China Energy Efficiency Program

Motor, Transformer, and Ballast Market Assessment

Workshop Proceedings

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CONTENTS

Preface i
Acknowledgements ii
Introduction 2
Welcome Remarks 2
Summary of Workshop Presentations 3
Ballast Market Assessment and Strategic Options 3
Motor Market Assessment and Strategic Options 5
Transformer Market Assessment and Strategic Options 8
Financial Institution Support 12
Panel Discussions 15
Summary and Conclusions 17

Preface

IIEC has embarked on a 3-year initiative, the CFC Energy Efficiency Program (CEEP), to develop the market for energy-efficient products in China and India. This initiative is funded by the Common Fund for Commodities (formed under the auspices of the United Nations), the International Copper Study Group, and the International Copper Association.

The goal of the Program is to promote greater demand for energy-efficient, products. Three technologies were selected for the project focus: energy-efficient motors, energy-efficient transformers, and energy-efficient magnetic ballasts. These technologies were selected for preliminary market assessments because all three technologies present significant energy savings opportunities. Once the market and technology assessments are complete and following input received at the Workshop, one technology will be selected for further market development activities.

Strategic initiatives include:

- Assessing technology and market conditions,
- Increasing domestic energy efficient product manufacture,
- Market support activities such as training, education, and promotion, and
- Establishing energy-efficiency investment mechanisms.

IIEC has completed the market and technology assessments for energy-efficient motors, transformers, and magnetic ballasts and presented the China assessment results at the "China Energy Efficiency Program (CEEP) Market Assessment and Strategy Workshop" on June 9, 1999 in Shanghai, China. These proceedings summarise the workshop presentations and discussion.

Acknowledgements

IIEC would like to express its deep appreciation to the workshop participants for sharing their experiences, technical expertise, and market knowledge. IIEC would also like to thank those individuals who contributed significantly to our understanding of the China markets, even though they were unable to attend the workshop. Without the contributions of these individuals, companies, and organisations, our understanding of the dynamics impacting development of the market for energy-efficient products would not have been complete.

We are grateful for the support of the workshop organiser, the China Energy Conservation Association (CECA). CECA is a strong supporter of IIEC and the China Energy Efficiency Program, since the program's inception.

Finally, we would like to recognise the project funders, the Common Fund for Commodities, the International Copper Study Group, and the International Copper Association for their support in promoting energy-efficiency.

Introduction

IIEC, in partnership with the State Economic and Trade Commission, the State Development and Planning Commission and the China Energy Conservation Association, organised a one-day workshop, the **China Energy Efficiency Program (CEEP) Market Assessment and Strategy Workshop** on June 9, 1999, at the Tong Mao hotel, in Shanghai. The primary objectives of the workshop were to present the findings of the market and technology assessment study and to discuss proposed strategy options for transformer, motor and ballast market transformation. Other objectives were to solicit input and direction on the strategies and to gain manufacturer, end-user and other organisation support and interest in participating in CEEP implementation. More than 80 invitees attended the workshop, including representatives from the State Development and Planning Commission, the State Economic and Trade Commission, the State Bureau of Quality and Technical Supervision, the China Energy Conservation and Investment Corporation, manufacturers, end-user organisations and financial institutions.

Welcome Remarks

Officials in charge of energy efficiency from SDPC, Mr. Chen Heping, and SETC, Ms. Feng Yan, addressed participants in opening ceremony speeches. They said that small and medium motors are on the government's priority list to improve efficiency. Further, they said that it is necessary to review the motor efficiency testing methodology and to begin the process for issuing new minimal efficiency standards. They highlighted on-going activities in the transformer and magnetic ballast industry. Mr. Chen highlighted the Memo of Co-operation between SDPC and IIEC, and both Mr. Chen and Ms. Feng expressed appreciation for IIEC's efforts on China efficiency.

Ms. Dong Lie, CECA, welcomed the workshop participants, and invited their involvement in China energy efficiency.

Ms. Denise E. Knight, Senior Program Manager, IIEC

IIEC provides technical and policy assistance to promote sustainable energy in developing countries as a tool for socially and environmentally sound economic development. IIEC focuses in three strategic areas: End-use Efficiency, Renewable Energy and Climate Change. IIEC's strategy for market transformation includes; developing finance tools and a pipeline of renewable and efficiency projects for funding agencies; business development initiatives such as market assessments and facilitation of business partnerships; and policy initiatives. IIEC began its operations in China with the launch of the China Energy Efficiency Program (CEEP). IIEC conducted market assessments and economic technology evaluations of motors, transformers and fluorescent lamp ballasts and developed strategic options for market transformation. The workshop objectives are:

Participant input is critical to successful strategy development

- To share results of the market assessments
- To present strategies for overcoming market transformation barriers
- To solicit comments and suggestions regarding the proposed strategies
- To seek inputs for developing an action plan

Summary of Workshop Presentations

The CEEP Team presented the market assessments and proposed strategies for energy efficient motors, transformers and ballasts. The presentations were given in Chinese with simultaneous English translation available through earphones.

Following the Market Assessment presentations, options for financing energy efficiency programs were presented by Ms. Zhang Ruiying of the China Energy Conservation Investment Corporation (CECIC), Mr. Zhou Xiaotao of Shenzhen Jiangneng of the Machine and Electricity Control Technology Co. under CECIC, and Ms. Georgia Badelt of GTZ (the German Development Cooperation).

