) Energy savings are generally difficult to measure precisely. They will usually be calculated using pro-rate estimates based on the assessment results and on generally accepted industry technical coefficients.

(3) Q-Production is some relevant indicator of the volume of goods produced at the production site, expressed, for instance, in tonnes, meters, pieces, …