EEMODS '07 Side Event – Workshop (14 June 2007, Kunlun Hotel, Beijing, China)

Defining a Clean Development Mechanism Pilot Program to Promote High-Efficiency Electric Motor Systems

BACKGROUND PAPER

Promotion of High-Efficiency Electric Motor Systems Under the Clean Development Mechanism

Abstract

Since EEMODS 05, carbon markets have developed rapidly, in particular under the Kyoto Protocol Clean Development Mechanism (CDM). This paper will provide an overview of trends, current status and prospects for promotion of high-efficiency motor component technologies and systems under the CDM, addressing the following broad topics:

- status of motor technology/system promotion under the CDM, including case studies;
- availability of suitable baseline and monitoring methodologies and results of recent analytical work to overcome key methodological challenges with particular relevance to motor systems;
- framework for assessing the role of CDM in the promotion of high-efficiency motor component technologies and systems;
- design of an effective CDM program of activities: key stakeholders, barriers, policies and incentive programs, implementation partners and modalities, etc.

The carbon market has developed to a multi-billion dollar business, and the Clean Development Mechanism has the potential to facilitate innovative incentives for end-users, manufacturers and governments. From the perspective of the different actors involved (e.g., manufacturers, utilities, distributors, ESCOs, building owners, end-users), this paper will provide a systematic overview of barriers to market transformation towards high-efficiency motor systems, and which types of incentives will be most effective in addressing the barriers faced by each group. It will also consider what role the CDM can play and suggest possible models for the design of effective CDM programs that target different stakeholders.

Status of and Barriers to Motor (System) Promotion under the CDM

Countries around the globe increasingly recognize that the efficient use of energy is essential for sustainable development and climate change mitigation [1]. Meanwhile, the carbon market has developed into a multi-billion dollar business [2], and the expectation of countries worldwide is that the Kyoto Protocol Clean Development Mechanism (CDM) will speed the market penetration of efficient equipment, products and services. The sustainable development benefits of improved energy efficiency are widely acknowledged, and a number of countries – for example, China – have made energy efficiency a national CDM priority. Yet the CDM has only managed to catalyze a handful of demand-side energy efficiency projects [3, 7], and progress since our report at EEMODS 05 [4] has been disappointing.

In principle, industrial electric motor systems are a prime target for the CDM: They are pervasive throughout the global economy (responsible for approximately 40% of global electricity demand) and represent a large potential source of emission reductions at no net cost (taking into account energy savings) and using existing technologies and practices [5, 6]. However, the CDM has failed to stimulate the uptake of high-efficiency motor systems significantly.

This paper was presented by Anne Arquit Niederberger and Conrad U. Brunner (A+B International (Sustainable Energy Advisors)) at the EEMODS 2007 conference (www.eemods.cn). It is being distributed to participants in the Workshop "Defining a Clean Development Mechanism Pilot Program to Promote High-Efficiency Electric Motor Systems" to provide background material for the discussion and is also available in Mandarin.

Registered Projects

As of early April 2007, a total of 630 CDM projects had been approved by the CDM Executive Board and about 45 million tons of Certified Emission Reductions (CERs) had been issued. Few of these projects are demand-side efficiency projects, most of which are small-scale and undertaken by Indian industry [7]. Several small-scale projects involving motor systems have been approved, and we give three examples here. One of these involves installation of variable frequency drives to increase the energy-efficiency of the motors used in the humidification towers of the worsted mill and flax spinning department of Jayshree Textiles Division, Rishra, West Bengal India[1]. Prior to the CDM project, air flow dampers were used to match heat demand, with motors running seasonally at only partial load.

Another Indian industry sector project applies adjustable speed drive technology to optimize the power consumption of the compressed air generation system of the Patalganga division of Reliance Industries Limited (a leading manufacturer of petrochemicals and fiber intermediates)[2].

The third project – the small-scale retrofit of the ITC Hotel Sonar Bangla Sheraton and Towers in Kolkata, India – goes beyond individual motor technologies to address not only motor systems, but a comprehensive suite of building efficiency measures. Although the hotel was relatively new (built in 2002), in-depth energy audits uncovered a suite of supply and demand-side efficiency measures, including installation of three new variable frequency drives (one each for the main kitchen exhaust fan, the banquet kitchen exhaust fan and the air handling unit (Pan Asian AHU) of the hotel), retrofit of pumps to better match load requirements and various chiller system optimization measures[3].

Note that all of these projects are small-scale and are located in India. The scope for motor system efficiency improvement under the CDM is enormous, and we need to focus on scaling up from these initial examples.

Approved Baseline & Monitoring Methodologies

Since registration of CDM projects by the CDM Executive Board requires use of previously approved baseline and monitoring methodologies, the lack of approved methodologies has been a serious barrier to promotion of demand-side energy efficiency under the CDM [7]. There has been little incentive for developers to invest in methodologies for energy efficiency (Sectoral Scope 3), not least because private project developers/investors expect higher returns from non-CO_2 greenhouse gas projects, but also because of the lack of guidance on how end-use efficiency methodologies must be designed to receive approval, which creates great uncertainty, on top of a lack of intellectual property protection. There is no common understanding of what constitutes a good or best practice energy efficiency CDM methodology, and almost no one is willing to pay for this [3].

Only one large-scale and four small-scale methodologies applicable to industrial electric motor systems have been approved to date:

- AM0020 ("Baseline methodology for water pumping efficiency improvements"), which is narrowly applicable to retrofit or replacement projects that reduce the amount of grid electricity required to deliver a unit of water to end-users in municipal water utilities.
- AMS II.C ("Demand-side energy efficiency programmes for specific technologies"), which is a small-scale methodology (i.e., resulting in annual energy savings of <60 $GWh_{electric}$) applicable to projects, bundles of projects and programs of activities that encourage the adoption of energy-efficient equipment (explicitly including motors and fans, but open to other motor system applications).

