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International Industrial Sector Energy Efficiency Policies

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1. Introduction

Over 40% of the energy consumed globally is used in the industrial sector. In China, this sector consumes an even larger proportion, reaching nearly 70% in 1997. A variety of energy efficiency policies and programs have been instituted in both industrialized and developing countries in an effort to improve the energy efficiency of the industrial sector. There are very few comprehensive evaluations of these industrial sector energy efficiency policies; however a number of recent workshops and conferences have included a focus on these policies. Three important meetings were the International Energy Agency's *Industrial Energy Efficiency: Policies and Programs Conference* in 1994, *Industrial Energy Efficiency Policies: Understanding Success and Failure – A Workshop Organized by the International Network for Energy Demand Analysis in the Industrial Sector* in 1998, and the American Council for an Energy-Efficient Economy's 1999 *Summer Study on Energy Efficiency in Industry*. Many articles from these meetings are included as attachments to this memo.

This paper provides a brief description of each of seven categories of individual industrial energy efficiency policies and programs, discuss which industrial sectors or types of equipment they apply to, and provide references for articles and reports that discuss each policy or program in more detail. We begin with mandatory-type policies and move to more voluntary-type policies. We then provide a brief description of four *integrated* industrial energy efficiency policies and provide references for articles and reports that describe these policies in greater detail.

There many types of policies and programs that have been used in countries worldwide to improve energy efficiency in the industrial sector. We classify these policies and programs as follows:

- Regulations/Standards
- Fiscal Policies
- Agreements/Targets
- Reporting/Benchmarking
- Audits/Assessments
- Information Dissemination and Demonstration
- Research and Development

Some of these policies and programs are implemented in specific sectors. For example, agreements and targets are usually made with an association or entity representing a particular sector such as the iron and steel or cement industries. Other polices and programs are directed at equipment that is found in many sectors. For example, regulations or standards for motors will affect motor energy use in almost all industrial sectors.

The most effective way to improve industrial energy efficiency is through an *integrated approach*, where a number of policies and programs are combined to create a strong overall industrial energy efficiency policy that addresses a variety of needs in many industrial sectors. Examples of such integrated industrial energy efficiency policies include the Danish Agreements on Industrial Energy Efficiency, Long-Term Agreements on Energy Efficiency in The Netherlands, the Canadian Industry Program for Energy Conservation, and the Norwegian Industrial Energy Efficiency Network.

2. Individual Industrial Energy Efficiency Policies and Programs

2.1 Regulations/Standards

Regulations and standards are mandatory policies for improving energy efficiency. Regulations and standards are typically applied to particular pieces of equipment such as motors or boilers that are used in a variety of industrial processes (Hall, 1997). Regulations and standards can also be used for equipment specific to an industry, such as electric arc furnaces or rotary kilns. In addition, regulations can require that industrial facilities conduct energy audits, employ an energy manager, or adopt an energy management system. Examples of regulations and standards include Brazil's adoption of minimum efficiency levels for high-efficiency motors (de Oliveira et al., 1997; Geller et al., 1998), Canada's Energy Efficiency Regulations (Whelan, 1997), the U.S. Energy Policy Act Motor Efficiency Standards (Balducci, 1997; Nadel and Elliott, 1997; Schiehing, 1997), the U.S. Federal Energy Management Program that requires federal facilities to purchase energy-efficient equipment (Clinton, 1999), the Mandatory Energy Manager programs in Italy and Japan (Rega and Mebane, 1994), and the mandatory energy audits and energy management systems required in the Danish Agreements on Industrial Energy Efficiency (Togebly et al., 1999).

2.2 Fiscal Policies

Fiscal policies include imposition of taxes, tax rebates, investment tax credits, and establishing investment bank lending criteria for promotion of energy efficiency.

Taxation policies are a mandatory means for influencing the introduction of energy efficiency. For example, Denmark has a mandatory CO₂ tax where the level of taxation depends on the purpose of the energy use, the type of energy used, and whether an agreement for improving energy efficiency exists between the company and the Danish Energy Agency (Ezban et al., 1994; Josefsen, 1999; Togebly et al., 1998; Togebly et al., 1999). Taxation policies can also influence energy efficiency through the use of tax rebates or investment tax credits. In Denmark, the government provides tax subsidies for energy managers. Both energy bonus taxes (subsidies to stimulate investments in energy efficient equipment) and investment grants and credits for combined heat and power systems have been used in The Netherlands (Farla and Blok, 1998). Finally, tax credits for investments in combined heat and power have been proposed in the U.S. (Geller, 1999).

