CLEAN DEVELOPMENT MECHANISM
PROPOSED NEW METHODOLOGY: MONITORING (CDM-NMM)
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SECTION A. Identification of methodology

A.1. Title of the proposed methodology:

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Cogeneration at an industrial facility.

A.2. List of category(ies) of project activity to which the methodology may apply:

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The methodology may be applicable to the following categories of project activities: (1) Energy industries (renewable / non-renewable sources), (4) Manufacturing industries and (5) Chemical industry.

A.3. Conditions under which the methodology is applicable to CDM project activities:

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Cogeneration involves the simultaneous production of heat and electricity from a single fuel source. The activities covered by this methodology could involve the installation of new cogeneration capacity or increase in existing cogeneration capacity. The project activity may involve fuel switching since cogeneration equipment normally require higher quality fuels (e.g. natural gas and petroleum distillate) so that there is likely to be increased consumption of such fuels and decreased consumption of other fuels such as coal, fuel oil, etc.

The methodology would apply to cases where cogenerated electricity meets some or all of the power demand at the industrial facility. The industry may purchase electricity from the grid in order to meet on-site demand or sell electricity to the grid when electricity generation exceeds on-site demand.

While fuel switching may be involved in the cogeneration project implementation, this methodology is not applicable to projects that are limited to fuel switching only for equipment generating thermal energy.

The methodology is not applicable to situations where the industry purchases from, or sells thermal energy to, other users, either in the baseline scenario or in the project scenario.

The methodology is also *not* applicable to project activities involving improvements in end-use efficiency, i.e. where thermal energy and/or electricity is used more efficiently. The methodology proposed here can be applied to projects where end-use efficiency improvements also take place in addition to the activities covered by this methodology. However, emission reductions resulting from efficiency improvement would not lead to creditable emission reductions in this methodology because the baseline is adjusted in accordance with actual thermal energy delivered to the industry's thermal load during the project. Consequently, efficiency improvements tend to decrease both project emissions and baseline emissions.

The methodology is applicable to industries with existing cogeneration equipment. However, if this is the case, and the new cogeneration equipment would replace some of the existing equipment, the crediting period would be limited by the remaining lifetime of any existing cogeneration equipment.

A.4. What are the potential strengths and weaknesses of this proposed new methodology?

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One potential strength of the proposed new methodology is that it is straightforward to apply. The methodology allows for baseline emissions to be determined in a dynamic manner, from monitored data following project implementation, thus allowing for changes in industrial demand.

On potential weakness of the proposed methodology is that it requires three years of reliable historical data to determine relationship between industrial parameters.

SECTION B. Proposed new monitoring methodology

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B.1. Brief description of the new methodology:

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The methodology is based on monitoring fuel used to produce heat and electricity for use at an industrial facility. Besides meeting industrial demand, electricity may also be sold through a power grid to which the industry is connected. On-site emissions are directly related to fuel consumption at the industrial facility, so that only project fuel consumption needs to be monitored in order to determine project emissions.

Electricity purchased from the grid results in emissions elsewhere in the power grid. Baseline emissions would depend on the *net* electricity purchased through the grid in the baseline scenario. Moreover, net electricity sold through the grid in the *project* scenario would reduce emissions elsewhere in the power grid. In the absence of the project activity, these emissions would have taken place. Thus these emissions that are *avoided* by the project activity also need to be counted as *baseline* emissions. The magnitude of these emissions may be expressed as the product of the amount of electricity purchased or sold and an emissions factor that characterises power generation in the rest of the grid. A determination of this emissions factor requires monitoring of key parameters in the interconnected grid. To this end, this new methodology incorporates the following procedures and methodologies:

- Approved consolidated baseline methodology ACM0002 "Consolidated baseline methodology for grid-connected electricity generation from renewable sources".
- For projects where power exported from the industrial facility through the power grid is below 15 MW, an alternative methodology is the Small-scale methodology AMS I. D "Renewable electricity generation for a grid."

