European Database of Energy Efficient Electric Motor Systems

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Synopsis:

Promotion of energy efficiency and quality in industrial electric equipment through a European database of efficient electric motors.

Abstract:

During 1995 the DG XVII has asked the Joint Research Centre (JRC) to create and develop a Database on Electric Motor Systems in the framework of SAVE European programme. DG XVII will use the database of electric motor systems as a tool to be made available to the European utilities for carrying out Demand Side Management (DSM) programmes as a new service to a competitive electricity market.

The informatic work for the creation of the European Energy Efficient Electric Motors database required the development of the All Motor DB (a stand alone database of all the standard and high efficiency electric motors collected from manufactures catalogues), the development of the Select Motor Application (linked to the All Motor DB for economic evaluation, load coverage, heating, electric consumption and energy & money savings) and development of the EEM Help & Tutor on-line (with educational and guiding capabilities). Although electric motor database can be an important tool for succeeding in energy saving, it cannot be considered as a stand-alone option. Other experiences, e.g. the US-DOE Motor Challenge Program, show that best results are gained through combined wide-angle measures.

The promotion and the distribution of the package had an important role in success of any electric motor program. The identification of the end-users and the support for Showcase and Database marketing are also important parts of the work.

1. Introduction

The Commission of the European communities, through its General Directorate for Energy (DG XVII), is promoting the improvement of energy efficiency in general, and by means of the SAVE programme in particular.

1.1. Background

The improvement of the performance of electric motor systems has been widely recognised to be as one of the most important energy saving targets, because motive power account for about 400 TWh/year in the European Union and about two-thirds of this amount could be saved through performance upgrading actions.

The European Commission is supporting a series of general actions aimed at exploiting the large energy saving potential. These actions include:

- Energy efficiency labelling of equipment
- Definition and implementation of efficiency standards
- Research, Development and Demonstration

✷ Voluntary agreements with Original Equipment Manufacturers (OEM)
✷ Financial Incentive for Demand Side Management (DSM) programmes
✷ Information Programmes (Conference, Courses, Publications)
✷ Technical Tools (Calculation aids, databases)

In this context the Joint Research Centre (JRC) of the EC has been asked by the DG XVII to develop a European database which should become an important tool for the promotion and circulation of information on Energy Efficient Electric Motors (EEM).

The market of electric motor system is not world-wide. European and North American motors differs, among other things, because of the electrical characteristics of their network Therefore, American databases cannot be, in principal, directly transferred for European uses.

1.2 Scope

In this presentation, the development activity carried out by the JRC for the European Database for Electric Motor Systems (EuroDEEM) is described. The primary objectives of the work are here below listed.

1. Establishment of a Restricted Advisory Group whose members have been chosen for quick consultancy
2. Development of the structure of the database and contents,
3. Implementation in PC-compatible format of the motor database together with the motor selection tools and the help on-line and glossary,
4. Development of strategies for dissemination.

During 1996 the focus was put on the development of the structure of the database and inputting data on Electric Motors characteristics. Extension to Variable Speed Drives (VSD) and Coupling Systems, to be part of the future version of the program, will begin in 1997.

2. Objectives and Clients

From past experience it is widely known that Energy Efficient Motor Technologies need to overcome various non-technical barriers towards the market penetration despite all the programmes to promote such technologies. The scope of a database containing high efficiency electric motor data is to make available an important information tool that allows users to carry out easily an evaluation of the best installation or replacement options, therefore helping the promotion of electricity savings. However, it should be clear that the development of this a tool cannot be considered as a stand alone option. Other experiences, e.g. the US-DOE Motor Challenge Program, show that best results are obtained only if a series of combined wide-angle measures are promoted in a coherent way.

