Approved baseline and monitoring methodology/ methodological tool clarification response form (Version 02.0)

INFORMATION TO BE COMPLETED BY THE SECRETARIAT OR PANEL/ WG	
Date and number of Panel/ WG meeting:	5–8 May 2014, SSC WG 44
Title/Subject of the request for clarification:	Clarification on monitoring of emission reductions for projects involving power factor correction equipment using AMS-II.C
Reference number of the request for clarification:	SSC_708
Exact reference (number, title and version) of the methodology or methodological tool to which the request for clarification applies:	AMS-II.C “Demand-side energy efficiency activities for specific technologies --- Version 14.0”
Fast track or Regular track:	☐ Fast track ☒ Regular track

Summary of the request for clarification

Original text from PP/CME:

This request seeks **clarification** whether it is **appropriate to monitor the parameters n_i x p_i x o_i as specified by AMS II.C jointly** (i.e. monitoring is constraint to the product of the three parameters). This question arises in the context of a CDM PoA set up as Energy Savings Company (ESCO) for power factor (PF) improvements. In the following, the query is substantiated by a brief description of the baseline- and project scenario as well as the proposed monitoring approach.

Baseline Scenario. The baseline scenario equals the prior to the project scenario. This scenario is characterized by no installation of power factor equipment. Large electricity consumers operate their equipment at a low power factor which results in electricity losses, a high maximum demand, high maximum demand payments by the facilities and high electricity costs. This hampers the host countries’ economic development through high costs for the production of goods and the provision of services based on high electricity costs, and limited availability of electricity resulting in load shedding and a low level of productivity.

The additionality proof shall demonstrate that the power factor, in the absence of this CDM activity, would remain the same or gradually decrease over time.

Project Scenario. The project scenario is characterized by the installation of power quality improvement equipment by EiL. The equipment will be owned, managed and controlled (through a GSM device) by Energy and Information Logistics (EiL) but installed at the premises of EiL’s clients. The installation will reduce EiL clients’ electricity demand.

This section now explores how the emission reductions can be calculated following the methodology’s provisions. Each facility’s annual total energy consumption will be determined by its electricity bill in terms of kWh/yr. This will be based on the new PF. The project emissions are determined as follows:

$$PE_y = E_{PJ,y} \ x \ EF_{CO2,y}$$

Where:

PE_y	Project emissions in year *y* (tCO2e)

$E_{PJ,y}$	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.

The energy consumption under the project scenario is determined as follows:

$$E_{PJ,y} = \sum_i \frac{(n_i \ x \ \rho_i \ x \ o_i)}{(1 - l_y)}$$

Where:

Σ_i	Sum over the group of *"i"* devices replaced, for which the project energy efficient equipment is operating during the year, implemented as part of the project activity
n_i	Number of devices of the group of *"i"* devices replaced, for which the project energy efficient equipment is operating during the year
$p_{i,y}$	Power of the devices of the group of *"i"* baseline devices. In the case of a retrofit activity, "power" is the weighted average of the devices replaced. In the case of new installations, "power" is the weighted average of devices on the market
o_i	Average annual operating hours of the devices of the group of *"i"* baseline devices
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/pilferage).

The actual load of all devices operated by a power consumer is determined based on the electricity:

$$n_i \ x \ \rho_i \ x \ o_i = E_{metered,y}$$

Where:

$E_{metered}$	Total electricity consumed by a facility. This shall be determined by the annual electricity bill.

The baseline emissions (without the implementation of the energy efficiency program) is calculated as follows:

$$BE_y = E_{BL,y} \ x \ EG_{CO2,y}$$

Where:

BE_y	Baseline emissions in year *y* (tCO2e)
$E_{BL,y}$	Energy consumption in the baseline in year *y* (kWh)
$EF_{CO2,y}$	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.

The energy consumption under the baseline scenario can be determined as follows:

$$E_{BL,y} = \sum_i \frac{(n_i \ x \ \rho_i \ x \ o_i)}{(1 - l_y)}$$

The parameters used in above formula have been introduced in the course of the definition of the project's energy consumption.

The savings being claimed are based on power factor improvements implemented in the facility but the actual savings take place in the electricity transmission- and distribution system. I.e. the facility reduces its local generation of reactive power and hence the power utility needs to supply less

electricity in the system to meet the facility's electricity demand. This results in less current flow from the power utility and less energy losses due to I^2R losses (heat) in the wires connecting utility generators to electricity users' facilities. For the further determination of baseline energy consumption, the following considerations were made:

The Active Power (kW) demanded by a facility is a function of the characteristics of the load i.e. motors, lights, heating equipment etc. and does not change when PF is improved.

