CLEAN DEVELOPMENT MECHANISM

AMS-II.S.

Small-scale Methodology

Energy efficiency in motor systems

Version 01.0

Sectoral scope(s): 03

United Nations
Framework Convention on
Climate Change

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1. Introduction

1. The following table describes the key elements of the draft methodology:

Table 1. Methodology key elements

Typical project(s)	Introduction of energy efficiency measures such as efficient motors, pumps, fans etc. through retrofit/replacements
Type of GHG emissions mitigation action	Electricity savings through increase in energy efficiency

2. Scope, applicability, and entry into force

2.1. Scope

2. This methodology comprises of energy efficiency improvement measures in motor system implemented at existing industrial facilities. Electrical motors and mechanical appliances (e.g. mechanical pump, compressor and fan) together constitute an industrial motor-system.

3. The project activities cover:

(a) Replacement of existing motors with new and efficient ones;

(b) Replacement of motor appliance like fan, pump, compressor and other appliance with new and efficient ones;

(c) Introduction of technology/measures to improve the overall efficiency of systems involving installation of speed/frequency control devices such as variable speed or frequency drives (VSDs or VFDs), replacement of inefficient throttling devices, optimize the pipeline efficiency, simplifying or avoiding wasteful mechanical transmissions, dynamic control system;

(d) Combination of (a), (b) and (c).

4. The possible interventions of technology/measures covered under this methodology are categorized into three modules (see table 2 below). The table also provides example applications (not exhaustive) and guides the user on which options provided in the methodology to explore.

Table 2. Description of modules

	Technology/measures	**Module**	**Examples**	**Options to estimate baseline or emission reductions available in the methodology**
1	Replacement of inefficient motor(s) with new and efficient ones (introduction of energy efficient motors only)	Module 1	Replace an existing motor without changing pump connected to the motor. The fluid flow rate remains the same as baseline scenario, with a fluctuating load	Option 1 [paragraph 24]
			Same as above system but with constant load condition	Option 2 [paragraph 25]
2	Replacement of motor appliance(s) (e.g. pump, fan, compressor, etc.) only (introduction of energy efficient mechanical appliances only)	Module 2	Use a polymer shaft fan with higher efficiency to replace the steel shaft fan. The output flow rate in the project scenario may be the same or different as baseline scenario, however, the physical properties of the output flow shall remain the same as the baseline scenario	Option 1 [paragraph 31] if the flow rate can be continuously measured during the crediting period, is recommended. Option 2 [paragraph 33] if the power (or energy consumption) is continuously measured
3	Replacement of motor(s) and their appliance(s). (introduction of energy efficient motors along with mechanical appliances i.e. improvement in energy efficiency in overall motor-system)	Module 2	Same as above. Here, the motor driving the pump (or fan) is also replaced	Same as the above i.e. Option 1 [paragraph 31] or Option 2 [paragraph 33]
4	Improvement in energy efficiency in overall motor-system through replacement of inefficient throttling devices and avoiding wasteful mechanical transmission	Module 3	Installation of VSD/VFD to the heat water pumps in a district heating network. Here, pump/ fan and motor are not replaced	Option 1 [paragraph 46] if the fluid flow rate can be directly measured
			Same measures as the above. Here, the control group approach is used for comparison between the same type of motor system with and without VSD/VFD	Option 3 [paragraph 55]
			Installation of VSD/VFD for various types of fans and pumps within one	Option 2 [paragraph 50]

	Technology/measures	Module	Examples	Options to estimate baseline or emission reductions available in the methodology
			process or unit (with measurable output) including the induct fan, exhaust fan, condensing pump, circulating pump	
5	Improvement in energy efficiency in overall motor-system through replacement of inefficient motors as well as throttling devices and avoiding wasteful mechanical transmission	Module 3	Same as above, Here, the fans/pumps and motors are also replaced	Same as above

2.2. Applicability

5. This methodology is applicable to only electricity driven motor systems i.e. emission reductions are accrued only due to the reduction in electricity consumption on account of efficiency improvement.

6. The project motor or motor system shall provide outputs or services (e.g. mechanical energy, compressed air, air or liquid flow, etc.) with comparable quality, properties and application areas[1] as of the baseline. This shall be transparently documented in the PDD and that allows for a physical verification by a designated operational entity.

7. Emission reductions primarily due to improved maintenance practices, for example, cleaning of filters, repairing valves, correcting system leaks, and using new equipment lubricants are not covered under this methodology.

8. The aggregate energy savings of a single project (inclusive of a single facility or several facilities) shall not exceed the equivalent of 60 GWh per year in terms of electricity savings.

2.3. Entry into force

9. The date of entry into force is the date of the publication of the EB 81 meeting report.

3. Normative references

10. Project participants shall apply the "General guidelines for SSC CDM methodologies", "Guidelines on the demonstration of additionality of small-scale project activities" available at: <http://cdm.unfccc.int/Reference/Guidclarif/index.html#meth> mutatis mutandis.

