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The Kyoto Protocol, The clean development mechanism and the building and construction sector

A report for the UNEP Sustainable Buildings and Construction Initiative

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THE KYOTO PROTOCOL, THE CLEAN DEVELOPMENT MECHANISM, AND THE BUILDING AND CONSTRUCTION SECTOR

A REPORT PREPARED FOR THE UNEP SUSTAINABLE BUILDINGS AND CONSTRUCTION INITIATIVE

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LIST OF ABBREVATIONS

AAU	Assigned Amount Unit
ACEEE	American Council for an Energy Efficient Economy
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CFL	Compact Fluorescent Lamp
CH_4	Methane
CO2	Carbon Dioxide
COP	Conference of the Parties (to the UNFCCC)
COP/MOP	Conference of the Parties / Meeting of the Parties to the Kyoto Protocol
CPA	CDM Program Activities
DNA	Designated National Authority
DOE	Designated Operational Entity
DSM	Demand Side Management
EB	UNFCCC Executive Board
EE	Energy Efficiency
EEB	Energy Efficient Building(s)
ERU	Emissions Reduction Unit
ESCO	Energy Service Company
EIA	Energy Information Administration (US Department of Energy)
EIT	Economy in Transition countries
GHG	Green House Gas(es)
Gt	gigatonne
HFC	Hydrofluorocarbon
HVAC	Heating Ventilation and Air Conditioning
IEA	International Energy Agency
IET	International Emissions Trading
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
JI	Joint Implementation
LDC	Least Developed Countries
LEED	Leadership in Energy and Environmental Design (US Green Building Council)
N2O	Nitrous Oxide
P-CDM	Programmatic Clean Development Mechanism
PDD	Project Design Document
PFC	Perfluorocarbons
PoA	Program of Activities
RMU	Removal Unit
SB	Sustainable Building(s)
SBCI	Sustainable Building and Construction Initiative
SOP	Standard Operating Procedure
SSN	South*South*North
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
URC	UNEP Risø Centre on Energy, Climate and Sustainable Development
USGBC	US Green Building Council
WBCSD	World Business Council for Sustainable Development

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EXECUTIVE SUMMARY

Buildings are responsible for more than one third of total energy use and associated greenhouse gas emissions in society, both in developed and developing countries. Energy is mainly consumed during the use stage of buildings, for heating, cooling, ventilation, lighting, appliances, etc. A smaller percentage, normally 10-20%, of the energy consumed is used for materials manufacturing, construction and demolition.

The potential for drastic reductions of the energy consumption in buildings is significant. With proven and commercially available technologies, the energy consumption in both new and old buildings can be cut by an estimated 30-50 percent without significantly increasing investment costs. Energy savings can be achieved through a range of measures including smart design, improved insulation, low-energy appliances, high-efficiency ventilation and heating/cooling systems, and incentives to building users to conserve energy.

The Intergovernmental Panel on Climate Change (IPCC) stated in its fourth assessment report that the building sector not only has the largest potential for significantly reducing greenhouse gas emissions, but also that this potential is relatively independent of the cost per ton of CO_2 eqv achieved. This is partly due to the fact that most measures aimed at greenhouse gas emission reduction from buildings also result in reduced energy costs over the buildings' life cycle, which over time off-sets increased investment costs.

Despite the obvious need and opportunities for reducing energy consumption in buildings, the potential remains largely untapped in most countries. Out of more than 3,000 Clean Development Mechanism (CDM) projects in the pipeline (as of May 2008) only six seek to reduce energy demand in buildings. The most important reasons for this failure include:

Many, but individual small, reduction opportunities: Although the building sector presents the largest single opportunity for drastic greenhouse gas emission reduction, this opportunity is spread over hundreds of millions of individual buildings, each one presenting multiple and very diverse types of interventions. As opposed to many other sectors, the buildings sector does not present a few big emission reduction options, but requires many small interventions in a very large number of buildings.

Fragmentation of the building sector: Buildings normally have a long life cycle with only limited interaction among stakeholders involved in different phases of a building's lifetime. Furthermore, different aspects of the buildings, such as architecture, engineering, building management, building function, occupant profiles etc. are often poorly or not at all coordinated. There is therefore no natural incentive for, or convergence of interest in, a life-cycle approach to managing energy use in buildings.

Split economic interests: The parties typically making decisions about building design (designers and investors) are seldom the ones who would benefit from energy efficiency improvements and associated costs reductions (owners and users).

Lack of information and understanding (at all levels) of the importance of the building sector in relation to climate change. Lack of know-how about how to reduce energy use in buildings and about what indicators to use for comparing the relative performance of a building or multiple buildings.

High perceived business risk and under-estimation of the life-cycle cost benefits from energy efficiency investments in buildings. Lack of track record from real projects, including risk-benefit analyses.

Energy costs are often a comparatively small part of the overall costs for a building. The economic incentive provided by reduced energy costs is therefore often weak.

A number of the CDM's features respond to the challenge of realizing energy efficiency projects in buildings. These include:

- The potential of programmatic CDM to implement similar measures in a large numbers of buildings, thereby creating the opportunity to move from a one-by-one approach to large, coordinated common approaches.
- The quality assurance and green features associated with CDM projects, which reduce the investment risks and should attract financing for energy efficiency projects in buildings.
- The provision of standardized and documented methodologies, facilitating replication of projects as well as transparency and accountability.
- The requirement for monitoring, which provides standardized tools for active energy performance management.

Although buildings are eligible for support from the Kyoto Protocol's flexible mechanisms, only six of the more than 3,000 projects in the CDM pipeline are related to energy efficiency in buildings (as of May 2008). In addition, within the six projects, only one is today generating Certified Emission Reduction credits (CERs). Thus CDM is apparently not having any impact on this sector, which has been identified as offering the greatest potential for greenhouse gas emission reductions. This study has identified the following main reasons for this situation:

1. The economic benefits generated by CDM projects targeting Energy Efficiency in Buildings (EEB) are generally not significant enough to justify the associated transaction costs. The economic incentive provided by CDM is, in other words, too weak to justify the transaction costs for developing CDM projects.

2. The typical EEB project is small in scale and uses a range of different measures to improve energy efficiency, including improved energy systems, improved insulation, improved design, improved monitoring and control, improved user behavior, etc. The CDM is not well equipped to support these kinds of projects for the following reasons:

   - The CDM methodologies applicable for EEB projects are technology specific and require that validation demonstrates substantial evidence for each and every technology and measure. The verification of emission reductions also requires detailed monitoring of each implemented technology and measure. Most EEB projects include numerous measures, which results in a very high administrative and economic burden on proponents of EEB projects to CDM.

- Some of the typical energy efficiency improvement measures found in EEB projects are difficult to verify with the current technology-specific CDM methodologies. This includes common measures such as improved insulation, form and orientation of buildings and changed behavior of users.

3. The lack of references for baselines for EEB CDM projects in new buildings presents a major challenge to project developers. Buildings are typically designed to last 50 to 100 years or more, and are individually designed based on function of the building, climate, economy, culture, availability of building materials, know-how, etc. There are normally only a few comparable buildings to use as reference for baseline design in CDM when new buildings are built. There is also in most countries a lack of established and/or enforced standards for energy efficiency in buildings that could be used as references in the absence of comparable data from existing buildings.

4. The CDM's additionality requirement means that a project must prove that GHG emissions are reduced below those that would have occurred in the absence of the CDM project. Because of the fragmentation of the building market it can be almost impossible to prove what building design would have been selected in the absence of the CDM project. Investment costs (rather than life cycle costs) as well as architectural, cultural and other considerations often decide what design and technologies are used in a building. There is also considerable uncertainty about how to interpret another aspect of the additionality requirement: that CDM projects must at least meet national standards and regulations, unless these are systematically not enforced. The question is how to prove that such standards and regulations are not systematically enforced.

5. In developing countries many housing projects primarily aim at providing shelter for poor segments of the population. These groups are essentially not consuming enough energy to meet even basic human needs. Their need for more energy, however, may be partly offset through more energy efficient buildings, which may also help to lower energy costs for the poor. Nevertheless, because of low or negative emission reduction potential in such projects, the CDM is not a viable mechanism to provide added funding for investments in energy efficient measures. In these circumstances, the CDM is promoting neither emission reductions nor sustainable development. Clearly, there is a need to rethink how the flexible mechanisms can better link reduced emissions with support for sustainable development.

The above analysis generates two main conclusions:

1. *The CDM does not have any real attraction for EEB projects in its current form and needs to be reformed. Assuming that this can be done in a way that reduces*

administrative and transaction costs, and that the carbon price will increase in the future, the CDM has the potential to become an important financial incentive for such projects.

2. *With or without the CDM, governments need to adopt additional policy measures to support and encourage the building sector to adopt energy efficiency investments as part of its normal business practices.*

To better support EEB projects under the CDM, this study makes the following recommendations:

1. **Allow EEB CDM projects to use Performance Based Indicators**, i.e., energy use per m^2, for project validation, monitoring and verification. This will remove several economic, technological and social barriers including:

   a. The restriction of bundling different measures in the same project would be removed as it would be the overall efficiency of the building, and not the technology, that decides the success of the project.

   b. Uncertainties about what measures could be included in a CDM project would be removed. Any measure resulting in reduced energy consumption/reduced greenhouse gas emissions would be recognized, allowing flexibility in such factors as design, use of building materials, user behavior improvements, etc.

   Performance based indicators would also encourage the continuous pursuit of energy efficiency throughout the crediting period, as all measures resulting in emission reductions could be credited, even if they were adopted at a later stage after the project was registered.

2. **Supplement technology-based methodologies for verification and monitoring with statistical management tools, and replace direct and constant monitoring with sampling.** This would reduce overhead costs in projects with a large volume of smaller individual measures, each one of which is too small to justify separate monitoring and verification.

3. **Develop common performance-based baselines for different types of buildings to support and allow performance-based EEB CDM projects.** Such baselines would most likely best be established by the National Designated Authorities and would need to take into account local factors such as climate, building type, availability of materials and technologies.

4. **Allow the CDM to more easily support projects aimed at providing poor people with sufficient access to energy to meet their basic needs.** For example, CERs could be issued with a premium for projects having a strong sustainability component (e.g., provision of energy services in an efficient manner to poor people) provided a certain minimum energy efficiency standard was met. CERs could also be issued for "avoided emissions" that would otherwise be generated if low-income housing were constructed without energy efficiency considerations.

5. **Allow the CDM to generate CERs in projects that aim to meet national standards for energy efficiency in buildings.** Such an arrangement would encourage developing countries to establish such standards and would provide a de facto incentive to EEB projects in countries where the enforcement capacity of standards is low.

6. **Strengthen the role and capacity of Designated National Authorities to help promote the CDM more widely and to be able to manage rapidly increasing volumes of demand side energy efficiency projects.**

In summary, there is great potential to improve the CDM in ways that would encourage the development of more energy efficiency projects in buildings for the CDM, and at the same time would more directly support the sustainable development benefits generated by such projects.

There is an urgent need for governments to establish national policies that promote energy efficiency in the building sector, both for the benefit of improving the CDM's effectiveness, and as a strategy for reducing national energy demand and GHG emissions, regardless of what support may be achieved through the CDM.

I. RESEARCH MOTIVATION, BACKGROUND AND METHODOLOGY

1.1. Research motivation and background

The Clean Development Mechanism is regarded as one of the most important internationally implemented market-based mechanisms to reduce carbon emissions. Created under the Kyoto Protocol, the CDM was designed to help developed nations meet domestic greenhouse gas (GHG) reduction commitments by investing in low-cost emission reduction projects in developing countries. The CDM has quickly grown to fund thousands of projects worldwide and attain a several-billion-euro market value.

The building sector is a large source of GHG emissions and has significant potential as a source of cost-effective emissions reductions. The number of building sector projects approved for CDM funding, however, is very low compared to other sectors. Out of over 3,000 CDM projects approved or in the pipeline as of May 2008, only six small-scale projects[1] are targeting energy efficiency improvements in the buildings sector.

This report analyzes the project development environment in the building sector and explores why building sector projects have been under-represented in the CDM's project portfolio. Among other things, the report finds that difficulties stem from the design of the CDM, as well as from issues inherent in the building sector environment that can hinder the promotion of energy efficiency projects. The report proposes CDM rule changes that may stimulate more buildings sector projects, and it points the way toward increasing the use of CDM incentives to develop and scale up more energy efficient building projects.

UNEP's Sustainable Buildings and Construction Initiative (SBCI) commissioned this study. SBCI is a UNEP-led partnership between the UN and public and private stakeholders in the building and construction sector. SBCI aims to promote sustainable building practices globally. This study furthers one of the SBCI's key objectives, which is to ensure that parties to the Kyoto Protocol, which are currently negotiating a post-2012 agreement, have the information needed to promote energy efficiency improvements in buildings. The study was conducted by UNEP'S Risø Centre on Energy, Climate and Sustainable Development (URC). URC is a UNEP center of expertise in the area of energy efficiency and the Kyoto Protocol's mechanisms.

1.2. Research methodology

The assessment reviews the prevailing environment for project development in the building sector and examines the current CDM requirements to understand the underlying reasons causing difficulties in project development. The assessment also investigates the project development cycle and stakeholder dynamics in the building sector. The findings in this study are based on a thorough assessment that included an investigation of current CDM projects, interviews with project participants and consultants, a synthesis of the opinions of experts in the host countries of investigated projects and a review of related literature.

This assessment started with a two-fold assumption:

1. Aspects of the building sector in potential project host countries may

[1] In order to be qualified as a small-scale energy efficiency project, the limit is set to a maximum energy consumption reduction of 60 GWh per year (or an appropriate equivalent). Modalities and procedures for small-scale project activities are simplified. (UNFCCC web site, SSC methodologies). See 'SSC' in the Appendix 1 glossary for further information about small-scale projects.

discourage the inclusion of energy efficient building projects in the CDM.

2. The CDM itself may be providing either additional barriers or, at least, insufficient incentives.

The assessment, therefore, focused on two discrete sets of issues:

a. Generic difficulties related to policy, socio-economic conditions, business culture, and life-styles, etc., in host countries' building sectors. These factors affect the ability of building projects to attract investors in all countries, especially developing ones.

b. CDM rules and procedures that hinder potential energy efficiency building projects, particularly those that limit the ability of projects to be verified and credits to be certified.

At the inception of this study, in June 2007, only 14 CDM projects qualified as building sector projects. This number included eight projects from Brazil that were rejected during the course of this study. The project team focused on these 14 projects for further investigation and in-country studies. The project team also reviewed other residential and service sector energy use projects in the pipeline (see Appendix 4). These projects featured energy efficiency improvements from single equipment sources, such as cooking stoves, district heating, lighting improvements, etc. Single-equipment energy efficiency improvement projects are discussed in general, as energy efficiency improvement measures, but are not investigated in detail.

Based on a review of energy efficiency improvement measures implemented in buildings, building use types and host countries, the project selected the following four representative projects for more in-depth investigation:

- Kuyasa, Cape Town, South Africa
- ITC Sonar Hotel, Kolkata, India
- Technopolis IT Building, Kolkata, India and
- Pão de Açúcar supermarkets, Brazil.

See Appendix 2 for detailed descriptions of the investigated projects. The project team also investigated two building projects that had not applied for CDM funding and represented project types: the iEEECO Village project (South Africa) and the Genesis project (Brazil). See Appendix 3 for further detail.

During the course of the investigation, the project team interviewed more than twenty experts, including CDM consultants, energy efficiency and building experts, financial experts, CDM project validators and project participants. See Appendix 5 for a list of the experts interviewed. The assessment also drew on a large body of literature involving the fields of energy efficiency, buildings and the CDM. Please refer to the References section.

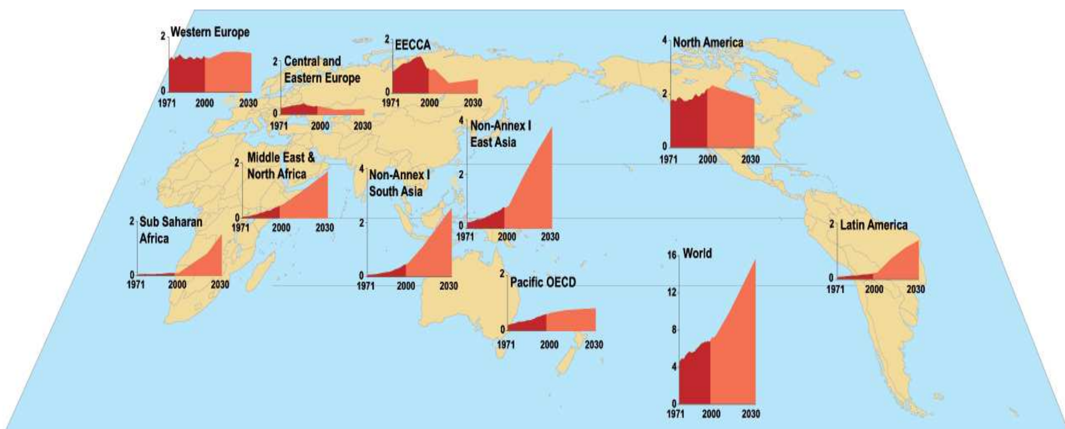
The findings of this research suggested a number of potential improvements to the CDM. Following further review of the report's findings and proposed recommendations by the SBCI Think Tank, industry representatives and other experts, the report's conclusions and recommendations were finalized.

It is important to note that, although this study focuses on the CDM, one of three flexible mechanisms adopted under the Kyoto Protocol, the same factors limiting the effectiveness of CDM in the buildings sector most likely also apply to the Protocol's Joint Implementation projects.

II. BUILDINGS AND CLIMATE CHANGE: STATUS AND POTENTIAL

2.1. The potential for emission reduction in the building sector

Buildings are responsible for 30-40 percent of total energy use worldwide. (UNEP, 2007, World Business Council for Sustainable Development (WBCSD), 2007, de T'Serclaes, 2007). Increasing demand for housing and office space in developing countries will further push up energy consumption from the buildings sector. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), building-related CO_2 emissions (including the use of electricity) could increase from 8.6 billion tonnes in 2004 to 11.4 billion tonnes in 2030, under a low-growth scenario. Under a high-growth scenario, that number increases even more dramatically, to 15.6 billion by 2030 (Levine, et al., 2007). In both cases, the building sector's 30 percent share of total CO_2 emissions is expected to remain. The increase in emissions will mostly come from the developing world. Asia, Middle East/North Africa and Latin America are all expected to contribute substantial increases in CO_2 emissions from the building sector, especially under the high-growth scenario (see Figure 1, Levine, et al., 2007). At the same time, the expected huge building boom in developing countries also provides an opportunity to minimize or reduce growth in emissions through the use of energy efficiency measures.



Note: Dark red – historic emissions; light red – projections 2001–2030 data; 2000–2010 data adjusted to actual 2000 carbon dioxide emissions. EECCA = Countries of Eastern Europe, the Caucasus and Central Asia. Source: Levine et al., 2007.

Figure 1. *CO_2 emissions from buildings (including through the use of electricity) - IPCC high growth scenario*

Approximately 80-90 percent of the energy a building uses during its entire life cycle is consumed for heating, cooling, lighting, and other appliances. The remaining 10-20 percent is consumed during the construction, material manufacturing, and demolition phases (UNEP, 2007). Many technologies and methods are available to save energy in buildings. Heating and cooling loads can be reduced through ventilation, heat sinks, the use of solar and other natural heat sources, and improved insulation, windows and equipment. Power loads can be reduced through improved lighting (e.g., LED, compact fluorescent light bulbs and increased use of natural lighting) and the use of energy-efficient appliances.

Integrated building design and the modification of building shapes, orientations and related attributes can also reduce energy demand, as can changing energy-wasting behavior and improving operations and maintenance. (Levine et al., 2007). The technologies for these efficiency improvement measures are commercially available and have been validated through their use in contemporary buildings.

The energy saving potential in the building sector is large. The Fourth Assessment Report of the IPCC, based on the results of over 80 surveys worldwide, concluded that there is a global potential to reduce approximately 29 percent of the projected baseline emissions from residential and commercial buildings by 2020 and 31percent from the projected baseline by 2030 at a net negative cost. The potential is the highest and cheapest among all sectors studied (Levine, et al., 2007). The IPCC report compared the energy savings potential of the building sector with that of other economic sectors and found that the building sector has the greatest potential among all sectors, in all countries, and at all cost levels (Figure 2).

<table>
<tr><th rowspan="3">Sector</th><th rowspan="3">Region</th><th colspan="4">Mitigation potential in different cost categories* (US$/tCO2-eqv)</th></tr>
<tr><th><0</th><th>0-20</th><th>20-50</th><th>0-100</th></tr>
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* The mitigation potential figures per cost category are mid-range numbers.

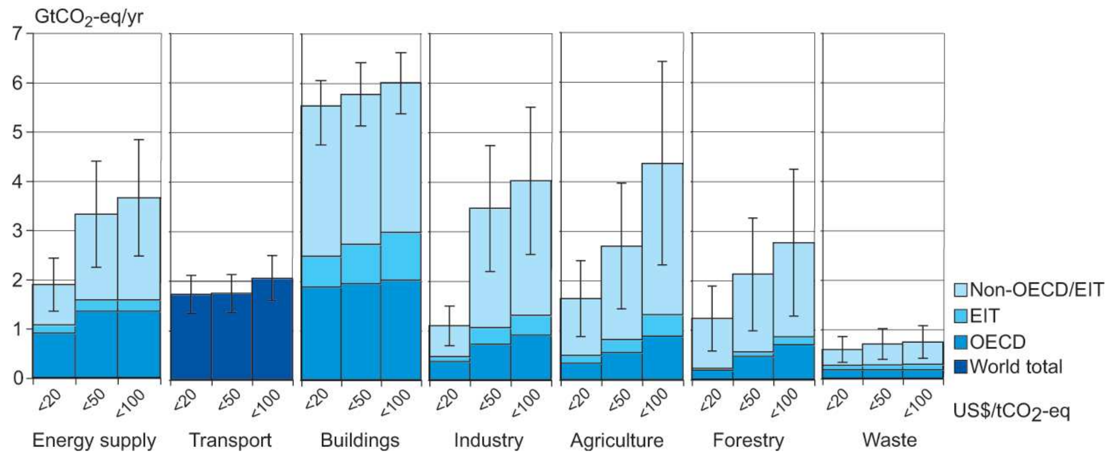
** For the buildings sector the literature mainly focuses on low-cost mitigation options, and the potential in high-cost categories may be underestimated.

Source: adapted from Barker et al., 2007

***Table 1**: Estimated economic potential for GHG mitigation at a sectoral level in 2030 for different cost categories (US$/ tonne of CO_2 equivalent)*

The costs of realizing such high potential GHG reductions are relatively low when measured from a life cycle point of view. The IPCC report estimates that in 2030 approximately 5.0 billion tonnes of CO_2 could be reduced at a marginal cost of less than zero, and an additional 0.5 and 0.6 billion tonnes of CO_2 could be mitigated at positive costs of less than 20 and 100 US$/tonne of CO_2 equivalent, respectively, at the mid-range estimation (see Table 1, Barker, et al., 2007, Levine, et al., 2007). Among all economic sectors, over 80 percent of the reductions achievable at negative costs, in the IPCC estimation, come from the building sector.

