Indicative simplified baseline and monitoring methodologies
for selected small-scale CDM project activity categories

TYPE II - ENERGY EFFICIENCY IMPROVEMENT PROJECTS

Project participants shall apply the general guidelines for the small-scale (SSC) clean development mechanism (CDM) methodologies, Guidelines on the demonstrating of additionality of SSC project activities at <http://cdm.unfccc.int/Reference/Guidclarif/index.html#meth> *mutatis mutandis*.

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

Technology/measure

1. This methodology comprises activities that involve the installation of new, energy-efficient equipment (e.g. lamps, ballasts, refrigerators, motors, fans, air conditioners, pumping systems, and chillers) at one or more project sites. Retrofit as well as new construction (Greenfield) projects are included under this methodology. In the case of new construction projects, a stepwise approach is indicated for determining the baseline under paragraph 19 of version 17.0 of the general guidelines to SSC CDM methodologies.

2. This methodology is only applicable if the service level (e.g. rated capacity or output) of the installed, project energy-efficient equipment is between 90% and 150% of the service level of the baseline equipment. Examples of service levels are light output for lighting equipment, water output and temperature for water heating systems, and rated thermal output capacity of air conditioners. The relationship of the service level of the project energy-efficient equipment to the baseline equipment can be one to one replacement (e.g. replacement of inefficient refrigerator with new and efficient refrigerator) or many-to-one (e.g. replacement of small multiple chillers with a central chiller plant). In the latter case, the service level of the project and baseline can be compared on an aggregate basis.

3. Requirements pertaining to the baseline of the retrofit projects and projects involving capacity increase are indicated in paragraphs 20 to 21 in the above cited general guidelines to SSC CDM methodologies. In the event that project output in year *y* is greater than the average historical output (average of the three most recent years prior to the project implementation[1]) and the demonstration of the baseline for the incremental capacity is not undertaken, the value of the output in year *y* is capped at the value of the historical average output level.

4. If the energy-efficient equipment contains refrigerants, then the refrigerant used in the project case shall have no ozone depleting potential (ODP).

5. This methodology credits emission reductions only due to the reduction in electricity and/or fossil fuel consumption from use of more efficient equipment. However, the calculation of project emissions shall include any incremental emissions, as compared to the baseline, associated with refrigerants used in the project equipment.[2]

6. The aggregate energy savings by a single project may not exceed the equivalent of 60 GWh per year for electrical end-use energy efficiency technologies. For fossil fuel end-use energy efficient technologies, the limit is 180 GWh thermal per year in fuel input.

[1] A maximum of +10% variation is permitted.

[2] See EB 34 report, paragraph 17.

Boundary

7. The project boundary is the physical, geographical location of all equipment and systems affected by the project activity.[3] For example:

- The boundary includes each lighting fixture and circuit and any affected space heating and/or cooling systems in the case of a lighting replacement project;
- If two or more pumps are configured to operate in parallel at a pumping station and the project activity is retrofitting only one of the pumps, the boundary shall include the entire pumping station to enable appropriate metering and monitoring and any upstream or downstream pumping stations that may be affected by changes in pumping at the project pumping station;
- The boundary includes the entire chiller plant, including distribution pumps and cooling tower systems, and all of the heating, ventilation and air conditioning systems for chiller replacement projects.

Procedure for estimating the end of the remaining lifetime of existing equipment

8. The point in time at which the baseline equipment and/or systems would have been replaced in the absence of the project activity, and thus triggering the requirement for a new baseline scenario, shall be estimated in a conservative manner using the "Tool to determine the remaining lifetime of equipment". The project activity shall be considered as one possible baseline scenario at the end of the useful life of existing, baseline equipment.

Baseline

Baseline calculation for projects involving electricity savings

9. If the energy displaced is electricity, the emission baseline is determined using one of the three following options:

Option 1 – Constant load equipment

10. This option is applicable to retrofit and Greenfield projects. It applies to equipment that requires the same power (kW) to operate whenever it is energized within specified limits, i.e. is (are) constant load equipment.