The baseline methodology associated with this monitoring methodology requires baseline emissions to be determined in a dynamic manner, adjusting baseline emissions in terms of the total heat output of the cogeneration plant following project implementation. Monitoring heat output is thus one of the elements included in this monitoring methodology. The procedure for determining baseline emissions from monitored heat output, and other parameters, is also included in this monitoring methodology.

Leakage emissions are small and would be estimated without the need for additional monitoring.

B.2. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario:

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B.2.1. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
P.1.	FC_i	*Industrial facility*	*GJ*	*m*	*monthly*	*100%*	*Electronic (paper can be used for field record)*	*For each fuel* **i** *used at the industrial facility in the project scenario*

B.2.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

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The project activity involves installing, or increasing the capacity of, cogeneration equipment. Project emissions on-site depend on the consumption of different fuels used and corresponding emissions factors. As a result of project implementation, there would be reduced power generation in the interconnected grid. The corresponding emissions reductions are accounted for as *baseline* emissions, since those emissions would take place in the absence of the project activity. Note that this same approach is taken in projects involving electricity generation from renewable energy sources: emissions offset by power generation are included as baseline emissions, in ACM0002 and other approved methodologies. Indeed, this approach was recommended in AM0014, which involves cogeneration using a fossil fuel.

The project emissions E (expressed in tonnes of CO_2 equivalent per year, tCO_2e/yr) are therefore given by:

$$E = \sum_i FC_i \cdot (EF_i + MEF_i \cdot GWP(CH_4) + NEF_i \cdot GWP(N_2O)) \qquad \text{(Eq. 1)}$$

where:

FC_i consumption of fuel *i* used in the project scenario, measured in energy units (e.g. gigajoule, GJ)

EF_i carbon dioxide emission factor per unit energy of fuel *i* (e.g. tCO_2e/GJ) (combustion)

MEF_i methane emission factor per unit energy of fuel *i* (e.g. tCH_4/GJ) (combustion)

$GWP(CH_4)$	global warming potential of CH_4 set as 21 tCO_2e/tCH_4 for the 1st commitment period
NEF_i	nitrous oxide emission factor per unit energy of fuel *i* (e.g. tN_2O/GJ) (combustion)
$GWP(N_2O)$	global warming potential of N_2O set as 310 tCO_2e/tN_2O for the 1st commitment period

B.2.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of greenhouse gases (GHG) within the project boundary and how such data will be collected and archived:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
B.1. ES	*Electricity supplied to grid*	*Industrial facility / electricity purchaser*	*MWh*	*m*	*monthly*	*all*	*Electronic (paper can be used for field record)*	
B.2. EP	*Electricity purchased from grid*	*Industrial facility / electricity supplier*	*MWh*	*m*	*monthly*	*all*	*Electronic (paper can be used for field record)*	
B.3. $\eta_{n,i}$	*Efficiency of boiler n using fuel i,*	*Industrial facility*	*%*	*m*	*yearly*	*all*	*Electronic (paper can be used for field record)*	*For each equipment and fuel combination involved in the project scenario.*
B.4. EFy	*CO_2 emission factor of the grid*	*Calculated from other data*	*tCO_2/MWh*	*c*	*yearly*	*100%*	*Electronic (paper can be used for field record)*	*Calculated as the average of the OM and BM emission factors.*
B.5. EFOM,y	*CO_2 Operating Margin emission factor of the grid*	*Calculated from other data*	*tCO_2/MWh*	*c*	*yearly*	*100%*	*Electronic (paper can be used for field record)*	*Calculated as indicated in the relevant OM baseline method in ACM0002.*