Ballast Market Assessment and Strategic Options

Mr. Hank Qiu, China Representative, ICA - China

Lighting accounts for 11% of total electricity consumption. In 1997, 6.05 billion lamps were produced, including 5.5 billion incandescent lamps and 190 million ballasts. Magnetic ballasts accounted for 80M (42%) units and electronic ballasts 110M (58%). Fluorescent lamps (FL) and circular fluorescent lamps (CF) are the traditional markets for magnetic ballasts. Electronic ballasts dominate the compact fluorescent lamp (CFL) market. Electronic ballasts have penetrated the FL and CF market, accounting for 31.5% share, 95M units per year. In recent years, magnetic and electronic ballasts have experienced average annual growth of 11% and 27%, respectively. The traditional market drivers for ballast sales are: growth of the FL and CF market, new building construction, and increased living standards. Two relatively new drivers further supplement this growth: energy conservation and a government energy efficient lighting campaign. These supplemental drivers are largely responsible for the rapid growth and market penetration of the electronic ballast.

Technology improvements and increased market penetration offer significant energy savings opportunity.

There are two opportunities for energy efficiency improvement in the magnetic ballast industry. The first is to improve the efficiency of existing magnetic ballasts through technology improvements. The second is to shift the market from incandescent lamps to fluorescent lamps. Improving the efficiency of the existing magnetic ballast market would result in 271 million kWh of savings annually, assuming a 30% market penetration. Shifting just 10% of the residential market from incandescent to fluorescent lamps would save 2.6 billion kWh annually.

There are three types of ballast customers: luminaire manufacturers (OEMs), organizational end-users (industry and commercial) and individual residents. All three customer segments include price and reliability in their purchase decision. The differences between the customer segments are that the luminaire manufacturer focuses on the ballast suitability to lamps, while the organizational user places more emphasis on energy efficiency and the residential customers are more interested in aesthetics.

There are over 2,000 lighting product manufacturers and 300 ballast manufacturers. Most ballast enterprises are small, with the top 10 serving 1/3 of the market. There are only two magnetic-type ballasts manufactured in China: E-type and Ring-type. Most ballast manufacturers produce the standard E-type magnetic ballast. Energy

efficient Ring-type magnetic ballasts are new to the market. Only 3 manufacturers own the Ring-type ballast technology and the 1998, production capacity was only 1 million units.

Currently there is a magnetic ballast over-supply and competition is fierce. E-type ballast manufacturers compete on price to maintain their market share. Ring-type ballasts are the emerging technology, there is limited supply, and little competition among the Ring-type manufacturers. The greatest competitive threat to magnetic ballasts is electronic ballasts. Electronic ballasts are gaining market share, despite their higher price (300% higher) and shorter life expectancy (1/3 the life expectancy), because of the substantially lower losses and effective governmental campaign promoting the use of electronic ballasts. Typical 40-watt electronic ballasts have 4 watts of loss compared to 10 watts for the E-type magnetic ballast. The Ring-type ballast offers a magnetic ballast competitive alternative to the electronic ballast, with only 5.5 watts of loss and substantially lower price. However, Ring-type ballasts are larger and heavier than E-type ballasts and they are not be appropriate for all applications.

Ring-type ballast technology is cost-effective.

Two economic analyses were reviewed; the economics of Ring-type ballasts compared to E-type ballasts and the cost-effectiveness of shifting the market from incandescent lamps to fluorescent or compact fluorescent lamps. First, comparing the economics of E-type and Ring-type ballast technology and their relative competitiveness to electronic ballasts, in all cases (residential, commercial, and industrial), Ring-type ballasts were the most cost effective. Payback periods for Ring-type ballasts ranged from 2.4 years, 1.2 years, and 0.6 years based on 3 hours, 6 hours, and 12 hours of operation per day, respectively. While for the same period and assumptions, electronic ballasts were 11.6 years, 5.8 years, and 2.9 years, respectively. In fact, electronic ballasts become cost effective only at higher operating levels and are advantageous in more limited applications.

The second analysis evaluated the cost effectiveness of shifting incandescent lighting to fluorescent lamps, circular fluorescent lamps, electronic CFLs and magnetic CFLs (with Ring-type ballasts). Compact fluorescent lamps (CFLs) were the most cost-effective option. Electronic and magnetic CFLs were equal on both a payback and a TOC basis.

The China Green Lights program is the most significant in-country lighting initiative.

The most significant in-country lighting activity is the “China Green Lights” program, which is backed by the government. This program supports the use of energy efficient lighting and the conversion of incandescent lighting to FL, CF and CFLs. In addition, ballast efficiency standards, for electronic and magnetic ballasts, have been drafted and are currently under review. Finally, Energy Service Companies (ESCOs) and other organizations have implemented energy efficient lighting projects.

Strategic options for transforming the market to energy efficient magnetic ballasts, include:

- Increasing the availability of Ring-type magnetic ballast;
- Creating customer demand through customer education and government policy; and,
- Co-operating with the China Green Lights program.

Motor Market Assessment and Strategic Options

Mr. Peter Liu, China Representative, IIEC - China

There are four primary motor categories in China: large/medium motors (>220 kW), small motors (.55 kW – 200 kW), factional horsepower motors, and mini-motors. Fractional horsepower motors and mini-motors are small, intermittently used, and do not offer a cost-effective opportunity for energy savings. The large/medium motor and small motor segments can be further classified as AC (alternating current) and DC (direct current) motors. DC motors are a low volume segment of the market and are being replaced with more advanced variable frequency motor systems. The focus of the motor market assessment is on AC motors.

China produced 41.2 thousand megawatts of motors in 1997. The average annual growth rate was 2.8% over the past 8 years. Small motors account for 70% of total production, over 70% of connected load and about 90% of the energy losses. Annual electricity consumption is estimated at 610M kWh and 5,240M kWh for large/medium and small motors, respectively. Large motors, in general, are custom designed to meet the user specifications and efficiency is included. On average, as motor size increases, motor efficiency increases. Analyzing the small motor production by size, the weighted energy efficiency of small motors is 89.3%, much lower than large motors (~96%), and the weighted copper density is 0.74 kg/kW. The greatest opportunity for energy efficiency is the small AC motor segment between 3 kW and 90 kW. In 1997, 28.6 thousand MW of small AC motors were produced and the average annual growth rate has been 3.2% over the past 8 years.