Investment bank lending criteria can be established to give higher priority for funding projects that improve energy efficiency (Inaba, 1994). Recently, an analysis of this type of program was made that evaluated ways that the Industrial Development Bank of India could improve energy efficiency in ten industrial sectors of the Indian economy (Sathaye et al., 1998).

2.3 Agreements/Targets

Agreements to meet specific energy use or energy efficiency targets are used widely in the industrial sector (Bertoldi, 1999; Chidiak, 1999; Hansen and Larson, 1999; Mazurek and Lehman, 1999; Newman, 1998). Such agreements, which are typically but not always voluntary, are defined as "agreements between government and industry to facilitate voluntary actions with desirable social outcomes, which are encouraged by the government, to be undertaken by the participants, based on the participants' self-interest" (Storey, 1996). An agreement can be formulated in various ways; two common methods are those based on specified energy efficiency improvement targets and those based on specific energy use or carbon emissions reduction commitments. Either an individual company or an industrial subsector, as represented by a party such as an industry association, can enter into such agreements.

A recent analysis of five of these voluntary agreements found significant differences between the structure of the agreements and the performance and effectiveness of the agreements. This analysis concluded that "the effectiveness of voluntary agreements can be seen as strongly dependent on the accompanying policy mix and the supporting framework which has to be adapted to the specific conditions of the target group envisaged" (Krarup and Ramesohl, 2000).

Examples of industrial sector agreements and target programs include the following:

- Australia: Energy Smart Business Program (Cooper et al., 1999)
- Canada: Industry Program for Energy Conservation (CIPEC) (Jago, 1999; McKenzie, 1994)
- Denmark: Agreements on Industrial Energy Efficiency (Togebly et al., 1998; Togebly et al., 1999)
- France: Voluntary Agreements on CO2 Reductions
- Finland: Agreements on Industrial Energy Conservation Measures
- Germany: Declaration of German Industry on Global Warming Prevention (Ramesohl and Kristof, 1999)
- Japan: Keidanren Voluntary Action Plan on the Environment (Japan Federation of Economic Organizations, 1998)
- Netherlands: Long-Term Agreements on Energy Efficiency (Ministry of Economic Affairs, 1997; Nuijen, 1998; Rietbergen et al., 1998)
- Sweden: ECO-Energy
- U.K.: Energy Efficiency Best Practice Program (Miles, 1994), Make a Corporate Commitment Campaign (MCCC)
- U.K.: Energy-Intensive Industry Sector Efficiency Targets (Environmental News Service, 1999)
- U.S.: Voluntary Aluminum Industrial Partnership; PFC Emissions Reduction Partnership for the Semiconductor Industry

2.4 Reporting/Benchmarking

Programs or policies that promote or require reporting and benchmarking energy consumption have been implemented in some countries (Sun and Williamson, 1999). Reporting facility energy use has been shown as an effective means of raising management awareness of internal energy consumption trends while benchmarking energy use provides a means to compare the energy use of one company or plant to that of others producing the same products. Reporting and benchmarking programs have been established in Canada (Jago, 1999; Munroe, 1999), Norway (Finden, 1998; Helgerud and Mydski, 1999; Institute for Energy Technology, 1997), the U.K., and the U.S. (Martin et al., 1999; U.S. EPA, 1998). In addition to such national programs, specific industrial sectors such as the petroleum refining industry have benchmarking programs (Solomon Associates, 1999).

2.5 Audits/Assessments

Audits or assessments of industrial facilities provide managers with information regarding current energy use patterns as well as opportunities to reduce energy use through implementation of energy efficiency measures. Such audits can be done through a government program, such as the U.S. Industrial Assessment Centers (Clark and Birkmore, 1999; Muller and Barnish, 1998), the Iowa Energy Center (Haman, 1999); the Danish energy audits (Josefsen, 1999), the TERI Bangalore/GTZ audit program in India, and the Annual Self Audit and Statement of Energy Accounts Scheme in Ireland. Audits and assessments can also be performed by independent energy service companies (ESCOs). ESCOs typically assume the technical, financial, and operational risks associated with implementation of the identified energy efficiency measures and are paid through the realized energy savings (Vine et al., 1998).

