MARKET TRANSFORMATION STRATEGIES FOR ELECTRIC MOTORS

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1. ABSTRACT

Under the PACE programme, an European Union action programme for improving the efficiency of electricity end use, a number of different actions are being pursued. These actions are selected so as to achieve the biggest impact in terms of cost and effort of achieving these savings. One of the priority areas for PACE is electric motor systems, because they are responsible for about 70% of the electricity used in the industrial sector and about 35% in the commercial sector.

The paper presents the results and conclusions of a European characterization study. The study examined the average usage of motors, the market structure and the estimated energy consumption for the major application of motors in the industrial and commercial sectors. The paper discusses the main barriers to the penetration of efficient motor systems and presents the European strategy to achieve part of the large savings potential. The strategy will be based on a mix of policy actions (energy labels, minimum efficiency standards and demand-pull actions) to transform the market.

The paper focuses particularly on the use of market forces to achieve energy efficiency improvements, given the present political climate adverse to mandatory efficiency standards.

2. INTRODUCTION

Electricity has a particular importance in the energy sector in the European Union, with electricity generation accounting for about 35% of total primary energy use and about 30% of all man-made CO_2 emissions. At present, the total European Union electricity consumption stands at about 2000 TWh per year and demand is forecast to grow at about 2% per annum. Considering the environmental impact of electricity generation and the need to limit CO_2 emissions and the cost and difficulty of meeting new capacity requirements it is clear that action must be taken to reduce the growth in electricity demand. With this scenario in mind, the European Council adopted a Decision on 5 June 1989 establishing a Union action programme for improving the efficiency of electricity end-use, PACE. The Decision calls for the Commission to manage actions within the Member States by playing a co-ordinating role and, where appropriate, leading its own actions.

Under the PACE programme a number of different actions are being pursued in the domestic, commercial and industrial sectors. These actions in the different areas are all based on a common principle: they must be economically viable and achieve energy savings, i.e. the efficiency improvement cost must be paid back in a reasonable time by the electricity saved (Bertoldi 1995). The need for governmental action to transform the market is, at the present, subject of long discussions among policy makers in the European Union: several policy makers claim that if energy efficiency is economically viable it should happen by itself and insist on the need to reduce legislation and governmental intervention in economic affairs, this has largely affected energy efficiency policy and programmes and it has resulted in an increased use of non-regulatory options such as voluntary agreements.

This paper focuses on policy options and measures to transform the market and foster the penetration of more efficient electric motors. Although motors convert at least 80% of their electrical input into useful mechanical energy and thus can be seen as efficient compared to other electrical loads such as lighting, if their efficiency is raised by optimised motor designs by a few percentage points it will result in large energy savings. This is due to the large amount of energy that is transformed in electrical motors, typically about half of the electricity consumption in industrialised countries. Lighting by comparison accounts only for just 10% of the EU's electricity consumption.

To identify the present load of electric motors in the tertiary and industrial sectors and to help design a European strategy to promote energy efficient electric motors, a comprehensive study (University of Coimbra, 1996) has been carried out for the European Commission and presented at the recent International Conference on Energy Efficiency Improvements in Electric Motors (Lisbon, October 1996).

3. THE MOTOR SYSTEM

Motor systems are composed of several parts such as the speed controller, the electric motor, the gearbox, the transmission system and the end-use device (e.g. fan, compressor, pump, etc.). Although larger energy savings can be achieved by looking at the system and in particular through the use of variable-speed drives, the present paper focuses on electric motors as the first step to improve efficiency in motor systems. This is because in the European Union context, the use of variable-speed drives is still very limited (fewer than 10 % of electric motor are driven by variable-speed drives); in addition, the extra cost to install variable-speed drives is much higher compared to the price premium for a more efficient motor. Accordingly, it has been decided to concentrate the initial efforts on the motor itself, while a strategy to increase the penetration of variable-speed drives will be designed during 1997; in addition variable-speed drives would achieve even larger energy savings when driving an efficient motor. The study investigated all the factors which affected the overall motor system efficiency, including system over-sizing, the transmission and mechanical components, the maintenance and commissioning practices.

4. THE MOTOR LOAD, THE MARKET STRUCTURE AND THE SAVINGS POTENTIAL.

One of the first issues to arise when preparing a strategy to improve efficiency is to correctly assess the present consumption of electric motors, both in terms of size and quantity of installed motors, and the efficiency levels of the motors present on the market. Also it is important to evaluate the structure of the motor market including: the number of manufacturers, the level of imports, and the typical product path from manufacturer to user. The study concentrated on AC three phase squirrel cage induction motors in the range 0.75 KW to 750 KW, since these motors represent about 90% of the total motor electricity consumption. The motor load in the European Union was in 1992 548 TWh in the industrial sector and 170 TWh in the tertiary sector, i.e. the about 38 % of the total Union electricity consumption. It was estimated that the growth rate of the motor load would be about 1.5% per year in the industrial sector and by 2.2% per year in the tertiary sector up to 2010. Some difficulties were encountered in the estimation of the average number of operating hours for the various sizes of motors and the load profile. The average number of operating hours was calculated from the installed stock data (number and capacity of motors in operation) and data on motors' electricity consumption, assuming an average load factor of 60% and a typical average efficiency by power range. The resulting European Union average number of operating hours, about 2000 hours, seems rather low. One reason for such uncertainty and disparity on electric motors operating hours was the fact that many industries have a substantial number of unused spare motors. Those motors are taken into account in number and power, but they operate only in case of emergency, which means only a few hours per year. As it is extremely important to determine accurately the number of operating hours it has been decided, as part of the Commission's actions towards more efficient motors, to launch some monitoring campaigns on the typical usage of motor (type of load, load profile, number and usage of

