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Policies for Promoting Industrial Energy Efficiency in Developing Countries and Transition Economies

Executive Summary

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Acknowledgements:

We would like to express our appreciation to the following individuals for their contributions to this paper:
Erik Gudbjerg, Lokalenergi
Klaas Jan Kramer, Lawrence Berkeley National Laboratory visiting researcher
Brian Motherway, Sustainable Energy Ireland
Wayne Perry, Kaeser Compressors
Paul Scheihing, US Department of Energy
Robert Williams, United Nations Industrial Development Organization

Special thanks to Bunmi Adesola of Lawrence Berkeley National Laboratory for her work editing this paper.

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1. Introduction

The industrial sector represents more than one third of both global primary energy use and energy-related carbon dioxide emissions (Price et al., 2006). In developing countries, the portion of the energy supply consumed by the industrial sector is frequently in excess of 50% and can create tension between economic development goals and a constrained energy supply. Further, countries with an emerging and rapidly expanding industrial infrastructure have a particular opportunity to increase their competitiveness by applying energy-efficient best practices from the outset in new industrial facilities. For example, 80% of global industrial growth in over the past ten years has been in China (IEA, 2007). Integrating energy efficiency into the initial design or substantial redesign is generally less expensive and allows for better overall results than retrofitting existing industrial facilities, as is typically required in more developed countries. Conversely, failure to integrate energy efficiency in new industrial facility design in developing countries represents a large and permanent loss in climate change mitigation potential that will persist for decades until these facilities are scheduled for major renovation.

Despite the potential, policy makers frequently overlook the opportunities presented by industrial energy efficiency to have a significant impact on climate change mitigation, security of energy supply, and sustainability. The common perception holds that energy efficiency of the industrial sector is too complex to be addressed through public policy and, further, that industrial facilities will achieve energy efficiency through the competitive pressures of the marketplace alone. Neither premise is supported by the evidence from countries that have implemented industrial energy efficiency programs. The opportunities for improving the efficiency of industrial facilities are substantial, on the order of 20-30% (IEA 2007], even in markets with mature industries that are relatively open to competition.

Example 1.1: Industrial System Energy Efficiency in the United States

A study of 41 completed industrial system energy efficiency improvement projects completed in the US between 1995 and 2001 documented an average 22% reduction in energy use. In aggregate, these projects cost $16.8 million and saved $7.4 million and 106 million kWh, recovering the cost of implementation in slightly more than two years (Lung et al., 2003).

A more recent series of three-day steam and process heating assessments conducted in 2006 at 200 industrial facilities by the US Department of Energy identified a total of $485 million dollars in annual energy savings and 55 petajoules (PJ) of annual natural gas savings, which, if implemented, will reduce US annual carbon dioxide emissions by 3.3 million tons. Six months after their assessments, 71 plants had reported almost $140 million worth of energy savings recommendations either completed, underway or planned (U.S. DOE, 2007b).

The principal business of an industrial facility is production, not energy efficiency. This is the underlying reason why market forces alone will not achieve industrial energy efficiency on a global basis, "price signals" notwithstanding. High energy prices or constrained energy supply will motivate industrial facilities to try to secure the amount of energy required for operations at the lowest possible price. But price alone will not build *awareness* within the corporate culture of the industrial firm of the potential for energy savings, maintenance savings, and production benefits that can be realized from the systematic pursuit of industrial energy efficiency. It is this lack of awareness and the corresponding failure to manage energy use with the same attention that is routinely afforded production quality, waste reduction, and labor costs that is at the root of the opportunity.

Companies (i.e.-Dow, Dupont, 3M, Toyota) that have made the shift in organizational culture required to effectively manage energy report improvements in company-wide energy intensity of 20% or greater in less than a decade (McKane, A., et al., 2007).

Industrial energy efficiency is dependent on operational practices, which change in response to variations in production volumes and product types. Due to this dependence, industrial energy efficiency cannot be fully realized through policies and programs that focus solely on equipment components or specific technologies. Companies that actively manage their energy use seek out opportunities to upgrade the efficiency of equipment and processes because they have an organizational context that supports doing this wherever cost effective, while companies without energy management policies do not. Providing technology-based financial incentives in the absence of energy management will not result in significant market shifts *because there is no organizational context* to respond to and integrate the opportunity into ongoing business practice.

A portfolio of industrial policies is needed that is designed to assist companies in developing this supporting context, while also providing consistency, transparency, engagement of industry in program design and implementation, and, most importantly, allowance for flexibility of industry response. When these criteria are met, industry has shown that it can exceed expectations as a source of reductions in energy use and corresponding GHG emissions, while continuing to prosper and grow.

Example 1.2: Target Setting Agreements in the United Kingdom

The UK Climate Change Program was established in 2000 to meet both the country's Kyoto Protocol commitment of a 12.5% reduction in GHG emissions by 2008-2012 relative to 1990, and the domestic goal of a 20% CO_2 emissions reduction relative to 1990 by 2010 (DEFRA, 2000). A key program element is the Climate Change Levy, which is an energy tax applied to industry, commerce, agriculture, and the public sector. Certain companies can also participate in Climate Change Agreements (CCAs). There are 44 sector agreements representing about 5,000 companies and 10,000 facilities. The goal of the CCAs is to reduce carbon dioxide emissions by 2.5 MtC (9.2 $MtCO_2$) by 2010, which is ten times the estimated savings from the Levy without the agreements. During the first target period (2001-2002) total realized reductions were three times higher than the target for that period (Pender, 2004). Sectors did better than expected because industry underestimated what they could achieve via energy efficiency. Industry also realized total reductions that were more than double the target set by the government during the second target period (Future Energy Solutions, 2005).

This paper presents a portfolio of policy options under the organizing structure of the *Industrial Standards Framework* that meet these criteria. The Industrial Standards Framework proposes a link between International Organization for Standardization (ISO) 9000/14000 quality and environmental management systems and industrial energy efficiency. The Industrial Standards Framework includes:

- target-setting agreements,
- an energy management standard,
- system optimization training and tools,

- capacity building to create system optimization experts, now and in the future,
- a System Optimization Library to document and sustain energy efficiency gains, and
- tax incentives and recognition.

In addition, the Framework could accommodate:
- standardized system optimization methodologies
- certification of energy efficiency projects for trading energy efficiency credits

The purpose of the Framework is to introduce a standardized and transparent methodology into industrial energy efficiency projects and practices. The Framework builds on existing knowledge of "best practices" using commercially-available technologies and well-tested engineering principles. This paper presents numerous examples of successful implementation of elements of the Framework in both developed and developing countries.

Taken together, the elements of the Industrial Standards Framework comprise an effective industrial policy package that combines energy reduction targets, energy efficiency standards, system optimization training, and documenting for sustainability. As described in this paper, there are well-documented opportunities for cost-effective energy reduction on the order of 18-20% or more, while reducing industry's CO2 emissions by 20-33% (IEA, 2007). The time to take action so that industrial energy efficiency becomes "business as usual" is now.

2. Overview of Industrial Sector Trends

The industrial sector uses 160 exajoules (EJ) of global primary energy, which is about 37% of total global energy use. Primary energy includes upstream energy loses from electricity, heat, petroleum and coal products production (Price et al., 2006).[1] The industrial sector is extremely diverse and includes a wide range of activities. This sector is particularly energy intensive, as it requires energy to extract natural resources, convert them into raw materials, and manufacture finished products. The industrial sector can be broadly defined as consisting of energy-intensive industries (e.g., iron and steel, chemicals, petroleum refining, cement, aluminium, pulp and paper) and light industries (e.g., food processing, textiles, wood products, printing and publishing, metal processing). The aggregate energy use depends on technology and resource availability, but also on the structure of the industrial sector. The share of energy-intensive industry in the total output is a key determinant of the level of energy use.

