



## Approved baseline and monitoring methodology AM0056

### “Efficiency improvement by boiler replacement or rehabilitation and optional fuel switch in fossil fuel-fired steam boiler systems”

## I. SOURCE AND APPLICABILITY

### Source

This methodology is based on NM0211 "Boiler replacement project at the Clinical Centre in Skopje, Macedonia", whose baseline study and project design document were prepared by Perspectives Climate Change GmbH, Hamburg, Germany.

For more information regarding the proposal and its consideration by the Executive Board please refer to the case NM0211 on <http://cdm.unfccc.int/goto/MPappmeth>

This methodology also refers to the latest approved versions of the following:

- AM0029 “Methodology for Grid Connected Electricity Generation Plants using Natural Gas”;
- AM0044 “Energy efficiency improvement projects: boiler rehabilitation or replacement in industrial and district heating sectors”;
- “Combined tool to identify the baseline scenario and demonstrate additionality”; and
- “Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion”.

### Selected approach from paragraph 48 of the CDM modalities and procedures

“Existing actual or historical emissions, as applicable”

### Applicability

This methodology is applicable to project activities that in an existing facility:

- Completely replace one or more boilers with some remaining lifetime; and/or
- Implement fitting of additional new equipment to an existing steam generating system (retrofitting); and
- Implement optional switch in fossil fuel.

The methodology is applicable under the following conditions:

- Steam generation in the project activity is carried out through the use of fossil fuel fired steam boiler(s);
- National/local regulations do not require the replacement or retrofit of the existing equipment. The project participants shall demonstrate this through documented evidence (e.g. building code documents). These documents shall be submitted to a DOE at the time of validation;
- There are no enforced national/local regulations/standards on minimum efficiency ratings for the boiler(s) included in the project boundary. The project participants shall confirm this through documented evidence (e.g. building code documents, industrial regulations, etc). These documents shall be submitted to a DOE at the time of validation;



- National/local regulations/programmes do not constrain the facility from using the fossil fuel being used prior to fuel switching;
- Steam quality (i.e. pressure and temperature) is the same before and after the start of the implementation of the project activity<sup>1</sup>;
- The existing steam generating system in the facility where the project activity is implemented may consist of more than one boiler;
- Only one type of fossil fuel is used in all boilers included in the project boundary. If the fossil fuel switch is implemented, it should involve all boilers in the project boundary. Small amounts of other start-up or auxiliary fuels can be used, provided that they do not account for more than 1% of total fuel use<sup>2</sup>;
- If the fossil fuel switch is implemented, only those project activities are eligible to use this methodology where both energy efficiency measures and fuel switch are additional.

This methodology is not applicable to:

- Project activities that include energy efficiency improvement measures in a steam distribution system and steam consuming processes (i.e. demand-side);
- Project activities where before the implementation of the project activity waste heat recovery takes place outside the project boundary for processes other than the steam generating process;
- Project activities that replace or rehabilitate boiler(s) in a combined heat and power (CHP) generation system;
- Project activities that involve fossil fuel switch only.

NOTE: Emission reductions under this methodology are only claimed for the duration of the shortest of the following two time periods:

- The remaining lifetime of the existing equipment, and
- The length of the crediting period.

Please refer to the section “Procedure for estimating the remaining lifetime of the equipment included in the project boundary” for further guidance on the matter.

## II. BASELINE METHODOLOGY

### Project boundary

The project boundary encompasses all equipment that is primarily used for the steam generating process (within the steam generation system), including auxiliary systems. The most relevant components of the steam generation system include the boiler(s), fuel supply, combustion air system, feed water system, including a condensate return system, and an exhaust gases venting system. In addition, all components that are required and predominantly used for steam generation are also part of the steam generation system.

<sup>1</sup> 95 % of the measured values (measured every 15 minutes) of  $PRESS_{PJ}$  have to be in the range of  $PRESS_{BL,MIN}$  and  $PRESS_{BL,MAX}$  and 95 % of the measured values (measured every 15 minutes) of  $TEMP_{PJ}$  have to be in the range of  $TEMP_{BL,MIN}$  and  $TEMP_{BL,MAX}$ . (see section II,7 and III for further guidance).