Market transformation of all new motors produced from Y-series to the YX-series would result in 33.7B kWh of savings per year, within 10 years. This is equivalent to about US $20B per year and approximately 9.7M metric tons reduction of CO_2 emissions. It is reasonable to assume that within 5 years, with appropriate government policy and energy efficient motor standards, 50% of the market can be converted to energy efficient motors, saving 1.4B kWh of energy. If 50% (5,000 MW) of annual failed J-series motors were replaced, instead of repaired, an additional 600M kWh could be saved.

Energy efficient motors could save 33.7B kWh per year within 10 years.

The overall economic growth is slowing and GDP has declined from a peak growth rate of 14% in 1992, to 7.8% in 1998. This has had serious repercussions for industry and motor manufacturers. The motor industry is experiencing slowing market growth, and over 40% of all manufacturers lost money in 1998. Industrial customers, in an effort to improve their poor financial performance, are purchasing the cheapest equipment that performs the specified function. They lack the cash resources to pay the price premium of the more efficient motor. Original equipment manufacturers, responding to the needs of their industrial clients, are reducing equipment costs and energy efficiency is not a consideration.

Compounding the industrial financial problems, which are not favorable for energy efficient motors, is a general lack of awareness of energy efficient motors and their benefits. The top three purchase criteria for motors are reliability, price and quality. The potential for motor efficiency and its economic justification, are rarely considered. Industrial leaders, those that recognize the value of efficiency, find it difficult to find energy efficient motors that meet their requirements. Demand is not

sufficient to justify manufacturer investment in energy efficient motor production. Those energy efficient motors that are produced for the domestic market, are custom designed and manufactured and have very high prices. The industrial motor *purchaser* is generally not the industrial motor *user*, especially in the large state-owned enterprises, and their objectives and interests differ significantly. Thus, even if the *user* requests an energy efficient motor, the *purchaser* will make the purchase decision based primarily on price.

Motor users can be grouped into four categories based on motor usage. The first user group is those industries with high volume requirements and heavy loading, such as the chemical industry, electric power plants, water companies, and oil and refining industries. The primary motor applications are pumps, blowers (fans) and compressors. The second user group is the textile industry. As a single industry, this group has relatively low volume requirements, but the textile machine motors are very heavily loaded. The third group is made up of farmers, individuals, and small industries. This group has a very high demand for motors primarily in general machine tools, but the motors are generally lightly loaded. The fourth group consists of individuals with low volume demand and who use the motors lightly or intermittently. It is the first two groups, the high use segments, for which energy efficient motors are easily cost-justified, and which have the volume requirements to justify motor manufacturer investments. These are the early adopters. The rest of the market will follow these industries, as energy efficient motor availability increases and prices decline.

Most motors for pumps, blowers, and compressors are purchased by original equipment manufacturers (OEMs). Replacement motors and experienced uses, will purchase motors directly from the manufacturer. About 50% of the sales are direct end-user purchases and 50% are through OEMs.

Currently, there are no motor minimum efficiency standards in China.

There are six types of motors installed or produced in China. The oldest is the J-series motor. In 1984, government policies forbid the use and purchase of these motors. However, it is estimated that about 120,000 MW remain in service, accounting for about 30% of the installed base. The Y-series motor is the dominant motor with about 98% share of the domestic market, and is considered the “standard”. It was locally developed in the early 80’s, and accounts for about 70% of total installment. The YX is an energy efficient model of the Y motor. To date, this motor has been unsuccessful in penetrating the market and is not readily available for purchase. In the early 90’s, the Y2 model was developed as an upgrade of the Y-series. It was also locally developed and designed to improve noise and vibration. The Y2 series has a much lower efficiency, lower than the Y-series motor. The Y2E motor is an energy efficient model of the Y2 motor, but efficiency just meets the Y model. In addition to the motors used in the domestic market, China produces motors that meet NEMA standards, tested under the IIEE methodology. These motors are for export only and are not available in the domestic market. The YX motor has the highest efficiency, 92% on average, of the domestic motors. The YX motor is very close to the US EPACT standard motor for efficiency. China has the technology and capability to produce energy efficient motors that meet international standards.

Currently, there are no motor efficiency standards in China. The traditional approach is for the government to initiate policies that either forbid production of low efficiency models or encourage use of high efficiency models. Further, there is no

standardized testing methodology for motor efficiency. The IEEE methodology is used for NEMA-type motors for export. Domestic motors are generally tested to the IEC methodology, or equivalent.

Motor manufacturers can be classified into two groups, small enterprises and large state-owned or joint venture companies. Small enterprises are generally, family or county-owned enterprises. They are characterized by inexpensive labor, low land costs, low social security costs, and tax "exemption". The motors produced by these manufacturers are low priced and often poor quality. Their competitive advantage is price. The large state-owned manufacturers have higher costs, but better quality. Many state-owned manufacturers are losing money due to the economic downturn, continued price pressure from the small manufacturers, and mismanagement. The joint venture companies also have higher costs, but substantially better quality products. Joint venture companies and the state-owned enterprises target exports, which are viewed as a more lucrative market. Internationally recognized manufacturers brand Chinese manufactured motors, and the Chinese manufacturer is unknown in international markets. The export market is reserved, by the government, for select manufacturers. Not all manufacturers are allowed to sell motors for export. Five motor manufacturers serve 50% of the export market and 15 manufacturers serve 50% of the domestic market. There is no dominant motor manufacturer for the domestic market.

