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 to 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.P. Energy efficient pump-set for agriculture use

Technology/measure

1. The methodology comprises of activities that adopt energy efficient pump-sets that run on grid electricity at one or more agricultural sites. The following definitions apply:

(a) Agricultural site: is the area where agricultural and horticultural crops are irrigated. This shall be established by official records such as land use records, electricity utility consumer identification;

(b) Pump-set: comprises of the pump and motor assembly together with starter and other electrical accessories/devices to operate the unit to deliver water through an irrigation system. Pump-set type refers to operating mechanism of the pump e.g. submersible pump-set, mono-block surface pump-set;

(c) Pump-set category: Pump-sets are considered to belong to the same category when they are of the same type and have the same power rating (e.g. 5 HP submersible pump-sets, 5 HP mono-block pump-sets);

(d) Pump-set performance curve: refers to discharge versus head curves along with similar curves for discharge versus power and discharge versus efficiency for a pump-set. These curves are generated as per national and international standards;

(e) Irrigation system: comprises of the intake assembly which may include suction pipe, pump-set and where necessary a foot valve, net work of pipelines, control valves, filters, other devices to deliver water to the agricultural sites;

(f) Head: is the mechanical energy per unit of weight of the water pumped by the irrigation system. The total head results from the geometric head (static head), which is the difference in height, in meters, of the points of water inlet and outlet/discharge, both considered as exposed to the atmospheric pressure, and the head losses due to friction of the flowing water with the components of the irrigation system;

(g) Initial head: is the total head of the baseline irrigation system serviced by the baseline pump as measured when the pump discharge valve is in fully open condition during the field test;

(h) Replacement Head: Farmer typically replaces the baseline pump-sets when the flow reduces beyond an acceptable level well before the pump reaches its shut-off head.[1] For the purpose of this methodology a head equivalent to 90% of the shut-off head is defined as replacement head and it is assumed the farmer replaces the pump at this point;

(i) Pump-set efficiency: is the rate of mechanical energy of the water delivered by the pump-set under certain operational conditions of flow and head divided by the rate of electrical energy consumption;

(j) Pump-set power demand or electricity consumption rate: is the amount of electrical energy consumed by a pump-set at a certain operational condition (head and flow). The following relationship apply:

$$EC_P = H \times Q \times \rho \times g / \eta \quad \textbf{(1)}$$

Where:

EC_P	Pump-set power demand or electricity consumption rate (watts)
H	Head (m)
Q	Flow of water (m^3/s)
ρ	Water density (kg/m^3)
g	Gravity (m/s^2)
η	Efficiency of the pump-set (%)

2. The project pump-sets replace existing grid connected pump-sets. In the case of new agricultural sites i.e. Greenfield scenario, project pump-sets replace grid connected pump sets that would have been installed in new agriculture sites. When the project pump-sets substitute a different type of existing pump-sets, such as when replacing a mono-block pump-set with a submersible pump-set, Greenfield scenario applies.

3. The project pump-set efficiency shall be higher than the baseline pump-set for the whole range of operating conditions during the crediting period.

4. The methodology is not applicable for retrofitting pump-sets (e.g. replacement of impellers).

5. The project pump-set discharge i.e. water output corresponding to the initial head shall be higher or at least equal to that of the baseline pump-set discharge at the initial head. However, the power rating of the project pump-set can be lower than the power rating of the baseline pump-set.

6. The irrigation system or the practice is not negatively affected by the project activity i.e. if drip or sprinkler irrigation system existed in the baseline it shall not be replaced by less efficient irrigation system such as flood irrigation while vice versa is permissible. Only increased efficiency of the project pump-set over the baseline pump-set are considered under this methodology. Projects that aim to claim emission reduction for introducing more efficient irrigation practices (e.g. drip irrigation) are encouraged to submit a revision to this methodology.

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[1] Shut-off head is the head measured when the pump discharge valve is in fully closed condition during the field test.

7. The pump-sets used in the project activity shall be new and marked for clear unique identification.[2] The replaced baseline pump-sets will also be individually marked and stored to allow for necessary inspection.[3]

8. The project design document shall explain the proposed procedures to eliminate double counting of emission reductions, for example due to pump-set manufacturers, electricity supply companies or local retailers or users or others possibly claiming credit for emission reductions from the project pump-sets.