11. This methodology also refers to the latest approved versions of the following tools, methodologies and standards mutatis mutandis:

    (a) "Tool to determine the remaining lifetime of equipment";

[1] For example in the case of industrial fans/compressors, comparable quality/properties and application areas means same fluid at same pressure.

(b) "Tool to calculate project or leakage CO_2 emissions from electricity consumption";

(c) "AMS-I.D: Grid connected renewable electricity generation";

(d) "Sampling and surveys for CDM project activities and programme of activities".

4. Definitions

12. The definitions contained in the Glossary of CDM terms shall apply.

13. For the purpose of this methodology, the following definitions apply:

(a) **Existing industrial facility** - existing facilities are those that have been in operation for at least three years immediately prior to the start date of the project activity;[2]

5. Additionality

14. The project activity is deemed automatically additional (positive list) if the project involves replacement of an inefficient motor (at least IE1 standard or equivalent)[3] up to size 375 kW (input power rating)[4] with premium efficiency standard motors (NEMA[5] Premium) with or without the installation of VSDs/VFDs provided that there is no legally binding standard/regulation mandating the installation of VSD/VFD.

15. This positive list is valid for three years from the date of entry into force of Version 1.0 of AMS-II.XX on the date of the publication of the EB 81 meeting report on 28 November 2014; the CDM Executive Board may reassess the validity of the list and extend or update them if needed. Any update does not affect the projects that request registration as a CDM project activity or a programme of activities by 28 November 2017 (i.e. three years from the date of entry into force) and apply the positive list contained in version 1.0 of AMS-II.XXX.

16. Technology/measures that are not defined as positive list shall apply "Guidelines on the demonstration of additionality of small-scale project activities" for the purpose of demonstrating additionality.

6. Baseline methodology

6.1. Project boundary

17. The project boundary is the physical, geographical site of the industrial facilities including all processes and equipment that are affected by the project activity. The material

2 See definition of start date of project activity in Glossary of CDM terms available at: <http://cdm.unfccc.int/Reference/index.html>.

3 Efficiency classes of electric motors in different countries and the corresponding international standard are provided in Table1 of the appendix of this methodology.

4 Motor sizes up to 375 kW only covers small and medium sized motors as per the definition provided in: UNIDO. 2013. Energy efficiency in electric motor systems: Technical potentials and policy approaches for developing countries, United Nations Industrial Development Organisations and IEA. 2011., Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems, International Energy Agency;

5 National Electrical Manufacturers Association. See also Table1 of the appendix.

(feedstock) and/or energy input to and output from the project boundary shall be transparently defined in the project design document (PDD).

6.2. Baseline scenario

18. The baseline scenario is the continuation of the current practice and consists of electricity consumption (or electricity consumption per unit of production) that would have occurred in the absence of the project activity for the motor or motor-system that is replaced, modified or retrofitted.

19. The emission reductions accrue only up to the estimated remaining lifetime of the baseline motor system (i.e. the time when the affected baseline system would have been replaced in the absence of the project activity). From that point of time onwards, the baseline scenario is assumed to correspond to the project activity, and baseline emissions (*BE*) are assumed to equal project emissions (*PE*) and no emission reductions are assumed to occur.

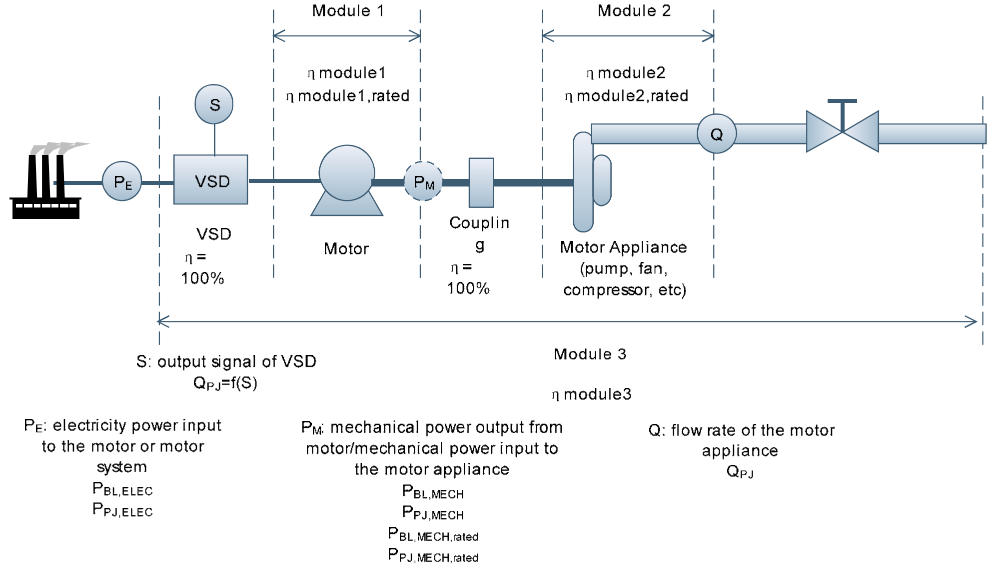
20. The remaining lifetime of any existing system/equipment that is retrofitted/ replaced/modified shall be estimated using the “Tool to determine the remaining lifetime of equipment”.

