Approved baseline and monitoring methodology AM0067

"Methodology for installation of energy efficient transformers in a power distribution grid"

I. SOURCE, DEFINITIONS AND APPLICABILITY

Source

This methodology is based on the project activity "Installation of energy efficiency transformers in Shandong power grid", proposed by Hitachi Industrial Equipment Systems Co., Ltd, whose baseline and monitoring methodology and project design document were prepared by Hitachi, Ltd., Japan.

For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0243: "Methodology for installation of energy efficiency transformers in a power grid" on <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>.

This baseline and monitoring methodology refers to latest version of the following tools[1]:

- "Combined tool to identify baseline scenario and demonstrate additionality"; and
- "Tool to calculate emission factor for an electrical system"

Selected approach from paragraph 48 of the CDM modalities and procedures

"Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment".

Definitions

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

Distribution grid. A distribution grid is the portion of the electric system that is dedicated to delivering electric energy to the end-users. It delivers power at medium voltage levels (generally less than 50 kV).

Load losses. Load losses or coil losses are losses due to resistance in the electrical winding of the transformer. These losses include eddy current losses in the primary and secondary conductors of the transformer.

No-load losses. No-load losses or core losses are losses due to transformer core magnetizing or energizing. These losses occur whenever a transformer is energized and remain constant regardless of the amount of electricity flowing through it.

Geographical region. The geographical region is defined as the concession area[2] which contains project activity areas.

[1] Please refer to: < http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>
[2] Concession area is the territory where an specific utility has the authorization to operate.

Project activity area. It is defined as a distinct predefined area within the geographical region where the project activity is implemented.

Performance level. It is certified maximum level of load and no-load losses for transformers installed in the geographical region, which is provided either by an agency appointed by the Government or by an independent qualified entity.

Type of transformer. The type of transformer for the purpose of this methodology is defined by its capacity (kVA) and transformation ratio.

Applicability

The methodology is applicable to the following project activities:

(1) Replacement of existing lower-efficiency transformers with higher efficiency transformers in an existing distribution grid; or
(2) Install new high efficiency transformers in the new areas covered by expansion of the distribution grid where in the absence of the project, lower efficiency transformers would have been installed.

The following conditions apply to the methodology:

(a) Emission reductions due to reduction in no-load losses[3] alone are claimed;
(b) Installation of transformers within the distribution grid is governed by performance levels established by local or national regulation, which define maximum permissible load losses and no-load losses;
(c) Load losses, at rated load, of the transformers implemented under the project activity are demonstrated to be equal or lower than the load losses in transformers that would have been installed in absence of the project activity;
(d) The transformers installed in the project activity comply with national / international QA/QC standards. This shall be demonstrated through certification based on test conducted using relevant national / international testing standards from an accredited entity / government recognised entity. The certification report shall include information on the measured performance levels for load losses and no-load losses in various operational conditions and in addition, the associated uncertainty;
(e) Project proponent implements a system to ensure that the replaced transformers are not used in other parts of the distribution grid or in another distribution grid;
(f) A complete list of co-ordinates uniquely identifying each transformer installed under the project activity is provided;
(g) Data on total number and type of transformers installed over the last three years previous the project implementation is available.

In addition, the applicability conditions included in the tools referred above apply.

[3] The methodology does not credit reduction in emissions due to reduction in load-losses as the load-losses of the transformer vary with the load and, therefore, crediting such reduction would requires continuous monitoring of the load on the project activity transformer.

Further notes on applicability of the methodology

Note 1:
The methodology is not applicable if the technology of the transformers installed in the project activity represents more than 20% of the total installed transformers in the geographic region during a period of 3 years prior to the implementation of the project activity.

For example if the project activity starts in 2009, then project proponent shall use historical data for the years 2006, 2007 and 2008 and evaluate if 20% or more of the total transformers installed during these years, irrespective of the type of transformer, are of the same technology as that used in the project activity. If yes, then this methodology is not applicable for the project activity.