[1] Project details available at http://cdm.unfccc.int/Projects/DB/SGS-UKL1137764792.88/view.html

[2] Project details available at http://cdm.unfccc.int/Projects/DB/TUEV-SUED1171633547.84/view.html

[3] Project details available at http://cdm.unfccc.int/Projects/DB/DNV-CUK1160721623.56/view.html

- Motor system efficiency improvements can also be undertaken under the small-scale methodologies AMS II.D (industrial facilities), II.E (buildings) and II.F (agricultural facilities).

A methodology proposed for the "Electric motor replacement program in Mexico" (NM0100) was rejected by the CDM Executive Board and never re-submitted. Another methodology prepared by the World Bank that would be applicable to a range of equipment such as pumps, chillers, refrigerators, and air conditioners is currently under consideration by the CDM Executive Board. This methodology would pave the way for accelerated replacement of non-system integrated electrical equipment with variable output under a program of activities.

Design of an Effective CDM Program of Activities

Identifying the "filet" of the Motor Market

Based on preliminary findings, the best target areas can be identified taking into account four main factors, which are explained below: potential for energy efficiency improvement, CDM eligibility, monitoring and other transaction costs, and institutional capacity to implement CDM efficiently.

Potential for Energy Efficiency Improvement

- Installation size: A mid-size to large factory or infrastructure system with a multitude of similar installations and professional operating & maintenance personnel is the ideal context for energy efficiency and CDM projects. An inventory of systems and a preventive maintenance plan can be established rapidly as a first step for an efficiency program. A total volume of installed motor capacity above 1000 kW (i.e.100 motors at 10 kW) lends itself easily to systematic auditing and monitoring, as well as related training. Problematic might be if large stocks of "old" motors are available.

- Motor system size: The installation and transaction costs per kW in small systems (especially for ASD) are much higher than in larger systems. However, the number of large systems is limited, and larger motor systems tend to have higher efficiencies to begin with, leaving less scope for efficiency improvement. Between 10 and 100 kW (or up to 1000 kW) is a potential target area.

- Motor system sized to match load: Oversized systems running in partial load are prevalent. These systems are often highly inefficient and represent very cost-effective improvement potential, since engineering and installation of properly-sized motors can reduce both capital cost (of the smaller motor) and operating expenses (electricity cost).

- Operation: The more hours a system is in operation every year, the better the economical potential for high efficient equipment. Systems with a duty factor above 4000 hours per year are economically more feasible; below 2000 hours, cost-effectiveness decreases significantly. Existing systems with low average load factors (< 50%) have large losses and can benefit by size adjustments and use of ASD.

- Monitoring: Determining system energy use in the baseline and tracking energy savings requires either *in situ* measurement or conservative assumptions based on standard operating conditions (duty and load factor, life cycle). Simple water pumping systems, for example, or factories with a number of similar systems, are more viable to monitor than other types of applications. Given that the principle of "conservativeness" must be applied under the CDM, such project types that can be monitored using *in situ* measurements (rather than assumptions) can yield more CERs.

- Equipment lifetime: For the retrofit market, CDM baseline and monitoring methodologies are required to take into account the remaining lifetime of the equipment to be replaced. Motor systems are designed to run between 10 and over 20 years (equivalent to 50’000 to 100’000 nominal operating hours), depending on motor size, duty and maintenance practices. Existing databases can be used to derive generic values. In addition, assumptions have to be made about the practice of replacing vs. rewinding motors and its effect on emissions. A conservative assumption is to ignore any effect of motor rewinding in the baseline, as rewinding typically results in at least some loss of efficiency.

- Sector: The large industrial sectors (metal and non-iron metals, chemical, oil & gas (incl. refineries), pulp & paper, etc.), together with municipal infrastructure and energy supply systems (gas and oil pipelines), are the most important users of electricity and motor technology. They have the greatest potential for successful energy efficiency and CDM projects.

CDM Eligibility

- Additionality: It must be demonstrated that the motor system to be used in the CDM project is different from and better than the business-as-usual solution (be it a retrofit, replacement or new project). Emissions reductions are calculated with respect to a baseline, which is the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases (GHG) that would occur in the absence of the proposed project activity. Additionality can be demonstrated by various means; the tool provided by the CDM Executive Board involves barrier analysis, investment analysis and common practice analysis. Given that many demand-side efficiency projects represent profitable investments, barrier and common practice analysis are crucial.

- Availability of approved methodology: One important feasibility consideration is the availability of approved methodologies, since CDM rules require the use of pre-approved baseline and monitoring methodologies to calculate baseline emissions and estimate emission reductions *ex ante*, as well as to monitor project performance. To date, only two methodologies relevant to motor systems have been approved (see above).

  If existing energy intensity based methodologies (kWh electricity per "service unit or product"), such as AM0020, can be used, the transaction costs will be lower and the timeline shorter. This favors projects that involve an easily defined "product" (m^3 drinking water, tons of oil, etc.) that can be readily monitored and that has no (large) variation of temperature, pressure, quality, etc.

Monitoring and Other Transaction Costs

- Retrofit vs. replacement vs. new equipment market: New systems can be designed from the outset to maximize efficiency, thus reducing the additional investment (technology) and transaction costs (e.g., monitoring); however, baseline emissions and reduction potential could be lower, thus raising the bar for the CDM. The same generally holds true for the replacement market, with the added complications that (i) reserve, low-efficiency motors might have already been purchased and (ii) rewinding (rather than replacement) is a real option. Retrofits of functioning systems are the least likely to occur without the CDM, as there are significant opportunity, transaction and additional investment costs involved.