The greatest and cheapest potential for reducing energy demand in buildings was found to be in developing countries. The combined potential in countries that are not members of the Organisation for Economic Co-operation and Development (OECD) and countries with economies in transition (EIT) reaches an estimated 3.15 Gt CO_2-equivalent at zero cost or below (net savings) in 2030. The corresponding potential in OECD countries is believed to be 1.8 Gt CO_2-equivalent. The recent construction boom in some fast-developing countries, such as China, could potentially provide opportunities to substantially reduce energy use and greenhouse gas emissions in these countries.



Note: The mitigation potentials under each cost category are cumulative. Source: Metz, et al., 2007.

Figure 2: *Potential emission reduction**s** in different sectors in 2030 as a function of the cost assigned to reduction measures (US$/tonne of CO_2 equivalent)*

2.2. The role of the Kyoto Protocol and the CDM

Introduction to UN Framework Convention on Climate Change and the Kyoto Protocol

The Kyoto Protocol is an international treaty ratified by over 190 countries to reduce greenhouse gas emissions that could cause global climate effects.

Negotiations to formulate an international treaty on global climate protection began in 1991 and resulted in the adoption of the United Nations Framework

Convention on Climate Change (UNFCCC) in May 1992. The UNFCCC was opened for signature during the Earth Summit in Rio de Janeiro, Brazil, in June 1992, and entered into force in March 1994. The objective of the Convention is to stabilize atmospheric concentrations of greenhouse gases at safe levels. To achieve this objective, all Parties have committed to address climate change, adapt to its effects, and report their actions to implement the Convention

(Fenhann, et al., 2004). The Convention divides countries into two groups: Annex I Parties, which comprise developed countries and economies in transition, and non-Annex I Parties, which include primarily developing countries (Fenhann, et al., 2004).

The Convention established the Conference of Parties (COP) as its governing body with the responsibility to advance implementation and oversee progress toward the Convention's goals. During the COP-3 meeting held in Kyoto, Japan in 1998, the Parties agreed to a legally binding set of obligations that required Annex I countries to lower their GHG emissions to an average of approximately 5.2 percent below their 1990 levels. The emission reduction goal needs to be accomplished over the commitment period of 2008-2012 (Fenhann, et al., 2004). The non-Annex I countries also agreed to emission-reduction objectives, but, under the principle of "common but differentiated responsibilities", did not undertake binding obligations to achieve emission reduction targets (Baker & McKenzie, 2004). This agreement is known as the Kyoto Protocol.

In order to give Parties a degree of flexibility in meeting their emission reduction targets, the Protocol developed three innovative mechanisms, known as the Clean Development Mechanism, Joint Implementation and International Emissions Trading, (United Nations, 1997, UNFCCC web site):

1. The Clean Development Mechanism was established under Article 12 of the Kyoto Protocol. The CDM enables Annex I Parties to implement projects that reduce GHG emissions in non-Annex I Parties in return for certified emission reductions (CERs)[2]. CDM projects also assist host Parties in achieving sustainable development and in contributing to the ultimate objective of the Convention. The CDM Executive Board (EB) supervises the CDM. See Appendix 1 for a glossary of CDM terms.

2. The basic principles of the Joint Implementation (JI) mechanism are defined in Article 6 of the Kyoto Protocol. Under JI, an Annex I Party with an emission reduction and limitation commitment under the Kyoto Protocol may implement an emission-reduction or emission-removal project in the territory of another Annex I Party with an emission reduction and limitation commitment under the Protocol. The Party implementing the project may count the resulting emission reduction units (ERUs) towards meeting its own Kyoto target. Most JI projects are implemented in EIT countries.

3. International Emissions Trading (IET), as set out in Article 17, provides for Annex I Parties to acquire emission units from other Annex I Parties and to use those units towards meeting a part of their targets. These units may be in the form of the initial allocation, or Assigned Amount Units (AAUs), Removal Units (RMUs), a unit issued for the amount generated from domestic sink activities, CERs under the Clean Development Mechanism, or ERUs generated through Joint Implementation. AAUs and RMUs are issued in developed nations.

The three "market-based" flexible mechanisms allow developed nation Parties to earn and trade emissions credits through projects implemented either in other developed countries or in developing countries. The emissions

[2] A CER is issued for emission reductions from CDM project activities and is defined as a unit equal to 1 metric tonne of CO_2 equivalent (UNFCCC, 2003).

credits can be used to help nations meet their GHG reduction commitments. These mechanisms also help to identify lowest-cost opportunities for reducing emissions and to attract private sector participation in emission reduction efforts. Developing nations benefit from technology transfers and investment brought about through collaboration with industrialized nations under the CDM (UNFCCC, 2001).

During the COP-7 meeting in Marrakech, Morocco, in 2001, the Parties finalized most of the Kyoto Protocol's operational details and set the stage for its ratification. This agreement, known as the Marrakech Accords, sets forth the operational rules for the CDM, JI and IET (UNFCCC, 2001).

On 16 February 2005, the Kyoto Protocol became legally binding for the 128 Parties that ratified the Protocol. (A number of additional parties signed the UNFCCC but remain outside the Kyoto Protocol.) At this point, the industrialized countries became legally bound to meet quantitative GHG reduction targets, the CDM moved from an early implementation phase to being fully operational, and the international carbon trading market become legal (UNFCCC, 2004).

Introduction to the CDM

The basic principle of the CDM is simple: developed countries can invest in abatement opportunities in developing countries and receive credits for the resulting emission reductions. This could reduce the need for developed countries to invest in more expensive mitigation projects within their own borders (Fenhann, et al., 2004).

According to Article 12 of the Kyoto Protocol, the purpose of the CDM is threefold: (1) to assist Annex I Parties in achieving compliance with their quantified emission limitation and reduction commitments, (2) to assist non-Annex I Parties in contributing to the Convention's ultimate objective, and (3) to assist non-Annex I Parties in achieving sustainable development (United Nations, 1998). Markets for trading certified emission reduction credits generated by the CDM projects are also enacted by Kyoto Protocol agreements. The CDM thus is regarded as one of the most important internationally implemented mechanisms to finance emission reduction projects and to support sustainable development in developing countries.

In order to qualify as a CDM project, a project must satisfy the criteria set forth in Article 12 of the Protocol, the Marrakech Accords, and other decisions of the Conference of Parties/Meeting of Parties (COP/MOP) and the CDM Executive Board (EB). Specifically, this requires that:

(i) the project activity be undertaken in a non-Annex I country (i.e., a developing country) that is a Party to the Kyoto Protocol;

(ii) the participation of all project participants be voluntary and approved by the non-Annex I Host Country and any Annex I Party involved in the project;

(iii) the project activity be of a type that results in emission reductions by producing real, measurable and long-term benefits related to the mitigation of climate change;

(iv) the emission reductions be additional to any emission reductions that would occur in the absence of the certified project activity, (commonly referred as the additionality criterion); and

(v) the project activity contribute to the goal of national sustainable development for the Host Country (commonly referred as the sustainability criterion)(Baker & McKenzie, 2004).

Building projects in the CDM

The CDM has successfully established a new market for GHG emission reduction projects. Since its inception, CDM has developed projects with a market value of several billion euros (Schneider, 2007). As of December 2007, a total of 859 projects had been registered (formally approved by the CDM Executive Board). These projects are expected to deliver emission reduction of 185 million tonnes of CO_2-equivalent each year (Fenhann & Lima, 2007). Another 1,924 projects have been created and are awaiting validation (third-party verification that the project meets CDM requirements) and registration. If all these projects in the pipeline [3] are registered, 418 million tonnes of CO_2-equivalent will be delivered each year. Assuming a cost of US$15 per tonne of CO_2-equivalent, the total market value of these projects will be US$ 6 billion.

As discussed in section 2.1, the building sector offers the potential for relatively low cost, high-impact mitigation projects. A large number of technologies that could substantially lower energy use in buildings are commercially available. Combined with the CDM's strong financial and technology transfer incentives, the building sector is positioned to become one of the primary targets for CDM project developers. Six years after the inception of the CDM, however, only a handful of building projects have managed to enter the CDM pipeline, and nearly half of them were rejected during the registration phase. As a result, the CDM's contribution to reducing GHG emissions in the building sector is almost non-existent, and the vast energy-savings potential of the sector remains virtually untapped.

[3] The CDM project pipeline includes projects requesting registration, registered projects and validated projects (Fenhann & Lima, 2007).

2.3. Characteristics of current CDM projects

The distribution of CDM activities during the project investigation period (June-December 2007) provided a first clue to the gap between the building sector's high potential and low CDM project realization. (See Table 2, adopted from URC's CDM project pipeline, Fenhann & Lima, 2007). Most CERs comes from hydroflouro-carbons (HFCs), perflourocarbons (PFCs) and nitrogen oxide (N_2O) reduction projects. The 72 projects in this category, which represent 2.6 percent of all projects in the pipeline, could potentially generate 127 million CERs per year, around 32 percent of the total CERs, assuming all expected CERs could be verified. In fact, 32 registered projects are responsible for 71 percent of the CERs issued so far in this category (not shown in the table). These projects enjoy high CER yield due to the high global warming potential of HFC, PFC and N_2O. CH_4 also has a higher global warming potential than CO_2. Projects targeting CH_4 emission reductions are, therefore, also common (Table 2).

Among the CO_2 reduction projects, renewables have the largest number of projects. The majority comes from wind, hydro and biomass energy projects. Energy efficiency projects have recently started to gain momentum as well. Energy efficiency projects include supply-side efficiency and demand-side efficiency. Supply-side energy efficiency projects are mostly large-scale waste heat generation or cogeneration projects, which provide relatively high CER yields. By contrast, there are fewer demand-side energy efficiency projects, despite the fact that this category presents the largest carbon-lowering potential (IEA, 2006). Over 90 percent of the 127 demand-side energy efficiency projects come from industrial energy efficiency improvement – only six emerged from the building sector.

The distribution of projects among project categories follows logically from the quantity of CERs typically produced by each project type. On average, for example, a HFC, PFC, or N_2O reduction project can produce 1,764,000 CERs per year; a CH_4 project 104,000 CERs annually; a renewable energy project 74,000 units of CERs per year; and a supply-side energy efficiency project 164,000 CERs annually. The lowest CER production category is demand-side energy efficiency projects, which produce 38,000 units per project per year. Within this category, building sector energy efficiency projects generate only 12,000 units annually on average, which is the lowest among all project categories (calculated from Fenhann & Lima's CDM pipeline analysis, Dec., 2007).

Project Category	Project Sub-Category	Total Projects in pipeline *	Total CER/yr (1000)	CER /yr/ project (1000)	Revenue/ project @ $15 (1000)	Total CER issued (1000)
HFCs, PFCs & N2O Reduction	HFCs , PFCs , SF6, N2O	72	126,978	1,764	26,454	66,635
Renewables	Wind, Biogas, Biomass Energy, Geothermal, Hydro, Solar, Tidal	1,703	126,694	74	1,116	13,756
CH4 Reduction and Coal Mine/Bed Methane	Agriculture ,Coal Bed/Mine Methane, Fugitive , Landfill Gas	456	47,328	104	1,557	5,070
Cement	Lime Replacement	29	4,073	140	2,107	703
Fuel Switch	Fossil Fuel Switch	89	32,411	364	5,463	1,166
Supply-Side EE	EE Supply Side, EE Own Generation, Energy Distribution	287	47,021	164	2,458	6,794
Demand-Side EE	EE Households, EE Industry, EE Service (including EE Buildings)	127	4,785	38	565	387
EE Buildings	Building Sector EE Improvement	6	69	12	173	2
Afforestation and Reforestation	Afforestation, Reforestation	13	989	76	1,141	0
Transport	More Efficient Transport	7	594	85	1,274	59
Total	All Projects	2,783	390,873	150	2,250	94,420

* Include registered projects, projects requested registration, and projects at validation

Source: calculated from Fenhann & Lima's CDM pipeline analysis, Dec., 2007

Table 2. *CDM project types, CER distribution and issuance by sector*

In general, building projects simply are not attractive enough to investors from an economic point of view. In a new building project, where buildings can be designed to maximize carbon credits, more economic benefit can be generated. The Technopolis project in Kolkata, India, for example, is a newly designed commercial building with many energy efficiency features and a floor area of 6,279 square meters. The project is expected to receive $132,000 per year, assuming all estimated credits are realized. See Appendix 2 for additional details. By contrast, however, the carbon revenue generated from the retrofitting of the ITC Sonar Hotel, also in Kolkata, is only approximately $45,000 per year, based on a $15 per ton CDM price estimation[4].

Positive project attributes	Negative project attributes
1. High CER yield, economically attractive	1. Low CER yield, economically unattractive
2. Initiated by Annex I country, with private sector support or interest	2. Proposed by non-Annex I country, with a focus on meeting sustainable development needs
3. Large-scale	3. Small-scale
4. Single or few locations	4. Scattered locations
5. Single-technology deployment	5. Multiple technology improvements
6. End-of-pipe GHG control	6. Process improvement based on GHG mitigation (mostly CO_2 reduction)
7. Involves energy supply-side technologies	7. Involves energy demand-side technologies, small end-user projects
8. Single or few stakeholders in project life cycle	8. Multiple stakeholders in project life cycle
9. Easy to monitor and collect data	9. Difficult to monitor and collect data
10. Main product is emission reduction or energy	10. Many joint products, and main products/services are not energy.

Table 3. *Comparison of CDM project characteristics*

In countries where the electricity sector's carbon emission factor is low, such as Brazil, the financial incentives to pursue carbon revenue are even lower. In the Pão de Açúcar stores that applied for CDM registration (8 projects were rejected), the estimated carbon revenue would have been merely $3,000 per store. This level of revenue would not even cover the basic operating costs for managing and monitoring the projects, let alone repay the energy efficiency investment.

[4] The average prices for Certified Emission Reductions (CERs) from developing countries were US$10.90 or €8.40 in 2006, with the vast majority of transactions in the range of US$8-14 or €6-11, according to *State and Trends in the Carbon Market Report 2007* (World Bank 2007). According to *Determining a Fair Price for Carbon*, published by UNEP Risø Centre for the CD4CDM, issued CERs have traded at an average price of €15-16, while registered projects have traded at a price of €12 in the primary market. The World Bank estimates, therefore, are at the lower end (Hodes, et al., 2007).

In addition to economic considerations, a number of other project characteristics influence how likely a project is to emerge and receive CDM approval. These characteristics reflect project types and affect how easy it is to organize a project and to register it as a CDM project. A review of the CDM project pipeline, the various project characteristics and the CDM requirements makes the distinctions clear. Table 3 summarizes attractive and unattractive project attributes from the perspective of potential CDM project development. In general, projects having more positive attributes are more attractive for CDM implementation, and projects having more negative attributes are less attractive. For example, HFC, PFC and N_2O reduction projects have all of the above-listed attractive attributes and are the biggest winners among all project categories. Energy supply-side projects, such as wind, hydro, cogeneration and waste-heat generation, and CH_4 reduction projects, such as landfill gas and coal mine and coal bed methane reduction projects, also have several positive attributes and are among popular project categories. Most industrial sector energy efficiency demand-side projects are small-scale, but relatively straightforward, with, e.g., a single site and a single technology, and thus are gradually entering the project pipeline. By contrast, building sector energy efficiency projects, which have all the above-listed disadvantages, are not attractive to investors and project developers.

III. CHALLENGES TO ENERGY EFFICIENCY IN THE BUILDING SECTOR

This chapter investigates the general characteristics of energy efficiency in buildings (EEB) projects and describes underlying problems in the sector that are contributing to the CDM project development difficulties discussed in Section 2.3. Many of these difficulties are associated with energy efficiency projects in general and are identified in the literature as reasons for energy efficiency market failures. Other barriers are unique to the building sector, but are also well recognized in the energy efficiency literature (such as the principle-agent problem). In general, building sector energy efficiency projects share generic difficulties with other energy efficiency projects, but small project sizes, multi-stakeholder dynamics, and the sector's fragmentation further complicates the situation. This section synthesizes literature about energy efficiency, the building sector, and CDM, while taking into account country experts' opinions and practical experiences, which were identified through interviews.

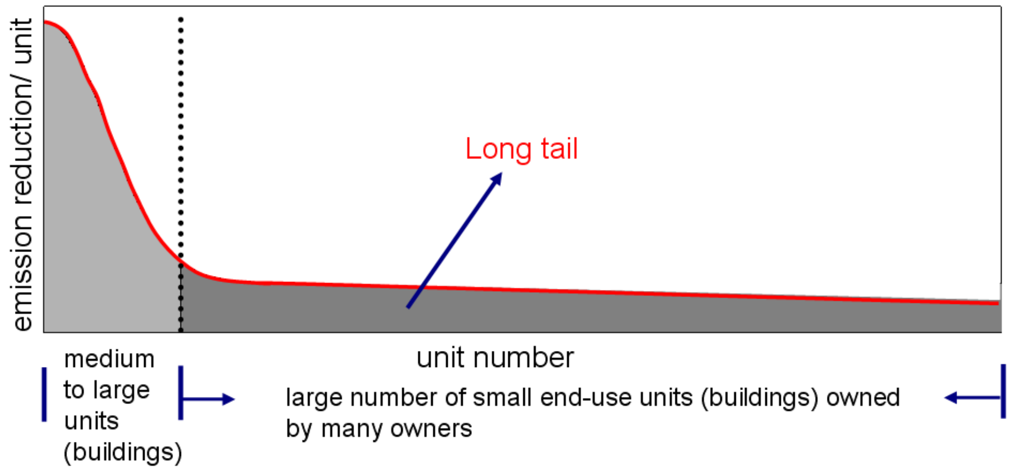
3.1. Many buildings but small individual savings

The most prominent characteristics of EEB projects are their dispersed nature and the numerous, individually small savings opportunities they present. Some end-use efficiency CDM experts refer to such projects as "long tail" projects. The idea of the long-tail projects was first proposed by Hinostroza, et al. (2007) and further used by Figueres and Philips (2007) to describe the GHG emission reduction potential of dispersed energy end-use projects.

A statistical distribution of a long-tail curve (also known as Pareto Distribution) indicates the high potential of few interventions (events) and the lower potential of the majority of interventions, which gradually "tails off" asymptotically. This distribution is typical for end-use energy efficiency improvement projects. Figure 3 illustrates this concept using the building sector as an example. More often than not, though not always, the low-amplitude events—the long tail—can cumulatively outnumber or outweigh the events signified in the initial portion of the graph. In aggregate, in other words, the long-tail events tend to comprise the majority of events (Hinostroza, et al., 2007) and can, through the aggregation of small savings, yield the majority of energy savings from the energy end-use sectors.

The building sector has all of the distinctive characteristics of long-tail projects: small savings per technology improvement, large numbers of buildings, widespread locations, many technologies used to achieve efficiency improvements, various specifications for dispersed end-use requirements, varying end-user knowledge levels and decentralized energy use decision making. All of these factors make managing and controlling building sector projects comparatively difficult and costly.

Dispersed end-use sectors, such as the building sector, are often difficult to reach with traditional policy interventions or to affect through private sector investment programs. Command-and-control type government policies work best when targeting large, aggregated energy consumers, but rarely reach the tail effectively. Significant efforts and high transaction costs are often associated with achieving small efficiency gains. These factors often hamper the willingness of investors and financial institutions to undertake projects. Coordinated, collective approaches can help to tap the potential of such projects, but these kinds of efforts are not easily orchestrated and suitable leadership is not easily found. Poor cooperation among builders, owners and users combined with dispersed building locations often make it difficult to voluntarily coordinate actions. These challenges are even more prominent in existing buildings, where savings are smaller and opportunities more dispersed, than they are in new building projects.



Source: Adapted from Hinostroza et al., 2007, and Figueres and Philips, 2007

Figure 3. *Small savings from large numbers of end-use units constitute the long-tail distribution of the building sector projects*

3.2. Business status quo and management difficulties

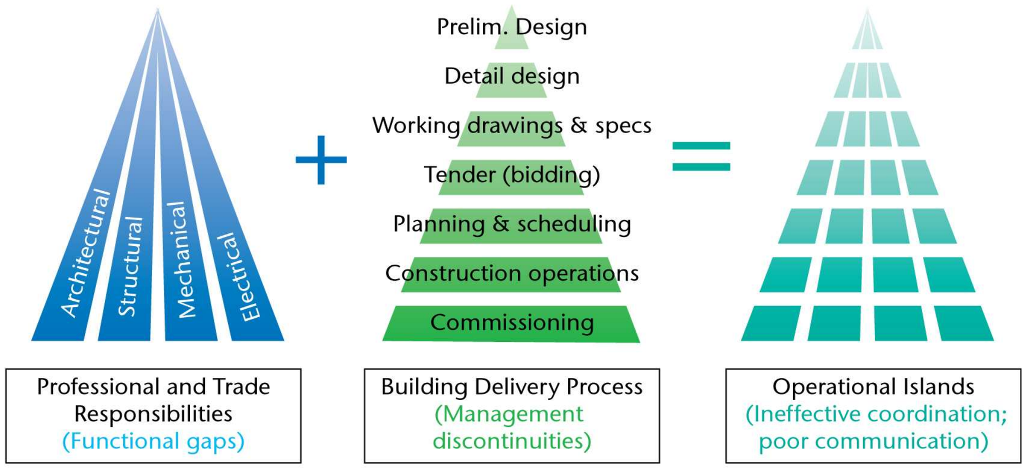
The complex nature of the building business and the risks associated with building projects present challenges to initiatives that go beyond "business as usual", such as EEB projects.

Fragmentation and complexity of the construction sector

The construction sector is highly fragmented, with many, often poorly integrated actors involved in the value chain (Levine, et al., 2007). Key stakeholders include developers, capital providers, designers, engineers, contractors, agents, owners, users, and local government. The complexity of interaction among these participants is one of the greatest barriers to energy efficient buildings (WBCSD, 2007).

The fragmentation, complexity and resulting management and coordination problems in a construction project are well illustrated in WBCSD's "operational island" graphs. See Figure 4 below. The first pyramid represents the various technical disciplines involved in the building sector. The second pyramid represents the building delivery process. (Note that in developing countries, and in small, privately owned buildings, this process may be simplified.) The third pyramid represents the resulting fragmentation, which often causes lengthy delays and inhibits coordination among project participants and between project stages (WBCSD, 2007).

The segmentation of the construction sector generally is compounded in EEB projects, in which energy saving incentives and responsibilities are shared by a number of different players. Project management is complex and difficult. Even if individual actors try to optimize their own performance, there is often no system to optimize the total building process (UNEP, 2007, Levine, et al., 2007). A fully integrated building design and construction process requires stronger management, better coordination, and the full commitment of all players. This type of integration is not often seen in construction projects in developing countries, especially in countries where construction booms have been taking place in recent years.



