The China Motor Systems Energy Conservation Program: A Major National Initiative to Reduce Motor System Energy Use in China

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ABSTRACT

Electric motor systems are widely used in China to power fans, pumps, blowers, air compressors, refrigeration compressors, conveyers, machinery, and many other types of equipment. Overall, electric motor systems consume more than 600 billion kWh annually, accounting for more than 50% of China's electricity use. There are large opportunities to improve the efficiency of motor systems. Electric motors in China are approximately 2-4% less efficient on average than motors in the U.S. and Canada. Fans and pumps in China are approximately 3-5% less efficient than in developed countries. Even more importantly, motors, fans, pumps, air compressors and other motor-driven equipment are frequently applied with little attention to system efficiency. More optimized design, including appropriate sizing and use of speed control strategies, can reduce energy use by 20% or more in many applications. Unfortunately, few Chinese enterprises use or even know about these energy-saving practices. Opportunities for motor system improvements are probably greater in China than in the U.S.

In order to begin capturing these savings, China is establishing a *China Motor Systems Energy Conservation Program.* Elements of this program include work to develop minimum-efficiency standards for motors; a voluntary "green motor" labeling program for high-efficiency motors; efforts to develop and promote motor system management guidelines; and a training, technical assistance; and financing program to promote optimization of key motor systems.

The Current Situation in China

In 1998, China consumed 1,159 billion kWh of electricity (SSB 2000), which is about 36% of U.S. consumption (EIA 2000a) and ahead of all other countries (EIA 2000b). Of this figure, about 60% was consumed by motors, split roughly evenly between fans/pumps and other equipment. The installed capacity of electric motors in China exceeds 450,000 MW (CECIDC 2000).

In the following sections, we briefly describe the Chinese market for motors (including the market for motors), motor-driven equipment (e.g., fans, pumps, and compressors), speed control equipment, and motor system design services. Following this, we briefly summarize the many opportunities to improve motor system efficiency in China and the barriers that hinder capture of these opportunities, and discuss current programs and policies that are designed to overcome these barriers. This information is intended to provide context for a discussion later in this paper on a planned national program to improve motor system efficiency in China.

China's Motor Market

Motors. In China, most factories operate on 380 volt, 50 hz electricity, and most motors follow the IEC design parameters, the same parameters that are widely used in Europe. In China today, there are presently three series of motors in widespread use — the JO series (originally developed in the 1950s in Russia and redesigned in China in the 1970s), the Y series (designed in China in the 1980s), and the Y2 series (developed in China in the early 1990s). In general, the newer series of motors have better optimized designs and use less materials. However, while the newer series are better optimized, much of this optimization has been used to reduce materials — as shown in Table 1 below, efficiency improvements from series to series are generally either small or non-existent. Under government regulations, the production of JO series motors has been banned since 1984, but these motors are still in place in many factories and now account for about one-third of the installed motor stock. Approximately 95% of motor sales in China are now of the Y series, with the Y2 series accounting for about 5%. In addition, a higher efficiency Y2e series has recently been introduced but currently is a special order item produced by just a few manufacturers. Table 1 summarizes the relative efficiencies of these different types of motors (these efficiencies are generally tested according to the IEC test procedure; relative to the IEEE 112-B test procedure used in the U.S., the IEC procedure generally results in a higher efficiency rating).

Table 1. Comparative Efficiency of Chinese Motor Series

Motor Size		Efficiency			
kW	Horsepower	JO	Y	Y2	Y2e
.75	1	76.5	74.5	73.0	75.5
3.75	5	85.0	84.5	84.0	86.0
15	20	88.0	88.5	89.0	91.0
45	60	91.0	92.3	93.0	94.2
90	125	92.0	93.5	94.2	95.0

Values are for 4-pole motors. For JO, Y2 and Y2e, motors were tested according to the IEC test procedure. For Y motors, tests are according to a Chinese standard that is claimed to be similar in results to IEEE 112-B.
Source: Hinge et al. 1997.

Presently, China has hundreds of motor manufacturers, ranging from small backyard manufacturers to large industrial enterprises. The top 15 manufacturers account for about half of the market. In recent years, economic growth has slowed in China (although growth is still rapid by international standards). With the slowdown, and due to economic troubles at many old state-owned Chinese factories, the size of the Chinese domestic motor market has shrunk significantly. As a result, competition in the domestic market is fierce, and customers are expecting steadily lower prices for motors. In this market, the majority of Chinese motor manufacturers are now losing money. On the other hand, the export market has been growing rapidly. The top five Chinese manufacturers serve approximately half the export market. China exports NEMA-design motors for the North American market (these meet the U.S. Energy Policy Act (EPAct) efficiency standards), Y2 motors for the European market, and Y motors for markets in the Middle East and Southeast Asia.