11. The constant load condition shall be demonstrated by monitoring or using the historical records of energy consumption data for a one-year period prior to the project implementation. The data recording interval is monthly or less, i.e. a minimum of 12 data points. Data is considered to demonstrate a constant rate of energy consumption if 90% of the energy consumption values are within $\pm$ 10% of the annual mean.

12. Examples of what are typically constant load equipment are lighting equipment controlled by on/off switches and electric resistance heating. Electric motors may also qualify provided the rate of energy consumption is constant. Examples also include residential furnace blower motors

and irrigation pump motors delivering a constant volume at a constant head. Annual operating hours may vary but the rate of energy consumption is fixed.

13. The equations for calculating baseline energy use and emissions are as follows:

$$BE_y = E_{BL,y} \times EF_{CO2,ELEC,y} + Q_{ref,BL} \times GWP_{ref,BL} \tag{1}$$

$$E_{BL,y} = \sum_i (n_i \times \rho_i \times o_i / (1 - l_y)) \tag{2}$$

Where:

BE_y	Baseline emissions in year *y* (tCO_2e)
$E_{BL,y}$	Energy consumption for the baseline in year *y* (kWh)
$EF_{CO2,ELEC,y}$	Electricity emissions factor. If electricity displaced is grid, the emission factor in year *y* shall be calculated in accordance with the provisions in AMS-I.D (tCO_2/MWh). If electricity displaced is captive electricity, the emission factor in year *y* shall be calculated in accordance with the "Tool to calculate baseline, project and/or leakage emission from electricity consumption"
$\sum_i$	Sum over the group of *i* baseline equipment (e.g. 40W incandescent lamps, 5 hp motors) replaced or that would have been replaced. The devices in group *i* must be closely related by type (e.g. motor), size (e.g. 5 hp), service (e.g. conveyor belt, office building chilled water pump), and any other relevant factors that determine energy consumption of the equipment
n_i	Number of pieces of equipment of the group of *i* baseline equipment replaced or that would have been replaced
ρ_i	Electrical power demand (kW) of the group of *i* baseline equipment (e.g. 40W incandescent lamps, 5 hp motors). In the case of a retrofit activity, electrical power demand is the weighted average of the rated power (kW) of group *i* baseline equipment. For motors, the electrical power demand of baseline equipment is determined based on spot-measurement and/or short-term monitoring data.[3] For motors, nameplate data are not sufficient due to the potential for partial loading. Nameplate data may be used for lighting equipment with on/off controls; however it does not apply to lighting equipment with dimming controls. For large populations of motors, the spot-measurement and/or short-term monitoring data can be taken on a representative sample of motors. In the case of new construction (Greenfield projects), the baseline equipment demand can be determined using one of the following approaches: • The weighted average demand of the equipment of group *i* that complies

[3] Short-term monitoring compensates for small, short-term rapid fluctuations in power in an otherwise constant process. Short-term monitoring should be conducted for a period of at least six hours.

with but does not exceed regulatory efficiency codes and standards, or the weighted average power demand of equipment determined to be representative of equipment on the market, if no codes or standards apply;

or

- Baseline demand is calculated by multiplying the demand during the crediting period for group *i* project equipment by the ratio of project to baseline efficiencies

o_i	Average annual operating hours of the group of *i* baseline equipment. The operating hours of the baseline equipment in year *y* can be determined using surveys by continuous measurement of usage hours of baseline equipment for a minimum of 90 days. For a large population of baseline equipment: (a) Use a representative sample (sampling determined by a minimum 90% confidence interval and 10% maximum error margin); (b) Apply correction for seasonal variation, if any; and (c) Ensure that sampling is statistically robust and relevant, i.e. the selection of the equipment to be analysed for operating hours has a random distribution and is representative of target population (size, location). For project activities where it can be demonstrated that the operating hours would not vary due to project implementation, for example, fixed scheduling of the operation of water pumps in the baseline and in the project, it can be assumed that operating hours during the project are equal to the operating hours in the baseline
l_y	Average annual technical grid losses (transmission and distribution) during year *y* for the grid serving the locations where the devices are installed, expressed as a fraction. This value shall not include non-technical losses such as commercial losses (e.g. theft). The average annual technical grid losses shall be determined using recent, accurate and reliable data available for the host country. This value can be determined from recent data published either by a national utility or an official governmental body. The reliability of the data used (e.g. appropriateness, accuracy/uncertainty, especially exclusion of non-technical grid losses) shall be established and documented by the project participant. A default value of 0.1 shall be used for average annual technical grid losses, if no recent data are available or the data cannot be regarded accurate and reliable
$Q_{ref,BL}$	Average annual quantity of refrigerant used in the baseline to replace the refrigerant that has leaked (tonnes/year). Only applies to projects that replace equipment containing ODP refrigerants. Values from Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances, Volume 3, Industrial Processes and Product Use, 2006 IPCC Guidelines for National Greenhouse Gas Inventories may be used
$GWP_{ref,BL}$	Global Warming Potential of the baseline refrigerant (tCO_2e/t refrigerant)