With PF improvement what changes is the amount of Apparent Power (kVA) provided by the utility to the facility. The PF equipment generates local Reactive Power (kVAr), which does not have to come from the power utility.

This results in a reduction in current (I) flow from the utility generators to the facility and a reduction in I^2R losses in the cables and transformers supplying the facility; where R is resistance to current (I) flow and is given by Ohm's law. I^2R losses manifest as heat in the wires, which is lost to the atmosphere.

The energy savings due to power factor improvement are added to the baseline energy consumption. The actual load of the baseline scenario can be quantified as follows:

$$n_i \; x \; \rho_i \; x \; o_i = E_{metered,y} + E_{metered,y} \; x \; \Delta P_{Losses,y}$$

Where:

$\Delta P_{Losses,y}$	Ratio of active power (P) lost under the business as usual scenario compared to active power lost under the project scenario; a figure between 0 and 1.

The ratio between active power lost under the business as usual scenario compared to the active power lost under the project scenario can be determined as follows:

$$\Delta P_{Losses,y} = 1 - \left(\frac{PF_{Old,y}}{PF_{New,y}}\right)^2$$

Where:

$PF_{old,y}$	Power factor of the facility without the operation of the reactive compensation equipment.
$PF_{new,y}$	Power factor after the installation of the reactive compensation equipment.

Monitoring Approach. In order to quantify and claim potential emission reductions, each CDM project has to monitor relevant key parameters. Following above approach for the calculation of the emission reductions, the subsequent parameters are monitored.

Table 1: List of Envisaged Monitoring Parameter		
Parameter	Description	Monitoring Approach
$E_{metered,y}$	Electricity paid by the facility in the year y.	The annual electricity consumption will be determined based on the annual electricity bill.
$PF_{old,y}$	PF without the operation of the reactive compensation equipment, in the year y	The old PF will not be fixed ex-ante which would lead eventually to an overestimation of the energy savings. If the facility would e.g. install more efficient equipment, the PF may improve. Fixing the old PF would not allow for taking such improvements into account. Instead the program would determine the old PF by switching off the reactive compensation equipment. Then the old PF will be measured by a mobile PF meter. These measurements will be carried out four time per year and only at times where the facilities operate at full load (at full load the PF is higher).

		This approach will allow for determining the old power factor in a conservative and transparent way.
$PF_{new,y}$	PF with the operation of the reactive compensation equipment, in the year y	The reactive compensation equipment always works to a target PF so that the actual achieved PF equals the target PF and remains constant throughout the year (e.g. a PF of 0.98). The reactive compensation equipment includes a PF meter which will measure the new PF steadily throughout the year. The data will be send by build in GSM units to the project participant / CME where it may be stored for financial accounting and the monitoring of the CDM PoA's CERs.

The below table presents the envisaged Quality Assurance / Quality Control procedures which shall ensure a conservative determination of energy savings and hence result in a conservative determination of emission reductions.

Table 2: List of Envisaged Quality Assurance / Quality Control Procedures		
Parameter	Description	Monitoring Approach
$E_{metered,y}$	Electricity paid by the facility in the year y.	The annual electricity consumption will be determined based on the annual electricity bill.
$PF_{old,y}$	PF without the operation of the reactive compensation equipment, in the year y	There are two options to determine PF_{old}: A) PF_{old} is determined at the time of the installation of the power factor correction equipment. B) PF_{old} is determined regularly through switching off the power factor correction equipment. Over time, new electricity consumption devices may be installed which may improve the PF. Hence option B is proposed. Currently there are no PF caps or thresholds established in Zimbabwe, which require electricity consumers achieving a certain PF. A PF cap of 0.9 is established in Uganda. If a company operates below the cap, penalties are to be paid; if it operates above the cap the company will be rewarded. If, in the future, a mandatory cap will be established, then the PoA could use either PF_{old} or the cap, whatever is higher. PF_{old} will be determined through switching off the power factor correction equipment, when the facility operates on a high load. If equipment is operated at a high load, the PF generally will be higher (more efficient) compared to a low load, which is considered to be conservative. Use of Smart Meters could also facilitate simple measurements of PF_{Old}. The determination of PF_{old} will not only be the basis for the calculation of emission reductions, it will also be the basis for the determination of the ESCO's electricity savings and the related benefit sharing with the facility. Hence the facility has strong financial interests that the

		PF_{old} is measured at a high load. The ESCO must coordinate the period of monitoring PF_{old} with the facility. Given the facility's financial interests, this will ensure that the PF_{old} is measured in a conservative manner.
$PF_{new,y}$	PF with the operation of the reactive compensation equipment, in the year y	The reactive compensation equipment always works to a target PF so that the actual achieved PF equals the target PF and remains constant throughout the year (e.g. a PF of 0.98). The reactive compensation equipment includes a PF meter which will measure the new PF steadily throughout the year. The data will be send by build in GSM units to the project participant / CME where it may be stored for financial accounting and the monitoring of the CDM PoA's CERs.