Note 2:
To demonstrate applicability condition (c), project proponents shall show, for each type of transformer installed, that the rated load losses for project activity transformers are lower than or equal to load losses of baseline transformer load losses.

$$\forall k, \quad LL_{PR,k} \leq LL_{BL,k}$$

Where:

$LL_{BL,k}$	=	Load loss of the transformer type k which would have been installed (Watt)
$LL_{PR,k}$	=	Load loss of transformer "k" installed during project activity (Watt)
k	=	Type of transformer

$LL_{BL,k}$ should be the minimum value of the load losses defined by the performance levels as per national regulations and the performance levels provided by the manufacturers of commercially available transformers that would be installed in the baseline scenario.

Note 3:
Transformers can be installed at any time during the crediting period in the project activity area, but they will only be eligible to obtain CERs from the beginning of the subsequent monitoring period. Project participants shall provide the following information related with each of the installed transformers under the project activity:

- Date of installation;
- Exact localization of the transformer (providing serial number and co-ordinates of the location);
- Technical data of each transformer, for example transformation ratio, capacity, etc.;
- Load losses and no-load losses provided by the manufacturer.

For transformers installed after registration of the project activity, the verifying DOE shall ensure that relevant applicability conditions are met. The DOE shall clearly identify the number of new transformers installed and present its assessment of above check.

II. BASELINE METHODOLOGY PROCEDURE

Procedure for selection of baseline scenario and demonstration of additionality

The baseline scenario is identified using latest version of the "Combined tool to identify baseline scenario and demonstrate additionality". In applying the following list of credible and plausible alternative scenarios for the replacement of transformers, *inter alia*, shall be considered:

(1) Replacement or installation of transformers adopting a more efficient technology other than the technology of the project activity;
(2) Continuation of current practice. Replacement or installation of transformer with the most commonly used transformers in the geographical region where the project activity is implemented;
(3) Replacement or installation of transformers as per new performance levels enforced by regulation;
(4) Replacement or installation of transformers adopting the project activity technology without CDM benefits.

The list of credible and plausible alternatives will be narrowed down, by removing those, which do not comply with legal requirements.

Barrier analysis

Barriers may include, among others:

Technological barriers, *inter alia*:

- Manufacture of energy efficiency material is a state-of-the-art technology and there is only limited production in the host country. Insufficient availability of the material could also lead to limited production of energy efficiency transformers. In addition, the manufacturing technology of energy efficiency transformers is not widely disseminated in the host country;
- Lack of familiarity or first-of-its-kind project significantly hinders the ability to implement the proposed project activity;
- Lack of information regarding the technical performance of the type of transformers installed in local environmental and operational conditions in the host country.

Investment barriers, *inter alia*:

- Financing capacity of the project proponent vis-à-vis other investment opportunities;
- Debt funding may not be available for innovative project activity;
- Lack of domestic or foreign direct investment in the country where the CDM project activity is to be implemented;
- Subsidies may exist that inhibit investments in energy efficiency projects; or,
- Inability of the management to dedicate resources for implementation of the CDM project activity.

Prevailing practice barriers, *inter alia*:

- Commonly used technology (e.g., Silicon steel plate) for distribution transformers are preferred from the aspects of reliability and stability;
- Continue procuring transformers from a specific manufacturer, e.g. long-term contract as a common commercial practice.

The methodology is applicable only if any of the following scenarios are identified as the most likely baseline options:

- Scenario 2: "Continuation of current practice i.e. replacement or installation of transformer with the most commonly used transformers in the geographical region where the project activity is implemented"; or
- Scenario 3: "Replacement or installation of transformers as per performance levels enforced by regulation".

Project boundary

The project boundary is the geographical region where project activity transformers are installed during the crediting period. The boundary includes the electricity system (or grid) within which the project activity area is located.