The majority of motors are sold to OEM manufacturers for installation in fans, pumps, and other OEM equipment. However, about 40% of production is sold directly to users, either by manufacturers or through retailers.

Fans. Overall, China has an installed base of approximately 7 million fans, with a combined capacity of about 30,000 MW of power. Fans consume approximately 10% of the total electricity in China. In some sectors such as mining and the metallurgical industries, electricity consumption by fan systems can be much higher, reaching 20-30% (Wang 2000).

Currently, there are more than 4,500 different fan products produced in China by a wide range of manufacturers. By the end of 1997, there were 87 members in the Fan Manufacturing Association, most of which are small manufacturers. In 1997, Fan Manufacturing Association member plants produced more than 240,000 fans with a combined motor capacity of 2,690 MW. In 1997, the value of shipments by the Fan Manufacturer Association reached RMB[a] 2.89 billion (approximately $350 million), a 10% increase over the previous year. Centrifugal fans, axial-flow fans, and other types of special purpose fans account for more than 95% of product sales. For example, in 1997, axial-flow fans and centrifugal fans accounted for 23% and 31%, respectively, of product sales on a volume basis and other types of special purpose fans accounted for an additional 42% of sales (Xu 1999).

Fans manufactured in China prior to the 1980s primarily used Russian technology and the overall efficiency of these fans were 10-15% lower than advanced international standards of the time. In the 1980s, China began a sustained effort to develop new efficient fan products and to introduce advanced international fan manufacturing technologies (mainly from Japan and Germany). Even so, there still exists a gap in the overall standard of Chinese-made fans relative to international fans in terms of design, efficiency, overall performance, and manufacturing quality.

Currently, overall fan system efficiency is only 30-40%. The low overall efficiency of fan systems in China can be attributed to insufficient appropriate products in the marketplace, poor system design, motor over-sizing, and poor operational practices. In order to increase the overall system efficiency, since 1982 the Chinese government has issued regulations to phase out (ban production of) outdated fan products and promote new efficient products. So far, more than 110 products have been listed for elimination and more than 80 new products for promotion.

Today, there is strong competition in the domestic market for fan products. On the one hand, strong competition exists among the domestic manufacturers for commodity small- and medium-sized fan products. On the other hand, international manufacturers have come into the Chinese market in large numbers. Currently, approximately half of the domestic market for high quality and large capacity fans is occupied by imported products. Approximately 3% of Chinese-made fan products are exported and most of the exported products are small- to medium-sized fans.

Pumps. There are currently approximately 30 million pumps in use in China with a combined motor capacity of approximately 80,000 MW, accounting for approximately 20% of total national electricity use. In particular, pumps consume a very high proportion of electricity in facilities such as oil fields, mines, and thermal power plants (reaching 30-35% of plant electricity use) (Wang 2000).

China now produces more than 1,200 different types of pumps. Pumps in China are manufactured by a wide range of enterprises and the vast majority of these are small. In 1997, over 2.2 million pumps were sold in the Chinese market. Of these, approximately

[a] The unit of Chinese currency is the Reminbi (RMB). At current exchange rates, $1 = 8.26 RMB.

400,000 were industrial pumps and about 1.8 million were agricultural pumps. Based on a survey in 1998, 163 member companies in the Pump Manufacturing Association produced just over 1.25 million pumps, accounting for less than 60% of total Chinese pump production (many small producers are not in this association). In 1997, total sales volume of the Pump Manufacturer Association reached approximately RMB 5.15 billion (approximately $625 million), a 7% increase over the previous year. Single-stage single-suction water pumps and submersible pumps are two of the major products accounting for approximately 35% and 20%, respectively, of total annual production. Other major products include multi-stage centrifugal pumps and pipeline pumps.

Over the past 20 years, numerous advanced pump technologies and products have been introduced into China, mainly from Europe and North America. These introductions have significantly increased the technology level of Chinese pumps. In order to increase pump system efficiency, since 1982 the Chinese government has issued regulations to phase out old products and encourage use of new, more efficient pump products. So far, 192 old products and 291 new efficient pumps have been included in the list of banned and encouraged products, respectively. Overall, the new products are 3-6% more efficient than the old ones.

Still, overall technical standards and quality of pumps manufactured in China lag behind international standards. For example, many less efficient pumps are still on the market, which are 2-5% less efficient on average than typical international products. Furthermore, large gaps in pump reliability and lifetime also exist between Chinese and international products.