14. An example illustrating the application of Option 1 is provided in the apppendix 1 to this methodology.

Option 2 – Variable load device(s), regression approach

15. This option is limited to the retrofit of existing equipment and does not apply to Greenfield projects. It applies to baseline equipment for which the rate of energy consumption, demand (kW), varies in response to independent variable(s) such as weather. An example is cooling equipment used to condition an office space where demand changes with outdoor dry bulb and wet bulb temperatures, solar gain and office occupancy. A mathematical function is developed, using regression techniques, to determine baseline energy consumption as a function of the relevant independent variable(s). The independent variables are measured during the crediting period and used in the regression function to predict baseline energy consumption throughout the crediting period.

Where:

16. The baseline emissions under Option 2 are calculated as follows:

$$E_{BL,y} = \sum_i (n_i \times kWh_i)/(1-l_y) \tag{3}$$

$$BE_y = E_{BL,y} \times EF_{CO2,ELEC,y} + Q_{ref,BL} \times GWP_{ref,BL} \tag{4}$$

Where:

kWh_i	Annual average electric energy use for the equipment in group *i*. Based on regression analysis[4] of relevant independent variables that have a physical influence on energy use, for example outside air dry bulb temperature for space cooling applications. Takes for example the form of: $kWh=f(x)+\varepsilon$, where x are the independent variable(s) causing the device(s) to use energy and ε is the error term The data for the analysis must cover a period of 12 continuous months. The data measurement interval will depend on the application but is typically 0.25 to 1.0 hour in length

17. In order to utilize the regression model to determine emission reductions, the t-test associated with relevant independent variables that have a physical influence on energy use has to be at least 1.645, for a 90% confidence. The regression model must be documented with a complete report indicating at least who completed the regression analyses, when it was completed, key assumptions, how the independent variables were selected and basis for including these variables and rejecting others, the regression results, the survey instrument(s), final sample results, and predicted baseline energy consumption with respect to key variables (e.g. outdoor dry bulb and wet bulb temperatures and office occupancy).

[4] Regression analysis is a statistical method used to establish cause-effect for the investigation of relationships between the variables.

18. An example illustrating the application of Option 2 is provided in the apppendix 1 to this methodology.

Option 3 – Production efficiency/specific energy consumption approach

19. This option does not apply to Greenfield projects. This option is only applicable if the ratio of energy output to energy input for the baseline equipment can be shown to not be variable over the range of outputs experienced during the crediting period.

20. The baseline is calculated by using specific energy consumption per unit of output in the baseline multiplied by the output in project year *y* multiplied by the emission factor for the electricity displaced. This option can only be used where comparable conditions for the output in the baseline and project can be established. For example, in the specific case of a water pumping system comparable conditions can be established by one of the options below:

(i) Show that average baseline water flow rate (discharge) is within ±10% of the flow rate during the project;[5] or

(ii) Choose the nameplate head and discharge specifications of the baseline pump and corresponding power/energy consumption (weighted average values can be used when pumps are operated in parallel) for a conservative estimate of EER.