The greenhouse gases included in or excluded from the project boundary are shown in the following table.

Table 1: Emissions sources included in or excluded from the project boundary

	Source	Gas	Included?	Justification / Explanation
Baseline	Fossil fuel power plants in the grid	CO_2	Yes	Emissions that would have occurred at the fossil fuel power plants if the baseline transformers would have been installed
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification
Project Activity	Fossil fuel power plants in the grid	CO_2	Yes	Emissions at the fossil fuel power plants when the energy-efficient transformers introduced by the proposed project activity are used
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification

Baseline emissions[4]

The baseline emissions, BE_y, in a year '*y*' are given by:

$$BE_y = \sum_{k=1}^{n} \left(NLL_{BL,k} \times n_{k,y} \right) \times MP \times (1 - Br) \times EF_{CO2,grid,y} \times 10^{-6} \quad \textbf{(1)}$$

[4] An example on how to estimate the baseline emissions is presented in Annex 1 of the methodology.

Where:

BE_y	=	Baseline emissions in year '*y*' (tCO_2/year)
k	=	Index 'k' represents type of transformers, installed in the project activity
$NLL_{BL,k}$	=	No-load loss rate of the transformer type 'k' that would have been installed by the end of the year '*y-1'* in the baseline scenario. No-load loss rate for each baseline transformer type 'k' is determined individually, as given in equation 2 below.
MP	=	Duration of each monitoring period (hours).
Br	=	Black out rate of each monitoring period (%).
$EF_{CO2,grid,y}$	=	CO_2 emission factor of the grid for year 'y' where the project activity is implemented (tCO_2/MWh). EF is calculated adopting the combined margin and as described in the "tool to calculate the emission factor of an electricity system".
$n_{k,y}$	=	Cumulative number of type 'k' transformers installed by the project activity at the end of year 'y-1'

Procedure to estimate Baseline no-Load Loss ($NLL_{BL,k}$)

(1) Baseline scenario 2: $NLL_{BL,k}$ is calculated as per the procedure defined as follows:

$$NLL_{BL,k} = \min\left\{NLL_{reg,k}, NLL_{AVG,k}\right\} \quad \textbf{(2)}$$

Where:

$NLL_{reg,k}$	=	No-load loss rate defined by the national regulations for *k* type of transformers (W)
$NLL_{AVG,k}$	=	Average of no-load loss rate provided by the manufacturers of all *k* type of transformers whose performance is among the top 20 % (W)[5] [6].

Procedure to calculate $NLL_{AVG,k}$:

(i) List all transformer type k installed in geographical area during the most recent five years before the implementation of the project activity (N);
(ii) Order the transformers from least to highest No-Load Losses, the No-Load Losses as defined by the manufacturer's performance level specification;
(iii) Take the first 20% (0.2N) of all transformers from the order arrived at in (ii) and average them.

(2) Baseline scenario 3: $NLL_{BL,k}$ is defined by the performance levels enforced through regulation.

[5] This means averaging out the no-load losses of selected top 20% of manufacturers who have lowest no-load losses.

[6] If a specific type of transformer installed in the project activity in last five years, was not installed before in the distribution grid / or was not manufactured in the geographic region then the baseline NLL for such transformer cannot be estimated using this procedure. In such cases, a revision to this methodology should be proposed.

Project Emissions

The project emissions PE_y in a year *y* is given by:

$$PE_y = \sum_{k=1}^{n}\left[(1+UNC)\times NLL_{PR,k,y}\times n_k \times MP\times(1-Br)\times EF_{CO2,grid,y}\times 10^{-6}\right] \quad (3)$$

Where:

PE_y = Project emissions in year '*y*' (tCO_2/year)

k = Index 'k', type of transformer, in the geographical region of the project activity area installed by the project activity at the end of year 'y-1'

$NLL_{PR,k,y}$ = No-load loss rate of the energy efficiency transformer i which will have been installed by the end of the year '*y-1'* in the project activity (Watts)

MP = Duration of each monitoring period (hours)

Br = Black out rate of each monitoring period (%)

$EF_{CO_2,grid,y}$ CO_2 emission factor of the grid for year 'y' where the project activity is implemented (tCO_2/MWh). EF is calculated adopting the combined margin and as described in the "tool to calculate the emission factor of an electricity system".