Source: WBCSD, 2007

Figure 4. *Complexity and fragmentation of the construction sector – operational island illustration*

High business risk and perceived high risk

The business environment of the building and construction sector is considered to be highly uncertain and risky, especially in fast developing countries. The sector's history of construction bubbles and recessionary cycles have fostered a generally conservative and risk-averse culture. New types of initiatives, such as EEB projects, are generally not welcome because they require deviation from practices that have been known to work. The benefits to asset value and profitability are unknown or unclear, and the risks are not quantifiable. Investment decision makers, therefore, are often reluctant to take the risk.

The same conservative business environment is also seen in other building efficiency-related sectors, making efficiency improvements even more difficult. Manufacturers of efficient appliances and building materials are uncertain about market demand for high efficiency models and are reluctant to improve their production lines. Limited availability and the high costs of efficient products and materials further discourage investors from taking on new initiatives. For example, in the building CDM projects UNEP investigated, equipment and materials often needed to be imported, which increased construction costs and created additional project implementation difficulties.

Other initiatives to improve energy efficiency in buildings share the same conservative business environment. Energy services companies (ESCOs), for example, have been developed to help create a market for energy efficient products and services, and have been supported by international donors such as the World Bank (ESMAP and UNEP Risø, 2006, 2007). However, ESCOs established in developing countries are often thinly capitalized and rarely have sufficient collateral and track records to secure needed capital (Painuly et al., 2007). Due to the harsh business environment in developing countries and their relatively newly established business practices and opportunities, ESCOs are cautious about embracing new initiatives. ESCO experts interviewed for this study have shown reluctance to become engaged in CDM projects in buildings until there are more predictable procedures and examples to learn from.

3.3. Split incentives and diverse interests of stakeholders

One of the main, well-identified barriers to improving energy efficiency in the building and construction sector is the fact that the person deciding about energy efficient investments in buildings is seldom affected directly by the consequences of the decision. (Jaffe and Stavins, 1994, Figueres and Philips, 2007, Painuly, et al., 2007, de T'Serclaes, 2007, Levine et al., 2007). This phenomenon is known as the principal-agent issue or the landlord/tenant paradox. In most cases, the owner and user of a building are different persons. The landlord is responsible for installing equipment, and is generally interested in low investment costs. Low efficiency equipment is often chosen and installed to minimize costs. On the other hand, tenants who pay for the energy costs are often unwilling to pay for energy efficient equipment that they will not be able to take with them. In the end, investments in energy efficient equipment will not be priorities for either actor (de T'Serclaes, 2007).

Similar paradoxes can be found among many stakeholders in the building cycle. In most cases, developers, builders, owners and users of commercial and residential buildings are not the same person/company/organization. These stakeholders have widely disparate interests in energy service and consumption. Most technology improvement costs are paid with capital investments, whereas energy costs (and saving) arise during a building's operational phase. Developers making investment decisions generally are not concerned about the energy use of the buildings. Builders and contractors who install energy services may not have enough decision-making power and do not use the buildings. Owners may or may not be the users of the buildings, but may in any case not have control over the building's energy features during the construction stage. And users who pay the energy bills can only use buildings as they find them after construction. The multi-player and multi-stage characteristics of the building life cycle make coordination of these stakeholder interests difficult.

In construction, management or ownership contracts formalize the parties' responsibilities. These documents normally do not describe the various parties' interests in energy consumption or how such issues will be coordinated. This is partly because energy, energy services, and energy consumption have not been regarded as an asset, commodity or main feature of a building. Tools to evaluate and attribute rights and responsibilities of energy services and consumption have also not been established as a common practice in building contracts.

3.4. Lack of information, asymmetrical information, and misinformation

The building sector is subject to various information barriers within the building industry itself and among end-users. Information about energy efficiency options is often incomplete, unavailable, expensive and difficult to obtain and verify (Levine, et al., 2007).

For example, in the building and construction industry, misperceptions exist regarding the extent of GHG emissions from buildings and the costs of building and operating sustainable buildings [5]. These misperceptions are impeding progress in making buildings more energy efficient and sustainable. A WBCSD research found that building professionals underestimate the contribution of buildings to GHG emissions by half. When asked, professionals estimated, on average, that buildings contribute approximately 19 percent of total GHGs, whereas the real contribution is typically between 30 and 40 percent (WBCSD, 2007). The same research also suggests that perceptions of the cost necessary to achieve greener buildings are significantly higher than actual costs. Estimated costs range from 11-28 percent. Studies of actual properties, however, suggest real costs are likely to be between 5-10 percent in developed countries and possibly a bit higher in fast developing countries (WBCSD, 2007). UNEP's interview with the Technopolis building project manager in Kolkata confirmed the tendency to overestimate costs (Mehta, 2007).

According to the same WBCSD's survey, building professionals generally have a high awareness of sustainable buildings and energy efficient buildings and their importance to the environment. Building professionals who are aware of the practice of sustainable buildings range from 98 percent of those surveyed in Germany to 64 percent in India (WBCSD, 2007). The actual involvement of those interviewed in green buildings, however, dropped to 45 percent in Germany and 5 percent in India. This gap may be partially attributable to a lack of practical information for decision-making. Misinformation or lack of information among building professionals on a variety of issues, including equipment quality, energy efficiency features of buildings, energy saving technologies and appliances has been identified as a major barrier to decision making by building professionals. In WBCSD's 2007 survey, the "lack of personal know-how about how to improve a building's environmental performance" and the "lack of knowledge about where to go for good advice" were ranked as the leading considerations influencing decisions regarding energy features in buildings.

Lack of information and experience causes lack of trust and more risk-adverse attitudes toward new equipment and practices. Business decision makers, designers, and building contractors tend to choose to continue business as usual rather than trying new approaches not yet proven in the local context. Local customs, and habitual behaviors conspire to maintain the status quo in design, construction, equipment purchasing decisions and commissioning.

Lack of information about energy consumption also influences end-user decision making. Energy features and energy consumption information are generally not provided by building sellers and owners to buyers or renters, and are generally not major decision-making considerations. Imperfect information and a lack of energy consumption information feedback channels between builders and building users is a partial cause of the split incentives discussed in section 3.3.

End-users normally have limited knowledge about how their daily behavior influences their energy consumption, or how changed behavior can reduce energy costs. Similarly, the links between energy use and environmental quality are generally not well understood. The public is often simply not aware of why it is

[5] In this report, the concepts of energy efficient buildings and sustainable buildings (or green buildings) are considered separately. In general, the concept of a sustainable building includes the energy efficient building concept. In addition to aiming at efficient use of energy, which is the main focus of energy efficient buildings, sustainable buildings also implement measure to ensure efficient use of other resources, such as water and materials, and to reduce impacts on human health and the environment.

important to save energy or how to do it. And even if users are aware of these links, they may have limited rights/abilities to change their building's energy consumption features. There is also typically no feedback provided by utilities, appliances manufacturers, or building owners about how user behavior affects their energy consumption and costs.

3.5. Lack of expertise, management tools and indicators for energy management in buildings

Energy management is an important means to further reduce energy consumption in buildings. The concept of energy management begins at building design and extends through the entire building cycle from construction to operation. Energy management includes various "soft" measures, such as procedures and methods to ensure continual improvement of energy performance in buildings, as well as the "hardware", such as control and monitoring instruments needed to implement them.

Good energy management requires proper tools and the formation of management norms and a culture capable of sustaining best practices. It also requires trained expertise with the knowledge to organize and implement best practices in energy management. Because energy performance in the building and construction sector has typically not been required in developing countries investments in developing knowledge, expertise and tools are still needed.

In the construction phase

One of the most important steps for energy management in buildings is commissioning. After a building has been constructed, a systematic testing process is conducted to ensure that the building systems have been designed, installed and made ready to perform in accordance with the design intent and the building owner's operational needs. This process is called commissioning. Proper commissioning of the energy systems in commercial and residential buildings is crucial to the efficient operation of the building later in its life cycle (Levine et al, 2007). According to case studies in the USA, proper building commissioning has yielded impressive results, with energy savings of up to 38 percent in cooling and/or 62 percent in heating and an overall energy savings average higher than 30 percent (Levine et al, 2007).

Energy performance has rarely been required, tested, or measured as part of building construction and commissioning practices, especially in developing countries. Due to the lack of energy performance requirements, energy management tools and procedures have not been systematically established and applied to the design and commissioning of buildings. Some international certification and practices for energy efficient and green buildings, such as Leadership in Energy and Environmental Design (LEED)[6], have been established in developed countries and are starting to be adopted in developing countries. The accessibility, applicability and adaptation of foreign technologies to local business environments have posed great challenges. On the other hand, the introduction of proper tools and procedures creates hope that business as usual will increasingly give way to improved energy performance management.

[6] Leadership in Energy and Environmental Design (LEED) is a Green Building Rating System™ promoted by the US Green Building Council (USGBC) to encourage and accelerate global adoption of sustainable green building and development practices through the creation and implementation of universally understood and accepted tools and performance criteria (USGBC, 2007).

In the operational phase

During a building's operational phase, continuous monitoring and periodic adjustments to design features are essential in order to maintain energy savings. Fine-tuning based on post-occupation conditions can further lower energy consumption. In this phase, as with commissioning, refined testing measures and procedures are required in order to optimize energy systems performance. If done well, further energy saving from post-occupancy fine-tuning can be substantial. For example, monitoring at a sustainable building site in Oberlin, Ohio in the USA, resulted in controls and equipment changes that reduced initial site energy use by 37 percent (Torcellini et al., 2006). Experiences in developing countries show similar results. One study found that fine-tuning during the first year of operation reduced 20-30 percent of total energy consumption in several sustainable building cases in Kaula Lumpur, Malaysia (Kristensen, 2007).

Post-occupation fine tuning and monitoring with specific, quantitative [7] energy performance goals could further improve and sustain energy savings by inducing changes in end-user consumption behaviors. Indicators and energy management tools could be introduced to end-users such as commercial building tenants and employees, and residential building occupants.

In commercial buildings, quantitative energy-use indicators could be used as a management tool to encourage employees to adopt energy conservation measures, thus becoming part of business norms. One CDM building project, the ITC Sonar Hotel in Kolkata, has successfully employed energy performance indicators and management measures to establish an energy-saving culture (see subsection 4.4). The availability of indicator results comparable to those in similar businesses or buildings would equip end users with clear information that could, and in some case already has, inform energy consumption choices (Chattopadhyay, 2007).

Implementing post-occupation energy management measures involves additional challenges in residential buildings, which are more dispersed and where privacy concerns are greater. Nevertheless, some studies have shown that providing residents with energy consumption information can help to reduce household energy consumption. In one study, installing systems that provided residents of Japanese households with information on power consumption, city gas consumption and room temperatures in 30-minute intervals reduced household energy consumption by approximately 9 percent (Ueno, et. al., 2006). Conventional billing and metering arrangements in most residential buildings, however, makes access to such information unlikely in the near term.

Apart from some experiences in developed countries, and limited initiatives started in developing ones, the above-mentioned energy performance assurance practices are generally not in use. Energy performance information, management tools and indicators have not been well developed and adopted into common practice in construction and post-construction building management. As a result, knowledge and expertise remain at a low level in most developing countries.

3.6. Investment costs and life-cycle savings

The adoption of energy efficient design and technology solutions in buildings often requires additional up-front capital

[7] Quantitative management tools and indicators have been proven to be more effective than qualitative guidelines.

investments. These investments can be offset by lower operational costs over the building's lifetime (de T'Serclaes, 2007). The additional costs associated with energy saving design and equipment typically constitute 5-10 percent of construction costs in new buildings (WBCSD, 2007), but may be higher for retrofitting projects. Although additional incremental investments for energy efficiency features may not seem high in percentage terms, buyers and investors have been reluctant to pay these additional costs.

House buyers and users typically do not want to pay extra initial costs to achieve energy savings. The main determining factors for their investments are, most of the time, personal and financial needs, such as design, comfort, lifestyle and future market value considerations. Energy features and energy savings are seldom important considerations for house buyers.

Similarly, for typical real estate investors, energy is not a central concern in their investment decisions. Investors are more focused instead on design and construction features that fulfill housing, commercial services or real estate marketing needs. In this context, additional investments in energy services and saving features are of only marginal interest and are generally viewed as not being well justified. Builders wishing to take the initiative to improve the energy performance of their construction projects generally find it difficult to convince investors and financiers to pay for energy features.

Additional investments in energy efficiency provide lower energy costs during the building's operational phase. EEB projects are cost effective, therefore, when calculated in life cycle or IRR[8] terms, i.e., when taking into account the energy savings that will be achieved during a building's use. This explains the low mitigation costs presented in most studies of the energy saving potential in buildings.

[8] Internal rate of return (IRR) is an investment appraisal metric commonly practiced by firms to determine whether they should make particular investments.

Accounting for life cycle cost savings is an important means of encouraging investments in EEB projects. Some projects estimate relatively short payback periods, which increase their attractiveness to investors and makes them more viable. For example, the estimated payback period for the energy saving features of the Technopolis project is five to six years (Mehta, 2007).

Investors, however, have reservations regarding the return on investment for energy efficiency measures based on life-cycle cost savings. The payback on capital investments in energy savings is relatively uncertain and intangible when compared with other types of investments. The level of energy savings achieved depends not only on the physical features of the buildings, but also on the behavior of the building user, which in turn is subject to many external factors such as energy costs, operational conditions, environmental and climate factors, equipment quality and who will finally benefit from the savings (i.e., who will be paying the energy bill in the future).

In addition, energy saved, by definition, is energy that should have been used but was not. Evaluating payback, or return on investment, based on events that do not happen is very difficult. The baseline used to determine the "savings" is often indirect and unclear. This is especially true of new investment projects, where there may be no baselines for comparison. Investors, therefore, tend to consider cost-benefit calculations using life-cycle approaches to be risky and prefer to require very short payback periods on investments. Skepticism toward life-cycle calculations is well documented as a major barrier to energy efficiency-related investment (Figueres and Philips, 2007, de T'Serclaes, 2007).

EEB projects are also subject to other risks, some of which were described in sections 3.1 - 3.5. These risks include multiple ownership of buildings, relatively small size of the investment, the business environment of the construction and building sector, lack of a financing history, lack of information, and shortage of expertise to ensure delivery of energy saving features and designs. These difficulties make repayment of investment costs less certain, increase risks, and generally discourage investors from pursuing EEB projects. Residential building projects seem to be more exposed to these risks than do commercial building projects.

Early movers who are willing to accept the risks and invest in EEB projects will still have problems raising funds from the financial sector. The difficulties partially come from the lack of data and financial tools available for project investment evaluation. Banks and investors generally have limited experience and expertise in evaluating energy efficiency project risks and assessing the payback potential of these projects. Engineers and building designers are often unable to provide data and information in a format that financing professionals can interpret and use for risk assessments. The absence of essential information makes it virtually impossible for most investors to consider energy efficiency projects in the context of the risk-return framework that is fundamental to investment decision-making (Mills, et al., 2004).

Another financing difficulty comes from integrating the concept of energy savings and lowered life cycle costs into commonly used loan schemes for capital investment. The benefits of energy saving do not fit into either existing, and commonly used financing schemes for builders or personal loan products for individual investors. The cost saving from the operation phase is often not translated into payment streams for capital investment. In other words, cost savings in the operational phase cannot directly pay off additional capital investments into energy efficiency. This disconnection between capital investments for energy efficiency and resulting operational cost savings discourages investors from increasing loan amounts to pay for energy efficiency.

The CDM projects investigated in this study confirm the difficulties of financing EEB projects. Most CDM building projects are self-financed by the project proponents. The exception to this finding was the Kuyasa project, in Cape Town, South Africa, which requires other sources of financing, including the resident's own funding. This indicates that banks have not become involved in CDM projects in the building sector. An interview with Banco Sumitomo in Brazil[9], a Japanese bank that has been deeply involved in CDM project investment and has assisted the development of potential CDM projects, provided evidence that the building sector has not been an area of consideration for CDM investment (Cowman & Toyama, 2007).

Country experts identified some indications of changes in the investment climate. For example, a development bank in Brazil has recognized the importance of corporate environmental responsibility and has launched a program to encourage sustainable building investments in construction projects [10] (John, 2007). These kinds of projects,

[9] Banco Sumitomo Mitsui Brasileiro, Sao Paulo has been active in identifying suitable CDM projects in Latin America for Japan, and has invested in the development of CDM projects that meet the bank's requirements.

[10] Banco Real in Brazil developed a program called Real Obra Sustentável (Real Sustainable Workmanship) working with the companies in the construction sector, and developed guidelines for resource uses in Bank-financed residential construction projects.

however, are small in scale and largely superficial, with a strong focus on promoting the corporate image of the banks (Esparta, 2007).

3.7. High transaction and management costs

Because energy management has not been commonly practiced, transaction and management costs have not been properly estimated in most EEB projects, despite the fact that such data is required for EEB project financial analysis. Transaction and management costs are high when building projects are small and scattered in nature. Large amounts of effort and resources are required in order to implement energy efficiency building designs, and maintain and monitor designed features. Transaction costs include costs related to verifying technical information, acquiring suitable equipment, preparing viable projects, and negotiating and executing contracts (Levine et al., 2007). Management costs are related to commissioning, auditing, maintenance, monitoring, data collection, end-user education, etc.

An indication of the potential magnitude of transaction and management costs is provided by the iEEECO project, a low-income energy efficiency housing development in Cape Town, South Africa. See Appendix 3 for details. The developer estimates that the iEEECO project is 20 percent more expensive than typical low-income housing projects. The majority of these costs have been associated with additional expertise, coordination of professionals, contracting, monitoring, evaluation and certification, additional government approvals, and the integration of energy interventions (Guy, 2007). This estimate may vary in other building types. The structure of the iEEECO low-income houses is relatively simple and the energy efficiency features are limited.

Data on commissioning for energy performance in commercial buildings gives some additional indication of the potential magnitude of management costs. A sustainable building case study in Colorado, USA, found that the cost of commissioning was approximately 0.5 percent of the total construction budget (USEPA, 2007). A report of six high-energy performance buildings in the USA also concluded that commissioning required 0.5 to 1.5 percent of total construction costs or 1.5 to 2.5 percent of mechanical system costs (Torcellini et al., 2006). Based on these estimates, management costs for commissioning, post-occupation fine-tuning, monitoring and re-commissioning during a building's life cycle may equal 5-10 percent of construction costs. If the costs of maintenance, management, and end-user education were taken into account, this estimate would be higher.

The scope of transaction and management costs is closely related to the challenges inherent in organizing and maintaining a viable EEB project, such as the complexity of stakeholder dynamics, scale of individual improvements, level of energy savings to be achieved, amount of automation, degree of quality control to be maintained, and the business and regulatory environment in a given project location. EEB project costs, therefore, may vary according to building uses, construction type (new or retrofits), energy-saving specifications and approaches to be used, and the general economic and social conditions of the host countries. In most developing countries, where the resources, knowledge, technologies, information, and institutional support for EEB projects are lacking and need to be introduced, higher transaction and management costs can be anticipated.

IV. POTENTIAL SUPPORT FROM CDM TO ENERGY EFFICIENCY IN BUILDINGS

This chapter describes how the CDM could address the challenges energy efficiency projects face and support energy efficiency investments in buildings.

In principle, the CDM's project-based approach and quality assurance features offer a good platform for promoting energy efficiency in the building sector. The current development of new CDM rules, together with the gathering of lessons learned from project implementation experiences, will further improve CDM's capacity to facilitate EEB projects.

As described in the previous chapters, however, it seems unlikely that the CDM alone will be sufficient to overcome the many challenges to energy efficiency projects in the building sector. Nevertheless, the CDM could strongly complement other initiatives, such as government policies, private investments, voluntary certification programs and other incentives, by supporting the implementation of "long-tail" projects and by helping to replicate successful projects relatively quickly.

This chapter begins with a general overview of the CDM project development cycle and the various requirements and actors involved in the process. This is followed by an examination of the CDM's design, rules and procedures, and an explanation of the CDM's potential to help tackle the building sector's difficult, long-tail characteristics. Project implementation experiences, approaches taken in actual CDM projects, and evolving good practices to help reduce energy consumption in the building sector are also discussed. Finally, the section examines CDM's potential to support other measures, interventions or incentives to promote wider adoption of EEB practices.

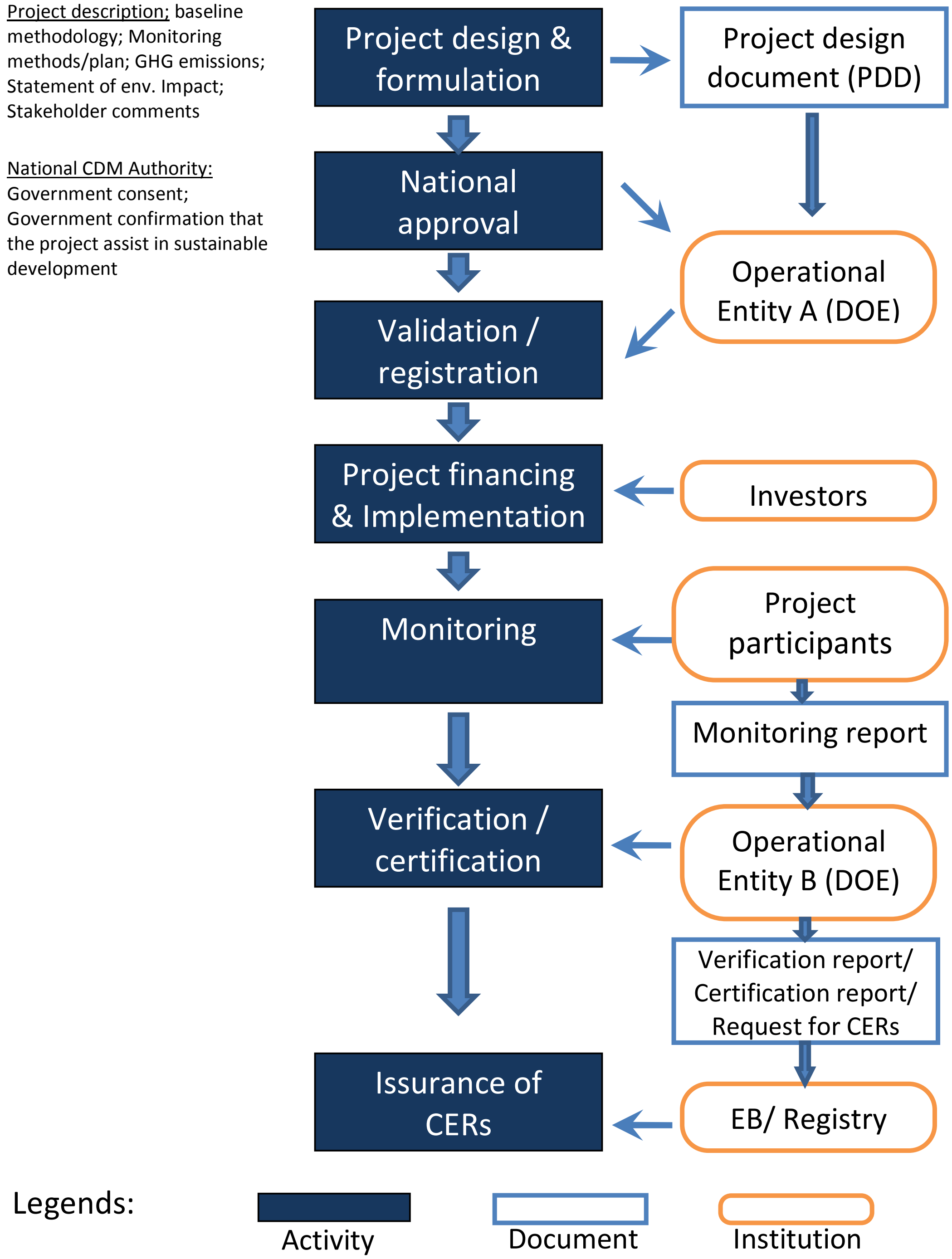
4.1. CDM procedures and programmatic CDM

This subsection provides a brief overview of CDM project development and the new rules of programmatic CDM. The CDM's various actors, project procedures and registration requirements are explained.