21. In the case of project activities involving several facilities, the baseline needs to be established separately for each site. In the case of project activities involving multiple energy efficiency measures at individual facilities, the interaction between the measures should be taken into consideration when establishing the baseline. The relevant elements of the “Guidelines for the consideration of interactive effects for the application of multiple CDM methodologies for a programme of activities” may be referred for the purpose.

6.3. Determination of emission reductions

22. The figure below shows types of technology/measure and corresponding parameters under each module that would be used to determine emission reductions.

Figure 1. Types of technology/measure and corresponding parameters under each module that would be used to determine emission reductions



[a] Note: The efficiency of VSD devices and mechanical coupling between motor and motor appliance are considered as 100 per cent for conservativeness.

6.3.1. Module 1 (replacement of inefficient motor with new and efficient motor)

6.3.1.1. Emission reductions calculation

23. The following two options can be used to determine emission reductions:

24. **Option 1- MOD1-ER:** this option is limited to the cases where project replaces exiting motors with new and efficient ones but with similar sizes. For projects involving replacement of oversized motors with proper sized motors, option 2 shall be applied.

$$ER_y = \sum_{i}^{n} \frac{(EC_{i,PJ,y})}{(1 - l_y)} \times \Delta\eta \times EF_{CO2,y}$$ Equation (1)

Where

ER_y		Emission reduction in year *y* (t CO_2e/year)
EC_{i,PJ_y}	=	The amount of electricity consumption by project motor(s) *i* (MWh) monitored in year *y* during the crediting period
n	=	Number of motor systems which consumes electricity in baseline scenario
ly	=	Applies only in the case of grid electricity savings. Average annual technical grid losses (transmission and distribution) during year *y* for the grid serving the locations where the motor systems are installed, expressed as a fraction

$\Delta\eta$ = Efficiency gain due to improved energy efficiency of project motors as compared to baseline motors i.e. $\frac{\eta_{PJ}-\eta_{BL}}{\eta_{BL}}$

Take default values for $\Delta\eta$[6] as follows:

Rated motor output	$\Delta\eta$
motor < 1 kW	0.06
1 kW < motor < 10 kW	0.05
10kW < motor < 50 kW	0.03
motor > 50 kW	0.02

This default value can be applied only if the project motors implemented are of higher than IE1 standard (see appendix for details on standards), else option 2 shall be applied

$EF_{CO2,y}$ = Baseline emission factor of the electricity displaced in year *y*. In case of grid electricity, emission factor is calculated in accordance with methodology “AMS-I.D: Grid connected renewable electricity generation” (t CO_2e/MWh).

For project activities that saves both grid and captive electricity the baseline emission factor should reflect the emissions intensity of the grid and the captive plant in the baseline scenario i.e. the weighted average emission factor for the displaced electricity is calculated using historical information immediately three years prior to project implementation. In cases where historical information is deemed not suitable to determine the relative proportion of these two sources used in the baseline (e.g. the available data is not reliable due to various factors such as the use of imprecise or non-calibrated measuring equipment) then the most conservative emission factor for the two energy sources shall be used

25. **Option 2-MOD1-ER:** this option is based on actual energy consumption values and the following applies:

(a) Motors shall be with constant rate of energy consumption. 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 per cent of the energy consumption values (non-zero values) are within $\pm$10 per cent of the annual mean;

(b) Emission reductions shall be adjusted if operating hours is decreased and/or for the period operating in abnormal condition for example force majeure (shut down of plants due to major overhaul, strike, etc.).

[6] For details on how $\Delta\eta$ values are derived, see paragraph 2 of the appendix to this methodology.

26. The emission reduction due to the project activity in year *y* is calculated as follows:

$$ER_y = \sum_{i}^{n} \frac{(EC_{i,BL} - EC_{i,PJ,y})}{(1 - l_y)} \times EF_{CO2,y}$$ Equation (2)

Where:

$EC_{i,BL}$	=	The amount of electricity consumption by baseline motor(s) *i* (MWh) determined as per paragraph 27 below
EC_{i,PJ_y}	=	The actual amount of electricity consumption by project motor(s) *i* (MWh) in year *y* monitored during the crediting period

27. The amount of electricity consumption by baseline motor(s) shall be based on full one year of average historical electricity consumption data (immediate prior to project implementation) or determined from baseline measurement campaign. The measurement campaign shall be carried out (before or in parallel with the project implementation) on the baseline motor system, covering the period sufficient to capture the entire operating conditions i.e. it covers a time sufficient period to capture the range of the independent variables expected to be, or actually, encountered during the crediting period. In the case where direct metering of electricity consumption (kWh) by motors is not possible, electricity consumption can be determined based on power demand (kW) and operating hours (h) using the procedure such as the below:

(a) The electrical power demand (kW) of baseline equipment is determined based on spot-measurement and/or short-term monitoring data.[7] For large populations of motors, the spot-measurement and/or short-term monitoring data can be taken on a representative sample of motors. Average values from the measurement campaign shall be used. The parameters from the measurement campaign are used to calculate emission reductions in year *y*;

(b) The operating hours of the baseline motors 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 motors: (a) use a representative sample (sampling determined by a minimum 90 per cent confidence interval and 10 per cent 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 motors to be analysed for operating hours has a random distribution and is representative of target population (size, location). For sampling, the “Standard for sampling and surveys for CDM project activities and programme of activities” shall be followed;

(c) 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 motor-system 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. In such cases, no separate determination of operating hours in the baseline and in the project is required.