UNC = Maximum allowable uncertainty for the no-load losses stated in the certification report provided by an accredited entity

n_k = Total cumulative number of type 'k' transformers installed by the project activity at the end of year 'y-1'

Leakage

No significant leakage is anticipated from the project activity, provided that the system is place to ensure that the replaced transformers are not used elsewhere. To demonstrate that the replaced transformers are not used, the project proponents shall provide documentary evidence that the transformers were scrapped. Verification by the DOE determining that replaced transformers have not been distributed at other places is required.

Emission reductions

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y \quad (4)$$

Where:

ER_y = Emission reductions during the year *y* (tCO_2)

BE_y = Baseline emissions during the year *y* (tCO_2)

PE_y = Project emissions during the year *y* (tCO_2)

Changes required for methodology implementation in 2nd and 3rd crediting periods

It is required to address the validity of the baseline scenario at the start of the second and third crediting period for a project activity.

Common practice analysis shall be carried out for the 2nd and 3rd crediting periods to demonstrate the validity of the baseline scenario. It has to be demonstrated that the ratio of transformers technology type used in the project activity should be lower than 20%, when compared with the total operational transformers in the same geographical region.

Baseline emissions have to be reassessed before start a new crediting period

Data and parameters not monitored

In addition to the parameters listed in the tables below, the provisions on data and parameters not monitored in the tools referred to in this methodology apply.

The following items are demanded to confirm applicability conditions:

ID Number:	1.
Parameter:	$LL_{BL,k}$
Data unit:	W
Description:	Load loss rate of the transformer type 'k' that would have been installed in the baseline scenario
Source of data:	There are two sources of information: 1. Local, national legislation for transformer performance levels; 2. Information provided by the manufacturer.
Measurement procedures (if any):	The parameter should be the minimum value for load losses between the performance levels defined by national regulations and the performance levels provided by the manufacturers of commercially available transformers that might be installed in the baseline scenario.
Any comment:	

ID Number:	3.
Parameter:	$NLL_{reg,k}$
Data unit:	W
Description:	No-load losses defined by the national regulations for *k* type of transformers (W)
Source of data:	Local, national legislation for transformer performance levels
Measurement procedures (if any):	
Any comment:	Use the latest regulations only

ID Number:	4.
Parameter:	$NLL_{AVG,k}$
Data unit:	W
Description:	Average of no-load loss rate provided by the manufacturers of all *k* type of transformers installed in the geographical region whose performance is among the top 20 % of their type in last five years prior to the implementation of the project activity
Source of data:	Specifications supplied by manufacturers at the time of installation
Measurement procedures (if any):	
Any comment:	

III. MONITORING METHODOLOGY

Monitoring procedures

This monitoring methodology requires the monitoring of the following items to confirm applicability conditions:

- The actual installed type, capacity, transformation ratio and load loss rate (W) of each high-efficiency transformer installed by the project activity;
- Historical installation data of the transformer types for the past five (5) years.

This monitoring methodology requires the monitoring of the following items to complete project emission calculations:

- Load and No-load loss rate (W) of energy efficiency transformers installed by the project activity;
- Specifications of each high-efficiency transformer installed by the project activity (date of installation, localization, technical data);
- CO_2 emission factor (tCO_2/MWh) of the grid;
- Yearly blackout rate of the grid during the year '*y*' (%);
- The number of transformers which are installed in the project activity and are in operation. (i.e. consider the number of high-efficiency transformers removed since installed).