B.6. EFBM,y	*CO_2 Build Margin emission factor of the grid*	*Calculated from other data*	*tCO_2/MWh*	*c*	*yearly*	*100%*	*Electronic (paper can be used for field record)*	*Calculated as defined in the BM baseline method in ACM0002.*
B.7. $F_{i,y}$	*Amount of each fossil fuel consumed by each power source / plant*	*Power producers, dispatch centres or latest local statistics.*	Mass or volume	*m*	yearly	100%	*Electronic (paper can be used for field record)*	
B.8. $COEF_i$	*CO_2 emission coefficient of each fuel type i*	*Plant or country specific values to calculate COEF are preferred to IPCC default values.*	tCO_2/mass or volume unit	*m*	yearly	100%	*Electronic (paper can be used for field record)*	*When plant or country specific values to calculate COEF are not available, IPCC default values may be used.*
B.9. $GEN_{j/k/n,y}$	*Electricity generation of each power source / plant j, k or n*	*Power producers, dispatch centres or latest local statistics.*	MWh/year	*m*	yearly	100%	*Electronic (paper can be used for field record)*	
B.10.	*Identification of power source / plant for the OM*	*Power producers, dispatch centres or latest local statistics.*	Text	*e*	yearly	100% of set of plants	*Electronic (paper can be used for field record)*	

B.11.	*Identification of power source / plant for the BM*	*Power producers, dispatch centres or latest local statistics.*	Text	*e*	yearly	100% of set of plants	*Electronic (paper can be used for field record)*	
B.12 λy	*Fraction of time during which low cost/ must-run sources are on the margin*		Number	*c*	yearly	100%	*Electronic (paper can be used for field record)*	*For Simple Adjusted OM Factor accounting for number of hours per year during which lowcost/ must-run sources are on the margin.*
B.13	*The merit order in which power plants are dispatched by documented evidence*		Text	*e*	yearly	100% of set of plants	*Electronic (paper can be used for field record)*	*For Dispatch Data OM*
B.14. GENj/k/ll,y IMPORTS	*Electricity imports to the project electricity system.*		kWh	*c*	yearly	100%	*Electronic (paper can be used for field record)*	

B.2.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

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The baseline scenario for the project, which is eligible to use this methodology, is that the current fuels (coal and/or petroleum fuels; denoted by *i* in the formula below) are continued to be used in the existing facility to produce heat and any electricity without any substantial investments in equipment to increase the electric power output of the facility. As stated in the associated baseline methodology, any existing cogeneration equipment is expected to have a lifetime exceeding that of the crediting period and this needs to be demonstrated by the project proponent.

Baseline emissions *on-site* depend on the fuel consumption at the industrial plant or in the boiler room /power station within the industry, as defined by the project boundary selected. Emissions also depend on the emissions factor of each fuel used.

Electricity purchased through the interconnected power grid in the baseline scenario results in emissions at power plants elsewhere in the grid, and must be included as baseline emissions. Electricity sold through the power grid following project implementation would also increase baseline emissions, since this power would have been generated elsewhere in the grid, in the absence of the project activity. In principle, electricity could also be sold through the grid in the baseline scenario, and purchased through the grid following project implementation. Thus, the relevant variables are the *net* electricity purchases (purchase less sale) through the grid in the baseline scenario and the *net* electricity sales through the grid in the project scenario. In both cases, the resulting emissions need to be included as part of baseline emissions. Emissions in the power grid from net electricity purchases in the baseline scenario (and electricity sales in the project scenario) are related to the magnitude of electricity generation by an emissions factor for the power grid.

Baseline emissions *BE* (expressed in tonne CO_2equivalent per year, tonne CO_2e/yr) are thus given by:

$$BE = \sum_i BFC_i (EF_i + MEF_i \cdot GWP(CH_4) + NEF_i \cdot GWP(N_2O)) + (NBEP + NPES) \cdot EF_{elec\ gen} \quad \text{(Eq. 2)}$$

where:

BFC_i	consumption of fuel *i* used in the baseline scenario, measured in energy units (e.g. gigajoule, GJ)
EF_i	carbon dioxide emission factor per unit energy of fuel *i* (e.g. tCO_2/GJ) (combustion)
MEF_i	methane emission factor per unit energy of fuel *i* (e.g. tCH_4/ GJ) (combustion)
$GWP(CH_4)$	global warming potential of CH_4 set as 21 tCO_2e/tCH_4 for the 1st commitment period
NEF_i	nitrous oxide emission factor per unit of energy of fuel *i* (e.g. tN_2O/ GJ) (combustion)
$GWP(N_2O)$	global warming potential of N_2O set as 310 tCO_2e/tN_2O for the 1st commitment period
$NBEP$	net electricity purchased (electricity purchased less electricity sold) through the grid in the baseline (e.g. MWh)
$NPES$	net electricity sold (electricity sold less electricity purchased) through the grid in the project scenario (e.g. MWh)
$EF_{elec\ gen}$	baseline "combined margin" emission factor for grid electricity generation (e.g. kg CO_2e/MWh)

Note that we consider *net* electricity purchase from the grid in the baseline scenario and *net* electricity sold through the grid in the project scenario, as explained in the definitions of *NBEP* and *NPES*. This equation allows for one or other of these quantities to be negative. In the typical project covered by this methodology, both terms are expected to be positive.

The emissions associated with electric power generation depend on the sum $NBEP + NPES$ and $EF_{elec\ gen}$, the emissions factor for electricity generation in the connected power grid.

The CDM Methodology Panel and Executive Board have already proposed a consolidated methodology for determining $EF_{elec\ gen}$. We recommend the Approved consolidated monitoring methodology ACM0002 "Consolidated monitoring methodology for zero-emissions grid-connected electricity generation from renewable sources" as a component of the proposed new methodology, for the purpose of determining $EF_{elec\ gen}$. ACM0002 offers some alternative pathways for determining $EF_{elec\ gen}$, and each specific PDD should adopt a specific procedure, according to its circumstances. For projects where power exported from the industrial facility through the power grid is below 15 MW, an alternative methodology is the Small-scale methodology AMS I.D " Renewable electricity generation for a grid."

ACM0002 and AMS I.D both involve electricity generation from renewable sources. Note, however, that the emissions factor of the connected power grid does not depend on how electricity is generated in the proposed project activity. Thus 1 kWh generated and exported from an industrial cogeneration facility would reduce emissions elsewhere in the power grid by exactly the same amount as if that kWh were generated using renewable energy sources. While the kWh generated by a cogeneration plant would have emissions, these are already accounted for as emissions from all fuels burnt at the industrial facility.

Thus to estimate the emissions impact of cogenerated electricity sold through the grid, on *other* power plants on the interconnected power grid would be the same as if this electricity were generated using renewable energy sources. Thus, ACM0002 and AMS I.D. should be perfectly applicable. Indeed, another new methodology submission, "Natural gas-based package cogeneration", was accepted as AM0014 under the condition that ACM0002 or AMS I.D be used to determine the emissions factor of the power grid.

Thus, this proposed new methodology recommends the use of either ACM0002 or AMS I.D, as appropriate.

For the purpose of the PDD, baseline and project emissions are determined from thermodynamic analysis of the system configuration before and after project implementation. No monitoring is involved for estimating these *ex-ante* emissions.

Ex-post baseline emissions are determined in a dynamic manner from monitored data, using a scaling parameter that compensates for changes in demand of the cogeneration system.

As explained in the associated baseline methodology, the most appropriate scaling parameter is total enthalpy of steam demand by the industry. When the cogeneration system produces steam at different temperatures and pressures, this methodology recommends that the total heat output be determined by summing the enthalpies of all steam output streams.

Ex-post baseline emissions should be determined in a dynamic manner from project monitoring data through the following steps:

1. From historical data, determine the relationship between fuel input and total steam enthalpy output and total electric power output (if any).
2. If more than one fuel type is used prior to project implementation, determine average ratio of fuel input of different fuels, again from historical data.
3. Following project implementation, determine total enthalpy value of steam produced by the cogeneration system from monitored data.
4. Using the historic relationship (step 1 above), determine baseline fuel consumption and electric power output corresponding to the measured project data. When more than one fuel is used prior to project implementation, determine consumption of each fuel using historical ratios of the different components (step 2 above). These are the values of BFC_i.
5. From step 4 estimate of electric power output and monitored power demand of industry, determine net purchase of electricity from the grid in baseline, *NBEP*.
6. From monitored data, following project implementation, determine electricity sale through the grid, *NPES*.
7. Once the dynamic estimates of BFC_i, *NBEP*, and *NPES*, have been obtained (steps 4, 5, and 6), *ex-post*, dynamic baseline emissions should be determined using Eq. (2).

