Policies and Measures to realise Industrial Energy Efficiency and mitigate Climate Change

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The group focuses on substantive and collaborative actions both in regard to policy development in the energy area and its implementation as well as in maintaining an overview of major ongoing initiatives within the system based on the UN-Energy work program at global, regional sub-regional and national levels.

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Policies and Measures to Realise Industrial Energy Efficiency and Mitigate Climate Change

Foreword

The industrial sector is responsible for a significant share of global energy use and carbon dioxide (CO_2) emissions. Energy efficiency is commonly seen as the most cost-effective, least-polluting, and most readily-accessible industrial energy saving option available in the industrial sector worldwide. Capturing the full extent of these potential end-use energy efficiency improvements rapidly is essential if the world is to be on a path to stabilise greenhouse gas (GHG) concentrations to a level that would prevent dangerous anthropogenic interference with the climate system.

In the International Energy Agency (IEA) 450 parts per million stabilisation scenario, over a quarter of all energy efficiency gains need to come from the industrial sector by 2050, largely by changing the pattern of industrial energy use. The reduction potential estimated by IEA and the Intergovernmental Panel on Climate Change (IPCC) for five energy-intensive industrial subsectors ranges from about 10 to 40 per cent, depending upon the sector.

There is significant potential to reduce, at low or no cost, the amount of energy used to manufacture most commodities. Many policies and programmes - at a national level - have already demonstrated significant improvements in industrial energy efficiency. The associate reduction in energy needs often also improves economic competitiveness as well as mitigates GHG emissions. However, at an international level, approaches such as the Clean Development Mechanism (CDM) are not yet delivering the expected energy efficiency improvements.

Existing and effective industrial energy efficiency policies and measures could be replicated at a global level. Key elements of those policies and measures include increasing facility management attention to the issue of energy efficiency; promoting the dissemination of information, practice, and tools; increasing the auditing and implementation capacity; and developing the market for industrial energy efficiency investment.

Better energy efficiency can produce substantial benefits both for global economic growth and poverty reduction as well as for mitigating climate change. The paper details examples of effective industrial energy efficiency policies and programmes. It provides a list of recommended actions to accelerate the adoption of industrial energy efficiency technologies and practices. Many policies and programmes have elements which seem likely to be readily deployable, replicable and transferable. A successful post-Kyoto architecture, regardless of its specifics, should therefore enable these elements see the light of reality.

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Executive Summary

The Bali Action Plan provides the principal framework for a post-2012 climate agreement. It focuses on a shared vision for long-term cooperative action and for enhanced national and international action to mitigate climate change, on adaptation, on supporting technology development and transfer, and on the provision of financial resources and investment. The Copenhagen agreement could help provide the foundation for scaling up industrial energy efficiency to levels that reflect its share of the global mitigation potential. To that end, the following recommendations are made:

- Energy sector policy reform - including the removal of broad-based subsidies - is needed to ensure that market signals fully reflect the true cost of producing and consuming energy and stimulate investment in energy efficiency markets.

- National Energy Efficiency Action Plans should be developed that set ambitious, achievable national energy efficiency goals or targets for the industrial sector based on studies which document the full costs and benefits of adopting energy-efficient technologies, practices, and measures.

- Better public datasets and indicators should be developed on industrial energy efficiency and cost of improvement options. A database of existing successful and potential industrial energy efficiency policies and measures should be compiled and documented. These should be assessed for their scalability, transferability (from one country/region to another, from one industry to another, or from one plant to another) and full costs (including local variations in fuel, technology and implementation costs).

- The use of technology cost-curves to assess industrial energy efficiency potentials should be extended to include the costs incurred to build the institutions needed to implement industrial energy efficiency policies and measures as well as the cost of the policies and measures themselves. Including these programme, institutional, and other transaction costs is particularly important for developing countries where markets and institutions may not be as mature as in their developed country counterparts.

- Proprietary energy efficiency technologies and processes that have significant energy-savings potential should be identified systematically and options to facilitate the wider deployment of these technologies in developing countries and transition economies should be explored. More attention should be focused on systems approaches, especially in industries that require a range of energy services (wherein potential synergies can be taken advantage of to reduce costs.)

- Capacity needs to be built in the skills and knowledge needed to tackle industrial energy efficiency. This capacity building should be a strong focus of post-2012 climate change agreements. It should aim to identify and transfer lessons learned from successful industrial energy efficiency policies and programmes, along with information on best practice technologies and measures that can be applied in the industrial sector.

- Countries should be required to provide an assessment of potential (in terms of GHGs mitigated) and a description of their existing industrial energy efficiency policies within their formal National Communications reporting to the UNFCCC. This will help promote the development of national energy efficiency plans, where they do not already exist.

The industrial sector is responsible for one third of global primary energy use and two fifths of global energy-related carbon dioxide (CO_2) emissions. There is significant potential to reduce the amount of energy used to manufacture most commodities. The technical reduction potential ranges from about 10% to 40% for five energy-intensive industrial sub-sectors. The economic potential is smaller, but also significant.

Historically, energy efficiency has improved, and emission intensities have reduced, as countries have become more economically developed. End-use energy efficiency has the capability to reduce GHG emissions very significantly, and at low cost. Many industrial energy efficiency options reduce costs and allow for higher levels of production for the same amounts of energy use. They can therefore indirectly[1] help to combat poverty.

Since 1973, energy efficiency and structural change have met about 58% of the new demand for energy services in industrialised countries. Without those energy efficiency improvements, energy demand would have been considerably higher (IEA, 2008a). More conventional fuel would have had to have been supplied and used, thereby increasing GHG emissions.

Industrial Energy Efficiency Potential

In terms of the CO_2 savings that might be achievable, IPCC analysis suggests that industry might be expected to make savings of 2.5 to 5.5 $GtCO_2$ equivalent in 2030 compared to a baseline scenario. This would represent a saving of 15 to 30% of the total projected baseline emissions in 2030. This picture is reinforced by IEA analysis that suggests that energy efficiency would constitute more than half of all industry's contribution to a scenario which envisages global CO_2 emissions halving by 2050. 90% of this potential, most of which would come from energy efficiency improvements, could be achieved at less than USD 50/tCO_2

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[1] In the household sector, improved energy efficiency can directly reduce household expenditures on energy services, and therefore directly help to reduce poverty. The impact of industrial energy efficiency on poverty is less direct, but nonetheless potentially substantial.

saved. The remaining 10% could be achieved at between USD 50 and USD 100/tCO2 saved (IPCC, 2007). 80% of the potential is in developing countries and transition economies.

While important, cost generalisations can be difficult. Considering only one industry type, costs can vary from an old to a new plant. Retrofitting existing facilities is usually more expensive than introducing efficient technologies in a greenfield plant. The same energy efficiency measure may have a different cost in industrial facilities that differ only in size. Per unit costs tend to be lower for larger plants, due to economies of scale. Further, due to differing: commodity prices, fuel prices, GHG penalties; labour conditions; and - amongst others - market peculiarities, implementation costs can vary by a factor of two or more due to local conditions. Together with differing institutional capacities, these aspects make cost generalisations difficult - and the need for careful documenting when compiling comparative databases important.

Countries differ in terms of their level of industrial energy efficiency. In part this is due to structural reasons: older plants tend to be less efficient than newer ones, so countries that have developed later tend to be more efficient. For example, the most efficient aluminium smelters are in Africa. India has a very energy efficient cement sector. And China has very ambitious efficiency targets for the coming years - a task helped by its growing and modernising economy. In spite of structural differences, policies demonstrably make a difference, as shown by reduced energy use per unit of output by industries in countries such as Japan and the Netherlands, for example.

Action to help spread and apply the most effective approaches, policies and measures has the potential to rapidly help raise the efficiency of all industrial plant nearer to that of the best. It is on this that this study particularly focuses.

Industrial Energy Efficiency Policies and Programmes

Since the 1970s, numerous energy efficiency policies and programmes have been implemented in many countries around the world with demonstrable success. Lessons learned from these programmes can be used to identify successful elements that can be more widely disseminated. In general these policies **deal directly with the informational, institutional, policy, regulatory, and market-related barriers to improving energy efficiency in industry**. They also provide policy and fiscal environments which enable industrial enterprises more easily to implement energy efficient technologies, practices, and measures. Below is a summary of key lessons:

- Distorting **subsidies are removed** and, as far as possible, mechanisms are put in place fully to **carry the cost of environmental impacts into the market**. Industrial subsidies can be provided in other forms that do not discourage the uptake of energy efficiency measures, but rather accelerate them and are more economically efficient than subsidising the energy price.

- Industrial **corporate culture is changed to include high level management commitment** to assign and realise the potential of energy efficiency in terms of improving competitiveness and furthering corporate social responsibilities.

- **Ambitious energy efficiency or GHG emissions reduction targets are set**. Such targets can be established in legal mandates or voluntarily at national or sectoral levels or even at facility level.

- Within industries, **measurable energy management systems are established**. (**Energy management standards** can provide an organising framework for industrial facilities. ISO 50001, the international energy management standard, is expected to have far-reaching effects on the energy efficiency of industry when it is published early in 2011[2])

- **Building human capacity, skills and training programs must be developed at various levels.** These include within industrial facilities, external experts and service providers as well as within key institutions expected to take part in the implementation of PAMs.

- **Information dissemination and sharing, as well as the promotion or provision of energy assessments and related services** provide a useful enabling environment for promoting industrial energy efficiency.

- **Benchmarking exercises are needed to calibrate industrial performance** to national or international best practice energy use levels (these may need to be carefully adjusted to allow for differing local conditions).

- Mandatory industrial **equipment and system performance and assessment[3] standards** are an effective way of increasing the market penetration of more efficient equipment.

- **Energy efficiency investment funds and carbon trading initiatives** can assist the deployment of energy efficiency practice. In this context, financial instruments such as taxes, subsidies, and programmes that improve access to capital are often employed.

- **The implementation of energy efficiency PAMs needs to be monitored and evaluated** (at both facility and national level) in terms of their key attributes, such as cost, GHG mitigated, intensity reductions etc.

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[2] http://www.unido.org/index.php?id=5844

[3] System assessment standards can provide a common framework for conducting assessments of the components of industrial systems such as motor systems, steam systems, combined heat and power generation, where a large share of the energy efficiency potential exists (Sheaffer and McKane, 2008). The formal and objective certification of plant energy efficiency performance can provide a standardised approach for identifying, developing, documenting, and reporting energy efficiency progress in industrial facilities. It also provides a framework for continuous improvement.

Policies and Measures to Realise Industrial Energy Efficiency and Mitigate Climate Change

I. Background

Many people assume that industries are already relatively energy efficient given the competitive pressures under which they operate and their technical capability to use energy efficiently. But there is in fact considerable scope to reduce the amount of energy used to manufacture most commodities. Many of these reductions can be achieved very cheaply or even at a profit once the value of the savings is taken into account.

The International Energy Agency (IEA) and the Intergovernmental Panel on Climate Change (IPCC) have estimated that five energy-intensive industrial subsectors could achieve savings of between 10% and 40% of their current energy use worldwide. In addition, further savings could be achieved by improving systems that are common to a number of industries such as electric motors and steam boilers, increasing the use of combined heat and power (CHP), integrating processes more effectively, recycling more, and recovering more wasted energy (IEA, 2007a; Bernstein et al., 2007).

Historically, energy efficiency has improved, and emission intensities have reduced, as countries have become more economically developed. This trend is expected to continue. Improvements in industrial energy efficiency can significantly contribute to environmental, social and economic sustainable development goals. They are an integral part of national socio-economic development (see for example Winkler et al., 2008). As the IPCC has noted: "it is often more cost-effective to invest in end-use energy efficiency improvement than in increasing energy supply to satisfy demand for energy services. Efficiency improvement can have a positive effect on energy security, local and regional air pollution abatement, and employment." And as economies have to cope with the challenges of high energy prices and rapid increases in energy demand, energy efficiency is simply economically efficient. Improving energy efficiency is also, at a global level, the most cost effective way of reducing greenhouse gas GHG emissions. Accelerating improvements in energy efficiency to meet GHG mitigation goals can also speed up socio-economic development and reduce poverty.

Governments, through appropriate policy-making and regulation, can create an environment in which industry is incentivised or even required to take action to improve energy efficiency levels. The IEA's World Energy Outlook 2007 urges all governments to undertake the "vigorous, immediate and collective policy action," which is "essential to move the world onto a more sustainable energy path" (IEA, 2007b). The IPCC notes that "governments can play an important role in technology diffusion by disseminating information about new technologies and by providing an environment that encourages the implementation of energy-efficient technologies" (Bernstein et al., 2007).

Recent global analyses of the potential to mitigate GHGs and the costs of doing so (IEA, 2007a; IEA, 2008a, IPCC, 2007) show that many energy efficiency measures involve relatively low investment costs. They result in energy use reductions which rapidly payback the initial capital expenditures and continue beyond that to contribute economic benefit. But few country-specific analyses have been completed of the benefits of energy efficiency programmes for economic development. Governments may be able to make good use of better information on the scope for improving industrial energy efficiency as well as the policies and programmes available to realise that potential.

In December 2007, the United Nations Framework Convention on Climate Change's (UNFCCC's) Ad Hoc Working Group on Long-term Cooperative Action issued a proposal, now commonly referred to as the Bali Action Plan or Bali Roadmap. This outlined areas to be addressed in the post-Kyoto agreement to be negotiated in Copenhagen in 2009 (UNFCCC, 2007). The successful adoption of industrial energy efficiency technologies, measures, policies, and programmes can both be supported by and contribute to a number of important elements in this action plan. Industrial energy efficiency can also play a particularly important role under the joint vision track of the action plan. Energy efficiency can contribute both to the development goals related to reducing poverty and to the global sustainability goals related to reducing emissions.

Experience shows that effective industrial sector energy efficiency policies and programmes depend on strong action to overcome informational, institutional, policy, regulatory, price, and other market-related barriers to better performance. The urgency of the climate challenge underlines the importance of identifying, distilling and where appropriate transferring the key features of the most successful energy efficiency policies and programmes. Short term measures to reduce energy use have the potential significantly to reduce the longer term cost of mitigating global climate change. A failure to seize these opportunities will result in much higher costs in the longer term.

Against this background, UN-Energy is promoting a dialogue on industrial energy efficiency. This includes side events at important international meetings, such as that held in the margins of the COP-14/MOP 4 meetings in Poznan in December 2008. Such activities help further to substantiate the importance of the role of energy efficiency in climate change mitigation, sustainable growth and development. They also provide an opportunity to focus on some specific issues that have been addressed in the post-Bali negotiation process and to discuss the further development of the role of industrial sector energy efficiency in delivering climate change mitigation strategies in any post-2012 framework.

In preparation for the side event during the COP-14/MOP 4 meetings in Poznan and for the study reported in this document, UN-Energy held an Expert Group Meeting (EGM) in Washington, DC on 22 and 23 September 2008[4]. The EGM focused on industrial energy efficiency and its role in climate change mitigation policies, including some critical technical issues in the ongoing climate change negotiations. It highlighted a number of effective industrial energy efficiency policies and measures and examined issues related to the quantification and reporting of emission reductions due to industrial energy efficiency. For each of these areas, the EGM addressed a variety of practical arrangements, mechanisms and policies that could be implemented to further the adoption of energy efficiency in industry as central elements of the international effort beyond 2012 to mitigate climate change.

The energy system is extensive and complex. Various configuration changes can reduce its costs - and are economically efficient. Various configuration changes can reduce its emissions - and are environmentally sound. And, various configuration changes can reduce the energy required to supply a service - and these are thermodynamically efficient. In this report, we consider "energy efficiency" measures, which normally meet all three of these goals: they are environmentally sound, economically and thermodynamically efficient (while there are energy efficiency measures which can increase costs, emissions and induce energy use rebound, those and their trade-offs are not discussed here, but should be born in the policy-makers' mind). The rebound effect refers to increases in emissions and/or energy use that results from actions (such as energy efficiency measures) intended to reduce the former.

Energy efficiency measures in this document refer to improved appliances, processes or systems of energy using technologies in an industrial facility. (These use energy to provide a service, such as heating, cooling or motive power, for example.) It is to be noted that this energy use is part of a broader energy system. That system consists of resources that are extracted, converted into useful energy carriers and transported to end users. Each step has associated costs, emissions and thermodynamic efficiencies. Focusing on reducing energy use in a demand sector (such as industry) will invariably not consider some of the gains or trade-offs associated with coordinated changes in the broader energy system. Such broader policies may include, for example, energy supply, fuel switching or integrated supply and demand policies (such as Demand Side Management). A simple illustrative example is that energy efficiency measures may not reduce emissions if the supply of the energy used is based on renewables. They may significantly reduce emissions where the supply system based on coal (without Carbon Capture and Storage). Again, such integrated interactions and trade-offs are to be accounted for in the broader energy policy context.