<sup>2</sup> Besides the main fuel type used in the boiler system, other fuel types may be used only for start-ups as long as the start-up fuel is a less or equally carbon intensive fuel and the amount of start-up fuel does not exceed 1 % of the main fuel used during one year (i.e. on a NCV basis). This means that a coal-fired boiler may be started with oil or natural gas only, as long as the amount of oil or gas used does not exceed 1 % of the coal used in each year of the operation (on a NCV basis).

In order to ensure a common approach for determination of the project boundary as well as a common approach for determination of specific fuel consumption, international/national acknowledged norms and guidelines equivalent to ASME PTC 4-1998<sup>3</sup> have to be applied in conjunction with this methodology.

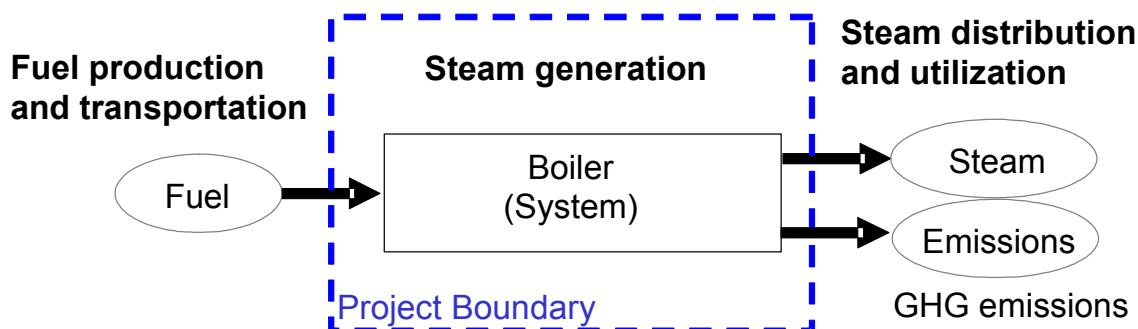


Figure 1: Illustration of the project boundary

#### Emission sources included in or excluded from the project boundary

	Source	Gas	Included?	Justification / Explanation
Baseline	Fossil fuel consumption in the boiler(s)	CO <sub>2</sub>	Yes	Main source of GHG emissions
		CH <sub>4</sub>	No	Minor source, negligible
		N <sub>2</sub> O	No	Minor source, negligible
Project Activity	Fossil fuel consumption in the boiler(s)	CO <sub>2</sub>	Yes	Main source of GHG emissions
		CH <sub>4</sub>	No	Minor source, negligible
		N <sub>2</sub> O	No	Minor source, negligible

#### Procedure for estimating the remaining lifetime of the equipment included in the project boundary

The following approaches shall be used to estimate the remaining lifetime of the boiler(s), i.e. the time when the existing boiler(s), replaced in the project activity, would have been replaced in the absence of the project activity:

- The typical average technical lifetime of the type of equipment may be determined on the basis of common practices in the sector and the country (e.g. based on industry surveys, statistics, technical literature, etc.);
- The practices of the responsible company regarding replacement schedules may be evaluated and documented (e.g. based on historical replacement records for similar equipment)

<sup>3</sup> American Society of Mechanical Engineers: Performance Test Codes for Fired Steam Generators, ASME PTC 4-1998



The time of replacement of the existing equipment in the absence of the project activity should be chosen in a conservative manner, i.e., the earliest point in time should be chosen in cases where only a time frame can be estimated. The determination of this date shall be made on a case-by-case basis, for each piece of equipment that is being replaced. If more than one boiler is replaced, then the shortest lifetime of the replaced boilers shall be considered as the lifetime of the existing steam generation system.

### **Procedure for the identification of the most plausible baseline scenario and the demonstration of additionality**

The project participants shall use the latest version of the “Combined tool to identify the baseline scenario and demonstrate additionality” approved by the Executive Board.