CDM procedures

In order to apply for a CDM project and receive credit for emission reductions from project activities, project developers must follow a series of procedures set out by the COP/MOP agreements and the CDM Executive Board (EB). A project needs to be audited ("validated" in CDM terminology) by an authorized auditor (a Designated Operational Entity or DOE), approved and registered by the EB before the CERs generated by the project can be approved ("verified") and sold on the market. Figure 5 shows the procedures required in the entire project cycle.

First, project developers must formulate the concept and prepare a Project Design Document (PDD) according to the format and requirements of one or a set of pre-approved CDM methodologies. In order to qualify as a CDM project, certain criteria must be met. Projects must result in real and measurable climate change benefits, and these benefits should be additional to any that would occur in the absence of the project activity (the "additionality" requirement). A PDD needs to establish the project's eligibility by including information showing that the project's emission reduction plan meets these two criteria. To demonstrate additionality, project emissions must be compared to the emissions of a reasonable reference case, identified as the baseline. The baseline for a CDM project activity is a hypothetical reference case, representing the volume of GHGs that would be emitted were the project not implemented. Project participants establish the baseline on a project-specific basis and in compliance with approved methodologies (Fenhann, et al., 2004).



Source: Fenhann et al., 2004

Figure 5. *Project cycle for the CDM*

A project PDD must also contain a plan to monitor and collect accurate emissions data. The monitoring plan is the basis for CER verification when the project is implemented and the CERs generated. Project developers will need to provide evidence that the emission reductions and other project objectives have been achieved. Like the baseline, the monitoring plan must be devised according to approved methodologies (Fenhann et al., 2004).

The PDD needs to be evaluated and the project activities (or plan) audited by an authorized third-party auditor (DOE). At the same time, the national CDM authority (the designated national authority or DNA) must review the project to ensure that it meets sustainability and environmental requirements and must provide a letter of approval before the project is submitted to the EB for registration. After it has been confirmed that the project activities comply with all CDM requirements and that the PDD follows all methodological requirements, the DOE validates the project. (Fenhann et al., 2004).

After a project is registered and implemented, the project needs to follow the monitoring plan strictly. After a certain period of time, usually one year, a project developer (owner) may call in a different DOE to verify the amount of emission reductions achieved. The project needs to provide detailed monitoring and operational records showing that the project has been properly implemented and that the emission reductions have occurred and are attributable to the project activity. The DOE may then certify the emission reductions, and the EB will issue CERs accordingly.

Programmatic CDM

The CDM rules were originally designed for individual, stand-alone, emission reduction projects that are implemented at a single site. Later, the rules were revised to allow the “bundling” of several projects to reduce CDM-related transaction costs to small projects. Project sites needed to be close to each other, and projects needed to be implemented at the same time. Although project developers welcomed bundling, the number of projects that could be bundled into a small-scale project was limited due to the above conditions.

In December 2005, the COP/MOP decided to include a “Programs of Activities” (PoA) in the CDM. The PoA has its origins in a decision of the COP/MOP that local/regional/national policies or standards cannot be considered CDM project activities. The PoA concept makes it possible for a large number of interrelated project activities (referred to as “CDM Programme activities or CPAs) in different locations, even in different countries, to be registered as a single CDM project and implemented in a coordinated fashion. Because a PoA is essentially a program to coordinate individual CDM activities, it is commonly referred as “Programmatic CDM”.

Although CPAs are similar to traditional CDM projects, CPAs under a PoA are distinctive in a number of respects (Hinostroza, 2007):

1. **Multiple locations.** PoAs may create many GHG reduction activities over time and in multiple sites (i.e., in one or more cities, regions or countries, so long as each country involved submits a Letter of Approval).

2. **Coordinating entity**. A PoA is coordinated or managed by one public or private entity that does not necessarily achieve the reductions itself but promotes others to do so. The coordinating entity is responsible for arranging for the distribution of CERs and for communicating with the EB.

3. **CPAs.** A CPA is a single measure, or set of interrelated measures, designed to reduce GHG emissions within a designated area. This area can include one or several locations. All CPAs in a program must apply the same approved baseline and monitoring methodology. At registration, the program must define the type of real and measurable information that is to be provided for each CPA. A PoA can implement an unlimited number of CPAs.

4. **Validation.** A PoA is distinct from a bundle of small-scale projects, because it is possible to add new CPAs to a PoA without undertaking the validation process anew. No registration fee is required for CPAs that are added after validation.

5. **Duration.** GHG-reducing activities do not need to occur at the same time. A PoA can have a duration of up to 28 years, during which time the managing entity may add a CPA, or several CPAs, to the program.

6. **Monitoring and verification.** The total volume of emission reductions to be achieved by a program may not be known at the time of registration. Each CPA shall be monitored according to the monitoring methodology approved for the type of project activity. In cases where there are many small GHG reductions, statistically sound sampling methods may be proposed in the monitoring methodology submitted for approval.

4.2. The benefits of project and programme-based CDM approaches

Section 3 discussed the difficulties that small end-user activities have in attracting investments for energy efficiency improvements. It also addresses the challenges of managing projects that are dispersed and involve diverse stakeholder interests. Differences in end-user requirements are best dealt with on a coordinated, case-by-case basis.

By design, the CDM allows individual GHG mitigation opportunities to be addressed on a project-by-project basis. The project-based approach ensures that opportunities to increase energy efficiency and to mitigate emissions are appropriately tailored to emission sources. This flexibility is particularly important for projects that have strong end-use characteristics and multiple stakeholders, and that require the ability to deploy case-specific mitigation strategies. The project-based approach of the CDM ensures individual mitigation opportunities are captured and optimized from the bottom up.

The new programmatic design of the CDM enables the bottom-up intervention approach to be implemented on a larger scale. For private and public investments, the size of the project is important. Most building projects are small scale. To make investments worthwhile, energy end-use projects offering small emission reductions need to be aggregated, so that activities can be replicated and per unit transaction costs lowered. By allowing small, dispersed projects to be aggregated and coordinated, Programmatic CDM has opened the door to supporting broader, more systematic EEB interventions.

In most countries, the building sector is well developed and has longstanding business networks, financing models, commissioning processes and contracting relationships. It will be essential for those pursuing programmatic CDM to understand the existing system and to find opportunities for coordinated action that builds on regional, national and local agendas and practices. Efforts to integrate the programmatic CDM approach into existing networks are especially important given the complex and conservative nature of the building sector business environment. Integrating the CDM process into existing building-sector networks would help to reduce resistance to CDM projects while building a common body of know-how and resources to support EEB projects.

Effective coordination is essential to the success of programmatic CDM. A number of different types of stakeholders involved during the building life cycle could potentially promote broader-scaled interventions and contribute to coordination of programmatic CDM. These include building developers and designers, financing institutions, contractors and those involved in equipment purchasing and commissioning. Opportunities for coordination may also exist in major retrofitting or renovation programs. With properly designed business models, coordinating entities could bring together interests, allocate rights and responsibilities, and provide incentives among various stakeholders. Programmatic CDM holds a strong potential to provide new incentives and bring much-needed organization to an otherwise generally unorganized sector.

4.3. Replicating building energy efficiency projects

Another feature of the CDM that is well suited for small end-use projects is its replicability. All CDM projects are required to follow a standardized methodology that can serve as a template for subsequent project design and implementation. PDDs and other relevant documents are available to the public on the UNFCCC website. Project developers or owners from around the world who wish to implement similar projects have easy access to CDM-approved project concepts and implementation measures that serve as blueprints for their own projects. CDM's project replicability has been further improved by programmatic CDM, which is specifically designed to enable the same project ideas and implementation modules to be replicated in a large number of similar units/projects.

The replicability of CDM projects has helped certain project types and certain countries with favorable development conditions to apply CDM systematically and to scale up projects very rapidly. In China, for example, nearly all recently constructed natural gas power plants claimed CDM credits (Schneider, 2007). Similarly, out of a total of 1.3 gigawatts (GW) of wind power capacity installed in China during 2006, 0.9 GW applied for the CDM (Ellis and Kamel, 2007). Replication does not yet seem to have occurred in building sector projects. Given more favorable conditions, however, this aspect of the CDM could help to speed up GHG mitigation efforts in the building sector.

4.4. CDM quality assurance requirements and change of user behaviors

The CDM's rules and procedures contain quality assurance and quality control measures aimed at ensuring "real, measurable and verifiable" emission reductions (COP 1, Decision 5). PDDs need to meet all CDM methodological requirements. Project monitoring plans need to be strictly implemented. Third-party DOEs must review records and validate all carbon emission reductions. Carbon emission reduction-related project activities need to be well documented. These quality assurance mechanisms are checked annually in all CDM projects to ensure the effectiveness of mitigation measures and verify the CERs produced.

In the case of EEB projects these rules also contribute to the effective management of energy features in the design, construction, and operational stages of a building. After six years of development, the CDM has become better tailored to support different kinds of projects. Experience has been gained in the field, where more resources have been put into project development and implementation.

As more projects have reached the CER production phase, the role of project management has become increasingly important. CDM quality assurances for CER delivery have been translated into good project management and business practices in some successful projects. In the building sector, CDM project management could potentially help to introduce much-needed energy management practices and positively change end-user behavior.

The only project in the building sector that is currently producing CERs is the ITC Sonar Hotel in India. The hotel has integrated many energy-saving practices into its daily management operations to ensure that the CDM project's objectives are realized. Energy-saving goals have been clearly established by the hotel's top management. Energy conservation practices are designed for, and required of, hotel employees. Energy-saving goals are also translated into management norms. The hotel gives credits to all employees for their energy-saving activities and factors those activities into employee performance evaluations that affect remuneration. The hotel's energy management team also shares CER benefits. Altogether, such practices have created a proactive and healthy energy-saving culture in the business (Chattopadhyay, 2007). Although these changes in the hotel's business practices cannot be entirely attributed to implementation of the CDM project, the project is clearly a key driver of change.

Indeed, an additional benefit of the CDM's strong quality assurance requirements is that it seems to inspire project owners to take on additional quality control measures, such as voluntarily adopting internationally recognized standards and management tools. The stricter and more specific quality control measures contained in these international standards further increase the management quality of CDM projects. For example, the ITC Sonar Hotel project uses the Six Sigma Concept[11], score cards[12], and the ISO 9001 and 14001[13] management systems. The good quality control practices contained in these management tools and standards – such as documentation, internal audits, employee training, and continuous improvement – are adapted for energy management purposes. These additional quality control measures not only ensure the delivery of CERs, but also eventually help to institutionalize energy conservation practices.

Changing user behaviors is perhaps the most challenging aspect of project management and potentially one of the largest co-benefits of the CDM, which requires effective monitoring. Internalizing energy-saving behavior requires not only education and training to induce changes but well-designed programs to sustain them. Information feedback on end-user consumption behavior is an effective tool to bring about conscious behavior changes.

[11] Six Sigma is a business management strategy originally developed by Motorola to systematically improve manufacturing and business processes by eliminating defects and errors. Six Sigma asserts that: (1) continuous efforts to reduce variation in process outputs is key to business success; (2) manufacturing and business processes can be measured, analyzed, improved and controlled; and (3) achieving sustained quality improvement requires commitment from the entire organization, particularly from top-level management (Motorola University, 2008).

[12] The score card systems implemented by the ITC Sonar Hotel measures employee revenue generation, work quality and cost, and the energy-saving activities of each employee in the cost calculation. Overall performance, as measured by these three criteria, is tied to employees' salary and bonus evaluation system (Chattopadhyay, 2007).

[13] ISO 9000 and 14000 are international management system standards developed by the International Organization for Standardization. ISO 9001 contains a generic set of requirements for implementing a quality management system, as does ISO 14001 for implementing an environmental management system (ISO, 2007).

The Technopolis project has implemented several energy-conservation training programs aimed at changing the energy consumption behavior of the building's commercial tenants. The effectiveness of these efforts will be measured when the CDM project enters the implementation stage (Mehta, 2007). In the ITC Sonar Hotel, real-time and daily reminders of energy consumption data (using per square meter energy consumption as an indicator) are displayed in the work place. The display also includes comparative information from other ITC hotels, which provides goals, confirmation of performance and competition in the daily work routine.

Apart from end-users, stakeholders in the building and construction business require various levels of training and commitment to implement effective energy-saving features in building construction. The required training includes best practices in energy efficiency design, construction and commissioning. Although governments, industrial organizations, and international donors have organized such training in the past, the impacts of these efforts tend to stay at a superficial level unless the lessons are put into practice. Engaging stakeholders in CDM's quality control and project management scheme could provide necessary learning-by-doing and helping building professionals to internalize best practices.

In summary, CDM projects in principle offer good opportunities to stimulate energy efficiency practices among businesses and building end users. CDM projects and programs provide a platform for coordinated actions and commitment, and to educate all stakeholders, and internalize energy saving behaviors in the building sector. The effect could be sustained as long as the projects are effective. The success could be replicated by other CDM projects or programs, and may spill over to other building projects.

4.5. CDM as a complement to policy implementation

Favorable government policies are considered to be among the cheapest and most important means of achieving reduced GHG emissions from buildings (Koeppel and Ürge-Vorsatz, 2007). Strong policies have the potential to stimulate new business activities and change prevailing business practices on a wide scale. The speed, extent, and depth of adaptation to new practices are often strongly related to the level of enforcement of standards and regulations. In most cases, mandatory policies have faster and deeper effects than voluntary ones.

Government standards and regulations designed to reduce different types of emissions have long been adopted in developed countries. The experience from these countries, however, shows that enforcing compliance with top-down approaches has been slow. Building codes have been thought to be one of the most effective instruments for achieving energy efficiency in buildings. Still, only 40 percent of new buildings comply with building codes in the UK, and this figure is as low as 20 percent in the Netherlands (Koeppel and Ürge-Vorsatz, 2007). Energy efficiency codes for existing buildings have even lower compliance rates.

Many developing countries don't yet have adequate building codes, let alone regulations for energy efficiency in buildings. Governments, especially in least developing countries, often have limited capacity to design and implement energy efficiency policies and programs (Painuly, et al., 2007). Some faster-developing countries recognize the importance of the building sector in saving energy and have incorporated energy conservation regulations into their building codes. Standards in many countries remain voluntary, however, and some have only been implemented in economic sectors where the regulatory environment is more mature. For example, South Africa and Brazil recently introduced voluntary energy efficiency standards for commercial buildings[14].

In a few developing countries where building energy efficiency standards have been made mandatory, compliance has been a problem. In China, for example, compliance with new building codes in small cities and rural areas has been low. In the cities where compliance appeared high, studies have found very high rates of false compliance. One study found that 70 percent compliance with the standard for new buildings was in reality only 30 percent compliance (Koeppel and Ürge-Vorsatz, 2007).

A key reason for low compliance is weak enforcement. Local governments, on which the enforcement burden often falls, typically have limited workforces and little expertise to undertake inspection, supervision and enforcement tasks. These responsibilities require large numbers of professionals with sufficient knowledge and experience in energy efficiency and various engineering fields. This knowledge and experience is greatly lacking in least developed countries (Painuly, et al., 2007). Human and financial resources are simply not sufficient to implement policies at the local level.

In fast developing countries, construction booms and the business community's desire for fast growth and profitability exacerbate these enforcement challenges. Most regulated entities lack adequate human resources, quantitative techniques, tools and monitoring matrices to help design, evaluate, monitor, and manage building projects based on a project's individual needs. Compliance also requires regulated entities to obtain financing for capital investments and management (operational) costs for interventions. As explained in sections 3.6 and 3.7 above, a number of obstacles exist to obtaining this financing. Lacking the means and the financing to comply, and in the absence of effective enforcement, most entities have little incentive to comply with the law.

Many of the CDM's elements – its project-based approach, the availability of programmatic CDM, the accessibility of project design documents, and built-in quality control and management mechanisms –can complement government policies and help to bridge the building standards compliance gap. By providing some financial incentive, mobilizing human resources, providing methodologies to quantify and measure results, and by supplying monitoring mechanisms and resources to ensure compliance, the CDM can provide the necessary means to assist EEB project development and accelerate implementation of national energy efficiency agendas.

At the same time, strong government policies could equally help to motivate broader participation by private businesses and individuals in CDM projects or other EEB activities. The evidence to date suggests that voluntary approaches can be expected to continue to yield only sporadic action given the obstacles to building sector energy improvements. Major incentives will be needed to create momentum and exploit the CDM's potential to reduce GHG emissions through EEB projects. Mandatory energy efficiency standards have proven to be efficient if enforced. Tax incentives, financial incentives and capacity building programs could provide additional stimulus. And efforts will be needed to educate and make building sector stakeholders aware of the opportunities and benefits presented by complying with government policies and participating in the CDM.

[14] South Africa has two voluntary commercial building standards: SANS 204, which regulates artificially ventilated commercial and public buildings, and SANS 283, which regulates naturally ventilated buildings.

4.6. CDM financing for energy efficiency projects in buildings

There are three ways in which the CDM could serve as a good complementary mechanism for financing EEB projects:

- by reducing various financial risks inherent in EEB projects;
- by making life cycle-based financing more acceptable to investors; and
- by providing complementary financing to offset increased investment and transaction costs.

The CDM can reduce financial risks

The CDM reduces the financial risks associated with small-scale projects and "long-tail properties". In the financial market, it is always easier to obtain funding for large projects than for small ones. By encouraging coordination and enabling the bundling of multiple small investment opportunities the CDM, and in particular programmatic CDM, helps to create economies of scale that lower transaction costs and increase investor interest in project financing.

The CDM's various quality-control requirements provide an added layer of security to prospective investors. CDM project registration indicates a project's overall intention to adhere to a set of external performance standards and to maintain project quality. Similarly, validation and verification requirements help to confirm project viability and provide some assurance that a project's energy-saving features will be implemented and will deliver promised CERs. Thus, the CDM's quality control mechanisms could help to increase a project's survival rate and reduce the risk of default.

The CDM can make life cycle-based investments more acceptable

The uncertainty and the perceived high risks associated with life cycle-based approaches to financing were described in section 3.6. The CDM's strict rules for evaluating a project's emissions reductions, however, could help to define and confirm energy cost savings. The CDM requires projects to adhere to approved methodologies in order to establish baseline emissions and to calculate the emission reductions to be achieved. The validation of a project by third-party DOEs, based on approved methodologies, can confirm at the project's outset that an approved project will deliver energy savings from implemented measures. In this sense, CDM-validated projects offer a degree of certainty that other projects lacking verifiable baselines and energy-saving features cannot offer. This is especially important in new buildings where the relative energy savings are difficult to estimate.

During a project's operational phase, the verification of CERs also offers a way to confirm energy savings in a building. CERs are verified based on pre-approved methods and the results of a strict monitoring plan. A third-party DOE reviews all related operational records and quantifies the energy savings and GHG emissions reductions attained. The CDM thus offers authorized proof of energy savings during the building's operation cycle. CER verification could drastically reduce the uncertainty and high perceived financial risks associated with proving energy savings and measuring energy cost reductions.

The CDM's risk reduction benefit could be used to design new financing products for EEB projects. For example, the reduced project risk could be reflected in reduced interest rates or favorable payment terms conditioned on project validation or registration as well as CER verification and certification. Linking energy savings to project financing terms could provide further incentives for project participants to increase energy savings.

Although the tools and evaluation methods offered by CDM methodologies and the DOEs could not substitute for a financier's own assessment of project risks and returns, they could serve as a commonly accepted framework for evaluation and an additional layer of security for investors. The CDM thus has great potential to ease the uncertainties surrounding energy efficiency project financing.

The CDM can provide complementary financing for EEB projects

Financial institutions are often instrumental in financing construction projects. In the same way, the support of financial institutions for future green building initiatives will also be essential. Most developers and real estate investors, however, have established networks, credit arrangements, and financing models with financing institutions. The financial institutions have traditionally acted as the first 'gate keepers' for project quality control. In this regard, the financial sector is still weak in many respects.

The CDM has the potential to complement and enhance the financial sector's ability to fund energy efficiency projects. The CDM's risk reduction function and quality control mechanism could help projects to achieve healthy financing conditions. In addition, funding from CERs for CDM project management could complement capital available from financial institutions to increase the overall amount of funds available for EEB projects.

The complementary financing available from CDM is especially promising with respect to programmatic CDM. Programmatic CDM has the potential to generate support for implementation of building sector energy efficiency policies/standards. Under this approach, all buildings and regulated entities, including medium and small builders, would need to comply with efficiency standards and policies. In most developing countries, the financial sector is not currently ready to finance energy efficiency projects encompassing a large number of smaller activities/buildings. CDM's unique support mechanisms could provide very useful, if not essential, financial support for the implementation of such policies. The additional financing provided by CDM credits could help to pay for increased management and transaction costs occurred in the small EEB activities. The support of the CDM would be especially important for medium and small businesses and in areas where local financial institutions have limited resources and expertise.

4.7. CDM as a green indicator

Sustainability has become an increasingly attractive feature for businesses and housing alike. The "climate friendly" brand identity of CDM projects is useful for verifying a building's energy savings, climate-friendly features and, therefore, added value. This aspect of the CDM is especially attractive to business stakeholders, including builders, owners, tenants, and even banks.

The visibility of "green behavior" is important to environmentally conscious consumers and businesses. Visible behaviors rapidly denote a green identity. When a "green authority" sanctions a certain type of behavior, the processes of identity formation tend to be accelerated. The degree of visibility of a behavior and its relationship to identity formation and image is important for behavioral changes (Linden et. al., 2006). The

CDM's green identity is an important motivation for building projects, as it is clear now that the financial incentive is not a sufficient driver for CDM projects in buildings. Thus far, all commercial building CDM projects have been motivated to a greater or lesser extent by the added value that CDM's green identity has given the building. Gaining an improved corporate image via the green identity associated with CDM project approval has been one of the most significant motivations for CDM project development, several studies indicate (Chattopadhyay, 2007, Mehta, 2007, Esparta, 2007). CER revenues are only considered an additional benefit. Several project participants also indicated that they had received increased publicity due to CDM registration or application (Chattopadhyay, 2007, Mehta, 2007, Esparta, 2007).