Initial feedback provided to the Submission Author (communicated on 28 April 2014):

Energy saving formulation is simple and based on sole assumption that improvement of power factor (PF) in industrial facilities (demand side) would lead to loss reduction (I^2R losses at transmission and distribution end) and emission reductions are accrued from the equivalent electricity production (supply side) that is avoided due to loss reductions (corresponding to reduction in KVA demand). The baseline emission factor for the portion of energy that would be saved/avoided is determined using tool to calculate grid emission factor).

However the following are the number of issues related to the determination of electricity savings/avoided due to PF correction using the proposed approach and needs further clarifications/confirmations from the PPs for the consideration by the SSC WG:

1. **A reduction in kVA demand due to PF improvement may not necessarily translate into emissions reductions**: A methodology to quantify emission reduction attributable to PF correction equipment may not be that straight forward as proposed by the authors which only accounts impact on grid in terms of loss reductions due to placement of capacitor in industrial facility. Improving the power factor does reduce the losses the but may not be necessarily reduce the active power (kW) production – which is governed by fuel-input and hence associated with emission reductions. A reduction in kVA demand due to capacitor placement may not necessarily translate into savings in kWh demand and hence may not lead to KWh electricity production avoided at the generation side. Since the generators, power cables and transformers are rated in kVA capacity (not in kW capacity) and due to the fact that power factor on a kW load reduces kVA (kVA =kW/PF), PF correcting capacitors increase system current-carrying capacity. In other words, by improving power factor, generator/transformer can deliver more real power (kW) to the loads. This case is obvious where the system is already overloaded or constrained to meet increase in kW demand, power factor correction could avoid the need for additional generation/transformer capacity. This is illustrated by the example below. So, loss reduction claimed due to power factor correction may not eventually translate to reduction in electricity generation and emissions reductions thereof.

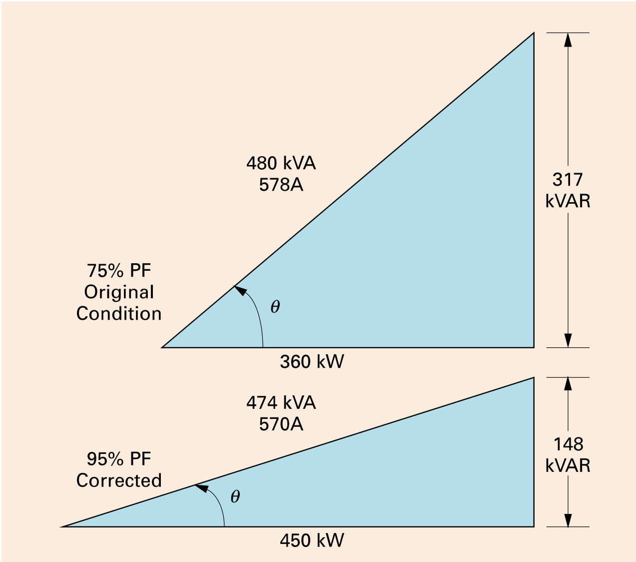
   Example:

   a. An industrial facility has a 500 kVA, 3 phase transformer operating near capacity. It draws 480 kVA or 578 A at 480V [$(\sqrt{3} \times voltage \times current) / 1000$]. The present PF is 75% and the actual working load is 360 kW (480 x 0.75).

   b. It is desired to increase the production by 25% which would require additional 450 kW working load to be supplied. To supply 450 kW demand at 75% power factor load, addition of a new 600 kVA transformer would be the solution. However, a

better solution would be to improve the power factor from 75% to 95%, and release enough capacity to accommodate the increased load

c. Similarly, at the generation end (which is also rated in kVA) , improvement in power factor at demand side may release the generation capacity and hence would supply more actual power (kW) to the grid.



