

U.S. Department of Energy's Motor Challenge Program: A National Strategy for Energy Efficient Industrial Motor-Driven Systems

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ABSTRACT

Over 40 million electric motors convert electricity into useful work in U. S. manufacturing operations. Industry spends over \$30 billion (US) annually on electricity dedicated to electric motor-driven systems. Because nearly 70% of all electricity used in industry is consumed by motor systems, increases in the energy efficiency of existing motor systems will lead to dramatic nationwide energy savings. The United States Department of Energy's (DOE) Motor Challenge program is an industry/government partnership designed to help industry capture 5 billion kilowatt-hours per year of electricity savings by the year 2000. [DOE projects a much larger and longer-term national energy savings opportunity of over 100 billion kilowatt-hours per year, which could be achieved by the year 2010]. The savings from the 5 billion kwh/year translate to \$250 million (US) in energy cost savings and 1.2 million metric tons of carbon equivalent (MMTCE) of emissions reduction per year. A specific goal of the Program is to increase the market penetration of energy-efficient industrial electric motor-driven systems by helping industry adopt the systems approach in designing, purchasing, installing, and managing motors, drives, and motor-driven equipment such as pumps, fans, and compressors. The opportunities, industry needs, and market drivers associated with improving industrial electric motor-driven systems will be discussed. The key strategies and tactics being employed by the Motor Challenge program will also be described, along with some example products, services, and activities that Motor Challenge partners are using to help them accelerate the adoption of efficient motor-driven systems technology and practices within U.S. industry.

BACKGROUND

In the US industrial sector, more than 70 percent of all electricity consumption involves motor-driven systems, and a large portion of the cost of electricity for manufacturing is associated with pumps, fan and blower systems, and air compression. To date, most public and private-sector efforts to improve motor system energy efficiency have focused on the motor, rather than other individual motor-driven system components or, more importantly, on the system as a whole. Starting in October 1997, the Energy Policy Act of 1992 (EPACT) requires that general purpose, polyphase, single speed, squirrel-cage induction motors manufactured for sale in the US and rated from 1-200 hp meet minimum efficiency standards. In addition to these standards, EPACT also requires standardized testing procedures and labeling. Although improvements in motor efficiency beyond these efficiency standards, as described in National Manufacturers Association (NEMA) standard 12-10, are clearly possible, economic returns on further increases in motor efficiency appear to be diminishing.

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Industry buys 20% of all U.S. electricity to operate motor-driven systems. The potential savings in system improvement opportunities are very large - over 100 billion kwh/year energy savings and \$3 billion (U.S.) annual energy cost savings

opportunity with existing and new technology by 2010. System improvement opportunities may include: improved sizing and proper matching to load, use of more efficient drive trains, improved system layout, updated and well-maintained controls, improved operation and maintenance, and use of adjustable speed drives (ASDs). A "systems approach" seeks to increase the efficiency of electric motor systems by shifting the focus from individual components and functions to total system performance (see Figure 1). New market transformation initiatives that encourage behavioral change and infrastructure development play an important role in achieving this shift. Motor Challenge is an industry/government initiative that uses market forces to promote a systems approach to the design, purchase, installation, and management of electric motor-driven systems. Program objectives, in addition to improving industrial energy efficiency, include: enhancing manufacturing productivity, and reducing energy-related greenhouse gas emissions Beginning in 1992, US DOE Industrial Technologies Program (ITP) sought to design a program that promoted increased energy efficiency of motor systems and was responsive to industry needs. The Motor Challenge program evolved from a series of events that presented industrial end-users and the companies that serve them with a unique opportunity to share in and help shape the program. The result is a program "designed with industry for industry" that relies extensively on existing market forces to bring program messages to the industrial end-user(1). The first major event sponsored by DOE-ITP was the 1993 National Energy Efficient Electric Motor System Conference, which was co-sponsored by the Electric Power Research Institute (EPRI). DOE and EPRI convened a Roundtable on Efficient Electric Motor Systems for Industry(2) to draw together participants involved in the market distribution chain. This meeting helped to characterize the complex industrial electric motor system market delivery system, identify problems impeding market penetration of efficient industrial electric motor systems, and suggest solutions for mitigating these barriers. From the initial Roundtable discussion and subsequent industry interactions, the following program needs were identified to support better decisions about motor systems:

objective, reliable, timely information, technical expertise, easy-to-use design-decision and management tools, a robust market for efficient motor systems, and effective coordination of diverse market players.