Green identities have been an important driver for buildings to go green in countries where no energy efficiency standards are mandated. An example of a widely accepted green identity offered for buildings is the LEED certification promoted by the US Green Building Council. As a voluntary third-party rating system, LEED has certified approximately 1,500 projects. Another 12,000 projects are currently registered for certification in the USA predominantly, but also in 30 other countries (USGBC, 2007). In India, LEED certification is in its start-up phase. The Technopolis project was one of the first few buildings designed and constructed to meet LEED standards. When Technopolis opened in 2006, the market was highly responsive to this green identity, and all office spaces were leased out in a very short period of time (Mehta, 2007).

During interviews for this report, several consultants indicated that they had been approached by large real estate developers interested in exploring the possibility of CDM registration for their green building plans (Stiles, 2007, Spalding-Fecher, 2007). The Technopolis' development group also stated that it was considering developing additional CDM EEB projects. The CDM has the potential to create a highly visible and internationally recognized "climate friendly" identity for its registered projects. With proper support and positioning, the CDM, in combination with other green certificates, could play a significant role in encouraging buildings to go green.

V. THE CHALLENGES TO USING CDM FOR ENERGY EFFICIENCY IN BUILDINGS

The evidence shows that the CDM has hardly at all realized its potential as a support mechanism for the promotion of building energy efficiency in developing countries Limitations in the CDM's modalities, procedures and methodologies are contributing to the CDM's under utilization. This section summarizes aspects of the CDM which present challenges to its full utilization as a stimulus for building energy efficiency projects.

5.1. CDM additionality and policy implementation

Under Articles 6.1b and 12.5c of the Kyoto Protocol, all CDM projects must result in emission reductions that are *additional* to any emission reduction that would occur in the absence of the CDM project (United Nations, 1998). The additionality requirement is intended to make projects ineligible for CDM support if they would have been implemented even without CDM support. The Marrakech Accords defined additionality as follows:

> *A CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity." (Marrakech Accords, Decision 17/CP.7, 2001)*

The ability of CDM to help governments implement policies has been examined extensively (Cosby et al., 2007). Although the CDM has the potential to assist governments in the implementation of mandatory standards, the additionality requirement has been identified as a major challenge to realizing this potential. Mandatory standards and other policies are among the most effective mechanisms to mobilize stakeholders to pursue energy efficiency improvements in buildings. By their inherent nature, however, emissions reductions based on policies and standards can be argued not to be additional to those that would occur otherwise, i.e., under law.

The CDM rule-making process has been lengthy and inconclusive at best with respect to additionality in policy projects. Indeed, additionality-related rulings and tools involving policy implementation have not only not set forth clear criteria, but have been criticized for being ambiguous, misleading and sometimes inconsistent. This makes proving additionality with certainty, and obtaining validation of projects implementing mandatory policies, difficult, if not impossible, in many cases (Schneider, 2007).

According to the additionality tool[15] that the CDM Executive Board published, in order to demonstrate a project's additionality, the project needs to use as a baseline all plausible alternative scenarios to implementing the proposed project. If the alternative scenarios would not comply with all mandatory applicable regulations, the project must also show that the regulations are "systematically not enforced". This was further clarified in a 2004 EB decision stating that:

> *If the proposed project activity is the only alternative amongst the ones considered by the project participants that is in compliance with mandatory regulations with which there is general compliance, then the proposed CDM project activity is not additional* (EB 15, Annex 3, 2004).

[15] The additionality tool is a methodology approved by the Executive Board that can be used to determine whether a project meets the CDM additionality requirements (EB 39, Report, Annex 10).

Many project developers have interpreted this ruling to mean that projects activities complying with mandatory regulations would automatically fail to meet the additionality requirement. There was an underlying notion that the existence or introduction of a climate-friendly policy or regulation in a developing country would make a project affected by such a policy non-additional and thus not eligible for the CDM (Hinostroza et al., 2007).

Another EB ruling, in 2005, clarified that baseline scenarios need not take climate-friendly policies into account if the policy was implemented after November 2001 (EB 22, Annex 3, 2005, see box 1). If this is the case, then projects adhering to energy efficiency-related policies, regulations and standards implemented after 2001 could still be considered additional. The additionality tool, however, does not reflect this ruling. Instead, confusion remains regarding how projects implementing mandatory climate friendly policies can prove additionality.

In practice, DOEs examine additionality to government policies by checking with local regulatory authorities regarding compliance status. If relevant government policies have low compliance rates, this part of the additionality test is considered to have been passed (Biswas, 2007). The extent to which a regulation is considered not implemented, however, depends on the judgment of the CDM's validation and registration bodies and has not been well defined or communicated in the rulings.

Programmatic CDM rules on additionality for policy projects are also unclear. COP/MOP decisions and EB rulings have allowed PoA's to implement government policies. The COP/MOP decision in Montreal, 2005 opened the possibility for policy-related projects under a PoA to be registered as CDM projects:

> *…a local/regional/national policy or standard cannot be considered as a clean development mechanism project activity, but that project activities under [a] programme of activities can be registered as a single clean development mechanism project activity provided that approved baseline and monitoring methodologies are used that, inter alia, define the appropriate boundary, avoid double counting and account for leakage, ensuring that the emission reductions are real, measurable and verifiable, and additional to any that would occur in the absence of the project activity. (Decision 7/CMP.1, paragraph 20, 2005)*

This decision to permit programmatic CDM to support national policies or standards was further clarified by the EB 28 meeting in 2006:

> *A programme of activities (PoA) is a 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 CPAs.*
>
> *PoA addressing mandatory local/regional/national policies and regulations are permissible provided it is demonstrated that these policies and regulations are not enforced as envisaged. If they are enforced, the effect of the PoA is to increase the enforcement beyond the mandatory level required. (EB 28 Meeting report Annex 15, 2006b)*

The introduction of programmatic CDM and the decision to allow programmatic CDM to implement mandatory policies that are not well enforced has been generally regarded as a leap forward.

Box 1. *The most recent Executive Board ruling clarifying policy and CDM eligibility: EB 22, Annex 3, 2005*

1. A baseline scenario shall be established taking into account relevant national and/or sectoral policies and circumstances, such as sectoral reform initiatives, local fuel availability, power sector expansion plans, and the economic situation in the project sector.
2. As a general principle, national and/or sectoral policies and circumstances are to be taken into account in the establishment of a baseline scenario, without creating perverse incentives that may impact host Parties' contributions to the ultimate objective of the Convention.
3. The Board agreed to differentiate the following two (2) types of national and/or sectoral policies that are to be taken into account when establishing baseline scenarios:

   (a) National and/or sectoral policies or regulations that give comparative advantages to more emissions-intensive technologies or fuels over less emissions-intensive technologies or fuels[1];

   (b) National and/or sectoral policies or regulations that give comparative advantages to less emissions-intensive technologies over more emissions-intensive technologies (e.g., public subsidies to promote renewable energy or finance energy efficiency programs)[2].
4. The Board agreed that these two (2) types of policies shall be addressed as follows:

   (a) Only national and/or sectoral policies or regulations under paragraph 6 (a) that have been implemented before adoption of the Kyoto Protocol by the COP (decision 1/CP.3, 11 December 1997) shall be taken into account when developing a baseline scenario. If such national and/or sectoral policies were implemented since the adoption of the Kyoto Protocol, the baseline scenario should refer to a hypothetical situation without the national and/or sectoral policies or regulations being in place.

   (b) National and/or sectoral policies or regulations under paragraph 6 (b) that have been implemented since the adoption by the COP of the CDM Modalities & Procedures (decision 17/CP.7, 11 November 2001) need not be taken into account in developing a baseline scenario (i.e., the baseline scenario may refer to a hypothetical situation without the national and/or sectoral policies or regulations being in place).

[1] So called type E+, policies that increase GHG emissions
[2] So called type E-, policies that decrease GHG emissions

Source: UNFCCC website

These advances are particularly important for energy efficiency projects, which directly address the CDM's core purpose and the root cause of climate change – our carbon-dependent consumption economies. Unless the additionality rulings are further clarified, however, the potential of programmatic CDM to support mandatory policies and promote energy efficiency projects will not be fully realized.

Additionality is essential to ensure CDM's environmental integrity and to screen out free-rider projects. The additionality requirement, however, has limited the CDM's potential to support climate-friendly policy implementation, as demonstrated previously in section 4.5. The challenge ahead for the CDM is to find a delicate balance that avoids free riders without losing great opportunities for the mechanism to achieve its core mission of GHG emission reduction

Box 2. *Methodologies AMS-II.E and AMS-II.C*

CDM methodologies are normally developed for large-scale projects and contain a full set of stringent requirements. In an effort to encourage more small projects to apply to the CDM simplified methodologies were developed. AMS-II.E and AMS-II.C are the small-scale methodologies most relevant to EEB projects. Neither methodology is applicable to projects with aggregated energy savings exceeding the equivalent of 60 GWh per year.

AMS-II.E: *Energy efficiency and fuel switching measures for buildings*
This project category comprises any energy efficiency and fuel-switching measure implemented in a single building, such as a commercial, institutional or residential building, or group of similar buildings, such as a school, district or university. This category covers project activities aimed primarily at energy efficiency. Examples include technical energy efficiency measures (e.g., energy-efficient appliances, insulation, arrangement of equipment) and fuel-switching measures (e.g., from oil to gas). The technologies may replace existing equipment or be installed in new facilities.

AMS-II.C: *Demand-side energy efficiency activities for specific technologies*
This project category comprises activities that encourage the adoption of energy-efficient equipment, lamps, refrigerators, motors, fans, air conditioners, appliances, etc. These technologies may replace existing equipment or be installed at new sites.

Source: UNFCCC website/methodology/small scale methodology

5.2. Difficulties related to technology-based methodologies

Due to the generally small-scale nature of building sector projects, the most important approved methodology for building efficiency improvement is AMS-II.E, "Energy efficiency and fuel switching measures for buildings". Another methodology that could be used for energy efficiency improvement in buildings is AMS-II.C, "Demand-side energy efficiency activities for specific technologies". Both of these technology-based methodologies are described in Box 2.

In general, CDM modalities, methodologies, and project auditing methods are reductionist and micro-managing in their use of technology-by-technology and measure-by-measure project controls. Such requirements and practices make validation, auditing, monitoring, and verification unreasonably cumbersome for project proponents and auditors. Management requirements and associated costs impose hardships on small-scale building projects, which generally implement many different types of energy efficiency measures, often in many buildings.

CDM methodologies for energy-efficiency projects generally require that all installed technologies produce "real and measurable" emission reductions. Direct measurements are preferred for all projects, with the exception of small end-use technology deployments, such as Compact Fluorescent Lamp (CFL) distribution, for which some sampling is allowed. Direct and continuous metering is required, however, for each sampled light bulb. For example, a methodology for large-scale CFL distribution (AM0046) requires direct metering of all light bulbs in the sample and control groups. The resulting monitoring burden and costs are huge. By one estimate, at least 2 million CFLs would need to be distributed and 500,000 would need to be metered in order to make a CFL programme attractive and viable (Michaelowa, 2007). AMS-II.C could be used for CFL distribution, but similar sampling and metering are required. Without a distribution volume that is large enough to achieve economies of scale, high monitoring costs diminish the possibility that such projects will be viable. The recent approval of a "deemed savings" methodology [16] for CFL distribution (AMS-II.J, EB, 2008) is an encouraging step toward reducing monitoring burdens for end-use energy efficiency projects.

Current CDM EEB projects also face the challenge of technology-based validation and verification requirements. For example, the ITC Sonar Hotel project employed many energy efficiency features before and after the project's inception. Some retrofitting improvements, however, such as improved shading, could not be taken into account due to the difficulty of proving the direct emission reduction contributions of the particular technologies. In addition, projects need to retain detailed records, from purchasing and installation to operation, for all registered technologies. All of the CERs from a particular technology will not be approved if only one or two pieces of records are unobtainable (Chattopadhyay, 2007). In practice, these requirements present significant hurdles for project development.

5.3. Difficulty in establishing baselines for new buildings

Successful EEB projects often include energy-efficient building envelopes and holistic designs that anticipate efficient use (Levine et al., 2007, UNEP, 2007, Hinostroza et al., 2007). This may include using energy-efficient equipment, measures to facilitate energy-saving habits, and built-in monitoring and information feedback systems during the design and construction stages. In new commercial buildings, integrated design combined with energy-saving behavioral changes and full commissioning and maintenance can result in 30-50 percent savings, and up to 80 percent savings if more advanced approaches are used (Levine et al., 2007). Implementing EEB concepts from the design stage in new buildings is always more beneficial and cost-effective than retrofitting later. In the building sector, construction costs typically increase by only 5-10 percent due to the introduction of energy efficient solutions, although this figure may vary according to construction type (UNEP, 2007).

Incorporating energy efficiency concepts into new buildings has special significance for developing economies. Construction booms in fast-growing economies, such as China, India, and some Latin American countries, have substantially boosted energy demand in the building sector. Due to the long life cycle of buildings and the projected new demand for public and private construction, energy consumption in the building sector is expected to continue to grow dramatically over the next 30 years (WBCSD, 2007, EIA, 2006, Levine, 2007). In most developing countries, it makes perfect sense to focus the implementation of energy efficiency on new buildings rather than on

[16] The World Bank first submitted the deemed savings methodological approach for use in CFL deployment. The approach is suitable for small end-use technologies with known performance. The methodology derives from a lifetime of deemed electricity savings (kWh) that requires no direct metering (Bosi, et al., 2008).

retrofitting existing ones (Hinostroza et al., 2007). Designing and constructing these buildings properly from the beginning will save money and effort over the long run.

Current CDM methodologies for developing baselines, however, are not well adapted to construction projects. According to country experts interviewed, the lack of a methodology for establishing emissions reductions baselines in new buildings is one of the leading obstacles to CDM participation. Establishing a baseline requires that data be collected from comparable buildings. Buildings typically have long life spans, and unique and sometimes site-specific designs. They also have different uses and undergo regular renovation. These factors make it very difficult to find comparable buildings, as does the frequent absence of good quality surveys or statistical data in developing countries. By contrast, establishing baselines for retrofit projects can be easier, provided older monitoring data for the target buildings are available.

So far, not a single project targeting new buildings has been registered in the CDM pipeline. The two newly constructed commercial building projects in the pipeline, the Technopolis and Olympia projects in India, are still under validation. In these cases, the project developers used as a baseline data from a hypothetical "typical" building that would have been built had the project activities not been implemented. The acceptability of this approach is still subject to EB review. Should they be validated, the two projects would serve as indicators of how the baseline issue could be handled in future new building projects.

5.4. Evaluating the thermal performance of buildings

Thermal performance is an essential aspect of a building's energy use and efficiency. The current methodology available for building energy efficiency improvement, AMS-II.E, is not suitable for estimating patterns of heating and cooling and improvements in thermal performance. The difficulty comes from its technology-based evaluation approach. Many thermal improvement measures are not specific, installed technologies and do not fit within the building envelope improvement categories listed in AMS-II.E. For example, orientation, passive cooling, building shape, shade, and opening designs are effective measures that can be used to improve thermal performance of buildings. These measures, however, are part of a building's structure design and are difficult to classify as specific technologies for baseline, validation, monitoring and verification purposes.

Another difficulty comes from the complexity of establishing baselines for cooling and heating systems. Energy consumption for cooling and heating buildings is based on a number of variables. Consumption can be related not only to specific technologies, but also to how, and to what extent, technologies are used, operated and maintained. Different building types employ different materials and technologies, and are subject to varying climate conditions, end-user comfort requirements, and cultural and consumption habits. For small projects with many end-users, such as residential buildings, establishing baselines is complex if average values and estimates for consumption patterns and conditions are not allowed. Baselines for commercial buildings may be relatively easier, because their use and consumption patterns are more predictable, particularly where centralized heating/cooling systems are used. Nevertheless, local data and usage patterns can still be difficult to obtain for new commercial buildings.

5.5 The combination of different methodologies is not allowed for programmatic CDM

The latest version of the PoA guidance (June, 2007) states that a PoA must apply one single approved baseline and monitoring methodology (EB32, Annex 38, 2007). The rules do not allow a combination of methodologies to be used in the same CPA. A CPA could be an area in which a group of efficiency measures (e.g., efficient lamps, ballasts, air conditioners, fans, etc.) are applied to many homes, but they all must apply the same CDM methodology (Figueres and Phillips, 2007). These rules seriously constrain projects in the building sector, especially large-scale projects, which require the flexibility to deploy a variety of energy-saving approaches. In theory, the restriction is less onerous for small-scale projects, where small-scale methodologies can be applied. AMS-II.E allows small-scale projects to combine the use of different energy efficient technologies in a CPA for one PoA. AMS-II.C also allows a CPA to include several different types of energy efficiency improving appliances. Nevertheless, the possibility of using a holistic design approach to include multiple types of carbon emission reduction technologies is still limited.

Other methodologies that could potentially be used for building energy efficiency improvements include:

a. AMS-II.D, *Energy efficiency and fuel switching measures for industrial facilities*, for community heating system improvements;
b. AMS-I.C, *Thermal energy for the user with or without electricity,* for cooking, home heating and water heating; and
c. AMS-I.A, *Electricity generation for users,* for renewable energy generation that supplies individual households.

The one-methodology constraint of programmatic CDM implies that a CPA could not include, for example, building envelope improvements, appliance improvements, and/or community heating projects at the same time, because these approaches require the use of three different methodologies. Similarly, a development project that includes energy efficient equipment, solar heating, and photovoltaic electricity features in a number of buildings would have to apply for three PoAs or face rejection, because AMS-I.C, AMS-II.E, and AMS-I.A could not be used at the same time. Such combinations of measures, however, are not only very common in the demand-side management strategies being implemented, e.g., by ESCOs and utilities, but are crucial to optimizing overall energy savings. In addition, this restriction imposes unnecessary transaction costs on project proponents seeking to use combined technologies. Ultimately, the restriction prevents some of the best practices in the building industry from being implemented in the CDM.

5.6. Restrictions on recognizing soft measures

When it comes to saving energy, changing consumption behaviors and instilling basic energy awareness is often as important as deploying technological improvements. The impacts of EEB projects could be significantly enhanced by combining technological changes with soft (or management) measures to reduce energy consumption. These include using good standard operation procedures (SOPs), proper commissioning, good maintenance, optimizing operational conditions, recordkeeping, linking energy savings to professional evaluation and advancement, using energy-consuming devices on an as-needed basis, providing proper consumption information feedback, and learning how to change consumption patterns and save energy (Hinostroza et al., 2007). Soft measures are essential to optimizing the energy-saving benefits of a technological improvement project.

Being technology based, the CDM does not allow direct accounting for energy savings from soft measures incorporated into EEB projects, even though they increase emission reductions from technological improvements. For example, the proper commissioning and fine-tuning of energy systems in new buildings is crucial to maintaining efficient operations throughout the buildings' life cycles (Levine et al, 2007). Building commissioning has shown potential energy savings of up to 38 percent in cooling and/or 62 percent in heating (Levine et al, 2007). On the other hand, the installation of efficient technologies without proper commissioning would needlessly forsake substantial energy savings. Commissioning is usually done in an integrated manner and, therefore, could not be attributed to a specific technology improvement. Post-occupation fine-tuning, the optimization of operational conditions, and the changing of consumption patterns during a building's operation phase are other measures that could result in significant savings but are not associated with specific technology improvements. Because such management measures are not required and cannot be directly accredited, this energy-saving potential is not being tapped by CDM projects.

The Pão de Açúcar projects studied in this report are the first to seek CER credits from soft measures. The endeavor has undergone tough reviews as it seeks to fulfill validation and verification requirements. The projects have passed validation by a DOE but were rejected by the EB. The EB decision stated that the project had failed *"to sufficiently substantiate that the monitoring requirements of AMS-II.E, in particular with respect to ensuring that CERs can be claimed only for energy savings due to the measures installed, would be correctly applied in the project activity"* (EB, 2007). The decision demonstrated the difficulty of providing sufficient evidence and drawing direct linkages between soft measures and emission reductions in the current CDM modality. Resubmission and further development of the Pão de Açúcar projects will test CDM's flexibility and ability to embrace soft measures using the methodologies currently available.

5.7. Challenges in low-income residential building projects

The low-income housing sector has struggled to take advantage of the CDM. . Low-income families often suffer from energy poverty, i.e., having the ability to consume only the minimum amount, or less, of the energy required to meet basic needs. Although the technologies used in low-income family buildings generally have large capacities for energy-efficiency improvements, the actual amount of energy consumption is so low that not much carbon emission reduction could be achieved from the efficiency gain. On the other hand, low-income housing projects that aim at reducing energy poverty, by default, often increase the energy use of low-income families, even though the amount of energy use remains very small in real terms. Nevertheless, the low overall energy consumption level means that at best comparatively small energy saving (and GHG reductions) and only minimal financial benefits can be generated in these types of buildings. As a result, many efforts to use the CDM to tackle energy poverty and improve energy end use in this sector have never materialized. Many developers have decided that the CDM is not viable for low-income housing and have chosen not to pursue CDM registration. The iEEECO Village project investigated in this study provides a case in point (see Appendix 3 for detail).

The Kuyasa project, on the other hand, found a way to overcome this challenge and registered as a CDM project. The Kuyasa project made a breakthrough in the CDM at a time when the CDM rules were less stringent and a highly sustainable first project from Africa was much needed. The project uses a "suppressed demand" model, which has made it possible for it to receive credits based on hypothetical rather than actual current energy consumption levels. The suppressed demand model counts avoided future emissions based on a calculation of "normal" energy demand that is not experienced by low-income families. In the case of space heating, for example, the suppressed demand model determines a baseline based on heating provided by electric heaters to a level of thermal comfort in houses without insulated ceilings. This hypothetical baseline assumes an "improved lifestyle" because the current practice among the Kuyasa project families is to use kerosene stoves for space heating, and only for a short period of time when it is very cold. Similarly, the project's suppressed demand model assumes on-demand hot water consumption using electric water heaters as a baseline technology, instead of the current practice of batch water heating on kerosene stoves. These assumptions maximized the CER that could be generated and helped the project to be at least initially viable under the CDM.

Even with the help of the suppressed demand model, however, the financial benefits from the CDM are not enough to cover the additional capital costs of emission reduction investments in buildings. Additional financial support from other sources is still needed. The Kuyasa project has been registered since August 2005. Except for ten demonstration houses, the project had not been implemented at the time of the study team's visit due to funding issues. Despite the fact that the Kuyasa project was given the best conditions for project approval, CER crediting and pricing, the project's lack of progress illustrates the difficulty that low-income housing projects confront and the CDM's shortcomings as a mechanism for financing such projects.

The suppressed-demand approach is not without shortcomings. The baselines are technology specific. Technologies are chosen to maximize CER gain, despite the fact that they may not be best suited to the energy technology needs of low-income families. For example, the solar water heaters installed in the Kuyasa project are of minimal use in most of the demonstration households. Residents are accustomed to heating water while they are cooking, and washing with buckets. Solar water-heated shower facilities are considered a waste of water.

