Documenting Greenhouse Gas Emission Reductions From End-Use Efficiency Activities in the Kyoto Protocol's Clean Development Mechanism Offset Program

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ABSTRACT

This paper discusses how calculation of avoided emissions from end-use energy efficiency measures is addressed in the world's largest greenhouse gas (GHG) emissions offset program, the United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM). Sections of the paper describe the CDM, basic issues associated with calculating avoided emissions from efficiency activities, and CDM baseline and monitoring methodologies for efficiency activities. The CDM provides valuable information and insight for those interested in documenting avoided emissions from end-use efficiency actions.

Introduction

End-use energy efficiency represents a significant, cost-effective approach to reducing greenhouse gas (GHG) emissions. This has been well documented in studies by the Intergovernmental Panel on Climate Change and numerous other government, private and non-governmental organizations (IPCC 2007; McKinsey 2009). However, as with the implementation of energy efficiency programs solely for the purpose of energy use and demand reductions, energy efficiency for GHG mitigation suffers from the difficulty of cost-effectively documenting the benefits of efficiency activities at levels of certainty that can satisfy both regulators and project proponents—addressing the question, "How good is good enough?" In other words, how certain does one have to be of an energy savings estimate, and is that level of certainty properly balanced between the amount of effort (e.g., resources, time, money) required to obtain that level of certainty and the risk of incorrect indications of savings.

This has always been a fundamental issue for energy efficiency and is a result of the counterfactual nature of efficiency actions. Energy savings (or avoided emissions) are not measured, but estimated to varying degrees of accuracy by comparing energy consumption (or emissions) after a project or program has been implemented with an estimate of how much energy would have been consumed in the absence of the project or program. This fundamental conflict—maintaining environmental integrity (ensuring that credited savings are real savings) while actually being able to implement projects (by not making the transaction costs too high)—is what evaluators must consider when devising measurement and verification (M&V) methodologies for emission mitigation programs and energy programs alike.

With respect to this conflict, it should be noted that addressing the question of "How good is good enough?" is connected with answering another question: "As compared to what?" Evaluators typically think of this in terms of the baseline against which efficiency actions are compared for determining avoided emissions and whether attribution (causes of efficiency-based savings) should be considered. For example, should gross savings be documented, i.e., the savings from efficiency actions irrespective of their cause, or should attempts be made to document net savings, i.e., those savings directly attributable to the subject efficiency program? However, there are broader "as compared to what" questions that relate to the alternatives of not implementing efficiency activities because of the uncertainty of the energy savings or avoided emission values. Because other types of activities (building more wind turbines or nuclear power plants, for example) could be implemented, the risk and uncertainty of efficiency should be compared against the relative risks and uncertainties of other energy resources and GHG mitigation strategies.

This paper describes how one program, the UNFCCC Clean Development Mechanism (CDM), attempts to balance the environmental integrity issue with sustainable development and climate change mitigation objectives. The CDM was established as part of the Kyoto Protocol and is the world's largest GHG emissions offset program. The CDM allows emission-reduction projects in developing countries to earn Certified Emission Reduction (CER) credits, each equivalent to one ton of CO_2. These CERs can be traded and sold, and used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol.

The CDM is also one of the few programs with a formal regulatory oversight structure in which offsets are directly used in a mandatory cap and trade program. This paper describes some of the CDM methodologies used for documenting avoided emissions from efficiency activities. Methodologies are central to any project-based mechanism, as they indicate the procedures for defining project eligibility, calculating baseline and project emissions, and monitoring emission reductions from a project activity over time. The development of methodologies has proved to be critical in order to expand the reach of the CDM, as each new methodology has the potential to unleash a new path for a different type of project/activity to access carbon finance (World Bank 2010).

The Clean Development Mechanism (CDM)[1]

At the 1992 United Nations Conference on Environment and Development in Rio de Janeiro, participating countries agreed to the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC contained a non-binding commitment by industrialized countries (listed in Annex I of the Convention) to reduce their GHG emissions to 1990 levels by the year 2000. At the 3rd Conference of Parties (COP) to the Convention held in 1997 in Japan, Parties agreed on the Kyoto Protocol, which set targets for industrialized countries to reduce their domestic emissions by an average of 5% below 1990 levels in the period 2008-2012, known as the first commitment period. To help reduce the cost of meeting these commitments, three market-based "flexible mechanisms" were included in the Protocol: Emissions Trading (ET), Joint Implementation (JI) and the Clean Development Mechanism (CDM).