2.1 Economic Development Trends

Historical trends show that the importance of industry within an economy varies by its stage of economic development. The structure of the industrial sector varies between

[1] In this paper, we define primary energy as the energy used on-site plus the energy used to produce purchased electricity and other fuels. Factors for converting from on-site energy consumption to primary energy for ten world regions were developed based on International Energy Agency statistics and reported in Price et al., 2006. The use of primary energy allows for a better comparison accounting for the full energy demand of the industrial sector.

countries and their level of development since the materials demanded by an economy differ through successive stages of development (Cleveland and Ruth, 1999; Gronenberg, 2005). Industrialization drives an increase in materials demand for construction of basic infrastructure needs such as roads, railways, buildings, power grids, etc. As countries develop, the need for basic infrastructure declines and consumer demand shifts increasingly towards services. China's industrial sector energy consumption accounted for over 60% of total energy consumption in 2000 (Zhou, 2006) with the iron and steel and cement industries constituting the largest energy users, accounting for 15% and 14% respectively. Even though these general trends can be observed, economic development trends vary by country and there is no standard development path. India, for example, has a very high share of the service sector, accounting for 51% of total value added; even so, the industrial sector continues to grow, particularly in material production (MOSPI, 2007).

2.2 Commodity Production Trends

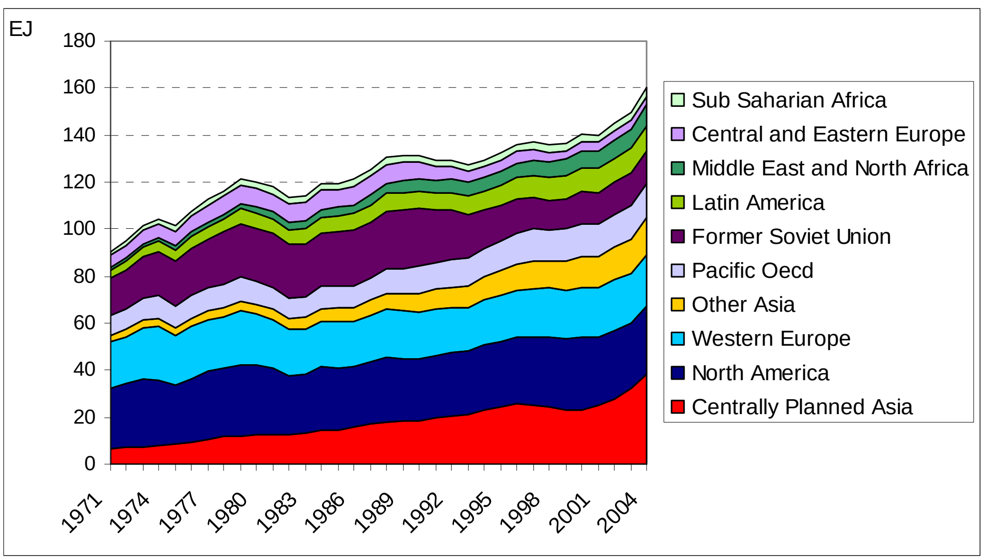
In general, production of energy-intensive commodities is declining or stable in most industrialized countries and is growing in most developing countries as infrastructure and housing are being constructed. For example, between 1975 and 2002, production of steel declined at an average rate of -0.8% per year in the US, while growing at a rate of 10.4% per year in China (UN, 2005a; USGS, 2007e). Energy-intensive industries account for more than half of the industrial sector's energy consumption in many developing countries (Dasgupta and Roy, 2000; IEA, 2003a; IEA, 2003b). Global cement production tripled over the last 30 years, largely due to the impressive growth of production in China which manufactured 45% of the world's cement in 2005 (USGS, 2007a, UN, 2005a). Growth in the paper industry is dominated by developed countries, where consumption continues to grow with income. The US is the largest paper producer with 23% of world production, followed by China with 15% and Japan with 8% (UN FAO, 2007). China is the largest producer of aluminium with 23% of world production, followed by the Russian Federation with 12% (USGS, 2007b). Global ammonia production increased 235% between 1975 and 2005 (USGS, 2007c), with China now the world's largest producer of ammonia with 32% of world production, followed by India with 9% and the Russian Federation with 8%. Copper production grew 221% over this period, with Chile producing 35% of the world's copper, followed by the US with 8% and Peru with 7% (USGS, 2007d). Between 1975 and 2005, the production growth of refined oil products increased 141%, which represents an annual average growth of 1.2% (IEA, 2006a, b). The largest producers are the US, China, and the Russian Federation.

2.3 Energy Consumption and Energy-Related Carbon Dioxide Emissions Trends

Energy use in the industrial sector varies widely between countries and depends principally on the level of technology used, the maturity of plants, the sector concentration, the capacity utilization and the structure of sub-sectors. A recent study compares regional levels of energy use intensities in 2004 and calculates that if all developing countries met the developed country average manufacturing energy use intensity, energy consumption could potentially be reduced by 70% (Luken, 2007).

Figure 1 provides historical energy consumption in the industrial sector for ten world regions from 1971 to 2004. Primary energy consumption in the industrial sector grew from 89 EJ to 160 EJ during this period (Price et al., 2006). Developing countries accounted for 48% of total industrial primary energy use in 2004 and grew at an average annual rate of 4.9% per year over this time period.[2] Industrialized countries experienced much slower average growth of 0.6% per year, while primary energy consumption for industry in the countries that make up the former Soviet Union and Eastern and Central Europe declined at an average rate of -0.5% per year. The decline in these regions was particularly strong after the collapse of the Soviet Union, since many large industrial plants closed down and industrial activity slowed considerably. The Centrally Planned Asia region is the largest industrial energy-consuming region, surpassing North America in 2003. Global growth in industrial energy consumption ranged between 7% and - 4%, with the declines seen in 1975 and 1982, when oil prices increased sharply. Growth rates in the Other Asia and Middle East and North Africa regions were also remarkably high in 2004 - 8.3% and 7.1% respectively. The North America and Western Europe regions have both experienced fairly low average annual growth rates of 0.3% even though these two regions still represent one third of global industrial consumption. The Pacific OECD region has experienced a growth similar to the world average of 1.7%. Finally the Latin America and Sub-Saharan Africa regions had average growth of 3.4% and 2.3% respectively.

Figure 1. Historical Industrial Sector Energy Consumption by Major World Region



Source: Price et al., 2006

In 2004, global energy-related CO_2 emissions from the industrial sector were approximately 10 gigatonnes (Gt) of CO_2, which represented 37% of global CO_2

[2] Developing countries include the region of Centrally Planned Asia, Other Asia, Latin America, Sub Saharan Africa, and Middle East/N. Africa. Developed Countries include Pacific OECD, North America, and Western Europe. Transition economies include Central/E. Europe and Former Soviet Union. See Appendix 1 for a listing of which countries are in each region.

emissions (Price et al., 2006).[3] The largest emissions are from industrial energy use in the Centrally Planned Asia region, with more than a third of global CO_2 emissions, due to increasing energy-intensive industrial production and the heavy use of coal in the industrial and power sectors. Developed countries account for 35% and transition countries for 11% of global CO_2 emissions from the industrial sector, while the remaining countries account for 54%.

Two scenarios of the *Special Report on Emissions Scenarios* (Nakićenović et al., 2000) published by the Intergovernmental Panel on Climate Change (IPCC) in 2000 have been disaggregated by sector (Price et al., 2006). Both scenarios forecast most growth to occur in the developing countries due to the energy required to fuel their growing economies. In general, the A1 scenario envisions more intensive growth in the developing countries than the B2 scenario. The Centrally Planned Asia region is the region that is expected to have the highest growth by far, reaching an energy consumption level of 68 EJ in the A1 scenario and 55 EJ in the B2 scenario by 2030. In both scenarios, industrial CO2 emissions are projected to continue increasing for all regions until 2010 when CO2 emissions from the developed countries of the North America, Western Europe and Pacific OECD regions will peak and start declining. Both scenarios forecast emissions from developing countries and economies in transition to continue their growth after 2010, albeit at a much slower pace. In absolute terms, developing countries are expected to be by far the largest contributor to the growth in annual emissions due to increased industrial activity. The A1 scenario forecasts that all developing country regions will exceed the CO_2 emissions from developed regions in the industrial sector by 2020. In the B2 scenario, only the two Asian regions will surpass the emissions of the North America region.