This paper:

- provides an overview of the energy and GHG reductions that might be achievable through the more effective adoption of industrial energy efficiency technologies, measures, policies, and programmes;
- draws on national and UN agency experience, as presented at the energy efficiency EGM, to identify good practice; and
- makes recommendations related to the areas of the Bali Roadmap where industrial energy efficiency can play a particularly significant role, including its contribution to the shared vision of reduced GHG emissions and economic development.

II. Industrial Energy Efficiency Potentials

There is significant scope to improve energy efficiency in industry. Many energy efficiency improvements are cost effective in their own right. The wider adoption of best available technologies could yield significant gains in the short and medium term. New technologies offer the prospect of additional gains in the longer term. These energy efficiency improvements need to be captured if GHG concentrations are to be put on a path to stabilise at levels between 450 ppm and 550 ppm by 2050. Governments should exploit industrial energy efficiency as their energy resource of first choice. It is the least expensive large scale option to support sustainable economic growth, enhance national security, and reduce further climate damage.

Total final energy use in industry amounted to 121 EJ in 2006 (Table 1). This includes petrochemical feedstocks that are not counted in the IEA statistics as industrial energy, but which are

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[4] The United Nations Industrial Development Organisation (UNIDO) and the International Atomic Energy Agency (IAEA), the organisations mandated by the group to lead its work on energy efficiency under the UN Energy Energy Efficiency Cluster, played the leading role in organising the EGM. They will continue to frame the discussion on industrial energy efficiency by coordinating inputs from other programmes and agencies such as the United Nations Environment Programme (UNEP), the United Nations Development Programme (UNDP), the United Nations Economic Commission for Europe (UNECE), the United Nations Economic and Social Commission for Western Asia (ESCWA), the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) and possibly other members of UN-Energy that are actively involved in energy efficiency programmes and projects.

TABLE 1. INDUSTRIAL FINAL ENERGY USE, 2005 (EJ/yr) (IEA, 2008A)

	World	OECD	Africa	Latin America	Middle East	Non-OECD Europe	FSU	Asia (excl. China)	China
Chemical and Petrochemical	35.2	18.4	0.4	1.5	2.6	0.3	3.2	3.4	5.3
Iron and Steel	25.0	7.5	0.4	1.2	0.1	0.3	3.5	1.6	10.4
Non-metallic Minerals	11.3	3.7	0.1	0.4	0.0	0.1	0.8	1.4	4.7
Paper, Pulp and Printing	6.7	5.1	0.0	0.4	0.0	0.0	0.3	0.2	0.7
Food, Beverage and Tobacco	6.1	2.9	0.0	1.0	0.0	0.1	0.5	0.7	0.9
Non-ferrous metals	3.9	2.0	0.1	0.4	0.0	0.0	0.1	0.0	1.2
Machinery	4.2	2.3	0.0	0.0	0.0	0.0	0.3	0.2	1.4
Textile and Leather	2.2	0.8	0.0	0.1	0.0	0.0	0.1	0.2	1.1
Mining and Quarrying	2.3	1.0	0.2	0.1	0.0	0.0	0.4	0.1	0.4
Construction	1.6	0.7	0.1	0.0	0.0	0.0	0.2	0.0	0.4
Wood and Wood Products	1.2	0.8	0.0	0.0	0.0	0.0	0.1	0.0	0.2
Transport Equipment	1.4	0.8	0.0	0.0	0.0	0.0	0.2	0.0	0.4
Non-specified	19.7	4.5	2.4	1.8	2.3	0.1	1.3	6.5	0.9
Total final energy	***120.7***	***50.5***	***3.8***	***7.0***	***5.0***	***1.1***	***11.1***	***14.3***	***27.9***
Total primary energy	***491.5***	***231.8***	***25.7***	***22.2***	***21.9***	***4.5***	***42.6***	***55.7***	***79.4***

Note: Includes petrochemical feedstocks, coke ovens and blast furnaces. FSU: Former Soviet Union.

nonetheless closely linked to industrial activities. These 121 EJ represent 32% of total final energy use across all end-use sectors.

65% of industrial final energy use is accounted for by four sectors: chemicals and petrochemicals, iron and steel, non-metallic minerals (especially cement) and pulp and paper. Industry also uses significant amounts of electricity. Refineries are not counted in the IEA statistics as part of manufacturing industry but they use also significant amounts of energy (11.7 EJ in 2006, additional to that used by manufacturing industry). Industrial direct CO_2 emissions from fossil fuel use and process emissions accounted for 25% of total global CO_2 emissions. This increases to 40% if the indirect emissions entailed in generating electricity for industrial use are also taken into account.

Developing countries and transition economies account for 58% of total industrial final energy use. China's share alone amounts to 23%. Asia as a whole accounts for 35%. Africa accounts only for 3.1%.

In terms of primary energy[5], total industrial consumption in 2006 amounted to 156 EJ, equivalent to 32% of total global primary energy use. Regional shares of the total primary energy used in industry vary from 19% in Africa to 46% in China. In some countries such as China, industry consumes more energy than any other sector. Industry's share of primary energy use has declined from 36.5% in 1971 to 31.7% in 2006. But most of this reduction occurred in the early part of this period. Industry's share of the total has remained fairly constant over the last ten years, with percentage reductions elsewhere being largely offset by rapid industrialisation in China.

Despite significant effort in recent years to collect efficiency data for energy intensive industries, important gaps remain, especially in the data for developing countries and transition economies. 17% of all industrial energy use is reported as "non-specified". This poses a major problem for industrial energy and climate change policy making and decision making worldwide. Collection of better data should be a priority, in order to ensure a solid basis for policy making. UN-Energy can play an important role in this data collection, especially for developing countries and transition economies.

According to IEA statistics, 35% of industrial energy use is accounted for by non-energy intensive industries, including a category for non-specified industrial uses (Figure 1). Some of the non-specified energy use should in fact be allocated to energy intensive industries, so 30% is probably a better estimate of the energy used in non-energy intensive industries. The way in which energy is used in these industries is not well understood. Some of them, such as food and beverages, textiles and leather, machinery and wood processing, are of special importance in developing countries. It is recommended that indicators be developed, and appropriate data collected, for these sectors.

Since 1973, improvements in energy efficiency and structural change across all sectors have helped to keep final energy use virtually constant in IEA countries. It is difficult to split energy efficiency and structural change accurately, but it has been estimated that the bulk of this gain, at around 1.4% a year, can be attributed to efficiency improvements. Accurate data do not exist for non-OECD countries. It is likely that energy efficiency improvements have been even larger in non-OECD countries, but these have been more than offset by increases in industrial production.

Without those energy efficiency improvements, energy demand would have been 58% higher (IEA, 2008a). More conventional fuel would have had to have been supplied and used, increasing

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[5] Derived from final energy statistics, assuming electricity conversion at 40% efficiency.

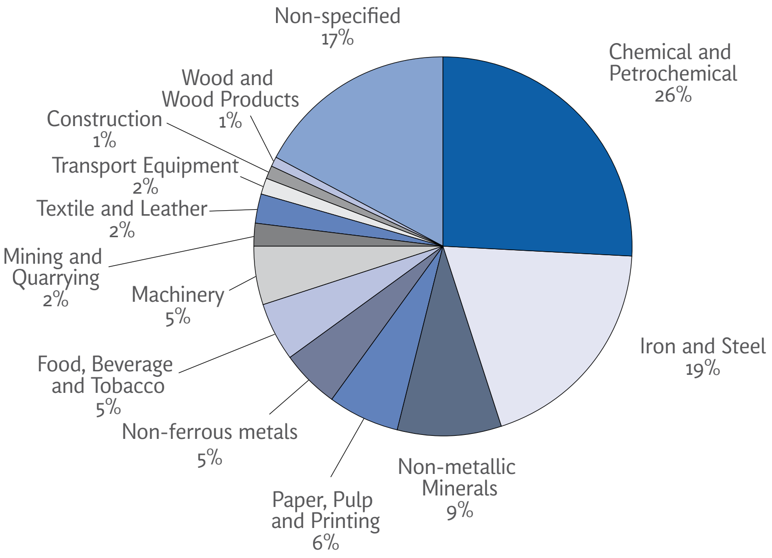

Figure 1. Share of industrial sectors in total industrial energy use (primary energy equivalents assuming 40% efficiency in power generation), 2006 (IEA, 2009)

GHG emissions. In the United States alone energy demand would be four times higher than it was in 1970 (Laitner, 2008).

Reduction of direct CO2 emissions in industry can be achieved by improving efficiency, but also through other means such as enabling fuel switching and capture and storage. Figure 2 shows the role that those technologies are expected to play in 2050 in a scenario whereby global emissions are reduced by 50% and those related to industry by 20%. The largest contribution to emissions reduction comes from energy efficiency (IEA, 2009).

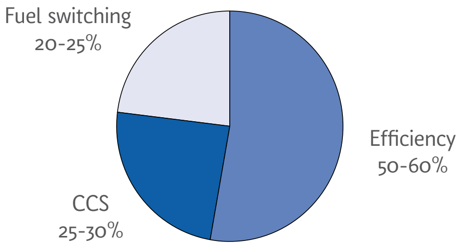

Figure 2. Long-term CO2 emissions reduction potentials in industry considering a 50% and 20% reduction globally and in industry respectively by 2050 (IEA, 2009)

Given its consumption of one third of all annual primary energy use and its production of a similar share of the world's energy and process CO2 emissions, industrial efficiency deserves special attention. There remains considerable scope to achieve further improvements.

Benchmarking studies allow for estimating the potential energy and emission saving in industrial sectors. They commonly feature the comparison of the energy or emission intensity of a fleet of plants with some of the best performing plants. The potential is estimated by means of comparing current performance with that of a reference (benchmark). Such benchmark represents an achievable target, i.e. the Best Process Technologies (BPTs) that are well established and have proven their economic viability in practice.

In Figure 3, the energy intensity of single plants, sorted from the least to the most efficient, is plotted against the cumulative production of those plants for various sectors. The energy intensity ratio is obtained by dividing the energy intensity of each plant by the energy intensity a hypothetical plant that would be producing at 10% of the cumulative production (benchmark). Global benchmarking studies show the potential for a further 10 to 20% improvement if all industrial plants were to operate at least at the levels of efficiency achieved by the benchmark plant (Gielen, 2009)[6].

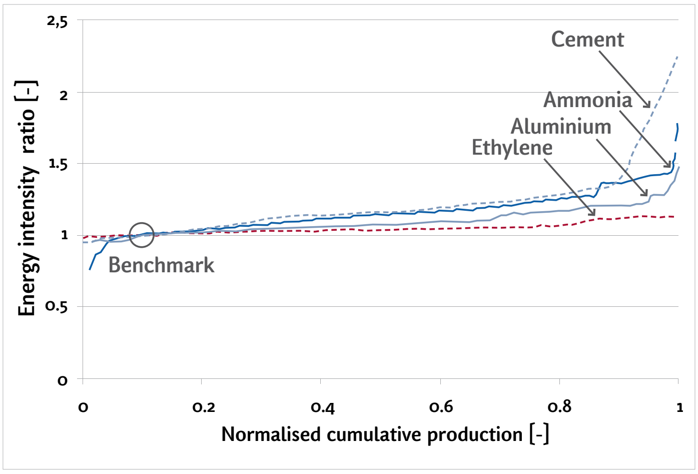

Figure 3. Indexed benchmarking curves for energy intensive commodities, 2006/7 (Knapp, 2009; IFA, 2009; Solomon, 2005; GNR, 2009). Note: Includes feedstock energy.

These benchmarking exercises tend to be supported mostly by well managed, and often more energy efficient, plants. The benchmarking curves may therefore underestimate the global efficiency potentials. Using Best Available Technologies (BATs), and moving beyond this to promising new technologies that are not yet commercially available, would also increase this potential substantially. To enable these issues to be understood more clearly, comprehensive benchmarking datasets for key energy intensive commodities should be developed as a matter of priority.

Table 2 sets out the potential for energy savings in each of the most energy intensive industrial sectors. This shows the potential for savings of 10 to 20% as against BPT. The potential saving is significantly higher if BATs or new technologies are assumed, rising to between 20% and 30%. Given the slow rate of technology development, it is possible to forecast future improvements with some level of confidence.

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[6] The curves in Figure 3 show that the 90% percentile is 12 to 37% above the 10% percentile for the four commodities analysed. The efficiency potential for the sector as a whole is half of this percentage, i.e. 6 to 20%.

TABLE 2. SECTORAL TECHNICAL ENERGY EFFICIENCY POTENTIALS BASE ON BENCHMARKING AND INDICATORS ANALYSIS (PRIMARY ENERGY EQUIVALENTS)

	Share of total global energy demand [%]	BPT [%]	BPT, BAT and breakthrough technology [%]	BPT, BAT, breakthrough technology and additional systems options [%]	Source
Iron and steel	5	15	25	35	Gielen, 2009, UNIDO estimate
Aluminium	1	15	30	35	Gielen, 2009, UNIDO estimate
Ammonia	1	15	25	40	Gielen 2009, UNIDO estimate
Petrochemicals	5	15	20	30	Saygin et al, 2009
Pulp and paper	1	20	30	35	IEA, 2007, 2008a, UNIDO estimate
Cement	2	25	30	35	GNR, 2009, UNIDO estimate
Petroleum refineries	2	10-20	15-25	15-25	Worrell and Galitsky, 2005, UNIDO estimate

Analysis of energy and materials systems can also provide interesting insights, especially for the 30% of energy used outside the energy intensive sectors. For example, the more efficient use of compressed air in the United States has been shown to achieve savings of to 20% or more (CAC/U.S. DOE, 2004). Steam supply systems offer potential energy efficiencies of 10% or more and electric motor systems offer potential efficiencies of 15 to 25% (IEA, 2007a). Fuel-use reductions of up to 35% can be achieved by the wider adoption of combined heat and power[7]. Similar substantial gains are possible if heat flows were to be optimised between different processes and between neighbouring installations. There is a limit however in terms of the distance over which the transport of hot water or steam makes sense which limits the potential of this option. Furthermore, increased recycling and energy recovery from organic waste materials such as plastics and wood, and improvements in the way in which industrial commodities are used (e.g. stronger steel, more effective nitrogen fertilizers) can raise these potentials still further.

To some extent the potentials identified in such an analysis will overlap with the BPT potentials listed in Table 2. But a broader systems perspective will often reveal the potential for significant additional energy efficiency improvements over and above those that would be identified by a narrow process perspective.

Achieving these energy efficiency potentials will depend heavily on the deployment of existing BPTs and on research, and on the development and demonstration of new technologies and systems. Production of most industrial commodities is projected to double between now and 2050. Energy efficiency alone will not be sufficient to achieve deep emission cuts. But given the magnitude and urgency of the energy and CO_2 challenge and the relatively limited potential of alternative options, energy efficiency must be called upon to make an important and early contribution.

The practical, cost-effective potential for energy savings is much smaller than the technical potential identified above. One important factor is the fact that much of the existing capital stock has a long life still in it. Retrofitting is usually much more costly than greenfield investment and replacing plant earlier than necessary in order to increase its energy efficiency, given the scale of most industrial investment, is rarely economic.

Efficiency potentials are not uniformly distributed across the world. Generally, efficiency potentials are higher in developing countries than in industrialised countries. Outdated technology, smaller scale plants and inadequate operating practices all play a role. But this is not always the case. The most efficient aluminium smelters are in Africa. India has the most efficient cement industry worldwide. And China has some state-of-the art steel factories. To some extent this can be attributed to the young age of the capital stock in these countries, and the older age of plant in OECD countries.

Government policies with regard to energy efficiency play an important role. In terms of the CO_2 savings that might be achievable, IPCC analysis suggests that industry might be expected to make savings of 2.5 to 5.5 $GtCO_2$ equivalent in 2030 compared to a baseline scenario. This would be a saving of 15 to 30% of the total baseline emissions in 2030. 90% of this potential, most of which would come from energy efficiency improvements, could be achieved at less than USD 50/tCO_2 saved. The remaining 10% could be achieved at between USD 50 and USD 100/tCO_2 saved (IPCC, 2007). 80% of the potential is in developing countries and

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[7] Although a proportion of this saving should be attributed to the power generation sector.