2. In a complex grid, the analysis on how the improvement of power factor at demand side would avoid kWh at generation may require complex load-flow modeling exercise.
3. In addition, PF improvement not only would release KVA capacities but also improves system voltages. As per the standard engineering calculations, voltage losses in a high voltage transmission and distribution lines (where reactance X is much greater than resistance R) is directly proportional to the amount of reactive power being delivered to the load. Hence, improving the power factor would reduce the reactive power flow in a grid and this may translate into increased real power flow (kW). For example, energy consumption (kWh) of lighting increases as the square of the voltage. So kWh energy flow may increase with the improvement in voltage due to capacitor addition.
4. The case is different where there is a direct energy savings due to energy efficiency improvement at demand side (e.g., replacement of inefficient motors with efficient motors) where the amount of saved energy is translated into avoided generation that would occur elsewhere in the grid and the grid emission factor as determined using grid tool. Please note that small scale demand side energy efficiency methodologies such as AMS-II.C is applicable for activities that involve the installation of new, energy-efficient equipment or retrofit (e.g. lamps, ballasts, refrigerators, motors, fans, air conditioners, pumping systems, and chillers) resulting into the direct energy savings installation of capacitors which leads to reduction in electricity demand (kVA). The methodology is not intended for modifications to distribution systems/transformers/capacitors/etc. More specifically the equations and requirements are not written for PF correction devices and do not address PF measurement, monitoring or impacts on energy consumption or emissions. In summary, AMS II.C is for end-use energy efficiency activities and PF correction is distribution system enhancement.
5. Other issues specific to power factor correction measures:
   a. Introduction of capacitors may exacerbate harmonics in the system and causing increased copper losses in transformers. So unless integrated filters along with capacitor are introduced loss reductions calculated merely from capacitor placement

may not be fully accounted for.

b. Automatic power factor controllers would be required to ensure the desired power factor is maintained through the operating period.

c. The amount of loss reduction also may vary and depends upon where the capacitors are placed. If capacitors are placed in the entry point of the grid (e.g., substation of an industry), this may have less effect on line losses since the reactive power KVAr must still be sent all the way from the substation to the motor loads.

d. Lock-in situation for industrial facilities that claim emission reduction through loss reduction due to power factor improvement: After the implementation of power factor improvement measures under CDM, would there be incentives for industrial facilities to implement efficiency measures ex post (e.g., replacement of inefficient motors with efficient ones). It is claimed in the submission that introduction of new equipment will have higher power factor and hence potentially reduced the baseline, which is established, based on ex –post measurement. What if the introduction of other efficiency measures lower the power factor of the facility for example replacement of incandescent lamps (power factor =1.0) with CFLs (power factor could be as low as 0.5?).

6. The above issues could be some of the reasons why AMS-II.A (which is for energy efficiency improvement in T&D system) excludes energy efficiency measures involving capacitor applications. It states "The methodology does not include the introduction of capacitor banks and tap changing transformers for reducing losses in an electricity distribution; this is because technical loss reductions due to such measure cannot be determined using the simplified approaches defined in this methodology"

7. It thus seems that currently written AMS-II.C is not applicable to PF correction projects and that a new methodology or a significant modification to AMS II.A or II.C to include PF corrections would be required.

Please note that the above issues are still under consideration by the SSC WG and does not represent a final response. Your feedback on the issues would be useful for the consideration by the SSC WG and facilitate the decision making. If required, we will organize a conference call with you during the meeting, tentatively on Wednesday,7 May.

Response from the submission author (01 May 2014) :

Question 4:

We would like to start out with this specific statement, as we feel that this addresses the core of the clarification request submitted to the SSC Team:

§ The proposed intervention is taking place on the demand side (the equipment is installed in the premises of industrial electricity consumers and will locally generate kVAr; without the intervention, the kVAr would need to be supplied by the transmission and distribution system), it is also clear that the intervention results in a reduction of energy losses in the transmission and distribution system (i.e. the savings take place on the supply side).

§ The installation of reactive power compensation equipment may be considered as 'installation of new energy-efficient equipment'. Still the equipment does not change the actual load of the facility, but reduces electricity losses in the distribution system.

§ It is clear that AMS II.C was not specifically written to address PF improvements; the accommodation of PF improvement under the methodology would need e.g. to jointly monitor ni, pi and oi.

If the SSC Team should decide that PF cannot be accommodated under AMS II.C, as indicated by the draft response, we would be considering to develop a new AMS which allows for a sound and resilient approach for the determination of the baseline as well as the monitoring of energy savings and related emission reductions. We would be thankful for any further support of the SSC Team in this regard, e.g. the opportunity for technical

exchanges on the quantification of energy savings and/or the design of the monitoring methodology. This would support EiL and any other company addressing the energy losses in countries like Uganda where the technical transmission and distribution losses are as high as 17.7% while contributing to climate change mitigation.