The strategy for the development of the EuroDEEM has been conceived and developed to meet the following objectives:

- To make available, as soon as possible, a European market directory of all electric motor system components and, in particular, of the most energy efficient ones;
- The EuroDEEM should be a concrete starting point for very wide promotion and dissemination of information to a large range of end-users.
- The information provided within the database must be easy to comprehend, so that even non-motor experts (e.g. electricians, plant engineers, maintenance personnel) will be able to query the database and to understand all technical terms.
- The software must have powerful educational and guiding capabilities such as complete On-Line Help, Glossary of Terms and On-Line Tutorial with energy and financial savings demonstration.
- The development should be neutral, not only with respect to manufacturers (catalogue data of all suppliers to the European market will be included) but also the customers' needs should be taken into account.
- The database, with its attached modules, must be easy to use and a real support to the decisions to the users in

finding and choosing the best alternatives and cost-effective solutions.
- The accuracy of the results must reflect a good compromise between sophisticated software modules requiring a heavy data input (calculations of motor performance under user defined load cycles) and ease of use with minimum data entry.

Main users of this information system is intended to be not only technicians in charge of designing and bidding electrical drive systems but also sales staff and motor dealers.

The database should target the largest possible range of users, thus it will be designed to require a minimum of user knowledge of computers and software programs. The database should be designed to provide useful information to a variety of professions, including:
- Designers and Engineers
- Plant Managers and Energy Managers
- Electric Utilities staff
- Energy Saving Companies (ESCo) personnel
- Electric Maintenance Service staff
- Electric Motor dealers and sales staff
- Marketing Directors of Original Equipment Manufacturers (OEM)
- Persons concerned with installation/ replacement/ repairing of Electric Motors.
- Electric Motor Professionals and Consultants

3. The Development Steps

3.1. Review of existing databases.

During the starting phase of this action, major existing databases and the available information tools have been collected and critically assessed. The most widely known among these are:

- OPAL Database developed by Semafor, Switzerland.
  The main feature of Opal is its simulation of the motor parameters in transient conditions and the evaluation of the electric and mechanical performance with any duty cycle. Special emphasis is given to overheating.

- Motor Master Database, which is a very popular tool for the USA.
  MotorMaster is an MS-DOS computer program designed to help motor buyers make the choice when selecting a three-phase motor. It produces a list of all motors in a selected motor class, ranked from highest to lowest efficiency depending on the horsepower, enclosure type, speed and voltage rating. MotorMaster can calculate energy consumption and dollar cost of using a particular motor in a specific application. It can also compare motors with different efficiencies and prices, determining the most cost-effective choice. MotorMaster is suitable for rewind-replace analysis. An improved version is now available for the Windows environment.

- Motor Selector developed in New Zealand for Canada.
  Motor Selector is a Windows based application which can assist buyers with their three phase induction motor selection and replacement decisions by taking into account operational modes, motor efficiencies, and prices involved in replacing or rewinding motors. After taking advantage of the forms provided and entering relevant plant and application data, Motor Selector will calculate the simple payback of each model over the least cost option. Comparisons are made as easy as examining a graph or printing out the list of options. In addition to a NEMA MG-1[1]_ minimum efficiency version, an alternate IEC 34.2 minimum efficiency based version is also available for countries outside North America.

- Best Practice Programme (ETSU, UK).
  Under this programme as a set of videocassette and Diskette software is made available to the large public. The software cannot be considered as a database but only a very elementary and useful tool directly distributed to users. The diskettes contain very simple software which allow the users to estimate the money savings and the

payback time of investments related to the choice of efficient motors, Variable Speed Drives (VSD) and oversizing of power cables with respect to corresponding reference baseline situation entered by the user. The software is based on data supplied by British Energy Efficiency Office (EEO) Case Studies.

These four databases and informatic tools have been analysed and compared according to the following criteria:
1. of description of the overall electric and mechanical system.
2. Detail of description of the motor's electrical and mechanical properties.
3. Ease of use of software (user-friendliness).
4. Detail of Help and guiding tools (on-line help, tutorial, etc.)

The results of the review and a draft recommendation for the European database structure and layout have been submitted to the foreseen Restricted Advisory Group described below.