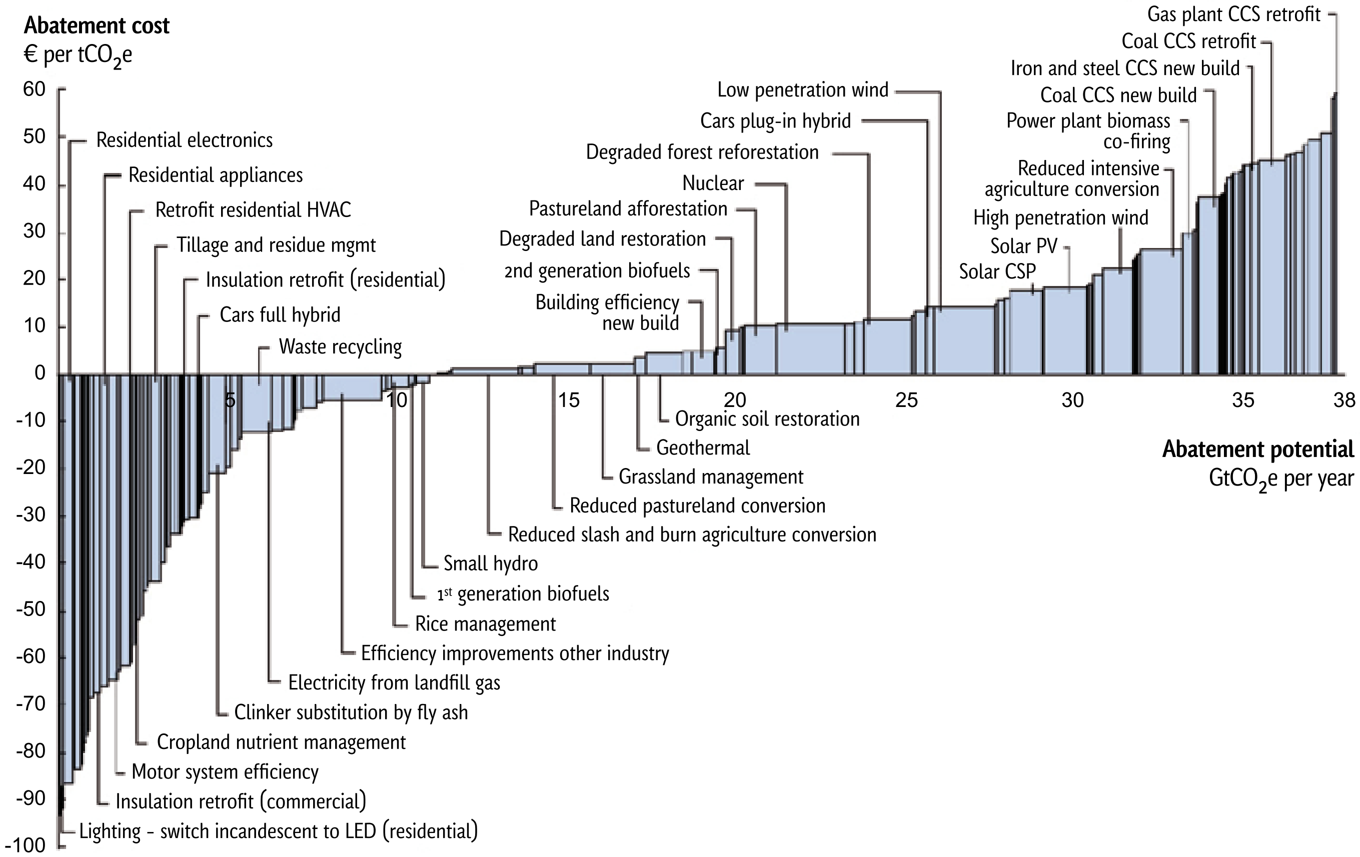

Figure 4. Global GHG abatement cost curve beyond business-as-usual - 2030 (McKinsey, 2009)

transition economies. This picture is reinforced by IEA analysis that suggests that energy efficiency would constitute more than half of all industry's contribution to a scenario which envisages global CO2 emissions halving by 2050.

Industrial energy efficiency has improved historically at a rate of about 1% per year, although effective policies and programmes have resulted in that rate being doubled in some countries (UNF, 2007). Countries that have had ambitious policies for some time, such as Japan and the Netherlands, tend to be more efficient than countries without such policies. Based on this experience, the G8 has made a commitment to reduce industrial energy intensity by 1.8% a year by 2020 and 2% a year by 2030. These are ambitious targets.

McKinsey & Company has assessed more than 200 GHG abatement opportunities across 10 major sectors and 21 world regions between now and 2030. The results comprise an in-depth evaluation of the potential, costs and investment required for each of those measures. Cost curves have been developed for the world (see Figure 4) and for a range of individual countries (Australia, Belgium, Brazil, China, Czech Republic, Germany, Sweden, United Kingdom, United States). These cost curves show a significant potential for energy efficiency at low or negative life cycle cost. Capturing all the potential will be a major challenge: it will require change on a massive scale, strong global cross-sectoral action and commitment, and a strong policy framework.

Energy efficiency is the most cost-effective, least-polluting, and readily-available energy "resource"[8] available in all[9] end-use sectors in all countries.

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[8] In a strict sense energy efficiency is not a resource, but a term referring to technological and behavioural measures which improve the productivity of energy usage. Increasing energy efficiency allows a fixed level of energy services to be delivered using less energy, or more energy services to be delivered for the same amount of energy. So increased energy efficiency enables the avoidance of energy resources. We therefore - to provide a powerful illustration - loosely refer to energy efficiency as an "energy resource" in its own right.

[9] We however make a strong statement that this does not include situations where energy poverty reduces the end user to having no access to energy. It is noted that "energy efficiency" potentials only exist where affordable energy is can be accessed.

III. Capturing Industrial Energy efficiency Potential through Policies and Programmes

Many energy efficiency technologies and measures that could be implemented in industry already exist. They fall short of full deployment for a number of reasons, some of which can be addressed through effective policies and programmes. Table 3 sets out a range of ways of addressing the barriers to energy efficiency improvements that have been identified by industry itself. It identifies against each of these some policies and programmes, based on the presentations from the EGM as well as on other material presented in this paper, that could be implemented to give effect to the removal of these barriers.

To maximise the potential impact of energy efficiency measures, the lessons learned from the implementation of policies and programmes needs to be distilled, disseminated, and adopted as appropriate in a way which fits local conditions. Removing these barriers is rarely cost free. So when policies are adapted to other settings, allowance needs to be made for the institutional, transactional and other costs necessary to make the deployment of the policy effective. In the context of least developed and developing countries it may require a good deal of analysis and appropriate support to help build institutional capacity and markets.

A. Energy Efficiency Barriers

Obstacles to the implementation of energy efficiency technologies and measures include:

- a lack of information about the possibilities for, and costs of, improving energy efficiency;
- a lack of awareness of the financial or qualitative benefits arising from energy use reduction measures;
- inadequate skills to implement such measures;
- capital constraints and corporate cultures that favour investment in new production capacities rather than in energy efficiency measures;
- greater weight being given to investment costs than to recurrent energy costs. This can be exacerbated where energy costs are a small proportion of production costs (Monari, 2008);
- slow rates of capital stock turnover in many industrial facilities (Worrell and Biermans, 2005), coupled with the risks perceived to be inherent in adopting new technologies; and
- an emphasis in many industrial investment decisions on large, attractive investment opportunities rather than on the more modest investments needed to improve energy efficiency, even where the profits can be relatively large.

Policy and regulatory-related barriers to the implementation of industrial energy efficiency technologies and measures fall into two broad groups. The first relates to *the adoption and prioritisation of industrial energy efficiency policies and measures at a national level, especially in developing countries*. Here the main barrier is inadequate information, skills, and methods to assess the costs and benefits of industrial energy efficiency policies and measures. Methods to address this have been developed (Howells and Laitner, 2003). But they are not widely deployed and they do not account for the institutional requirements and costs of supporting specific programmes. For example, the marginal cost of adopting policies and measures in a developed country which has many of the required institutions in place can be significantly lower than in a developing country. Although the adoption of industrial energy efficiency policies and measures may have benefits that far outweigh the costs, a substantive assessment of those costs and benefits is needed before policy changes can be mobilised.

The second group relates to the fiscal and regulatory framework within which energy efficiency technologies and measures sit. These include such issues as the non-economic pricing of energy, inappropriate tariff structures, distorted market incentives which encourage energy suppliers to supply more rather than less energy, and inadequate regulatory or legal frameworks to support energy service companies (Monari, 2008). The absence of supportive enabling environments for technology transfer can also present a barrier to energy efficiency technology adoption in some countries (IPCC, 2000).

TABLE 3. INDUSTRIAL ENERGY EFFICIENCY NEEDS AND GOALS ADDRESSED BY POLICIES AND PROGRAMMES

	POLICIES and PROGRAMMES						
NEEDS/GOALS	Target-Setting Voluntary Agreements	Industrial Energy Management Standards	Capacity Building for Energy Management and Energy efficiency Services	Delivery of Energy efficiency Products and Services	Equipment & System Assessment Standards	Certification and Labeling of Energy efficiency Performance	Financial Mechanisms and Incentives
EE INFORMATION AND TOOLS							
Increased information on EE technologies and measures			X	X	X	X	
Increased information on EE standards			X	X	X	X	
Improved access to high-quality energy auditing services and assessment tools			X	X		X	
Access to training and tools for energy management (EM)			X			X	
Increased tracking of EE/GHG emissions: GHG inventories, product life-cycle and supply chain energy/GHG assessments	X		X			X	
Robust measurement, monitoring, and verification	X	X	X	X	X	X	
Development of high-quality EE data for analysts, policy-makers	X					X	
International best practice information	X	X	X	X	X	X	X
SKILLED PERSONNEL							
Increased EE training at the college level			X	X			
Technical assistance providers for energy management			X			X	
Improved capability of energy efficiency service providers-assessment and EE services		X		X	X		
Increased EE focus of equipment suppliers and vendors		X	X	X	X		
Increased and enhanced skills of independent measurement and verification experts (GHG, EM, EE)		X	X	X	X	X	
Increased capacity for energy management at industrial facilities	X	X	X	X		X	
INCREASED MANAGEMENT ATTENTION TO EE							
Increased upper management support for energy efficiency/GHG mitigation investments	X	X				X	X
Management commitment to an energy management system	X	X				X	
Sustained, continuous improvement in EE/GHG mitigation	X	X				X	
EE/GHG MITIGATION COSTS AND FINANCING							
Improved access to capital for EE/GHG mitigation investments	X			X			X
Reduce transaction costs associated with smaller EE projects				X			
Improved understanding of among investors and financiers of potential financial returns		X				X	
Training in preparing project and loan request documents				X			
Pricing of energy to reflect actual costs, encourage EE efficiency							X
Reduce risks associated with assessing and securitising revenues generated through using less energy				X		X	

Market-related barriers to the implementation of industrial energy efficiency technologies and measures include a lack of awareness and experience among investors and financiers, particularly at the local level, of the potential financial returns, high transaction costs associated with smaller projects, and risks associated with assessing and securitising revenues generated through using less energy. In addition, limited access to systems and skills for the measurement, monitoring and verification of reduced energy use create barriers for project financing (Monari, 2008). In developing countries and emerging markets, industry can find it more difficult to secure loans due to a lack of credit history or collateral as well as a lack of experience in preparing project and loan request documents (UNF, 2007; Sambucini, 2008).

In seeking to secure project finance, it is important that all project implementation costs, including the costs of accessing and implementing a technology such as import costs, duties and tariffs, and the costs of securing capital, are included in financial calculations. In making a case for an energy efficiency programme, it is also important to be clear about other costs such as project design costs (e.g. end-use consumer awareness programmes, energy audits), institutional development costs (e.g. the cost of setting up energy efficiency agencies and energy service companies (ESCOs), the training of personnel, etc.), and the cost of monitoring and verifying energy use reductions (e.g. testing labs, testing protocols, testing personnel). These are often overlooked when the value of energy efficiency programmes is being promoted (Sarkar, 2008), undermining confidence in the overall benefit of the programme when such costs are brought to book.

An essential requirement for analysing the success of past and existing policies and programmes, as well as for developing robust recommendations for future efforts, is access to high-quality energy efficiency data. The IEA recently highlighted a significant gap in this respect (IEA, 2007c). In the absence of accurate data it is difficult to target and develop appropriate energy efficiency policies. Governments should support the IEA and others involved in energy efficiency indicator analysis by ensuring that accurate energy intensity time series data is reported regularly for all major industrial sectors (Mollet, 2008).

The wider adoption of industrial energy efficiency management practices, technologies and measures will depend critically on a number of factors, including increased management attention to industrial energy efficiency, the wider dissemination of industrial energy efficiency information and tools, an increased number of people skilled in the assessment and implementation of industrial energy efficiency practices, technologies, and measures, the creation of essential policy supporting institutions and an efficient industrial energy efficiency investment climate.

B. Policies and Programmes to Promote Industrial Energy Efficiency

Since the 1970s, a wide range of energy efficiency policies and programmes have been implemented in many countries around the world[10]. *Effective industrial sector policies and programmes are essential to increase the adoption of energy-efficient practices by overcoming informational, institutional, policy, regulatory, and market-related barriers. They also need to provide enabling environments for industrial enterprises more easily to implement energy-efficient technologies, practices, and measures.* Lessons learned from these programmes can be used to identify successful elements that can be more widely disseminated. These can be used to develop potential amendments to, or supplementary, GHG mitigation mechanisms. The VISA fund described in Appendix A is one example of the sort of wider institutional change that can emerge from such an analysis.

The IEA's Energy Efficiency Database contains details of 170 industrial energy efficiency policies and measures introduced at local, regional, and national levels in 32 countries and the EU (IEA, 2008c). The IEA's World Energy Outlook Policy Database includes 530 entries for policies and programmes in the industrial sector, drawn from information from the IEA Climate Change Mitigation Database, the IEA Energy Efficiency Database, the IEA Global Renewable Energy Policies and Measures Database, the European Conference of Ministers of Transport, and contacts in industry and government (IEA, 2008b).

Furthermore, the IEA has prepared 25 energy efficiency recommendations across 7 sectors for the G8 summit in Japan in 2008. Four of these recommendations relate to industry (IEA, 2008d):

- collection of high quality energy efficiency data for industry (development and application of energy indicators);
- energy performance of electric motors (performance standards for motors, barriers busting for motor systems optimization);
- assistance in developing energy management capability (energy management systems for large industry, support tools and capacity building for energy management, compulsory efficiency reporting systems);
- policy packages to promote energy efficiency in small and medium sized enterprises (information, audits, benchmarking, incentives for life cycle costing).

One review of twelve industrialised nations and the EU identified programmes that provided more than 30 types of energy efficiency product and service which were disseminated to industry through a wide range of delivery channels. These included

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[10] See McKane et al., 2007 and Price et al., 2008a for additional background information on industrial energy efficiency policies and programmes

reports, guidebooks, case studies, fact sheets, profiles, tools, demonstrations, roadmaps and benchmarking data and services. Delivery mechanisms included customer information centers and websites, conferences and trade shows, workshops and other training mechanisms, financial assistance programmes, voluntary agreements, newsletters, publicity, assessments, tax and subsidy schemes and working groups (Galitsky et al., 2004).

One example of an effective industrial energy efficiency programme in a developing country is the Kenyan programme on the Removal of Barriers to Energy Efficiency and Conservation in Small and Medium Scale Enterprises (SME), financed by the Global Environmental Facility (GEF) and managed by the Kenya Association of Manufacturers (Kirai, 2008). This programme has shown that publicly initiated programmes, including those with social and/or environmental objectives, can attract private sector participation if they are effectively linked to the economic and business motives of the private sector. A sound institutional framework and the active participation of private sector top management are fundamental to success. Demonstration projects and experience sharing have been shown to be powerful tools for increasing confidence and for spreading and replicating the programme (Kirai, 2008).

1. Industrial Energy Efficiency Target-Setting, Voluntary Agreements, and Voluntary Actions

One of the barriers to the adoption of energy-efficient technologies, practices, and measures is a corporate culture that understandably focuses more on production rather than on energy efficiency. Policies and programmes need to raise awareness of the importance of energy efficiency as a means of achieving and sustaining competitiveness in global markets. Successful energy efficiency policies and programmes depend heavily on top management commitment to energy efficiency.

Establishing appropriate and ambitious energy efficiency or GHG emissions reduction targets can provide a strong incentive for the adoption of energy-efficient technologies, practices, and measures. These can be legally mandated through government programmes or they can be adopted by high-level corporate management as a matter of company policy. Examples of national-level target-setting programmes include the GHG emissions reduction targets established through the Kyoto Protocol, country-specific energy efficiency or GHG emissions reduction targets such as those established in the United Kingdom, and China's goal to reduce energy consumption per unit of gross domestic product by 20% between 2005 and 2010 (Price et al., 2008a).

Examples of corporate targets include programmes at Dow Chemical, DuPont, and BP (see Box 1). Other companies have engaged in company-specific programmes having been stimulated to do so by government or non-governmental organisation (NGO) programmes such as those run by the Carbon Trust in the United Kingdom, the Business Environmental Leadership Council of the Pew Center on Global Climate Change, the World Wildlife Fund for Nature's Climate Savers Programme, or through government programmes such as the United States Environmental Protection Agency's Climate Leaders programme (US EPA, 2008a). Voluntary actions of this kind can spur information exchange between companies, put pressure on poor performing companies to meet industry averages, provide awareness-raising and encourage the deployment of improved technology (Bernstein, 2008). Although some early programmes performed poorly, corporate programmes since 2000 have shown positive benefits.

BOX 1: EXAMPLES OF CORPORATE ENERGY EFFICIENCY OR GHG MITIGATION TARGETS

- Dow Chemical set itself a target to reduce energy intensity (energy use/unit product) from 1994-2005 by 20%. The company actually achieved a 22% energy intensity reduction, saving USD 4 billion. Dow Chemical's energy intensity reduction goal for 2005 to 2015 is 25% (Foster, 2006).