21. The baseline under Option 3 is calculated as follows:

$$BE_y = E_{BL,y} \times EF_{CO2,ELEC,y} + Q_{ref,BL} \times GWP_{ref,BL} \quad (5)$$

$$E_{BL,y} = \sum_i \left[EER_i \times Q_{i,y} / (1 - l_y) \right] \quad (6)$$

Where:

EER_i	Specific energy consumption in the baseline (MWh/unit/year) for equipment in group *i*. EER is calculated as the total annual energy consumed in the baseline divided by the total quantity of annual output of the baseline equipment in the baseline. A group is a collection of devices sharing similar sizes, functions, schedules, outputs or loads. The calculation of EER must be based on data recorded at a fixed interval over a period of at least 12 continuous months. Examples of the recording interval are 15 minute, hourly, daily. EER values must be reported with 10% or higher precision at the 90% confidence level
$Q_{i,y}$	Total quantity of output in project year *y* for equipment in group *i*

22. An example illustrating the application of Option 3 is provided in the appendix 1 to this methodology.

[5] Use three years historic data. For recent facilities (<3 years) a minimum of one year's data are required.

Baseline calculation for project involving fossil fuel savings

23. 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. Reliable local or national data for the emission factor shall be used; IPCC default values should be used only when country or project-specific data are not available.

24. For project activities that improve the energy efficiency through retrofits or replacement of the existing system by a new system, the baseline efficiency can be determined using the relevant provisions from the "Tool to determine baseline efficiency of thermal and electricity systems"[4] where appropriate and applicable.

Project activity emissions

25. Project emissions consist of electricity and/or fossil fuel used in the project equipment, determined as follows.

$$PE_y = EP_{PJ,y} \times EF_{CO2,y} + PE_{ref,y} \quad \textbf{(7)}$$

Where:

PE_y	Project emissions in year *y* (tCO_2e)
$EP_{PJ,y}$	Energy consumption in project activity in year *y*. This shall be determined ex post based on monitored values
$EF_{CO2,y}$	Emission factor for electricity or thermal baseline energy. The emissions associated with grid electricity consumption should be calculated in accordance with the procedures of AMS-I.D. For fossil fuel displaced reliable local or national data for the emission factor shall be used; IPCC default values should be used only when country or project-specific data are not available or difficult to obtain
$PE_{ref,y}$	Project emissions from physical leakage of refrigerant from the project equipment in year *y* (tCO_2e/y) as determined using equation 10 below

26. Project energy consumption in the case of project activities that displace grid electricity is determined as follows using the data of the project equipment or system:

$$EP_{PJ,y} = \sum_t \sum_i (n_i \times \rho_i \times o_i) / (1 - l_y) \quad \textbf{(8)}$$

Where:

n_i	Number of group *i* project devices operating in time interval *t* year *y*
ρ_i	Electrical power demand (kW) of the group *i* project devices measured during the time interval *t* in year *y*
o_i	Operating hours of group of *i* project devices in the time interval *t* in year *y*
	Note that ρ_i and o_i may be determined separately or in combination, i.e. as energy consumption

27. Project emissions from physical leakage of refrigerants are accounted for. All greenhouse gases as defined per Article 1, paragraph 5 of the United Nations Framework Convention on Climate Change (UNFCCC) shall be considered as per the guidance by the Board.[6] $PE_{ref,y}$ is calculated as follows:

$$PE_{ref,y} = (Q_{ref,PJ,y}) \times GWP_{ref,PJ} \quad \textbf{(9)}$$

Where:

$PE_{ref,y}$	Project emissions from physical leakage of refrigerant from the project equipment in year *y* (tCO_2e/y)
$Q_{ref,PJ,y}$	Average annual quantity of refrigerant used in year *y* to replace refrigerant that has leaked in year *y* (tonnes/year). Values from Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances, Volume 3, Industrial Processes and Product Use, 2006 IPCC Guidelines for National Greenhouse Gas Inventories may be use
$GWP_{ref,PJ}$	Global Warming Potential of the refrigerant that is used in the project equipment (tCO_2e/t refrigerant)

Leakage

28. If the energy efficiency technology is equipment transferred from another activity, leakage is to be considered.

Emission reduction

29. The emission reduction achieved by the project activity shall be determined as the difference between the baseline emissions and the project emissions and leakage.

$$ER_y = (BE_y - PE_y) - LE_y \quad \textbf{(10)}$$

Where:

[6] Paragraph 17 of report of EB 34.