Energy efficient motors often payback in less than 2 years.

Energy efficient motors are cost effective on the basis of total owning cost, but most industries evaluate various options based on the time required to payback the higher investment. An energy efficient 55 kW motor would payback a 25% price premium investment in less than 13 months. This analysis is based on the following parameters typical for China industry: average industrial energy cost of $0.06/kWh, annual cost of capacity of $26/kW, typical loading rate of 75%, and 3000 hours of annual hours of operation. Payback times vary with hours of operation and loading, but in most cases the energy efficient motor pays back the added investment in less than 2 years, after which they continue to provide energy and economic benefits for the remaining years of operation. A similar analysis evaluating the cost effectiveness of replacing a failed motor with a new energy efficient motor indicates that the investment would payback in about 1.5 years.

The recognized potential for motor efficiency has resulted in numerous activities to capture the energy, environmental, and economic benefits. In-country, both the State Economic and Trade Commission and the State Development and Planning Commission have announced support for energy efficient motors and motor systems. The China Energy Conservation and Investment Corporation (CECIC) is supporting energy efficient motor leasing and investment opportunities. ESCOs, funded by the World Bank, are still in the early development stage, but are well positioned to implement motor efficiency programs. The China Electric Power Research Institute is currently funded by GTZ, the German aid organization, to establish motor efficiency standards and a motor testing laboratory. The Quality and Technology Standards Bureau has initiated activities to establish energy efficient motor standards. In addition to these China directed initiatives, the US Department of Energy, in collaboration with the China government, is implementing the Motor Challenge program, which is focused on motor systems efficiency. The Technical Cooperation Agreement Pilot Project, funded by the US Environmental Protection Agency, has

identified energy efficient motors as a key area for technical cooperation. By coordinating these organization activities and sharing information and results, the potential to increase motor efficiency is enhanced.

A premium quality motor brand can address issues of quality and efficiency.

To transform the market to energy efficient motors, government policies and motor efficiency standards are required. It has been 15 years since the introduction of the Y-series motor to replace the J-series; thus the timing is right for government efficiency standards. CEEP can help drive an energy efficient motor transformation strategy by initiating actions to address the market barriers. The CEEP strategic goals are to:

- Develop a premium quality motor brand, incorporating efficiency, performance standards, customer service, and product certification and verification. The brand will link quality, efficiency, and environmental benefits;
- Establish a motor component brand to support OEMs with energy-efficient motors;
- Identify financing support for manufacturing and purchase of energy efficient motors;
- Initiate government policy support and standards; and
- Educate customers on energy efficiency and its benefits to their businesses.

Transformer Market Assessment and Strategic Options

Mr. Victor Zhou, Project Manager, ICA - China

The transformer market, RMB 7.52 billion, is segmented into power transformers (110 kV and above) and distribution transformers (35 kV, 10 kV and below). Power transformers are step-up (generation) or large step-down (transmission) transformers and represent 58% of the market, over 124,000 MVA. The average size of each unit is enormous, thus; the number of units purchased each year is limited. Power transformers are custom designed and represent a substantial investment (capital and operating cost) to the electric utility. Efficiency requirements are specified in the design.

Distribution transformers are small step-down transformers used to reduce high voltages needed for efficient transmission to lower voltages for safer consumption by end-users. They average only 330 kVA per unit and totalled over 140,000 units in 1998. Distribution transformers are purchased in volume and are substantially less efficient than power transformers. They tend to be purchased based on lowest price with little or no consideration for efficiency.

Amorphous metal transformers offer the greatest opportunity for improved efficiency.

Transformer demand typically follows demand for electric power and economic growth trends. While recent years (1992-1998) has seen a levelling or slight decline in the annual demand for transformers, historically, annual transformer growth has averaged over 7% per year since 1978. However, the government has recently initiated a 3-year project to upgrade the urban and rural power grid. The project will result in the replacement of a large number of outdated distribution transformers, increasing the demand for distribution transformers over the next couple of years.

Distribution transformers may be oil-filled or dry-type and may be designated by the core material, such as amorphous metal transformers (AMTs). Oil –filled transformers represent 85% of the annual production (47M kVA) with dry-type and amorphous metal transformers making up the balance.

Amorphous metal transformers (AMTs) and foil-wound (copper) dry-type transformers offer the greatest opportunity for improved energy efficiency. Comparing the no-load (core) losses and load (coil) losses of various 315 kVA, 10kV distribution transformers, amorphous transformers have substantially more efficient cores and slightly more efficient coils than the other oil-filled S7 and S9 distribution transformers. In the dry-type transformer market, foil-wound transformers have significantly more efficient core and coils than the standard wire-wound transformer.

Today, distribution transformers account for over 17 billion kWh of energy loss per year. At the current rate of transformer growth and adding/replacing with conventional transformers, distribution losses will increase to almost 55 billion kWh within 20 years. If, instead of the current conventional high-loss transformers, energy-efficient amorphous metal core transformers were installed, transformer losses would only increase to 30 billion kWh of loss per year. The potential savings are 25 billion kWh per year within 20 years. Twenty-five billion kWh is equivalent to 31 billion RMB, if the additional power is sold. From an environmental perspective, saving 25 billion kWh would result in a 28 million metric ton reduction of CO2 emissions.

Electric utilities are the largest purchasers of distribution transformers.

Electric utilities are the largest purchasers of distribution transformers, accounting for 67% of the total demand: 75% of the traditional oil-filled transformers, 20% of dry-type and 100% of the amorphous metal transformers. Industrial, commercial and residential buildings make up the balance and are the primary customers for dry-type transformers, which account for 80% of the market. Reliability, safety, and meeting technical specifications are the basic purchase requirements for distribution transformers. The second most important factor is price. Losses or energy efficiency are not considered and are ranked after the design institute recommendations.