All data collected as part of monitoring should be archived electronically and be kept at least for 2 years after the end of the last crediting period. 100% of the data should be monitored if not indicated otherwise in the tables below. All measurements should be conducted with calibrated measurement equipment according to relevant industry standards.

In addition, the monitoring provisions in the tools referred to in this methodology apply.

Data and parameters monitored

	$EF_{CO_2,grid,y}$
Data unit:	t CO_2 /MWh
Description:	v
Source of data:	Official statistics or data obtained from local power company
Measurement procedures (if any):	Calculated by the "combined margin method" described in specified in "Tool to calculate emission factor of an electricity system"
Monitoring frequency;	Yearly
QA/QC procedures:	
Any comment:	

Data / Parameter:	*MP*
Data unit:	Hours
Description:	Duration of each monitoring period
Source of data:	Official statistics or data obtained from local power company
Measurement procedures (if any):	
Monitoring frequency:	To be specified in the CDM-PDD document
QA/QC procedures:	
Any comment:	Project participant shall define the period (i.e. if monitoring period is a year, then MP=8760)

Data / Parameter:	*Br*
Data unit:	%
Description:	Black out rate in the corresponding monitoring period.
Source of data:	Official statistics or data obtained from local power company
Measurement procedures (if any):	
Monitoring frequency:	Yearly
QA/QC procedures:	The blackout data will be collected as part of normal business operations. The data shall be cross-checked with other internal company reports.
Any comment:	

Data / Parameter:	*k*
Data unit:	type of transformer (type based on capacity and transformation ratio)
Description:	Index 'k' represents type of transformers, installed by the project activity
Source of data:	Record of installation of high efficiency transformers provided by installation entities
Measurement procedures (if any):	Reported
Monitoring frequency:	At each transformer installation or replacement in the project boundary
QA/QC procedures:	The installation data will be collected as part of normal business operations. The data shall be cross-checked with other internal company reports.
Any comment:	

Data / Parameter:	$n_{k,y}$
Data unit:	Number
Description:	Cumulative number of transformers of type 'k' installed in the project activity by the end of year 'y-1'
Source of data:	Record of installation of high efficiency transformers provided by installation entities
Measurement procedures (if any):	Reported
Monitoring frequency:	Yearly
QA/QC procedures:	The installation data will be collected as part of normal business operations. The data shall be cross-checked with other internal company reports.
Any comment:	

Parameter:	$NLL_{PR,k,y}$
Data unit:	W
Description:	No-load loss rate of the high energy efficiency transformers type 'k' installed by end of year 'y-1' by the project activity
Source of data:	Manufacturer's performance test report which measured at the time of pre-delivery inspection
Measurement procedures (if any):	According with local, national or international standards
Monitoring frequency:	Every time a transformer is installed
QA/QC procedures:	Manufacturer's performance test report submitted by the manufacturer validated by certification entity.
Any comment:	A certification report shall be provided by an accredited entity

Data / Parameter:	$LL_{PR,i}$
Data unit:	W
Description:	Load-loss rate of energy efficiency transformers installed by the project activity
Source of data:	Manufacturer's performance test report which measured at the time of pre-delivery inspection
Measurement procedures (if any):	Load-losses values at a rated current which measured at the time of pre-delivery inspection
Monitoring frequency:	Every time the transformers are installed
QA/QC procedures:	Manufacturer's performance test report submitted by the manufacturer validated by certification entity
Any comment:	A certification report shall be provided by an accredited entity

Data / Parameter:	Number of transformers installed under the project activity
Data unit:	No unit
Description:	Historical record of installed transformers under the project activity

Source of data:	The record shall include following information:
	• Date of installation;
	• Exact localization of the transformer (providing serial number and co-ordinates of the location);
	• Technical data of each transformer (ratio, capacity, etc.);
	  • Rated load losses;
	  • Nominal no-load losses.