While different in operation, these three mechanisms are based on the same principle: to allow industrialized countries to reduce emissions wherever in the world those reductions are least expensive, and then count those reductions toward their national targets. The CDM and JI are two project-based mechanisms targeting GHG reduction projects in developing countries and Annex I countries, respectively (with the focus of JI being on countries with economies in transition). CDM has the twin goals of GHG emissions reductions and sustainable development in the host (developing) country.

The basic concept is that the CERs, which are offsets, are sold to entities in the Annex I countries at a cost less than these entities' costs to reduce their own emissions. The money generated from the sale of CERs pays for projects in the developing countries. GHG emissions are reduced in an economically efficient manner and developing countries receive funds to invest in sustainable development projects.

At the 7th COP to the UNFCCC in 2001, most of the rules for the CDM were agreed to and enshrined in the Marrakesh Accords. These agreements served as the foundation for CDM rules. The

[1] Information for this section of the report is taken, in some case verbatim, from a number of sources, including the primary UNFCCC CDM website (http://cdm.unfccc.int) and documents such as the *The Clean Development Mechanism (CDM) Toolkit* (2010) prepared by CDM Watch (www.cdm-watch.org), the 2010 CDM *Executive Board Annual Report* (http://unfccc.int/resource/docs/publications/10_cdm_anrep.pdf), the UNEP Risoe CDM/JI Pipeline Analysis and Database (http://cdmpipeline.org), the online CDM Rulebook (http://www.cdmrulebook.org/Page/home) and the UNFCCC *CDM Methodology Booklet* (November 2010) (http://cdm.unfccc.int/methodologies/documentation/meth_booklet.pdf).

Kyoto Protocol entered into force in February 2005. It has been ratified by all Annex I countries except the United States of America. The first CDM project was registered in 2004, and as of June 15, 2011, there were 3,176 projects registered with 480,806,269 annual average CERs. Now, with more than 2,400 additional projects in the 'pipeline', the CDM is expected to generate more than 2.7 billion CERs in the first commitment period of the Kyoto Protocol (UNFCCC 2011). As of June 2011 the value of a CER is about 16 U.S. dollars. (Bluenext 2011).

Implementing the CDM

Projects can earn CERs equivalent to the volume of the emissions reduced as compared with the "business-as-usual" baseline level of emissions. Hence, each project requires a baseline methodology—to calculate the emissions expected without the project—and a monitoring methodology—to measure the actual level of emissions with the project. Project proponents can use an existing, applicable and approved methodology, or submit a new methodology for approval. Once approved, each methodology is published on the UNFCCC website (http://cdm.unfccc.int/index.html) and becomes a public good.

There are two main types of CDM projects and methodologies—large-scale and small-scale (a third type is for forestry projects). Most end-use energy efficiency activities are now implemented as collections of small-scale projects. Methodologies for large-scale projects can be used for projects of any size, whereas simplified small-scale methodologies can only be applied for renewable energy projects under 15 MW, energy efficiency projects that have less than 60 GWh of annual savings, and "other" projects generating under 60 kilotons of emission reductions per annum.

Most CDM activities are implemented as individual projects, such as upgrading a power plant or retrofitting a large factory. However, projects can be grouped over time to form a Program of Activities (PoA). The PoA is a relatively new concept in the CDM and there are about 100 PoAs in the CDM pipeline with a quarter of them associated with end-use energy efficiency (UNEP 2011). Two PoAs have been registered for compact fluorescent lamp (CFL) projects. Many project proponents hope PoAs will be used to implement very significant efficiency programs in developing countries.

A vast infrastructure and industry have been established to implement the CDM. The CDM Executive Board (EB), answerable ultimately to the countries (parties) that have ratified the Kyoto Protocol, oversees the mechanism. These parties are collectively known as Conference of the Parties (COP), serving as the Meeting of the Parties to the Kyoto Protocol (CMP). The EB has several panels and expert groups to develop methodologies, register projects, issue CERs and accredit designated operational entities (DOE). Two of these panels/expert groups are the Small-Scale Working Group (SSC-WG) and the Methodology Panel (MP), which oversee methodological work in small- and large-scale areas, respectively. Recently, the SSC-WG has been developing new methodologies for high-interest energy efficiency and renewables activities in response to requests from the EB and CMP.

A DOE is an "independent/third-party" organization accredited and designated to validate and subsequently request registration of a proposed CDM project activity. DOEs verify emission reductions of a registered CDM project activity, certify them as appropriate, and request the EB to issue certified emission reductions accordingly. Designated national authorities (DNA) represent the project's host country and provide approval letters attesting to whether the project activities represent sustainable developments. Projects are initiated by Project Proponents who submit a Project Design Document (PDD) to the UNFCCC Secretariat. Figure 1 summarizes the CDM process and role of these entities. The Secretariat, a part of the United Nations, staffs the CDM and is located in Bonn, Germany.