2.6 Information Dissemination and Demonstration

Information dissemination and demonstration programs provide industries with information on energy efficiency technologies and practices that may be difficult, costly, or time-consuming for individual enterprises to gather. Examples of these programs are the U.S. Industrial Assessment Centers (Muller and Barnish, 1998), Norway's Industrial Network for Energy Conservation (Finden, 1998), and the U.K.'s Energy Efficiency Best Practice Program (Miles, 1994).

Utility or national demand-side management (DSM) programs provide information on energy efficiency technologies and measures, design assistance, financial information, technology demonstrations, and many other information-type services. Industrial DSM programs have been established in the U.S., Europe, and some developing countries such as Brazil (de Almeida and Fonseca, 1998; Schaeffer, R., 1998).

2.7 Research and Development

Research and development of technologies is defined as creative work undertaken on a systematic basis to increase the stock of knowledge, including knowledge of people, culture and society, and the use of this knowledge to devise new applications. Different stages of R&D can be distinguished, including basic research, applied research, experimental work and demonstration. R&D can have various goals, depending on the barriers to be tackled to implement a technology. Blok et al. (1995) differentiate between technical development of a technology, improving the technology to reduce costs, and exploration and alleviation of barriers to the implementation of a technology.

R&D for the industrial sector is performed by private companies as well as by governments. In the U.S., industrial sector R&D related to energy efficiency is carried out by the U.S. Department of Energy, Office of Industrial Technologies (Friedman and Podolak, 1999). The Joule program focuses on research and development in the field of innovative energy technologies in Europe while the Ministry of International Trade and Industry (MITI) is responsible for this research in Japan.

An important aspect of R&D for developing countries is that of adaptation of technologies to local conditions. The technical operating environment in these countries is often different from that of industrialized countries. For example, different raw material qualities, lower labor costs, poorer power quality, higher environmental dust loads, and higher temperatures and humidity require energy efficiency solutions that differ from successful solutions in industrialized country conditions. In practice, adaptation practices vary widely in various countries. For example, Chinese enterprises have spent, on average, only 9 (US) cents on assimilation for every dollar on foreign technology in contrast to countries such as S. Korea and Japan where the amounts spent on assimilation were greater than those spent on technology itself (Suttmeier, 1997).

3. Integrated Industrial Energy Efficiency Policies

3.1 Danish Agreements on Industrial Energy Efficiency

The Danish Agreements on Industrial Energy Efficiency are the most stringent of the four example integrated policies. This national policy integrates the following components:

- Regulations: Mandatory Energy Audits/Energy Management Systems
- Fiscal Policies: Taxation and Subsidies
- Agreements/Targets

Denmark has committed to reduce national CO₂ emissions from all sectors by 20% in the year 2005 compared to 1988 emissions (Togebjerg et al., 1999). The industrial sector is expected to contribute to this goal by reducing CO₂ emissions by 4.6% in 2005 relative to 1988 emissions (Togebjerg et al., 1998).

The Danish Agreements on Industrial Energy Efficiency are based on the imposition of a mandatory carbon dioxide emissions tax where the level of taxation depends on the purpose of the energy use, the type of energy used, and whether an agreement exists between the company and the Danish Energy Agency. The agreements, which are made by an individual company or an association of companies with the Energy Agency, are made for a period of three years in order to qualify for a lower CO₂ tax rate. Between 1996 and 1998, 143 companies entered into agreements with the Danish Energy Agency, representing 45% of total industrial energy consumption in Denmark. Under the agreements, the companies are required to implement all “profitable” energy savings projects which are defined as projects with payback periods of up to four years as identified in an energy audit. The energy audits are performed by an authorized energy consultant or company staff and they must be verified by an independent certified organization. In addition, companies must introduce energy management and motivate staff to ensure investments in new equipment will be energy efficient. Subsidies are provided for up to 30% of the cost of these investments in energy-efficient project.