Measurement procedures (if any):	
Monitoring frequency:	After every new installation
QA/QC procedures:	
Any comment:	

Data / Parameter:	Number of replaced transformers
Data unit:	No unit
Description:	Historical record of replaced transformers under the project activity. The record shall include information on how the transformers are not going to be use in other parts of the grid or in another grid
Source of data:	Record of removal / installation of transformers provided by installation entities Records of disposition of transformers provided by utility
Measurement procedures (if any):	
Monitoring frequency:	Yearly
QA/QC procedures:	
Any comment:	

References and any other information

Annex 1: Example to estimate baseline emissions:

Transformer type	No-load losses as per regulation	Number of transformers installed in the last five years previous implementation of the project activity (y=0)			No load losses rate (NLL_k) (Watts)		
		Existing transformers in the host country			Existing transformers in the host country		
		Manufacturer A	Manufacturer B	Manufacturer C	Manufacturer A	Manufacturer B	Manufacturer C
1	55	10	30	20	50	60	80
2	80	10	15	0	75	80	95
3	95	0	0	20	90	100	110
4	98	0	20	50	100	120	125

Estimation of $NLL_{BL,k}$

$$NLL_{BL,k} = \min\{NLL_{reg,k}, NLL_{AVG,k}\}$$

a) Estimation of no-load losses rate (NLL) for transformer type 1:

$NLL_{reg,1}$=55

b) Estimation of no load losses for the top 20% transformers

The following table sorts the transformers (of type 1) installed ordering them in an ascending order starting from least no load losses.

Manufacturer	No load losses Transformer type 1	Number transformers installed	Percentage of transformers in the total
A	50	10	17% (10/60)
B	60	30	50% (30/60)
C	80	20	33% (20/60)

In above table, the least no load loss transformers only comprises 17% of the total. This means that the remaining 3% of number of transformers (as the losses of top 20% are to be averaged out) of the next least no-load loss transformer manufacturer (manufacturer B) have to be included in above number representing 17% of total.

Therefore final table gives the top 20% of the total number, which is 12, of transformers of type-I.

Manufacturer	No load losses Transformer type 1	Number of transformers	Percentage of transformers in the total
A	50	10	17%
B	60	2	3%

$NLL_{AVG,1}$ will be calculated as the average of the no load losses of the top 20% transformers type 1 (12 units):

$$NLL_{AVG,1} = \frac{10 \times 50 + 2 \times 60}{12} = 51.67W \text{ (Average of top 20\%)}$$

Therefore,

$$NLL_{BL,1} = \text{Min } \{\text{top 20\%, regulation}\} = \text{Min}\{51.67, 55\} = 51.67 \text{ W}$$

Summary of NLL for each type of transformer in the baseline scenario

No load losses for different types		Value	Reference
$NLL_{BL,1}$	=	51.67 W	From the top 20%
$NLL_{BL,2}$	=	75 W	From the top 20%
$NLL_{BL,3}$	=	95 W	From the regulation. Top 20% value is 110. Transformers with no load losses of 90W and 100W were not installed
$NLL_{BL,4}$	=	98 W	From the regulation. Top 20% no load losses value is 120.

Transformer type	Total transformers installed by year 'y-1'
1	10
2	12
3	20
4	10

Baseline Emissions are estimated as follows:

$$BE_y = \sum_{k=1}^{n} \left(NLL_{BL,k} \times n_{k,y-1}\right) \times MP \times (1 - Br) \times EF_{CO2,grid,y} \times 10^{-6}$$

$$= (51.67 \times 10 + 75 \times 12 + 95 \times 20 + 98 \times 10) \times MP \times (1 - Br_y) \times EF_{CO_2,grid,y} \times 10^{-6}$$

$$= 4296.7 \times MP \times (1 - Br_y) \times EF_{CO_2,grid,y} \times 10^{-6}$$

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History of the document

Version	Date	Nature of revision(s)
01	EB 38, Annex 2 14 March 2008	Initial adoption