- DuPont set itself a target to reduce GHG emissions by 65% from its 1990 levels by 2010. The company has, as a result, achieved USD 2 billion in energy savings since 1990 and reduced its GHG emissions by over 72%, by increasing output while holding its energy use at 1990 levels (DuPont, 2002; McFarland, 2005).

- BP's target to reduce GHG emissions by 10% in 2010 compared to a 1990 baseline was reached nine years early, in 2001 (BP, 2003; BP, 2005).

- Hasbro, Inc. achieved an internal emissions reduction goal by reducing total GHG emissions by 43% from 2000 to 2007 for its U.S. manufacturing facilities (US EPA, 2008a).

- In 2005, 3M reduced absolute GHG emissions in its U.S. facilities by 37% from a 2002 base year (U.S. EPA, 2008a).

Target-setting, voluntary and negotiated agreements, have been used by a number of governments as a mechanism for promoting energy efficiency within the industrial sector. A recent survey identified 23 energy efficiency or GHG emissions reduction voluntary agreement programmes in 18 countries (Price, 2005). International experience of such programmes suggests that they work best when they are supported by the establishment of a coordinated set of policies that provide strong economic incentives as well as technical and financial support to the participating industries. Effective target-setting agreement programmes are typically based on signed, legally-binding agreements with realistic long-term (typically 5-10 year) targets. They require facility or company level implementation plans for reaching the targets and the annual monitoring and reporting of progress toward those targets, coupled with a real threat of increased government regulation or energy/GHG taxes if the targets are not achieved. And they in parallel provide effective supporting programmes to assist industry in reaching the goals outlined in the agreements.

The key elements of such a programme are:

- the target-setting process;
- the identification of energy efficiency technologies and measures through benchmarking and energy efficiency audits;
- the development of an energy efficiency action plan;
- the development and implementation of energy management protocols;
- the development of financial incentives and supporting policies;
- monitoring progress toward targets; and
- programme evaluation (Price et al., 2008a).

An example of such a programme can be seen in the Climate Change Agreements (CCA) programme implemented by the United Kingdom (see Box 2).

BOX 2: CLIMATE CHANGE AGREEMENTS IN THE UK

The UK has a Kyoto Protocol target of a 12.5% reduction in GHG emissions by 2008-2012 relative to 1990. It also has a national goal to reduce CO2 emissions by 20% by 2010 relative to a 1990 baseline (DEFRA, 2006).

The UK established a Climate Change Programme in 2000 to address both goals through the application of an energy tax - the Climate Change Levy - applicable to industry, commerce, agriculture, and the public sector as well as through the implementation of Climate Change Agreements (CCAs) with energy-intensive industrial sectors. Through the CCAs, industry agrees to meet energy targets in exchange for an 80% reduction in the Climate Change Levy (DEFRA, 2004). The programme has established agreements with over 50 different industry sectors covering 10,000 sites. The agreements are attractive to industry because of the tax reduction. Participating industries must meet targets every two years to benefit from the tax rebate and the risk of losing the tax reduction is sufficient to ensure real energy-reducing actions are taken. The CCAs include a baseline and a credit emissions trading scheme in which, if targets are missed, companies can buy allowances and, if targets are beaten, companies can sell allowances targets through the UK Emissions Trading Scheme (DEFRA, 2005a; Pender, 2008).

Companies that sign CCAs commit to either absolute or relative energy-reduction targets for 2010. Sectors did better than expected, even though they genuinely believed they were already energy-efficient, because the CCAs brought new rigour to the measurement and management of energy use that identified additional opportunities and led to higher reductions. In addition, finance directors took an interest and authorised spending because a tax reduction was available (Pender, 2008).

As a result of the CCA programme, CO2 emission reductions were nearly three times higher than the target (Table 4) (Pender, 2004) during the first target period (2001-2002), more than double the target set by the government during the second target period, and almost double the target during the third target period.

TABLE 4. RESULTS OF THE UK CLIMATE CHANGE AGREEMENTS: PERIODS 1-3

Absolute Savings from Baseline	Actual Savings (MtCO2/year)	Target (MtCO2/year)	Actual minus Target (MtCO2/year)
Target Period 1 (2001-2002)	16.4	6.0	10.4
Target Period 2 (2003-2004)	14.4	5.5	8.9
Target Period 3 (2005-2006)	16.4	9.1	7.3

Sources: DEFRA, 2005b; Future Energy Solutions, 2005; DEFRA, 2007, Pender, 2008)[11]

As a result of the CCA programme, energy has become a board level issue. Top management is alert to the importance of ensuring they meet their targets and maintain their levy reductions. Industry is saving over £1.5 billion (USD 2.23 billion) a year on energy costs as well as the savings it is achieving by avoiding the Climate Change Levy itself (£350m or USD 520 million).[12] Overall, the CCAs improve efficiency and so improve competitiveness (Pender, 2008; Barker et al., 2007).

Another example is the China's 11th Five Year Plan, announced in 2005, which established an ambitious goal for reducing energy consumption per unit of gross domestic product by 20% between 2005 and 2010. One of the main vehicles for realising this energy intensity reduction goal is the Top-1000 Energy Consuming Enterprises programme (Top-1000 programme). This has set energy reduction targets for China's 1000 highest energy consuming enterprises. The participating enterprises are from nine energy-intensive sectors (iron and steel, non-ferrous metals, chemicals, petroleum/petrochemicals, power generation, construction materials, coal mining, paper, and textiles) that jointly consumed 33% of national energy consumption and 47% of industrial energy consumption in 2004 (Kan, 2008; Price et al, 2008b).

The Top-1000 programme, launched in April 2006 (NDRC, 2006), set the goal that energy intensity (energy used per unit of production) should in all

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[11] Note that adjustments to the target have been made due to significant changes in the steel sector; see referenced material for details.

[12] Based on a currency conversion rate of 1 GBP = 1.488 USD.

enterprises reach the level of advanced domestic production and in some enterprises either international or industry advanced levels of energy intensity. The Top-1000 enterprises were each given individual goals which, taken together, sought to achieve a reduction in annual energy use of 100 Mtce (2.9 EJ) by 2010 (Price et al, Article in Press). Financial support for the programme has been provided by the national and provincial governments as well as through international projects, such as the China End Use Energy Efficiency Project funded at USD 17 million[13] for three years through the World Bank's Global Environment Facility and the EU-China Energy and Environment Programme funded at a level of EUR 42 million (Kan, 2008).

The reported energy use reductions for the first year of the programme (2006) indicate that it is on track to achieve the goal of reducing energy use by 100 Mtce in 2010. Progress reported in 2007 suggests that the programme may even surpass this goal. Depending on the GDP growth rate, the programme could contribute between 10% and 25% of the savings required for China to meet a 20% reduction in energy use per unit of GDP by 2010 (Price et al., 2008b).

2. Industrial Energy Management Standards

Once targets have been established and/or corporate management has made a commitment to improve energy efficiency or reduce GHG emissions, it is essential to institutionalise energy management in a wider culture for sustained improvement. Energy management standards can provide a useful organising framework for accomplishing this in industrial facilities.

Energy management standards seek to provide firms with the guidance and tools they needs to integrate energy efficiency into their management practices, including into the fine-tuning of production processes and steps to improve the energy efficiency of industrial systems. Energy management seeks to apply to energy use the same culture of continuous improvement that has successfully stimulated industrial firms to improve their own quality and safety practices. Energy management standards have an important role to play in industry, but are equally applicable to commercial, medical, and government operations.

Table 5 compares the elements of the energy management standards in a range of countries and regions with existing energy management standards or specifications, two sets of standards under development, and one country for which energy management is a legislated practice for many industries. In all instances, the standards have been developed to be compatible with the International Organisation for Standardisation (ISO) quality management (ISO 9001:2008) and environmental management (ISO 14001:2004) standards.

Typical features of an energy management standard require the organisation to put in place:

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

A successful programme in energy management begins with a strong corporate commitment to the continuous improvement of energy performance through energy efficiency and energy conservation and the increased use of renewable energy. A first step once the organisational structure has been established is to conduct an assessment of the major energy uses in the facility to develop a baseline of energy use and set targets for improvement. The selection of energy performance indicators, targets and objectives help to shape the development and implementation of action plans. An important element in ensuring the effectiveness of an action plan is involving personnel throughout the organisation. Personnel at all levels should be aware of the organisation's energy use and its targets for improving energy performance. Staff need to be trained both in skills and in general approaches to energy efficiency in day-to-day practices. In addition, performance should be regularly evaluated and communicated to all personnel, with appropriate recognition for high achievement. The emergence over the past decade of better integrated and more robust control systems can play an important role in energy management and in reducing energy use.

In March 2007, UNIDO hosted a meeting of experts, including representatives from the ISO Central Secretariat and the nations that have adopted energy management standards. That meeting led to submission of a UNIDO communication to the ISO Central Secretariat requesting that ISO consider undertaking work on an international energy management standard.[14] In February 2008, the ISO approved a proposal from the American National Standards Institute (ANSI) and the Associação Brasileira de Nor-

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[13] USD 80 million if you include governmental and private cost-sharing.

[14] http://www.unido.org/index.php?id=086084

TABLE 5. COMPARATIVE ANALYSIS OF ENERGY MANAGEMENT STANDARDS

Participating Countries	Participating Countries	Develop Energy Management Plan	Establish Energy Use Baseline	Management Appointed Energy Representative	Establish Cross-Divisional Implementation Team	Emphasis on Continuous Improvement	Document Energy Savings	Establish Performance Indicators & Energy Saving Targets	Document &Train E mployees on Procedural/ Operational Changes	Specified Interval for Re-evaluating Performance Targets	Reporting to Public Entity Required	Energy Savings Externally Validated or Certified	Year Initially 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 %
Japan[3]	yes	yes	yes	licensed	implied	yes	yes	yes	yes	yes, annually	yes	yes	1979	90 %
Korea	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes, annually	optional	optional[4]	2007	data not yet avail
Netherand[5]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	optional[1]	2000	20-90 %[6]
Sweden	yes	yes	yes	yes	unclear	yes	yes	yes	yes	yes[1]	yes	optional[1]	2003	50 % elect
Thailand	yes	yes	yes	yes	implied	yes	yes	yes	yes	industry sets own	yes	evaluation plan	2004	not known[7]
United States	yes	yes	yes	yes	yes	yes	yes	yes	yes	annual recomm	no	no[8]	2000	< 5 %[8]
Under Development														
CEN (EU)	yes	yes	yes	yes	implied	yes	yes	yes	yes	industry sets own	national schemes	national schemes		
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 Japan has the Act Concerning the Rational Use of Energy, which includes a requirement for energy management
4 Korea invites large companies that agree to share information to join a peer-to peer networking scheme and receive technical assistance and incentives
5 Netherlands has an Energy Management System, not a standard, per se, developed in 1998 and linked to Long Term Agreements in 2000.
6 800 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.
7 Thailand has made the energy management standard is mandatory for large companies, linked it to existing ISO-related program activities, coupled with tax relief; program evaluation not yet available
8 To date, the US government has encouraged energy management practices, but not use of the standard. A program was initiated in 2008 to address this which also includes validation; program evaluation results anticipated in 2011.
NOTE: National standards and specifications were used as source documents

Source: McKane et al., 2007 as updated by the author in 2008 mas Técnicas (ABNT) to lead development of this standard (ISO, 2008).

The ISO has recognised energy management as one of its top five global priorities through the initiation of work on "ISO 50001: Energy management systems - Requirements with guidance for use" (ISO 2008). ISO 50001 is due to be published in early 2011.

The emergence of ISO 50001 is expected to have far-reaching effects in stimulating greater energy efficiency in industry when it is published. This will be especially true in developing countries and emerging economies, where indications are that it will become a significant factor in international trade, as ISO 9001 has become.

3. Capacity Building for Energy Management and Energy Efficiency Services

Capacity Building for Energy Management

Experience in countries with energy management standards or specifications has shown that the appropriate application of energy management standards requires significant training and skills. The implementation of an energy management standard within a company or an industrial facility requires a change in existing institutional approaches to the use of energy, a process that may benefit from technical assistance from experts outside the organisation. There is a need to build not only internal capacity within the organisations seeking to apply the standard, but also external capacity from knowledgeable experts to help establish an effective implementation structure.

The core of any energy management standard involves the development of an energy management system. Organisations already familiar with other management systems, such as ISO 90001 (quality) and ISO 14001 (environmental management), will recognise a number of parallels in the implementation of an energy management system. For these organisations, the need for outside assistance may be limited to an orientation period and initial coaching. For organisations without such experience, varying degrees of technical support will likely be required for several years until the energy management plan is well-established.

The suite of skills required to provide the technical assistance needed for energy management is unique, since it combines both management systems and energy efficiency. Individuals and firms familiar with management systems for quality, safety, and environmental management typically have little or no expertise in energy efficiency. Industrial energy efficiency experts are highly specialised in energy efficiency, but are likely to be less familiar with broader management system approaches. Globally, the need for energy management experts is expected to increase rapidly once ISO 50001 is published in early 2011. Capacity building is urgently needed now to meet the growing demand for high quality energy management expertise.

UNIDO is continuing its interest and support for energy management through the inclusion of capacity building as part of its regional and national programmes in a number of countries in Southeast Asia, Russia, and Turkey. Since system optimisation is not taught in universities or technical colleges, these programmes also include modules on system optimisation, based on a successful model developed for a pilot programme in China.

Capacity Building for System Optimisation

The optimisation of industrial systems and processes can make a significant contribution to improving energy efficiency in many industrial contexts. But it requires skills that are not learned in many existing programmes

For example, as part of the UNIDO China Motor System Energy Conservation Programme, 22 engineers were trained in system optimisation techniques in Jiangsu and Shanghai provinces. The trainees were a mix of plant and consulting engineers. Within two years of completing their training, these experts had conducted 38 industrial plant assessments and identified nearly 40 million kWh of savings in energy use. Typical system optimisation projects identified through this initiative are summarised in Table 6.

TABLE 6. REDUCED ENERGY USE FROM SYSTEM IMPROVEMENTS (CHINA PILOT PROGRAMME)

System/Facility	Total Cost (USD)	Energy Use Reductions (kWh/year)	Payback Period (years)
Compressed air /forge plant	18,600	150,000	1.5
Compressed air /machinery plant	32,400	310,800	1.3
Compressed air /tobacco industry	23,900	150,000	2
Pump system /hospital	18,600	77,000	2
Pump system /pharmaceuticals	150,000	1.05 million	1.8
Motor systems /petrochemicals[*]	393,000	14.1 million	0.5

[*] Note that this was an extremely large facility
Source: Williams, et al., 2005

The goal in this respect is to create a cadre of highly skilled system optimisation experts. Careful selection is needed of individuals with prior training in mechanical, electrical or related process engineering, who have an interest and the opportunity to apply their training to develop projects. This training is intensive and system-specific. Experts may come from a variety of backgrounds, including government sponsored energy centres, factories, consulting companies, equipment manufacturers and engineering services companies. International experts in pumping systems, compressed air systems, ventilating systems, motors and steam systems are used to develop local experts.

Ideally, the completion of the intensive training programme is coupled with formal recognition for the competency of the trained local experts. Testing of skills through the successful completion of at least one system optimisation assessment and preparation of a written report with recommendations that demonstrates the ability to apply system optimisation skills should be a prerequisite for such recognition.

Trained local experts can also be used to offer awareness level training to factory operating personnel on ways of recognising system optimisation opportunities. This awareness training can be used to build interest in and demand for local system optimisation services.

4. Delivery of Industrial Energy Efficiency Products and Services

Most industrial plant managers are focused on production levels. They have neither the time nor the incentive thoroughly to investigate and evaluate the many ways in which energy use could be reduced. Industrial energy efficiency information programmes aim to make it easier for them to do so by creating and disseminating relevant technical information through energy efficiency assessment and self-auditing tools, case studies, reports, guidebooks and benchmarking tools (Galitsky, et al., 2004). Industrial energy efficiency products and services can be provided by governments, utilities, consulting engineers, equipment manufacturers or vendors, or by ESCOs.

Government Programmes

Energy audits or assessments can help plant managers to understand their energy use patterns and identify opportunities to improve efficiency. In the mid-1990s, the IEA convened an expert group on industrial energy audits and initiated a project on Energy Audit Management Procedures. These procedures provide information on training, authorisation, quality control, monitoring, evaluation, energy audit models, and auditor tools based on auditing programmes in 16 European countries (Väisänen, et al., 2003). Such project allowed for discussing a variety of auditing tools used within European auditing programmes (Ademe, 2002), and describing energy auditor training, authorisation of energy auditors, and quality control of energy audits. The US DOE's Industrial Technologies Programme (ITP) provides energy assessments for industrial facilities through the Industrial Assessment Center (IAC) and the Save Energy Now initiative. US DOE has also developed a software tool called the Quick Plant Energy Profiler that characterises a plant's energy consumption and provides industrial plant personnel with a range of relevant information on energy use and costs, opportunities to reduce energy use, and a list of recommended actions, including the use of ITP software tools for specific systems (U.S. DOE, 2008a). ITP has also developed a number of software tools focused on assessment of technologies and systems that are found in many industrial facilities and are thus not industry-specific. These include motors, pumps, compressed air systems, and process heating and steam systems.