B.3. Option 2: Direct monitoring of emission reductions from the project activity:

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NOT APPLICABLE

B.3.1. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

B.3.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

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NOT APPLICABLE.

B.4. Treatment of leakage in the monitoring plan:

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Fugitive CH_4 emissions from fuel production and transport, and CO_2 emissions from fuel transportation are categorized as leakage. Emissions from fuel production/transportation is counted only if the fuel is produced/transported in a non-Annex I country.

Since emissions associated with leakage are very small compared with project and baseline emissions, they are estimated from IPCC default values, without any requirement for monitoring.

B.4.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity:								
ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

B.4.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

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The leakage LE_y is expressed as

$$LE = (FC_i - BFC_i) \bullet FE_i(CH_4) \bullet GWP(CH_4) + \sum_j TF_j \bullet EF_j - \sum_k BTF_k \bullet EF_k \qquad \text{(Eq. 3)}$$

where $FE_i(CH_4)$ is the IPCC default methane emission factor of fuel i associated with fugitive emissions. Typical fuels might be natural gas and coal, the former more likely in the project scenario and that latter more likely in the baseline. Fugitive methane emissions are associated with natural gas production and pipeline leakage. Fugitive methane emissions are also associated with coal mining. In case that the effect of these methane emissions cannot be neglected, they should be included here.

The second line in the above formula refers to emissions from fuel transportation, shown as a product of the transportation fuels used and the corresponding CO_2 emissions factor for the fuel. The first sum applies to transport fuels used in the project scenario while the second corresponds to the baseline scenario (such as marine, railroad or truck). In case those information and data are not available due to uncertainties and diversities in energy market, the IPCC default value could apply. Otherwise, it could be estimated qualitatively in view of the relatively small magnitude of CO_2 emissions from fuel transportation in typical industrial fuels.

B.5. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

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The emission reductions ER by the project activity are given by:

$ER = BE - E - LE$ expressed in tonnes of CO_2 equivalent (tCO_2e/yr). (Eq. 4)

Where
BE are baseline emissions determined in a dynamic manner as explained in section B.2.4,
E are project emissions determined as indicated in section B.2.2, and
LE are leakage emissions estimated as indicated in section B.4.2.

Note that an important component of determining emissions reductions depends on baseline emissions associated with electric power generation connected to the grid. The corresponding procedures can be found in the Approved consolidated monitoring methodology ACM0002 “Consolidated monitoring methodology for zero-emissions grid-connected electricity generation from renewable sources”.

B.6. Assumptions used in elaborating the new methodology:

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Assumptions have been expressed in sections above.

B.7. Please indicate whether quality control (QC) and quality assurance (QA) procedures are being undertaken for the items monitored:

Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
P.1.	*Low*	*These data will be directly used for calculation of emission reductions.*
B.1.	*Low*	*These data will be directly used for calculation of emission reductions.*
B.2.	*Low*	*These data will be directly used for calculation of emission reductions.*
B.3.	*Low*	*These data will be used to determine baseline emissions in a dynamic manner. When adequate QA/QC procedures are not possible, conservative default values may be used.*
B.4.to B.14	*Low*	*These data will be directly used to determine electricity baseline emission.*

B.8. Has the methodology been applied successfully elsewhere and, if so, in which circumstances?

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While this methodology incorporates approved methodologies such as ACM0002 and AMS I.D, for determining the emissions factor for electric power generation connected to the grid, the proposed new methodology has not been applied previously.

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