ER_y	Emission reductions in year y (tCO_2e)
LE_y	Leakage emissions in year y (tCO_2e)

Monitoring

30. If the equipment installed replaces existing equipment, the number and "power" of a representative sample of the replaced equipment shall be recorded in a way that allows for a physical verification by a designated operational entity (DOE).[7]

31. For projects using Option 1, i.e. if the project equipment installed has a constant current (ampere) characteristic, monitoring shall consist of monitoring either the "power" and "operating hours" or the "energy use" of the equipment installed using an appropriate method. Appropriate methods include:

- Recording the "power" of the project equipment installed (e.g. lamp or refrigerator) using nameplate data or bench tests of a sample of the units installed and metering a sample of the units installed for their operating hours using run time meters; or
- Metering the "energy use" of an appropriate sample of the project equipment installed.

32. For any option, for electricity or fossil fuel savings projects, monitoring shall include annual checks of a sample of non-metered systems to ensure that they are still operating.

33. For projects using Option 2, i.e. if the project equipment has variable load characteristics, monitoring shall consist of metering the "energy use" of an appropriate sample of the equipment installed. Monitoring shall also include annual checks of a sample of non-metered systems to ensure that they are still operating.

34. For projects using Option 3, output and the energy consumption are metered. For example, in the case of pumping systems, monitoring of the project activity shall consist of metering the pumping energy use, hourly or daily discharge (m^3 per day or hour) and the total delivery head (m).

35. When sampling is employed, the "Standard on sampling and surveys for CDM project activities and PoA" shall be followed.

Project activity under a programme of activities

The following conditions apply for use of this methodology in a project activity under a programme of activities:

36. In case the project activity involves the replacement of equipment, and the leakage effect of the use of the replaced equipment in another activity is neglected, because the replaced equipment is scrapped, an independent monitoring of scrapping of replaced equipment needs to be implemented. The monitoring should include a check on whether the number of project activity

[7] This shall be monitored while replacement is underway to avoid, for example, 40W lamps being recorded as 100W lamps, greatly inflating the baseline.

equipment distributed by the project and the number of scrapped equipment correspond with each other. For this purpose, scrapped equipment should be stored until such correspondence has been checked. The scrapping of replaced equipment should be documented and independently verified.

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Appendix 1

Examples of projects applying various options of the methodology

Example project using Option 1

An example is irrigation pumping where water is drawn from an aquifer with a constant depth. The pumps are constant volume. Hours of operation vary seasonally and annually depending on rainfall patterns. The measure is to replace existing pump motors with premium efficiency units. Monitoring data collected monthly over a one-year period of the rate of energy consumption (kW) demonstrates a constant load condition; 90% of records are ± 10% of their mean. Short-term monitoring is conducted for the period of six hours and the data are used to establish the baseline demand. Operating hours of the efficient motors are recorded during the crediting period.

Example project using Option 2

Consider a project at a school facility where space cooling in the baseline case is provided by a distributed population of packaged rooftop units. The project will replace the rooftop units with chilled water supplied from a central chiller plant and new air handler units. The project proponent will build a baseline model using regression analysis to predict annual kWh use. For this simple example all the rooftop units are the same size and a single regression model can represent all units. The independent variables driving kWh use are outside air dry bulb temperatures and building occupancy. The equation below is the general form of the regression equation determining kWh demand for each unit:

$$kWh_i = \sum_k (b + x_1 \times (OAT - T_{cp})_+ \times occ + x_2 \times (OAT - T_{cp})_+ \times unocc)_k \quad (1)$$

Where:

k	The k^{th} hour of the cooling season
b	Regression coefficient
x_1	Regression coefficient when the school is in session
OAT	Average daily outside air dry bulb temperature
T_{cp}	Change point temperature, the outside dry bulb temperature at which cooling is no longer required
x_2	Regression coefficient when school is not in session
occ	Occupancy value; 1 = school in session, 0 = school not in session
$unocc$	Unoccupied value; 1 = school not in session, 0 = school in session

Hourly data of OAT and energy (kWh) use for a sample of rooftop units were collected for 12 months. The collection period captured temperatures under peak design conditions and the lower end of the expected cooling range. The collection period also covered holidays when school was not in session. Daily average kWh use per rooftop unit was regressed against daily average OAT using a change-point regression analysis routine. Daily averages were used instead of hourly values because the resulting model gave a better fit to the data. Average daily temperatures were developed for all days for the cooling season where the school was located. Using the coefficients and change point temperature developed by the regression analysis, kWh use was predicted for the year for a single rooftop unit using equation (11) above. $E_{BL,y}$ was calculated using equation (3).