3.2 Restricted Advisory Group.

In order to check the preliminary Database design features proposed by the JRC, a European Restricted Advisory Group has been created. The role of the Advisory Group is intended to be a supply of a quick consultancy on the most critical issues during the whole development period of the EuroDEEM.

The Group has been set up involving five voluntary representative of the main concerned social actors in the field of Electric Motors, that is:
- EC (DG XVII) officials
- Electric Motors manufacturers
- Electric Motors system analysts and informatic experts
- End-Users
- Research Organisations.

At their first meeting, the Restricted Advisory Group agreed that:

- The existing motor databases analysed do not have a complete description of the overall motor drive system.
- The goal of saving energy must be extended to all the components of the electric motor system.
- The technology improvements in the field of electricity and speed regulation devices (frequency converters, VSD, etc.) and in transmission components (belts, gears, etc.) need to be included in the system for proper energy efficient countermeasures.
- Clear and easy information and correct training concerning energy efficiency motors and systems must be given to end-users.
- At this particular stage priority must be given to the development of a widely applicable instrument for promoting high efficiency concepts among the end-users.

Concerning the first 3 remarks, an electric motor database must be able to evaluate, at least in principal, the overall system performances and give suggestions for replacing poor energy efficient components with more adequate ones.

The last 2 remarks focus on the issue of information penetration for overcoming the barriers against high efficiency. Such information is still lacking in the European Countries.

According to the suggestions of the Advisory group, the main line of the Database design has been established and the implementation of the informatic work has started with the collaboration of a company that has already developed an electric motor database. It was considered reasonable not to start from scratch, but from a good level of expertise and data availability.

Obviously, the JRC intends to submit the whole development product to the validation of a larger group of likely users who cannot be involved in each development step.

4. The EuroDEEM Selection Tool.

The informatic work for the creation of the European Energy Efficient Electric Motors database required the development of the following modules:

1. The Motor DataBase (a stand alone database of all the standard and high efficiency 3-phase electric motors collected from manufactures catalogues),
2. The Select Motor Application (linked to the Motor database for economic evaluation, load cycle, energy & financial savings) and,
3. The EEM Helper Application (an on-line hypertextual help with educational and decision guidance capabilities).

The *Motor DataBase* part in EuroDEEM contains the characteristics of high efficiency electric motors, as defined by manufacturers. In this part, in accordance to the conclusions of the Restricted Advisory Group first meeting, the final definition of the *Motor Database* content (data-set entries) and structure has been achieved.
It was decided to incorporate in the database the largest amount of data available from catalogues or that can be easily calculated. Extensive and costly measurements for data collection have been excluded. For instance, thermal properties of motor components are important data requirements since they permit an evaluation of reliability in overloading conditions. In this case, a list of extra data had to be included in the fields of the database, making more difficult and incomplete the data collection due to the absence of this particular type of data from most of the motor catalogues. This kind of assessment is very useful but only vertically integrated manufacturers can supply proper data. Therefore the Advisory group suggested that heat dissipation simulations should not be provided. The motor specifications stored in the *Motor Database* module are reported in Table 1.

Table 1 – Specifications of motor data and consumption results:

Name	Description	Units
MANUF[a]	Manufacturer	Name
MODEL[a]	Model	Name
ROUT[a]	Rated Output	kW
RNOM[a]	Rated (Full Load) Speed	rpm
REFF[a]	Rated (Full Load) Efficiency	%
REFF75	Efficiency at 75% Load	%
REFF50	Efficiency at 50% Load	%
RVOLT[a]	Rated Voltage	V
POLES	Number of Poles	
RFREQ	Rated Frequency	Hz
RCURR	Rated Current	A
RTORQ	Rated Torque	Nm
RCOS	Power Factor at Full Load	
RCOS75	Power Factor at 75% Load	
RCOS50	Power Factor at 50% Load	
STTORQ	DOL Starting Torque Ratio	
STCUR	DOL Starting Current Ratio	
PUTORQ	Pull-out Torque Ratio	
ROTIN	Rotor Inertia	$Kg^* m^2$
INSCL	Insulation Class	
FRAME	Frame Size	
WEIGHT	Weight	kg
PRICE	List Price	C.U.
AENC	annual energy consumption	kWh
AOPC	annual operating costs	C.U.