More importantly, the future replicability of the Kuyasa project is in doubt. The CDM project evaluation process has become stricter since the Kuyasa project was registered. The interpretation of "real and measurable" emission reductions is now more stringent. Future projects using the suppressed demand model may face new scrutiny by CDM auditing and regulatory bodies and may no longer be acceptable, despite the benefits this innovative approach has provided.

The CDM was created for two purposes: to combat climate change through GHG emission reductions and to support sustainable development in developing countries. In its current form, the CDM only assigns monetary value to GHG emission reductions, and not to project contributions towards sustainable development. The CDM has been heavily criticized for not sufficiently fulfilling its sustainable development mandate, which is one of its most challenging tasks (Schneider, 2007). CDM projects in the low-income housing sub-sector are closely tied to livelihood creation, poverty reduction and sustainable development in host countries. At the same time, these projects also tend to be smaller and, therefore, require less capital. By facilitating more low-income housing energy improvements the CDM could help to alleviate poverty and address its sustainable development goal.

VI. From constraints to opportunities in CDM for buildings

This section sets forth a set of recommendations aimed at increasing the quantity and quality of EEB projects supported by the CDM. Taken together, the recommendations provide a consistent, energy performance-based regulation concept as well as proposals for changes to various aspects of the CDM regime. The recommendations are based on findings from the field and concepts and ideas for improving CDM found in related literature. Some recommendations requiring negotiation will be best discussed within the framework of a post-Kyoto mechanism. Other recommendations call for methodological changes that could be implemented immediately and would pave the road for future regime change. An additional group of recommendations call for basic research that could be initiated now in preparation for new negotiations and new methodological proposals.

6.1. Moving away from technology-based methodologies for small end-use energy efficiency projects and programmatic CDM

As discussed in section 5.2, the regulation, methodological design and management practices of the CDM employ a micro-management approach. Recently, as project volumes have increased sharply, and more CO_2 reduction and small-scale projects have entered the pipeline, the overhead burdens for validators and CDM regulators have increased proportionately. Should the CDM begin to allow standards and regulation activities in EEB projects, the project volume is expected to increase tremendously.

For small end-use energy efficiency and programmatic CDM projects, the problem of overhead costs and the efforts required to register CDM projects is even more prominent relative to the sizes and potential benefits of the projects. In programmatic CDM, including small end-use energy efficiency projects, the number of individual activities could be in the range of thousands to hundreds of thousand, depending on the program design and project boundaries used. In such cases, tremendous administrative burdens would fall on project and program coordinators, validators, and CDM regulators. At the same time, project-by-project, technology-by-technology, and measure-by-measure project management methods would become increasingly burdensome and ineffective.

As project volumes increase, CDM project management methods will need to be able to accommodate and effectively process large quantities of work. A change in the CDM's project management philosophy and processes will be required in order to reduce the overhead burden, increase project management quality (including validation, registration, and verification), decrease the lead time for project registration and CER verification, and lower the number of requirements placed on project proponents.

A number of approaches can be used to reduce overhead costs and management burdens as the number of projects increases. Some of the well-tested methods described below could be included in CDM methodologies to ensure effective and efficient project management outcomes.

Adopting statistical management tools

Sampling, verifying sampling results, and estimating project outputs are important elements of large-quantity project management. Monitoring large quantities of projects requires the use of established sampling and estimation methods, which reduce time and ensure valid results. These approaches need to be included in methodologies for small-scale projects and PoAs.

Reduce direct and constant monitoring of activities with small efficiency gains

A large part of the CDM overhead burden comes from the monitoring requirement. Direct and continuous metering is currently the monitoring method preferred for proving emission reductions. In buildings and small end-use appliances, however, not all technologies implemented can or should be directly metered. Requiring direct metering for interventions that produce minimal emission reductions is a waste of time and resources. More cost-effective, science-based ways to prove emission reductions should be considered in projects implementing small energy end-use technologies.

Use existing design tools and methods, management standards and protocols

For end-use energy efficiency projects that bundle small technology improvements in large quantities, CDM methodologies could include existing design tools, simulation models and other methods to assist with the evaluation of emission reductions. This is critical in order to reduce the time and effort otherwise required for validation and monitoring. Moreover, many building energy efficiency standards and protocols could also be adopted in CDM methodologies. It would be administratively easier and less costly for project proponents to be able to use the same reliably verified standards and protocols inside and outside the CDM framework.

6.2. Allow performance-based methodologies

In most building projects, combining technologies is a common and cost effective approach. Validating, monitoring, and verifying projects technology-by-technology and measure-by-measure is however resource consuming. Performance-based methodologies offer a good alternative means of accommodating energy end-use projects, which are characteristically small in scale and large in quantity.

Measuring energy performance per square meter is a common indicator for energy management in buildings and is suitable for project management purposes. Brazil submitted a methodology based on per square meter energy performance for food stores, but this submission was rejected (Esparta, 2007, de Almeida Prado, 2007, UNFCCC, 2005).

Performance-based methodologies offer several advantages for sustainable building and EEB projects:

- A combination of technologies could be implemented in one project. This is especially important for residential buildings. Because most residential buildings do not have centralized control systems for appliances or heaters, it is not practical to require metering and monitoring of all installed equipment and appliances, as is currently preferred by the CDM methodologies.

- Flexibility could be used in selecting building designs and materials, which is especially important for improving building envelope efficiency.

- Developers could more easily employ indigenous technologies and locally developed materials that are best suited to local culture, customs, and environmental conditions in developing countries.

- Performance-based methodologies would stimulate innovation and self-governance. Businesses would be empowered to choose and/or develop emission reduction technologies and measures most appropriate for their buildings.

- Soft (management) measures using performance-based methodologies could fulfill the CDM requirement for real and measurable results. Projects could include direct and indirect measures. The results of these measures are difficult to prove using technology-based methodologies, but are essential for improving emission reductions.

- Projects verified based on overall energy performance improvements, rather than specific technologies installed, could be continuously improved. New technologies and measures could be installed even after a project has been registered.

- Auditing and monitoring would be less cumbersome for project proponents and DOEs. Performing technology-based monitoring for multiple technologies is too costly in small projects. By relieving projects of this burden, performance-based approaches would facilitate general improvements in project management.

- Performance-based indicators could be combined with monitoring devices or information feedback mechanisms to send valuable energy consumption information to energy end-users. Such feedback systems are essential to inducing behavior changes in end-users.

- Performance-based methodologies would help facilitate better sectoral policies, a standard-based, post-Kyoto CDM scheme and total accounting of building sector CERs, as described in the following subsections.

6.3. Establish common baselines

Establishing common baselines that represent “business as usual” energy consumption levels in buildings and facilitate the determination of baseline emissions for buildings could overcome two major difficulties facing EEB projects in the CDM. The first is the difficulty that new buildings have in obtaining a representative and conservative baseline. The second is the challenge involved in establishing a reference for “suppressed demand” projects. They would also help to enable the development of a sectoral-standard CDM approach, as described in subsection 6.3 below.

Common baselines would facilitate scaled-up adoption of emission reduction projects in new buildings

The complexity involved in establishing baselines has affected the types of building projects that have been able to emerge. Project proponents must propose baselines against which the project’s emission reductions can be measured. As discussed in subsection 5.3, these baselines are relatively easy to obtain in retrofitting projects, but difficult when the project is a new installation.

Commonly accepted baselines established by authorized institutions or countries’ Designated National Authorities would be very helpful for project developers and could catalyze a significant increase in the number of EEB projects. A common baseline would be especially helpful for new construction projects that have the potential to be recognized as CDM programmatic actions. Baselines could be established at the country, regional and provincial levels based on building types, primary energy used and climate zones. Differences in building materials, designs, construction technologies, equipment and appliances, however, would make technology-based baselines difficult to develop. Performance-based baselines would be more practical, less complicated to establish and more likely to gain the acceptance of various key CDM stakeholders.

Computer simulation programs and other tools have made it possible to construct baselines using data on building types and materials, orientation, cooling and heating-degree days, etc., in different countries and climate zones. Data availability, however, may still be a problem in many developing countries. Estimations and extrapolations based on developed country data may be used for certain building types (e.g., commercial air-conditioned buildings), as long as CDM authorities could accept the methods used and results. Large-scale surveys would be needed in order to obtain data sufficiently realistic to establish baselines that meet the CDM's "real and measurable" requirement. Because of the diverse construction and energy use patterns in residential buildings, common baselines would be especially helpful to residential building projects seeking to participate in the CDM.

Those who are concerned that common baselines would not be representative of all building types and could not take into consideration local conditions and future variations, may consider the concept of common baselines problematic. Refining and adjusting baselines according to data availability, technology developments and changes in CDM crediting approaches, however, could solve technical concerns. Given the difficulties inherent in setting up EEB projects, the broader inclusion of these types of projects in CDM seems highly unlikely unless CDM regulators and authorized entities provide assistance for baseline development. The CDM has used a similar approach to solve problems in areas where project proponents have had difficulty obtaining data. For example, to facilitate the calculation of emissions from electricity use, commonly accepted emission factors published by local utility authorities are used to calculate emission reduction baselines. In many cases, the emission factors are "average" values that do not strictly reflect the actual emissions of the electricity producers from which the project draws power (UNFCCC, Annex 12, EB35, 2007b).

Common low-income building baselines would help achieve sustainability benefits

Having commonly accepted baselines could also address a difficult issue that the CDM was expected to address: promoting sustainable development. Establishing baselines for low-income housing has important implications for sustainable development in poor communities. Low-income families generally use only enough energy to sustain their survival. Consumption levels are so low that only limited GHG emission reductions can be achieved through improved efficiency. A programmatic approach does not help because energy savings per household are still too small to justify CDM financing. The current CER-focused evaluation system prevents projects with high sustainable development value but low CER generation potential to gain CDM support.

In one case, a suppressed-demand approach to developing the baseline has been accepted in a registered low-income project. Despite the shortcomings of this approach, described more fully in subsection 5.7, the suppressed-demand model could serve as a prototype for establishing low-income housing project baseline(s). A commonly accepted consumption baseline(s) could be chosen for the low-income housing sector. The baselines would not need to be strictly based on actual consumption but instead could use a hypothetical "normal" consumption level as a reference point. The baselines could be set to take into account a country's low-income family needs, development requirements, possible future demand and poverty reduction targets. This approach has the potential to improve the CDM's capacity to meet its explicitly stated sustainable development goal through projects in the low-income building sector.

6.4. Implement standards and regulations in the post-2012 regime

Strong links exist between the CDM and national standards and regulations. By facilitating the implementation of standards and regulations, the CDM helps to accelerate GHG emission reduction in developing countries. Better yet, however, would be to design into the post-2012 agreement a more comprehensive mechanism that makes more direct, proactive use of standards and regulations. To illustrate this possibility, an example of a sectoral proposal for a post-Kyoto mechanism based on the results of this study is set forth below:

The proposed sectoral crediting scheme would reach its optimal emission reduction results if the host countries were to implement mandatory energy efficiency standards and regulations. The developing countries, particularly emerging economies, would take responsibility for establishing sector energy efficiency standards based on energy performance in key economic sectors, especially ones with long-tail characteristics, such as the building sector. Regulated entities, i.e., businesses and companies, could apply to the CDM to obtain CERs for their emission reduction investments and activities that would help them comply with mandatory sectoral standards. The sectoral standards would be regulated as performance standards. In the building sector, the performance standard could be energy consumed per square meter.

There would be no binding targets for developing countries under this proposal. Host country and business responsibility could be established by setting a crediting baseline below the existing emission baseline. Not all emission reductions achieved from compliance with the sectoral standards would be creditable. As illustrated in Figure 6, only the portion of emission reductions that are achieved by energy performance improvements and that are exceeding the crediting baseline would be eligible for CERs. A crediting system of this kind would take advantage of the CDM's capacity to support implementation of standards and regulations, while also recognizing the need for host countries and businesses to take responsibility for emission reductions. The crediting baseline and the standards could be adapted over time to respond to science-based policy shifts, changing emission reduction requirements, technology developments, country development level differences, increased national responsibility for emission reduction and other factors.

Should regulated entities choose to go beyond compliance and meet a more ambitious goal, premium credits (potentially resulting in more value) could be issued. This extra incentive recognizes that emission reductions exceeding the regulatory requirement would require technological and management innovation as well as extra investments that would most likely be disproportional to the extra increment of emission reductions to be achieved.

Adopting a sectoral proposal with energy performance-based standards and common baselines would have a number of advantages:

- *Simplicity:* The proposal would be simple, measurable and understandable to all CDM project stakeholders, including business managers, end-users, project developers, verification entities, and CDM regulators.

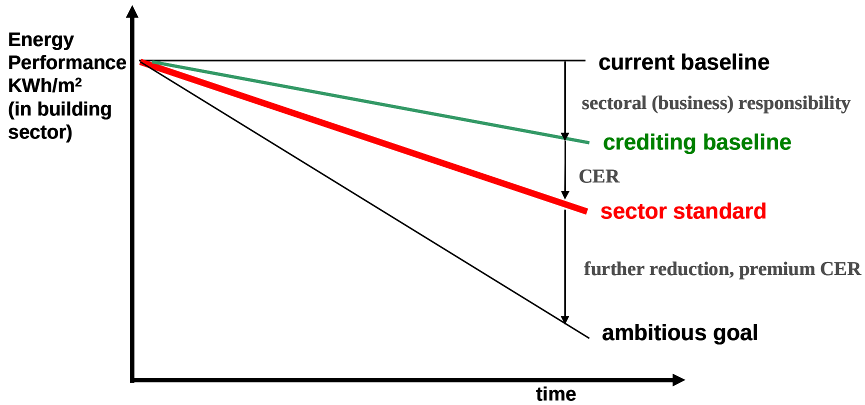


Figure 6. *Example of a crediting mechanism to include sectoral energy standards*

- *Consistency*: The use of an energy performance-based evaluation matrix would make it possible to establish consistency and greater transparency across CDM negotiations, CDM regulations, national policies, methodologies and project management requirements.

- *Ease of integration*: Baselines and indicators based on energy performance and per output energy consumption, rather than GHG intensity and carbon emissions, would integrate better with energy management systems in regulated entities. These energy savings could be converted to GHG emission reductions and CERs for overall GHG management at the national and international levels.

- *Country acceptance*: This approach has the potential to more easily gain acceptance among fast developing countries because (1) there is no binding target; and (2) most of these countries are developing, or have developed, building energy standards and codes with the goal of making them mandatory some time in the future. The CDM could help to accelerate this process.

- *Incentives*: Projects would be encouraged to go beyond compliance with sector standards, and technological innovation would be spurred. Projects that go beyond compliance could "make up" the CER "loss" related to the business responsibility portion.

- *Broad applicability*: The proposed approach is suitable for energy efficiency improvement and management in various economic sectors, all of which could apply the performance-based, energy-consumption-per-unit-of-output approach.

- *Countries meet Bali commitment*: Implementing mandatory sectoral energy efficiency standards through CDM would enable developing countries to fulfill their commitments to take "measurable, reportable and verifiable" actions, as expressed in the Bali Roadmap (COP 13, 2007).

At the country level, the adoption of performance-based standards would mean a shift from purely technology-based standards to regulations with clear targets. Performance-based standards are generally are more cost effective than technology-based standards (Coglianese and Nash, 2004). By providing the flexibility to choose the means to achieve goals, performance-based standards enable firms to develop or adopt the most effective or lowest cost options. Performance-based standards, however, depend on the ability of government agencies to specify, measure and monitor performance. (Coglianese and Nash, 2004). The advances in national energy efficiency regulations foreseen by this approach would be consistent with, and strengthened by, the CDM's regulation and project management scheme, which already emphasizes bottom-up quality management. At the same time, this regulatory approach would deepen country commitments to the CDM goal of reducing carbon emissions cost effectively.

6.5. Improving additionality tools and requirements

The Kyoto Protocol's additionality requirement has limited the ability of CDM projects to support implementation of mandatory policies and to complement government and private end-use energy efficiency improvement initiatives. In principle, programmatic CDM enables CDM support for environmentally friendly policies. The additionality requirement, however, discourages many well-intentioned project developers. There is a need for clear guidance on how the additionality requirement should be applied to regular CDM and programmatic CDM projects seeking to support policy implementation. Helpful changes could be made in two stages.

Short-term recommendation: clarify additionality requirements

The additionality requirements pertaining to how public policies and the CDM may be linked are ambiguous and need to be better defined. It is important either to clarify the existing additionality tool or to develop a special additionality tool or tools for climate friendly policies, as defined in the EB 22, Annex 3, 2005 ruling. It also might be helpful for the EB to define a special set of additionality requirements for energy efficiency policies. Energy efficiency implementation typically relies to a large extent on interventions in the form of public policies. Misunderstanding could also be reduced by having DNAs and validating entities communicate relevant rulings and related information to project developers.

Long-term (post-2012) recommendation: additionality based on crediting baselines

Consistent with the recommendation that common baselines be created to facilitate standards and regulations, common baselines would also simplify the demonstration of additionality. A commonly agreed benchmark for additionality would greatly reduce ambiguity and the possibility of subjective interpretation. In the proposed mechanism described in subsection 6.3, the crediting baseline could automatically become a clear and measurable benchmark against which a project's additionality could be determined. Because the evidence proving additionality (i.e., proof that performance has reached the benchmarked level) would, in such cases, mainly come from internal data and information provided by project proponents, the project validation and registration processes would be simplified and made less burdensome.

6.6. Strengthen the role of DNAs

Country DNAs could play very important roles in helping to scale up EEB projects in the CDM. DNAs could perform some of the above-proposed interventions, including developing benchmarks and common baselines, conducting CDM awareness raising, capacity building and training, taking steps to increase the accessibility and transparency of CDM projects, coordinating policies with CDM activities, and promoting the replication of successful local projects.

At present, in some countries the DNAs have power to coordinate policy, manage the government's policy interface with the CDM, and bridge the functions of different government departments. They are also active in promoting emission reduction, CDM and climate change activities. DNAs in other countries are more passive and mostly perform their primary function of screening and approving projects. If programmatic CDM begins to support policy implementation, the DNA's role will become more crucial and their capacities will need to be strengthened. This will be especially important in the least-developed countries.

VII. THE WAY FORWARD

The December 2007 COP13 and COP/MOP 3 meeting held in Bali set forth a roadmap for negotiating a new climate regime that would begin in 2012. During the meeting, the Parties agreed to take "enhanced national/international action" on climate change mitigation, considering:

(i) Measurable, reportable and verifiable nationally appropriate mitigation commitments or actions, including quantified emission limitation and reduction objectives, by all developed country Parties, while ensuring the comparability of efforts among them, taking into account differences in their national circumstances;

(ii) Nationally appropriate mitigation actions by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner.

In order to reach expected levels of GHG mitigation, all three flexible mechanisms under the Kyoto Protocol – CDM, JI and IET – will need to be reinforced. The Parties' emphasis on "measurable, reportable and verifiable" actions and sustainable development and technology, financing, and capacity building in developing countries largely is entirely consistent with the CDM's goals.

Although it is still not clear what future GHG reduction mechanisms might look like, the experiences gained during the current CDM implementation will provide valuable lessons for the design of any new mitigation mechanism. The language of the Bali COP agreement suggests that the CDM's measurable, reportable and verifiable elements will likely be incorporated into the new mechanism, and that support for technology, financing, and capacity-building may be stronger under the new agreement.

Discussions during the recent UNFCCC Climate Change Talks held in Accra also involved options to improve the CDM and to overcome its various known shortcomings (UNFCCC, 2008). Reform of the CDM is on the main agenda of the Climate Talks leading to the negotiation of a new climate regime in Copenhagen[17] and is regarded by many Parties as one of the main options for combating climate change in the future agreement.

As this report confirms, if CDM regulators do not provide clear guidance and facilitate more small-project-friendly methodologies and rules, EEB projects will probably continue to be under-represented in the CDM, and the enormous GHG reduction potential of the building sector will remain unrealized. Apart from CDM rule changes and the development of a new climate regime, the following additional interventions are recommended to support improved CDM-like emission reduction mechanisms, and ultimately, the reduction of GHGs through energy efficiency improvements in buildings:

1. *Develop national regulations and standards for building energy efficiency and/or sustainable building*:

A 2007 SBCI policy study concluded that regulatory and control instruments, such as building codes and appliance standards, are the most effective and cost-effective categories of instruments for managing energy consumption in buildings, provided

[17] The UNFCCC COP 15 to be held in Copenhagen in December 2009 will conclude two years of international talks, starting from the UNFCCC COP 13 in Bali, to agree to a successor to the Kyoto Protocol, which expires at the end of 2012.

enforcement can be secured (Koeppel and Ürge-Vorsatz, 2007). The development of national standards and regulations for building energy efficiency, therefore, is probably the single most important step countries can take to promote building energy efficiency. Regulatory and policy assistance from the international community would be needed for most countries. The sharing of experiences learned in countries that have already established such regulations would undoubtedly help in the development of appropriate and politically supported national policies. The CDM can and should play an increasingly active role in the policy implementation process.

2. *Develop common baselines and building benchmarking for the CDM*:

DNAs or DNA-authorized research institutes should begin developing common baselines, which are essential for facilitating CDM projects in new and existing buildings. Developing common baselines will require large-scale surveys and building benchmarking efforts. These time-consuming tasks should be started immediately.

3. *Engage the financial sector, and develop evaluation tools for building energy efficiency and CDM projects*:

The financial sector will play an indispensable role in future building sector CDM financing. Energy efficiency and CDM project financing, however, is still new to most financial institutions in developing countries. The experience of creating ESCOs in developing countries suggests that public sector (government) interventions and funding initiatives (e.g., designated government funds and/or low-interest government loans) will likely be needed in order to build financial sector confidence and stimulate investments in building energy efficiency (ESMAP & UNEP Risø, 2006). Recent developments in the global financial system and housing markets are likely to make this need even greater than ever before. Helping financial institutions to integrate building energy efficiency and CDM considerations into their project risk evaluation schemes would also increase the likelihood of investments in building energy efficiency and CDM projects. Such tools need to be developed in the financial sector, with assistance from international financial institutions and/or large financial (or research) institutions with sufficiently strong research and development capacities.

4. Develop case studies and demonstration projects:

Demonstration projects and case studies are good ways to test new project ideas, gain practical experience, and establish and promote good practices. Many high-quality energy efficient and sustainable building projects and concepts have been tested and implemented in developing countries. These good models can and should be used as a basis for developing high-quality CDM or programmatic CDM projects.

Given the ever-expanding weight of scientific evidence that human activities is a substantial contributing cause of global climate change, it is clear that efforts to reduce greenhouse gas emissions are not only necessary but need to increase in number and effect. The evidence is equally clear that buildings are a substantial source of global GHG emissions. It is obvious, therefore, that any scheme or agreement to limit GHG emission should support steps to reduce emissions and promote energy efficiency in buildings.