3. Industrial Energy Efficiency

Industrial energy efficiency – or conversely, energy intensity, which is defined as the amount of energy used to produce one unit of a commodity – is determined by the type of processes used to produce the commodity, the vintage of the equipment used, and the efficiency of production, including operating conditions. Energy intensity varies between products, industrial facilities, and countries depending upon these factors.

Steel, for example, can be produced using either iron ore or scrap steel. Best practice primary energy intensity for producing thin slab cast steel from iron ore using a basic oxygen furnace is 16.3 gigajoules (GJ) per metric ton, while production of the same product using scrap steel only requires 6.0 GJ/ton (Worrell et al., forthcoming). The energy intensity of the Chinese steel industry dropped from 29 GJ/ton steel in 1990 to 23 GJ/ton steel in 2000 despite an increased share of primary steel production from 79% to 84%, indicating that the efficiency of steel production improved over this period as small, old inefficient facilities were closed or upgraded and newer facilities were constructed (Editorial Board, 2004

[3] These calculations account for upstream CO_2 emissions from electricity and heat reallocated in proportion to the electricity and heat consumed. They also account for upstream CO_2 emissions due to the production of petroleum and coal products reallocated similarly according to the use of petroleum and coal products in the industrial sector. For a description of the methodology, see Price et al.,2006.

Within industry, systems that support industrial processes that can be found to varying degrees in virtually all industrial sectors, regardless of their energy intensity. These *industrial systems*, which include compressed air, pumping, and fan systems (referred to collectively as motor systems), steam systems, and process heating systems are integral to the operation of industrial facilities, providing essential conversion of energy into energized fluids or heat required for production processes. Motor and steam systems account for 15% and 38%, respectively, of global final manufacturing energy use, or approximately 46 EJ/year (IEA 2007).

Because these systems typically support industrial processes, they are engineered for reliability rather than energy efficiency. Industrial systems that are oversized in an effort to create greater reliability, a common practice, can result in energy lost to excessive equipment cycling, less efficient part load operation, and system throttling to manage excessive flow. Waste heat and premature equipment failure from excessive cycling and vibration are side effects of this approach that contribute to diminished, not enhanced, reliability.

More sophisticated strategies, made possible through the emergence of modern controls, create reliability through flexibility of response -and redundancy in the case of equipment failure—rather than by brute force. The energy savings can be substantial, with savings of 20% or more common for motor systems and 10% or more for steam and process heating systems (USDOE 2004a) (IEA 2007).

3.1 Opportunities for Industrial Energy Efficiency

Opportunities to improve industrial energy efficiency are found throughout the industrial sector (de Beer et al., 2001; ECCP, 2001; IPCC, 2001). Assessments of cost-effective efficiency improvement opportunities in energy-intensive industries in the United States, such as steel, cement, and paper manufacturing, found cost-effective savings of 16% to 18% (Martin et al., 1999, 2000a; Worrell, et al., 2001); even greater savings can often be realized in developing countries where old, inefficient technologies have continued to be used to meet growing material demands (Price et al., 1999; Price et al., 2002; Schumacher and Sathaye, 1999; WEC, 2004). An estimate of the 2010 global technical potential for energy efficiency improvement in the steel industry with existing technologies identified savings of 24% in 2010 and 29% in 2020 using advanced technologies such as smelt reduction and near net shape casting (de Beer et al., 2000).

While the energy efficiency of individual system components, such as motors (85-96%) and boilers (80-85%) can be quite high, when viewed as an entire system, their overall efficiency is quite low. Motor systems lose approximately 55% of their input energy before reaching the process or end use work and steam systems lose 45%. (USDOE 2004b). Some of these losses are inherent in the energy conversion process; other losses are due to system inefficiencies that can be avoided through the application of commercially available technology combined with good engineering practices.

At present, most markets and policy makers tend to focus on individual system components (motors and drives, compressors, pumps, boilers) with an improvement potential of 2%–5%—that can be seen, touched, and rated—rather than systems. While systems have impressive improvement potential—20% or more for motor systems and 10% or more for steam and process heating systems – achieving this potential requires engineering and measurement (DOE 2004a) (IEA 2007).

The presence of energy-efficient components, while important, provides no assurance that an industrial system will be energy-efficient. System optimization requires taking a step back to determine what work (process temperature maintained, production task performed, etc) needs to be performed.

Improved energy system efficiency can also contribute to a company's bottom line by increased production through better utilization of equipment assets, greater reliability, and reduced maintenance costs. Payback periods for system optimization projects are typically short – from a few months to three years – and involve commercially available products and accepted engineering practices.

3.2 Barriers to Industrial Energy Efficiency Improvement

The decision-making process regarding investments in energy-efficient technologies is shaped by firm rules, corporate culture, and the company's perception of its level of energy efficiency. A survey of 300 firms in The Netherlands found that ***most firms view themselves as energy efficient even when profitable improvements are available*** (Velthuijsen, 1995). ***Lack of knowledge*** or the limited ability of industrial commodity producers to research and evaluate information on energy-efficient technologies and practices is another barrier. Uncertainties related to energy prices or capital availability can lead to the ***use of stringent investment criteria and high hurdle rates for energy efficiency investments that are higher than the cost of capital to the firm*** (DeCanio, 1993). Capital rationing is often used within firms as an allocation means for investments, especially for small investments such as many energy efficiency retrofits.

The ***relatively slow rate which industrial capital stock turns over*** can prove to be a barrier to adoption of energy efficiency improvements since new stock is typically more energy-efficient than existing facilities. Another barrier is the ***perceived risk involved with adopting new technology*** since reliability and maintenance of product quality are extremely important to commodity producers.

Optimizing industrial systems for energy efficiency is not taught to engineers and designers at university- it is learned through experience. Systems are designed to maintain reliability at the lowest first cost investment, despite the fact that operating costs are often 80% or more of the life cycle cost of the equipment. Facility plant engineers are typically evaluated on their ability to avoid disruptions and constraints in production processes, not energy efficient operation. Equipment suppliers also have little incentive to promote more energy efficient system operation, since commissions increase when equipment size is scaled upward and educating a customer to choose a more efficient approach requires extra time and skill.

Plant engineering and operations staff frequently experience difficulty in achieving management support. Industrial managers are rarely drawn from the ranks of facilities operation- they come from production and often have little understanding of supporting industrial systems. This situation is further exacerbated by the existence of a budgetary disconnect in industrial facility management between capital projects (incl. equipment purchases) and operating expenses.

In addition, most ***optimized industrial systems lose their initial efficiency gains over time*** due to personnel and production changes. Detailed operating instructions are not integrated with quality control and production management systems. Without well-documented maintenance procedures, the energy efficiency advantages of high efficiency components can be negated by clogged filters, failed traps, and malfunctioning valves.