[a] displayed in motor list also

The *Select Motor Application* of EuroDEEM has been structured in a way that when the user specifies a simple set of load requirements (see Table 2), the system produces a list of motors suitable for the user's needs. It is also possible to browse the database with different search criterion's: manufacturer, rated output, efficiency rated voltage and display the results in a list containing the most needed motor data (one line per motor).

This list contains general performance information together with the expected energy consumption and total annual costs (where motor prices are available). Within this list the user can select the motor he prefers and generate a detailed report that can be previewed and printed out.

Table 2 - Input Data: load requirements and cost information

Name	Description	Units
P2[a]	Output Power	kW
N	Speed	rpm
UL	Voltage	V
OH	Annual Operating Hours	h
EP	Energy Price	C.U./kWh
IC	Installation Costs	C.U.
MP[b]	Motor Price	C.U.
DC	Dealer Discount	%

[a] or alternatively Torque in Nm
[b] could be included in the motor database

The *Select Motor Application* will be linked to the *Motor Database* for queries related to electric motor properties or load requirements. It will have a query module, a user-project module for simple end-user system description, an economic evaluation module, an electric motor simulation module for evaluation of load coverage, and electric consumption. It has been decided to develop the application for the most used software platforms.

The *Select Motor Application* structure and visual options have been defined in a pre-release form. This application will permit users to select the most suitable electric motor for their purposes, evaluating energy and financial savings.

Another primary task for this work has been the development of help tools. Although the *Select Motor Application* has been developed to be as easy as possible to use, help tools were needed to provide extra information concerning high efficiency motors. For this purpose the *EEM Helper Application* has been developed.

The EEM Helper Application is composed of three parts:
1. The *Select Motor Application Help-Online* for guiding through the application inputs, masks, outputs, and other options.
2. The *Glossary of Terms* for providing useful explanation of acronyms, symbols, and electric motor terms.
3. The *EEM Tutorial* for training and demonstration of benefits of installing or replacing high efficiency electric motors.

It must finally be reminded that end-users do not only ask for technical data but also for answers to their doubts and suggestions for gaining higher quality in the management of the plant. Suitable software modules attached to the database can supply such answers.

5. Promotion of the Database Tool

The promotion of any energy saving action, either in the field of industrial applications or in the residential or service sectors, is not only a technical and economical action, but also includes social and behavioural aspects which must be carefully considered. In fact, the introduction of new technological products that modify the current investment patterns, is not at all an easy task. The availability of a database or any other information tool, although very well conceived, cannot alone ensure the success of the action.

It is therefore of utmost importance to combine and integrate the development of the information tool with other parallel efforts, such as:

- Partnership activities that should involve industrial end-users, suppliers, utilities and environmental and technical assistance organisations, in improving energy efficiency knowledge and tools, while enhancing the environment.
- Marketing and deployment initiatives, involving utilities, suppliers, distributors, trade associations and other organisations.
- Showcase demonstrations that should target electric motor system efficiency and productivity opportunities in specific industrial applications.
- Market transformation efforts supported by financial incentives, availability of technically viable energy efficiency products and related assistance services and infrastructure,
- Wide range circulation of information through bulletins, newspapers, brochures, etc. for increasing the education and awareness of the benefits associated with increased energy efficiency.

The best way of exploiting the large energy saving potential by means of the market introduction of EEM's is to design and implement specific Demand Side Management programmes. In fact, these programmes can include various integrated marketing approaches, which can lead to large number of users adopting EEMs. A database on EEM can be an essential tool when integrated in a DSM programme. However, even as a stand-alone option, it can be very useful for a large number of users.