[7] 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.

6.3.2. Module 2 (Replacement of motor appliances (fan/pump/compressor system)

6.3.2.1. Emission reductions calculations

28. The emission reduction due to the project activity in year *y* is calculated as follows:

$$\mathrm{ER_y} = \frac{\left(\mathrm{EC_{i,BL,y}} - \mathrm{EC_{PJ,y}}\right)}{(1 - \mathrm{l_y})} \times \mathrm{EF_{CO2,y}}$$ Equation (3)

Where:

EC_{i,BL_y}	=	The amount of electricity consumption in baseline determined as per procedure described under paragraph 29 below (MWh)
EC_{PJ_y}	=	The amount of electricity consumption in project determined as per procedure described under paragraph 38 below (MWh)

6.3.2.2. Calculation of baseline electricity consumptions

29. The baseline electricity consumption in year *y* is calculated as follows:

$$EC_{i,BL,y} = \sum_{i} n_i \times EC_{BL,i,j,y} \div 1000\,\mathrm{kWh/MWh}$$ Equation (4)

Where:

$EC_{BL,i,j,y}$	=	Electricity consumption (kWh) associated with baseline motor appliance *i* in hour *j* in year *y* determining as per the procedure described under paragraph 30 below
n_i	=	Number of motor-system *i*
i	=	Type of motor system

30. The average electricity consumption in year *y* associated with baseline motor appliance *i* can be determined using one of the following two options:

31. **Option 1- MOD2-BL:** Performance curve **(shaft power-flow rate, P-Q):** This option is applicable to industrial pumps/fans and not applicable to the compressor system.

$$EC_{BL,i,j,y} = \sum_{j=1}^{8760} P_{BL,MECH,i,j,y} \times k \div \eta_{BL,module1,\mathrm{i}}$$ Equation (5)

Where:

$P_{BL,\text{MECH},i,j,y}$	=	Average shaft power of baseline motor appliance *i* in hour *j* in year *y*, and determined as per paragraph 32 below (kW)
k	=	Correction factor in case the actual fluid is different from the one used to determine the performance curve. $k = \rho_{PJ,i,j,y}/\rho_{0,i}$ $\rho_{PJ,i,j,y}$ is the density of the actual medium (kg/m3), measured yearly. $\rho_{0,i}$ is the density of the testing medium (kg/m3), obtained from the manufacturer specifications or measurement campaign as prescribed in paragraph 32 below
$\eta_{BL,\text{module1,i}}$	=	Rated name plate full-load efficiency from manufacturer or determined using efficiency measurements following the latest international standards (IEEE 112 or IEC 60034-2) or equivalent national standards. Use 1.0 as default.
J	=	Hour *j* in project year *y*

32. The average shaft power ($P_{BL,i}$) of baseline motor-system *i* is determined ex ante using the "Shaft Power-Flow rate" performance curve (i.e. P-Q curve) and the associated best-fit model (reflecting the correlation between the shaft power and output flow rate) for each baseline motor-system *i* provided by manufacturers or derived based on the baseline measurement campaign[8] in the following form.

$$P_{BL,i} = f_i(Q)$$

The model of the performance curve of each type of motor appliance *i* shall be transparently documented in the PDD.

The average shaft power of baseline motor-system *i* $\left(P_{BL,\text{MECH},i,j,y}\right)$is determined ex post during the project by plugging the actual monitored values of flow rate of motor appliance *i* in hour *j* in year *y* ($Q_{PJ,\text{MECH},i,j,y}$) in the ex ante model developed above.

33. **Option 2- MOD2-BL**: On-site performance test (Efficiency versus power)

$$EC_{BL,i,j,y} = \sum_{j=1}^{8760} P_{PJ,ELEC,i,j,y} \times \eta_{PJ,system,i,j} \div \eta_{BL,system,i,j}$$ Equation (6)

Where:

$\boldsymbol{P_{PJ,\text{ELEC},i,j}}$	=	Measured actual input power (kW) to project motor system *i* in hour *j* in year *y*
$\eta_{BL,\text{system,i,j}}$	=	Overall efficiency of the whole motor-system (electric motor and motor appliance), determined prior to the implementation of the project activity using paragraph 34 below

[8] See paragraph 27.