4. Policies for Promoting Industrial Energy Efficiency in Developing Countries and Transition Economies

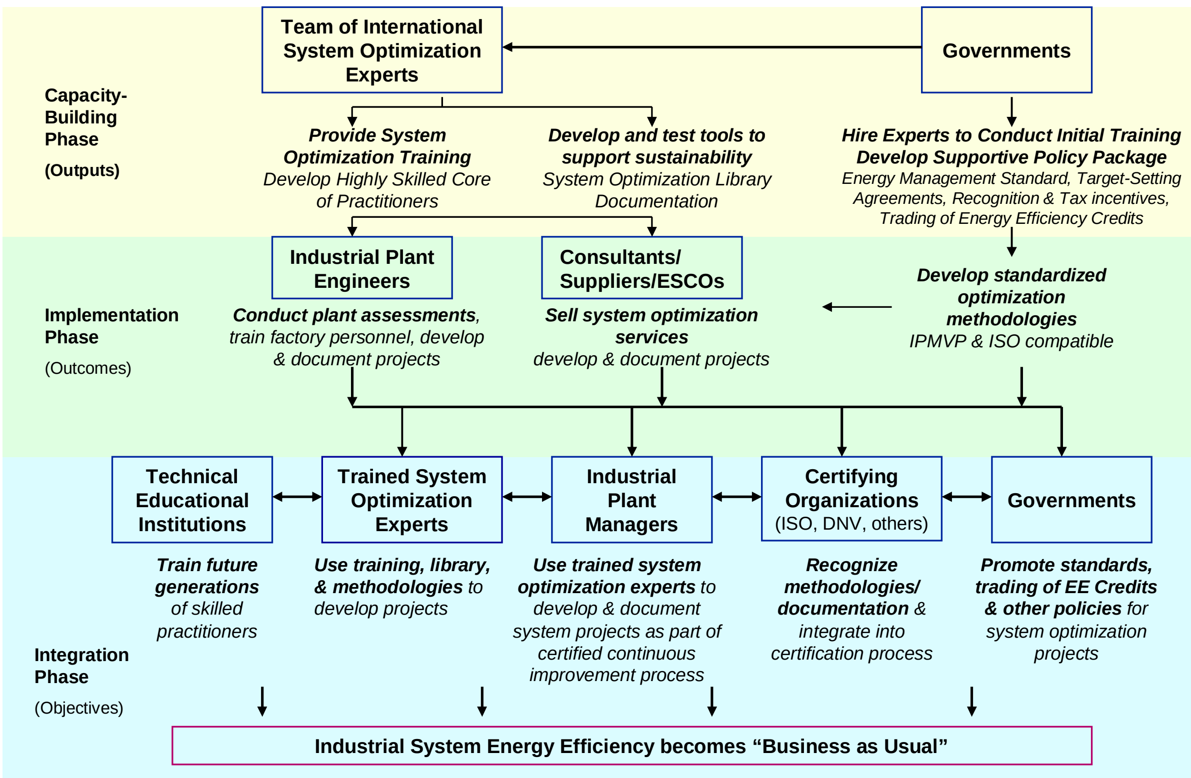
4.1. Overview – Industrial Standards Framework

The Industrial Standards Framework proposes a link between ISO 9000/14000 quality and environmental management systems and industrial energy efficiency. A number of management systems are currently used by industrial facilities across most sectors to maintain and improve production quality. ISO has been selected for the Framework because it has been widely adopted in many countries, is used internationally as a trade facilitation mechanism, is already accepted as a principal source for standards related to the performance of energy-consuming industrial equipment, and has a well-established system of independent auditors to assure compliance and maintain certification. For the purpose of this discussion, ISO includes both the quality management program (ISO 9001:2000) and the environmental management program (ISO 14001), which can share a single auditing system. Although the discussion of the Framework will include references to ISO 9000/14000 management systems, the elements of the Framework are equally applicable to other management systems, such as Six Sigma, Total Quality Management, or Lean Manufacturing.

The purpose of the Framework is to introduce a standardized and transparent methodology into industrial energy efficiency projects and practices including: system optimization, process improvements, waste heat recovery and the installation of on-site power generation. Factories can use the Framework to approach energy efficiency incrementally in a way that maximizes positive results and minimizes risk and downtime. The goal is to make optimization for energy efficiency as much a part of typical industrial operating practices as waste reduction and inventory management. The objective is a permanent change in corporate culture using the structure, language, and accountability of the existing ISO management systems. This approach is equally applicable in industrialized or industrializing countries. Figure 2 provides a schematic of how the elements of the Industrial Framework interact to effect an institutional culture change in which industrial energy efficiency becomes “business as usual”.

Sections 4.2 - 4.6 provide additional details on the elements of the Industrial Standards Framework, including: target-setting agreements, energy management standards, system optimization training and capacity building, documenting for sustainability through the use of the Systems Optimization Library, and recognition programs, tax incentives, and the relationship between industrial energy efficiency and carbon offset programs, including the Clean Development Mechanism (CDM).

Figure 2: Industrial Standards Framework



Source: McKane, 2007. Note: IPMVP= International Performance Measurement and Verification Protocol, ESCO= Energy Services Company

4.2 Target-Setting Agreements

Target-setting agreements, also known as voluntary or negotiated agreements, have been used by a number of governments as a mechanism for promoting energy efficiency within the industrial sector. A recent survey of such target-setting agreement programs identified 23 energy efficiency or GHG emissions reduction voluntary agreement programs in 18 countries, including countries in Europe, the U.S., Canada, Australia, New Zealand, Japan, South Korea, and Chinese Taipei (Taiwan) (Price, 2005).

International best practice calls for establishment of a coordinated set of policies that provide strong economic incentives as well as technical and financial support to participating industries. Effective target-setting agreement programs are based on signed, legally-binding agreements with realistic long-term (typically 5-10 year) targets, require facility- or company-level implementation plans for reaching the targets, require annual monitoring and reporting of progress toward the targets, include a real threat of increased government regulation or energy/GHG taxes if targets are not achieved, and provides effective supporting programs to assist industry in reaching the goals outlined in the agreements.

This policy instrument is entirely compatible with other aspects of the Industrial Standards Framework. A target-setting agreement provides a broad, but measurable target while an energy management standard provides an industrial facility with a methodology for meeting the target and system optimization techniques identify projects that help the facility meet both the goals of the standard and the efficiency targets of agreement.

4.2.1 Examples of Successful Target-Setting Agreement Programs

Three examples of model target-setting agreement programs are the UK's Climate Change Agreements, Denmark's Energy Efficiency Agreements, and The Netherlands' Long-Term Agreements. The UK program is addressed in the Introduction to this paper.

In 1990, the Danish Parliament established an ambitious target to reduce its national CO_2 emissions by 20% by 2005, relative to the 1988 level. Under the Kyoto Protocol, a new target was set to reduce GHG emissions by 21% below 1990 levels by 2008-2012. To reach these goals, voluntary Energy Efficiency Agreements were introduced in 1996. Between 1996 and 2001, approximately 300 companies entered into such agreements, representing 60% of total industrial energy consumption in Denmark (Hansen, 2001). The Agreements led to a reduction in energy consumption of 9% (Bjørner and Jensen 2000), reduced energy consumption by 2 to 4% of total energy consumption per agreement after three years (thereby exceeding business-as-usual by about 1% per year) (Togeby et al., 1999), sped up the process of adopting energy-efficiency measures (Krarup et al., 1997), and led companies to take energy management more seriously (Johannsen and Larsen 2000).

In the Long-Term Agreements (LTAs) in The Netherlands, voluntary agreements between the Dutch Ministries and industrial sectors consuming more than 1 petajoule (PJ) per year, were established in support of achieving an overall national energy-efficiency improvement target of a 20% reduction in energy efficiency between 1989 and 2000. In total, 29 agreements were signed involving about 1000 industrial companies and representing about 90% of industrial primary energy consumption in The Netherlands. The average target was a 20% increase in energy efficiency over 1989 levels by 2000 (Nuijen, 1998; Kerssemeeckers, 2002). The overall LTA program ended in 2000 with an average improvement in energy efficiency of 22.3% over the program period (Kerssemeechers, 2002). Recent evaluations of the LTAs found that the agreements helped industries to focus attention on energy efficiency and find low-cost options within commonly used investment criteria (Korevaar et al., 1997; Rietbergen et al., 1998).

In 2005, the Chinese government announced an ambitious goal of reducing energy consumption per unit of GDP by 20% between 2005 and 2010. One of the key programs for realizing this goal is the Top-1000 Energy-Consuming Enterprises program. The energy consumption of these 1000 enterprises accounted for 33% of national and 47% of industrial energy usage in 2004. Activities to be undertaken through this program include benchmarking, energy audits, energy saving action plans, information and training workshops, and annual reporting of energy consumption (Price and Wang, 2007).