Status of the CDM and Energy Efficiency

As the Kyoto Protocol is set to expire in 2012, Parties to the Treaty are currently discussing what will happen after 2012 in the so-called second commitment period (2013-2020). The expectation is that the CDM or some form of the CDM will continue in part because no other offset mechanisms have been agreed to by the Parties.[2] To its credit, the CDM is also expected to continue because it has an established infrastructure and because the mechanism stimulates sustainable development and emission reductions while giving industrialized countries flexibility in how they meet their emission reduction or limitation targets. It has also generated a great many hard-learned lessons on implementing a global offset program.

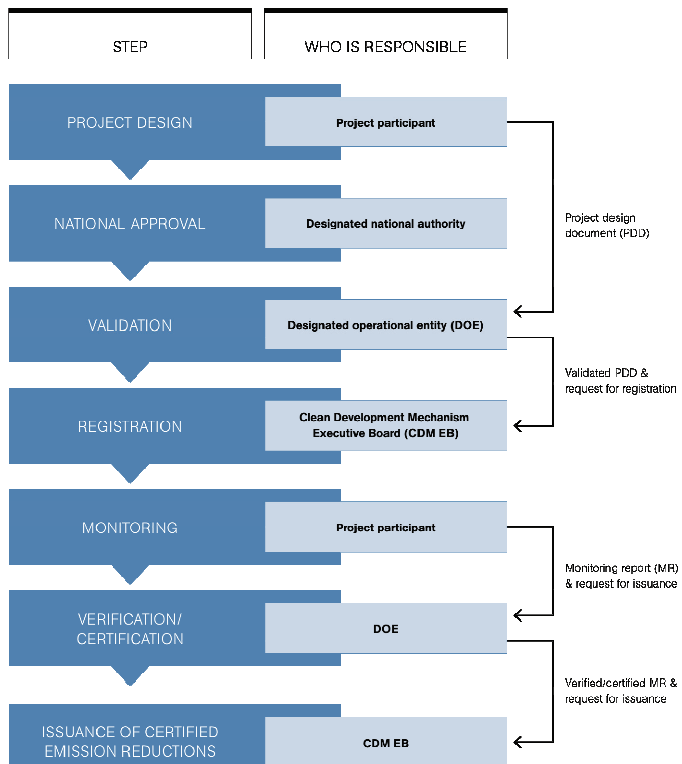

Figure 1. Clean Development Mechanism Project Cycle (UNFCCC 2011)

The CDM is not without controversy, however, and it has come under attack from all corners of the climate mitigation industry. Complaints are that it is too complex, too slow, too bureaucratic, supports some projects that do not actually reduce emissions, and supports some projects that do not actually result in sustainable development. In terms of efficiency activity, the CDM has been criticized for generating end-use efficiency projects that represent less than 4% of the CDM projects in the pipeline and these are only expected to generate about 1% of the expected CERs (UNEP 2011), even though efficiency is seen as perhaps the most cost-effective mitigation strategy with significant potential for avoiding large amounts of global GHG emissions (Figueres 2011).

The energy efficiency barriers in the CDM are very similar to those seen with efficiency in general: front-end capital investment requirements, the principal agent problem, widespread and diffuse opportunities, transaction costs, scaling issues and difficulty in documenting energy and emission savings. To address this last issue, the CDM Small-Scale Working Group has been working to update existing methodologies and establish new methodologies that balance the environmental integrity of the CDM with the need for sustainable development projects, such as end-use efficiency. In a program such as the CDM, environmental integrity has a specific implication. The CDM projects generate offsets, and

[2] However, at the 2010 Cancun CMP, two mechanisms were included in agreements: a Technology Mechanism, which will support the innovation, development and spread of new technologies, and a Green Climate Fund, to provide long-term financing to projects, programs, policies and other activities in developing countries. (Figueres 2011)

if offsets are not "real," the entity that buys the offsets will have GHG emissions that are not mitigated, and the emissions cap will be exceeded.

Efforts have also been accelerated to develop new tools, guidance documents and methodologies as the EB and the CMP recognize that end-use efficiency has so far not met its potential as a strategy for both GHG mitigation and sustainable development. These accelerated efforts include:

- Bringing more guidance and acceptability to the concept of sampling for data gathering,
- Use of stipulated values and deemed savings calculations,
- Introducing the use of computer simulation models and control groups,
- Simplified additionality criteria for micro-scale projects and programs, and
- Inviting a wide range of input from efficiency and CDM project development experts.