9. If the lifetime of the pump-sets introduced by the project activity is shorter than the crediting period, the crediting period will be restricted to the lifetime of the installed pump-sets, or the project design document shall describe a system to replace the equipment reaching the end of lifetime by another one with same or higher efficiency.

10. The aggregate electricity savings by a single project shall not exceed 60 GWh per year.

Boundary

11. The project boundary encompasses the physical, geographical location of each pump-set installed and/or replaced.

Baseline

12. The baseline are the emissions associated with the energy consumption of the baseline pump-set or the pump-set that would have been installed in the absence of the project activity after considering the technical grid losses.

13. The baseline energy consumption is established following one of the two options below:

(a) Constructing performance curves, ex ante, for each of the baseline pump-set through field tests in the respective project agricultural site. Optionally a representative sample of baseline pump-sets in the project agricultural sites can be chosen for testing. Simple random sampling is not allowed. Sampling scheme used (e.g. stratified random sampling, systematic, etc.) shall take into consideration the different characteristics of the baseline pump-sets. Pump-sets shall be tested for head, flow rate and power demand for at least three sets of operating conditions including the initial head and the shut-off head. Testing shall be done prior to the replacement of the baseline pump-sets in accordance with national or international standard/or guidelines for testing of pump-sets.[4] In case of Greenfield, the procedure provided in paragraph 16 shall be followed;

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[2] For example, physical marking/label on pump-set, Radio Frequency Identification (RFIDs).

[3] In case replaced pump-sets are scrapped, the scrapping can precede verification. The project design document shall propose and explain the verifiable method for collection and scrapping of the replaced pump-sets. An example method is collection of replaced pump-sets, recording of their identification/marking and disposal in decentralised or centralised locations, and scrapping documented via witnessing by local environmental officials or time stamped video records.

[4] For example, "Test for agricultural and water supply pumps.- Code of acceptance"- IS 11346-2002; "Centrifugal, mixed flow and axial pumps- Code for hydraulic performance tests. Precision class"- BS EN.

(b) In case the field tests are not undertaken, the performance curves as provided by the manufacturer of the baseline pump-sets replaced by the project activity shall be used for the calculations.

14. For the above options 13(a) to (b), if the performance curves are not available ex ante, it shall be made available at the time of first verification.

Requirement for Greenfield project scenario

15. The baseline pump-sets operating at a head that is greater than the replacement head are due for replacement and thus the baseline has to be established treating them as Greenfield projects in those cases.

16. For Greenfield projects, the baseline pump-set is the one which would have been installed in the absence of project activity to meet the head and flow requirements in the project agricultural site. In such cases, the baseline performance curve is established based on the prevailing practices in the project agricultural site or contiguous[5] area (hereafter referred to as the area) in the following manner:

(a) Identify the available pump-sets in the area that can meet the required head and flow of the project agricultural site;

(b) Obtain the head and flow data from the pump-sets in the area to deduce the likely characteristics (range of head and flow) of the baseline pump;

(c) List pump-sets, from those identified under step 16(a) above, which are potential baseline candidates, i.e. have head and flow characteristics able to meet the requirements of the project agriculture site;

(d) Sort the pumps in the decreasing order of power demand at the initial head and select the top 20% pump-sets;

(e) The statistical mode of power demand values identified in step 16(d) above is selected as power rating of the baseline pump. Select a new pump-set that closely matches the power rating identified. The performance curves provided by the manufacturer of this pump-set shall be taken as the baseline performance curve.