The State Machinery Bureau (SMB) is responsible for the management and regulation of the transformer industry. It also initiates government transformer policy. The State Economic and Trade Commission (SETC) and the State Development and Planning Commission (SDPC) are the key decision-makers on energy conservation policies and program implementation. The Shenyang Transformer Research Institute is responsible for technology development and it influences transformer technology innovation. Transformer purchasing processes are complex and bureaucratic.

Industry/commercial purchase process: The transformer purchase for an industry or commercial application begins at the industrial company's power department, which submits a transformer request and proposal for purchase to the company's "decision-makers" for approval. Once approved, the power department sends their requirements to the design institute. The design institute provides the transformer design and technical advice. The finalized design is then sent to the electric utility for approval. Without utility approval, the transformer may not be allowed to operate. After receiving approval from the electric utility, the industry's purchasing department begins the transformer manufacturer selection and bid process. The budget for the transformer purchase generally comes from the company's internal funds, although they can apply for commercial loans. Some projects may apply for energy conservation loans from international or domestic financing sources.

Utility purchase process: The transformer purchase process for the utility is less complex, because the utilities have more transformer technical expertise and

departments to manage the transformer design and selection process. Although the utility does not rely on the design institute for transformer designs and technical advice, they must still work with the institute for final approval.

The standard distribution transformer technology in use is oil-filled transformers with silicon-iron cores and copper windings. The cores are stacked laminations using a variety of grades of silicon steel, depending on the level of efficiency. Most silicon-iron core material is manufactured domestically. The cold-rolled, grain oriented silicon iron ranges in thickness from 0.3 mm to 0.35 mm and has losses from about 1.47 Watts/kg to 1.51 Watts/kg. The coils are circular and use copper wires.

The technology to produce energy efficient transformers is available in China.

Amorphous metal transformers, which offer the greatest opportunity for energy efficiency, are manufactured in limited quantities in China. There are three technology obstacles that are limiting market penetration of this technology. First, the technology, to commercially produce amorphous metal, is owned by AlliedSignal, Inc. and thus the material is imported from the United States. Second, the process for manufacturing an amorphous metal core is different from conventional cores and requires technology and capital investments. AlliedSignal has established a core production facility in the Pudong area of Shanghai. This facility has an annual capacity of about 700 MT or 340 MVA. The government has made substantial investments to develop amorphous core manufacturing capability and recently announced successful completion of their research and trial production. It has been announced that by the end of 1999, a local company to manufacture amorphous metal cores will be established, with 1000 MT of capacity. Thus, by 2000, the total domestic core supply will by 1,700 MT or about 820 MVA. The third obstacle is the technology to produce the amorphous metal transformers. A number of transformer manufacturers have produced amorphous metal transformers in trial quantities, as prototypes. Currently, there is only one commercial amorphous metal transformer production plant, Zhixin Transformer Company, which has established volume production capacity, utilizing GE transformer technology and cores from AlliedSignal. Additional demand would have to be met with imported transformers, at higher costs. Thus in the short-term, the market penetration for amorphous metal transformers is limited.

For the dry-type transformer segment, transformers with coil windings made of copper foil (foil-wound) are the emerging technology. The current standard dry-type transformer has coil windings of copper wire. Increasing the copper content of the coil windings increases the transformer's efficiency. A 315 kVA standard dry-type transformer has no-load losses of about 1500 watts and load losses of 4000 watts. The same size energy efficient foil-wound dry-type transformer would have no-load losses of 900 watts and load losses of about 3300 watts, a 40% improvement in core losses and about an 18% improvement in coil losses. The primary barrier, to foil-wound dry-type transformer market penetration, is the lack of foil winding technology and equipment. The equipment is not available in China and import costs are high

Most distribution transformer manufacturers are state-owned and the top 10 manufacturers account for about 1/3 of total production, the other manufacturers are small. Shanghai Transformer Plant is the largest distribution transformer manufacturer with production of 2,177 MVA in 1997. The large manufacturers supply transformers nation-wide, while the small manufacturers service the local or provincial utility. The large manufacturers compete based on quality and price. The

small manufacturers compete based on price and rely heavily on their relationships with the utility. Most transformers, for daily operations, are purchased from local suppliers where the utility has an established relationship or is familiar with the product. For large projects, or projects with foreign investment capital, a transformer bidding process is initiated. Although there have been discussions regarding Total Owning-Cost evaluation methodology and capitalization of losses, no utilities in China have adopted this purchase process. Higher priced energy efficient transformers cannot compete in a price-only decision process. The market penetration of amorphous transformers is largely due to government support for amorphous metal trials and prototype units. A few utilities continue to be interested in these energy efficient transformers and make special quantity purchases.

Dry-type transformer manufacturers are centrally located in Quangdong and Shanghai. The top 8 serve 80% of the market. Shunde Special Transformer Manufacturer is the largest producer and supplies demand in China and Asia, with production of 2,470 MVA in 1997. Like the distribution transformer market, dry-type transformer manufacturers compete exclusively based on price. Dry-type transformers are sold directly to the to the residential building, industrial or urban utility customers. For distribution transformers and dry-type transformers reliability and safety are standard requirements, which must be met, before the manufacturer is qualified to compete for the transformer business.

The greatest barrier to energy efficient transformer market penetration is first cost purchase practices.