Another major area for CDM improvement and reform is the introduction of standardized baselines and monitoring methodologies This standardization requires reliable data that documents baseline conditions (i.e., what technologies are in place and how they are operated) in developing countries and is aimed at maintaining environmental integrity while reducing transaction costs, enhancing transparency and predictability, and facilitating access to underrepresented project types and regions. A significant reduction in transaction costs is needed in order to scale up the number of CDM projects in least developed countries (LDCs); CDM projects are almost non-existent in LDCs. This is particularly important in the face of the European Union's recent decision to, after 2012, only utilize CDM CERs from projects located in LDCs.

The last section of this report discusses some of the small-scale methodologies that incorporate results from the efforts listed above, but first the basics of calculating avoided emissions are discussed.

Issues Associated With Calculating Avoided Emissions From Efficiency Activities

Energy efficiency can avoid emissions associated with the production of electricity and thermal energy from fossil fuels. These avoided emissions are the "conventional pollutants" such as sulfur dioxide (SO_2), Nitrogen Oxides (NO_x), Mercury (Hg) and particulates (PM), as well as GHGs—primarily Carbon Dioxide (CO_2), which is emitted during fossil fuel combustion. Avoiding or reducing GHG emissions is called mitigation. In this section, we present several basic mitigation concepts: where and how efficiency avoids emissions and the role of suppressed demand; two basic approaches to calculating avoided emissions; additionality; assessment boundaries; and special issues for efficiency under cap and trade programs.

Direct and Indirect Emissions, Primary and Secondary Effects and Suppressed Demand

Direct and indirect emission reductions are the two categories for consideration when defining what emissions are to be avoided by an efficiency program or activity. Avoided direct emissions are changes in emissions at a project site (controlled by the project sponsor or owner). For efficiency projects affecting onsite fuel use (e.g., high-efficiency boilers), the avoided emissions are direct. Avoided indirect emissions are changes in emissions that result from an activity that occurs at an emissions source away from the project site (e.g., a power plant). Indirect emissions are the primary source of avoided emissions for end-use electrical efficiency projects. The GHG Protocol (World Resources Institute and World Business Council for Sustainable Development 2004), a widely used tool for GHG accounting, further categorizes these direct and indirect emissions into three broad scopes:

1. All direct GHG emissions.
2. Indirect GHG emissions from consumption of purchased electricity, heat or steam.
3. Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity,

electricity-related activities (e.g., transmission and distribution losses) not covered in Scope 2, outsourced activities, waste disposal, etc.

Another pair of important categories relating to avoided emissions are:

1. Primary effects: the intended change in emissions caused by a GHG mitigation action. Efficiency programs generally have only one primary effect—energy savings at facilities (a home, a power plant, etc.) that consume energy that in turn translate into avoided emissions.
2. Secondary effects: an unintended change in emissions caused by a program. All types of secondary effects are sometimes grouped together and called "leakage." Secondary effects, leakage and interactive effects are similar concepts that can get confused. Leakage is a more "global" issue, whereas interactive effects tend to be considered within the facility where a project takes place.

In the CDM, leakage is defined as the "net change of anthropogenic emissions by sources of greenhouse gases which occurs outside the project boundary, and which is measurable and attributable to the CDM project activity." With CDM end-use efficiency activities, leakage is not usually considered, because leakage is in almost all cases a minor issue relative to the primary effects of energy efficiency programs, particularly when compared to baseline secondary effects. For example, the manufacturing, maintenance and installation of energy-efficient motors have no meaningfully different associated emissions than the emissions associated with standard efficiency motors.

While addressing secondary effects is a relatively minor concern in most energy efficiency activities, there is one issue that is not necessarily well covered by the definitions of leakage or secondary effects, but that is important for efficiency: suppressed demand. Suppressed demand for energy occurs when energy services are under-utilized due to poverty or a lack of energy infrastructure.

This is a major issue in the developing world where CDM projects take place. Related to the "rebound" and Jevons Paradox[3] issues that have gathered much interest in the United States, when suppressed demand is met, partially or fully, energy consumption can rise with or without CDM efficiency projects. Thus, a fundamental issue for CDM end-use efficiency methodologies is whether baselines consider energy consumption service levels (e.g., how well a home is heated) at existing levels or at levels when demand is satisfied. This is not a fully resolved issue for the CDM, but many of the CDM efficiency methodologies for residential and "local" activities allow service levels for both the baseline and project scenarios to be calculated at the level of service associated with the post-project implementation level. In CDM terminology, this is allowing for *avoidance of future emissions*.