Other auditing or assessment approaches include:

- energy audits conducted as part of the Dutch Long Term Agreements (Nuijen, 2002);
- the Danish CO_2 Tax Rebate Scheme for Energy-Intensive Industries (Ezban et al., 1994);
- Taiwan's energy auditing programme in which 314 industrial firms were audited between 2000 and 2004 (Chan et al., 2007); and
- the IFC's industrial audit programme (Shah, 2008).

In 2006, the Ministry of Trade and Industry in Finland held a 3-day workshop on energy auditing and issued the Lahti Declaration in which 39 countries and 8 international organisations emphasised the importance of energy auditing and established the International Energy Audit Programme (IEAP) (Lahti Declaration, 2006).

Case studies documenting the use of specific industrial energy efficiency technologies and measures can provide plant managers with insights into the implementation costs, energy savings, and experiences of other industrial facilities. The US DOE provides case studies that describe energy efficiency demonstration projects in industrial facilities in the aluminium, chemicals, forest products, glass, metal casting, mining, petroleum, steel, cement, textiles, and other sectors[15] and tip sheets, technical fact sheets and handbooks, and market assessments for industrial systems.[16] Case studies providing information on commercial energy-saving technologies for a number of industrial sectors are also provided by the Centre for Analysis and Dissemination of Demonstrated Energy Technologies (CADDET).[17]

Reports or guidebooks can provide more comprehensive information on the many industrial energy efficiency technologies and measures that are available for specific end-use sectors or for specific energy-consuming systems.[18]

Benchmarking can be used to compare a facility's energy use to that of other similar facilities or to national or international best practice energy use levels. Canada's Office of Energy Efficiency has benchmarked the energy use of ammonia, cement, fertiliser,

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[15] http://www1.eere.energy.gov/industry/bestpractices/case_studies.html
[16] http://www1.eere.energy.gov/industry/bestpractices/technical.html
[17] http://www.caddet.org/index.php
[18] See for example, Australia's Energy Efficiency Best Practice Guides the Netherlands' Long-Term Agreements and the UK Carbon Trust technology guides and similar initiatives in Canada and the United States. The Cement Sustainability Initiative has also published a sector-specific study for the cement industry (ECRA, 2009).

food and beverage, mining, oil sands, petroleum products, pulp and paper, steel, textiles, and transportation manufacturing facilities.[19] In the Netherlands, Benchmarking Covenants encourage participating industrial companies to benchmark themselves to their peers and to commit to becoming among the top 10% most energy-efficient plants in the world or one of the three most efficient regions (Commissie Benchmarking, 1999). The U.S. ENERGY STAR has developed a benchmarking tool called the energy performance indicator (EPI) for the cement, corn refining, and motor vehicle assembly industries that ranks a facility among its peers based on norms for the energy use of specific activities or on factors that influence energy use.[20] Lawrence Berkeley National Laboratory has developed the BEST: Benchmarking and Energy Saving Tool for industry to use to benchmark a plant's energy intensity against international best practice and to identify energy efficiency options that can be implemented. BEST has been developed for the cement and steel industries in China (Price et al., 2003) and in the California wine industry (Galitsky et al., 2005).

The sharing of information about energy efficiency technologies and measures between industrial organisation is a key element of the United States Environmental Protection Agency's (US EPA) Energy Star for Industry programme, the second phase of the Dutch Long-Term Agreements (LTA-2), and the Carbon Trust's work in the UK. The Energy Star for Industry programme convenes focus groups for a number of major industrial sectors. These groups meet regularly to discuss barriers to energy efficiency and share energy management techniques (US EPA, 2008b).

Under the LTA-2 programme, knowledge networks have been established by SenterNovem, an agency of the Dutch Ministry of Economic Affairs, in the areas of bio-based business, process engineering, sustainable product chains, heat exchangers, separation technology, drying processes, process intensification, and water technology. A website has been established for companies, institutions and consultants interested in sharing their knowledge and experience. The knowledge networks organise several meetings a year that provide an opportunity for members to make presentations and to discuss recent developments, research findings, and new applications in the network area. They maintain a website with surveys of the main organisations involved in the field as well as recent articles and other publications. They also support new projects, maintain contacts with similar networks and researchers in other countries and develop roadmaps related to the network area (SenterNovem, 2008).

There are several measures which help reduce emissions from industrial energy use. As industrial energy efficiency is prominent among these it is often promoted via carbon reduction actions. The UK's Carbon Trust is a government-funded independent entity set up to help businesses and the public sector to reduce their carbon emissions by 60% by 2050 (UK DTI, 2003). The Carbon Trust identifies carbon emissions reduction opportunities, provides resources and tools, provides interest-free loans to small and medium sized enterprises, funds a local authority energy financing scheme, and promotes the government's Enhanced Capital Allowance Scheme. It also has a venture capital team that invests in early-stage carbon reduction technologies as well as management teams that can deliver low carbon technologies (Carbon Trust, 2008).

5. Industrial Equipment and System Assessment Standards

Equipment Standards

Motors are very widely used in industry. Most motors perform at levels well below those of the high efficiency motors available today. Improving motor efficiency would offer a significant opportunity for energy savings.

High efficiency motors cost 10 to 25% more than standard motors. But they offer motor losses 20% to 30% lower. So, depending on their hours of operation, the additional cost of a high efficiency motor can often be recovered in less than three years.

When motors fail, they are frequently repaired rather than replaced. A typical industrial motor will be repaired 3 to 5 times over its life. The quality of the repair is the most important factor in maintaining the efficiency of the repaired motor. In general, quality repairs will reduce energy efficiency by 0.5% or less, while poor repairs can reduce efficiency by 3% or more. When future operating costs are taken into account, it is usually more cost effective to replace standard motors with more energy efficient ones rather than to repair them. Under some conditions, it can be more cost effective even to replace a fully functioning motor with a more energy efficient one (Nadel, et al., 2002).

The adoption of minimum efficiency performance standards (MEPS) has been shown to be the most effective way generally to improve the energy efficiency of motors in industry. Where standards for high efficiency motors have been mandatory for some time, such as in the United States and Canada, high-efficiency motors make up about 70% of the current stock. Where they are not mandatory, such as in the European Union, more than 90% of all industrial motors operate at or below standard efficiency (Table 7). Australia's MEPS for electric motors has also been shown to have helped to protect its market from a flood of lower efficiency imported motors from Asian suppliers (Ryan, et al., 2005).

System Assessment Standards

Systems, as distinct from components, can also be the source of very significant industrial energy inefficiencies. Providers of system assessment services can help industrial facilities both to reduce operating costs and increase reliability.

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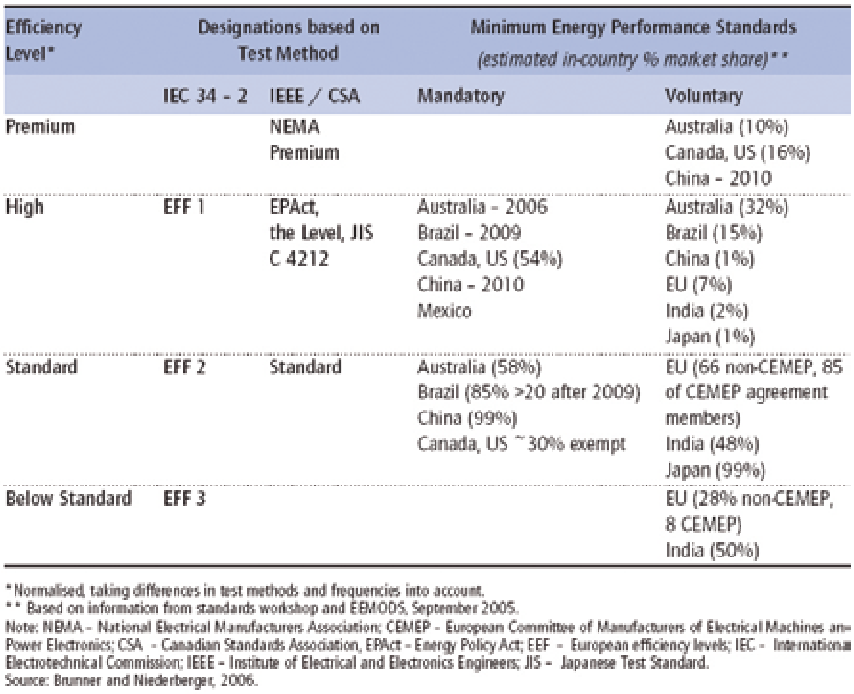
[19] http://oee.nrcan.gc.ca/industrial/technical-info/benchmarking/benchmarking_guides.cfm?attr=24

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

TABLE 7. MOTOR EFFICIENCY PERFORMANCE STANDARDS AND THE MARKET PENETRATION OF ENERGY EFFICIENT MOTORS



Efficiency Level*	Designations based on Test Method		Minimum Energy Performance Standards *(estimated in-country % market share)***	
	IEC 34 - 2	IEEE / CSA	Mandatory	Voluntary
Premium		NEMA Premium		Australia (10%) Canada, US (16%) China - 2010
High	EFF 1	EPAct, the Level, JIS C 4212	Australia - 2006 Brazil - 2009 Canada, US (54%) China - 2010 Mexico	Australia (32%) Brazil (15%) China (1%) EU (7%) India (2%) Japan (1%)
Standard	EFF 2	Standard	Australia (58%) Brazil (85% >20 after 2009) China (99%) Canada, US ~30% exempt	EU (66 non-CEMEP, 85 of CEMEP agreement members) India (48%) Japan (99%)
Below Standard	EFF 3			EU (28% non-CEMEP, 8 CEMEP) India (50%)

*Normalised, taking differences in test methods and frequencies into account.
** Based on information from standards workshop and EEMODS, September 2005.
Note: NEMA - National Electrical Manufacturers Association; CEMEP - European Committee of Manufacturers of Electrical Machines an Power Electronics; CSA - Canadian Standards Association, EPAct - Energy Policy Act; EEF - European efficiency levels; IEC - Internationa Electrotechnical Commission; IEEE - Institute of Electrical and Electronics Engineers; JIS - Japanese Test Standard.
Source: Brunner and Niederberger, 2006.

Source: IEA, 2007a

But it is difficult for plant personnel to easily identify quality services at competitive prices. The lack of market definition also creates challenges for the providers of quality system assessment services to distinguish their offerings from others that are either inadequate to identify energy efficiency opportunities or merely thinly-veiled equipment marketing approaches.

There is also very little reliable data on system performance, in particular on accurate operational measurements of the performance of motor, steam, and process heating systems. Measuring the energy efficiency of components (motors, furnaces, boilers) is reasonably straightforward and well documented, although the treatment of some losses in the measurement process for motors is inconsistent and the efficacy of testing techniques for installed boilers and furnaces can vary substantially. But the measurement of system energy efficiencies, where most of the energy efficiency potential exists, is far less well developed.

Few industrial facilities can quantify the energy efficiency of motor, steam, or process heating systems without the assistance of a systems expert. Even system experts can fail to identify large savings potentials if variations in loading patterns are not adequately considered in the assessment measurement plan. And even where permanently installed instruments such as flow meters and pressure gauges are present, they are often non-functioning or inaccurate. It is not uncommon to find orifice plates or other devices designed to measure flow actually restricting flow as they age.

A large pool of expert knowledge exists on the most effective way to conduct energy efficiency assessments of industrial systems such as compressed air, fan, pump, motor/drive, process heating, and steam systems. A body of literature, primarily from the United States, UK and Canada, has been developed in the past fifteen years to identify these best practices. These assessment techniques have been further refined in recent years in the United States. Best practices that contribute to system optimisation are system specific, but generally include:

- evaluating work requirements and matching system supply to them;
- eliminating or reconfiguring inefficient uses and practices such as throttling or open blowing;
- changing or supplementing existing equipment (motors, fans, pumps, boilers, compressors) better to match work requirements and increase operating efficiency;
- applying sophisticated control strategies and speed control devices that allow greater flexibility to match supply with demand;
- identifying and correcting maintenance problems; and
- upgrading and documenting regular maintenance practices.

The system assessment standards define, on the basis of current expert knowledge and techniques, a common framework for assessing the energy efficiency of industrial systems. This will help define the market both for users and for the providers of these services. By establishing minimum requirements and providing guidance on questions of scope, measurement, and reporting, these standards will provide assurance to plant managers, financiers, and other non-technical decision-makers that a particular assessment represents a recognised threshold for accuracy and completeness. The system assessment standards will also assist in training graduate engineers and others who want to increase their skills in optimising the energy efficiency of industrial systems (Sheaffer and McKane, 2008).

To assist industrial firms in identifying individuals with the necessary skills properly to apply the system assessment standards, the United States initiative will also include the creation of a professional credential for Certified Practitioners in each system type. This programme will be administered by an organisation with experience in managing these types of professional technical credentials and is expected to become available in late 2010.

6. Certification and Labelling of Energy Efficiency Performance

The US DOE has been developing and offering an extensive array of technical training and publications since 1993 to assist industrial facilities in becoming more energy efficient. Although the United States has had energy management standard since 2000, participation in the standard has not been widespread (McKane et al, 2007). In 2007, the US DOE supported the formation of the Superior Energy Performance (SEP) partnership, a collaboration of industry, government, and non-profit organisations that seeks to improve the energy intensity of manufacturing through a series of initiatives, most notably, by developing a market-based Plant Certification programme.

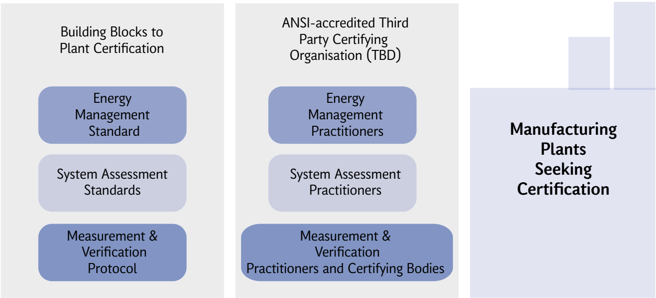


Figure 5. Proposed Plant Certification Framework
Source: USDOE, 2008b[21]

Another programme that focuses on the certification of energy management systems is the Programme for Improving Energy Efficiency in Energy Intensive Industries (PFE), managed by the Swedish Energy Agency (SEA). This programme offers reduced taxes for companies that introduce and secure certification of a standardised energy management system and undertake electrical energy efficiency improvements (Björkman, 2008). The programme requires a five-year initial commitment, with a requirement to report the achievement of specific milestones by the end of two years, as follows:

- implementation of the energy management standard that is certified by an accredited certification body;
- completion of an in-depth energy audit and analysis to baseline use and identify improvement opportunities. A list of measures identified in the energy audit with a payback of three years or less must be submitted to the SEA;
- establish procurement procedures that favour energy efficient equipment; and
- establish procedures for project planning and implementation.

By the end of five years, the company must implement the listed measures, demonstrate continued application of the energy management standard and procurement procedures, and assess the effects of project planning procedures. As of May 2009, 124 companies had signed up to participate in PFE, representing approximately 50% of all Sweden's industrial electricity use.

7. Demand Side Management

Energy users do not demand energy at the same time each day nor each season of the year (More heating may be required in winter, cooling in summer, lighting at night, etc.). By managing the "demand-side" the profile of energy use can be changed. Various Demand Side Management (DSM) options exist. Sometimes the demand for energy can be shifted, with so called "load shifting" measures. Peak demand can be changed by, amongst other things, improving the efficiency of appliances that contribute to peak demand.

The energy supplier may have various motivations for implementing DSM, such as providing services at a lower cost, increasing his market share, reaching more customers without expanding his supply infrastructure, and mitigating the need to build more plant consequently limiting the cost of increases of supply.

By changing the load profile of consumers, to one that is flatter, utilities get to run their supply infrastructure more during the year. The higher utilization of this infrastructure, the lower the per-unit cost of supply.

In recent decades Utilities (electric, gas and others) or ESCOs have been running DSM programs. A key element of these programs has been the deployment of energy efficiency measures. These programs can be voluntary or legislated.

8. Utility Programmes

Many utility companies, especially those whose profits have been decoupled from sales and/or who have dedicated funding for energy efficiency through a public benefits charge, have demand-side management programmes for industry. In the United States, 18 states have energy efficiency programmes funded through public benefits charges (Kushler et al., 2004). Such programmes are based on the ability of utilities to provide the financial, organisational, and technical resources needed to implement energy efficiency investments. In some cases, utilities can collect the repayment of loans for energy efficiency investments through electricity bills (Taylor et al., 2008). Utility-based industrial energy efficiency programmes typically include energy assessments, payments for large energy efficiency projects through standard offer programmes, and rebate programmes for less complex measures (see Box 3) (China-US Energy Efficiency Alliance, 2008).