Determination of emission baseline

17. The emission baseline is the energy baseline of the pump-sets multiplied with the grid emission factor accounting for any technical losses as under:

$$BE_y = EC_{BL,y} \times EF_{CO2,ELEC,y} \qquad \textbf{(2)}$$

[5] Contiguous area refers to areas close to the project agricultural sites, and where similar agricultural practices and sources of water are used. These areas may be used to identify the baseline pump-sets for the case of the project pump-sets being installed in sites where the Greenfield scenario applies.

$$EC_{BL,y} = \sum_{c=1}^{N} \left[\sum_{p=1}^{QPJ,c,y} \left\{ (EC_{BL,p,c} \times O_{p,c,y}) / (1 - l_y) \right\} \right] \quad \textbf{(3)}$$

Where:

BE_y	Baseline emissions in tCO_{2e}
$EC_{BL,y}$	Energy consumption of the all baseline pump-sets in MWh in the year *y*
$EF_{CO2,ELEC,y}$	The emissions associated with grid electricity consumption should be calculated in accordance with the procedures of AMS-I.D in tCO_2/MWh
N	Total number of baseline pump-set categories
p	Counter for pump-sets
C	Counter for pump-set category
$Q_{PJ,c,y}$	Total number of pump-sets installed under the project activity belonging to category ‘c’. Once all of the project pump-sets are installed, $Q_{PJ,c,y}$ is a constant value independent from *y*
$O_{p,c,y}$	Operating hours[6] of the project pump-set ‘p’ belonging to category *c*, in hours in the year *y*, see paragraph 31 below
$EC_{BL,p,c}$	Power demand or electricity consumption rate of the baseline pump-set ‘p’ belonging to category c, in MW fixed ex ante for the entire crediting period. This shall be estimated as per the applicable scenarios provided under paragraph 19 below
l_y	Average annual technical grid losses (transmission and distribution) during year *y* for the grid serving the locations where the project pump-sets are installed, expressed as a fraction. This value shall not include non-technical losses such as commercial losses (e.g. theft/pilferage). 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. 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

Determination of head at the end-of-life or end of crediting period

18. The baseline (and/or project) pump-set power demand varies with the prevailing ground water level, during the crediting period, as these changes impact the head requirements. For

[6] This methodology is based on the assumption that project pump-set and baseline pump-set are operated for the same number of hours during each year, and the lower power demand of the project pump-set to meet the operational head requirement will result in reduced energy consumption.

estimating the power demand at the end-of-life or at end of crediting period, the variation in groundwater level ($V_{p,c}$ in meters/year) shall be established using latest available data from official agencies or by any other credible sources/surveys. This shall be fixed ex ante for the entire crediting period. $V_{p,c}$ shall be treated as a negative number for descending groundwater level and a positive number for rising groundwater level. The end-of-life time and the head at the end-of-life or at the end of crediting period for the pump-set are calculated as follows.

$$L_{p,c} = [(RH_{p,c} - H_{0,p,c}) / V_{p,c}] \times (-1) \text{ for descending groundwater level} \quad \textbf{(4)}$$

$$H_{E,p,c} = H_{0,p,c} - V_{p,c} \times \text{Minimum}\,(L_{p,c}, \text{Project crediting period}) \quad \textbf{(5)}$$

Where:

$L_{p,c}$	End-of-life time of baseline/project pump-set *p* belonging to category *c* (year)
$RH_{p,c}$	Replacement head, calculated as 90% of the shut-off head of baseline/project pump-set *p* belonging to category *c* (m)
$H_{0,p,c}$	Initial head (in m), determined through field test of the baseline/project pump-set *p* belonging to category *c*
$H_{E,p,c}$	End-of-life head or head at end of crediting period (m) of baseline/project pump-set *p* belonging to category *c*

19. According to formula 5 above, the head at sites with rising or descending groundwater levels will decrease or increase over time, respectively, moving away from the initial settings, thus affecting the power demand. The power demand for the baseline pump-set is established according to the following eligible scenarios:

IF		THEN
Initial head ($H_{0,p,c}$)	**Ground water level variation ($V_{p,c}$)**	**Baseline power demand ($EC_{BL,p,c}$)**
Is less than the replacement head ($RH_{p,c}$)	Positive (rising ground water level, decreasing head)	Scenario 1
	Negative (descending ground water level, increasing head)	Scenario 2
Is greater than the replacement head ($RH_{p,c}$) / Greenfield sites	Positive (Rising ground water level, decreasing head)	Scenario 1
	Negative (descending ground water level, increasing head)	Scenario 2

20. For initial pump-set head less than the replacement head:

(a) **Scenario 1:** for rising or stagnant groundwater level, the power demand of the baseline pump-set ($EC_{BL,p,c}$) is determined conservatively from the baseline performance curves corresponding to the initial head and is fixed ex ante for the entire crediting period;

(b) **Scenario 2:** For descending groundwater level, the power demand of the baseline pump-set ($EC_{BL,p,c}$) is determined conservatively from the baseline performance curves corresponding to the head calculated at the time of end-of-life or at the end of crediting period and is fixed ex ante for the entire crediting period.