Two Approaches to Calculating Avoided Emissions

For any type of energy efficiency activity, the avoided emissions are determined by comparing the emissions occurring after the activity is implemented to an estimate of what the emissions would have been in the absence of the activity; that is, emissions under a baseline scenario. Conceptually, avoided emissions are determined using the net energy savings attributable to the influence of a particular climate program (such as the CDM), and one of two different approaches:

- Emission Factor Approach: Multiplying the activity's net energy savings by emission factors (e.g., kilograms of CO_2 per MWh) representing the characteristics of displaced emission sources to compute hourly, monthly or annual avoided emission values (e.g., tons of CO_2).
- Scenario Analysis Approach: Calculating a base case of sources' (e.g., power plants connected to the grid) emissions without the efficiency activity and comparing that with the

[3] The Jevons Paradox is the proposition that technological progress that increases the efficiency with which a resource is used tends to increase (rather than decrease) the rate of consumption of that resource.

emissions of the sources operating with the reduced energy consumption associated with the efficiency activity. For large projects/programs affecting an electric grid this is done with simplified spreadsheet methods to sophisticated computer simulations.

One important consideration for both of these approaches is that the net energy savings calculated for the purposes of an energy resource program may be different from the net savings that need to be calculated to meet the requirements of an avoided emissions program. Three potential causes of a difference are discussed briefly below: different definitions of additionality, different definitions of boundary areas, and the characteristics of emissions control mechanisms/regulations that are in place.

Additionality

"Additionality" is the term used in the emission mitigation industry for addressing the key question of whether a project will produce reductions in emissions that are additional to reductions that would have occurred in the absence of a climate program. This is directly related to defining proper baseline conditions and free ridership. As the baseline is a "what-if" value, baselines—and thus additionality—cannot be directly measured, and must be inferred from available information.

While the basic concept of additionality may be easy to understand, there is no common agreement on the procedures for defining whether individual projects or whole programs are truly additional (i.e., different from a baseline scenario). As such, there is no technically correct level of stringency for additionality rules. Program designers and evaluators need to decide, based on their policy objectives, what tests and levels of scrutiny should be applied in additionality testing. For example, program objectives that focus on obtaining avoided emissions credits as part of a regulatory offset program may necessitate stringent additionality rules. If a project would have happened anyway, then its offsets do not represent any reduction in total emissions. For the CDM, this means that a non-additional project, just like a project with overestimated avoided emissions, will generate "false" carbon credits that an Annex I country can use to avoid making real emission reductions domestically. Ultimately this would lead to an increase in global emissions above what is laid down in the Kyoto Protocol, representing a failure of "environmental integrity" in the mitigation system.

Additionality is thus a very big issue in the CDM. There are many tests used for determining additionality within the CDM, such as comparing projects with common practices (barrier tests) and financial viability (investment tests). There is significant controversy over the viability of these tests and how one can actually tell if the activity would have occurred without the CDM benefits. Barrier tests analyze prevailing practice, technology barriers, institutional capacity, etc., to determine if a project would happen without the CDM. The investment test works on the assumption that CDM projects are additional only if they happen due to the incentive provided by the revenues from CER sales. Criticism of the investment test has been that it allows too much flexibility with respect to choice of risk premiums, that it is too complex, and that DOEs lack the knowledge to verify assumptions. Similarly, barrier tests are criticized for lacking solid indicators of the prohibitive nature of barriers, for requiring knowledge of local conditions, and based on a general distrust of Project Proponent reported barriers.

Fortunately, most efficiency activities tend to fall in the "small-scale" category, which has simpler and in the case of some micro-scale projects (such as end-use efficiency projects implemented in LDCs at a scale of no more than 20 Gigawatt-hours per year) no additionality test requirements. In addition the EB has clarified that national and/or sectoral policies or regulations, established after a date in 2001, that give comparative advantages to less emissions-intensive technologies over more emissions-intensive technologies (e.g. public subsidies to promote the diffusion of renewable energy or to finance energy efficiency programs) do not have to be considered in the development of baselines. On the other hand, policies or regulations that give comparative advantages to more emissions-intensive technologies are to be taken into account for the definition of baselines (these are known as the E+/E- policies – see

Annex 3 of the EB's 22nd meeting report). With these CDM policies - and because of the known barriers and growing interest in promoting efficiency through the CDM - there has been less controversy over additionality for CDM efficiency projects than for other types of activities.