$\eta_{PJ,\text{system,i,j}}$	=	Overall efficiency of the whole motor-system(electric motor and motor appliance), determined after the implementation of the project activity using paragraph 34 below
j	=	Hour *j* in project year *y*

34. Regression analysis shall be conducted to establish the correlation between overall efficiency vs power input/output for baseline and project motor-system:

$\eta_{BL,system,i,j} = f_i(P_{output,i,j})$; prior to the implementation of the project activity.

Where:

$P_{output,i,j} = P_{ELEC,i,j} \times \eta_{PJ,system,i,j}$

$\eta_{PJ,system,i,j} = f_i(P_{ELEC,i,j})$; after the implementation of the project activity.

35. In order to utilize the regression model, the t-test associated with relevant independent variables has to be at least 1.645, for a 90 per cent confidence. The regression model is documented with a complete report indicating, key assumptions, how the independent variables were selected and basis for including these variables and rejecting others, the regression results final sample results, and predicted efficiency values with respect to power consumptions.

36. The overall efficiency of the motor system (project and baseline) is determined as follows:

$$\eta_{system} = \frac{power\ output}{power\ input} = Q \times \Delta H \div P_{ELEC}$$ Equation (7)

Where:

Q	=	output flow rate (m^3/s) of the motor appliance
ΔH	=	total pressure difference (Pa) between motor appliance inlet and output
P_{ELEC}	=	power input (kWh) associated with the motor appliance

37. The measurement of efficiency and power input shall be conducted using relevant standard test procedure (international/national). Relevant test standards or equivalent, for example: ASME-PTC 8.2 for centrifugal pumps and ASME-PTC 11 for fans can be followed.

6.3.2.3. Calculation of project electricity consumptions

38. The project electricity consumptions in year *y* are calculated as follows:

$$EC_{PJ,y} = \sum_{i}^{m} n_i \times EC_{PJ,i,j,y}$$ Equation (8)

Where:

$EC_{PJ,i,j,y}$	=	Electricity consumption (kWh) associated with project motor appliance *i* in hour *j* in year *y* determining as per the procedure described under paragraph 39 below
n_i	=	Number of motor-system *i*
i	=	Type of motor system

39. The project electricity consumptions are determined using the following options that corresponds to the options selected under baseline calculations:

40. **Option1- MOD2-PJ: Manufacturer performance curve**

$$EC_{PJ,i,j} = \sum_{j=1}^{8760} P_{PJ,MECH,i,j,y} \times \mathrm{k} \div \eta_{PJ,module1}$$ Equation (9)

Where:

$\boldsymbol{P_{PJ,MECH,i,j,y}}$	=	Average shaft power (kW) of project motor appliance *i* in hour *j* in year *y*, determined as per paragraph 41 below
k	=	Correction factor in case the actual fluid is different from the one used to determine the performance curve by the manufacturer, refer to *k* value for baseline electricity consumption
$\eta_{PJ,module1,\mathrm{i}}$	=	Rated name plate full-load efficiency from manufacturer or it is determined using efficiency measurements following the latest international standards (IEEE 112 or IEC 60034-2) or equivalent national standards. Use 1.0 as default

41. The average shaft power of project motor-appliance i is determined ex ante using the P-Q performance function or curve provided by the manufacturer:

$$P_{PJ,i} = f_i(Q)$$

42. Average flow rate is determined by monitoring flow rate at each hour *j* in project year *y*. The average shaft power of motor-system *i* is determined ex post during the project by plugging the actual monitored values of flow rate in the ex ante model developed using one of the options below:

(a) Project participants may either derive a mathematical function from the curve or develop a table with shaft power vs flow rate. The mathematical function or the table should closely represent the manufacturer's performance curves;

(b) If the manufacturer supplies a mathematical relationship, this relationship can be used directly to derive shaft power for the relevant flow rate.

43. **Option 2- MOD2-PJ**: Direct measurement of electricity consumption

$$EC_{PJ,i,j,y} = \sum_{j=1}^{8760} P_{PJ,ELEC,i,j,y}$$ Equation (10)

6.3.3. Module 3 (Application of VSDs/VFDs)

6.3.3.1. Emission reductions calculations

44. The emission reductions due to the project activity in year *y* is calculated as follows:

$$\mathrm{ER_y} = \frac{\left(\mathrm{EC_{BL,y}} - \mathrm{EC_{PJ,y}}\right)}{(1 - \mathrm{l_y})} \times \mathrm{EF_{CO2,y}}$$ Equation (11)

Where:

$\mathrm{EC_{BL,y}}$	=	The amount of electricity consumption in baseline determined as per procedure described under paragraph 45 below (MWh)
$\mathrm{EC_{PJ,y}}$	=	The actual amount of electricity consumption in project determined as per procedure described under paragraph 56 below (MWh)

6.3.3.2. Calculation of baseline electricity consumptions

45. The baseline electricity consumption is determined using one of the following three options:

46. **Option 1- MOD3-BL** (**Performance measurement**):[9]

$$EC_{BL,y} = \sum_{i}^{m} \sum_{j}^{8760} P_{BL,ELEC,i,j,y}$$ Equation (12)

Where:

$P_{BL,ELEC,i,j}$	=	Average input power (kW) to baseline motor system *i* in hour *j* in year *y*, determined as per paragraph 47 below

47. The correlation between average power input to the baseline motor-system *i* and the flow rate is established ex ante using regression model.

$$P_{BL,i} = f_i(Q_i)$$

48. The average input power of baseline motor-system i is determined ex post during the project by plugging the actual monitored values of flow rate in the ex ante model.