4.2.2 Key Program Elements of Target-Setting Programs

The key program elements of a target-setting program are:

- target-setting process;
- identifying energy-saving technologies and measures;
- benchmarking current energy efficiency practices;
- establishing an energy management plan (see Section 4.3 below);
- conducting energy-efficiency audits;
- developing an energy-savings action plan;
- developing incentives and supporting policies;
- measuring and monitoring progress toward targets, and
- program evaluation.

Target-Setting

Typically, the process for setting energy efficiency or GHG emission reduction targets requires a preliminary assessment of the energy efficiency or GHG mitigation potential of each industrial facility, which includes an inventory of economically-viable measures that could be implemented. These assessments, which can be made by the subject companies or an independent third party, are provided to the government and form the basis for discussions and negotiations related to target-setting between the industries and the government. Such assessments are often partially or entirely funded by the government – often as a benefit of participating in target-setting programs -- with funding varying from 40 to 100% of the cost of the audit in countries such as Denmark, the Netherlands, Sweden, and the U.S. (WEC, 2004).[4]

Identification of Energy-Saving Technologies and Measures

Countries with strong industrial energy efficiency programs, whether or not they are associated with agreement programs, provide information on energy-efficiency opportunities through a variety of technical information sources including: fact sheets, brochures, guidebooks, technical publications, energy efficiency databases, software tools, and industry- or technology-specific energy efficiency reports. The U.S. Department of Energy's Industrial Technologies Program has a website with a broad array of software and technical information[5]. Peer-to-peer information sharing networks have also proven effective in several countries, notably the Netherlands, Australia, and South Korea.

Benchmarking

Benchmarking provides a means to compare the energy use within one company or plant to that of other similar facilities producing similar products or to national or international best practice energy use levels. Benchmarking can compare plants, processes or systems. Canada's Office of Energy Efficiency (OEE) develops benchmarks for energy efficiency

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[4] The exception to this approach is the European Union's Emissions Trading Scheme in which the EU countries allocated emissions targets on the basis of past emissions. While only small efforts are being made to account for a company's ability to abate its emissions, a complex trading market is in place to enable them to sell excess emissions credits or purchase emissions credits to cover gaps between their actual performance and their target.

[5] See http://www1.eere.energy.gov/industry/bestpractices/software.html

of facilities in each sub-sector that is targeted.[6] In The Netherlands, industrial companies participating in Benchmarking Covenants agree to become among the top 10% of the most energy-efficient plants in the world or one of the three most efficient regions. The U.S. ENERGY STAR for Industry has developed an energy performance indicator (EPI) for several industrial sectors that measures how efficiently a manufacturing plant uses energy compared to others.[7] Lawrence Berkeley National Laboratory has developed an Excel-based spreadsheet tool called BEST: Benchmarking and Energy Saving Tool for use by industry to benchmark a plant's energy intensity to "best practice" and to identify energy-efficiency improvement options (Price et al., 2003) (Galitsky et al., 2005) .

Energy-Efficiency Audits or Assessments

Energy efficiency audits or assessments involve collecting data on all of the major energy-consuming processes and equipment in a plant, documenting specific technologies used in the production process, and identifying opportunities for energy efficiency improvement throughout the plant as presented in a written report. An audit is an essential first step in identifying opportunities that can contribute to an organization's energy efficiency targets. See Section 4.4 for more information.

Energy Saving Action Plans

An energy action plan outlines a company's plan for improving energy-efficiency during the period covered by energy efficiency targets and is a required component of compliance with an energy management standard. The energy action plan provides primary guidance for the internal implementation of the activities that will be undertaken to reach the energy-saving target. It also serves as a reference to evaluate progress on an annual basis. The plan, which is typically reviewed by an independent third party and updated as needed in response to changes over time, includes: a description of the facility's energy uses, a description of the energy-efficiency measures considered, a description of the planned energy-efficiency measures, a timeframe for implementation of the energy-efficiency measures, and expected results in terms of energy efficiency.

Monitoring

Monitoring guidelines for energy efficiency and GHG mitigation projects have been developed by numerous entities in order to understand the progress and results of specific energy-efficiency projects. Such guidelines are included in the World Business Council for Sustainable Development and World Resources Institute's Greenhouse Gas Protocol Initiative (WBCSD/WRI, 2002), the Global Reporting Initiative's Energy Consumption Protocol (GRI, 2002), the U.S. Initiative on Joint Implementation, the World Bank's guidelines for the Global Environment Facility, the International Performance Measurement and Verification Protocol, the U.S. Environmental Protection Agency's Conservation Verification Protocols, and the Dutch LTAs (Vine and Sathaye, 1997).

[6] http://oee.nrcan.gc.ca/industrial/technical-info/benchmarking/benchmarking_guides.cfm?attr=24

[7] See http://www.energystar.gov/index.cfm?c=in_focus.bus_industries_focus

4.3 Energy Management Standards[8]

The purpose of an energy management standard is to provide guidance for industrial facilities to integrate energy efficiency into their management practices, including fine-tuning production processes and improving the energy efficiency of industrial systems. Although the focus of this paper is industrial energy efficiency, it is important to note that the energy management standards referenced here are equally applicable to commercial, medical, and government facilities.

An energy management standard requires a facility to develop an energy management plan. In companies without a plan in place, opportunities for improvement may be known but may not be promoted or implemented because of organizational barriers. These barriers may include a lack of communication among plants, a poor understanding of how to create support for an energy efficiency project, limited finances, poor accountability for measures or perceived change from the status quo.

Table 1 compares the elements of the energy management standards in five countries with existing energy management standards (or specifications) and one under development. In all instances, the standard has been developed to be entirely compatible with the ISO quality management program (ISO 9001:2000) and environmental management program (ISO 14001).

Typical features of an energy management standard include:

- a strategic plan that requires measurement, management, and documentation for continuous improvement for energy efficiency;
- a cross-divisional management team led by an energy coordinator who reports directly to management and is responsible for overseeing the implementation of the strategic plan;
- policies and procedures to address all aspects of energy purchase, use, and disposal;
- projects to demonstrate continuous improvement in energy efficiency;
- creation of an Energy Manual, a living document that evolves over time as additional energy saving projects and policies are undertaken and documented;
- identification of key performance indicators, unique to the company, that are tracked to measure progress; and
- periodic reporting of progress to management based on these measurements.

4.3.1 Supportive Policies and Programs

In the six countries studied, the energy management standards are designed to be applicable to all types and sizes of companies; however, in each instance, the largest, most energy intensive industries are the focus of additional programs and initiatives. By concentrating efforts on these large energy users, policy makers seek the greatest

[8] The information in this section was drawn from: McKane, Aimee, 2007, *Industrial Energy Management: Issues Paper* and McKane, A., R. Williams, W. Perry, and T. Li. 2007. *Setting the Standard for Industrial Energy Efficiency*.

reduction in industrial energy consumption and overall GHG emissions. Not surprisingly, the proportionally greatest impact on industrial energy consumption has been in Denmark, which has had financial incentives since 1992 in the form of a CO_2–tax rebate, coupled with voluntary agreements and, as of 2001, energy management standards. The coupling of target-setting agreements with an energy management standard seems to be particularly effective.

