Leveraging CDM Finance to Promote Efficient Industrial Motor Systems

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Abstract

The Kyoto Protocol entered into force for 140 countries and the EU on 16 February 2005. The Protocol's Clean Development Mechanism (CDM) is designed to encourage the financing of climate protection projects with local sustainable development benefits in developing countries. We report on several projects designed to leverage additional CDM financial flows to promote efficient industrial motor systems in developing countries. With reference to case studies, we will discuss the potential for the CDM to remove barriers to efficient motor system investments, thus contributing to market transformation and more rapid diffusion of advanced technologies in the developing world. We will present an overview of current efforts to develop credible baseline and monitoring methodologies under such models, discuss specific project examples and assess prospects for the viability of such industrial motor system projects under the Clean Development Mechanism.

1 Motor system efficiency in the climate policy context

Greater diffusion of efficient industrial motor systems will reduce energy use and greenhouse gas emissions rapidly and significantly, while at the same time reducing local air pollution and associated health impacts and easing pressure to install additional fossil fuel electricity generation capacity. The energy efficiency path is of high priority in coal-powered countries with high growth rates like China. Due to pervasive barriers, however, efficient motor systems are not in widespread use. The UN Kyoto Protocol offers new incentives to facilitate efforts to promote efficient motor systems.

1.1 Significance of motor system improvements

In many developing countries, the industrial sector consumes a large fraction of total electricity, and both China and India – which are the largest developing country emitters of greenhouse gases on an absolute basis – rely heavily on coal for their electricity generation. Furthermore, by several estimates, the major electricity use in industry is electrical motor systems in all sizes (from 0,5 to 500 kW m) and in all typical functions (Nipkow and Brunner 2005):

- Pumps for hydraulic systems (water, heating, hot water, sewage, etc.)
- Fans for air systems (air conditioning and ventilation, cooling, heating, etc.)
- Compressors for compressed air

- Compressors for cooling systems, heat-pumps,
- Traction for elevators, transport belts, etc.

Existing motors systems often tend to have low peak and partial load efficiency, are over-sized, operated continuously without controls for load management, and use inefficient components (transformers, gears, coupling, throttles, etc.) and ill-designed mechanical functions (air ducts, water pipes, elevators, etc.) that decrease overall system performance considerably.

Because industrial motor systems are pervasive and a major source of electricity demand, offer great potential for efficiency improvement in new systems and can be upgraded with short payback periods, they are an important technology focus for climate mitigation efforts and application of the project-based Kyoto mechanisms, which are described below.

1.2 Promotion of efficient motor systems under the Kyoto Protocol

The Kyoto Protocol entered into force for 140 countries and the EU on 16 February 2005 (and has since been ratified by 150 Parties). The Protocol contains legally binding emissions targets for industrialized countries listed in Annex I of the agreement; these so-called “Annex I countries” are to reduce their collective emissions of six key greenhouse gases by at least 5% on average over the period 2008 – 2012, compared with 1990 levels.

One of the novel features of the Kyoto regime is the inclusion of three so-called “Kyoto mechanisms”, which give countries some flexibility in where, when and how they achieve the necessary greenhouse gas emission reductions. International emission trading allows developed countries to buy and sell emission allowances among themselves. The project-based mechanisms – joint implementation and the Clean Development Mechanism – make it possible for developed countries to acquire fungible credits for greenhouse gas emission reductions that result from the implementation of climate protection projects in other Annex I or in non-Annex I countries, respectively, to which they contribute financially.

In our paper, we explore how these new climate policy instruments can be used to facilitate programs to promote efficient industrial motor systems

1.2.1 Kyoto mechanisms: Spotlight on the Clean Development Mechanism

The focus of this paper is on the Protocol's Clean Development Mechanism (CDM), which has a twofold purpose, namely to assist:

- developing country (non-Annex I) parties in achieving sustainable development and contributing to the ultimate objective of the Convention; and

- developed country (Annex I) parties in achieving compliance with their emission limitation and reduction commitments under the Protocol.