savings at low cost for the society. User information could be also effective in shifting the whole energy efficiency distribution curve. To be successful, information schemes need support from national authorities, utilities, system designers and motor distributors. Technology procurement acts on the higher end of the market by accelerating the penetration of products into the market place (Nilsson 1992; Nilsson 1994; Geller 1994; Engleryd 1995). Technology procurement also aims at encouraging new products to meet the demand (in this case for energy efficiency) that existing products on the market are unable to fulfil. The idea is that a group of knowledgeable and influential purchasers, defined as a 'buyers group', formulate product specifications and let producers compete to meet these demands. Technology procurement is part of market-pull activities, characterized by showing manufacturers large potential markets (important buyers) and by providing manufacturers with consistent efficiency targets. It is important to notice that in the European context, 'buyers group' can be constituted both by 'final' owners/users of motors or by any intermediate 'actor' (e.g. OEM, retailers, etc.) in the product path from manufacturers to final users. Financial incentives, grants etc. are not part of the PACE 'tool box', because they are more effective when implemented at national or local level and, indeed, some actions have been carried out by utilities in Member States.

Test methods

One of the problems besetting energy efficient motors is that there is no generally agreed definition of what constitutes a 'high efficiency motor'. Moreover there is still some differences in the method of testing motor efficiencies. There are two main test standards, IEC34-2, used mainly in Europe, and IEEE112, used in the US. Although the IEC method is easy to use, it overestimates efficiencies by up to 2% for machines smaller than 10 kW and underestimates them slightly for machines larger than 700 kW. The IEEE method is more accurate, but is not perfect either since it relies on the accuracy of the torque transducer. There can be a 4% variation between efficiencies determined using the IEC and IEEE methods. The key problem for the IEC method is how to take account of stray load losses in the motor. All losses can be calculated, except for stray load loss. The IEC standard assumes that stray losses amount to 0.5% of a machine's input, but this is inaccurate, especially for small motors. The Commission agreed with experts that IEC34-2 needs urgent revision and accordingly it asked CENELEC, the European standardization body, to draw up a new efficiency standard using the IEEE procedures as a basis for this revision. Once the new measurement standard is adopted, the Commission together with the standardization body will specify efficiency levels to be met by motors to be designated as 'high efficiency motors'. This will offer a common European base for incentives schemes.

Labelling

Labelling helps to bridge the information gap to consumers about motor performance. Labelling also increases competition among manufacturers to raise the efficiency over the whole motor range. Motor testing and labelling can help consumers to make informed choices about motor efficiency. Labelling also helps consumers to compare relative performance against models from other manufacturers. The study indicated that in the European Union the average 'standard' motor can have significantly different efficiencies, depending on the manufacturer. The envisaged European label should contain information about equipment efficiency. As a motor seldom operates at full-load all the time, it would be desirable to have motor efficiency labelling covering also partial load conditions (no-load losses, 25%, 50% and 75% load). This information would help to optimise motor selection as a function of the load diagram of the motors. The no-load losses would help to verify if the rewinding work in a failed motor is carried out in a proper way.

Motor labels will likely influence the purchase decision maker. Labels can be useful in the used motor market by telling customers the motor's nameplate efficiency when it was new. On the other hand, efficiency information about energy efficient motors, on catalogue listings can be very useful in the new motor market; to this end the European Commission has set up a database with all the catalogue

7. CONCLUSIONS

This paper has presented the results of the study undertaken in the European Union under the PACE programme for the promotion of efficient motor systems. A variety of different policy options have been investigated and a strategy has been proposed. The paper has illustrated that the current electric motor sold in the Union are still far from the 'economic' optimum energy efficiency level. The potential savings are quite large; the actions described in the paper, if fully implemented, would lead to an electricity savings of about 30 TWh per year by year 2010 or about 1.5% of total Union electricity consumption. This would in turn result in a reduction of 14 Million tonnes of CO_2 emissions and in a large positive economic impacts, thus justifying the European Commission's efforts in the promotion of energy efficiency motors.

Although market forces are used whenever possible to contribute to market transformation, some legislative measurers might be needed and, in the case of the European Union, minimum efficiency standards (or an equivalent voluntary agreement) would yield the largest energy savings at the lowest implementation cost.

The paper has illustrated that a combination of different policy tools, such as minimum efficiency standards, information campaign and procurement are needed to transform the market and are complementary to each other.

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