As previously mentioned, utilities purchase transformers based first on price and second on their relationship with the manufacturer or familiarity with the product. New S-9 transformers were priced about 10% higher than the traditional S-7 transformers. Market penetration of S-9 transformers was limited, until the government ban production of the S-7 transformers. Demand has increased from 10%, prior to the policy, to 50% within 10 months of the policy announcement. The price for amorphous metal transformers has declined from 170% to 140% of the S-9 transformer. Amorphous transformers cannot compete based on price. The value of the amorphous transformer is the energy savings. In order to determine if these energy efficient transformers are cost effective, utilities analyze the time required to payback the price premium. At a 40% price premium, amorphous metal transformers payback within 5 years, after which the utility continues to benefit from energy savings over the remaining life of the transformer, 15 to 20 years.

The most significant in-country transformer initiative is the SDPC and SETC regulation, which as of January 1, 1999, bans production and sale of the inefficient S7 transformers. All manufacturers are now producing the S9 transformers. Further, the largest purchaser of distribution transformers, the State Power Co., has initiated a 3-year power grid-upgrading project, which will drive transformer sales and improve the efficiency of the distribution network. Further, the State Power Co. is being restructured from a government organization to an industry, although it is difficult to determine what impact this is likely to have on the transformer market.

To transform the market to energy efficient transformers a 4-pronged approach is required. The first strategy is targeted at the transformer purchaser. The value of energy savings must be included in the purchasing process. Education and promotion of the value and need to capitalize (place a monetary value on) energy losses and adopt a lowest total owning cost purchase practice is required. The electric utilities and government would be the target audience for this strategy. Government policies

must be initiated which encourage adoption of TOC purchasing practices and that provide incentives to purchase energy efficient transformers, are needed to drive utility actions. The availability of supply must be increased. Increased competition and volume driven purchasing may also help lower the price of energy efficient amorphous metal transformers. Finally, financial support is needed for manufacturing investments and to help break the high-price/low-volume cycle.

Financial Institution Support

Ms. Zhang Ruiying, Project Manager and Senior Engineer, China Energy Conservation Investment Corporation (CECIC)

The China Energy Conservation Investment Corporation was originally established in 1992, as a department under the State Development and Planning Commission (SDPC). In 1988, it was realigned under the State Energy Investment Corporation as an energy conservation company. Finally, in 1994, the Energy Conservation Company was restructured as CECIC. CECIC, headquartered in Beijing, is the only State investment corporation for energy conservation and environmental investments. It is directly under the State Council Large Enterprise Committee and has registered capital of US $242 million and assets of $1.2 billion. In addition, CECIC has 22 sole-owned companies.

There are numerous channels for financing energy efficiency investments including CECIC, the government "special loan for energy conservation", domestic commercial banks, international financing organisations, foreign government loans, and direct foreign investment. The government special loan for energy conservation investments was established in 1982, and provides about US $295 million in loans per year. CECIC is responsible for project evaluation for these loans and, once approved, the domestic commercial banks arrange the loan. Qualified projects may also get favourable interest rates from the Minister of Finance. Domestic commercial bank lending rates range from 6.33% for loans longer than 5 years to 5.58% for loans of 1-6 month duration.

There are numerous channels for financing energy efficiency investments.

In addition to domestic financing sources, there are a number of foreign lending sources. The World Bank (WB) provides about US $2.5 billion in loans to China annually. Industrial projects are generally 20 year loans (extendable by 4-5 years) at the London Inter-Bank Operation Ratio (LIBOR) +.75%. The Asian Development Bank (ADB) provides about US $1 billion in loans per year. Industrial loans are generally 24-25 year loans (extendable by 4-5 years) at LIBOR +.65%. Foreign government financing is provided for the primary purpose of supporting country development and 35% of this funding is donated. The sources of foreign government funds include the Overseas Economic Co-operation Fund (OECF), through energy loans, and the Black Font Flow-back from Japan, and other government loans. Additional information on foreign government loans is provided in the attached presentation. In addition to the multilateral development banks and foreign government loans, the Global Environmental Facility (GEF) provides funding for power generation and transmission, industrial energy efficiency, energy efficient equipment manufacturing, and heavy load industry processing. The US Energy Foundation provides funding in four focus areas including construction, electric

energy efficiency and renewable energy, transportation, and clean energy technologies.

Direct foreign investment for establishment of businesses is encouraged. There are three primary methods for direct foreign investments: sole-owned foreign enterprise, Sino-foreign joint venture, and Sino-foreign co-operation venture. The UN Industry Development Organisation (UNIDO) is an effective resource for companies interested in establishing an enterprise in China. UNIDO provides technical support for industry co-operation and capital investment for feasibility studies, project evaluations, and establishment of manufacturing processes. UNIDO has a network of over 30,000 enterprises in developed countries with experts in each industry. UNIDO helps to link the potential investor with the appropriate enterprise and local government. They provide investment suggestions, support the negotiation and project evaluation process, train officers in charge of the foreign investment, participate in investment discussions and help organise the training and education for the enterprise. UNIDO has established an investment assessment centre in Beijing. The Beijing Investment Assessment Centre was established in 1998, within CECIC, as a technical service organisation for UNIDO. To access the resources of the Beijing Investment Assessment Centre, an enterprise must initiate a project proposal for which they are seeking funding and sign a contract with the Centre. The Centre evaluates the project, according to UNIDO methodology, and provides an assessment report. Qualified projects are distributed to UNIDO foreign offices to seek investment funding and are registered on UNIDO global information network. The enterprise participates in UNIDO investment forums and UNIDO helps organise visits to potential foreign partners.

UNICO is a resource for companies interested in establishing businesses in China.

Mr. Zhou Xiaotao of Shenzhen Jiangneng of the Machine and Electricity Control Technology Co.

Mr. Zhou discussed the opportunity for energy efficient product leasing and provided examples of speed adjustable motor systems in the chemical industry. Once CECIC has invested in the equipment for the chemical manufacturer, they generally get paybacks within 2-3 years. The difficulty is getting the cash from the chemical company.