- Monitoring effort and cost: The effort to measure/monitor motor systems can be prohibitive. A motor system has to be easy to control and monitor to avoid big and unproductive measuring installations and monitoring costs. While monitoring of electric loads and operating hours are easy and cheap, the online measurement and monitoring of air and water flows, pressure differences, temperature variations, motor efficiency, etc. need more complex equipment and monitoring protocols. Different motor applications have different *in situ* monitoring requirements. Among the most feasible applications with respect to monitoring costs are the following, which account for rougly half of total electric motor electricity demand:

  - Mechanical traction systems: Large industrial conveyor systems with relatively constant load and long duty factors are relatively easy to monitor. They can be described by running hours and average hourly electric load (which is rougly proportional to weight transported). Metering can be handled externally without interfering with the process. Improved efficiency can be achieved rapidly by going to more efficient motors and ASD.

- o Fluid pumping systems: Pumps with clean cold water, full year operation and relatively constant load are easiest to monitor and therefore often feasible for CDM projects. This also applies to some extent to other liquids (sewage, oil, hot water) and other uses (heating, cooling), but the effort to control and monitor is somewhat higher, especially with heavy load changes due to seasonal effects. Pump system efficiency is describd by only two major parameters: volume (m^3 per hour) and pressure (Pa). For liquids – which can generaly be considered as being non-compressible in a wide range of temperatures – the monitoring is relatively easy and can be made with state of the art equipment without opening the piping system.

- o Air and gas systems: Fans are more difficult to control, but might also be feasible under the CDM. Usually the flow (air, natural gas, steam) is less constant and needs more effort to measure (temperature, pressure, vapor content, etc.) under steady state conditions. This is due to variations in volume resulting from temperature and pressure fluctuations. Air flow metering is considered to be more prone to inaccuracy, and it certainly needs more measuring points and effort to check the sensors and verify the results.

- o Compressor systems for cooling and compressed air are generally much more complex to describe and monitor. In industry, leaks in compressed air systems can be implemented and monitored cost effectively. However, besides the core compression loop, chiller systems have a series of pumps and fans on the condensing and evaporating end. To date, no methodology has been approved for such a complex system, but the CDM Executive Board will decide in 2007 on a methodology proposed by the World Bank, based on a chiller retrofit project in India[4].

Institutional Capacity to Implement CDM Efficiently

- Engineering know-how: Sufficient numbers of qualified and experienced engineers (e.g., in ESCOs) are needed to perform audits and (re-)design industrial motors systems. Pilot projects and training programs – such as the UNIDO efforts in Shanghai and Jiangsu [8] – are needed to standardize the approach and the most feasible testing equipment. This can lower the costs and increase the quality of the industrial energy efficiency projects.

- Least life cycle cost: Tools and standard data for rapid LLCC analysis and definition of the most cost-effective and sustainable improvement plan. Building on MotorMaster+ and Eurodeem, the International Motor Selection and Savings Analysis (IMSSA) software tool was developed for the U.S. Department of Energy, with sponsorship from Natural Resources Canada, Corporacion Nacional del Cobre de Chile, European Community - JRC, UK Action Energy (Carbon Trust), and the International Copper Association. The tool determines energy and dollar savings for motor selection decisions while taking into account such variables as motor efficiency at its load point, purchase price, energy costs, operating hours, load factor, and utility rebates. The software tool's analysis features include determination of energy savings, demand reductions, dollar savings, greenhouse gas emission reductions, simple payback, cash flows, and after-tax rate-of-return on investment.

Function of the CDM in Overcoming Barriers to High-Efficiency Motor Systems

In addition to determining which segment of the motor market has the largest cost-effective energy-saving potential and which project types lend themselves most readily to rapid CDM approval, we also need to consider how a CDM project or program can be designed to be most effective. A wide range of programs to promote efficient motors or motor systems have been established in various countries around the world (see table on next page). The table demonstrates that whereas some of the measures are broad-based, others target only part of the overall efficiency market, either because they:

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[4] http://cdm.unfccc.int/methodologies/PAmethodologies/publicview.html?OpenRound=17&OpenNM=NM0197&cases=B#NM0197

Programs Promoting Efficient Motor (Systems)

Type of Program	Program Description	Motor or System Scope	Efficiency Market
Mandatory energy performance standard	Minimum energy efficiency performance requirement (measured according to a specified testing standard) that must be met for product to be certified for sale/import in a given market	Motor / Several core systems	All
Voluntary energy performance standard	Standards and labels to identify and market premium efficiency motors	Motor	All
Procurement	Recommendation/requirement for government agencies for procurement to specify motors that meet advanced energy efficiency levels (based on standards or labels) *or* Large private company procurement programs and competitions backed by buyer groups	Motor	All
Voluntary agreements	Contract between government and motor using enterprise to achieve energy savings or implement motor system optimization efforts *or* Contract between government and motor manufacturers to achieve energy savings or implement motor system optimization efforts	Motor / System	All
Prescriptive incentives	Cash rebates or tax breaks to manufacturer, vendor or customer for specific pieces of equipment that meet prescribed energy-efficiency specifications or standards	Motor / Some systems	All
Custom incentives	Incentives based on energy savings achieved or on incremental or total project cost	Motor / System	Discretionary retrofit
New construction incentives	Variety of incentives to fund audits, feasibility studies, design, and/or prescriptive measures	Systems	New construction
Pilot demonstration projects	Implementation of demonstration projects for energy efficient motor systems and dissemination of results	Systems	Discretionary retrofit / New construction
Deemed measures	Incentive programs that do not require monitoring and verification of energy savings as a prerequisite for reimbursement. Relies on a standard / specification that defines product performance, or sufficient experience with the process to preclude the need to actually demonstrate that the projected savings were achieved.	Motor, other components (e.g., VSD)	All
Management plan	Support to implement management plan to deal with motor failures, encouraging better motor repair/replace decisions	Motor	Planned replacement
Standard Performance Contracts	ESCOs/EMCs or design engineering firms work with end-users to develop, finance and implement projects	Motor / System	All
Audit or inventory support	Technical and/or financial assistance for audits or full inventories	Motor / System	Discretionary retrofit / Planned replacement
Testing equipment leasing	Testing equipment leasing for systematic performance check to encourage preventive maintenance and replacement planning	Motor / System	Planned replacement
Awareness, education, tools and training	Wide variety of programs offering information, guidelines and tools on motor system efficiency, targeting various market players	Motor / System	All
Financial assistance	Programs to assist with financing of energy efficiency investment, often in combination with other incentives	Motor / System	All