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[21] http://www.superiorenergyperformance.net/pdfs/Plant_Certification_StrategicPlan_9_22_08.pdf

BOX 3: PRIMARY ELEMENTS OF UTILITY-BASED INDUSTRIAL ENERGY EFFICIENCY PROGRAMMES

Standard offer programmes offer to purchase energy savings from a list of pre-approved measures at a fixed price for each unit of energy avoided. Contractors and facility owners can develop projects that conform to the programme requirements. The offer price can vary by measure type, region, size of project, or any other parameter that helps to improve the programme's potential to succeed. Standard offer programmes can also accept customised measures not on the pre-approved list. Project developers submit a description of the measure with estimated savings and costs, and the programme manager calculates an offer price specific to the proposal. Standard offer programmes leverage existing contractor or distributor relationships and facility owners' knowledge about their own operations.

Energy audit programmes provide technical experts to assess energy efficiency opportunities in facilities within a target market. The audit results in a report submitted to the facility that describes how energy is currently being used, investigates promising energy efficiency measures, and recommends measures that will result in cost-effective savings while maintaining or improving service levels. Audits are usually linked to an implementation programme (rebate, standard offer, etc.) so that the recommended measures can be installed. Audit programmes also serve to educate the facility operations staff and increase awareness of the demand side management portfolio.

Rebate programmes operate by offering cash to offset the purchase of a high-efficiency device such as a motor or refrigerator. The cash is usually paid directly to the purchaser, who submits a proof-of-purchase receipt. The cash can also be paid to wholesalers and distribution centers, typically requiring proof-of-sale to a retail customer. Rebate programmes are simple to deploy and operate, and their immediate availability helps to promote relatively simple energy efficiency opportunities that might otherwise be overlooked. But they do not generally result in comprehensive projects.

Excerpted from China-US Energy Efficiency Alliance (2008)

9. Energy Service Companies

ESCOs are entities that provide services to end-users related to the development, installation, and financing of energy efficiency improvements. They help to overcome informational, technical, and financial barriers by providing skilled personnel and identifying financing options for the facility owner. ESCO projects are usually performance based and often use an energy performance contract (EPC) in which the performance of an energy efficiency investment in the client's facilities is usually guaranteed in some way by the ESCO and creates financial consequences for it (Taylor et al., 2008).

There are two primary financing models for ESCOs. In the shared savings model, the ESCO undertakes all aspects of the project, including its financing, and shares in the value of the energy savings over a designated time period. In the guaranteed savings model, the ESCO undertakes all aspects of the project except the financing, although it may assist in arranging finance, and provides a guarantee to the client of a certain level of energy savings over a designated time period (see Figure 6).

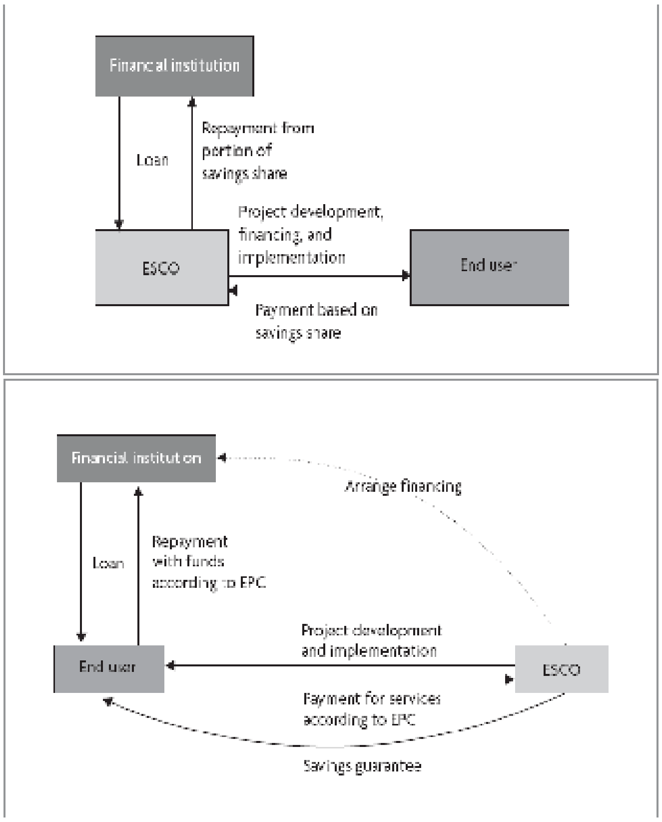

Figure 6. Shared Savings and Guaranteed Savings Energy Performance Contract Models.
Source: Taylor et al., 2008

A 2002 survey identified 38 countries with ESCOs, many of which were created in the 1980s and 1990s. The ESCOs typically focused on the commercial, industrial, and municipal sectors (Vine, 2005). In the United States, the ESCO industry is relatively mature but has had limited impact on the industrial sector. A database of almost 1,500 energy efficiency projects indicates that ESCO revenues had grown at an average rate of 24% during the 1990s and were between USD 1.8 and 2.1 billion in 2001 (Goldman et al., 2002). But few ESCOs in the United States have penetrated the market in industrial applications. Rather, they tend to concentrate on measures such as lighting and heating, ventilating, and air conditioning in commercial buildings. This misses most of the much larger energy savings that are likely to be available at industrial sites.

In recent years, suppliers of industrial system equipment have begun providing value added services that may include everything from sophisticated controls, drives, valves, treatment equipment, filters, drains, etc. to complete management of the industrial system as an outsourced provider. Their success appears to be attributable to their specialised level of systems skill and familiarity with their industrial customers' plant operations and needs (Elliott, 2002, IEA 2007a).

The World Bank's GEF introduced the ESCO concept to China in 1997 through three demonstration ESCOs in Beijing, Liaoning, and Shandong which were funded jointly by a GEF grant, an International Bank for Reconstruction and Development (IBRD) loan, and financing from the EU. At the end of 2006, the three ESCOs participating in the China Energy Conservation Project (CECP) had undertaken about 350 energy performance contracting projects, representing investments of about USD 170 million, mostly for building renovation, boiler/cogeneration, kiln/furnace, and waste heat/gas recovery projects. The Second CECP, designed to increase China's ESCO business, was initiated in 2003 with additional GEF grant funding. This project is focused on development of a national loan guarantee programme to assist ESCOs in obtaining loans from local banks (Taylor et al., 2008). China now has a large ESCO industry, with an estimated 212 ESCOs involved in contracts valued at RMB 1.89 billion (USD 277 million) in 2006 (Zhao, 2007).

It should however be noted that the success of ESCOs has often been constrained to particular types of end user and varies by country, making general replication not straightforward. Many focus on buildings, HVAC and refrigeration services, or specialize in energy intensive industry (Motiva, 2005). It is often difficult for ESCOs in markets or settings where energy efficiency practices are not common or the potential for reducing costs by energy management is not known or is unfamiliar. The service being supplied by the ESCO is regularly treated with suspicion. So too are the (novel) financing structures required to support the services provided. This leads to high perceived risk. That is often compounded where there is the added perception that ESCO services may interfere with the energy used for production, and therefore may interfere in an unwanted way with that industry's output.

10. Financing Mechanisms and Incentives for Industrial Energy Efficiency Investments

The following section focuses on international bodies and finance. In general, industrial energy efficiency projects find it difficult to access capital, even in carbon finance markets such as the Clean Development Mechanism (CDM) and other project based emissions trading markets. Energy efficiency projects are often small and dispersed, creating larger transaction costs than more traditional investments in energy supply. Investors and financiers often do not have an adequate understanding of the potential financial returns from such investments and, along with project managers at industrial facilities, do not have adequate training in the preparation of industrial energy efficiency project loan documents. In addition, the risk associated with assessing and securitising the revenues generated through energy savings needs to be reduced. Although the returns associated with energy efficiency projects may be high, their volumes can be low and thus less attractive than larger investments.

A number of financing mechanisms and incentives have been developed to overcome barriers and to promote the adoption of industrial energy efficiency opportunities. The CDM was designed specifically to promote sustainable development and cost-effective climate change mitigation in developing countries and transition economies. Energy efficiency projects can promote sustainable development as well as reduce GHG emissions. But some methodological and CDM-process related challenges will have to be addressed if end-use energy efficiency projects are to be given proper credit. The World Bank and many UN agencies have also established energy efficiency financing projects. In addition, a number of governments have promoted investment in industrial energy efficiency through various financial instruments such as taxes, subsidies, and programmes that improve access to capital.

Clean Development Mechanism Financing and demand side efficiency projects in industry

To date, the CDM has not catalysed significant investment in industrial end-use energy efficiency projects, although some progress has been made following various efforts to address the problem.[22] As of 1 October 2009, only 3% of the 1834 registered CDM projects were described as addressing industrial energy efficiency.[23] Another 7% fell under the general category of "energy efficiency, own generation"; these may include some industrial energy efficiency projects. And another 1% fell under the cement sector (Fenhann, 2009). Other energy efficiency categories play a minor role, with energy efficiency supply projects forming only 1% to the total, and energy efficiency in households and in services being far below 1%.

The CDM project-based framework, in which each project is subject to stringent and complex baseline, additionality, and monitoring requirements, is not well suited to energy efficiency projects. Transaction and carbon credit development costs tend to be the same whether a project is large or small. As the majority of energy efficiency projects generate only small or medium scale emission reductions, they are not developed (Tiktinsky, 2008). Industrial energy efficiency projects also typically have a favourable rate of return, making it difficult to meet the CDM additionality requirements. It can also be cumbersome to quantify emissions reductions for small, dispersed actions implemented under industrial energy efficiency programmes. And the approved project methodologies do not particularly suit the circumstances of those energy efficiency programmes that are likely to have the greatest impact (Arquit-Niederberger, 2007).

Recognising the low number of approved demand-side energy efficiency methodologies and projects, the CDM Executive Board commissioned a study to provide recommendations to address

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[22] http://www.unido.org/index.php?id=061189

[23] http://cdmpipeline.org/

the barriers faced by these projects. The study proposed the development of a number of energy efficiency tools and provided guidance on energy efficiency methodologies. The proposed tools include a tool on baseline load-efficiency function and a tool on energy benchmarking. Guidance will be provided related to best practices for sampling and surveys for energy efficiency project activities and the determination of equipment lifetime. In addition, although the CDM Executive Board views the CDM Programme of Activities (PoAs) as a means to accelerate energy efficiency (Rajhansa, 2008), methodologies are still lacking. Their development is difficult, time-consuming, and will probably require excessive monitoring and baselining (Tiktinsky, 2008). In order to increase the uptake of energy efficiency improvements through the CDM, there would need to be less focus on project-by-project approaches, and more use of benchmarks for additionality testing. The designated operational entities need to be strengthened and capacity needs to be built among the CDM participants (Rajhansa, 2008).

Drawing on the lessons outlined above, UNIDO has developed an outline proposal for mainstreaming industrial energy efficiency with a view specifically to delivering CO2 reductions and addressing the need for capacity building. This proposal is set out in Appendix B to this paper.

Financing for Developing Countries and Countries in Transition

As the financial mechanism of the UN Framework Convention on Climate Change (UNFCCC), the World Bank's GEF provides support for climate change and industrial energy efficiency projects. The GEF-4 climate change strategy includes a programme to promote industrial energy efficiency. Most of these projects are implemented with the UN Development Programme (UNDP), World Bank, and UNIDO. UNDP's approach includes capacity building, developing policies and regulations, implementing voluntary agreements, technology demonstration, encouraging the setting up of ESCOs, and creating revolving funds. The World Bank Group's International Finance Corporation (IFC) focuses on energy service companies (ESCOs), partial risk guarantees, revolving funds, on-lending, and technical assistance. UNIDO works in the areas of energy management standards, system optimisation, demonstration projects, the training of enterprise energy managers, and benchmarking (Zhang, 2008).

The IFC provides loans, equity, structured finance and risk management products, and advisory services to build the private sector in developing countries. The IFC has a programme to train their investment officers around the world in the development of energy efficiency projects (Shah, 2008), as well as to provide marketing, engineering, project development, and equipment financing services to banks, project developers, and suppliers of energy efficiency products and services.

The IFC's China Utility-based Energy Efficiency Programme (CHUEE) provides a sustainable financing mechanism for energy efficiency investments by establishing a risk-sharing fund with the Industrial Bank of China (IBC), which in turn provides energy efficiency loans. During the first phase of this programme, IFC provided up to USD 25 million to IBC which then provided USD 126 million in financing for 46 energy efficiency and GHG mitigation projects, mostly for small and medium enterprises to retrofit industrial boilers, recover waste heat for cogeneration, reduce electricity use and optimise overall industrial energy use. For the second phase of the project, IFC will provide USD 100 million for risk-sharing to the IBC, which in turn will provide USD 210 million in energy efficiency loans (IFC, 2008).

The UN Environment Programme (UNEP) set up a World Bank-Energy Sector Management Assistance Programme (ESMAP) multi-year technical assistance project on "Developing Financial Intermediation Mechanisms for Energy Efficiency Projects in Brazil, China, and India" (also known as the Three Country Energy Efficiency Project). This was funded by the UNF and ESMAP. The goal of this project was to generate innovative ideas and approaches for energy efficiency financing schemes. Such financing schemes included loan financing schemes and partial loan guarantee schemes, ESCO or third party financing, and utility demand-side management programmes. The major conclusion from the Three Country Energy Efficiency Project is that the institutional framework and customised solutions are the keys to success (Monari, 2008; Taylor et al., 2008).

The United Nations Economic Commission for Europe (UNECE) has initiated a new programme on Financing Energy Efficiency Investments for Climate Change Mitigation to assist Southeast European and Eastern Europe, Caucasus and Central Asia (EECCA) countries to enhance their energy efficiency, reduce fuel poverty from economic transition, and meet international environmental treaty obligations under the UNFCCC and the UNECE. The programme will:

- provide a pipeline of new and existing projects for public private partnership investment funds that can provide up to USD 500 million of debt or equity or both to project sponsors;

- establish a network of selected municipalities linked with international partners to transfer information on policy reforms, financing and energy management;

- initiate case study investment projects in renewable energy technologies, electric power and clean coal technologies;

- develop the skills of the private and public sectors at the local level to identify, develop and implement energy efficiency and renewable energy investment projects;

- provide assistance to municipal authorities and national administrations to introduce economic, institutional and regulatory reforms needed to support these investment projects; and

- provide opportunities for banks and commercial companies to invest in these projects through professionally managed investment funds.

The goal of the programme is to promote a self-sustaining investment environment for cost-effective energy efficiency projects for carbon emissions trading under the UNFCCC Kyoto Protocol (Sambucini, 2008).

Developed Country Experiences with Industrial Energy Efficiency Financing Mechanisms and Incentives

Integrated policies that combine a variety of industrial energy efficiency financing mechanisms and incentives in a national-level energy or GHG emissions mitigation programme are found in a number of countries.[24] These policies operate either through increasing the costs associated with energy use to stimulate energy efficiency or by reducing the costs associated with energy efficiency investments.

Incentives for investing in energy efficiency technologies and measures include targeted grants or subsidies, tax relief, and loans for investments in energy efficiency. Grants or subsidies are public funds given directly to the party implementing an energy efficiency project. A recent survey found that 28 countries provide some sort of grant or subsidy for industrial energy efficiency projects (WEC, 2004). In Denmark, energy-intensive industries and companies participating in voluntary agreements were given priority in the distribution of grants and subsidies (DEA, 2000). The Netherland's BSET Programme covered up to 25% of the costs for specific energy efficiency technologies adopted by small or medium sized industrial enterprises (Kræmer et al., 1997).

Energy efficiency loans can be subsidised by public funding or can be offered at interest rates below market rates. Innovative loan mechanisms include energy performance contracts through ESCOs, guarantee funds, revolving funds, and the use of venture capital. Many countries have guarantee funds, but these national funds are generally not adequate to support financing for energy efficiency projects and most of them have ceilings on the guarantees. With revolving funds, the reimbursement of the loans is recycled back into the fund to support new projects. These funds generally require public or national subsidisation of interest rates or of the principal investment.

Tax relief for the purchase of energy-efficient technologies can be provide through *accelerated depreciation* (where purchasers of qualifying equipment can depreciate the equipment cost more rapidly than standard equipment), *tax reduction* (where purchasers can deduct a percentage of the investment cost associated with the equipment from annual profits), or *tax exemptions* (where purchasers are exempt from paying customs taxes on imported energy-efficient equipment) (Price et al., 2005).

In Canada, taxpayers are allowed an accelerated write-off of 30% for specified energy efficiency and renewable energy equipment instead of the standard annual rates of 4% to 20% (Canada, DoF, 2004; Government of Canada, 1998). A programme in The Netherlands allows an investor more rapidly to depreciate its investment in environmentally-friendly machinery (IISD, 1994; SenterNovem, 2005a).