Under the CDM, projects that result in real, measurable and long-term climate mitigation benefits (either reduced emissions of greenhouse gases or enhanced uptake/removal of carbon dioxide from the atmosphere), and which are additional to any emission reductions that would otherwise occur, can be validated as CDM projects.

The project has to prove its additionality versus an assumed "business-as-usual" development that is defined as a baseline. The methodologies used to define the baseline, as well as to monitor the actual emission reductions achieved by the project versus the baseline, must be approved by the CDM Executive Board before a project can be registered under the CDM and generate CERs. The actual emission reductions achieved by CDM projects are independently verified *ex post* and result in the issuance of certified emission reduction (CER) credits.

These credits can be acquired by private and/or public entities and can be used to meet the Kyoto Protocol obligations of developed countries. Each CER represents a reduction or sink enhancement equal to 1 ton of CO_2-equivalent emissions. Comprehensive information on CDM institutions, rules and procedures is available from the web site of the UN Framework Convention on Climate Change (http://cdm.unfccc.int/).

1.2.2 Leveraging CDM finance for industrial motor system improvement

Energy efficiency projects are prime candidates for the CDM, because of their large greenhouse gas emission reduction potential, cost-effectiveness of greenhouse gas mitigation and wide range of typical sustainable development benefits (e.g., local pollution reduction, improved reliability of energy supply, reduced demand for fuel imports, job creation, cost savings compared with supply expansion, driver for technology innovation). However, they are poorly represented in the existing pipeline of CDM projects for a number of reasons, in particular, a lack of approved baseline and monitoring methodologies that are cost-effective for large numbers of small projects. In contrast, fuel switching or the use of renewables in power generation systems are relatively straightforward. The same holds true for single large end-use energy efficiency improvements (e.g., a local water pumping system). It is much more challenging to define and get approval for baseline and monitoring methodologies for a dispersed energy efficiency activity, such as the promotion of efficient industrial motor systems throughout an entire country. In this case, a more limited definition of the scope of a DSM project could be necessary to improve its coherence:

a) All motors in use at one large industrial facility;
b) All motors installed by an individual motor producer;
c) All standard-size pumps of a limited number of producers.

An important recent development was the submission in February 2005 of baseline and monitoring methodologies for the Electric Motor Replacement Program in Mexico (which is presented as a Case Study in the next section). This is the first industrial motor system project submitted under the CDM. Although the CDM Executive Board's Methodology Panel rejected the proposed methodologies at its 16th session in June 2005, its detailed justification will be of great value in preparing future industrial motor projects under the CDM.

2 Case Studies of industrial motor programs under the CDM

2.1 Mexico Motor Replacement Program

(Source: MGM International 2005, unless otherwise indicated)

Electric motors represent 45% of the national electricity consumption in Mexico (36% in industry, 5% in agriculture, 3% in residential sector, and 1% in municipal services). The proposed program for the entire country of Mexico (population 103 million) is intended primarily for three-phase induction motors among users in industry, agriculture and municipal services.

The purpose of the project is to offer financial incentives to users of electric motors so that they replace inefficient motors in use with new, high-efficiency motors that meet the standards of the FIDE seal ("Sello FIDE"). While voluntary and mandatory standards have improved the efficiency of new electric motors sold in Mexico since 1994, these standards have had little effect on motors that are in use and functional. Electric motors have very long life, and even when they face problems, users may rewind or otherwise repair them (which can reduce their efficiency even further) and continue their use.

The project sponsor, FIDE ("Fideicomiso para el Ahorro de Energía Eléctrica"), is an Energy Savings Trust that promotes electricity efficiency in Mexico, with revenues from various sources. However, revenues from CER sales are the only source of funding available to FIDE to provide the incentives under the motor replacement program, which will be the first of its kind in the country. As a result, it is unclear at present whether the project will go forward, given the Meth Panel rejection of the proposed new methodologies in June 2005.