In recent years, supply has exceeded demand in the domestic pump market and competition among the various manufacturers is strong. In addition, Chinese pumps are also sold in other countries, particularly the U.S., Japan, Germany, and Canada. Total export value was RMB 421 million (approximately $50 million) in 1997. Most pump exports are from the leading domestic manufacturers (CBMI 1998).

Compressors. Compressors are widely used to increase gas pressure in industrial facilities. There are currently about 5 million units of various compressors in operation in China, with a combined motor capacity of approximately 20,000 MW. In 1997, the amount of electricity consumed by compressors amounted to 8 billion kWh, which is 7% of total Chinese electricity consumption.

There are more than 1,300 types of compressors produced in China, most of which are small compressors (defined as 3-70 kW). Although small compressors dominate in terms of numbers, 90% of the electric power consumption is by larger compressors. In 1996, compressor sales totaled approximately 60,000 units with a combined motor capacity of more than 1,700 MW. In 1997, compressor sales were similar to 1996 on a capacity basis, although the number of compressors sold dropped by more than 20% (i.e., the average compressor size increased). In 1997 there were 78 compressor manufacturing enterprises in China. Of these, only 12 had sales revenue over RMB 100 million ($12 million) and the combined production value of these 12 firms accounted for over 65% of the total Chinese production value.

Current domestically made new compressors are comparable in terms of energy efficiency with international products. However, Chinese products lag behind their international counterparts in terms of reliability and control.

In order to improve compressed air system energy efficiency, the Chinese government has issued regulations to phase out 26 types of outdated compressors and encourage 34 new air compressor products. In general, new compressor products have much higher efficiency than the old ones. However, due to end-user habits as well as inefficient enforcement of these regulations, some old products on the banned list can still be found in the market (Wang 2000).

Speed control. As in most countries of the world, many motors used in China operate under varying load conditions and can potentially benefit from speed control technologies. Speed control technologies available in China range from eddy-current drives to two- and multi-speed motors to electronic variable speed drives (VSDs). In general, use of these technologies is limited, with less than 10% of motor systems in China using any of these measures (studies in China estimate that up to 70% of motor applications can potentially benefit from speed control technologies). Moreover, flow control measures in use are mainly of low efficiency such as baffle plates or valves, and the use of VSDs is low.

Domestic VSD production totals approximately 15-20 MW annually, whereas imported products total approximately 400 MW. Thus, imported VSDs have more than a 90% share of the Chinese market, even though imported products are subject to an import duty. Chinese-made VSDs are not of sufficient quality to meet market demands and also lack some features desired by purchasers.

The high price of imported VSDs restricts their use. The current market price for small and medium-sized VSDs (for motors of 200 kW or less) is approximately RMB 800-1,200/kW ($95-145/kW), while the price for larger capacity VSDs is RMB 1,800-2,500/kW ($215-305/kW).

Based on surveys in the metallurgical, chemical, and building material sectors, energy saving potential through motor speed control can be as high as 40 billion kWh/year in China. Energy savings in good VSD applications typically range from 20 to 40% and the investment in these good applications can be recovered in 1-3 years (CECIDC 2000).[b]

System design. Motor systems in China are traditionally designed by Design Institutes, which function somewhat like architectural and engineering firms in Western countries. In China, each industrial sector (e.g., steel and petroleum) has its own design institute or institutes. These design institutes are in many cases very conservative and often overly emphasize system safety in motor system design. They often rely on past experiences and even copy existing designs in some cases. These practices often lead to motor oversizing, resulting in low system efficiency. In addition, the design engineers are often specialized in certain specific subjects and are often not familiar with energy conservation issues. They tend to use existing or old products and equipment and are not aware of the latest energy-efficient products.

[b] Chinese electric rates vary from region to region but are roughly comparable to U.S. electric rates. Motor system improvements can be particularly attractive in southern China where electric rates can exceed the equivalent of $0.10/kWh.

Opportunities for Reducing Motor System Energy Use in China

There are large opportunities to improve the efficiency of motor systems. Electric motors in China are approximately 2-4% less efficient on average than motors in the U.S. and Canada. Fans and pumps in China are also commonly 3-5% less efficient than in developed countries. Even more importantly, motors, fans, pumps, air compressors, and other motor-driven equipment are frequently applied with little attention to system efficiency. More optimized design, including appropriate sizing and use of speed control strategies, can reduce energy use by 20% or more in many applications. Thus, motor system optimization is probably the single biggest source of motor system energy savings. Unfortunately, few Chinese enterprises use or even know about these energy-saving practices. Studies in the U.S. indicate that by using all of these techniques in cost-effective applications, motor energy use can be reduced by about 28-42% (Nadel et al. 2001). Opportunities in China are probably even greater due to the lower average current efficiency of Chinese motor systems.