Japan's Energy Conservation and Recycling Assistance Law provides a corporate tax rebate of 7% of the purchase price of energy-efficient equipment for small and medium sized firms (WEC, 2001). In South Korea, a 5% income tax credit is available for energy efficiency investments such as the replacement of old industrial kilns, boilers, and furnaces (UNESCAP, 2000). In The Netherlands, a percentage of the annual investment costs of energy-saving equipment can be deducted from profits in the calendar year in which the equipment was procured, up to a maximum of EUR 107 million. This was originally 40% and has now been raised to 55% (Aalbers, et al., 2004; SenterNovem 2005b). The UK's Enhanced Capital Allowance Scheme allows businesses to claim 100% first-year tax relief on their spending on energy saving technologies specified in an Energy Technology List (HM Revenue & Customs, n.d.; Carbon Trust, 2005).

In Sweden, companies that carry out an energy audit of their facilities, apply an energy management system, establish and apply routines for purchasing and planning, and carry out energy efficiency measures through Sweden's PFE programme are exempted from the electricity tax of EUR 0.5/MWh. Based on improvements planned for implementation by 2009 in 98 Swedish companies, tax exemptions of about €17 million will be realised by these companies through their participation in this programme (Swedish Energy Agency, 2007).

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[24] For additional information, see Galitsky et al., 2004.

IV. Industrial Energy Efficiency in the Post-2012 Framework: Bali Action Plan Recommendations

Although much has been achieved in mobilising the international effort to fight climate change under the UNFCCC and the Kyoto Protocol, current commitments and efforts have fallen short of the expectation of significant GHG emissions reductions. This is especially so in respect of the implementation of energy efficiency measures. These represent some of the most cost-effective, least-polluting, and readily available options for climate change mitigation.

The Bali Action Plan provides the principal framework for post-2012 activities to mitigate climate change. It focuses on a shared vision for long-term cooperative action and on enhancing action on mitigation, on adaptation, on supporting technology development and transfer and on the provision of financial resources and investment. For industrialised countries, the Bali Action Plan calls for measurable, reportable and verifiable nationally appropriate mitigation commitments or actions. These should include quantified emission limitation and reduction objectives. It also calls upon developing countries to undertake nationally appropriate mitigation actions in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner (UNFCCC, 2007).

It has been estimated that the investment in energy efficiency of as little as 1.6% of current global fixed capital investment each year to 2020 would produce an average return of 17% a year. This investment of USD 170 billion a year would produce up to USD 900 billion a year in energy cost savings by 2020 (Farrell and Remes, 2008).

The opportunity is enormous. But, as described above, the obstacles to realising that opportunity are also substantial. The post Kyoto agreements need to reinforce the embedding of policies, programmes and measures to enhance the adoption of energy efficiency measures in the industrial sector if industry is to maximise its potential for achieving cost-effective mitigation. Mechanisms to ensure sufficient human, institutional, and financial resources will have to be established and/or further strengthened in order to provide the fundamental underpinnings for all of these efforts.

Given the importance of capacity building and the spreading of good practice messages and lessons more widely, institutional and policy-based approaches will also have a critical role to play (Sarkar, 2008). This is particularly the case in developing, newly-industrialised economies and economies in transition. The capability of the private sector to make profitable investments in industrial energy efficiency projects also needs to be strengthened. And the active involvement and participation of citizens in public and private industrial energy efficiency programmes needs also to be promoted. At a strategic level, the aim should be to focus on development of the necessary energy efficiency strategies, policies, and programmes which will overcome both the hard (technology, financing) and soft (awareness, capacity) barriers to changing the habitual and investment behaviour of industrial end-users (Arquit-Niederberger, 2008a).

A. Defining a shared vision for global action on energy efficiency

Against the background of the foregoing analysis, this section outlines a framework of policies and measures designed to accelerate the realisation of energy efficiency potentials. It focuses particularly on industrial efficiency. It sets out a range of measures that would support this aim, and proposes priority actions to be taken immediately in order to stimulate rapid progress within an ambitious and shared vision for the contribution that energy efficiency can make to mitigating climate change.

The recommendations in this section are based on the proceedings of an Expert Group Meeting that was organised by UNIDO and the International Atomic Energy Agency (IAEA), in cooperation with Lawrence Berkeley National Laboratory (LBNL), the World Bank and other organisations[25]. The recommendations are intended to set out steps that can be taken, particularly in the UNFCCC process but also elsewhere, to deploy policies and measures to promote a lower-carbon and more energy efficient industry. With this in mind, the recommendations are listed in terms of the Bali Action Plan framework of a shared vision, capacity building, mitigation, technology and financing.

Industrial energy efficiency is part of the shared vision for long-term cooperative action

Improved industrial energy efficiency offers the lowest cost and largest impact route to significant GHG emission reductions. It can also, given sufficient will, be achieved more quickly than many other options and with minimum disruption to ongoing business. And by reducing energy requirements per unit of industrial output, industrial energy efficiency can also help reduce energy imports, improve energy security, and improve producer competitiveness.

Improving energy efficiency therefore offers a mitigation opportunity which aligns particularly well with other national development goals. There is accordingly a strong case for post Kyoto agreements (PKAs) and negotiations to promote its large scale uptake urgently so as to help accelerate national development at the same time as reducing the carbon intensity of an economy.

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[25] For details please see http://www.unido.org/index.php?id=7572.

Governments have both the power and the duty to set a lead in establishing frameworks for a step change in efforts to improve industrial energy efficiency. The European Union and the State of California have both recognised this in setting out action plans to address the barriers to the achievement of better energy efficiency performance.

These principles need to be spread more widely. As a priority measure to promote the integration of energy and climate change policies, National Energy Efficiency Action Plans (NEEAPs) could be developed to set ambitious, achievable national energy efficiency goals or targets for the industrial sector. This would do much to help attract the high-level attention and resources needed to produce meaningful action. To be most effective, such national plans should be developed as a collaborative effort between various levels of government and the private sector. They should set out programmatic objectives and implementation plans, establish near-term milestones as well as longer term goals, include internationally comparable data collection methodologies and metrics based on IEA and other guidelines, and commit to the regular reporting of progress on the implementation of energy efficiency policies (UNF, 2007).

B. The Imperative of Capacity Building

If the global economy is to capture the full potential of energy efficiency savings, the capacity to identify and deliver energy efficiency improvements needs to be built.

Such capacity building should aim to identify and transfer the lessons learned from successful industrial energy efficiency policies and programmes, together with information on best practice technologies and measures that can be applied in the industrial sector. More needs to be done to capture this information, in particular in terms of the full costs and benefits of effective industrial energy efficiency programmes, and to communicate this to member states.

Capacity also needs to be built in the skills and knowledge needed to develop and use mechanisms and tools for country-specific policy assessments. This includes indicators to measure the effects of policy change, information on successful delivery mechanisms, and skills in monitoring, reporting, verification, and evaluation. An important component of this is the building of national institutions that can effectively roll out appropriate industrial energy efficiency policies and measures.

C. Mitigation

There is a need for better information for governments and industry on what has been found to work well, on achievements and on costs and benefits[26]. It is important that such an information base can be added to easily, and that it is widely accessible.
Successful policies and measures may be situation-specific, depending on region or on levels of economic development. Developing countries may face different issues and objectives than more developed countries. For example, they may have particular needs for increased energy access or increases in supply, they may need to address issues of non-cost reflective energy pricing or they may need to focus their attention particularly on small and medium sized enterprises. The information base needs to be able to reflect such dimensions. Assessments also need to be made of the scalability, transferability (from one country/region to another, from one industry to another, or from one plant to another) and full costs of individual policies and measures. Such an assessment is necessary to enable technical mitigation scenarios (such as marginal abatement cost curves) to be turned into action plans with firm commitments.

Addressing market imperfections and barriers to the widespread uptake of high-efficiency equipment, systems and practices that promote energy conservation will require political will, cost money and take time. Marginal abatement cost curves for end-use efficiency technologies should be supplemented by estimates of the cost of implementing the technology, something which is often overlooked in current analyses.

Future PKAs should give entities the flexibility to adopt the most appropriate policies to suit their mitigation and development goals, as long as all policies and measures include appropriate, robust and objective mechanisms to measure, report and verify GHG reductions. In this regard, the ISO in cooperation with UNIDO and 35 participating countries has initiated the development of an energy management standard which includes requirements for measuring improvements in energy intensity against a baseline.[27]

Energy auditing, monitoring and verification, and minimum equipment and performance standards are basic tools in the energy efficiency armoury for delivering energy use and GHG emission reductions. Future PKAs should focus on the development of environments that enable the adoption of these tools. The PKA negotiations must make reporting against a set of industrial energy efficiency indicators an essential activity as a means of stimulating and acknowledging better performance.

The CDM could help stimulate GHG mitigation by encouraging energy efficiency advances in developing countries. But it has not yet delivered much in terms of demand-side energy efficiency, despite the potential. It is important to understand the reasons for the lack of energy efficiency projects in CDM and to develop remedies.

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[26] It is also important that the information base clearly documents any failures of programmes so as to avoid the replication of pitfalls or mistakes. Such an analysis should also include an assessment of possible rebound effects.

[27] ISO 50001- Energy management http://www.iso.org/iso/pressrelease?refid=Ref1157, http://www.unido.org/index.php?id=7881&tx_ttnews[tt_news]=220&cHash=a9b4b0eae2

D. Technology

The systematic identification of proprietary technologies and processes that have significant energy-savings potential needs to be institutionalised. The task could also extend to exploring options to facilitate the wider deployment of such technologies in developing and transition economies. Industry energy efficiency indicators should also include aspects relating to the rate of adoption of efficient technologies.

E. Financing

Changes in end-use technologies have contributed significantly to energy savings. But investment in energy efficiency technology research and development (R&D) has been limited. More R&D needs to be funded in this field.

More widely, investment will be needed in the range of measures described above if the global economy is to make the most of the potential of industrial energy efficiency. A detailed assessment of financing requirements needs to be undertaken considering different scenarios of industrial policy and technology deployment. This should include the full costs of institution and human capacity building, programme costs, technology costs, the costs of addressing market imperfections and barriers to the widespread uptake of relatively smaller and dispersed energy efficiency measures, as well as other transaction costs. This work could form a supplement to the UNFCCC 2007 report "Investment and Financial Flows to Address Climate Change" and/or contribute to the future work of this topic.

Based on lessons learned from programmes such as the UK's Climate Change Agreements (CCAs)[28] and other proposed sectoral mechanisms, methods to include industrial energy efficiency programmes within carbon trading or fiscal regimes should be given serious consideration. Notwithstanding the low uptake of industrial energy efficiency projects within the CDM, carbon finance could contribute to providing an additional revenue stream which could be targeted at incentivising the delivery of more energy efficiency programmes.

It is critical to address the barriers to end-use efficiency under the CDM in the discussions on possible CDM reforms[29]. CDM rules and methodologies that recognise the specificity of energy efficiency activities and programmes are needed. Suggestions for such a proposal are included in Appendix A.

V. Conclusions

There is very significant scope to improve energy efficiency in, and reduce GHG emissions from, industrial facilities. Capturing such opportunities is essential if the world is to achieve the reductions in global greenhouse gas emissions of 50 per cent or more by 2050 that are necessary to avoid exceeding the 2°C threshold and to stabilise GHG concentrations between 450 and 550 ppm. Yet energy efficiency policies and measures are not being implemented at anywhere near their potential and necessary levels. This is due to a range of barriers that prevent their adoption.

Effective industrial sector policies and programmes have demonstrated the more effective adoption of energy-efficient practices and technologies by overcoming informational, institutional, policy, regulatory, price, market-related and other barriers. Given the urgency of the climate challenge, it is important to identify and replicate where appropriate the key features of the most successful policies and programmes. Short term measures to reduce energy use have the potential significantly to reduce the longer term cost of mitigating global climate change. A failure to seize these opportunities will result in much higher costs in the longer term.

Overall, the key message is that energy efficiency - and especially industrial energy efficiency in many countries where infrastructure development is driving energy use - can make a significant contribution to reducing energy-related GHG emissions. It is a relatively cheap option with the potential to produce rapid, large scale benefits. It should be viewed as the first fuel of choice in the creation of global low-carbon energy system.

Only a handful of Annex 1 countries have strong and comprehensive industrial energy efficiency policies and measures in place. Successful experiences from these countries demonstrate the importance of raising awareness of management attention; establishing ambitious, yet achievable, targets; the adoption of energy management standards and implementation of energy management systems; and all of these underpinned by appropriate institutional support. Essential elements of a successful industrial energy efficiency policy include: support to provide capacity building for energy management and facility systems optimisation; energy audits and assessments; benchmarking; and information-sharing.

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[28] See: http://www.defra.gov.uk/environment/climatechange/uk/business/crc/index.htm.

[29] For the list of proposed reform measures, please see FCCC/KP/AWG/2008/L.12.

VI. Recommendations

With this in mind, a systematic review of existing successful and potential industrial energy efficiency policies and measures should be compiled and documented, including their full costs and benefits. These policies should be assessed for their scalability and for their transferability from one country/region to another, from one industry to another, or from one plant to another. This dataset should be made publicly available to help governments decide for themselves the market and policy initiatives, including bringing energy efficiency within carbon trading or fiscal regimes, they may wish to take to improve energy efficiency.

Industrial energy prices are currently subsidized in many parts of the world. Cheap energy masks inefficiency and disincentives efforts to make improvements. As a first step, if industrial energy efficiency is to be driven as it should be by market stimuli, **subsidies must be removed. And, as far as possible, governments should put mechanisms in place fully to carry the cost of the short and long term environmental impacts of energy use into the market.**

The new international energy management standard, ISO 50001, is expected to have far-reaching effects on the energy efficiency of industry when it is published at the end of 2010. This will be especially true in developing countries and emerging economies. Business interest, especially from companies operating in international markets, suggests that it will become a significant factor in international trade, as ISO 9001 has been. Globally, the need for energy management experts qualified to implement the standard is expected to increase very rapidly. In order to rise to this challenge, efforts need to begin as soon as possible to develop a cadre of experts with the requisite skills. UNIDO, and others, are already working with several countries and regions to initiate this capacity building effort, but a much broader effort is urgently needed.

The adoption of mandatory industrial equipment minimum energy performance standards is an effective means of increasing the market penetration of more efficient equipment. System assessment standards can provide a common framework for conducting assessments of industrial systems, where large energy efficiency potentials exist. The formal and objective certification of plant energy efficiency performance can provide a standardised approach for identifying, developing, documenting, and reporting energy efficiency progress in industrial facilities. It also provides a framework for continuous improvement.

It is recommended that **National Energy Efficiency Action Plans** be developed that set ambitious, achievable national energy efficiency goals or targets for the industrial sector. These should be based on studies which fully document the costs and benefits of the adoption of energy efficiency technologies, practices, and measures. **All countries should be required to provide in their National Communications reporting to the UNFCCC an assessment of the potential for achieving further energy efficiency improvements and a description of their existing policies.**

It is common practice to use technology cost-curves to assess industrial energy efficiency potentials. But at present these curves are misleading. They indicate the cost and benefits of the direct costs of introducing new technologies. But they do not include either the costs incurred to build the institutions needed to implement industrial energy efficiency policies and measures or the cost of the policies and measures themselves. These costs are particularly important for developing countries where markets and institutions may not be as developed as their developed country counterparts. **It is recommended that mitigation cost curve methodologies be developed that account not only for the direct costs, but also programmatic, institutional and other transaction costs.**

It is further recommended that **proprietary energy efficiency technologies and processes that have significant energy-savings potential should be systematically identified and that options to facilitate the wider deployment of these technologies in developing countries and transition economies should be explored.** More attention should be focused on systems approaches and energy intensive industry sectors such as cement, iron and steel, chemicals, petroleum refining, pulp and paper, and food processing textiles. And increased investment of R&D funds for energy efficient end-use technologies should be encouraged and facilitated.

It is clear that, although the CDM has been generally successful in delivering investment projects in several sectors particularly in renewable energy, there is room for improvement with respect to the inclusion of end-use efficiency projects in industry. It has not yet provided the required framework or incentives to spur significant investments in additional technologies and measures in end-use efficiency in industrial facilities in non-Annex 1 countries. The CDM could be expanded and reformed (as described above, see also Wara and Victor, 2008; Arquit-Niederberger, 2008b), new offset mechanisms based on sectoral approaches could be developed (as detailed in Appendix A), or sectoral approaches that focus on establishing agreements in specific industrial sectors could be pursued (see AWGLCA, 2008; Bodansky, 2007; Bradley et al., 2007; Schmidt, 2008).

Given the range of well documented distortions that can arise with tradable emission reduction schemes, two alternative approaches are being explored beyond strict offset programmes such as the CDM, the development of a Climate Fund, and a programme to fund infrastructure development deals in non-Annex 1 countries. The Climate Fund would accept funding donations from developed country governments and private firms to invest in particular projects and technologies ranked according to their GHG mitigation potential. The infrastructure development deals proposal focuses on investments to make large-scale shifts in infrastructure, such as moving away from coal-fired power generation to more use of natural gas in China. Both proposed approaches could be used as a complement to a reformed CDM (Wara and Victor, 2008).