Alternative scenarios shall include, but are not limited to, the following:

- Continuation of the current situation, i.e. use of the existing boilers without the fossil fuel switch;
- Implementation of replacement/rehabilitation of boiler(s) without being registered as a CDM project activity;
- Implementation of fossil fuel switch in the existing boiler(s) without being registered as a CDM project activity;
- Implementation of replacement/rehabilitation of boiler(s) and fossil fuel switch without being registered as a CDM project activity.

In case the project participant is a third party, the following scenarios should be assessed as well:

- Implementation of replacement/rehabilitation of boiler(s) by the owners of the sites where the boiler(s) are operated without being registered as a CDM project activity);
- Implementation of fossil fuel switch in the existing boiler(s) by the owners of the sites where the boiler(s) are operated without being registered as a CDM project activity);
- Implementation of replacement/rehabilitation of boiler(s) and fossil fuel switch in the existing boiler(s) by the owners of the sites where the boiler(s) are operated without being registered as a CDM project activity).

In case the project participants choose to conduct a barrier analysis, the following barriers, among others, may be considered:

- Access to capital required to replace/rehabilitate boiler(s) and implement fossil fuel switch by the owners of the project facility site is constrained;
- Access to capital by the third party to implement the proposed project activity is either constrained or expected returns are considerably low;
- Lack of technical expertise among the owners of the project facility to install/operate the new boiler(s) that may result in additional costs due to the need to hire required specialists.

The methodology is only applicable if the identified baseline scenario is the continuation of the current practice of using the existing boiler(s) without fossil fuel switch.



## Baseline emissions

Baseline emissions are calculated on the basis of specific fuel consumption (SFC)<sup>4</sup> for steam generation under the best possible operating conditions of the baseline steam generation system, the amount of steam generated by the project activity ( $P_{PJ,y}$ ), and the baseline fuel emission factor (EF).

The project activity may involve the two following situations:

- Case A: Single-boiler installation and
- Case B: Multi-boiler installation.

Steps 1, 2 and 3 outlined below should be undertaken prior to the start of the implementation of the project activity and reported in the CDM-PDD submitted for validation. Steps 1 and 2 apply to both cases A and B.

### Step 1: Determination of the capacity of the baseline equipment

The rated steam generation capacity (CAP) of the baseline steam generation equipment is the maximum possible long-term load of the single-boiler/multi-boiler system expressed in tonnes of steam per hour (t/h). To determine CAP, project participants shall choose the lowest among the following values:

- Actual measurements of the maximum long-term steam generation capacity of the single-boiler/multi-boiler system in accordance with well-recognized norms and guidelines (ASME PTC 4-1998 or equivalent national or international standard);
- Technical analysis of the steam generation capacity of the single-boiler/multi-boiler system taking into account various components of the equipment such as fuel system, feeding water system, steam distribution system, etc.; and
- The upper range of the final load class of the boiler in the case of a single-boiler installation or the sum of upper ranges of the final load class of each boiler in the case of a multi-boiler installation.

### Step 2: Determination of the load classes of the baseline boiler(s)

The baseline specific fuel consumption (SFC) for steam generation is function of the load of the boiler assuming constant steam quality (i.e. pressure and temperature). Therefore, the specific fuel consumption shall be estimated for load classes, where a load class is defined as a range of boiler load (i.e. tonnes of steam per hour).

- Project participants shall establish the load classes depending on the characteristics of the equipment, which shall reflect the boiler operating modes (On-Off-Operation, High-Low-Off-Operation or Modulating);
- The final load class for each single boiler cannot exceed the CAP of the boiler;
- In the case of a multi-boiler installation, each individual boiler load class does not exceed the capacity of each baseline boiler (baseline equipment).
- Load classes cannot be changed during the crediting period.

Note: Refer to Annex I for additional illustration on the determination of the load classes of the baseline boiler(s)

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<sup>4</sup> Expressed as fuel consumed per tonne of steam produced (TJ/tSteam).