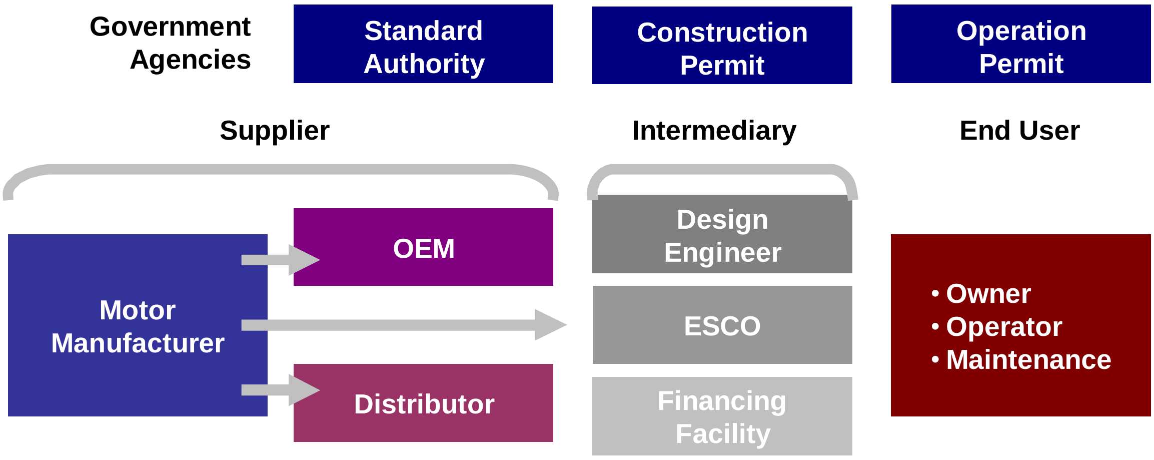
- only focus on motors (as opposed to complete systems);
- are designed for application in only one sector (e.g., voluntary agreements with industry);
- target specific market players (such as manufacturers or distributors); or
- are limited a specific efficiency market (such as the new construction market).

It is also evident that some measures offer some form of direct or indirect financial incentives, whereas others do not.

Below we quickly review the main barriers facing key players in the motor system market, consider which types of incentives would be most effective and discuss what role the CDM might play in helping to overcome them.

Barriers to High-Efficiency Motor Systems

The diagram below depicts the global motor market. Key market players include governments (e.g., mandatory standards, motor end-users in municipal infrastructure), manufacturers, original equipment manufacturers (OEMs), distributors, design professionals, contractors, ESCOs and operators/end-users.



Motor Market Decisionmakers

These groups face a variety of common and specific barriers to the use of high-efficiency motor systems, some of the most common being:

- Lack of awareness about technologies and strategies to improve motor system efficiency
- Lack of harmonized information on motor and system efficiency
- Higher up-front capital cost, coupled with conflicting incentives between those who purchase energy-using capital equipment and those who pay energy bills
- Capital investment decisions generally not made on the basis of what is cost-effective
- Equipment inavailability
- Aversion to taking on risks associated with adopting new technologies and/or systems, coupled with a lack of awareness of non-energy benefits, such as increased reliability and reduced downtime.

Barriers Specific to Different Efficiency Markets

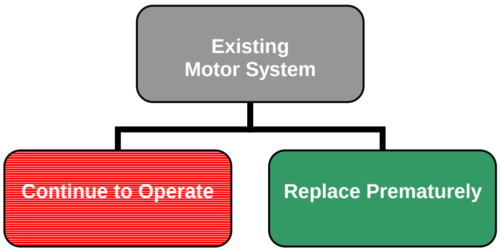
In addition to these general barriers, there are specific challenges to discretionary retrofit, replacement and new construction projects.

Definition of Efficiency Markets

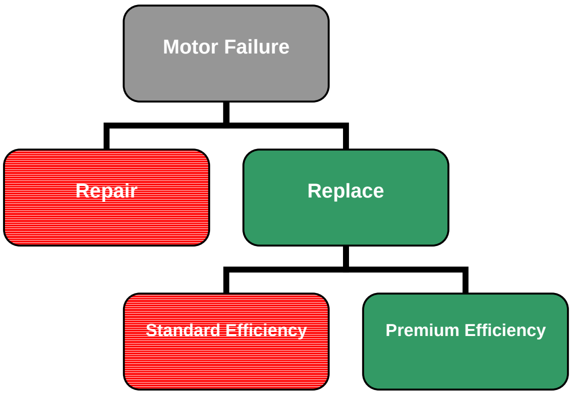
Market	Definition
Discretionary retrofit[5]	Decision to prematurely replace existing technology with high-efficiency equipment for the primary purpose of improving energy efficiency
Planned replacement	Decision to replace existing technology at the end of its useful lifetime (e.g., failure, replacement schedule) with high-efficiency equipment
New construction	Decision to select high-efficiency equipment over other alternatives to deliver the same energy service at the time of new construction

From the perspective of the motor system owner, there is a fundamental difference between discretionary retrofits and planned replacement or new construction.