Barriers to Motor System Efficiency Improvements in China

Primary among the barriers are the following:

1. **End-users lack information**: Few Chinese enterprises are aware of the opportunities for reducing energy use and improving operating practices through high-efficiency equipment and system optimization, and those that are aware of the opportunities generally lack the expertise to properly optimize their systems.
2. **Energy efficiency low on list of end-user priorities**: Most end-users are pre-occupied with other concerns and pay little, if any, attention to energy efficiency.
3. **Limited infrastructure to provide optimization services**: Experts on optimizing motor systems are few and far between in China, making it difficult, if not impossible, for a Chinese enterprise to obtain expertise on system optimization.
4. **Efficient/energy-saving equipment often not readily available**: One aspect of system optimization is often use of high-efficiency equipment including speed controls and high-efficiency motors, fans, pumps, and compressors. Most Chinese manufacturers do not produce this equipment, making it difficult for Chinese enterprises to purchase this equipment unless they resort to very expensive imported equipment.
5. **Shortage of financing**: Enterprises frequently lack the capital to pay for optimization projects or to pay extra to upgrade the efficiency of products they purchase. Motor and other equipment manufacturers sometimes lack capital for equipment or the purchase of higher quality raw materials that will help improve product efficiency.

Current Programs and Policies

Given the fact that motor systems are the preeminent electrical end-use in China and given the potential for substantially reducing this electricity use cost-effectively, a number of efforts have begun, or are scheduled to begin soon, that provide a useful foundation for efforts to improve motor system efficiency in China. Among the current programs are the following:

1. *International Institute for Energy Conservation (IIEC)/International Copper Association (ICA) China Energy Efficiency Program*: A project to promote high-efficiency motors in

China by encouraging and providing technical assistance to the Chinese government to develop motor minimum efficiency standards, a premium-quality motor brand, and a motor efficiency certification program. The program also provides information and training to manufacturers and end-users, identifies and explores financing mechanisms for energy efficiency investments, and facilitates demonstration projects.

2. *Sino-U.S. Motor Systems Team*: Developing and implementing pilot training programs and informational materials and tools on motor, pump, fan, and compressed air systems in order to lay the groundwork for a nationwide China motor systems program Principal participants include the Chinese State Development Planning Commission (SDPC), U.S. DOE, and the China Energy Conservation Investment Corporation (CECIC).
3. *Technology Cooperation Agreement Pilot Project*: A U.S. EPA-funded effort to demonstrate technology cooperation as called for in the Framework Convention on Climate Change. One of the initial target areas is motor systems, with a particular focus on the introduction and increased awareness of new technologies.
4. *China State Economic and Trade Commission/China Energy Conservation Association/Energy Foundation*: A multi-year effort focused on policies for improving industrial-sector efficiency; the effort will address establishing national energy use guidelines in selected industrial sectors. One of the areas under consideration for meeting these new guidelines is increased efficiency in industrial motor systems.
5. *GTZ/China Electric Power Research Institute motor test laboratory and test procedure project*: Funded by the German government, this project is working on establishing revised motor efficiency standards in China and establishing a new motor efficiency test laboratory; this effort is coordinated with the IIEC effort discussed above.
6. *World Bank/Global Environment Facility (GEF) Energy Management Company Project:* A multiyear project to help establish multiple energy management companies (EMCs) in China; so far three EMCs have been formed and more are planned. Motor systems are a significant area of focus for these EMCs.
7. *China Energy Conservation Information Dissemination Center*: Prepares case studies and good practice manuals on energy-saving measures; some of the case studies are on motor systems. The first manual published is on VSDs.
8. *United Nations Industrial Development Organization/SDPC/U.N. Foundation motor systems project in Shanghai and Jiangsu:* A project scheduled to begin in the spring of 2001 to offer a pilot motor systems program in two Chinese provinces.

The first and last of these projects are major foundations for the China Motor Systems Energy Conservation Program and merit further description.

IIEC/ICA China Energy Efficiency Program. Sponsored by ICA (International Copper Association) and CFC (Common Fund for Commodities), IIEC started the CEEP (Copper Energy Efficiency Program) in 1998. CEEP is a 3-year program to promote high-efficiency motors in China and improved efficiency transformers in India. In China, work began with a one-year market assessment that led to development of four strategies designed to transform the Chinese market towards higher-efficiency motors. The strategies are:

1. Encourage the Chinese government to develop motor minimum efficiency standards;
2. Facilitate the development and promotion of a voluntary program to certify high-efficiency motors;
3. Develop pilot projects to demonstrate the economic benefits of high-efficiency motors;

and
4. Identify financing mechanisms for high efficiency motors.