One analysis of this program found that firms with an agreement in 1993 had electricity savings of 7% while those who did not have agreements (and thus were subject to the full CO₂ tax) had electricity savings of 8% (Bjorner and

Togebly, 1999), illustrating that similar savings can be achieved through policies and measures as those achieved using taxation alone. To date, these agreements have seen a reduction in energy consumption of 2 to 4% of total energy consumption per agreement after three years (exceeding business-as-usual by about 1% per year) (Togebly et al., 1999). If this rate of improvement continues, it is projected that the goal of 4.6% reduction in total CO₂ emissions from industry in 2005 relative to 1988 will be met (Togebly et al., 1998).

3.2 Long-Term Agreements on Energy Efficiency in The Netherlands

The Long-Term Agreements on Energy Efficiency in The Netherlands are voluntary, but formal and legally binding agreements between industry associations and the Dutch Ministry of Economic Affairs. This national policy integrates the following components:

- Fiscal Policies: Investment Tax Credit
- Agreements/Targets
- Reporting: Energy Use Monitoring and Reporting
- Audits/Assessments: Energy Conservation Plans and Audits
- Information Dissemination and Demonstration: Demonstration Program

The initial agreements were made in 1989 and had an overall target of 20% improvement in energy efficiency in 2000 compared to 1989 (improvement of approximately 2% per year). There are 31 long-term agreements with 26 industries comprising 863 companies. These companies represent 90% of Dutch industrial energy consumption. Under the agreements, the companies prepare and implement energy conservation plans. The companies also monitor and report energy consumption data on an annual basis. The Dutch government provides an investment tax credit as an incentive for investments in new energy-efficient equipment as well as a demonstration and auditing program for the companies that have agreements in place.

Recent evaluations of the Long-Term Agreements have found that most industries are on schedule to meet their target reductions in energy efficiency by 2000, although some industries are having difficulty (Ministry of Economic Affairs, 1998; Ministry of Economic Affairs, 1999). However, due to unanticipated high economic growth (and associated industrial output) in The Netherlands during this period, overall CO₂ emissions actually will increase during the agreement period despite the significant improvements in energy efficiency (Nuijen, 1998). Following the current Long-Term Agreements on energy efficiency, a new agreement has been developed for the energy-intensive industries. In the new agreements, industry groups agree to strive to be among the world's most energy efficient producers by 2012. The agreement will use benchmarking of regions (with a similar production capacity as in The Netherlands) to monitor and verify the results of the industry efforts.

3.3 Canadian Industry Program for Energy Conservation

The Canadian Industry Program for Energy Conservation (CIPEC) is based on voluntary, collective targets for each industrial sector. This national policy integrates the following components:

- Targets
- Reporting/Benchmarking: Annual Measuring and Reporting; Industry Mean and Best Practice Benchmarking
- Audits/Assessments: Analysis of Energy Efficiency Opportunities

There are 21 sector task forces representing 31 trade associations and about 3000 companies. Under the program, the sector task forces identify energy efficiency opportunities, review and address the barriers associated with these opportunities, and develop and implement strategies for realization of the opportunities. The program includes annual measuring and reporting by industry participants. Benchmarking is conducted in which facilities are compared to the industry mean as well as to a "best practice" which is defined as the top quartile. Since 1990, this program has seen an average annual energy intensity improvement of 0.9%. Also since 1990, GDP from the CIPEC industrial sectors rose 17.2% and energy use rose 10%.

3.4 Norwegian Industrial Energy Efficiency Network

The Norwegian Industrial Energy Efficiency Network (IEEN) is a program designed for implementing national energy efficiency policies. This national policy integrates the following components:

- Reporting/Benchmarking
- Assessments: Sector and Technology Studies; Design and Implementation of Energy Management Systems
- Information Dissemination and Demonstration: Quarterly Newsletter and Annual Report; Demonstration Programs

The IEEN focuses on small and medium enterprises and, by March of 1998, was comprised of 534 companies from 13 industrial sectors representing 40% of industrial energy use in Norway (Institute for Energy Technology, 1998). The program is basically an information network that disseminates information through a quarterly newsletter and annual report, provides energy management and analysis support for the members of the network. The IEEN also collects energy use data and performs benchmarking by comparing a facility to its peers. Demonstration programs are financed up to 50% by IEEN and sector and technologies studies are financed completely by IEEN.

To date, this program has seen an average annual intensity improvement of 1.4% among participating sectors (Finden, 1998). One analysis found that a majority of the IEEN members experienced increased production and reduced specific energy consumption between 1995 and 1997 (Institute for Energy Technology, 1998).

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