6. Future Programmes.

Electric motor systems are comprised not only of the motor but also by other components, which can contribute substantially to the overall efficiency of the whole motor system. The technology improvements in the field of electricity and speed regulation devices (frequency converters, Variable Speed Drives, etc.) and in transmission components (belts, gears, etc.) need to be included in the system for proper energy efficient countermeasures and for avoiding oversizing[2]. A large number of VSD types and new coupling devices exist on the market. It is therefore important to get them into the motor database in order to improve the service the database can provide to its users. In the following year we will:

- Create an informatic database of all up-to-date VSD's and coupling devices,
- Modify the existing software for including the VSD part and the coupling systems,
- Develop software modules for the complete assessment of the motor systems,
- Develop an informatic Help & Tutor on Line for the software including VSD's and transmission devices.

The promotion and the distribution of the package have an important role in success of the electric motor program. Demonstration Showcases of ideal, optimal design and configuration of electric motor systems have to be set-up. The support for dissemination of information on EEM's and for Demonstration cases will also be an important part of the future work. We need to:

- Provide laboratory validation for the whole system,
- Provide Demonstration Showcase,
- Provide dissemination and promotion of the whole package through conferences and specialised journals.

• Provide a World Wide Web page on a dedicated server. The implementation of this system on a highly interactive Web application that can run on any Java-compliant Web browser should be realised.

As a particular important feature of this information system, it is foreseen that the database will be readable in many languages, at choice of the user. At the moment the software package is English. However, the knowledge of English language should not be assumed for users of many European countries. Therefore, different language files will be prepared. This possibility should improve the access to the database by a larger public.

It should be possible in the future to implement software modules calculating the starting current and time (Direct On Line, Star-Delta, Soft-Starter) and performance speed, current, power factor and heating under variable service conditions.

7. Conclusions

The European Commission has identified the field of Electric Motor systems as one among the most promising from the point of view of electricity efficiency. In fact, electric motors account for about half of all electricity uses. In order to tackle this energy saving potential suitable strategies have to be conceived and implemented in an integrated way. These strategies concern:

Education and Training
Technical Assistance
Financial Support
Labelling and Efficiency Standards
Support to DSM programmes for EEM's.

Each of these strategies implies various steps and actions. The information to different motor users is a basic step both for Education and Training and for Technical Assistance
strategies. The collection and dissemination of information on efficient motor systems has been identified as one of more urgent action to be carried out. The EuroDEEM has been designed and conceived in this framework.

The first development phase, which foresees the setting up of *Motor Database, Selector* and *Help-on-Line*, has been completed. Extension to VSD's and Coupling Systems is foreseen in the near future. Calculation modules must be added and checked.

However, complementary actions must also carried out.
A very crucial problem concerns the content of the database, that is the use of data obtained by means of common measurement procedures. Many motor manufacturers adopt different efficiency measurement standards, thus leading to non-comparable efficiency figures between motors. We have taken into account this particular problem by listing the motors' efficiency together with its measurement standard. This does not, however, solve the problem of the determination of the actual efficiency. Manufacturers, standardisation bodies and the European Commission, in order to overcome this problem and to guarantee a clear and common background for European users, must make a strong effort.

Another important action concerns the promotion and support to DSM programmes aimed at the installation of High Efficiency Electric Motors on a wide scale. The SAVE programme is, at the moment, the main tool for this action.

The European Commission is fully engaged in the action of transformation of the electric motor market according to principles of equity and neutrality with respect to all parties and stakeholders involved.

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[1] NEMA MG-1 is a US standard for the measurement procedures of electric motor efficiency and losses. IEC 34.2 although developed to be an International Standard, is actually used mainly in European countries.
[2] The use of motors having an output rating greater than the load (oversizing), often occurs when there is an improper plant design. This causes a reduction of the system's efficiency and of the power factor, with resultant additional losses in the distribution system.