One proposal - in this case framed in the context of China, but applicable in other contexts - calls for establishment of a fund to support the transfer of expertise from industrialised countries and partial funding for counterpart Chinese activities (see Appendix B). The fund would provide knowledge and capacity to develop and implement policies and programmes cost-effectively to promote energy efficiency and reduce GHG emissions. The fund would also be used to strengthen the capability of the private sector to make profitable investments in industrial energy efficiency and GHG mitigation projects. The activities funded by this effort must be derived from the needs of, and have the full commitment of, the non-Annex 1 country (Levine, 2008). Such a programme could be funded through a small surcharge of 0.5% to 1% on energy sales, as is done in several U.S. states including California, South Korea, and Switzerland (UNF, 2007).

Whatever approach or approaches may be adopted in future, **it is essential that proper support is given to the urgent need for capacity building in, and information sharing with, developing countries in the field of industrial energy efficiency. This should be a strong focus of the post-2012 agreements.**

New approaches are needed that address deficiencies in the current approaches, draw from successful policies and programmes, and promote new avenues of international cooperation if the significant levels of industrial energy efficiency and GHG mitigation that are potentially available are to be captured. Only with such approaches can the potential for significant energy efficiency improvements and GHG emissions reductions from the industrial sector be achieved.

Acronyms

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
AWGLCA	Ad Hoc Working Group on Long-Term Cooperative Action
BAU	business-as-usual
BEST	Benchmarking and Energy-Saving Tool
CADDET	Centre for Analysis and Dissemination of Demonstrated Energy Technologies
CCA	Climate Change Agreement
CDM	Clean Development Mechanism
CHUEE	China Utility-based Energy Efficiency Programme
CNIS	China National Institute of Standardisation
CO_2	carbon dioxide
CMP	Conference of the Parties serving as Meeting of the Parties
COP	Conference of the Parties
DEFRA	Department of Environment, Food, and Rural Affairs (UK)
DSM	Demand-Side Management
EEC	European Economic Community
EGM	Expert Group Meeting
EJ	exajoules
EPC	energy performance contract
EPI	energy performance indicator
ESCO	energy service company
ESCWA	United Nations Economic and Social Commission for Western Asia
ETS	emissions trading scheme
EU	European Union
EUR	Euro
GDP	gross domestic product
GEF	Global Environmental Facility
GHG	greenhouse gas
Gt	gigatonnes
HFC-23	Trifiluoromethane
IAC	Industrial Assessment Center
IAEA	International Atomic Energy Agency
IBRD	International Bank for Reconstruction and Development
IEA	International Energy Agency
IEAP	International Energy Audit Programme
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
ITP	Industrial Technologies Programme
kW	kilowatt
kWh	kilowatt-hour
LBNL	Lawrence Berkeley National Laboratory
LTA	Long-Term Agreement
MEPS	minimum efficiency performance standards
MOP	Meeting of the Parties
MSE	management standard for energy
Mtce	million tons of coal equivalent
M&V	monitoring & verification
NDRC	National Development and Reform Commission (China)
NGOs	non-government organisations
NIST	National Institute of Standards and Technology
PAMs	policies and measures
PFE	Programme for Improving Energy Efficiency in Energy Intensive Industries
PKAs	Post-Kyoto Agreements
ppm	parts per million
R&D	research & development
SME	small and medium enterprises
TBtu	trillion British thermal units
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UN ECE	United Nations Economic Commission for Europe
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNF	United Nations Foundation
UNFCCC	United National Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organisation
US	United States
USD	United States dollar
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
VISA	Voluntary International Sectoral Agreement

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Appendix A. Voluntary International Sectoral Agreement (VISA): A PROPOSAL

The Bali Action Plan outlines the key challenges to be addressed in the post-Kyoto agreement. These will be negotiated in Copenhagen in 2009. They relate to technology transfer; measurable and reportable mitigation commitments; and actions, policies and measures that have to be adopted to curb the GHG emissions in the short-term and then drastically reduce them. The aim is to achieve emissions levels that will stabilise human effects on the changing climate. The Bali Action plan makes specific calls for "cooperative and sectoral approaches and sector-specific actions" to enhance the implementation of the Convention.

Sectoral approaches (SA) are being addressed in the work of two Ad Hoc Working Groups (AWGs). These groups form the negotiation tracks for the post-2012 climate agreement. Several workshops have been held by the two AWGs focusing on some of the most difficult issues in the negotiations. Those issues included SAs and gave Parties an opportunity to express their views and concerns. The issue of SAs has generated a complex debate, with sensitivities and differences of opinion on how they should be realised.

SAs represent a new set of options and a potential multi-dimensional vehicle that can enhance GHG mitigation. This is particularly so in the context of formulating national mitigation strategies that are compatible with the national sustainable development priorities. A functional SA could help generate global GHG mitigation benefits without compromising national development.

Although experience of SAs, including voluntary sectoral agreements (VAs) is relatively widespread, SAs have appeared as an issue only relatively recently in the international climate policy debate. Some models of sectoral approaches, including in the field of industrial energy efficiency, have been in place for years and have already contributed to quantified GHG mitigation. Building on the successful experience of VAs, the objective of the proposal in this document is to develop an international sectoral mechanism that will support the generation of emission reductions from industrial energy efficiency.

The Bali Action Plan emphasises the importance of "various approaches, including opportunities for using markets, in order to enhance the cost-effectiveness and promote mitigation actions bearing in mind different circumstances in developing countries". The proposal outlined below is in line with this call for new market-based mechanisms that could support mitigation and sustainable development in a similar way to CDM. The proposal is based on the VA model and is tailored to the specific needs of industry in order to provide the necessary flexibility and incentives, as well as the capacity building, that are needed in order to encourage greater action on energy efficiency in the industrial sector and cost-effective mitigation of climate change.

Introduction

The proposed Voluntary International Sectoral Agreement (VISA) is a GHG mitigation mechanism aimed at realising CO2 offsets from industrial energy efficiency programs within Non-Annex 1 countries. Those offsets can be sold to and bought from an international fund. The fund will be overseen by the UNFCCC, but may exist within one or several other bodies.

In this proposal there are five significant actors: (1) the group of Annex 1 countries, (2) individual Non-Annex 1 governments, (3) individual national industries of those non-annex1 countries and (4) a group within the UNFCCC which administers sign up to and technical services of the VISA, and (5) the VISA fund.

Operation

A Non-Annex 1 government signs up to the VISA, after which it becomes eligible to sell CO2 offsets at a fixed rate for two years to the VISA fund. It acquires offsets from agreements with industries within its borders and it also owns those offsets. As a signatory to VISA, it must produce auditable sector GHG baselines and offer industries the opportunity to engage in an agreement based on these baselines. The agreement is to meet a GHG target which results in the sector baseline being maintained or bettered over a given period. If that agreement between the industry and government is bettered (i.e. emissions from industry are lower than the quantity agreed to), then industry will receive revenue based on the CO2 offsets generated. The revenue is to be received via an agreed effective instrument such as a tax break.[30] If compliance with an agreed target is not met, then the industry involved is penalised. Independent auditing of the industrial savings will be mandated by the national government, while national baselines and government-industry agreements (including audits of their performance) will in turn be audited via the VISA fund administration. Should the government not meet the criteria, it will not be able to sell CO2 off-sets. The national government's CO2 offsets will comprise the total offsets generated through government-industry agreements during that year.

The VISA fund will sell CO2 emissions offsets on the open market. The VISA fund administration will purchase qualifying offsets from Non-Annex-1 signatories, based on a common price. The price is set so as to cover the costs of its operation as well as the administration and related services. While activities will be managed and audited by the VISA administration, it is envisaged that the VISA fund itself could be flexibly constituted. It could be jointly housed by several organs such as the GEF, World Bank and others. Further, with agreement of the VISA administration, extra funds deposited into the VISA fund could be channelled to VISA administration services and activities. This may be particularly important while the fund is being initially capitalised.

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[30] Note that the level of reimbursement to (and penalty from) the industry for the CO2 offsets would be flexibly negotiated between the government and the industry concerned. Note also that industry reductions due to CDM, would not be eligible to receive reimbursements.

The VISA administration will coordinate at least four services to national governments. (1) The first service is for Non-Annex-1 countries with an interest in taking part in the VISA scheme. It will provide an analysis of instuitional requirements - including scenarios of costs and benefits of joining the VISA. This will not include obligations, and for different scenarios of industrial mitigation, potential development benefits of joining the VISA scheme will be highlighted. (2) The second service is that VISA will provide funding to cover the institutional start up costs and institutional capacity building needed to take part in the scheme. The latter will be undertaken with a national commitment to take part in the program[31]. (3) The third service will be to oversee the auditing of Non-Annex-1 signatories' participation to the VISA in order to establish that the claimed GHG savings are genuine. (4) Fourthly it will administer the purchasing and sales of CO2 offsets, and other activities decided by the COP.

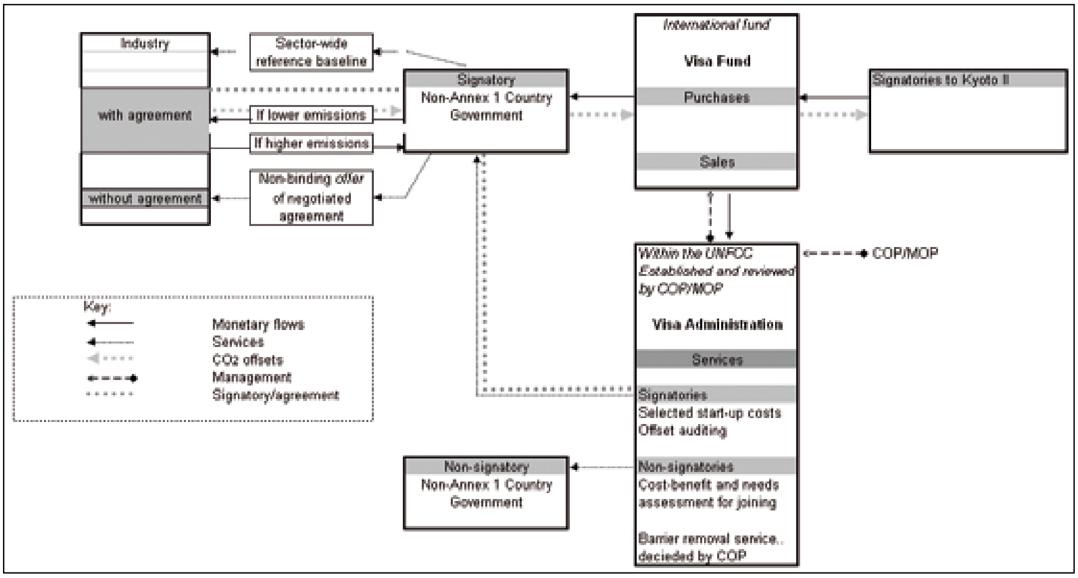

Figure 7. Summaries of the activity of each actor and notes on the Industry Agreements

These activities shall be funded from the CO2 revenues accrued by the VISA fund from offset sales from buying CO2 offsets from national governments at an agreed rate, and then reselling them onto the international market. Other activities could also be included in the VISA fund, depending on agreement at the COP. These will include barrier removal.

A macro-economic analysis should be undertaken at a country level to review the development benefits of the programme. The latter will be highlighted as a driver for developing country participation.

It is envisaged that the VISA fund and its administration will be reviewed annually as well as the offset purchase price. It is also envisaged that the VISA fund should be self financing. Profits will simply be offset by agreeing to higher purchasing costs of CO2 from signatory countries in subsequent years.

It is envisaged that national governments will recoup their costs from the difference between sales to the VISA and rebates to local industries. Further, as per the UK CCAs, industries could be authorised to trade offsets internally. However, the modalities of any such mechanisms would be for national governments to determine. Only the Non-Annex-1 country governments can sell offsets to the VISA fund.

The commitment period for the negotiated agreements will be agreed via the COP/MOP. Initially periods of 2, 5 and 10 years are envisaged in order to enable flexibility to allow for uncertainty and to capture a wide range of industrial energy efficiency mitigation measures, ranging from maintenance to new equipment purchases. At the end of each commitment period, the baseline for any future negotiated agreement with the individual industry will be revised to be more stringent in the case that the emissions target was bettered, or maintained if not. The revision of individual signatory industry baselines will also need to take cognisance of any national sectoral baseline revision.

National non-annex 1 governments

- Can receive a free non-obligatory assessment of the cost and benefits of joining the VISA (funded by the VISA fund)
- On signing, it:
  - Can receive funding for the programme "Start-up" and baseline analysis (note that the baseline must be at least equal to business-as-usual (BAU) expectations).
  - Determines auditable sector baselines or targets (which are to be revised bi-annually).
  - Offers negotiated agreements to industry, with no obligation to "sign industry up". Thus the country is under no-obligation to reduce emissions or force industry to "sign up" to meeting specific targets.
  - Sells CO2 reductions to the VISA fund based on sector negotiations
  - Reimburses industry at a negotiated level for their offsets over the baseline (or penalises local industry if baseline targets were not met.)

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[31] i.e. to develop sectoral baselines and offer industry an opportunity to meet or better them.

    - Commissions an independent audit of the savings and broad macro economic impact of the programme

- This approach allows flexible target setting as the baseline chosen by the country could be more stringent than the BAU.

Non-annex 1 Industry

- Can sign up and then negotiate a target (either hard or based on intensity) together with refund/penalty rate

- Reductions are reimbursed as a tax credit or other appropriate instrument

- Sign up is voluntary, but once signed is binding with non-compliance is penalised

- Agreements and performance of those agreements will be auditable

VISA fund administration

- Within the UNFCCC, activities to be reviewed by the COP annually

- Apart from start up funds, will be self financing

- Will sell offsets at the minimum price or at market rates

- Will determine the purchasing price of offsets from non-annex 1 countries to cover operational costs (this will be revised bi-annually)

- Will purchase all offsets provided they meet compliance rules

- Will audit non-annex 1 country performance

- Will provide a non-obligatory service estimating the costs and benefits of a non-annex 1 country on request, should it wish to join the programme

- Will provide an obligatory service providing start up costs and assistance with sectoral baseline development

    - Baseline assessment must be verified as being at least equal to BAU expectations

- Will provide a range of services to promote barrier removal depending on the agreement of the COP/MOP with an aim to improve the performance and generation of CO2 offsets.

- Similar services can also be arranged on an ad-hoc basis based on deposits into the VISA fund by donors.

The Industry-Non-Annex-1 Sector Agreements:

- Note also that while the agreement with industry is based on the sector baseline, the aim is to improve on the overall sector baseline. Thus if the specific industry within this sector is expected to better the sector baseline under BAU practices, its negotiated agreement will be more stringent than the sector baseline and at least equal its the BAU emissions expected from that industry.

- Note also that the detail and definition of the "sector" for which the baselines are drawn up are flexible, but should provide enough detail to assess whether offsets would result in an improved average emissions level.

- The agreements themselves will be either based on fixed GHG emissions targets or on intensity targets and these will be revised at the end/beginning of each agreement.

- All agreements will reviewed annually, indicated the annual quantities of CO2 offset available to the host country for sale.

Appendix B. Capacity-Building Fund Proposal

This proposal, to provide support to China in the form of expertise from industrialised countries and partial funding for counterpart Chinese activities, is based on experience to date with a number of capacity-building programmes.

An example of the type of programme envisioned under this fund is the multi-year training programme between Lawrence Berkeley National Laboratory (LBNL) and China's National Institute of Standardisation (CNIS) in which LBNL provided assistance to the Chinese in drafting and implementing appliance energy efficiency standards beginning in the early 1990s based on LBNL's experience developing such standards for the U.S.[32] The assistance consisted of training Chinese government officials and researchers to analyse standards for refrigerators. In return, the Chinese government committed to issuing energy efficiency standards for refrigerators 18 months after the training was initiated. The training consisted of the use of a computer model to simulate the performance of refrigerators, analysis of the economic impacts of standards, determination of the standard levels, use of complex tools to assess the standards, and measurement of appliance performance through refrigerator test procedures.

Following the training, the Chinese team established refrigerator efficiency standards in China which are strengthened every 5 years. Training was then carried out for the analysis of standards for other household products. As the Chinese government recognised the substantial benefits of the standards, they institutionalised the programmes within the government. Over a period of about a decade, the programme was successful in transferring the full capabilities of performing in-depth policy analyses on appliance energy efficiency standards, labeling programmes, and test procedures.

Appliance standards in China are estimated to save between 96 and 120 million metric tons of CO2 per year in 2020. Cumulatively, they will reduce CO2 emissions between 1 and 2 billion metric tons over the coming twenty years (Fridley et al., 2007; Levine and Aden, 2008). Valued at US$20/metric ton, 2 billion metric tons is US$40 billion, with a present value of ~US$15 billion depending on assumptions about discount rates and future values of CO2. The cost of the appliance standards training programme was less than US$5 million, spread over a decade (Levine, forthcoming).

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[32] Similar policy development or training programmes include the UNIDO China Motor System Energy Conservation Programme (described above in Section III.B.3) and the Shandong Province Energy Efficiency Agreement Programme/Top-1000 Programme in China (Price et al., 2003; Price et al., 2008).