Key CDM parameters of the project are as follows:

- Baseline methodology: The proposed new methodology draws from two approved methodologies and is based on the case where the baseline is defined in terms of "existing actual or historical emissions, as applicable", as defined in paragraph 48 (a) of the CDM Modalities and Procedures. This approach is deemed most applicable, because the project involves replacement of a full range of electric motors currently in service, which reflects the nature of demand-side management programs and best practice for evaluating energy savings and greenhouse gas emission reductions. Approaches 48b and c are not applicable, because there is no single technology that can be used as a reference (48b) and no motor replacement program has been conducted in the past and could not be implemented without CDM revenues (48c). For equipment with a fixed power input, total electricity purchase is given by the product of equipment quantity, power input and the number of operating hours per year. The decrease in electricity use resulting from equipment replacement due to the CDM project can be converted into units of CO_2 equivalent using an emission factor. Transmission & distribution losses within each grid are taken into account.

- Additionality: By applying the "consolidated tool for the demonstration and assessment of additionality", investment analysis demonstrates that the value of CDM certified emission reductions (CERs) allows the project sponsor (JPower) to overcome a clear investment barrier (without the value of the CERs, the sponsor would have no incentive to provide resources for the program). Barrier analysis is based on the fact that inefficient electric motors remain in use, despite minimum efficiency standards for new motors in operation for a decade. The barriers are likely to be a combination of investment barriers (e.g., required return on investment levels for energy investments) and those due to prevailing practice (e.g., practice of rewinding old motors, rather than replacing them).
- Greenhouse gas emission reductions: As a result of the CDM project, motor energy consumption will be reduced at the users' premises, transmission and distribution losses will be lower and electricity generation at power plants will be reduced, which lowers both fossil fuel consumption and related carbon dioxide emissions. The emissions reductions are estimated to be 0.6 million tonnes CO_2e over the first 7-year crediting period and 2.6 million tonnes CO_2e over the entire 21-year crediting period.

2.2 Jiangsu Efficiency Power Plant Project

(Source: Arquit Niederberger and Finamore 2005, unless otherwise indicated)

The Jiangsu project is being developed by the Jiangsu Provincial Economic & Trade Commission and the Natural Resources Defense Council, a US-based environmental organization. It is a multi-sectoral demand-side management program, which foresees the promotion of efficient industrial motor systems as one element in a package of energy efficiency programs. Taken together, these programs conceptually represent construction of an "efficiency power plant" (an EPP is a set of efficiency programs designed to deliver reductions in energy demand that represent the energy and capacity equivalent of a large conventional power plant). Preliminary analysis of the Jiangsu EPP (Asian Development Bank, 2005a) indicates that two years of such DSM investments can lead to a peak demand reduction equivalent to a 464 MW power plant.

Electric motor systems are responsible for over 60% of total electricity load in China and 70% of industrial load (Optimal Energy and State Grid Corporation DSM Instruction Center 2005). In Jiangsu Province (population 74 million), industrial motor systems are the single largest opportunity for energy savings. The planned industrial motor program is therefore a key element of the EPP that addresses all drive power systems in both existing and new industrial process facilities, including pumps, fans and compressed air systems. The program (Optimal Energy and State Grid Corporation DSM Instruction Center 2005) will rely on ESCOs as the primary marketing and delivery mechanism for:

- cash incentives and/or other financial strategies to reduce the first cost and improve the cash flow related to drive power efficiency improvements;
- technical analysis and assistance;
- education and training;
- information to customers and market actors on relevant policies (e.g. national labelling, certification, efficiency codes and equipment standards, etc.) that will help foster long term market transformation.

Even though investments in energy saving programs under the EPP can provide energy services at a quarter of the cost of constructing new power plants, they still require up-front capital investment. And, in contrast to the well-established practice of financing conventional power plants, lenders lack experience with such diversified programs and are reluctant to provide loans. In addition, tariff structures currently do not allow utilities to charge customers for energy services provided as a result of investments in increased efficiency. To overcome some of these barriers, the parties involved in the Jiangsu EPP are considering developing the proposed EPP under the CDM.