Table 1. Energy Management Standards, Details

Participating Countries	Management Commitment Required	Develop energy management plan	Establish energy use baseline	Identify Energy Coordinator	Establish Cross- Divisional Implementation Team	Emphasis on Continuous Improvement	Document Energy Savings	Establish Performance Indicators & Energy Saving Targets	Document & Train Employees on Procedural/ Operational Changes	Specified Interval for Re-evaluating Performance Targets	Reporting to Public Entity Required	Energy Savings Validated or Certified	Year Published	Approx Market Penetration by Industrial Energy Use
Existing														
Denmark	yes	yes	yes	yes	yes	yes	yes	yes	yes	suggests annual	yes	optional[1]	2001	60%[2]
Ireland	yes	yes	yes	yes	yes	yes	yes	yes	yes	industry sets own	yes	optional[1]	2005	25%
Netherlands[3]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	optional[1]	2000	20-90%[4]
Sweden	yes	yes	yes	yes	unclear	yes	yes	yes	yes	yes[1]	yes	optional[1]	2003	50%elect
United States	yes	yes	yes	yes	yes	yes	yes	yes	yes	industry sets own	no	no	2000	<5%[5]
Under Development														
China	yes	yes	yes	yes	yes	yes	yes	yes	yes	industry sets own	not avail	not avail		

1 Certification is required for companies participating in voluntary agreements (also specified interval in Sweden). In Denmark, Netherlands & Sweden linked to tax relief eligibility.
2 As of 2002, latest date for which data is available
3 Netherlands has an Energy Management System, not a standard, per se, developed in 1998 and linked to Long Term Agreements in 2000.
4 800 companies representing 20% of energy use have LTAs and must use the Energy Management System. The 150 most energy intensive companies, representing 70% of the energy use, have a separate, more stringent, bench marking covenant and are typically ISO 14000 certified, but are not required to use the EM System.
5 To date, the US government has encouraged energy management practices, but not use of the standard, therefore market penetration has been very limited. Program policies new in 2007 are designed to address this.

Source: McKane, et al 2007

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As shown in Table 1, the existing energy management standards have many features in common. This is not accidental. All the standards reviewed have been developed by individuals well-versed in the ISO management model for continuous improvement. Brazil, Spain, and Korea have also initiated work on an energy management standard. The European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) have formed a task force and undertaken development of a harmonized European standard on energy management. A dialogue on international harmonization of energy management standards has recently been initiated by the ISO Secretariat, UNIDO, CEN, and the countries with experience with energy management standards who participated in a UNIDO experts' group meeting on this topic in March 2007. Developing countries have requested UNIDO's support to conduct a feasibility study to identify opportunities, costs, and barriers resulting from widespread adoption of an international energy management standard.

4.4 System Optimization and Capacity Building

System optimization seeks to design and operate industrial systems (i.e. - motor/drive, pumping, compressed air, fan, and steam systems) to provide excellent support to production processes using the least amount of energy that can be cost-effectively achieved. The process of optimizing existing systems includes:

- Evaluating work requirements;
- Matching system supply to these requirements;
- Eliminating or reconfiguring inefficient uses and practices (throttling, open blowing, etc);
- Changing out or supplementing existing equipment (motors, fans, pumps, compressors) to better match work requirements and increase operating efficiency;
- Applying sophisticated control strategies and variable speed drives that allow greater flexibility to match supply with demand;
- Identifying and correcting maintenance problems, and
- Upgrading ongoing maintenance practices.

A system that is optimized to both energy efficiency and cost effectiveness may not use the absolute least amount of energy that is technically possible. The focus is on achieving a balance between cost and use that applies energy resources as efficiently as possible.

4.4.1 Building Technical Capacity

Since system optimization is not taught in universities or technical colleges, UNIDO has worked with a team of international experts to develop and pilot in China a training curriculum specifically designed to build the necessary technical capacity.

A carefully organized training program can have a significant impact. As a result of the UNIDO China Motor System Energy Conservation Program, 22 engineers were trained in system optimization techniques in Jiangsu and Shanghai provinces. The trainees were a mix of plant and consulting engineers. Within two years after completing training, these experts conducted 38 industrial plant assessments and identified nearly 40 million kWh in energy savings. Typical project paybacks were from six months to two years.

The goal of capacity-building training is to create a cadre of highly skilled system optimization experts. Careful selection is needed of individuals with prior training in mechanical or electrical engineering, who have an interest and the opportunity to apply their training to develop projects. Experts may come from a variety of backgrounds, including, but not limited to: government sponsored energy centers, factories, consulting companies, equipment manufacturers and engineering services companies. Training is intensive and system-specific, and includes both classroom and hands-on measurement and system assessment instruction. The resulting system experts are prepared to evaluate and optimize one or more industrial motor-driven systems or steam systems. Ideally, the completion of the intensive training program is coupled with practical testing of competency and a certificate of recognition for the trained local experts.

The trained local experts are also prepared to offer awareness level training to factory operating personnel on how to recognise system optimization opportunities. This awareness training can be used to build interest in and a market for the local experts' system optimization services. In addition, awareness training can provide a basic understanding of system optimization for factory operating personnel to apply in identifying energy efficiency project opportunities.

4.5 Documenting for Sustainability

With the renewed interest in energy efficiency worldwide and the emergence of carbon trading and new financial instruments such as white certificates, there is a need to introduce greater transparency into the way that industrial facilities identify, develop, and document energy efficiency projects. In order to ensure persistence for energy efficiency savings from system optimization projects, a method of verifying the on-going energy savings under a variety of operating conditions is required.

4.5.1 Documentation and ISO 9000/14000[9]

The purpose of ISO 14001 is to provide a framework for organizations to achieve and demonstrate their commitment to an environmental management system that minimizes the impact of their activities on the environment (a similar framework for ISO 9001:2000 pertains to quality). The framework does not include any specific requirements, only a means of achieving goals set by the organization. This ISO standard also provides for an audit procedure to verify that established policies of the organization are being followed. To maintain certification, participating companies must maintain a Quality Environmental Management (QEM) Manual. QEM documentation is characterized by policies, procedures, projects, and work instructions.

A procedure refers to a general description of a process and is incorporated into a company's QEM Manual. The first step is for a company to develop a policy of efficient operation of energy systems within their facility, then develop and implement system procedures that are consistent with that policy. Procedures may also refer to detailed work instructions that explain exactly how the work should be performed.

A project refers to a specific activity designed to contribute to meeting the ISO requirement for continuous improvement. Examples of projects include: initiating a leak management program or replacing a throttle valve on a pumping system with a speed control device. Work instructions are step-by-step information (text, diagrams, photos, specifications, etc) to assist operations staff in maintaining the improvements realized through implementation of a project. Work instructions are typically posted or easily accessible to operations staff.

The regular external audit process assures that proper and efficient operation of industrial energy systems is maintained and becomes part of each firm's operating culture, while transferring much of the burden and cost associated with regulatory compliance enforcement to these independent auditors. Linkage to ISO will also assist in providing verification of results for financial backers (including future CDM carbon traders), and

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[9] Much of this section is adapted from McKane, A., W. Perry, A. Li, T. Li, and R. Williams. 2005. *Creating a Standards Framework for Sustainable Industrial Energy Efficiency*.

provide a clear methodology for recognizing "investment grade" projects, which will help stimulate a significantly higher level of industrial energy efficiency.

4.5.2 Systems Optimization Library

To enable firms to comply with the energy management standards and to more easily include energy efficiency projects as part of a company's continuous improvement plan (whether ISO or not), UNIDO and its partners have developed the concept for a System Optimization Library. The System Optimization Library is an electronic reference document that organizes energy efficiency opportunities by system and includes a series of procedures, projects, and work instructions written in an ISO-compatible format that are designed to facilitate integration of energy efficiency system improvements into ISO 9000/14000 operational and compliance materials. The advantage of the Library is that it will standardize and streamline the process of developing and documenting energy efficiency improvement projects. By providing work instructions to support the new, more energy efficient operation, the Library will also increase the likelihood that the resulting energy savings would be sustained.

Providing evidence that sufficient documentation exists to support the persistence of energy savings is a critical pre-requisite to consider industrial energy efficiency projects for white certificates or carbon credits. Without such evidence, the value of these projects may be subject to deep discounts, since there would be no assurance that energy savings would persist over the life of the project (often ten years or more) without significant degradation in energy efficiency.

4.6 Recognition Programs, Tax and Fiscal Policies, and Carbon Offset Programs

4.6.1 Recognition Programs

Recognition programs have proven to be effective mechanisms for rewarding industrial facilities who participate in public programs to encourage more energy efficient behavior. Recognition programs also "lead by example", by building greater awareness of the benefits of industrial energy efficiency among companies that may not yet be active. Finally, recognition programs create peer pressure within sectors that encourages more energy efficient practices, as companies receiving awards or other types of recognition seek to use them for competitive advantage.