Step 3: Determination of the specific fuel (energy) consumption**Case A: Single-boiler installation***Step 3 a.1: Determination of the specific fuel consumption of the boiler in the baseline*

Specific fuel consumption of the boiler shall be determined through measurements based on performance tests as prescribed by international standards, norms and guidelines (ASME PTC 4-1998 or an equivalent national and international standard). The performance tests shall be conducted for a range of loads within a load class. Performance test for each load shall be repeated as per the standard used. The average value of these observations shall be considered as SFC for that load. The minimum value of SFC observed in the performance test for a load class shall be taken as representative SFC<sub>i</sub> for the load class 'i'.

$$SFC_i = \text{minimum} \left( \frac{FC_{BL,i,x}}{P_{BL,i,x}} \right) \quad (1)$$

Where:

$SFC_i$	Specific Fuel Consumption for load class 'i' (t or m <sup>3</sup> /tSteam)
$FC_{BL,i,x}$	Average observed fuel consumption for load x, using repeated performance test for that load, for load class 'i' (t or m <sup>3</sup> )
$P_{BL,i,x}$	Average observed amount of produced steam (tonnes of generated steam) for load x, using repeated performance test for that load, for load class 'i' (t)

*Step 3 a.2: Determination of the specific energy consumption of a load class 'i'*

$$SEC_i = SFC_i \cdot NCV_{BL,FF} \quad (2)$$

Where:

$SEC_i$	Specific Energy Consumption for the generation of 1 tonne of steam within the load class 'i' (GJ/t)
$SFC_i$	Specific fuel consumption within load class 'i' (t or m <sup>3</sup> /t), as determined using equation (1)
$NCV_{BL,FF}$	Net caloric value of fossil fuel used in the baseline (GJ/t or m <sup>3</sup> )

**Case B: Multi-boiler installation***Step 3 b.1: Determination of the specific fuel consumption for each boiler 'j' per load class 'i' within the steam generation system:*

Within each load class the lowest possible specific fuel consumption of the boiler will be determined by conducting measurements strictly following recognized international norms and guidelines (ASME PTC 4-1998 or equivalent national or international standard). These parameters shall correspond to the point of load where lowest specific fuel consumption occurs:



$$SFC_{i,j} = \text{minimum} \left( \frac{FC_{BL,i,j,x}}{P_{BL,i,j,x}} \right) \quad (3)$$

Where:

$SFC_{i,j}$	Minimum specific fuel consumption within load class 'i' for each boiler 'j' as observed from performance tests (t or m <sup>3</sup> /tSteam)
$FC_{BL,i,j,x}$	Average observed fuel consumption for load x, using repeated performance test for that load, within load class 'i' for each boiler 'j' (t) or (m <sup>3</sup> )
$P_{BL,i,j,x}$	Average observed amount of produced steam for load x, using repeated performance test for that load, within load class 'i' for each boiler 'j' (t)

*Step 3 b.2: Determination of the specific energy consumption within the capacity of the boiler system for each boiler 'j' per load class 'i'*

$$SEC_{i,j} = SFC_{i,j} \cdot NCV_{BL,FF} \quad (4)$$

Where:

$SEC_{i,j}$	Lowest specific energy consumption within load class 'i' for each boiler 'j' (GJ/t)
$SFC_{i,j}$	Lowest possible specific fuel consumption within load class 'i' for each boiler 'j' (t/t or m <sup>3</sup> /t)
$NCV_{BL,FF}$	Net caloric value of fossil fuel used in the baseline boiler (GJ/t) or (GJ/m <sup>3</sup> )

*Step 3 b.3: Determination of the specific energy consumption of the steam generation system (per load class)*

Specific energy consumption ( $SEC_{SYS,k}$ ) of each steam generation system's load class 'k' shall be estimated as weighted average of  $SEC_{i,j}$ , estimated in Step 3.b.2 above.  $SEC_{SYS,k}$  is minimum of weighted average  $SEC_{i,j}$  for each combination of individual boiler operation possible for that system load class 'k'.

$$SEC_{SYS,k} = \text{minimum} \left( \text{set of } \sum_{j=1}^J SEC_{ij,j} \cdot S_j \right) \quad (5)$$

Where:

$SEC_{SYS,k}$	Lowest of all calculated values of the specific energy consumption within each steam generation system's load class 'k' (GJ/t).
$SEC_{ij,j}$	Lowest specific energy consumption within load class 'ij' of boiler 'j' (GJ/t) as defined by equation (4) where 'i' corresponds to load class 'ij'
$S_j$	Percentage share of load of each boiler 'j' to achieve a steam output of the related steam generation system's load class 'k'
$J$	Number of boilers in the steam generation system
$ij$	Load class of boiler 'j' that is possible to operate in the steam generation system class 'k'. 0 ≤ ij ≤ k, where ij=0 corresponds to the situation when boiler 'j' is not in operation and ij=k when only boiler 'j' is in operation and other boilers do not operate.