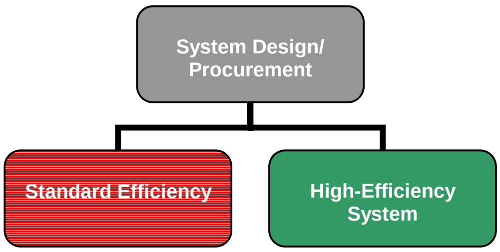
- **Discretionary retrofits** can involve just the motor or the entire system. The basic choice facing an enterprise is continue operation of existing motor (system) vs. retrofit with new equipment:



- **Planned replacement** is almost always only focused on the motor, core system or other discrete technology, as the entire system rarely fails at once. The basic choice facing an enterprise at the time a motor fails is repair vs. replace, and for the replacement option, the basic question is whether the replacement motor should be at the standard efficiency level in the given market – dictated by a minimum energy performance standard or prevailing practice – or whether to aim for premium efficiency:



- **New construction** normally would involve the entire motor system. The basic choice facing an enterprise is to aim for business-as-usual (BAU) efficiency vs. high-effieciency system in the design and procurement process.



[5] "Retrofit" has been defined by the UNFCCC for small-scale CDM projects as follows: To modify existing industrial, commercial and residential facilities, automobiles, energy conversion systems etc., which are already in service using new, improved or more efficient parts and equipment developed or made available after the time of original manufacture or installation of the facility.

By definition, discretionary retrofits would not have occurred in the absence of the CDM activity. The new construction market, on the other hand, faces lower hurdles. Unfortunately, the current rules for small-scale energy efficiency projects treat all efficiency markets identically, which puts discretionary retrofits – which are clearly additional – at a relative disadvantage to planned replacements or the new construction market.

The CDM as a Financial Incentive?

The CDM is generally in a position to address financial barriers to investment in high-efficiency systems either by creating a new revenue stream for quantifiable improvements in energy efficiency or by providing additional up-front capital for energy efficiency investments, although this latter model is the exception.

In the most common case where CER revenues accrue to a project owner in step with verified greenhouse gas emission reductions, these revenues are small in comparison with the resulting savings in electricity costs (likely < 10%, at current CER and electricity prices), and it is therefore unlikely that the CDM would do much to spur additional investment in high-efficiency motor systems. Although additional investment costs can typically be paid back by lower operating costs within one to three years, barriers such as the higher initial investment (plus 20% to 30%), other costs associated with system retrofits (such as plant down-time) and the necessary auditing still prevent motor system efficiency improvements.

The financial incentive therefore has to cover up-front costs, such as audits and a large part of the additional initial costs (30% to 50%). Since the CDM seldom provides up-front financing, it can only support financial incentive programs if the institution running the program is in a position to offer debt or equity funding itself that can then be repaid by CER revenues over time. There are examples of arrangements under which CER revenues flow directly to lending institutions to service debt repayment obligations. ESCOs can also perform this intermediary role, or a CDM model could be envisioned under which motor system equipment manufacturers would themselves provide up-front financing under a CDM project or program of activities (along the lines of the pay-as-you-save schemes offered under the UK Climate Change Levy by manufacturers including ABB and Baldor).

Assuming that a CDM project can be structured in an appropriate way, the additional CER revenues can be expected to be at least of the same order of magnitude as the additional investment cost (see table), which can make a real contribution to barrier removal.

CER Revenue and Additional Capital Investment

Scenario	Motor Size	Additional Capital Investment (EUR)	CER Revenue over 10-Year Crediting Period (EUR)	CER Revenue as Fraction of Additional Investment (%)
Baseline scenario	90 kW	not applicable	not applicable	not applicable
CDM project scenario (Premium motor, ASD)	75 kW	7372	4380	59

In this hypothetical calculation, which is based on manufacturer catalog data for US and European motor sales [9], CER revenues over a 10-year crediting period would cover roughly 60% of the additional cost to retrofit an existing motor with a re-dimensioned, high-efficiency motor fitted with an adjustable-speed drive[6]. It should be noted, however, that – due to a lack of regulatory uncertainty – it is currently difficult to monetize CERs to be generated after 2012.

Generic Models to Leverage CDM Funding for Industrial Motor Systems

The CDM can support either individual efficiency projects (either in isolation or bundled together), or the implementation of a CDM program of activities [10]. The key differences between bundled projects

[6] Calculation assumes a CER price of EUR 7.63 per ton of carbon dioxide and an electricity price of EUR 0.05 per kWh.

(which have only been officially defined for small-scale projects) and a program of activities are summarized in the following table.