In many countries, a recognition program is developed early in the process of creating a comprehensive industrial energy efficiency program. The advantages to this approach include: creating momentum for the program, providing positive public relations for both the company and the sponsoring government agency or ministry, and collecting case studies as examples for future training efforts. In addition, recognition programs are typically very cost-effective, serving as a stimulus for future energy savings far beyond their nominal cost. An effective recognition program is performance-based and provides awards or other benefits only if supported by documented energy saving improvements. Recognition programs are frequently used as an element of target-setting agreements.

4.6.2 Tax and Fiscal Policies

Tax and fiscal policies for encouraging investment in energy-efficient industrial equipment and processes operate either through increasing the costs associated with energy use to stimulate energy efficiency or by reducing the costs associated with energy efficiency investments. Various forms of these instruments have been tried in numerous countries over the past three decades, including: energy or CO_2 taxes; grants and subsidies such as energy efficiency loans and innovative funding mechanisms; and tax relief such as accelerated depreciation; tax rebates, deductions, exemptions. In addition, integrated policies that combine a variety of financial incentives in a national-level energy or GHG emissions mitigation program are also found in a number of countries. Such integrated policies are often national-level energy or GHG programs that combine a number of tax and fiscal policies along with other energy efficiency mechanisms such as voluntary agreements.[10]

Energy or CO2 Taxes

Energy or energy-related carbon dioxide (CO_2) taxes have been used in a number of countries to provide an incentive to industry to improve the energy management at their facilities through both behavioral changes and investments in energy-efficient equipment. Taxes on energy or energy-related CO_2 emissions are now found in Austria, the Czech Republic, Denmark, Estonia, Finland, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, and the UK. In target-setting programs that involve the use of energy taxes, such as in the UK and Denmark, rewards for meeting agreed-upon targets are provided in the form of a reduction of the required energy tax (DEFRA, 2004; Togeby et al., 1999).

Grants and Subsidies

A recent survey found that 28 countries provide some sort of grant or subsidy for industrial energy efficiency projects (WEC, 2004). Grants or subsidies are public funds given directly to the party implementing an energy efficiency project. Due to problems with free-riders, prohibitively high transaction costs or complex and long procedures to process forms, international best practice is to restrict such grants or subsidies to certain types of investment, such as a selected list of equipment with a long payback time but high efficiency gains, or to investments of a certain size or level of cost-effectiveness.

Developing countries with higher risk market environments for investments may find that direct public funding in the form of grants or subsidies is a viable option for encouraging investment in energy efficiency. Public funds may also be needed where competition with more traditional investments such as infrastructure expansion receives most of the available financing, where non-asset based energy efficiency projects are perceived to be riskier than asset-based investments, where energy efficiency projects are too small to gain enough attention or where energy prices do not reflect real costs of energy and are too low for energy efficiency projects to procure enough financial benefit for individual companies.

[10] Much of this section is based on information from Galitsky et al., 2004.

The goal of subsidized loans is to promote energy efficiency measures until they achieve market acceptance level and can be funded on their own. According to WEC (2004), public loans are less popular than subsidies in the countries surveyed.

Innovative funding mechanisms aimed at increasing the involvement of banks and private capital in energy efficiency investments are also being used in some countries. In an effort to reduce public debt, trends show a movement toward these types of private sector, rather than the public sector, funds (WEC, 2004). Innovative funding mechanisms include equity participation through energy service companies (ESCOs), guarantee funds, revolving funds, and venture capital. With a few exceptions, such as industrial purchased steam or co-generation, ESCOs have had little impact on the development of energy efficiency projects that involve industrial systems. There are many reasons for this, including: high cost of opportunity identification and deal completion, limited replicability site to site, and lack of expertise in specific industries (Elliott, 2002).

Tax Relief

Tax relief for purchase of energy-efficient technologies can be granted through tax exemptions, tax reductions, and accelerated depreciation. Such schemes are found in 22 countries (WEC, 2004). A common approach is to provide a list of technologies for special tax treatment.

4.6.3 Potential Links to Carbon Offset Programs

Industrial Energy Efficiency Projects and Joint Implementation (JI) and Clean Development Mechanism (CDM)

Even though a number of countries have made energy efficiency a CDM priority, it doesn't seem to be working well for the industrial sector. Among the 563 CDM projects approved up to 22 March 2007, only 19 are industrial end-use efficiency projects, representing only 3% of the total number of registered CDM projects. The estimated GHG reductions from these projects are < 300 kt CO_2e per year, which is a miniscule share of global industrial energy efficiency potential. The projects are also limited in terms of their geographical distribution (all but two projects are in India) and a range of applied technologies and energy efficiency know-how (Arquit Neiderberger 2007).

At a recent meeting hosted by UNIDO, Climate Technology Initiative (CTI), and UK Trade & Investment, the international climate change community expressed its concern with the limitations encountered by energy efficiency projects, and demand-side industrial energy efficiency projects in particular. Their under-representation in the CDM pipeline is not only a lost opportunity in terms of carbon emission reduction (CER) volumes, but is also a growing challenge to the CDM itself, particularly in light of the uncertainties with the post-2012 regulatory framework and the growing demand for projects with shorter pay-back period and the potential for the deliver of quality emission reductions. One recommendation from the meeting was to form a network of energy efficiency experts to advise the CDM Methodology Panel. Another was to make greater use of measurement and verification protocols, energy management standards, evaluation guidebooks on DSM and energy audits and other technical and engineering tools to improve transparency, consistency and certainty of energy efficiency methodologies and consequently, energy efficiency projects in CDM.

5. Policy Recommendations

This section provides some practical considerations for beginning an industrial energy efficiency program based on the portfolio of policies in the Industrial Standards Framework discussed in this paper. The key to an effective industrial energy efficiency policy is to find a balance between consistency and flexibility. Consistency in program message, goals, target industries, and basic program offerings is critical.

When announcing an industrial program, a policy maker should assume that industry will require at least a year to accept it and another year or more to respond. Most industries require at least 12-18 months for completion of an energy efficiency project after an assessment is done and opportunities have been identified. This is because any planned capital improvements must wait to be included in the following year's budget cycle. Changing organizational behavior takes time and permanent market change takes even longer. Assume that an industrial energy efficiency program will take at least five years to fully mature. If funds are too limited to consider a full-scale launch, a graduated program could begin with system optimization training (expert and awareness), followed later by target-setting agreements, energy management standards, and documentation for sustainability. For any program element to be successful, industrial markets must be engaged, as addressed in the discussion on enabling partnerships in Section 5.4.

5.1 Getting Started with Target-setting Agreements

In the UK, the process for setting the Climate Change Agreement targets began with information-gathering on the part of the government. The government obtained information regarding energy efficiency potential in energy-intensive industries through the Energy Efficiency Best Practices Program which produced good practice guides and case studies, new practice case studies, and information on future practices as well as through a report prepared by ETSU (now AEA Energy & Environment) on projections of industrial sector carbon dioxide emissions under a business-as-usual scenario as well as two scenarios that included all cost-effective and all technically-possible technologies. Then, for the ten largest energy-consuming sectors, individual companies made estimates of what energy efficiency improvements they could make based on an assessment of their potential and provided this information to their trade associations. The sector then offered a target for the whole sector to the government. Negotiation then drew the process forward, with government often requiring the industry sector to improve their offer to a more challenging level, based on information on cost effective processes and general standards of energy management in the sector.

For the Long-Term Agreements (LTAs) in The Netherlands, the process for establishing the industrial sector targets began with a preliminary assessment of the energy efficiency potential of the sector by the industry. A quantified target was then set for the improvement of energy efficiency in the sector, based on the outcome of the study. A

Long-Term Plan (LTP) described how the sector planned to realize its target. The LTAs include commitments for individual companies, such as the preparation of an energy conservation plan (ECP) and annual monitoring of developments in energy efficiency, expressed using an energy efficiency index (EEI). Then NOVEM, the Dutch Agency for Energy and Environment, established an inventory of economically viable measures that could be implemented by the companies in each industrial sector and based on this inventory set a target for energy efficiency improvement for each sector.