Ms. Georgia Badelt, Project Co-ordinator, German Development Co-operation, GTZ

GTZ is a non-profit, Federal German government agency for technical co-operation. GTZ supports sustainable development in emerging countries, by working in partnership with these countries to develop and implement technical assistance projects that enhance manpower and operational efficiency and that are designed to meet the specific needs and interests of that country. GTZ's principles and objectives are to improve human existence, preserve the natural environment, strengthen the country's human and institutional capacity, and ensure sustainable development.

GTZ provides technical assistance for sustainable development in emerging countries.

GTZ programs focus on awareness and capacity building through vocational training and education, often taking a train the trainer approach. They provide advisory services in the areas of price reform, and establishing appropriate legal, financial, and institutional frameworks. GTZ provides support for demonstration projects, such as schools and wind projects, and promotes private-public partnerships. It is not a

funding institution which provides grants and loans to partner countries, although they do support procurement of equipment.

Programs supported by GTZ go through an extensive pre-evaluation process, which starts with an official proposal from the partner country government, in China this is the Ministry of Finance and Technical Economic Commission (MOFTEC), to the German Federal Ministry of Economic Co-operation and Development. The proposal is reviewed, Sino-German negotiations are conducted, and an appraisal mission is initiated with GTZ and the in-country partners, to jointly define the project's objectives, measurables, and activities. Assuming a positive outcome, the project is then recommended for implementation, commissioned and finally executed by the in-country partners, with project support from GTZ.

GTZ has experience implementing projects and promoting energy efficiency on a multi-national basis, such as the DSM programs in the US, Germany, and Thailand and pilot projects in Jordan and Zimbabwe. GTZ also supports single country initiatives, such as energy audits and demonstration projects in India, implemented with their in-country partner the Tata Electric Research Institute (TERI), and Thailand energy conservation programs.

China receives 10% of GTZ funds to Asia.

Twenty-eight percent of all German technical assistance funds flow to Asia, of which, 10% is for projects in China. Project funding in China is for vocational training and education (34%), environmental protection (23%), sector programs (23%), and economics and restructuring reforms (13%). Technical co-operation programs on energy promote efficient energy supply and use as an essential element to ecological and economic sustainability. In 1999, GTZ is supporting 67 projects including:

- Promoting the application of international environmental standards;
- Promoting wind and solar energy;
- Supporting the protection of natural resources;
- Promoting CFC-substitution technology in the transportation industry; and,
- Promoting small and medium size industry.

Ms. Badelt highlighted 3 GTZ programs relative to the CEEP initiative. The first program focuses on environmentally sound urban energy planning in 3 select cities: Hohhot, Suzhou, and Beijing. The objective is to transfer know-how on integrated energy planning. The second program focuses on energy conservation and modernization of electric supply. The objectives are for energy consultants, manufacturers and users to take action based on internationally accepted norms and standards and for energy suppliers to apply modern techniques to ensure reliable, cost-effective energy supply. The third program targets the reduction of CO_2 emissions in industry in 3 provinces by applying co-generation technologies to improve energy efficiency.

GTZ is an important supporter and promoter of energy efficiency. Co-ordination and co-operation between GTZ programs and the CEEP initiative will be explored to identify synergies that will support the mutual success of these programs.

Panel Discussions

Transformers

Mr. Victor Zhou, ICA, Moderator

Participants: 20 delegates from transformer manufacturers, transformer material producers, utilities, and government departments in Shanghai, Zhejiang Jiangsu, Shandong, and Beijing.

Discussion: In general, there was consensus on the proposed transformer market strategy and participants were very interested in the market information and analysis. The background and evolution of the two emerging technologies, amorphous metal and foil-wound transformers, was discussed. The higher price for energy efficient transformers was identified as the most significant barrier to market penetration. Utility representatives pointed out that there is no loss evaluation process for distribution transformers, although the method is in place for large power transformers. The panel believed that government initiative and policy was essential to remove the barriers and that the volume-price guarantee strategy was an interesting proposal.

In addition to new transformer efficiency, the panel noted that half of the transformers in-service are inefficient. Replacement of these units with either S-9 or amorphous transformers would present additional energy savings. There was considerable discussion about the amorphous metal transformer technology and Shanghai Zhixin Transformer Co., an amorphous transformer manufacturer, was queried about production capacity, customer feedback, and operational performance. Zhixin noted that the price of an amorphous transformer is now less than 1.4 times the price of the S-9 transformer and that they can provide sizes up to 1,600 kVA. A customer from the petrochemical industry indicated interest in amorphous transformers and plans to purchase a unit for trial operation.

Manufacturers of transformer winding materials provided a review of the progress on the copper foil technology. Some domestic copper foil manufacturers now have the capability to produce qualified copper foil for dry-type and oil-type transformers. These manufacturers serve about 50% of the domestic copper-foil market. The copper-foil market for transformers is less than 1% of the total transformer copper winding market.

Government policies and support are critical for all the energy efficiency opportunities.

Motors

Mr. Peter Liu, IIEC, Moderator

Participants: 19 delegates from motor manufacturers, users, industry associations, and utilities from Beijing, Helongjian, Shangdong, Jiangsh, Shanghai, Hebei, and Henan provinces.

Discussion: In general, there was consensus that technology was not the major issue to energy efficient motor market penetration; manufacturing capability and capacity exists for the export market. Motor manufacturers expressed interest in developing the domestic market.