21. For initial pump-set head greater than the replacement head or for installations at new agriculture sites (Greenfield) the baseline power shall be established by following the steps:

(a) For rising or static groundwater level, the baseline pump-set is determined as established in paragraph 16 considering the conditions of initial head and the power demand of the baseline pump-set is determined as per Scenario 1 above;

(b) For descending groundwater level, the baseline pump-set is determined as established in paragraph 16 considering the conditions of head at the time of end-of-life or at the end of the crediting period and the power demand of the baseline pump-set is determined as per Scenario 2 above.

Leakage

22. No leakage calculation is required by this methodology.

Project activity emissions

23. The project activity emission consists of emissions from the use of electricity by the project pump-set after taking into account the technical grid losses. It is determined as follows:

$$PE_y = EC_{Pj,y} \times EF_{CO2,ELEC,y} \quad \textbf{(6)}$$

$$EC_{Pj,y} = \sum_{c=1}^{N} \left[\sum_{p=1}^{QPJ,c,y} \left\{ (EC_{p,c,y} \times O_{p,c,y}) / (1 - l_y) \right\} \right] \quad \textbf{(7)}$$

Where:

PE_y	Project emissions in tCO_2e
$EC_{Pj,y}$	Energy consumption of all the project pump-sets in MWh in the year y (summation of energy meter readings of meters installed on every project pump-set or on the basis of metering based on representative sample)
$EC_{p,c,y}$	Power demand of the project pump-set p belonging to category c in MW in the year y. This shall be estimated as per the following applicable Scenarios 3 or 4

24. For each project pump-set, the project pump-set power demand shall be established from performance curves[7] obtained prior to its first verification. Baseline and project pump-set performance curves shall be generated using the same standard.

[7] The laboratory/field test rig conducting and certifying the pump-set performance shall comply with the requirements of relevant national or international accreditation of laboratories. The performance curves shall include head, flow and power along with the motor efficiency.

25. The pump-set power demand is established as:

Ground water level variation ($V_{p,c}$)	Project power demand ($EC_{p,c,y}$)
Negative (descending ground water level, increasing head)	Scenario 3
Positive (rising groundwater level, decreasing head)	Scenario 4

(a) **Scenario 3:** for descending or stagnant groundwater level, the power demand of the project pump-set ($EC_{p,c,y}$) is determined conservatively from the project performance curves corresponding to the initial head and is fixed for the entire crediting period;

(b) **Scenario 4:** for rising groundwater level, the power demand of the project pump-set ($EC_{p,c,y}$) is determined conservatively from the project performance curves corresponding to the head at the end of life or end of crediting period and is fixed for the entire crediting period.

Emission reductions

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

$$ER_y = (BE_y - PE_y) \times N_{PJ,y} / \sum_{c=1}^{N} Q_{PJ,c,y} \quad \textbf{(8)}$$

Where:

ER_y	Emission reductions in year y (tCO_2e)
$N_{PJ,y}$	Number of project pump-set installed in the original location and operating in year y determined using ex post survey

Monitoring

27. A database with the identification of each participant agricultural site, the specifications of the replaced baseline pump-sets, and the pump-sets installed by the project activity shall be maintained by the project proponent during the crediting period and will be made available for verification.

28. The following data are to be monitored/ recorded during the crediting period:

(a) Number of pump-sets installed under the project activity, identified by the type of pump-set and the date of installation;

(b) The number of replaced pump-sets and their identification;

(c) Data to unambiguously identify the recipient of the pump-sets installed under the project activity;

(d) Performance curves of the baseline and project pump-sets;

(e) The electricity consumed by the project pump-set, where applicable;

(f) All the applicability conditions that need to be checked over the crediting period.