Thus, there is a constant search in the CDM for an improved method for additionality testing. Some commonly discussed ideas include default profitability benchmarks on a country level for investment analysis, payback-period-based investment tests for demand-side energy efficiency, positive lists of technologies that are de-facto additional, and the use of market penetration metrics, e.g., first-of-its-kind technologies in a target market.

Assessment Boundary

The "emissions assessment boundary" is used to define and encompass all energy uses and emission sources affected by activities associated with a project or program. For many types of activities, such as in the transportation sector, defining the assessment boundary can be both critical and difficult. For end-use energy efficiency, in the CDM and in general, if one ignores the Scope 3 emissions, then the boundary definition is not critical. In a typical CDM end-use energy efficiency methodology the boundary is defined as the physical location of each measure (e.g., the new energy efficiency motor) and the facility in which the measures are installed.

Special Issues Under Cap and Trade

Cap and trade is only one of the various mechanisms for controlling emissions. Under a cap and trade program, an overall emission cap is set for an affected sector or set of emitters (e.g., power plants or very large boilers). Allowances are created that represent the temporary right to emit one unit of the allowable cap. Using one or more methods, allowances are distributed to the affected emitters. The primary compliance requirement is that each capped emitter must hold allowances equal to its actual emissions at the end of each compliance period. However, each emitter's emissions are not limited to the allowances that it initially obtains, thus the "trade" in "cap and trade". It may purchase additional allowances from another emitter or sell allowances if it has a surplus.

With the Kyoto Protocol there is a cap on industrialized countries (the Annex I countries), and in many places there is a cap and trade program in place, such as the European Union Emissions Trading Scheme (EU ETS). However, the developing countries not included in the Annex I list do not have a cap. This lack of a cap in developing countries is the basis for the CDM concept of using reductions in developing countries as offsets in Annex I countries.

When emissions are not capped, as in developing countries, end-use energy efficiency provides clear incremental CERs by reducing the output of electricity generators, boilers, etc. However, this is not true for emissions from sources with emission caps, e.g., power plants in industrialized countries subject to the Kyoto Protocol. Such is the case in "capped" countries where end-use electricity efficiency projects result in emission reductions at the capped power plant, not at the project site, irrespective of the cause of the reduction (e.g., customer investment versus utility investment). Reductions in these capped-source emissions make extra allowances available. Those efficiency allowances can be sold and used elsewhere, or banked for use in a later year, so if the efficiency allowances are used, the total emissions will remain roughly equal to the cap level.

Thus, within a capped sector, under a cap and trade program, an efficiency program may not be able to claim avoided emissions unless the efficiency allowances are retired (removed from the market) or policies are put in place to ensure that the emissions trading cap and the amount of allowances allocated are reduced commensurate with the amount of energy efficiency implemented. Since the goal of the trading program is to achieve the cap at the lowest possible cost to society, by helping to minimize the compliance cost, energy efficiency contributes to the primary goal of the cap and trade program, but the electricity end-use efficiency allowances directly benefit the power plant owner, not the facility owner. While not an issue for the CDM, this is an important issue for the design of efficiency-related emissions mitigation programs in countries or regions that are also establishing cap and trade programs (Schiller et al. 2008; Schiller, Goldman and Galawish 2011).

CDM Methodologies For Efficiency and Renewable Energy

CDM methodologies for energy efficiency and renewable energy have been prepared for both large-scale and small-scale projects, with some small-scale methodologies also defining specific requirements for PoAs. In 2002, the COP approved an initial group of 14 simplified baseline and monitoring methodologies for small-scale (SSC) CDM project activity categories. As of June 2011 there are 180 CDM methodologies, 71 of which are small-scale methodologies and 12 of these are designated as energy efficiency methodologies (Type II in the UNFCCC vocabulary). Forty-eight of the small-scale methodologies are for Type III projects (essentially the "other" category) and tend to cover rather specific project activities, such as replacing refrigerators with consideration of refrigerant losses, transportation projects, and fossil fuel switching at a cogeneration facility.

With respect to energy efficiency activities, there are methodologies covering commercial/industrial/municipal facilities (e.g., retrofits and new construction projects associated with steam systems, water pumping, energy recovery, boilers, chillers, street lighting, district heating, metals production and agriculture) and households (retrofits and new construction projects associated with cook stoves, water pumping, water purification, refrigerators, lighting, and whole-building projects).