Many activities have been undertaken to implement these strategies. Activities in support of the first two strategies are discussed later in this paper.

UNITO/ SDPC Motor System Energy Conservation Project in Shanghai and Jiangsu. This project is an educational effort to promote motor system optimization in China and to put a local infrastructure in place in two provinces (Shanghai and Jiangsu) to promote greater efficiency in industrial motor driven systems. This project is a direct outgrowth of activities undertaken by SDPC and the U.S. DOE since 1997 as the result of a China-U.S. bilateral cooperation agreement.

Primary funding for the project is being provided by the United National Foundation (UNF) with substantial in-kind contributions from U.S. DOE and SDPC. Additional funding is being made available from The Energy Foundation. UNIDO is administering the project on behalf of UNF. The intent is to use lessons learned in the pilot phase of this project to develop an integrated program model that can serve as the foundation for a national program.

The project will concentrate on two provinces, Shanghai and Jiangsu, which have expressed strong interest, include a significant industrial base, have organizational support, and have a small cadre of energy professionals who can be trained on the technical specifics of motor system optimization. This will greatly assist the project in meeting program objectives within a relatively short period of time (3 years). The program will encompass the following activities:

1. Develop a series of educational materials and application tools (e.g., software) to assist motor system experts and factory engineers to assess and better optimize motor systems;
2. Revise existing Chinese national standards on the economic operation of motors, fans, and pumps;
3. Train a group of at least 10 motor system optimization experts who will work in Shanghai and Jiangsu;
4. Implement and evaluate a series of eight motor system improvement demonstration projects in different industrial sectors in Shanghai and Jiangsu and prepare case studies of these projects;
5. Provide training to at least 200 additional Shanghai and Jiangsu factory managers and engineers and provide technical assessments to at least 30 additional Shanghai and Jiangsu factories to assist them in identifying and undertaking their own motor system optimization projects;
6. Evaluate the different project components and assess how the project can be improved; and
7. Assist the Chinese government in planning for and laying the groundwork for a major national motor system improvement program.

Materials development and training of the Chinese motor optimization experts will be a primary responsibility of an international team of experts who will use information from existing motor system programs, most notably in the U.S. and the U.K. Topic areas will include motors and drives, pumping systems, compressed air systems, and fan systems. Post-training technical support will also be provided for plant assessments, project development, and case study preparation.

A Chinese organization will be selected by UNIDO through a competitive bidding process to become the primary subcontractor, which will be responsible for overall management of program implementation activities, including contracting with local agencies in Jiangsu and Shanghai. A substantial evaluation component is also included in the project to determine the effectiveness of the pilot programs. Evaluation will be the responsibility of a Project Management Office (PMO) established by the SDPC. Preliminary evaluation results are anticipated in 2002. The pilots will be completed by mid-2004

The China Motor Systems Energy Conservation Program

While the programs and policies listed above are making some progress towards improving motor system efficiency in China, relative to the size of the Chinese motor market, these efforts are small and much more work is needed for even one-quarter of the potential motor system energy savings in China to be captured. In order to make progress towards this larger potential, the Chinese government is now developing a major national program tentatively called the China Motor Systems Energy Conservation Program. In the following sections, the history, current status, and tentative plans for this new program are discussed.

Brief History

Work to develop the China Motor Systems Energy Conservation Program grew out of discussions between SDPC and U.S. DOE that began in 1997. These discussions recognized that most of the available motor savings in China are from system design and optimization, but that to capture these savings, a large-scale multifaceted effort is needed. Partial models for the China Motor Systems Energy Conservation Program are the China Green Lights Program, a major Chinese program to improve the efficiency of lighting systems (Nadel et al. 1999), and the U.S. Motor Challenge Program, a program that provides training and tools to industry and trade allies on techniques to better optimize motor systems (Nadel et al. 2001). A key step in the development of the China Motor Systems Energy Conservation Program is the UNIDO/SDPC project discussed above, which in many ways is a pilot for the national program.

Current Status and Schedule

In the tenth five year plan for energy efficiency prepared by the Chinese government, electricity savings from motor-driven systems has been classified as one of the key areas. Currently, a range of activities are being carried out to prepare for the initiation of the China Motor System Energy Conservation Program. The preliminary objective of this program is to reduce motor system energy use in China by at least 10% by 2010. Realization of this target will reduce annual Chinese electricity use by more than 60 billion kWh.

As a first step towards a national program, the UNIDO/SDPC China Motor System Energy Conservation Project is in the final stages of preparation. It is hoped that this program will provide a test ground for the concept of the full national program. Parallel to the UNIDO project, The Energy Foundation is supporting the Chinese effort by providing assistance for the development of the national program.