29. The number of project pump-sets placed in service and operating under the project activity is determined in the first ex post monitoring survey. It is used to determine the quantity of project pump-sets belonging to each category ‘c’ ($Q_{PJ,c,y}$) for use in ex post emission reduction calculations. Once all of the project pump-sets are installed, $Q_{PJ,c,y}$ is a constant value independent from *y*.

30. Subsequent ex post monitoring and adjustment for operational project pump-sets:

(i) Monitoring surveys are carried out at least once every two years (biennial) during the crediting period. After the inspection at year of installation, the inspections can be done in years 3, 5, 7, etc. and the results of such inspections can be applied to crediting years 3 and 4, 5 and 6, 7 and 8, etc. When biennial inspection is chosen, a 95% confidence interval and 10% margin of error requirement shall be achieved for the sampling parameter. On the other hand, when the project proponent chooses to inspect annually, a 90% confidence interval and 10% margin of error requirement shall be achieved for the sampling parameter;

(ii) The surveys will consist of identifying project pump-sets carrying project unique markings and operating in original location in the year *y*. While pump-sets replaced as part of a regular maintenance or warranty program can be counted as operating, pump-sets cannot be replaced as part of this monitoring survey process and counted as operating and determined as $N_{PJ,y}$.

Operating hours of the project pump-set

31. The operating hours of project pump-set shall be known, in order to calculate the electricity consumption of baseline pump-set. One of the following options shall be used:

(a) Option I: based on measured electricity consumption. If the project pump-set have electricity metering, record the annual kWh consumption and divide by the project pump-set power demand or electricity consumption rate, as determined based on the performance curve and the head according to the eligible scenario. Annual electricity consumption of project pump-sets can also be determined on sample basis;

(b) Option II: based on direct measurement through installed hour meters (or alternate arrangements like current sensor with data logger, etc.) at each project pump-set or at representative sample thereof to measure the number of hours of operation;

(c) Option III: in case it can be demonstrated that the feeder and/or transformer is supplying electricity only to project pump-sets. Divide the annual kWh consumption by the total connected power demand of the pump-sets connected to the transformer (kW) to obtain annual hours of operations;

(d) Option IV: measured at high voltage feeder level. If the project pump-sets are being supplied through a high voltage feeder such that at least 90% of the connected load of each such feeder are project pump-sets, record the annual kWh consumption on all feeders, and the electricity consumption of the other users with different connected loads i.e. load other than the project agricultural pump-sets.[8] The distribution losses shall be deducted from the amount of electricity measured. A default value of 10% shall be used for average annual technical distributions losses. Divide the annual kWh consumption that accrue to the pump-sets by the total connected power demand or electricity consumption rate of the pumps (kW) to obtain annual hours of operations;

(e) Option V: establish the operating hours data of agriculture pump-sets using the information provided by official bodies and data from independent sources/surveys used for the estimation of revenues for the electricity distribution company;

(f) Option VI: calculated from the information on crop types, soil type, agricultural practices and irrigation system in the project region. The average minimum water demand for the specific crop type ($m^3.ha^{-1}.year^{-1}$) shall be known by referring to the data from official agencies or credible literature/study/report. The total amount of water needed for irrigating the crops in each of the project agricultural sites will then be determined based on the area used for the cultivation of that crop and the operating hour can be calculated by dividing the annual total water demand by the water flow rate of the project pump-set. The determination of flow rate shall follow the same principle of conservativeness by taking into account the variable ground water level, e.g., in case of descending water level, the initial flow of the project pump-sets shall be used.

32. In case sampling is used, relevant requirements in the "Standard for sampling and surveys for CDM project activities and programme of activities" shall be followed.

Project activity under a programme of activities

33. The methodology is applicable to a programme of activities, no additional leakage estimations are necessary other than that indicated under the leakage section above.

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[8] Electricity consumption of the other users is excluded from the calculation. Alternatively, as a conservative assumption, the load of the users that are not agricultural pump-sets are recorded and assuming continuous operation i.e. 8760 hours per year, the electricity consumption is calculated and deducted.

History of the document

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01.0	20 July 2012	EB 68, Annex 18 Initial adoption.
Decision Class: Regulatory **Document Type**: Standard **Business Function**: Methodology		