5.2 Establishing an Energy Management Standard

As previously discussed, a number of energy management standards are currently in use, and the process of developing and international standard is being initiated. These standards all have much in common and provide a good foundation for developing a national energy management standard. Countries may choose to use an existing standard and to develop country-specific guidance details for implementation.

This work is typically undertaken by a governmental standards-making agency. Even if the agency decides to adopt an existing energy management standard, an advisory committee is needed to inform the process. An advisory committee typically includes representatives from companies with medium and large industrial facilities and from several of the industrial sectors most important to the country's economic growth. To be effective, the advisory committee should also include respected members of the consulting engineering and supplier community who have extensive experience in industry. The purpose of the advisory committee is to ensure that the standard, as adopted, can be practically applied to the country's industries and to build ownership in use of the standard prior to its announcement.

A public comment period is typically required; the length of this period and the number of informational workshops will be determined by the requirements of the implementing country. This period can be used to build ownership of the energy management standard prior to its formal announcement. Industrial companies do not like sudden changes in governance, so providing information well in advance can improve the chances for success of the standard.

The standard itself is fairly straightforward; the accompanying guidance provides the detail needed to assist companies in implementing the standard. Training will be required to familiarize companies with the requirements of the standard. Technical assistance is also needed to help companies develop the organizational structure for identifying and developing energy efficiency improvement projects for continuous improvement.

An energy management standard can be issued initially as a voluntary standard coupled with a recognition program for companies who demonstrate that they are applying the standard. A requirement for compliance with the energy management standard is a very effective element of a program of target-setting agreements, with penalties for non-compliance clearly identified. A phase-in period is required for industrial firms to develop the organizational infrastructure needed to effectively implement the standard; this transition period is needed to avoid unnecessary disruptions in industrial operations.

5.3 Capacity Building through Training Experts and Suppliers

A comprehensive training program is typically required to create a cadre of system optimization experts who are prepared to identify energy efficiency measurements and to develop efficiency improvement projects. For maximum effectiveness, the training should be targeted to plant and consulting engineers, as well as equipment suppliers.

Experts Training
The purpose of this training is to prepare a group of experts who will be expected to: (1) Provide awareness training to encourage plants to undertake system optimization improvements; (2) Conduct plant assessments to identify system optimization opportunities; (3) Work with plants to finance and develop projects based on these findings; and, (4) Prepare case studies of successful projects. A one-to-one, one-to-many, training and implementation scheme has been tested and proven effective. In this approach, international experts are engaged in the initial capacity-building to create a core of highly-skilled experts who will become a resource to their country and the region for years to come. To ensure success of the training, selection of the individuals to be trained must be rigorous and based on technical and training capabilities. Successfully negotiating this selection process will require the international team and the country coordinators to develop a shared vision of the project goals, which will vary somewhat from country to country in response to cultural, organizational, and social requirements. This cadre of experts will form the nucleus for future training of additional experts as well as conduct awareness training for factory personnel.

Suppliers Training
Concurrent with experts training, training should be conducted to introduce equipment suppliers, manufacturers' representatives, and vendors to system optimization techniques. The purpose of this training is to prepare manufacturers, suppliers, and vendors to: (1) participate in reinforcing the system optimization message with their customers; and (2) assist them in identifying what will be required to reshape their market offerings to reflect a system services approach. Combining the expert training and vendor training is not recommended, as their needs are different.

5.4 Building Industrial Awareness

A core element of any industrial energy efficiency program is an information campaign. This campaign is designed to introduce industry to the basic concepts of energy management and industrial system optimization. The message needs to be appropriate to plant managers and needs to make a direct link between industrial energy efficiency and cost savings, improved reliability, and greater productivity. If international corporations have already established or plan to establish industrial facilities in the country, they may be important allies in this campaign.

Once the in-country system optimization experts have been trained, additional awareness messages will be needed to help them build the market for system optimization services. It is important for the government to be active during this early stage of market transformation- by hosting factory awareness training sessions as part of the program response to the announcement of the energy management standard. A list of the trained experts can be kept and made available to companies seeking energy efficiency services.

Developing Enabling Partnerships

For an industrial energy efficiency policy to become effective, government officials will need to form partnerships. These enabling partnerships are needed to:

- build ownership in the proposed efforts to change existing practices and behaviors for greater energy efficiency;
- reach many industrial firms with the energy efficiency message through existing business relationships (such as with suppliers, trade associations, etc);
- develop credibility within specialized industrial sectors;
- ensure that proposed policies are practical given the current situation of industry in the country;
- engage the financial community and assist them in understanding the financial benefits of industrial energy efficiency;
- recruit the best talent to become trained in system optimization techniques; and
- successfully launch an industrial energy efficiency program.

The specific organizations that make effective partners will vary from country to country, but generally include: industrial trade associations, professional engineering societies or associations, equipment manufacturers and suppliers and their associations, leading and/or growing industrial companies, energy suppliers, technical universities, and commercial lenders.

6. Conclusions

Industrial energy efficiency is frequently overlooked by policy makers concerned about energy supply and use. Although designing an industrial energy efficiency program takes time and must be undertaken with some care, the opportunities for improving the efficiency of industrial facilities are substantial, even in markets with mature industries that are relatively open to competition. Developing countries with an emerging and expanding industrial infrastructure have a particular opportunity to mitigate GHG emissions while increasing their competitiveness by applying energy efficient best practices from the outset in new industrial facilities.

Evaluations of experience with target-setting agreements show that while results have been varied, the more successful programs have seen significant energy savings (Bjørner and Jensen, 2002), even resulting in a 50% increase over historical autonomous energy efficiency improvement rates (Reitbergen et al., 2002) and they can be cost-effective (Phylipsen and Blok, 2002). These agreements have important longer-term impacts including changes of attitudes and awareness of managerial and technical staff regarding energy efficiency. Overall, international experience shows that target-setting agreements are an innovative and effective means to motivate industry to improve energy efficiency and reduce related emissions, if implemented within a comprehensive and transparent framework (IEA, 1997a; IEA, 1997b).

International experience with energy management standards in industry has been very positive. Because energy management standards have only been in force since 2000 or later, most programs have not yet been subject to an independent evaluation. Their effectiveness can be inferred by the number of companies that seek affiliation with them, even when there is no penalty assessed for non-participation. Once a company meets the requirements of an energy management standard— establishing a cross-divisional management team led by an energy coordinator who reports directly to management; establishing a strategic plan that requires measurement, management, and documentation for continuous improvement for energy efficiency; developing policies and procedures to address energy purchase, use and disposal; initiating projects to reduce energy use on an ongoing basis; establishing key performance indicators to measure progress, and regularly documenting and reporting this progress— energy efficiency becomes part of organizational culture. This is the goal of the Industrial Standards Framework.

System optimization offers a way for companies to quickly realize cost, productivity, and operational benefits that can provide the reinforcement needed for management to proceed with the organizational changes required to fully integrate energy efficiency into daily operational practices. Capacity-building training creates a cadre of highly skilled system optimization experts that can provide the necessary technical assistance for industrial facilities to identify and develop energy efficiency improvement projects.

The System Optimization Library standardizes and streamlines the process of developing and documenting energy efficiency improvement projects, while also increasing the likelihood that the resulting energy savings will be sustained over the project life (typically 10 years or more). Evidence of sufficient documentation to support the persistence of energy savings is a critical pre-requisite for considering energy efficiency projects for emerging financial instruments such as white certificates or carbon credits.

Taken together, these elements comprise an effective industrial policy package that combine energy reduction targets, energy efficiency standards, system optimization training, and documenting for sustainability. The industrial sector represents more than one-third of global primary energy use and 36% of carbon dioxide emissions. As described in this paper, there are well-documented opportunities for cost-effective energy reduction on the order of 18-20% or more, while reducing industry’s CO2 emissions by 20-33%. The time to take action so that industrial energy efficiency becomes “business as usual” is now.

7. References

A complete listing of references is included in the full paper.