[9] This option is not applicable to Compressor system.

49. The following two alternatives are available to conduct regression analysis:[10]

(a) **Alternative 1** (historical data): this option can be used if hourly data on historical energy consumption and flow rate is available for full one year immediately prior to the implementation of the project activity;

(b) **Alternative 2** (Baseline measurement campaign): the measurement campaign is carried out (before or in parallel with the project implementation) on the baseline motor system covering the period sufficient to capture the entire operating conditions i.e. it covers a time sufficient period to capture the range of the **independent** variables expected to be, or actually, encountered during the crediting period . The measurement shall cover all the possible output flow rate range under the project scenario. If there is more than one baseline motor system within the same type *i*, measurement can be carried out on sampling basis. The standard “Sampling and surveys for CDM project activities and programme of activities” for the purpose of sampling shall be followed.

50. **Option 2-MOD3-BL: Specific energy consumption**

51. The baseline is calculated using energy consumption per unit of output (e.g. KWh per Nm^3 compressed air or per ton flow) in the baseline multiplied by the output in project year *y*.

52. In the case, where the baseline energy use is established as a function of finished product (e.g. KWh consumed per number of finished products produced per year or batch), the baseline energy use and emissions per unit of production does not vary from an average value by more than +/-10 per cent. This condition, however, does not apply if the baseline energy use is established based on direct output of motor-appliance (e.g. flow rate).

53. The baseline emissions are calculated as follows:

$$EC_{BL,y} = \sum SEC_{BL} \times Q_{PJ,i,y}$$ Equation (13)

Where:

SEC_{BL}	=	Specific energy consumption per unit output in the baseline (for motor system of group *i* as calculated using paragraph 54 below. A group is a collection of motor system sharing similar sizes, functions, schedules, outputs or loads (MWh/Nm^3 compressed air)
$Q_{PJ,i,y}$	=	Total quantity of output monitored in project year *y* in group *i* in units of weight or volume (kg or m^3)

54. The average specific energy consumption is calculated as follows:

$$SEC_{BL} = \left(\sum EC_{BL,i}\right) \div Q_{Hy}$$ Equation (14)

[10] Guidelines related to regression analysis provided under paragraph 35 above is applied.

Where:

$EC_{BL,i}$	=	Average annual baseline electricity consumption of motor system of group *i* (MWh)
Q_{Hy}	=	Average annual quantity of output in baseline in units of weight or volume, kg or m^3

The calculation of SEC_{BL} is based on data recorded at a fixed interval over a period of at least 12 continuous months. Examples of the recording interval are hourly, daily. SEC_{BL} values must be reported with 10 per cent or higher precision at the 90 per cent confidence level.

55. **Option 3- MOD3-BL:** in the specific case of the project activity that involves only the introduction of VSDs/VFDs in existing motor system i.e. all other components/process output of the existing system continue remains the same, the following procedure is used to determine the baseline energy consumption :

(a) Directly measure the electricity consumption ($EC_{i,BL,VSD,y}$) during the project year *y* with VSD/VFD turned off for the period sufficient to capture the entire operating conditions i.e. it covers a time sufficient period to capture the range of the independent variables expected to be, or actually, encountered during the crediting period.

6.3.4. Project emissions

56. Project emissions (tCO_2/yr) correspond to electricity consumptions associated with project including any electricity used to run auxiliary equipment is calculated using the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.

57. In the specific case of Option 3, directly measure the electricity consumption ($EC_{i,PJ,VSD,y}$) during the project year *y* with VSD/VFD turned on for the period sufficient to capture the entire operating conditions i.e. it covers a time sufficient period to capture the range of the independent variables expected to be, or actually, encountered during the crediting period.

6.4. Leakage

58. No leakage assessment is required.

7. Monitoring methodology

7.1. Parameters that are not monitored but required at validation (ex ante)

59. Documenting of the technical specification of the baseline motor system. The PDD shall document:

(a) The technical specifications of replaced motor system and new motor system planned to be installed (e.g. rated power, rated efficiency), number and locations. The details of replaced motor system and new motor system shall be recorded in a way that allows for a physical verification by a designated operational entity (DOE);

(b) Rated efficiencies of the replaced motors and of the new motors.

7.2. Parameters that are monitored (ex post)

60. Monitoring shall include the compliance of the performance level of the product to the appropriate national/international standard or industrial norms. The project proponent shall have a quality management system to ensure the performance level of the product. The scope of quality management system shall cover all processes, materials and skills required to manufacture products which meet the national or international standard or relevant industrial norms. The documentation of the quality management system shall be made available to the DOE for validation and verification.

61. The metering of all the relevant parameters shall be as per Table 3 below.

62. In the case of project activities involving several facilities, the monitoring procedure described shall apply for each facility.