(*i1 ... iJ*) Represents all possible combinations of the operation of the boilers in the steam generation system to achieve a steam output for the steam generation system's load class 'k', i.e.

$$\sum_{j=1}^J ij = k$$

$$S_j = \frac{ij}{k} \quad (6)$$

NOTE: Please refer to Annex II for additional illustration on using the described approach to estimate specific energy consumption of the boiler system.

#### Step 4: Calculation of baseline emissions

Baseline emissions  $BE_y$  (in  $tCO_2/y$ ) are estimated as follows (refer to Annex III for additional illustration):

$$BE_y = 44/12 \cdot EF_{C,FF,BL} \cdot OXID_{FF,BL} \cdot \sum_t \min^m (P_{PJ,i/k,t,y}, CAP \cdot t) \cdot SEC_{i/k} \quad (7)$$

Where:

$BE_y$	Baseline emissions resulting from steam generation within the capacity of the baseline equipment in the year 'y' ( $tCO_2/yr$ )
$P_{PJ,i/k,t,y}$	Amount of steam generated during the time period 't' in the year 'y' (tonne)
$SEC_{i/k}$	Specific energy consumption (GJ/t) where 'i' is used as a load class in case of a single boiler installation; and 'k' is used as a load class of a steam generation system in case of a multi-boiler installation. This shall be for the load class in which $P_{PJ,i/k,t,y}$ falls.
$EF_{C,FF,BL}$	Carbon emission factor of baseline fossil fuel (tC/GJ)
$OXID_{FF,BL}$	Oxidation factor of baseline fossil fuel
$44/12$	Ratio of the molecular weight of $CO_2$ to the molecular weight of carbon

While the implementation of the project activity may result in the increase in the capacity of the steam generation system, the baseline emissions are capped by the maximum capacity of the baseline steam generation system (CAP).

#### **Project emissions**

The  $CO_2$  emissions from fossil fuel consumption in the project activity ( $PE_y$ ) should be calculated using the latest approved version of the "*Tool to calculate project or leakage  $CO_2$  emissions from fossil fuel combustion*", where the process *j* in the tool corresponds to the combustion of fossil fuels in the project activity for steam generation in the boilers.



**Leakage<sup>5</sup>**

Leakage may result from fuel extraction, processing, liquefaction, transportation, re-gasification and distribution of fossil fuels outside of the project boundary. This includes mainly fugitive CH<sub>4</sub> emissions and CO<sub>2</sub> emissions from associated fuel combustion and flaring. In this methodology, the following leakage emission sources shall be considered:

- Fugitive CH<sub>4</sub> emissions associated with fuel extraction, processing, liquefaction, transportation, re-gasification and distribution of natural gas used in the project activity and fossil fuels used in the absence of the project activity.
- In the case LNG is used in the plant: CO<sub>2</sub> emissions from fuel combustion / electricity consumption associated with the liquefaction, transportation, re-gasification and compression into a natural gas transmission or distribution system.