From the manufacturer perspective, there are two primary barriers to market penetration: customer purchase considerations and government attitude. Customers have little knowledge about the benefits of energy efficient motors and are not willing to pay a premium for efficiency. Motor prices are being driven lower and lower and purchasing departments have difficulty getting approval for higher budgets to purchase the more efficient equipment. Government policy and actions still have a very strong influence on both the manufacturer and end-user attitude and actions and is required to move the market. Manufacturers are hesitant to be market pioneers and take risk, without the support of the central government. Without government support, manufacturers would have difficulty being successful developing the market.

The panel believed that there should be government policy providing an incentive mechanism, such as reduced duty or taxes, for energy efficient motor manufacturing and use. Without these incentives, they believe it will be hard to trigger the market, in the early stage. Regarding an energy efficient motor standard, there were two differing opinions. Those manufacturers, who have the capability and technology to produce products that meet the standard, welcomed the standard. Those manufacturers who did not have the technology, believed that a standard would increase R&D, marketing, and distribution costs.

In summary, motor manufacturers and users were very supportive of the project and are interested in co-operating to define the China Premium Quality Motor (CPQM) and to co-develop the market. Motor manufacturers were especially interested, because they view this as a good opportunity to upgrade the China motor industry. Defining the CPQM and driving government initiatives were identified as the next steps.

Ballasts

Mr. Hank Qiu, ICA, Moderator

Participants: 21 delegates from Guangdong, Fijian, Shanghai, and Beijing participated representing ballast and lamp (both domestic and foreign-funded) manufacturers, energy conservation centres, and government regulators.

Discussion: There was consensus from manufacturers of electronic and magnetic ballasts that both technologies would co-exist in the foreseeable future. The advantages and disadvantages of both technologies were discussed, and it was agreed that any widely accepted product must provide advantages in terms of environmental protection, energy conservation, and economics. Magnetic ballasts are believed to provide advantages environmentally and economically and to be competitive on efficiency. An analysis, conducted by the China Certification Centre for Energy Conservation Products and the Lawrence Berkeley National Laboratory, indicated that high-efficiency (ring-type) magnetic ballasts have a lower total owning cost (TOC) than that of electronic ballasts for household and public use.

The panel discussed the merits of Ring-type ballasts and generally supported the promotion and development of this technology, although there are some practical considerations. Ring-type ballasts may be superior for HID and fluorescent lamps above 15 watts, they are not competitive in CFLs. Most participants agreed that the

HID market was the best area to promote ring-type ballasts and that the potential for energy savings was large.

Regarding ring-type ballast technology, the early ring-type ballast technical issues are believed to have been resolved in recent years. There were no design issues and quality winding machines were now available from Shanghai Jason and Shanghai Hualiang. Winding speeds can reach 500-600 turns/minute for copper wire under 2 mm^2 and 200 turns/minute for wire of 4 mm^2, which is comparable to international standards. In addition, the price of domestically manufactured winding machines were substantially lower (RMB 18,000 $\simeq$ Us $2,200) than imported machines (US $25,000). Good quality cold-rolled silicon steel laminations are required for ring-type ballasts. Steel laminations from discarded transformers and scraps from lamination punching workshops can be used. Use of these lower cost raw materials can help reduce the final product price. Manufacturing capacity appears to be the major barrier to market growth. One manufacturer indicated that he did not have the capacity to meet demand and that he could not get the funds for technical renovation and capacity expansion. Representatives of large ballast manufacturers (Jiufo Co. in Guangdong and Guorong Co. in Shanghai) indicated that their companies are considering producing ring-type ballasts.

All ballast manufacturers, regardless of ballast type, agreed that the government must regulate the market and did not support "no-order" competition. They believed that manufacturers of low-quality, in-expensive products would compete, creating chaos in the market. Ballast standards, certification, and labelling of qualified products was discussed and a computer program designed to help consumers make the most cost effective (lowest TOC) choice was presented. The participants were interested in promotion and expansion of the software, after it has been appraised and accepted by the experts.

The participants supported the strategies and promotional activities to support development of the Ring-type ballast. However, the penetration of fluorescent lamps into the incandescent lamp market was viewed as a long-term process and unlikely to have a significant impact in the short-term. Two reasons were identified for this pessimism. First, incandescent lighting has a softer light and aesthetic value. Second, for residential use, incandescent lamps are more cost effective. Some participants suggested that energy conservation is like a culture, and, like system engineering, should be treated comprehensively. The government was viewed as the major player for continual efforts to educate the market and to regulate the technology.

Summary and Conclusions

ICA will continue market development initiatives for transformers and ballasts.

All three technologies, energy efficient motors, transformers, and low-loss magnetic ballasts, can provide substantial energy savings. All three technologies require government initiatives to drive the market. Recent government policies, in support of more efficient new S-9 transformers and banning the production of the inefficient S-7 transformers, will make a significant impact on distribution system efficiency. Further opportunities are available with amorphous metal distribution transformers and dry-type transformers. Low-loss magnetic ballasts have been included as part of the China Green Lights program and an energy efficiency standard is being

developed. The International Copper Association, through their energy-efficiency program, will continue to support the transformer and ballast initiatives.

CEEP will focus on energy efficient motors, where there is an enormous, untapped, energy saving opportunity. Government organizations, research institutes, and manufacturer interest is high and there are many relevant activities on going, although these efforts are not cohesive. Currently, no standards exist for energy efficient motors and it has been 15 years since the government issued a policy supporting motor efficiency. The timing is right for a government motor initiative. The challenge for CEEP, in order to drive a market shift to more efficient motors, is to act as the catalyst for action and to leverage the support and activities of all the on going motor programs.

CEEP will focus market development initiatives on energy efficient motors.

A PQM working team will be established.

Within the next couple of months, a Premium Quality Motor working team will be formed to lead the market transformation initiative and define the PQM brand. IIEC will follow-up with the workshop participants, providing a summary of the proceedings and soliciting participation on the team.