This section summarizes four small-scale methodologies—three for energy efficiency activities and one for a renewable energy activity. These examples show a range of approaches used in SSC methodologies. The renewable energy methodology is included as it is a new methodology that shows the unique use of a stipulated emission reduction value per project activity.

Methodologies define the requirements associated with determining the number of CERs generated by a mitigation project. The following sections are in each methodology:

- Description of the applicability of the methodology,
- Description of the project boundary,
- Procedure to identify the baseline scenario,
- Procedure to demonstrate and assess additionality (large scale methodologies only),
- Procedure to calculate emission reductions, and
- Description of the monitoring procedure.

In addition to the methodologies, a number of guides and tools have been developed over the years by the UNFCCC to support analysis and implementation of projects. These include tools for determining additionality, defining baselines, determining proper monitoring samples, calculating emission factors for electrical grids, and determining the remaining lifetime of equipment. One of the most valuable tools is the "Tool to calculate the emission factor for an electricity system." As stated in the tool (UNFCCC 2009), "This methodological tool determines the CO_2 emission factor for the displacement of electricity generated by power plants in an electricity system, by calculating the 'combined margin' emission factor (CM) of the electricity system. The CM is the result of a weighted average of two emission factors pertaining to the electricity system: the 'operating margin' (OM) and the 'build margin' (BM). The operating margin is the emission factor that refers to the group of existing power plants whose current electricity generation would be affected by the proposed CDM project activity. The build margin is the emission factor that refers to the group of prospective power plants whose construction and future operation would be affected by the proposed CDM project activity."

AMS.II.C Demand-Side Energy Efficiency Activities for Specific Technologies

AMS.II.C is a very simple methodology. It was one of the original small-scale methodologies, and might be considered as the generic end-use energy efficiency methodology. AMS-II.C is now at version 13, and there have been 11 projects and one PoA registered using AMS.II.C (with 28 projects and 9 PoAs in the pipeline). Table 1 summarizes key aspects of the methodology.

Table 1. AMS.II.C Demand-Side Energy Efficiency Activities for Specific Technologies

Applicability	Wide range of measures such as efficient lamps, refrigerators, motors, fans, air conditioners, pumping systems, etc., implemented at many sites. Projects can be retrofits or new construction. For each replaced appliance/equipment/system, the rated capacity or output or level of service (e.g., light output, water output, output capacity of air-conditioners, etc.) is not significantly smaller (maximum 10%) than the baseline or significantly larger (maximum + 50%) than the baseline.
Baseline Emissions	If the energy displaced is fossil fuel based, the energy baseline is the existing level of fuel consumption or the amount of fuel that would be used by the technology that would have been implemented otherwise. The emissions baseline is the energy baseline multiplied by an emission factor for the fossil fuel displaced. If the energy displaced is electricity, the emission baseline is determined by increasing the onsite energy savings by a grid (T&D) losses factor and then multiplying the total savings by a grid emission factor. Two options are provided for determining baseline energy use. If refrigerant is used in the baseline, the amount of refrigerant times its global warming potential is also included in baseline.
Project Emissions	Project emissions are simply the energy use in the project case times a fuel emission factor, or times grid emissions and T&D factors, plus a refrigerant factor if appropriate.
Monitoring	Monitoring requires determination of baseline and project energy use for all or a sample of devices. Monitoring also includes annual checks of a sample of non-metered devices to ensure that they are still operating.

AMS.II.J Demand-Side Activities for Efficient Lighting Technologies

AMS.II.J was prepared specifically for residential CFL retrofit projects. It has gone through a number of revisions in an attempt to simplify its application. It is the first methodology to allow the use of a deemed savings value—3.5 hours per day for residential lamp operating hours. AMS-II.J is now at version 3, and there have been 13 projects and one PoA registered using AMS.II.J. There are also 43 projects and nine PoAs in the pipeline using AMS.II.J. CFLs may be the most common CDM end-use efficiency measure. Table 2 summarizes key aspects of the methodology.

Table 2. AMS.II.J Demand-Side Activities for Efficient Lighting Technologies

Applicability	Projects that involve adoption of self-ballasted CFLs to replace incandescent lamps in residential applications—direct install or a distribution program. Quality and light standards are defined for CFLs. CERs can only be earned for the rated lifetime (rated life to 50% failures) of project CFLs, not to exceed 10 years.
Emission Reductions	Annual energy savings are calculated by multiplying the number of replaced lamps times change in wattage times operating hours times a net to gross factor (0.95) times a factor for T&D losses times the lamp failure rate. A calculation combined with a monitoring requirement is used to determine lamp failure rate.
Monitoring	First ex post monitoring survey, carried out within the first year after installation of CFLs, provides a value for the number of lamps placed in service and operating. Subsequent monitoring surveys are carried out about every three years to determine CFL failure rates. Also, if the stipulated 3.5 hours per day of operation is not used in the CER calculation, monitoring is required to determine operating hours. Guidance is provided for sample size selection for monitoring.