Characteristics of CDM Bundles and Programs of Activities

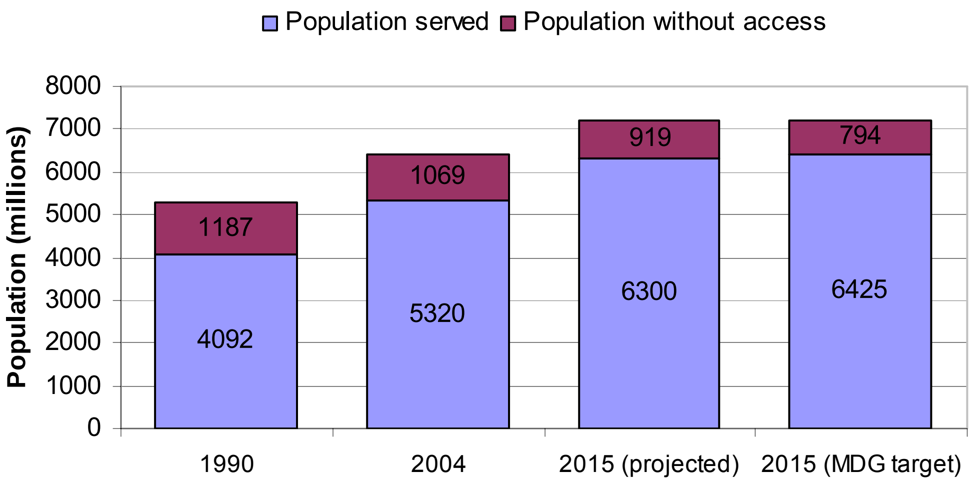
	SSC Bundle	**Program of Activities (PoA)**
Definition	Bringing together of several CDM project activities, to form a single CDM project activity or portfolio without the loss of distinctive characteristics of each project activity (incl. technology / measure; location; applicable baseline methodology).	Voluntary coordinated action by a private or public entity which coordinates and implements any policy/measure or stated goal (i.e. incentive schemes and voluntary programmes), which leads to GHG emission reductions or increase net greenhouse gas removals by sinks that are additional to any that would occur in the absence of the PoA, via an unlimited number of CDM program activities
Objective	Reduce transaction costs compared with implementing each project individually	Provide incentive for GHG reductions by program participants
Role of aggregator	Bundles separate projects with similar characteristics	Administers incentive program; coordinates the PoA and communicates with CDM Executive Board
Project participants	Project participants include aggregator and all entities achieving reductions Each single activity is represented by a CDM project participant	Project participants implement individual CDM program activities under the PoA The aggregator is not a project participant *per se*; rather it serves as the PoA coordinating entity vis a vis the CDM Executive Board and administers the program
Nature of project activity	Each activity in bundle is registered as an individual CDM project activity All projects in bundle must be defined *ex ante* (at the time of registration); composition of project activities does not change over time All CDM project activities in the bundle have the same crediting period	Only the PoA is registered (individual CDM program activities are not) PoA is registered based on one approved baseline & monitoring methodology and definition of the eligible type of activity (technology or measure); actual physical CDM program activities can be added to the PoA at any time The PoA can have a duration of up to 30 years; each CDM program activity has its own crediting period

The possible CDM implementation modes thus include:

- Individual project (small-scale < 60 $GWh_{electric}$ ≥ full-size)
- Bundling via intermediary
- Program of Activities

In all three cases, an approved baseline and monitoring methodology is required. At present, these are limited to the full-scale methodology AM0020, with its narrow application to municipal water pumping systems, the small-scale methodology AMS II.C, which is broadly applicable to demand-side energy efficiency programs that encourage use of specific high-efficiency technologies at many sites (retrofit or new installations) and the suite of small-scale methodologies AMS II.D-F that are applicable to improvements in energy efficiency in industrial facilities, buildings and agricultural facilities.

Given the great demand for modern water supply infrastructure in CDM-eligible countries (i.e., new construction, which lends itself ideally to system optimization), coupled with the significant potential for energy savings and the fact that the monitoring approach in the methodology is quite simple to implement, CDM opportunities in this sector should be pursued as a matter of urgency. Over 1.1 billion people do not use drinking water from improved sources, and the Millennium Development Goals (MDG) aim to cut by half the proportion of people without sustainable access to safe drinking water [11].



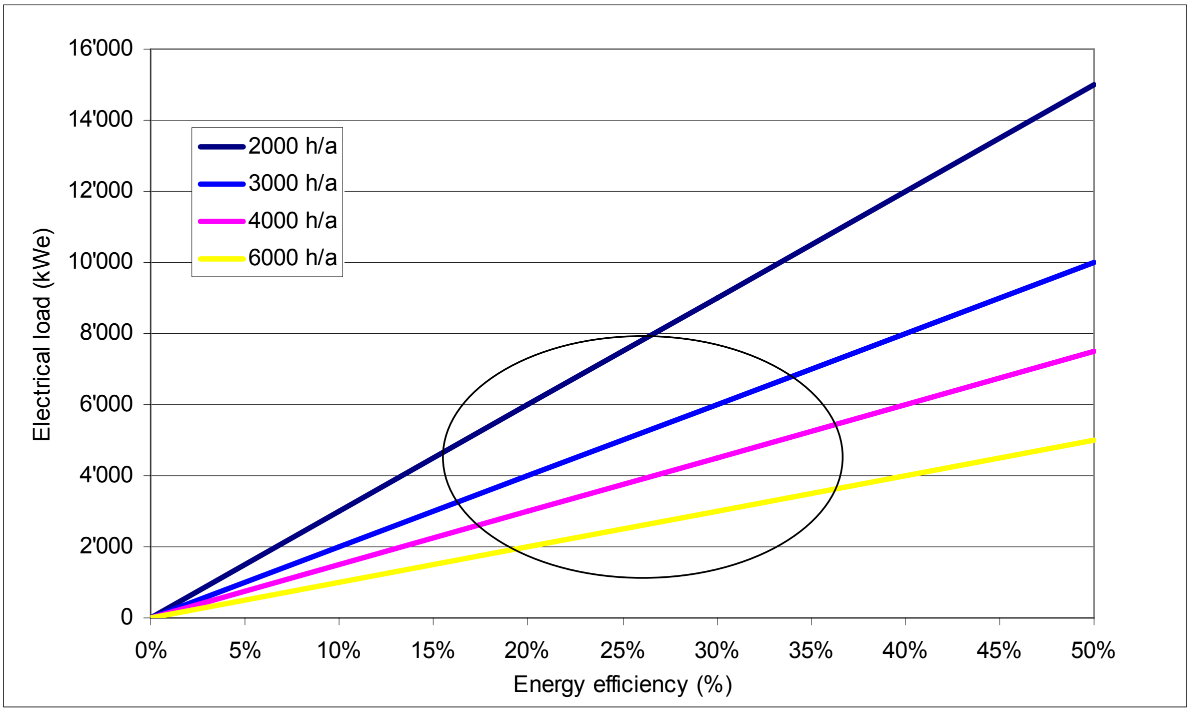
Access to Improved Drinking Water Source in 1990, 2004 and 2015 [11]

Reaching the MDG target will require the provision of services to an additional 1.1 billion (or 300 thousand people a day) over the next decade [11], which entails a major increase in investment to refurbish existing and build new drinking water infrastructure, particularly in rural areas. Even greater efforts are needed to meet the MDG sanitation goal. Recognizing that energy is the second highest budget item for municipal water and wastewater facilities in OECD countries after labor costs (and likely the greatest in developing countries), the CDM could provide a welcome source of project finance to complement the limited public resources available for water and wastewater treatment facilities in developing countries, while at the same time reducing the operational cost burden – and increasing the likelihood that the facilities will remain in operation – over the project lifetime.