This report has identified several major obstacles to promoting energy efficiency in buildings through the CDM. The report, however, has also identified measures to overcome those obstacles and has provided a number of concrete recommendations elaborating how the CDM could be reformed to provide better support to energy efficiency projects in buildings.

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81. Ward, M. & Höhne, N., *Ecofys Sectoral Proposal Template,* www.sectoral.org, 2007.

82. World Business Council for Sustainable Development, *Energy Efficiency in Buildings: Business Realities and Opportunities*, WBCSD, 2007.

APPENDIX 1. GLOSSARY OF CDM[18]

Additionality
The Kyoto Protocol articles on Joint Implementation (Art. 6) and the Clean Development Mechanism (Art.12) state that emissions reduction units (ERUs and Certified Emission Reduction, CERs) will be awarded to project-based activities provided that the projects achieve emissions reductions that are 'additional to those that otherwise would occur.'

Additionality of a programme of activities
A programme of activities (PoA) is additional if it can be demonstrated that in the absence of the CDM (i) the proposed voluntary measure would not be implemented, or (ii) the mandatory policy/regulation would be systematically not enforced and that noncompliance with those requirements is widespread in the country/region, or (iii) that the PoA will lead to a greater level of enforcement of the existing mandatory policy/regulation. This shall constitute the demonstration of additionality of the PoA as a whole.

Annex I countries
Annex I to the UNFCCC lists all the countries in the Organization of Economic Cooperation and Development in 1990, plus countries with 'economies in transition', Central and Eastern Europe (excluding Albania and most of the former Yugoslavia). By default, the other countries are referred to as Non-Annex I countries. Under Article 4.2 (a and b) of the Convention, Annex I countries commit themselves specifically to the aim of reducing GHG emissions individually or jointly to 5.2% below their 1990 levels over the 2008 - 2012 period.

Baseline
The baseline for a CDM project activity 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. A baseline shall cover emissions of all gases, sectors and source categories listed in Annex A (of the Kyoto Protocol) from within the project boundary. A baseline shall be deemed to reasonably represent the anthropogenic emissions by sources that would occur in the absence of the proposed project activity if it is derived using a baseline methodology referred to in paragraphs 37 and 38 of the CDM modalities and procedures.

CDM programme activity
A CDM programme activity (CPA) is a project activity under a programme of activities. A CPA is a single or a set of interrelated measure(s) to reduce GHG emissions or result in net anthropogenic greenhouse gas removals by sinks within a designated area defined in the baseline methodology. The applied approved methodology shall define whether the CPA is undertaken in a single facility/installation/land or undertaken in multiple facilities/installations/lands. In the case of CPAs that do not exceed the Small Scale CDM project activities (SSC) threshold, SSC methodologies may be used once they have been reviewed and, as needed, revised to account for leakage in the context of the particular CPA.

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[18] [Source: *Glossary of CDM terms (Version 03)*, UNFCCC CDM Executive Board, CDM-Glos-03, 2007. Definitions not provided in CDM Glos-03 were drawn from *Climate Change: A Glossary of Terms, 4th Edition*, International Petroleum Industry Environmental Conservation Association, London, December 2007.]

Certification

Certification is the written assurance by the designated operational entity that, during a specified time period, a project activity achieved the verified reductions in anthropogenic emissions by sources of greenhouse gases.

Certified emission reductions

A certified emission reduction (CER) is a unit issued pursuant to Article 12 and other relevant provisions of the CDM modalities and procedures, and equal to one metric tonne of carbon dioxide equivalent, calculated using global warming potentials defined by decision 2/CP.3 or as subsequently revised in accordance with Article 5 of the Kyoto Protocol.

Clean development mechanism

Article 12 of the Kyoto Protocol defines the clean development mechanism (CDM): “The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under article 3”.

Conference of the Parties

The Conference of the Parties (COP) is the supreme body of the UNFCCC. It comprises countries that have ratified or acceded to the Convention. The first session of the COP (COP-1) was held in Berlin in 1995, and sessions have been held annually since then.

Conference of the Parties serving as the meeting of the Parties

The Conference of Parties to the UNFCCC also serves as the meeting of the Parties to the Kyoto Protocol (COP/MOP or CMP), the Protocol’s supreme body. Only Parties that have ratified or acceded to the Protocol may participate in deliberations and make decisions.

Coordinating/managing entity and participants of a Programme of Activities

A Programme of Activities (PoA) shall be proposed by the coordinating or managing entity, which shall be a project participant authorized by all participating host-country DNAs involved and identified in the modalities of communication as the entity which communicates with the Board, including on matters relating to the distribution of CERs. Project participants of the PoA shall make arrangements with the coordinator or managing entity relating to communications, distribution of CERs and change of project participants.

Designated Operational Entity

A Designated Operational Entity (DOE) under the CDM is either a domestic legal entity or an international organization accredited and designated on a provisional basis until confirmed by the CMP, by the Executive Board (EB). A DOE has two key functions: 1) it validates and subsequently requests registration of a proposed CDM project activity, which will be considered valid after 8 weeks if no request for review has been made; and 2) it verifies the emission reductions of a registered CDM project activity, certifies as appropriate, and requests the EB to issue Certified Emission Reductions accordingly.

Designated National Authority

A Designated National Authority (DNA) is an office, ministry, or other official entity appointed by a Party to the Kyoto Protocol, i.e., a host country, to review and give national approval to projects proposed under the Clean Development Mechanism.

Executive Board of the CDM
The 10-member Executive Board (EB) supervises the CDM under the authority and guidance of the COP/MOP and is responsible for approving new methodologies, accrediting third-party validators and verifiers, approving projects and ultimately issuing carbon credits for CDM projects.

Gold Standard
The Gold Standard Foundation offers a quality label to CDM/JI and voluntary offset projects, fetching premium prices (generally $1 to $2 per CER by negotiation). Renewable energy and energy efficiency projects with sustainable development benefits are eligible. The Gold Standard is endorsed by over 49 non-governmental organizations worldwide. A range of government and private actors prefer Gold Standard projects.

International Emissions Trading
International Emissions Trading (IET) is one of the three Kyoto mechanisms by which an Annex I Party may transfer Kyoto Protocol emissions reduction units to, or acquire emissions reduction units from, another Annex I Party. An Annex I Party must meet specific eligibility requirements to participate in emissions trading.

Intergovernmental Panel on Climate Change
The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by governments under the auspices of the World Meteorological Organization and the UN Environment Programme. The IPCC prepares assessments, reports and guidelines on the science of climate change and its potential environmental, economic and social impacts; technological developments; possible national and international responses to climate change; and crosscutting issues. The IPCC is currently organized into three Working Groups that address: 1) Science; 2) Impacts, Adaptation and Vulnerability; and 3) Mitigation. The Panel also has a Task Force to develop methodologies for GHG inventories.

Joint Implementation
Joint Implementation (JI) is a mechanism under the Kyoto Protocol through which a developed country can receive emissions reduction units when it helps to finance projects that reduce net greenhouse-gas emissions in another developed country. In practice, the recipient state is likely to be a country with an "economy in transition". An Annex I Party must meet specific eligibility requirements to participate in JI.

Kyoto Protocol
A freestanding international agreement that requires separate ratification by governments, and is linked to the UNFCCC. Among other things, the Kyoto Protocol sets binding targets for the reduction of greenhouse-gas emissions by industrialized countries.

Kyoto mechanisms
Three procedures established under the Kyoto Protocol to increase the flexibility and reduce the costs of making greenhouse-gas emissions cuts are the Clean Development Mechanism, Emissions Trading and Joint Implementation.

Marrakech Accords
The Marrakech Accords are agreements reached at COP-7 in 2001 that set rules for operating the more complex provisions of the Kyoto Protocol. The accords include details for establishing a greenhouse-gas emissions trading system, and implementing and monitoring the Clean Development Mechanism. The Accords also addressed issues such as capacity

building, technology transfer, responding to the adverse effects of climate change, and established three funds: the Least Developed Countries (LDC) Fund, the Special Climate Change Fund (SCCF), and the Adaptation Fund.

Monitoring
Monitoring refers to the collection and archiving of all relevant data necessary for determining the baseline and measuring anthropogenic GHG emissions by sources within the project boundary of a CDM project activity as well as leakage, if any.

Project Design Document
The project design document (PDD) is the key document involved in the validation and registration of a CDM project activity. It is one of the three documents required for a CDM project to be registered, along with the validation report from the DOE and the letter of approval from the DNA. The DOE reviews the PDD during the validation process to ensure that a project meets the validation requirements. The PDD is also used as the basis for consultation with stakeholders, which is conducted by making the PDD and related documentation publicly available on the UNFCCC website.

Programme of activities
A programme of activities (PoA) is a voluntary, coordinated action by a private or public entity that coordinates and implements any policy/measure or stated goal (i.e., incentive schemes or voluntary programmes) that leads to anthropogenic GHG emission reductions or net anthropogenic greenhouse gas removals by sinks that are additional to any that would occur in the absence of the PoA, via an unlimited number of CPAs.

Project activity
A project activity is a measure, operation or action that aims to reduce greenhouse gas emissions. The Kyoto Protocol and the CDM modalities and procedures use the term "project activity" as opposed to "project". A project activity could, therefore, be identical with or a component or aspect of a project undertaken or planned.

Small-scale CDM project activities
In accordance with Decision 17/CP.7 (contained in document FCCC/CP/2001/13/Add.2), paragraph 6 (c), simplified modalities and procedures have been developed for the following types of small-scale CDM project activities, the revised definitions of which are provided in paragraph 28 of Decision/CMP.2: Type I: Renewable energy project activities with a maximum output capacity equivalent to up to 15 megawatts (or an appropriate equivalent); Type II: Energy efficiency improvement project activities that reduce energy consumption, on the supply and/or demand side, limited to those with a maximum output of 60 GWh per year (or an appropriate equivalent); and Type III: Other project activities limited to those that result in emission reductions of less than or equal to 60kt CO2 equivalent annually.

Validation
Validation is the process of independent evaluation of a project activity by a DOE against the requirements of the CDM, as set forth in decision 3/CMP.1, its annex and relevant decisions of the COP/MOP, on the basis of the PDD.

Verification
Verification is the periodic independent review and determination by the DOE of the net anthropogenic GHG removals achieved by sinks from the start of a project by an A/R CDM project activity under the CDM. Certification is the written assurance by a DOE that an A/R

CDM project activity under the CDM achieved the net anthropogenic GHG removals by from since the start of the project, as verified.

UN Framework Convention on Climate Change

The UN Convention on Climate Change (UNFCCC) sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases. The Convention enjoys near universal membership, with 192 countries having ratified it. The Convention entered into force on 21 March 1994. In 1995, the UNFCCC held the first session of the COP, the supreme body of the Convention, in Berlin. The UNFCCC Secretariat is based in Bonn, Germany.

APPENDIX 2. CDM PROJECTS INVESTIGATED IN THIS STUDY

This section briefly describes the CDM projects investigated in this report. The project descriptions synthesize project design documents and observations based on interviews and do not necessarily represent the opinions of the projects described and experts interviewed.

I. Kuyasa Housing Project, Cape Town, South Africa

The Kuyasa Housing Project is a low-income housing retrofit project in Kuyasa, Khayelitsha, Cape Town, South Africa. The project is registered by the City of Cape Town, and is being developed under a consultancy by SouthSouthNorth (SSN). The project aims to retrofit 2,039 residential houses that were constructed under the national housing subsidy program, commonly referred as the Reconstruction and Development Program (RDP) for low-income families.

The Kuyasa community is typical of RDP-constructed low-income housing. Due to limited funds and unsustainable practices by the builders, many houses were originally constructed at below-standard comfort levels. The homes, however, are better than the shacks that they originally replaced (Thorne, 2007, Guy, 2007, Stiles, 2007).

The single-family houses were constructed without ceilings and proper insulation, while walls were generally constructed with cement bricks (see Figure I, left). The thermal performance of such construction is poor, thus the indoor environment becomes very hot in the Cape Town summer and too cold in the winter. To improve the thermal comfort and enhance living conditions, the Kuyasa retrofit project introduced three EE interventions (see Figure I, right): a) insulated ceilings; b) solar water heaters; and c) compact florescent lights (City of Cape Town, 2005).

Because low-income families tend to use lower amounts of energy, retrofit projects focused on low-income communities offer lower GHG reduction potential. To overcome this hurdle, the project developed a suppressed demand model that used simulated energy use baselines and project activity levels to predict future consumption, instead of actual energy consumed. The rational was that the EE intervention would avoid future demand increases to a projected "normal consumption level". For space heating, the suppressed demand model determines the GHG emission reduction based on the difference in energy requirements to heat the homes to a level of thermal comfort in houses with and without insulated ceilings. For hot water heating, the suppressed demand model assumes a hot-water-on-demand use pattern using electric water heater as a baseline, instead of the current practice of batch water heating on kerosene stoves. These assumptions successfully maximized the emission reductions that would occur because of the project activities to a level that made the project viable. The project activity could result in 6,580 metric tonnes CO2 equivalent per annum (City of Cape Town, 2005).

Kuyasa is the first CDM-registered project to improve the thermal efficiency of low-income housing and the first building-related Gold Standard[19] project. Although the project was registered in August 2005,

[19] Gold standard is a quality label the Gold Standard Foundation offers to CDM/JI and voluntary offset projects, fetching premium prices. Renewable energy and energy efficiency projects with sustainable development benefits are eligible. The Gold Standard is endorsed by over 49 non-governmental organizations worldwide. A range of government and private actors prefer Gold Standard projects.

due to funding issues, the project had not been implemented at the time of the study team's visit, except for the retrofitting of 10 demonstration houses. This delay illustrates the generic difficulty of low-income housing projects, as well as the challenges of using the CDM to finance such projects. Despite the fact that Kuyasa had the best conditions in the CDM for project approval, CER crediting, and pricing, other incentives or funding sources were still needed.

SSN is planning to develop other projects in the low-income housing sector. In addition, new build social housing projects with optimized thermal performance have been in the research and fund-raising stages. A programmatic approach is also being considered. Uncertainties remain, however, regarding funding and the applicability of suppressed demand models in new buildings and programmatic projects.

House before intervention showing uninsulated roof and cement brick walls.

Insulated ceiling and CFL lamp installed in one of the demonstration houses.

Figure I. *Kuyasa Housing Project, before and after intervention*

II. ITC Sonar Hotel, Kolkata, India

The ITC Sonar Hotel is a five-star, 238-room hotel located in the Kolkata, India. The hotel was built in 2003, started preparation for CDM after one year of operation, and became a registered CDM project in November 2006. The ITC Sonar Hotel project is the first registered commercial EEB improvement project.

The project was developed by the hotel's own in-house expertise. Energy audits, however, were performed with the help of outside energy auditing experts. Based on the auditing recommendations, several EE technology improvements were implemented:

a. Installation of various frequency drive motors;
b. Retrofitting of existing heat, ventilation and air-conditioning systems to reduce moisture-laden air loads in the pre-cooled air unit (PAU) and to improve efficient heat transfer in the PAU pipes using imported USA technology and thus reducing the chiller load;
c. Retrofitting pumps located at various sites within the hotel facility;
d. Enhancement of the sewage treatment unit's efficiency to reduce electricity consumption;
e. Replacement of electric water heaters with solar alternatives;
f. Use of waste heat from the return steam condensate to generate hot water for the facility;
g. Installation of magnetizer in the boiler for better fuel atomization leading to improved fuel combustion; and
h. Reuse of low-energy waste heat from separator condensate and boiler flue (ITC Limited, 2005).

The total energy saving from the EE retrofit is 3.42 GWh/year, which results in 2,987/year metric tonnes CO2 equivalent reduction. The project was registered, and the first year verified CER totaled 1,886 tonnes, which was less than had been estimated. Possible reasons identified included various restrictions in proof of consumption data and strict verification of CER (Chattopadhyay, 2007).

III. Technopolis, Kolkata, India

Technopolis is a commercial building that the U.S. Green Building Council awarded a Gold-level LEED certification. The building is one of the few in India to receive the LEED Gold certificate. Construction was finished in 2005, and the fourteen floors of office spaces were rented within five months of completion.

The project was submitted for CDM approval in May 2007. Obtaining additional environmental recognition after the LEED certificate was an important motive for the project proponent to apply for the CDM. The project participant hired a consultant to help with PDD development and registration, and applied as a new installation project. The building includes various EE improvements in the envelope design and in the heating, ventilation and air conditioning (HVAC) system. The estimated electricity savings could reach 8.37 GWh/year, and the annual CO2 reduction has been estimated at 8,724 metric tonnes (Phoenix Software Limited, 2007).

Two aspects of the approval process for this project are indicative of conditions for CDM projects in the building sector generally. The project baseline is based on design data for similar buildings built by the same real estate developer. Since this was the first building sector project for newly constructed buildings, it was uncertain whether this baseline selection would be approved.

Second, in the case of the Technopolis project, the building had already been built and was in operation. Carbon financing thus did not enable the project financially. The project developer absorbed the additional capital costs for EE improvements, and energy savings are expected to provide a five to six year return on investment. Technopolis is a pioneering green buildings project that has been supported by the Kolkata city council. How the additionality issue is handled will provide an indication of CDM's tolerance for projects seeking to improve their green images. If the project is registered under CDM, the developer intends to scale up and promote its green building portfolio.

IV. Pão de Açúcar, Sao Paulo, Brazil

Pão de Açúcar is a supermarket chain in Sao Paulo, Brazil owned by the country's largest food retailer company, Companhia Brasileira de Distribuição (CBD), which owns five brand names and 551 stores 17 states. The company submitted eight similar CDM projects, bundling EE activities in 97 selected stores. The EB was evaluating these projects at the time this study was conducted and the project participants and the consultant were interviewed. In September 2007, shortly after the study team's visit, the EB's rejected all eight projects.

These projects have important implications for future building sector CDM projects, because (1) Pão de Açúcar projects are pioneering potential programmatic CDM projects in buildings; and (2) the projects combine technological changes with energy management measures in business and attempt to establish carbon credits for emission reductions achieved by management measures.

CBD stores implemented the following EE measures:

a. Identified the main opportunities for electricity consumption reduction.

b. Contracted specialized services to develop a management system to monitor and control electricity consumption.
c. Revised operational procedures aimed at creating a more efficient standard of operation for the stores with the establishment of daily electricity consumption targets focused particularly on peak-hour demands.
d. Identified energy demand benchmarks from a comparison of several stores in the group, taking into consideration the different consumption patterns of each one of the brands.
e. Best practices in the operation and maintenance of air conditioning and refrigerating systems.
f. Replaced light bulbs with more efficient models and changed operational procedures to light each area at more suitable and efficient illumination levels (Companhia Brasileira de Distribuição, 2007).

These activities will result in 19,275 tonnes of annual carbon reduction. The EB decision stated that the projects were rejected because they *"fail[ed] to sufficiently substantiate that the monitoring requirements of AMS-II.E, in particular with respect to ensuring that CERs can be claimed only for energy savings due to the measures installed, would be correctly applied in the project activity*" (Companhia Brasileira de Distribuição, 2007).

The projects implemented many management measures and submitted operation records as evidence. The projects passed DOE's validation procedure, but were rejected while seeking registration from the EB. The EB's rejection shows the difficulty of demonstrating soft EE measures and the disadvantages in using technology-based methodologies for small-scale project activities. The project also shows the difficulties of proving consistent implementation and performance across the project activities of large-quantity projects. As of the end of 2007, the project participants were evaluating their options for re-submission (Almeida Prado, 2007). Reevaluation of the CBD projects may provide good lessons for how programmatic CDM can be handled in the building sector.

APPENDIX 3. POTENTIAL BUILDING SECTOR CDM PROJECT IDEAS

In addition to the CDM projects currently in the pipeline, the project team also investigated two building sector projects that had not participated in the CDM activities, but offer strong potential for duplication and valuable lessons for future CDM project or program development.

I. Witsand iEEECO Project, Cape Town, South Africa

PEER Africa, an engineering company, developed the Witsand iEEECO Human Settlement Development Model by working with local communities and various stakeholders. The project was developed principally to help address South Africa's low-income housing problem. The project also takes into account a range of environmental problems, including deforestation, desertification, indoor air pollution and associated health issues, and the lack of access to clean and affordable energy supplies (PEER Africa, 2005).

PEER Africa has had an interest in the CDM since the CDM's inception and had been closely watching the possibility of registering a CDM project. During the last half of 1997, PEER Africa, the provincial Minister of Housing and the local government were invited to present their concept of sustainable housing to developing countries in South America, Africa and Europe. PEER Africa also held a side event at the COP-3 meeting in Kyoto, Japan (PEER Africa, 2005). However, due to the difficulty in making low-income housing projects viable for CDM and the onerous job of seeking CDM registration, which distracts efforts from project development, the project developer has never sought to register the projects for CDM. Instead, the developer has sought to create a self-sustaining financing structure for project implementation. It has done so by using government subsidies in combination with funds from other sources, such as Eskom, South Africa's utility company. Several projects have been developed in the past 10 years, including 400 units in Cape Town iEEECO(TM) Village, which the project team visited.

The technical interventions and quality assurance measures implemented at the iEEECO project included (Guy, 2007):

a. Technical walkthroughs to train local community teams how to monitor and inspect units and hold contractors accountable.
b. Integrated sustainable site plan incorporating economic and social amenities.
c. Passive solar design agreement that all buildings must face the north and have unobstructed sun angles in order to maximize natural winter space heating impact and to help reduce mold formation.
d. Installation of 600mm roof overhangs to shade north-facing windows in summer.
e. Building layout designed to allow optimal thermal comfort, with lounge and bedrooms positioned on the north sides of all buildings.
f. Improved window placement to maximize natural lighting and reduce the demand for artificial lighting.
g. Via an agreement with Eskom, the University of Cape Town's School of Engineering and the Built Environment monitors design and projected energy savings.
h. PEER Africa designed an integrated system to monitor, evaluate, verify and certify the thermal comfort of the building systems.

PEER Africa estimates that the project will save approximately 0.5 tonnes of CO_2 eqv per house per year. This number could triple if a suppressed model is used, as was found in the Kuyasa project (see Appendix 2, I, Guy, 2007). The iEEECO model includes components to ensure project quality, reduce environmental impacts, and promote sustainable development of poor communities. The project emphasizes continuous monitoring and recording of environmental and health performances of the buildings. It also uses materials and construction practices that minimize health and environmental impacts. In addition, iEEECO emphasizes community-based project management using expert teams and community participation throughout the project's life cycle.

All of these outcomes are desirable in order for CDM and programmatic CDM to scale up in the low-income-housing sector. Indeed, learning from the iEEECO model is essential for successful EEB and sustainable building projects in low-income communities. Experiences and data from this model would assist in the development and scaling up of low-income housing projects in the CDM. These lessons would be especially important for least developing countries seeking to develop CDM projects in the housing sector.

Village committee members demonstrate low-risk kerosene cook stove.