Based on these ideas, the EERE Information Center, Showcase Demonstrations, and the MotorMaster database were introduced as the initial Motor Challenge program elements and offerings. Additional industry input was sought in 1995 through a series of events: the Roundtable on Market Transformation Strategies for Industrial Electric Motor Systems, a national telecast, a national conference, and industry focus groups. These efforts resulted in additional program offerings and an overall design for program delivery. The key objectives of the 1995 Roundtable were to:

share perspectives on the market characteristics associated with motor, adjustable speed drive, fans and blower, air compressor, and pump system markets design a portfolio of specific actions to achieve market transformation for motor systems, and forge collaborative relationships that encourage stakeholders to shift the focus from individual components and functions to a total system performance perspective and actively participate in the development of market-based programs.

A road map of strategic actions for Motor Challenge resulted from the meeting. The U.S. DOE report: "National Market Transformation Strategies for Industrial Electric Motor Systems" provides a complete overview of these actions (3). The two-hour telecast, "Efficient Motor Systems: Strategies for Success" held in May

1995 had more than 8000 viewers. The telecast content included presentation of case histories followed by viewer questions of a panel of experts. The national conference "Motor Challenge '95: Gaining the Competitive Edge" provided participants with industry examples of how energy-efficient motor systems are working in plants throughout the US and delivering productivity gains as well as energy savings. To further refine Motor Challenge's message to industry, focus groups were held late in 1995 with industrial end-users and companies that serve them. Findings from these focus groups helped shape use of the program's logo, advertising, and the approach to program implementation. Key findings included: combining energy efficiency messages with productivity and competitiveness; emphasizing the value of networking, tailoring the message to a variety of decision making levels; use of existing market actors, such as utilities and distributors, to deliver the information; and reliance on case studies. Three overarching Motor Challenge program objectives resulted from this industry interaction:

develop market pull for energy efficient motor systems; maximize the best-available technology through system/performance optimization; and implement and improve motor system management systems and best practices.

MOTOR CHALLENGE PROGRAM STRATEGIES AND OFFERINGS

Program Strategies

The Motor Challenge program strategies are designed to provide the following: Information- third-party, unbiased, timely information and data to the industrial user so more informed choices and decisions can be made quickly. Tools- software and other tools to assist users in economic comparisons of system-integrated options so optimum systems may be design, specified and implemented. Case Histories- well-documented examples of varied motor-driven system efficiency applications showing clear cost-effective benefits in many different applications and industrial sectors. Model Corporate Management Plans-examples of specific corporate and plant site plans and industry programs that embrace continual improvement of motor systems management practices. Awareness- build industrial end-users awareness of the opportunities and resources available for improving motor-driven system technology and equipment. Education- educational products communicating strategies, approaches, and resources needed to capture the benefits.

Program Offerings

Program offerings are designed to fulfill the program strategies and include: the EERE Information Center, design decision tools, Showcase Demonstrations; and workshops, conferences, and training sessions. The EERE Information Center is the central point for accessing the wide array of products and services available through the Motor Challenge program. EERE Information Center staff include experts in motor system specification, design, and maintenance who are available by toll-free telephone to provide information and advice. Electronic resources include: databases of motor system components, bulletin boards, and chat services. Publications, the Motor Challenge Sourcebook, partnership applications, newsletters, technical bulletins, listings of education/training opportunities, and updates on program activities are all available through the EERE Information Center. Motor Challenge offers design-decision tools. Current offerings are MotorMaster and MotorMaster+ software, which catalog over 12,000 three-phase electric-induction motors available in the US, allowing motor users and others to select the best motor for a specific application. It also allows motor users or service providers to keep an inventory of all motors in use or in storage in any manufacturing plant, and to track maintenance, operation, and replacement details. Additional offerings available in 1998 include: ORMEL '96 (motor efficiency and load estimator-currently undergoing peer review) and ASDMaster (developed