Simplified modalities and procedures were developed to facilitate certain types of small-scale CDM (SSC) project activites, including energy efficiency improvement projects. These include pre-approved, simplified baseline and monitoring methodologies; a simplified PDD and provisions for environmental impact analysis; as well as lower registration fees and other special arrangements. Nonetheless the transaction costs associated with preparing and implementing a small-scale CDM project activity, relative to the revenue from carbon credits, remain significant, and very few energy efficiency projects have gone forward. In December 2006, the limit to qualify as a small-scale project was raised from 15 to the equivalent of 60 GWh per year aggregate energy savings (no limit on the respective load, primary energy or carbon emissions reduced).

This expands the applicability of the small-scale methodologies dramatically. A sewage treatment plant for a city of 120 000 people, for example, might have 200 motors with an average size of 25 kW, giving a total capacity of 5000 kW and an annual electricity demand of 17 GWh. Assuming motor system efficiency can be improved by 25%, some 4 GWh could be saved annually. Under the new SSC rules, up to such 15 plants could be optimized in a single bundled project. Similarly, in the industry sector, an individual factory might have an electricity consumption of the order of between 1 and 100 GWh/a. This means three large factories (or 200 small factories) could be bundled together in a single small-scale project or program. What this means in terms of motor systems more generally can be illustrated with the diagram on the next page.

The 60 GWh electricity savings can come from a combination of efficiency measures that might affect the coefficient of performance of the motor, operating conditions (e.g., hours per year) or the load split across the range of motor size. The figure illustrates a likely range of 20% to 35% total energy savings potential and a 3000- to 6000-hour range of annual operating hours. A motor system of any size (between 1 kW and 20 MW) running 3000 hours per year and delivering 30% efficiency gains would qualify as a small-scale CDM project (equivalent of < 60 GWh energy savings).



Conceptualizing the 60 GWh per Year Small-Scale Limit for Motor Systems

The resulting total load of motors to be improved is between 2000 and 6000 kWe. The load can then be attributed to individual motor systems within the same project boundary. Given the distribution of motor size, CDM projects will likely target the most common standard motor sizes between 5 kW and 500 kW (see table).

Number of Motor Systems Eligible under SSC Rules (assuming 30% efficiency improvement)

Average size of each motor unit (kWe)	Number of Units		
	3000 hours / year	4000 hours / year	6000 hours / year
500	133	100	67
300	222	167	111
100	667	500	333
70	952	714	476
50	1333	1000	667
30	2222	1667	1111
10	6667	5000	3333
7	9524	7143	4762
5	13 333	10 000	6667

The table illustrates that a CDM motor project that resulted in 30% efficiency gains for 100 large (500 kWe) or 10 000 smaller pieces of equipment (5 kW) operating 4000 hours annually would still qualify under the SSC rules. This calculation illustrates the significance of the new SSC limits for motor system efficiency initiatives under the CDM.

Given the relatively small scale of the vast majority of motor systems, transaction costs are a key consideration in CDM project viability. It will therefore be important to explore the potential role of

ESCOs, governments, development banks and perhaps other institutions as aggregators / intermediaries.

Call to Action: Public-Private Partnerships

Improved Guidance on Energy Efficiency CDM

Energy efficiency projects pose a range of unique methodological issues under the CDM, which presently are not being dealt with under the existing CDM structures. It has therefore been proposed that the CDM Executive Board create an Energy Efficiency Working Group (analogous to the working groups for small-scale projects and for afforestation / reforestation projects) or other mechanism to provide further clarity and guidance on these issues – for both regular and small-scale activities – as well as on programmatic CDM issues, since this form of CDM is so fundamental to the success of energy efficiency under the CDM [3, 7].

Two recent developments are very encouraging for energy efficiency under the CDM. First of all, the CDM Executive Board is working to clarify the concept of Programs of Activities, and the preliminary discussion at the Board meeting in March 2007 suggests that these clarifications could make it easier for ambitious end-use efficiency programs to qualify. Decisions are expected at the next Board meeting im May 2007. Secondly, energy efficiency was given a prominent spot at the annual CDM Joint Coordination Workshop hosted by the UNFCCC Secretariat in Bonn in March 2007. Many of those in the CDM community, in particular, experts from host countries, expressed their view of the importance of energy efficiency in climate mitigation and the need to address methodological barriers to energy efficiency under the CDM. The Board and UNFCCC Secretariat are now considering how to tap into the vast energy efficiency expertise [7] to provide better guidance, methodologies and tools to facilitate energy efficiency CDM. Issues that could be addressed with direct involvement of energy efficiency experts include:

- Consistent methodological framework (i.e., what is to be addressed in baseline / baseline adjustment / gross-to-net adjustment).
- Straightforward guidance/tools to demonstrate additionality of energy efficiency projects / programs through barrier analysis.
- Good practice methodological guidance/tools, including recommendations on: deemed values, equipment lifetimes, load factors, and other default values; gross-to-net adjustment rules/procedures (free riders/spillovers; secondary effects including leakage and rebound effects; reduced transmission & distribution losses); definition of robust Key Performance Indicators for systems / sectors; pre-approval of well-documented default models for key project types such as motor system optimization.