Leakage emissions are calculated as follows:

$$LE_y = LE_{CH_4,y} + LE_{LNG,CO_2,y} \quad (8)$$

Where:

$LE_y$	Leakage emissions in the year 'y' in tCO <sub>2</sub> e
$LE_{CH_4,y}$	Leakage emissions due to fugitive upstream CH <sub>4</sub> emissions in the year y in tCO <sub>2</sub> e
$LE_{LNG,CO_2,y}$	Leakage emissions due to fossil fuel combustion / electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system during the year y in t CO <sub>2</sub> e

***Fugitive methane emissions***

For the purpose of estimating fugitive CH<sub>4</sub> emissions, project participants should multiply the quantity of fossil fuel consumed by the project activity in year 'y' with an emission factor for fugitive CH<sub>4</sub> emissions ( $EF_{PJ,upstream,CH_4}$ ) from fossil fuel consumption and subtract the emissions occurring from fossil fuels used in the absence of the project activity, as follows:

$$LE_{CH_4,y} = (FC_{PJ,y} \cdot NCV_{PJ,y} \cdot EF_{PJ,upstream,CH_4} - FC_{BL,y} \cdot EF_{BL,upstream,CH_4}) \cdot GWP_{CH_4} \quad (9)$$

Where:

$LE_{CH_4,y}$	Leakage emissions due to fugitive upstream CH <sub>4</sub> emissions in the year 'y' (tCO <sub>2</sub> e)
$FC_{PJ,y}$	Quantity of fossil fuel combusted in the project plant during the year 'y' (t or m <sup>3</sup> ), monitored as described in the "Tool to calculate project or leakage CO <sub>2</sub> emissions from fossil fuel combustion"
$NCV_{PJ,y}$	Average net calorific value of the fossil fuel combusted during the year 'y' (GJ/t or GJ/m <sup>3</sup> ) monitored as described in the "Tool to calculate project or leakage CO <sub>2</sub> emissions from fossil fuel combustion"
$EF_{PJ,upstream,CH_4}$	Emission factor for upstream fugitive methane emissions of fossil fuel used in the project activity from production, transportation, distribution, and, in the case of LNG, liquefaction, transportation, re-gasification and compression into a transmission or

<sup>5</sup> Leakage shall be calculated as per the procedure described in the latest version of the approved baseline and monitoring methodology AM0029



	distribution system, (t CH <sub>4</sub> per GJ fuel supplied to final consumers)
$FC_{BL,y}$	Fossil fuel that would have been combusted in the absence of the project activity during the year 'y' (GJ)
$EF_{BL,upstream,CH_4}$	Emission factor for upstream fugitive methane emissions of baseline fossil fuel from production, transportation, distribution, and, in the case of LNG, liquefaction, transportation, re-gasification and compression into a transmission or distribution system, (tCH <sub>4</sub> per GJ fuel supplied to final consumers)
$GWP_{CH_4}$	Global warming potential of methane valid for the relevant commitment period. Use value of 21 for the first commitment period.

$$FC_{BL,y} = \sum_t \min^m(P_{PJ,i/k,t,y}, CAP \cdot t) \cdot SEC_{i/k} \quad (10)$$

Where reliable and accurate national data on fugitive CH<sub>4</sub> emissions associated with the production, and in case of natural gas, the transportation and distribution of the fuels is available, project participants should use these data to determine average emission factors by dividing the total quantity of CH<sub>4</sub> emissions by the quantity of fuel produced or supplied respectively. Where such data is not available, project participants should use the values provided in Table 2: "Default emission factors for fugitive CH<sub>4</sub> upstream emissions" of the latest version of AM0029.