by EPRI and Bonneville Power Administration (BPA))—a design and specification tool for ASDs. Showcase Demonstration case studies provide examples of how companies have undertaken improvements in their electric motor systems and have benefited from verified energy savings and related improvements in waste reduction and productivity. DOE has sought Motor Challenge Partners who are willing to participate as Showcase Demonstrations. In exchange for technical assistance and the opportunity to try out new technologies, Showcase participants must be willing to undertake detailed monitoring and analysis that will help all other Partners understand how to make their operations run better. To date, there are 29 Showcases that will in aggregate invest \$10 million US. Nine projects have already been completed and have achieved collectively an annual energy savings of \$1.2 million US. Early indications are that there is a large demand for well-documented case studies to be published by trade magazines. Workshops, training sessions, and conferences- provide flexible learning options, including: attending a regularly scheduled class or workshop; working with one of the Motor Challenge's Allied Partners, who can offer training using prepared training modules; purchasing training modules to deliver them as part of an ongoing meeting or training activities; or making the training modules available to individual staff members to learn on their own. These professionally developed modules include slides, trainer notes, and handout materials. A number of training modules are available: Introduction to Motor System Management, Motor Basics, Repair/Replace Decision-Making Policy, Using MotorMaster Software (on-line training is also available for MotorMaster+ software). Two hundred people in 1996 have received Motor Challenge training on the application of MotorMaster+ software. In addition, Motor Challenge has been offering a series of workshops on Performance Optimization for Pump Systems directed toward the municipal pumping industry. More than 1000 people have attended these workshops to date.

Levels of Participation

Motor Challenge Partnership

Joining as a Motor Challenge Partner is the entry point in to the Motor Challenge program. Motor Challenge Partners are organizations that are collaborating with USDOE to encourage increased market penetration of energy efficient motor systems. An organization that signs on as a Partner of the Motor Challenge sends a message to its employees that energy efficiency is an important consideration when developing electric motor system management strategies and decisions. Partners also play a key role in helping guide the program to ensure that it continues to meet the needs of US industry. Partners and any of their employees may register for and receive a copy of MotorMaster+ software, have access to the EERE Information Center, and receive the bimonthly "Turning Point" newsletter as well as a variety of free publications, among many of the Program's offerings. To become a Partner, an organization needs to complete a simple application, an agreement between USDOE and its Partner organizations that signifies each party's commitment to the goals of Motor Challenge. By September 1998, more than 2725 organizations had joined the program as Motor Challenge Partners.

Allied Partnership

The Allied Partnership is designed to facilitate the distribution of information about efficient motor-driven system technology and applications. The Motor Challenge Program recognizes the benefits of working within the existing marketplace of companies and organizations that routinely provide products and services to industry. Allied Partners make a greater level of commitment to the program than Motor Challenge Partners because they agree to promote increased energy-efficiency of motor systems among their customers as well as within their own company. Specifically, Allied Partners agree to distribute Motor Challenge products and information to their industrial end-user customers. Each Allied Partner is asked

to complete an Action Plan outlining the types of product distribution and what activities the Partner agrees to undertake. In exchange, Motor Challenge makes most of its resources available to Allied Partners in quantity and at minimal cost. Allied Partners have access to a broad array of Motor Challenge publications and decision tools, which they can distribute to industrial end users in the course of their daily business or in conjunction with customer education meetings or workshops. Typical Allied Partner Activities include: Motor Challenge product dissemination, conducting training workshops, Motor Master + software (MM+) dissemination, plant surveys/audits using MM+, cooperative advertising with Motor Challenge. More than 196 Allied Partners have joined the program since September 1998.