AMS.III.AE Energy Efficiency and Renewable Energy Measures in New Residential Buildings

AMS.III.AE was established in 2010 to address the installation of energy efficiency and optional renewable power generation measures in new grid-connected residential buildings. It is unique in that it allows the use of control groups or computer building simulation to determine energy savings. AMS-III.AE is at version 1, and no projects have been registered, although there is at least one PoA being developed in Mexico. Table 3 summarizes key aspects of the methodology.

Table 3. AMS.III.AE Energy Efficiency and Renewable Energy Measures in New Residential Buildings

Applicability	Efficiency and/or renewable energy projects in residential new construction
Emission Reductions	Two approaches are allowed: (a) Annual ex post comparison of measured annual average electricity consumption of a sample of the occupied project residences is compared to annual average electricity consumption of baseline residences as determined using a calibrated computer simulation model of the baseline residences, using actual weather conditions. (b) Annual ex post comparison of measured annual average electricity consumption of a sample of the occupied project residences with a sample of baseline residences (comparison group) using regression analyses.
Monitoring	If calibrated model simulation approach is used, survey data of baseline residence characteristics for model calibration, is required to be collected. If control group regression analysis is used, survey data of baseline and project residence characteristics is required. With both approaches, data are to be collected and analyses done for the first crediting period year and every third year thereafter.

AMS.III.AR Substituting Fossil Fuel Based Lighting With LED Lighting Systems

AMS.III.AR is also a relatively new methodology established to address replacing fossil fuel lamps, such as kerosene lanterns, with LED lamps. A quarter of humanity still obtains illumination by directly burning fuels, emitting nearly 200 million tons of CO_2 each year, the equivalent of 60 million cars (Mills 2010). This methodology is unique in that it allows for a fixed number of CERs per replaced fossil fuel lamp for a two-year period without the use of monitoring—the first true stipulated CER value in the CDM. AMS-III.AR was approved at the end of 2010, and no projects have been registered. There has, however, been a great deal of interest, and there is one PoA in the pipeline. Table 4 summarizes key aspects of the methodology.

Table 4. AMS.III.AR Substituting Fossil Fuel Based Lighting With LED Lighting Systems

Applicability	Activities that replace portable fossil fuel lamps (e.g. kerosene lanterns) with LED-based lighting systems in residential and non-residential applications. Quality and light standards are defined for the LEDs and their charging systems.
Baseline Emissions	A default annual baseline emissions factor is assumed for baseline lamps. A dynamic baseline factor is allowed for change in baseline fuel, fuel use rate and/or utilization during the crediting period, primarily to address suppressed demand.
Project Emissions	Project emissions are zero if the LED lamps are charged by renewable energy systems. If they are charged by an electrical grid, a calculation is used to determine how much electricity is used to charge the LED lamp and the grid emissions associated with that charging.
Monitoring	During project implementation, monitoring is required to confirm the number of LED lamps distributed. If CERs are to be claimed for up to seven years, monitoring is required of a sample of LED lamps to determine the percentage of lamps still operating each year.

Conclusions

The CDM provides valuable guidance and insights on how avoided GHG emissions can be calculated from efficiency projects and programs. While it is has limitations related to its complexity, the CDM has moved far up the learning curve from the first efficiency methodologies that were developed in 2002. It can be a valuable resource for those looking to establish offset and other types of efficiency programs that mitigate GHG emissions and support sustainable development. Moving forward, the CDM can also learn from the experience in countries, such as the United States, that have a long history of measurement and verification of efficiency actions. This experience can be related to efforts associated with reducing the cost of documenting energy savings, and thus avoided emissions. Examples include the use of more stipulated savings and standardized baselines, and taking more advantage of advanced metering technology, simulation models and sampling strategies. One CDM need that does however require specific experience in the developing countries is the obtaining and reliably documenting of energy efficiency baseline and project savings data that can be used to develop more robust stipulated savings values for typical efficiency projects.

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[4] Affiliation noted for identification purposes only and the views expressed herein are those of the author and do not necessarily reflect the views of the United Nations and in particular the UNFCCC, its Secretariat, or any of its affiliated Boards, Panels or Working Groups.

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