63. The applicable requirements specified in the "General guidelines for SSC CDM methodologies" (e.g. calibration requirements, sampling requirements) are also an integral part of the monitoring guidelines specified below and therefore shall be referred by the project participants.

64. When sampling is employed, the standard on "Sampling and surveys for CDM project activities and programme of activities" shall be followed.

7.3. Parameters for monitoring during the crediting period

Data / Parameter table 1.

Data / Parameter:	$EF_{CO2,y}$
Data unit:	t CO_2e/kWh
Description:	CO_2 emission factor of the grid electricity in year *y* CO_2 emission factor of captive plant in year *y*
Measurement procedures (if any):	For Grid emission factor, follow r the procedure described under AMS-I.D. For emission factor of captive plant , follow the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
Monitoring frequency:	Annual
Any comment:	In the methodology the same parameter is described for grid and captive plant

Data / Parameter table 2.

Data / Parameter:	$EC_{i,PJ,y}$
Data unit:	MWh
Description:	The amount of electricity consumption by project motor(s) *i* during year *y*
Measurement procedures (if any):	Direct measurement of electricity consumption as per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"
Monitoring frequency:	As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"

Any comment:	Applicable to module 1 and module 3 (option 1 and 2)

Data / Parameter table 3.

Data / Parameter:	$EC_{i,PJ,VSD,y}$
Data unit:	MWh
Description:	Project electricity consumption during the project year *y* with VSD/VFD turned on
Measurement procedures (if any):	Directly measure the electricity consumption as per “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” with VSD turned ON for the period sufficient to capture the entire operating conditions i.e. it covers a time sufficient period to capture the range of the independent variables expected to be, or actually, encountered during the crediting period. These measurements shall be carried out at least 12 times a year and the monitoring should be conducted for a period of at least six hours per measurement. Use the average value and annualize for that year
Monitoring frequency:	As per the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption
Any comment:	Applicable to module 3, Option 3

Data / Parameter table 4.

Data / Parameter:	$EC_{i,BL,VSD,y}$
Data unit:	MWh
Description:	Baseline electricity consumption determined based on the measurement during the project year *y* with VSD/VFD turned off
Measurement procedures (if any):	Directly measure the electricity consumption as per the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” with VSD turned OFF for the period sufficient to capture the entire operating conditions i.e. it covers a time sufficient period to capture the range of the independent variables expected to be, or actually, encountered during the crediting period. These measurements shall be carried out at least 12 times a year and the monitoring should be conducted for a period of at least six hours per measurement. Use the average value and annualize for that year
Monitoring frequency:	-
Any comment:	Applicable to module 3, Option 3

Data / Parameter table 5.

Data / Parameter:	**-**
Data unit:	Operating hours
Description:	Operating hours of project motor(s) *i* in year *y*

Measurement procedures (if any):	Measurements are undertaken using times/hour-meters. Where many motors with similar operating patterns are being replaced, operating hours can be determined based on sampling. Examples of such motor groupings are supply fan motors, exhaust fan motors, and boiler circulating pump motors. Each group type should have similar use patterns and comparable average operating hours. These aspects shall be demonstrated in the PDD
Monitoring frequency:	Continuous monitoring, hourly measurement and at least monthly recording
Any comment:	Applicable to module 1, option 2. (See paragraph 25(b)) and in the case where baseline electricity consumption is determined based on the actual operating hours of project during the crediting period

Data / Parameter table 6.

Data / Parameter:	$Q_{PJ,Mech,i,y}$
Data unit:	m^3/s or t/s
Description:	Average flow rate of project motor appliance *i* in hour *j* in year *y*
Measurement procedures (if any):	Measurements are undertaken using flow meter
Monitoring frequency:	Continuous monitoring, hourly measurement and at least monthly recording
Any comment:	Applicable to module 2, Option 1 and module 3, Option 1

Data / Parameter table 7.

Data / Parameter:	$Q_{PJ,i,y}$
Data unit:	Total quantity of output monitored in project year *y* in group *i*
Description:	Quantity (kg or m^3) per year
Measurement procedures (if any):	As per established industrial practice. Measurement results shall be cross-checked where applicable with records for sold production (e.g. invoices/receipts) or inventory records or by performing mass-balance. In the event that project output in year *y* is greater than the average historical output[11] (average from a recent year excluding abnormal data), the value of the output in year *y* shall be capped at the value of the historical average output level. For example, if $Q'_{PJ,i,y}$ is the total amount of product produced by the project element process in year *y* (uncapped), then *Q'PJ,i,y* = *QPJ,i,y* for *QPJ,i,y* <*QHy*, and *QPJ,i,y* = *QHy* for *QPJ,i,y*> *QHy*
Monitoring frequency:	Annual
Any comment:	Applicable for module 3 Option 2

[11] A maximum of ±10 per cent variation is permitted.

Data / Parameter table 8.