Question 1:

'A reduction in kVA demand due to capacitor placement may not necessarily translate into savings in kWh demand and hence may not lead to KWh electricity production avoided at the generation side.' The PF intervention will take place at the site of the industrial electricity consumer. The capacitor banks will generate the kVAr demand locally and less kVA will be required to be delivered from the transmission and distribution system. The reduction of kVA demand at the industrial electricity client will result into a reduction of energy losses in the transmission distribution system. The reduction of losses will require the power generator to generate less power. Consequently, PF intervention translates into energy savings.

Question 3:

'Hence, improving the power factor would reduce the reactive power flow in a grid and this may translate into increased real power flow (kW). For example, energy consumption (kWh) of lighting increases as the square of the voltage. So kWh energy flow may increase with the improvement in voltage due to capacitor addition.'

When you improve the PF at the site of the industrial electricity consumer, kVAr is generated locally and less kVA is to be supplied by the system. This however does not change the actual load of the facility (i.e. kW and kWh).

Question 5a:

The power factor improvement through capacitor banks does not alter the harmonics of the system. However the technology considered by EiL will also filter the harmonics resulting in eventual, additional energy savings not accounted for.

Question 5b:

The introduction of capacitor banks alone may not necessarily increase the PF to value close to 1. The equipment considered by the ESCO is a real time reactive power compensation equipment along with a power quality analyzer. The equipment measures kVAr demand with 1000 samples over one cycle (20ms). The system's reaction time is 13ms resulting in a PF of 0.98. However if a different equipment would be installed, resulting in a lower PFnew, the reduction of energy losses in the transmission and distribution system would be less and the claimed CER volumes would be less. This does not lead to an overestimation of emission reductions as long as PFnew is measured correctly.

Question 5c:

We share this assessment; however the interventions considered will take place in the premises of industrial electricity consumers.

Question 5d:

In general we believe that demand side- and supply side interventions do not necessarily contradict each other. However such a lock in may exist under very specific conditions:

§ The industrial facility owns the CERs and is the beneficiary of the carbon revenues.

§ The PFold must be determined by frequently switching off the reactive compensation equipment and measuring the PF; Such a lock in may not exist if PFold would be determined and fixed ex-ante.

§ The new installed equipment must have a lower demand of capacitive and/or inductive loads in order to improve the PFold without the operation of the reactive power compensation equipment. It is difficult to image what this equipment might be; E.g. the example of the CFL has a higher demand of inductive loads and hence its PF is 0.5 compared to an incandescent bulb with a PF of 1.

Consequently we share the vision that such a lock in may theoretically exist, however its occurrence may be unlikely.

Clarification by the secretariat or Panel/ WG

The Small-Scale Working Group (SSC WG) of the Executive Board (hereinafter referred to as the Board) of the clean development mechanism (CDM) would like to thank the author for the submission.

The SSC WG would like to thank the author of the query for their request for clarification with regards to AMS-II.C. It is the opinion of the SSC WG that AMS-II.C is not applicable to the proposed activity of installing power factor (PF) correction equipment in end-use facilities and it is not appropriate to modify, or clarify, AMS-II.C to include PF correction. AMS-II.C is applicable to installation of energy-efficient equipment and the proposed intervention while taking place on the demand side, results in a reduction of energy losses in utility transmission and distribution system and does not change the actual energy load of the facility. Furthermore, the equations and requirements of AMS-II.C are not written for PF correction devices and do not address PF measurement, monitoring or impacts on energy consumption or emissions.

The SSC WG also noted that a methodology to quantify emission reduction attributable to PF correction equipment may not be straightforward because the impact of such equipment on the electricity grid is complex and may not necessarily reduce GHG emissions; thus any potential reductions in electricity system emissions may very well be difficult to conservatively document using the simplifications inherent in small scale methodologies. With respect to the complexity of PF corrections, project proponents should note that AMS-II.A (which is for energy efficiency improvements in T&D system) excludes measures involving capacitor applications and states that "The methodology does not include the introduction of capacitor banks and tap changing transformers for reducing losses in an electricity distribution; this is because technical loss reductions due to such measure cannot be determined using the simplified approaches defined in this methodology".

The project proponents may, however, submit, a new methodology for demand side, PF correction equipment taking into account feedback provided by the SSC WG.

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Document information

Version	*Date*	*Description*
02.0	18 July 2013	Revised to remove the row “Date and signature of the chair and vice chair of Panel/WG (in case of clarification by Panel/WG)”
01.0	4 July 2013	Initial publication. This document supersedes and replaces the following documents: • Recommendation Form for Small Scale Methodologies (F-CDM-SSCwg) (Version 01.1) • Recommendation Form for Small Scale A/R Methodologies and Procedures (F-CDM-SSC-AR) (Version 01.1)

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