To date, an expert team has been organized to carry out a motor market survey and to analyze the motor market energy efficiency improvement potential. A number of seminars have been held to review the status of motor system energy efficiency, the application of motor systems in the various sectors, and the potential for motor system energy efficiency improvements. Efforts are also being made to investigate the motor manufacturing industry and market through further seminars and field investigation. A report on *the China Motor System Market and the Potential for Energy Efficiency Improvement* will be prepared. On the basis of this, the main contents and framework of the national program will be put forward.

Likely Program Components

While plans for the China Motor Systems Energy Conservation Program are still being formulated, based on discussions to date, several program components are likely to be included. These are discussed in the following sections. In general, the plan of approach is to pursue the Jiangsu/Shanghai pilot project over the next few years while also developing appropriate policies such as standards; efficiency labeling; and encouraging the consolidation of motor, fan, pump, and compressor manufacturers. Beginning in approximately 2003, the hope is to begin implementation of the overall national program.

Minimum efficiency standards for motors. Although motor efficiency is a part of product specifications for Y and Y2 series motors, there is not a requirement that each manufacturer has to test and report the efficiency of the products. Due to price pressure in the market, experts estimate that to reduce material costs, manufacturers representing more than 20% of motors in the market do not reach the published efficiencies in the Y and Y2 specifications. To address this situation, the China State Bureau of Technical Quality Supervision (with assistance from IIEC/ICA) is currently developing a minimum-efficiency standard for motors. The standard is currently in draft form and calls for motors to meet the "Efficiency 2" level developed by CEMEP (a European association of individual-country motor manufacturer associations) (Exico 2001). This efficiency level is illustrated in Figure 1, which also includes information on Chinese Y and Y2 motors as well as the U.S. EPAct minimum-efficiency standard.

In addition to developing new motor standards, the program will also investigate appropriate mechanisms for implementing these standards. Past Chinese government efforts to ban particularly inefficient products have met with mixed success and thus there is a need to develop improved legal, regulatory, and voluntary implementation frameworks.

Voluntary "Green Motor" labeling program for high-efficiency motors. Under China's new Energy Conservation Law, a China Energy Conservation Product (CECP) certification committee was formed with a mandate to certify, label, and promote energy-saving products in China. The Committee has already implemented certification and labeling procedures for refrigerators. Under the motor systems project, as motor and related standards are revised, a certification, labeling, and promotion program will be inaugurated for high-quality, high-efficiency motors. Equipment certification and labeling will allow purchasers to readily identify quality, efficient products in the market, something that is presently difficult to do as efficiency information is currently not readily available to purchasers and there are often inaccuracies in the efficiency information that is reported.

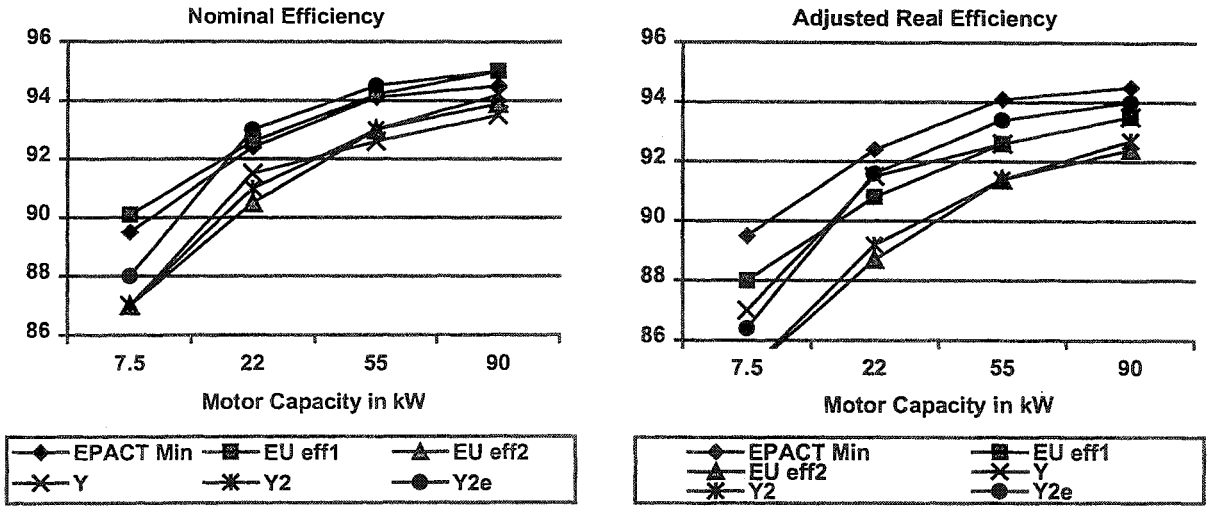

Figure 1. Comparison of EPAct and European Efficiency Standards to Chinese Y and Y2 Motor Efficiencies