Data / Parameter:	$\rho_{PJ,i,j,y}$
Data unit:	Density of the flow output associated with project motor appliance *i* in hour *j* in year *y*
Description:	Kg/m^3 at actual conditions
Measurement procedures (if any):	From standard data books. Value of density to be used for calculations should correspond to the average pressure and temperature of fluid
Monitoring frequency:	Yearly monitoring and recording
Any comment:	Applicable tor module 2, Option 1

Data / Parameter table 9.

Data / Parameter:	$\boldsymbol{P_{PJ,Elec,i,j,y}}$
Data unit:	Actual input power to project motor system *i* in hour *j* in year *y*
Description:	kW
Measurement procedures (if any):	Measurements are undertaken using either power meter or energy meter
Monitoring frequency:	Continuous monitoring, hourly measurement and hourly recorded
Any comment:	Applicable for module 2 ,Option 2

Data / Parameter table 10.

Data / Parameter:	***ly***
Data unit:	Fraction
Description:	Average annual technical grid losses (transmission and distribution) during year *y* for the grid serving the locations where the motor systems are installed
Measurement procedures (if any):	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
Monitoring frequency:	Annual
Any comment:	Applies only in case of grid electricity savings

7.4. Project activity under a programme of activities

65. The methodology is applicable to a programme of activities, no additional leakage estimations are necessary.

Appendix. Classification of motor efficiency standards and efficiency of motors

1. The table below provided motor efficiency classes in different countries and the corresponding international standard.

Table 1. Classification of motor efficiency standards

Motor efficiency class	International	United States	European Union (old system 1998[1])	European Union (new system 2009)	China	Australia
Premium	IE3	NEMA Premium	–	IE3	–	–
High	IE2	EPAct	Eff1	IE2	Grade 1 (under consideration)	AU2006 MEPS
Standard	IE1	–	Eff2	IE1	Grade 2	AU2002 MEPS
Below standard	IE0 (used only in this paper)	–	Eff3	–	Grade 3 (current minimum)	–

Abbreviations: EPAct – US Energy Policy Act, 1992; MEPS – minimum energy performance standard;

NEMA – US National Electrical Manufacturers Association.

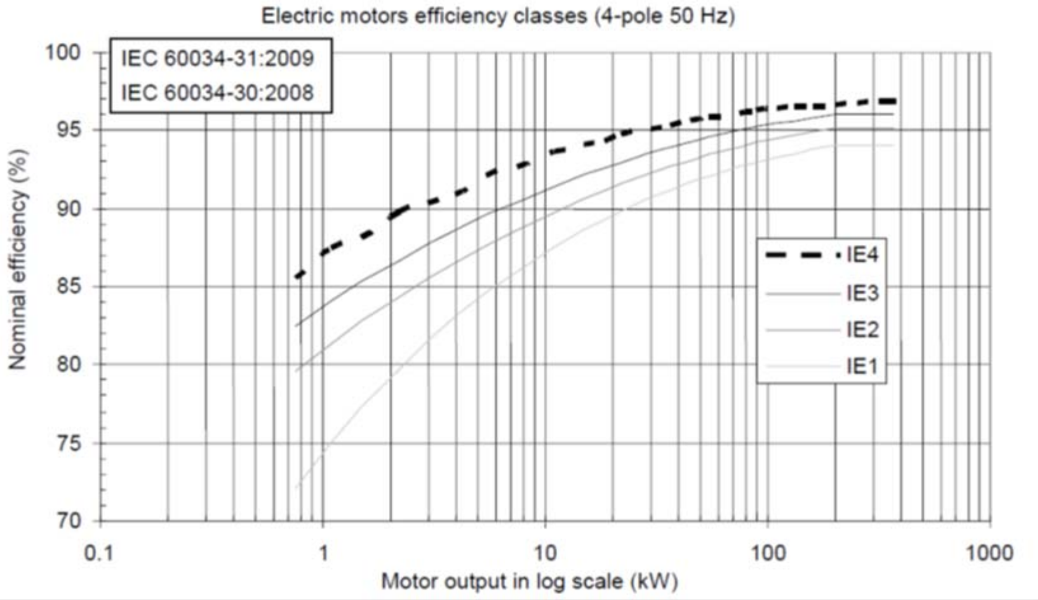
Source: A+B International, 2009.

Note: 1. With the backing of the European Commission, manufacturers representing 80% of the European production of standard motors, agreed to establish three efficiency bands or classes designated EFF1, EFF2, and EFF3, with EFF1 being the highest band.

[a] Source: IEA, 2011, pp 24, Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems, International Energy Agency, Paris

2. $\Delta\eta$ values are approximate average values estimated as the algebraic difference of the values corresponding to IE4 (Super premium standard) and IE2 (high standard) 4 pole 50 Hz motor from the graph below. It is assumed IE2 as a reference standard for conservativeness as it is evident that the standard class motors (IE1) have higher penetration rate in developing countries (IEA. 2007. Tracking industrial energy efficiency and CO_2 emissions (page 223)).

Figure 1. Efficiency classes of electric motors



[a] Source: IEA, 2011, Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems, International Energy Agency, Paris

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