The following Figure shows the capital investment cost in 2005-06 and the estimated value of the corresponding volume of CERs for the Jiangsu Province EPP (464 MW), with values given in 2005 present value, discounted at a rate of 6.4% (see Arquit Niederberger and Finamore 2005 for details). At this stage of project development, these estimates are still rough, as they are based on preliminary designs of DSM programs and the resulting rough estimates of abatement costs, energy savings and GHG emission reductions.

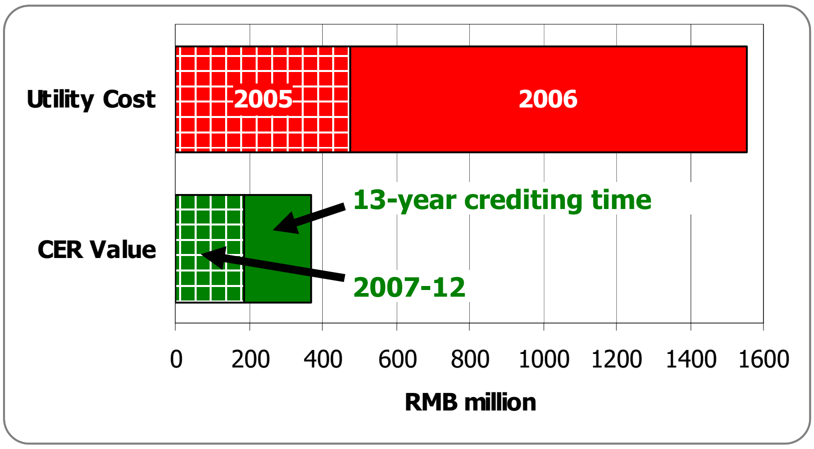

Figure 1: Jiangsu Province EPP Utility Cost & CER Value, discounted (Arquit Niederberger and Finamore 2005)

The resulting cumulative GHG emission reductions for the 2007-12 period are 6.3 million tons of CO_2, whereas total emission reductions for the two years of investment are much larger (15.5 Mt CO_2), as they continue over the average 13-year lifetime of the energy saving equipment installed. The Figure therefore shows the present value of CERs generated through 2012 (assuming revenues of RMB 40 / ton CO_2), as well as for the entire crediting period (assumed to be 13 years, for reductions implemented in 2006 and 2007).

3 Overcoming obstacles to motor promotion projects under the CDM

Leveraging additional CDM financial resources from foreign sources is fully compatible with the two motor system efficiency programs out lined above, and would have a number of advantages, including:

- providing a significant additional source of revenues from CER sales (or investment in CDM projects);
- contributing a secure hard currency revenue stream for debt servicing purposes (beginning with the second year of CER transactions, annual CER sales will amount to nearly RMB 48 million for the Jiangsu EPP, which could easily cover loan repayment needs);
- reducing or eliminating possible rate impacts from utility-funded DSM measures;
- improving access to the most advanced technologies available;
- ensuring full value for the Chinese contribution to global climate protection.

However, project developers are faced with a number of challenges to obtain CDM approval. A major hurdle is that new baseline and monitoring methodologies will need to be developed. Given the rejection of the proposed methodologies for the Mexico Motor Replacement Program (a relatively simple motor replacement scheme), deriving credible, cost-effective approaches for comprehensive motor system efficiency improvements promises to be quite challenging.

The “motor community” can promote the uptake of such projects under the CDM in a number of ways, for example, by working to establish some consensus on "best practice" for methodologies, which would provide the CDM Executive Board with greater confidence that the proposed approach(es) is(are) indeed credible.