The motor community will have to engage more actively in these climate institutions to address the methodological challenges to energy efficiency under the CDM.

CDM Methodology Development

As argued above, a broader range of approved methodologies to support energy efficiency projects and programs is urgently needed and will require a public-private partnership, for two main reasons:

- Approved methodologies are a public good: Although individual project developers made some initial attempts to propose new methodologies for energy efficiency, there is little incentive for them to do so, since the intellectual property that goes into methodology development is not protected once the resulting methodologies are approved.
- There is no common understanding of what constitutes a good or best practice energy efficiency CDM methodology. This makes it difficult for the Meth Panel to rule consistently on individual methodology proposals for energy efficiency activities, not the least because such projects/programs pose some unique methodological challenges (e.g., applicability of base-

line approaches to different efficiency markets, statistical sampling methods, addressing free-ridership, energy efficiency programs of activities). This creates crippling uncertainty for individual methodology developers. Thus there is a need for "top down" guidance on international good practice developed by practitioners in a multi-stakeholder "community of practice".

A+B International (Sustainable Energy Advisors) has been working with numerous international institutions and experts to build momentum to launch an independent Energy Efficiency Network. The purpose of the proposed Network is to facilitate energy efficiency promotion under the CDM and other voluntary and regulatory programs. It will serve as a practitioner forum to develop:

- good practice guidance on methodological issues related to energy efficiency projects / programs;
- proposed new methodologies for priority energy efficiency project/program types that are both cost-effective and credible.

Decisions on modalities for programs of activities, good practice guidance and methodology tools to streamline methodology development are absolutely critical for energy efficiency CDM. Given the complexity of these issues and the vast body of experience with energy efficiency promotion efforts around the world, it will be crucial to engage public and private entities with energy efficiency program implementation experience; experts involved in the development of monitoring, verification and evaluation protocols for energy efficiency programs and those involved in the CDM [7].

It is proposed that an initial focus of methodology development would be on industrial motor drive systems. A multi-stakeholder expert workshop on this topic in 2007 could pave the way for new methodological approaches and development of viable project models and pilots.

Pilot Innovative CDM Models

Given the "learning-by-doing" approach to the CDM, it is essential to develop appropriate methodologies to pilot promising models for energy efficiency CDM programs – drawing on experience with existing programs such as those outlined in the table on page 6 – that might lend themselves to promotion of high-efficiency motor systems. These might include:

- End-user CDM projects/programs (e.g., Consortium for Energy Efficiency National Municipal Water and Wastewater Facility Initiative).
- Technology supplier programs (e.g., ABB/Baldor pay-as-you-save finance programs in the context of the UK Climate Change Levy; Ghana Efficient Lighting Retrofit Project, under which Osram GmbH is to donate 45 000 compact fluorescent lamps to households to replace incandescent lamps).
- Host country energy efficiency credit obligations or trading schemes involving energy suppliers / distributors (e.g., New South Wales, Australia, GHG Abatement Scheme; white certificate schemes, such as those implemented in Italy, Great Britain, France, Belgium (Flanders), and a number of US States).
- Host country ESCO programs or energy efficiency revolving funds (e.g., International Finance Corporation China Utility Energy Efficiency Project).

References

[1] International Energy Agency. *World Energy Outlook 2006*. Paris, International Energy Agency, 2006.

[2] Capoor K. and Ambrosi P. *State and Trends of the Carbon Market 2006. Update (January 1 – September 30, 2006)*. Washington, The World Bank, October 2006.

[3] Arquit Niederberger A. and Spalding-Fecher R. *Demand-side energy efficiency promotion under the Clean Development Mechanism: lessons learned and future prospects*. Energy for Sustainable Development. Vol. X No. 4 (December 2006), pp. 51-64.

[4] Arquit Niederberger A., Brunner C.U. and Nipkow J. *Leveraging CDM finance to promote efficient industrial motor systems*. Proc. of EEMODS 2005 (Heidelberg, Germany, 5-8 September 2005). ISBN 3-8167-6905-5. Order from https://www.eemods.de/ or Fraunhofer IRB Verlag.

[5] International Energy Agency. *Industrial motor systems energy efficiency: Towards a plan of action*. Proceedings IEA Industrial Electric Motor Systems Workshop (Paris, 15-16 May, 2006). Download at http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=255.

[6] SEEEM. *Market Transformation to Promote Efficient Motor Systems*. SEEEM Launch Paper. Download at http://www.seeem.org/_data/SEEEM_Launch.pdf.

[7] Arquit Niederberger A. *Energy efficiency projects in CDM*. Seminar Issue Paper UNIDO/CTI/UK Trade & Investment Seminar on Energy Efficiency Projects in CDM and JI (Vienna, Austria, 19-20 March 2007). Download at http://www.unido.org/file-storage/download/?file_id=64951

[8] Williams R.O., McKane A., Zou G., Nadel S., Peters, J. and Tutterow V. *The Chinese motor system optimization experience: developing a template for a national program*. Proc. of EEMODS 2005 (Heidelberg, Germany, 5-8 September 2005). ISBN 3-8167-6905-5. Order from https://www.eemods.de/ or Fraunhofer IRB Verlag.

[9] Emerson Motor Company. *Personal communication*. January 2007.

[10] CDM Executive Board. *Guidance on the registration of project activities under a programme of activities as a single CDM project activity (Version 01)*. Annex 15, Report of the 28th Meeting of the Executive Board of the CDM. Download at http://cdm.unfccc.int/EB/028/ eb28_repan15.pdf

[11] World Health Organization/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. *Meeting the MDG drinking water and sanitation target: The urban and rural challenge of the decade*. ISBN 978 92 4 156325 3. Geneva, World Health Organization and UNICEF, 2006.