Note: The nominal efficiency chart includes motors tested according to both the IEC 34 and IEEE Method 112-B procedures (the IEEE 112-B is the procedure used in the U.S.). The difference between these two test methods is in how stray load losses are treated. Through an input-output test, IEEE tests and accurately measures stray load losses. The IEC procedure assumes that stray load losses are 0.5%, which is a very optimistic assumption. There is not a point-to-point relationship between IEEE112-B and IEC, and in fact this relationship varies as a function of motor size and individual motor designs. Still, a proposed new version of the IEC testing method indicates that a conservative estimate is that stray load loss varies from 2.5% for small motors to 0.5% for very large motors (IEC 2000). In the right-hand graph above, we use these figures to adjust the nominal efficiency from IEC current tests to approximate the efficiency with IEEE 112-B tests.

Concurrent with the work to develop a minimum-efficiency standard (discussed above), the State Bureau of Technology Supervision and CECP are developing a voluntary specification for high-efficiency motors; in the draft specification, this level is the same as the European "Efficiency 1" level now being used for voluntary motor promotions in Europe (see Figure 1). The intent of this voluntary specification is to encourage sales of more efficient motors in China. Such a specification may also assist export sales to Europe. In addition to the European "Efficiency 1" requirement, the draft Chinese high-efficiency motor specification requires that to be certified as high efficiency, a motor must also be tested according to the IEEE 112-B test method and measured stray load losses must be less than certain specified levels.[c]

While the labeling program will initially target motors, opportunities to expand the program to fans, pumps and compressors will also be explored and implemented if feasible.

Develop and promote motor system management guidelines. In China, many manufacturers are owned by various units of government and need to follow guidelines established by the government. In addition, guidelines developed by the government are

[c] China recognizes that the IEEE 112-B method is more accurate (because stray load losses are actually measured) and thus China plans to move towards the IEEE 112-B method once this method is incorporated into the IEC test procedure. IEC has been discussing ways to incorporate IEEE 112-B for several years and is expected to adopt such a change in the not too distant future.

often voluntarily used by other companies. In the 1980s, China developed guidelines on the economic operation of motors, fans, and pumps that include guidance on such issues as motor sizing, how to evaluate motor system economics, and recommended measures for improving motor system operating efficiency. Under the UNIDO/SDPC project, these guidelines will be revised, including a significant focus on good system design and optimization techniques. Following development of these new guidelines, training programs are planned to introduce and explain these guidelines to factory managers and engineers.

Training, technical assistance, and financing program to promote optimization of key motor systems. Training, technical assistance, and financing are the heart of the Jiangsu/Shanghai pilot project and are expected to be the heart of the national program. Among the steps being contemplated are:

1. Establish a Series of Provincial and Sector-Based Information and Training Centers: A centerpiece of the program will be a series of provincially based and industrial bureau-based (e.g., Bureau of the Chemical Industry) information and training centers that will undertake a wide variety of promotion, training, and information dissemination activities to inform local factories about opportunities to better optimize their motor systems. These centers will be housed within existing regional and sector-based organizations and will provide the following services:
   - Short workshops for factory managers and senior staff to summarize the many benefits of optimization, based on case studies, and how to obtain optimization services.
   - Medium-length workshops to train engineering staff at factories on how they can direct some of their own optimization projects.
   - Dissemination of informational materials and tools developed at the national level.
   - Other promotional activities such as tours of nearby showcase demonstration projects, talks at industry and regional conferences, etc.
   - Technical assistance to individual factories to help them obtain optimization services including referrals to skilled service providers.
2. Undertake a Series of Showcase Demonstration Projects and Prepare Case Studies on These Projects: In order to demonstrate motor system optimization techniques and benefits, a series of "showcase demonstration projects" will be developed in each of the targeted provinces and industries. These projects will provide hands-on experience to local service providers and will also provide local examples of the costs and benefits of motor systems optimization. Case studies will be prepared on each of the demonstration projects and these studies will be an important component in local and sector promotion efforts. Costs will be carefully tracked and savings will be determined through metering and appropriate engineering techniques. Showcase hosts will include a variety of industrial enterprises in China including state-owned enterprises, joint ventures, and cooperative and/or town and village enterprises. Showcases will be conducted across a range of system types including fan, pump, and compressor systems. Provincial and sector centers will assist with showcase engineering and evaluation. Financing for the showcase projects will come from host enterprises, and local banks and energy management companies.
3. Develop Informational Materials and Tools at the National Level: Information materials will be developed to cover a range of needs, including short pamphlets and videos for

senior managers; technical case studies, manuals, videos, and software for technical and financial staff; and policy pieces for government officials. Some of the information materials will be adapted from foreign sources and made appropriate for China; other materials will be prepared afresh. Development and distribution of information materials will be coordinated with (and perhaps some materials even subcontracted to) the China Energy Conservation Information Dissemination Center.