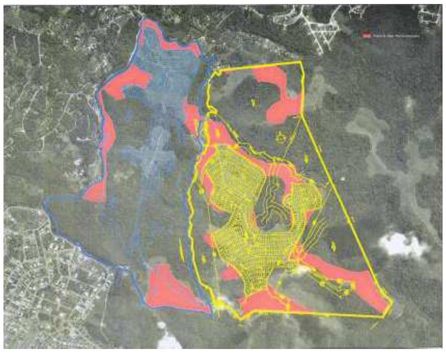
A house in iEEECO Village, with insulated ceiling and fireproof curtains.

Figure II. *iEEECO Village project in Cape Town*

II. Genesis project, outside Sao Paulo, Brazil

The Genesis project is a residential real estate development that emphasizes the preservation and restoration of forestry in the surrounding areas. Conceived in 1999, the development sought sustainable solutions to implementing a residential condominium in an area totaling three and half million square meters, about 30 kilometers from the center of the city of Sao Paulo. The project was well received. After its launch, 85 percent of the development's plots were sold in three weeks at a substantial price premium – over 10 percent higher than other developments in the region (Takaoka, 2007). The project reforested unused land to its natural state (Atlantic rainforest vegetation with mixed species). By 2008, the planted forest was expected to have neutralized all carbon emissions resulting from construction activities, such as grading, excavating and earthmoving, as well as the emissions from reforestation activities.

On the basis of these carbon benefits, the project is planning to apply to the CDM. The Genesis project does not include EE improvement in the buildings. Nevertheless, the realization of sustainable building concepts through carbon neutralization measures is worth looking into in the high-end housing sector, given its favorable reception by investors and homebuyers. Indeed, the idea of combining carbon neutralization activities and real estate project development is a potential programmatic CDM project area in the future.



Aerial picture showing location of the plots (yellow) and the areas of reforestation (red).

Reforested area beyond the fence after five years of vegetation growth.

Figure III. *Aerial and landscape pictures showing the Genesis development project*

APPENDIX 4. EXISTING BUILDING-RELATED CDM AND JI PROJECTS[20]

This list includes all EEB related CDM and JI projects that were in the pipeline as of October 2008, and which were reviewed but not investigated by the project team. These include single-technology EE improvement projects, combined-measure EE improvement in buildings, as well as programmatic CDM projects that were submitted after finalization of the rules in July 2007.

I. CDM PROJECTS (NON-PROGRAMMATIC)

a. Commercial Building EE, single or combined measures

1) Energy efficient design project – Olympia, India

Status: At Validation

Description: The project activity involves the design stage incorporation of energy efficient features in a commercial building to reduce its energy consumption. The features include the adoption of high efficiency equipment, high efficiency materials and advanced control systems to bring about an overall reduction in the total energy consumption of the building and an equivalent reduction in import of emission intensive grid electricity.

Methodologies: AMS-II.E. : Energy efficiency and fuel switching measures for buildings

2) Installation of High Efficiency Chillers in EIH Group Hotels, India

Status: At Validation

Description: The purpose of the project activity is to install high efficiency chillers in the EIH group hotels at its different locations in India. The project activity primarily aims to reduce the energy consumption of the hotels by installation of highly energy efficient chillers in place of existing less efficient chillers.

Methodologies: AMS-II.E. : Energy efficiency and fuel switching measures for buildings

3) Energy Efficient Information Technology Park by India Land & Properties Limited, India

Status: At Validation

Description: The Information Technology Park is an energy efficient building with thermal transmission reduced through high performance glasses with ceramic fritting and by improvement in the HVAC system and installation of a thermal storage unit. The building incorporates an Integrated Building Management System which controls and optimizes the operation of all systems and monitors the energy consumption, power factor and maximum demand.

Methodologies: AMS-II.E. : Energy efficiency and fuel switching measures for buildings

4) Energy Efficiency Measures in Office Building at BKC

Status: At Validation

Description: The energy efficiency measures have been undertaken primarily in the heating, venting and air-conditioning (HVAC) system of BKC-30 and lighting systems. The measures adopted in the HVAC system and lighting system result in reduction in electrical energy

[20] (sources: UNFCCC web site, 2008; UNEP Risø CDM pipeline, October 2008)

consumption, in comparison to that for a conventional building with similar size (in terms of floor area, carpet area and number of storey's), capacity (in terms of occupancy) and architectural perspectives.

Methodologies: AMS-II.E. : Energy efficiency and fuel switching measures for buildings

5) Energy Efficiency Measures at Mindspace Airoli Building No 3, 8 and 14 of Serene Properties Pvt Ltd at Navi Mumbai

Status: At Validation

Description: The project includes energy efficiency improvement measures installed at Mindspace Airoli Building No 3, 8 and 14 of Serene Properties Pvt. Ltd1 at Navi Mumbai, India. These buildings are for commercial leasing purpose. The energy efficiency measures have been undertaken primarily in the heating, venting and air-conditioning (HVAC) system and lighting system of the building. The measures adopted in the HVAC system result in reduction in electrical energy consumption, in comparison to that for a conventional building with similar size (in terms of floor area, carpet area and number of stories), capacity (in terms of occupancy) and architectural perspectives.

Methodologies: AMS-II.E. : Energy efficiency and fuel switching measures for buildings

b. Lighting and building PV source

1) Karnataka CDM Photovoltaic Lighting Programme, India

Status: At validation

Description: The purpose of the project activity is to install 10,000 solar home lighting systems (SHSs) based on LEDs and solar photovoltaic power supply and battery pack; and 200,000 LED Home Lighting Systems (HLSs) based on replacing existing 60 W incandescent bulbs with energy-saving LEDs.

Methodology: AMS-I.A.: Electricity generation by the user and AMS-II.C.: Demand-side energy efficiency programmes for specific technologies

2) Photovoltaic kits to light up rural households (7.7 MW), Morocco

Status: Registered

Description: The purpose of the project activity is to provide 101,500 rural households in all regions of Morocco with photovoltaic kits to enable them to meet their basic energy needs. Each PV kit will have an average capacity of 75.7 Wp (Watt peak), adding up to a total installed capacity of approximately 7.7 MW.

Methodology: AMS-I.A.: Electricity generation by the user

3) Installation of 30,000 Solar Home Systems (30-75Wp) in Rural Households, Bangladesh

Status: At validation

Description: Under the proposed activity, the Grameen Shakti envisions continuing their installation of solar home systems (SHS) in rural Bangladesh without increasing the price of the SHS against the recent trend of increasing prices of different SHS components internationally. The project aims to install 30,000 SHS units over five years. The systems will reduce GHG emissions by displacing conventional fuel sources for lighting, television and radio.

Methodology: AMS-I.A.: Electricity generation by the user

4) Rural Education for Development Society (REDS) CDM Photovoltaic Lighting Project, India

Status: At validation

Description: The purpose of the project activity is to install 300,000 photovoltaic lamps in 60,000 un-electrified rural homes and community centers in Tumkur District, Karnataka, India. The lamps use 3W compact fluorescent lights (CFLs) or LED luminaries that derive their power from photovoltaic modules using monocrystalline or amorphous panels. The systems are tried and tested. They will be supplied either by D.lightdesign1, Grameen Surya Bijlee Foundation, NEST3 or AMCO4 lighting systems companies, or by all, depending on the quantities required and choices of design and brand preferred by the users after technical tests. The aim of the project is to improve the quality of life of people in un-electrified households. Currently kerosene is used for lighting, but the quality of light is very poor. Photovoltaic electric lights will improve the standard of living by providing higher quality lighting. The project will also reduce GHG emissions to the atmosphere.

Methodology: AMS-I.A.: Electricity generation by the user

5) Visakhapatnam OSRAM CFL distribution CDM Project, India

Status: Correction

Description: The Visakhapatnam OSRAM CFL distribution CDM Project in India involves the distribution of 870,000 OSRAM CFLs to approximately 580,000 households in the district of Visakhapatnam.

Methodology: AMS-II.C.: Demand-side energy efficiency activities for specific technologies

6) Yamunanagar & Sonipat OSRAM CFL distribution CDM Project, India

Status: At validation

Description: The Yamunanagar & Sonipat OSRAM CFL distribution CDM Project in India involves the distribution of 882,000 OSRAM CFLs to approximately 630,000 households in the districts of Yamunanagar and Sonipat.

Methodology: AMS-II.C.: Demand-side energy efficiency activities for specific technologies

c. Solar Heating

1) Solar Steam for Cooking and Other Applications, India

Status: Registered

Description: The project activity includes the implementation and operation of solar community kitchens and similar solar steam applications in various regions in India. The project uses solar energy to prepare food and warm drinks for more than 28,000 people on a regular basis. Doing so, the project replaces conventional fuel such as diesel and unsustainably harvested firewood.

Methodology: AMS-I.C.: Thermal energy for the user with or without electricity

2) CDM Solar Cooker Project Aceh 1, Indonesia

Status: Registered

Description: The “CDM Solar Cooker Project Aceh 1” aims for the district of Sabang Islands/Aceh/Indonesia and Aceh Tenggara in the framework of a Small Scale CDM Project. The aim of the project is to substitute traditional biomass based cooking technologies by with newly developed solar cookers and heat retention containers for cooking, heating and sterilizing of water and for preserving food. The project is developed by cooperation of government of Aceh Province, Indonesia, PT Petromat Agrotech, Jakarta, Indonesia, Klimaschutz e.V., Bonn, Germany and German experts on solar cookers, fuel saving devices and CDM.

Methodology: AMS-I.C.: Thermal energy for the user with or without electricity

3) Bagepalli CDM Solar Hot Water Heating Programme, India

Status: At validation

Description: Through this project activity, 25,790 solar hot water heaters will be installed in Kolar District and Bangalore Rural District of Karnataka, India. The technology is proven and the project proponents have the management systems in place for implementing and monitoring the dispersed small thermal energy installations.

Methodology: AMS-I.C.: Thermal energy for the user with or without electricity

4) CDM Solar Hot Water Project of M/s Emmvee Solar Systems Private Limited Serial No 0001, India

Status: At validation

Description: The purpose of this CDM program of activities is to install flat plate solar collectors for the supply of hot water. The solar hot water systems are for community, public, domestic and private commercial use. The implementation of the project activity will result in emission reductions of 51,907 tCO_2e per annum over first crediting period of seven years.

Methodology: AMS-I.C.: Thermal energy for the user with or without electricity

5) Federal Intertrade Pengyang Solar Cooker Project, Federal Intertrade Yulin Solar Cooker Project, and Federal Intertrade Hong-Ru River Solar Cooker Project, and Ningxia Federal Solar Cooker Project, China (four projects)

Status: At validation

Description: Implemented by Ningxia Federal Intertrade Co. Ltd., the proposed projects will each install approximately 20,000 solar cookers for the rural residents. The rating power of each solar cooker is 654.5W, and the total capacity of the proposed project is 13.1 MW. The proposed project will enable the rural residents to efficiently substitute solar energy for a part of the fossil fuel (coal) used in daily cooking and water boiling, avoiding CO_2 emission that would otherwise be generated by fossil fuel consumption.

Methodology: AMS-I.C.: Thermal energy for the user with or without electricity

d. Biogas for Households

1) Vedaranniyam Biogas Project, India

Status: At validation

Description: The project activity proposes to set up 12,000 biogas plants of $2m^3$ capacity each at every single household in Nagapattinam District, Tamil Nadu, India, thus replacing the use of kerosene for cooking and water heating purposes in the village. The project will achieve 342,500 tCO_2e during the 10-year fixed crediting period.

Methodology: AMS-I.C.: Thermal energy for the user with or without electricity

2) Kolar District Biogas Project, India

Status: At validation

Description: The purpose of this CDM project activity is to set up 12,000 biogas plants (digesters) of $2m^3$ capacity each for single households in Kolar District, Karnataka, India, thereby replacing kerosene for cooking and hot water heating with biogas, a renewable energy. The project proposes to achieve 342,500 tCO2e over the 10-year crediting period.

Methodology: AMS-I.C.: Thermal energy for the user with or without electricity

3) Biogas Sector Partnership Nepal (6,500 units) Activity-1 & 2 (two projects)

Status: Registered

Description: Under the proposed project activity, the Biogas Sector Partnership Nepal (BSP-Nepal) aims to sell biogas digesters (biogas plants) to households located primarily in the rural areas of Nepal. The project activity intends to reduce GHG emissions by displacing conventionally used fuel sources for cooking, such as fuel wood and kerosene, and by enabling the proper disposal of animal waste. The proposed project activity is a sub-project of the BSP-Nepal umbrella biogas program that aims to install a total of 200,000 small biogas digesters throughout Nepal. Since it is the first sub-activity of the umbrella biogas program, the sub-project is named BSP-Nepal Activity-1.

Methodology: MS-I.C.: Thermal energy for the user with or without electricity

e. District Heating

1) Switching of fuel from Low Sulphur Waxy Residue (LSWR) fuel oil to natural gas at Gangnam branch Korea District Heating Corporation; & Switching of fuel from LSWR to natural gas at heat-only boilers in district heating system, South Korea (2 projects)

Status: Registered

Description: The project activity involves switching of LSWR to natural gas at Suseo heat source facility, Gangnam branch, Korea District Heating Corporation. The project will replace the existing four LSWR heat-only boilers with three natural gas heat-only boilers until the end of 2007. The project proposes to reduce 347,030 tons of CO2 equivalent over the 10-year crediting period.

Methodology: ACM0009: Consolidated methodology for industrial fuel switching from coal or petroleum fuels to natural gas

2) Yantai Coal-Fired Boiler Energy Efficiency Project, China (2 projects)

Status: At Validation

Description: The project activity includes conducting energy-optimisation diagnosis/training and installing automated control technologies at various buildings and industrial facilities in Yantai, Shandong Province, China. The diagnostic tool and control technology, the Boiler Operation Support System (BOSS) and an Automatic Combustion Control System (ACCS) will improve the operating efficiency of small to mid-sized coal-fired boilers. The BOSS and ACCS will be implemented on 10 boilers at six facilities. The increased efficiency will decrease the amount of coal combusted in the boilers, reduce emissions of CO2 and other pollutants, and contribute to GHG mitigation.

Methodology: AMS-II.D.: Energy efficiency and fuel switching measures for industrial facilities; AMS-II.E.: Energy efficiency and fuel switching measures for buildings.

f. Biomass Cook Stove

1) CDM Cook Stove Project Kupang 1, Indonesia

Status: At validation

Project Description: The CDM Cook Stove Project Kupang 1 would enable the city of Kupang in Indonesia to:

- Help people who depend on oil/kerosene/paraffin as an energy source to switch to renewably harvested biomass.
- Provide training in the implementation of these technologies in the region.
- Collect all data needed for the CDM project in the region.
- Demonstrate the possibility of financing environmentally friendly projects with the help of CDM.

Methodologies: AMS-I.C.: Thermal energy for the user

2) CDM Lusaka Sustainable Energy Project 1, Zambia

Status: At validation

Project Description: Consumption of charcoal in urban households is the main cause of deforestation in the surrounding area of Lusaka. The purpose of the project activity is to provide 30,000 households of Lusaka city with highly efficient cooking systems to replace the consumption of charcoal.
Methodologies: AMS-I.E.: Switch from non-renewable biomass for thermal applications by the user

g. Combined Household Appliances and Renewables

1) Demand Side Energy Efficiency Program by Coelba for Low-income Residential Customers in Salvador, Bahia, Brazil

Status: At validation

Description: The main purpose of the project is to carry out energy efficiency measures on the demand side or at the consumption points in low-income residential communities in the City of Salvador in the State of Bahia, so as to reduce electricity consumption.

Methodology: AMS-II.C.: Demand-side energy efficiency activities for specific technologies

2) Korea Land Corporation Pyeongtaek Sosabul-district new and renewable model city (Photovoltaic system + solar water heating system), South Korea

Status: At validation

Description: The main purpose of the project activity is to supply Pyeongtaek Sosabul-district with electricity from a photovoltaic system in the City of Pyeongtaek. Detached houses, schools, and public buildings will have photovoltaic systems installed on their roofs. Solar park lights will be installed in a park. A tower will be set up to create a building integrated photovoltaic system.

Methodology: AMS-I.C.: Thermal energy for the user with or without electricity; AMS-I.D.: Grid connected renewable electricity generation

II. PROGRAMMATIC CDM PROJECTS

a. Lighting and building PV source

1) Installation of Solar Home Systems in Bangladesh, Bangladesh

Status: At validation

Description: The SHS program is being implemented through fifteen NGOs and financial institutions referred to as Participating Organizations (POs). POs select project areas and potential customers, extend loans, install the systems and provide maintenance support. IDCOL is one of the financing agencies providing grants and refinance, sets technical specifications for solar equipment, develops publicity materials, provides training, and monitors PO's performance. IDCOL offers soft loans of 10-year maturity with 2-year grace period at 6% per annum interest to its POs.

Methodology: AMS-I.A.: Electricity generation by the user

2) CUIDEMOS Mexico (Campana De Uso Intelegente De Energia Mexico) – Smart Use of Energy Mexico ---Programme of Activities, Mexico

Status: At validation

Description: The programme of activities, CUIDEMOS Mexico, involves the distribution of energy efficient light bulbs to households across Mexico. Each small-scale CDM programme activity (SSC-CPA) will be implemented in geographically distinct areas across Mexico. The PoA and each CPA will be implemented and managed by Cool nrg Carbon Investments Pty Ltd ("Cool nrg Carbon Investments") and Cool nrg Mexico SRL de CV ("Cool nrg Mexico"), in collaboration with key operational partner organizations.

Methodology: AMS-II.C.: Demand-side energy efficiency activities for specific technologies

b. Solar Heating

1) New Energies Commercial Solar Water Heating Programme in South Africa, South Africa

Status: At validation

Description: The NewEnergies Commercial Solar Water Heating Programme in South Africa is a small-scale program of activities (PoA) developed by Prostart Traders 40 (Pty) Ltd and NewEnergies Pty Ltd. The PoA includes retrofitting of existing electric water heating technologies with solar based water heating technologies and/or installation of new solar water heating technologies in commercial and public oriented buildings or residential buildings with large-scale water consumption. Currently, hot water used for various purposes is heated by electrical water geysers using coal based electricity from the grid. The GHG emissions could be reduced through avoided electricity use.

Methodology: AMS-I.C.: Thermal energy for the user with or without electricity

III. BUILDING-RELATED JI PROJECTS

a. Cogeneration for District Heating

1) Reduction of Greenhouse Gases by (gas network) in the towns of Veliko Tarnovo, Gorna Oryahovitsa and Lyaskovets, Bulgaria

Status: At validation

Description: The project comprises the design, construction, and operation of a portfolio of one highly efficient gas turbine and two gas engines with a total electrical power capacity of approximately 37 MWs. The installations will be co-generation types, which guarantees highly efficient and reliable electric and thermal power. The co-generation installations will be installed at the local district heating companies in two towns. By installing three turbines/generators for the cogeneration of heat and electricity, the project is expected to reduction GHG emissions.

Note: unlike CDM projects, which needs to apply internationally approved baseline and monitoring methodologies, JI Projects have 2 options: apply the domestic rules or apply CDM methodologies.

APPENDIX 5. CDM PROJECT PARTICIPANTS/ CONSULTANTS AND COUNTRY EXPERTS LIST

Name	Company	Job Title	Notes
PROJECT PARTICIPANTS / CONSULTANT			
Steve Throne	SouthSouthNorth Africa	Director	Kuyasa project consultant
Aditya Mehta	Forum Project (Technopolis)	Exe. Asst. to M.D.	Technopolis project participant
Tarun Chattopadhyay	ITC Sonar Hotel	Chief Engineer	ITC Sonar Hotel project participant
A. Ricardo J. Esparta	Ecoinvest Carbon		Pão de Açúcar project consultant
COUNTRY EXPERTS			
Geoff Stiles	Marbek Resource Consultants Africa	Managing Director	http://www.ghgclearinghouse.org.za
Andries van der Linde	Energy Systems	PhD Electrical Engineering	
David EC Rogers	CSIR	Senior Researcher	
Chrisna du Plessis	CSIR Built Environment	Principle Researcher	
Christelle Beyers	CSIR Built Environment	Researcher	
D. Mothusi Guy	PEER Africa, South Africa	Director	http://www.peerafrica.co.za/
Thami Eland	Kutlwanong project, South Africa	Project Leader	
Soumik Biswas	Det Norske Veritas AS (DNV)	Project Manager	
Hajime Uchida	Banco Sumitomo Mitsui Brasileiro S. A.	General Manager	
Fernando A. de Almeida Prado	Sinerconsult Consultoria Treinamento e Participações Ltda	CEO	
José Roberto Moreira	MGM Intl Brasil and USP	Consultant	
Marina Akie Toyama	Banco Sumitomo Mitsui Brasileiro S. A.	Assistant Manager, Global Environment Department	
Fabiana Rodrigues Cowman	Banco Sumitomo Mitsui Brasileiro S. A.	Manager, Global Environmental Department	
Vanderley M. John	University of Sao Paulo	Associate Professor	
Jenny Sayaka Komatsu	Ecoinvest Carbon		
Rodrigo Aguiar Lopes	Ecoluz		
Maria Cecília Amaral	ABESCO	Diretora Executiva	ABESCO- Brazil's ESCO Association
Marcelo Takaoka	Takaoka Empreendimentos.	Diretor-Presidente	http://www.takaoka.org.

About the Sustainable Buildings and Construction Initiative

The Sustainable Buildings and Construction Initiative (SBCI) is a partnership between the United Nations Environment Programme (UNEP) and the Building and Construction sector. SBCI aims at providing a platform for global cooperation towards sustainable building and construction practices worldwide. SBCI works through Think Tanks, research projects, partner dialogues and pilot projects. Current focus areas for SBCI include:

- Provide research and information to enable global policy makers to develop support mechanisms, inside and outside the UNFCCC process, in support of sustainable and carbon lean buildings.
- Develop a global reference system for sustainable buildings to facilitate national initiatives and transfer of sustainable building technologies
- Provide tools and methodologies for local and national governments, in particular in developing countries, to integrate sustainable and energy efficient building approaches in overall development policies.
- Support capacity building in other relevant areas, including sustainable post-disaster reconstruction, green employment in the construction sector, education and capacity building at tertiary levels, and sustainable construction in less developed countries.

SBCI is served by the SBCI secretariat, hosted by UNEP DTIE in Paris

For more information,
see www.unepsbci.org

About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

- sustainable consumption and production,
- the efficient use of renewable energy,
- adequate management of chemicals,
- the integration of environmental costs in development policies.

UNEP DTIE activities focus on raising awareness improving the transfer of knowledge and information, fostering technological cooperation and partnerships, and implementing international conventions and agreements.

For more information,
see www.unep.fr

Buildings are responsible for more than one third of total energy use and associated greenhouse gas emissions globally, both in developed and developing countries. The potential for drastic reductions of the energy consumption in buildings is significant. However, research presented in this report indicates that the Clean Development Mechanism under the Kyoto Protocol has so far hardly at all been able to promote emission reduction projects in buildings.

The report analyses the underlying causes to this situation, and proposes changes to CDM which would allow CDM to support emission reduction projects in buildings and other similar sectors.

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