In addition, A + B International is currently developing a China Motor Model (CMM), which is a tool to define efficient/effective projects at lower transaction costs, as well as to justify the baseline. This requires that the major parameters for the design of a motor program be modeled *ex ante* (Figure 2) and that the program be designed to reflect quantitative information on energy savings, emission reductions and project duration and cost. Experience shows that most motor system efficiency projects would have an excellent and rapid return on investment, but still fail to overcome the barrier of industrial owners' preference to keep a running system in place uninterrupted and unchanged, even at higher cost.

1 **Motors** **number by size** **and age (existing stock)** **and new stock (2005-2015)**	**2** **Motors** **number by size** **and function**	**3** **Motors** **numbers by size** **and exist. efficiency (nominal)** **and new efficiency**	**4** **Motors** **by size** **and use hours** **and load factor**
5 **Motors** **number by size** **and electrcity consumption**	**6** **Motors** **number by size** **and electricity savings**	**7** **Motors** **systems efficiency** **4 steps** **investments for 4 steps**	**8** **Power plant** **production efficiency** **emission factor actual** **emission factor predicted** **energy price**
9 **Power Transport** **efficiency for** **transport** **and transformation**	**10** **Replacement Plan** **participation rate** **by size** **and age** **and function**	**11** **Replacement results** **investment cost** **audit cost** **project managment cost** **energy savings**	**12** **Emissions** **actual** **predicted** **CER**

Figure 2: China Motor Model contents
(Brunner and Arquit Niederberger 2005)

The first element of the CMM consists of a quantitative description of the existing motor park (size, age, efficiency, function, operation hours, load factor, etc.) and an extrapolation for future sales and installation of new and replacement motor systems during the project period.

The second element of the CMM defines typical energy efficiency data on the cost effectiveness of systematic motor system improvements in 4 steps:

- exchange existing used motors with new high efficiency motors;
- reduce new motor size and improve components for system effectiveness;
- add variable speed control to better adapt to partial load;
- improve total motor system efficiency from transformation to pipes and ducts, etc.

Depending on quantities of motor families installed at one industrial plant and motor size, the cost of auditing (testing, measuring, redesigning) varies greatly. Specific data on cost effectiveness of both hardware exchanges in the above-mentioned 4 steps plus the necessary auditing have to be taken into account.

The program design can then focus on specific motor parks that produce the best cost-effectiveness. The key parameters suggest the following priorities:

- Old motors that have already reached their life expectancy produce no sunk cost: 10-15 years for small motors (< 1 kW m), 20-30 years for intermediate (10 kW m) and 30-40 years for large motors (>100 kW m).

- Motors with long hours of operation (> 3'000 hours per year) deliver a faster return on investment.
- Highly oversized large motor systems (> 130% typical in pumps and fans) gain efficiency through correct selection of motor size.
- Motor systems without existing load management (pumps, fans, etc.), that can easily be upgraded with variable speed drives, benefit from reduced operating hours at nominal load and increased efficiency at partial load.
- Large numbers of similar motors in one industrial plant (like 100 motors of 10 kW m) facilitate systematic testing, reduce engineering cost and improve replacement programs even with small and intermediate size motors.
- Big typical efficiency defects in systems (leaks in compressed air systems, unnecessary high velocity in air ducts, inefficient components with high resistance in pipes for heating and hot water systems, etc.) can be systematically identified, tested and improved.