4. Develop a National-Level Training and Information-Sharing Program for Center Staff and Other Experts: Key technical staff at the centers will need specialized advanced training in motor system optimization procedures. In addition, key staff at large enterprises may want advanced training so that they can implement a full range of optimization projects in-house. Furthermore, staff at universities, design institutes, and consulting firms will also need advanced training so that they can offer services on a consulting basis to factories that lack skilled in-house staff.

   To help train all of these people, a national training center will be established at a major engineering school in China. The training center site will be a school that emphasizes practical work with enterprises and not research. The training center will offer one- to four-week advanced classes on optimization techniques, with a major focus on practical, hands-on training in industrial enterprises. Training courses will be run by experts with extensive practical experience (technical staff from large enterprises, equipment manufacturers, design engineers, university professors, and others). Prior to beginning operations, these teachers will have opportunities to meet and work with international training experts. At the completion of each training course, students will be given practical exams, and students who pass the exams will be given certificates indicating that they have passed particular advanced training courses. In addition to training courses at the center itself, center instructors will also offer advanced training classes at other locations around China in association with regional universities and the provincial and sector training centers discussed above. Over time, the national training center will assist in the establishment of several regional training centers modeled after the national center but serving specific regions in China such as the Northeast or Southwest.

   In addition to offering regular training courses, the national training center will also hold an annual conference for center graduates and other experts in order to facilitate information exchange among optimization practitioners. The center will also publish a regular newsletter to provide news on new approaches, activities, projects, and lessons learned.

5. Expand the Availability of Financing for Motor System Optimization Projects: One of the major barriers for the adoption of energy efficient motors is that many end-users lack access to capital. While some profitable factories have internal sources of capital, other factories lack the capital or cash flow to finance projects themselves. In recent years, the China Energy Conservation Investment Corp. (a government-capitalized investment company that focuses on energy conservation) and the World Bank/GEF[d]-supported Energy Management Companies have invested in motor system energy efficiency projects through leasing and performance contracting mechanisms, achieving some success. Still, the investments being made in motor system energy efficiency are much too low in view of its vast potential in China.

[d] A multilateral environmental protection fund set up at the 1992 "Earth Summit" in Rio.

In order to expand the availability of financing, the program will undertake efforts to encourage domestic banks and other financial institutions to expand the capital they provide for motor system optimization projects. This work will include workshops and educational material targeting financial institution staff in order to increase their understanding of the opportunities for profitable investments in motor system energy efficiency improvement projects. These activities will be undertaken in coordination with national and provincial financial agencies and organizations.

In addition, the project will work with factories and technical assistance providers to educate them on the types of information and data they need to develop in order to have a good chance of obtaining credit. The project will work with financial experts to develop model financial templates for motor system optimization projects and will provide training in how to collect and summarize the required information in order to provide financial institutions with the information they need to make favorable loan determinations.

Discussion and Conclusion

China's new Five-Year Plan for the energy sector places equal emphasis on energy supply, energy conservation, and environmental protection. Motor systems account for approximately 60% of China's electricity use, and thus reducing motor system energy use is a primary target for China's energy conservation effort. Furthermore, improving motor system efficiency helps reduce factory operating costs and thereby can contribute to China's efforts to bring many failing state-owned enterprises into profitability. Current programs to promote motor system efficiency provide a good foundation for a major national program to reduce motor system energy use.

However, motor system efforts have made only limited progress in developed countries such as the U.S. Targeting motor system improvements will present great challenges in a developing country such as China. On the other hand, China is one of a handful of developing countries that has already made substantial progress on energy efficiency. Also, due to the long history of central planning in China, many Chinese companies are likely to participate in programs run by the Chinese government and thus China is often able to achieve high program participation levels more easily than in countries (such as the U.S.) without this history.

In the next year, China will be refining its program approach and plans to apply to the GEF to help fund its motor program. Over this period, Chinese program planners welcome input on program elements and strategies that can make the China Motor Systems Energy Conservation Program a success. The China Green Lights Program has made substantial strides in building the market share of efficient lighting products in China (Nadel et al. 1999). Hopefully the China Motor Systems Energy Conservation Program can be at least as successful.

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