Excellence Partnership

The Excellence Partnership is an emerging initiative under Motor Challenge designed for end-user companies that commit to undertake efforts aimed at continuous improvement of their motor systems management practices. As an Excellence Partner, companies will have access to the materials and support available to all Motor Challenge Partners, but they will also have access to tailored program resources to implement and improve motor system management activities at one or more domestic plant sites. The primary objective of the Excellence Partner initiative is to: develop, improve, measure, benchmark, report, and recognize motor-driven system management practices (current and best) at specific manufacturing facilities or business units. This activity seeks to transform a corporation and their plants to a complete motor systems management approach: starting with motor management, then to more of a system optimization approach (pumps, fans, etc.), and then to an overall process optimization approach.

Industry Partnerships

The current portfolio of high quality materials, workshops, and software tools available through Motor Challenge focus primarily on energy-efficient motors and drives. Through Industry Partnerships, Motor Challenge is cooperatively developing new educational products, materials, and services that focus on motor-driven equipment such as air compressors, pumps, and fans and blowers. This is a highly leveraged activity that draws on the technical strengths of trade associations representing manufacturers of motor-driven equipment (also referred to as original equipment manufacturers or OEMs). Industry partnerships seek to build and strengthen networks of relationships among OEM trade associations, industrial end-users, and energy providers to create new types of information, tools, and technical materials. To reach the program goal to increase the energy efficiency of motor driven systems used in industrial applications, Motor Challenge must make information on energy efficient motor-driven systems readily available to both industrial end-users and the network of suppliers and technical professionals that serve them. For each type of motor-driven equipment and end-use industry, the market structure for supply and services is slightly different. Working with industry partners and Allied Partners, Motor Challenge seeks to find the most effective methods of presenting and delivering information on energy-efficient motor systems. Two examples of industry partnerships include:

Compressed Air Gas Institute (CAGI) is a trade organization of 45 manufacturers of compressed air system equipment: compressors, compressed air dryers, filters, pneumatic tools, and blowers. CAGI has formed an Energy Awareness Committee specifically to work on energy-related issues for compressed air systems and has recently decided to become a Motor Challenge Allied Partner. The following projects have been identified and are being developed to meet the goal of more efficient compressed air systems:

A common means of certifying and reporting performance of compressors,

compressed air dryers, and filters. Standardized data sheets will allow purchasers to more easily compare products. This project will begin with air cooled rotary screw compressors, refrigerated compressed air dryers, and regenerative desiccant compressed air dryers. A consumer fact sheet that will explain the methods of testing a compressor and the importance of the standard performance reporting forms (standard data sheets) A database, accessible via the Internet, that will contain the information found on the standard data sheets An educational video or series of videos to address proper selection, installation, and maintenance of compressed air systems and components. The video will stress items such as leak detection and repair, proper piping, controls, etc. A certification and training program for plant compressed air system auditors.

Electrical Apparatus Service Association (EASA) is an international trade organization with over 2,500 member companies that sell and/or service industrial electric motors, generators, transformers, controls, variable frequency drives, DC adjustable speed drives, and related equipment. EASA publishes standards for the repair of electrical apparatus, has published a booklet entitled "Understanding A-C Motor Efficiency", and has developed a motor repair quality management system called "EASA-Q". EASA is an Allied Partner and has undertaken the following in cooperation with Motor Challenge:

Publishing a motor repair guidebook developing follow-on video products that address motor replacement and repair issues

Other Motor Challenge industry partnerships include:

The Hydraulic Institute, a trade organization of approximately 70 pump manufacturers that is preparing and marketing a video training program, entitled "Energy Reduction in Pumps and Pumping Systems"; Air Movement and Control Association International, an international trade organization dedicated to the certification of performance ratings on fans, louvers, dampers, and other air handling equipment; National Electrical Manufacturers Association, a trade organization representing the manufacturers of electric motors, drives, and other electrical equipment throughout the US. NEMA is working closely with USDOE officials to disseminate information to manufacturers of motor-driven equipment on upcoming efficiency standards for motors as part of the Energy Policy Act of 1992. the Power Transmission Distributors Association, representing approximately 500 manufacturers and distributors of power transmission equipment; the Institute of Electrical and Electronics Engineers, Inc. Industry Applications Society, Pulp " Paper Industry Committee; and the Technical Association of the Pulp and Paper Industry, an international technical association with over 33,000 members. Utility organizations working with Motor Challenge include: the Consortium for Energy Efficiency (information on applications for premium efficiency motors), the Bonneville Power Administration (AirMaster - a new air compressor design-decision tool in development), and the Electric Power Research Institute (ASDMaster).