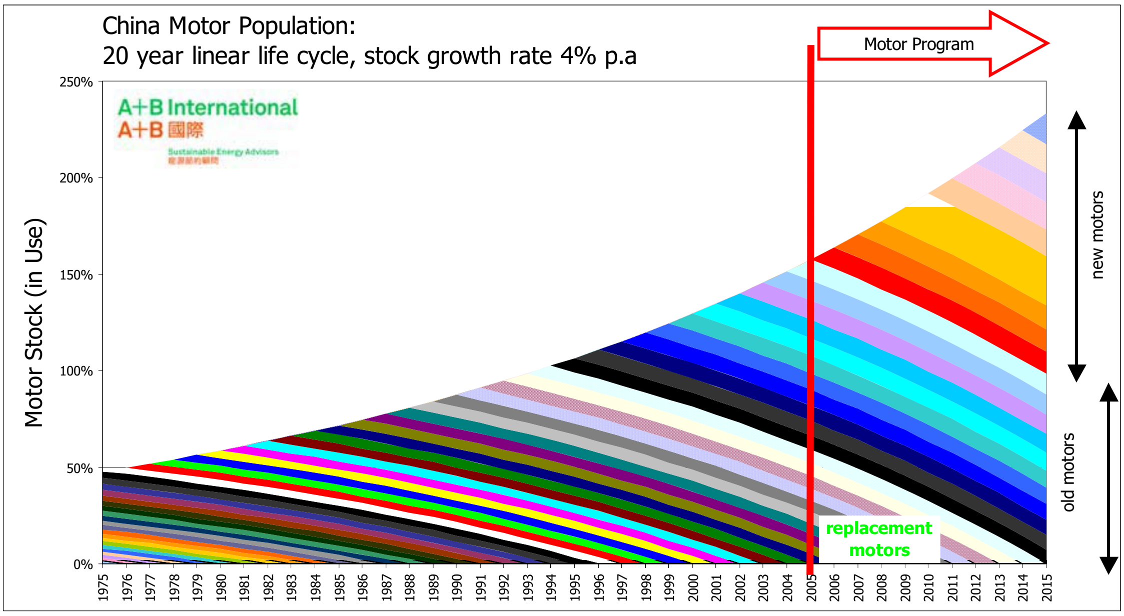

Figure 3: China Motor Model: Motor replacement and new motors (Brunner and Arquit Niederberger 2005)

Together with the specific cost of the 4-step improvement, the analysis of these typical motor before/after situations helps to quantify the crucial participation rates in replacement and new motor programs. The average kWh saved in typical motor systems, the specific cost per kWh saved and ton of CO_2 not emitted and the annual participation rate in percentage of the total motor stock give the overall energy savings and emission reduction. The necessary technical assistance provided (training, tools, mobile testing facilities, standard replacement schemes) and the incentives (participation on cost of audit, rebates on higher efficiency motors and components, etc.) define the speed of the program. The investments plus the total project management cost (including audits, training, tools, monitoring, etc) then define the overall cost effectiveness of the motor system program.

To be cost-effective, viable for investors/operators and credible enough to prove the program's additionality to obtain CERs, motor replacement programs must target clearly identified locations, functions and motor systems.

4 Conclusions

The CDM can give a financial boost to demand-side strategies with sound energy efficiency programs. The choice of electrical equipment for energy efficiency programs is especially important in countries with high demand growth rates and a large share of fossil thermal (in particular, coal-fired) power generation. Every kilowatt-hour saved in decentralized electrical equipment is equal to three to four kilowatt-hours in coal in central power plants.

Methodologies for the verification of energy efficiency programs are more complex than for supply side projects. This is especially true with large numbers of small-scale equipment like motor systems in dispersed locations and on a broad geographic scale. The path to a sound energy efficiency program with low transaction costs, little leakage, small "Mitnahme-Effekt" (which is not exactly the same as the free-rider effect) and solid impact is long.

The project definition has to resolve the conflict between a life cycle oriented and cost effective energy efficiency program (replace old motor with smaller high efficiency motor with variable speed drive and major improvement on the function side) versus a simple motor replacement strategy (replace old motor with new high efficiency motor of the same size). In the former, a comprehensive audit with testing by qualified personnel is necessary; in the latter, a low cost quick fix is possible.

The underlying assumptions in the baseline and the project (existing motor stock efficiency, life expectancy, annual hours of operation, oversized equipment, etc.) are crucial and need clear individual testing, sample testing or statistical verification procedures.

It is our intention to stimulate demand side programs and energy efficiency projects to apply for the CDM status in order to prove the point that every energy unit not used is the best way to reduce all loads to the environment.

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