Example project using Option 3

Consider an energy efficiency improvement of a water pumping station. The purpose of this project is to reduce the energy required for the water delivery service from the pumping station. The plant maintains accurate production records including volume of water output per day and sets up a monitoring programme to record monthly energy use. The EER is calculated based on data recorded at an hourly interval over a period of at least 12 continuous months. EER values are reported with 10% precision at the 90% confidence level. The $E_{bl,y}$ is determined for each credit year using equation (6).

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History of the document*

Version	Date	Nature of revision(s)
14.0	20 July 2012	EB 68, Annex 21 Revision to expand the methodology to cover the replacement of multiple chillers and elaborate a procedure to calculate energy savings for equipment having constant and variable loads.
13	EB 48, Annex 16 17 July 2009	To clarify the consideration of increased output over the historic average and boundary definition, and to add an option to use specific energy consumption for the baseline emission calculations.
12	EB 47, Annex 22 28 May 2009	Elimination of baseline penetration calculations and cross effect calculations.
11	EB 44, Annex 20 28 November 2008	The revisions clarify the consideration of capacity increase of the project equipment, electricity transmission and distribution (T&D) losses in the baseline and cross effects of lighting and heating. With regard to equipment containing refrigerants, the revisions clarify the calculations of direct emissions from refrigerants.
10	EB 41, Annex 17 02 August 2008	Additional guidance on baseline selection for new facilities and for capacity increase due to retrofit; consideration of electricity transmission and distribution losses; guidance on treatment of direct emissions from refrigerants where relevant.
09	EB 33, Annex 26 27 July 2007	Revision of the approved small-scale methodology AMS-II.C to allow for its application under a programme of activities (PoA)
08	EB 28, Annex 29 15 December 2006	The threshold of small-scale Type II methodologies was increased from 15 GWh to 60 GWh. The consideration of transmission and distribution losses in the baseline estimation was removed.
Decision Class: Regulatory **Document Type**: Standard **Business Function**: Methodology		

* This document, together with the ‘General Guidance’ and all other approved SSC methodologies, was part of a single document entitled: Appendix B of the Simplified Modalities and Procedures for Small-Scale CDM project activities until version 07.

History of the document: Appendix B of the Simplified Modalities and Procedures for Small-Scale CDM project activities

Appendix B of the Simplified Modalities and Procedures for Small-Scale CDM project activities contained both the General Guidance and Approved Methodologies until version 07. After version 07 the document was divided into separate documents: 'General Guidance' and separate approved small-scale methodologies (AMS).		
Version	**Date**	**Nature of revision**
07	EB 22, Para. 59 25 November 2005	References to "non-renewable biomass" in Appendix B deleted.
06	EB 21, Annex 22 20 September 2005	Guidance on consideration of non-renewable biomass in Type I methodologies, thermal equivalence of Type II GWhe limits included.
05	EB 18, Annex 6 25 February 2005	Guidance on 'capacity addition' and 'cofiring' in Type I methodologies and monitoring of methane in AMS-III.D included.
04	EB 16, Annex 2 22 October 2004	AMS-II.F was adopted; leakage due to equipment transfer was included in all Type I and Type II methodologies.
03	EB 14, Annex 2 30 June 2004	New methodology AMS-III.E was adopted.
02	EB 12, Annex 2 28 November 2003	Definition of build margin included in AMS-I.D, minor revisions to AMS-I.A, AMS-III.D, AMS-II.E.
01	EB 7, Annex 6 21 January 2003	Initial adoption. The Board at its seventh meeting noted the adoption by the Conference of the Parties (COP), by its decision 21/CP.8, of simplified modalities and procedures for small-scale CDM project activities (SSC M&P).
Decision Class: Regulatory **Document Type**: Standard **Business Function**: Methodology		