PUTTING IT ALL TOGETHER

The four main elements of the Motor Challenge program are shown below in Figure 2. A prime focus of Motor Challenge will be the Excellence Partnership (industrial end-user companies implementing model corporate motor system management plans). All other Motor Challenge Program elements and partnership will be focused on developing and delivering the key strategic elements of the Program - information, tools, case histories, awareness, and education - in support of the end-users (Excellence Partners) needs.

KEY PROGRAM ACCOMPLISHMENTS

In the fiscal year 1996 (ending in September 30, 1996):

The Partnership grew by over 50% to 1,600 Motor Challenge partners; Over 5200 people were served by the EERE Information Center; \$1.2 million in annual energy savings has been validated from 9 showcase projects; 75 new Allied Partners have been enlisted; 2 Excellence Partner have drafted action plans (3M and Dupont); Major products were released: 4 training modules, Motor Master+ software; 3 types of training workshop series were prototyped: motor system management, performance optimization, and the virtual/on-line MotorMaster+ software training; New collaborative products are under development for compressed air, pump, motor repair/rewind, and fan and blower systems in cooperation with the respective trade associations; 23 new International Affiliates were enlisted. Information was shared with the governments of : Australia, Chile, Canada, China, Finland, Ghana, India, New Zealand, South Africa, Vietnam; A program testimonial campaign with industrial end-users- showcase demo participants was developed; advertisements were placed in 8 magazines;

EVALUATING PROGRAM EFFECTIVENESS

Motor Challenge is conducting a market assessment study in 1996-97 that will include 300 plant surveys for the purpose of establishing a baseline of motor system usage as well as industry profiles. Program effectiveness is being measured through a series of annual performance metrics. Current performance metrics/goals at the end of FY 1997, include:

15 total Showcase Demonstrations completed to save in aggregate \$2 million US, annually. 150 Allied Partners participating; have documented annual energy savings of \$1 million US, annually. 10 Excellence Partners participating; target is 10 corporations and 25 plant sites for FY1997 with \$1 million savings for the first year growing rapidly (\$25 million estimate for FY1998) as additional corporations join the program and plan implementation is more fully realized.

CONCLUSION

Although many of the program offerings from Motor Challenge are relatively recent, the response to the program from industry has been overwhelmingly favorable. The program is unique in its degree of interaction with industry to design and develop the program offerings and to deliver information concerning motor system energy efficiency to industrial end-users. The series of steps undertaken to obtain industry input in the program design- most notably: the 1993 National Energy Efficient Electric Motor System Conference, the 1995 Roundtable on Market Transformation Strategies for Industrial Motor Systems, and the focus groups with industrial end-users and their suppliers- all contributed to a very different program "look and feel" than what was originally envisioned. One major result of these interactions was the decision to work within the market to deliver the program message through the Allied Partner framework. Another major outcome of this interaction is the reliance on leading by example- creating Showcase Demonstrations where one company's example can be used as an instructional tool for others. Finally, industry participation in program planning led to a realization that the portfolio of program offerings can be substantially expanded through a cooperative development approach as evidenced by the Industry Partnerships initiative. Industry partnerships provide numerous opportunities to enter into highly leveraged cooperative projects that also bring together end-user and OEM trade organizations in new networks that further carry the program message.

Managing a market-based program is challenging. The program has multiple points of program entry, many levels of participation, and an ever expanding list of participants. As Motor Challenge grows, it becomes increasingly difficult to track the range and impact of program activities. The keys to program success are: a common goal that focuses on changing end-user behavior and practices, a commitment to technical excellence in the products and materials offered, and

easily understood metrics to measure performance improvements. The program must be viewed as offering information that adds tangible value, such as training and design and decision tools. At the same time, the program model must be sufficiently flexible to respond to new opportunities in the marketplace. Balancing these objectives has resulted in a "work in progress" that offers a program model for others interested in promoting energy-efficient motor systems and effective motor system management.

REFERENCES

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