**Table 2. Default emission factors for fugitive CH<sub>4</sub> upstream emissions**

Activity	Unit	Default emission factor	Reference for the underlying emission factor range in Volume 3 of the 1996 Revised IPCC Guidelines
<b>Coal</b>			
Underground mining	t CH <sub>4</sub> / kt coal	13.4	Equations 1 and 4, p. 1.105 and 1.110
Surface mining	t CH <sub>4</sub> / kt coal	0.8	Equations 2 and 4, p. 1.108 and 1.110
<b>Oil</b>			
Production	t CH <sub>4</sub> / PJ	2.5	Tables 1-60 to 1-64, p. 1.129 - 1.131
Transport, refining and storage	t CH <sub>4</sub> / PJ	1.6	Tables 1-60 to 1-64, p. 1.129 - 1.131
Total	t CH <sub>4</sub> / PJ	4.1	
<b>Natural gas</b>			
<b>USA and Canada</b>			
Production	t CH <sub>4</sub> / PJ	72	Table 1-60, p. 1.129
Processing, transport and distribution	t CH <sub>4</sub> / PJ	88	Table 1-60, p. 1.129
Total	t CH <sub>4</sub> / PJ	160	
<b>Eastern Europe and former USSR</b>			
Production	t CH <sub>4</sub> / PJ	393	Table 1-61, p. 1.129
Processing, transport and distribution	t CH <sub>4</sub> / PJ	528	Table 1-61, p. 1.129
Total	t CH <sub>4</sub> / PJ	921	
<b>Western Europe</b>			
Production	t CH <sub>4</sub> / PJ	21	Table 1-62, p. 1.130
Processing, transport and distribution	t CH <sub>4</sub> / PJ	85	Table 1-62, p. 1.130
Total	t CH <sub>4</sub> / PJ	105	
<b>Other oil exporting countries / Rest of world</b>			
Production	t CH <sub>4</sub> / PJ	68	Table 1-63 and 1-64, p. 1.130 and 1.131
Processing, transport and distribution	t CH <sub>4</sub> / PJ	228	Table 1-63 and 1-64, p. 1.130 and 1.131
Total	t CH <sub>4</sub> / PJ	296	

Note: The emission factors in this table have been derived from IPCC default Tier 1 emission factors provided in Volume 3 of the 1996 Revised IPCC Guidelines, by calculating the average of the provided default emission factor range.

Where default values from this table are used, the natural gas emission factors for the location of the project activity should be used. The US/Canada values may be used in cases where it can be shown that the relevant system element (gas production and/or processing/ transmission/distribution) is predominantly of recent vintage and built and operated to international standards.

Since the fugitive upstream emissions for coal depends on the source (underground or surface mines), project participants should use the emission factor that corresponds to the predominant source (underground or surface) currently used by coal-based power plants in the region.

Note further that in case of coal the emission factor is provided based on a mass unit and needs to be converted in an energy unit, taking into account the net calorific value of the coal.

Note that to the extent that upstream emissions occur in Annex I countries that have ratified the Kyoto Protocol, from 1 January 2008 onwards, these emissions should be excluded, if technically possible, in the leakage calculations.

Where net leakage effects are negative ( $LE_{CH_4,y} < 0$ ), project participants should assume  $LE_{CH_4,y} = 0$ .

CO<sub>2</sub> emissions from LNG

Where applicable, CO<sub>2</sub> emissions from fuel combustion / electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system ( $LE_{LNG,CO_2,y}$ ) should be estimated by multiplying the quantity of natural gas combusted in the project with an appropriate emission factor, as follows:

$$LE_{LNG,CO_2,y} = FC_{PJ,y} \cdot NCV_y \cdot EF_{CO_2,upstream,LNG} \quad (11)$$

Where:

$LE_{LNG,CO_2,y}$	Leakage emissions due to fossil fuel combustion / electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system during the year 'y' (t CO <sub>2</sub> e)
$FC_{PJ,y}$	Quantity of natural gas combusted in the project plant during the year y ( m <sup>3</sup> ) monitored as described in the "Tool to calculate project or leakage CO <sub>2</sub> emissions from fossil fuel combustion"
$NCV_y$	Average net calorific value of natural gas combusted during the year y in GJ/m <sup>3</sup> monitored as described in the "Tool to calculate project or leakage CO <sub>2</sub> emissions from fossil fuel combustion"
$EF_{CO_2,upstream,LNG}$	Emission factor for upstream CO <sub>2</sub> emissions due to fossil fuel combustion / electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system (t CO <sub>2</sub> /GJ Fuel)

Where reliable and accurate data on upstream CO<sub>2</sub> emissions due to fossil fuel combustion / electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system are available, project participants should use these data to determine an average emission factor. Where such data are not available, project participants may assume a default value of 6 t CO<sub>2</sub>/TJ as a rough approximation.

**Emission Reductions**

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad (12)$$

Where:

$ER_y$	Emissions reductions of the project activity during the year 'y' in tCO <sub>2</sub> e
$BE_y$	Baseline emissions during the year 'y' in tCO <sub>2</sub> e
$PE_y$	Project emissions during the year 'y' in tCO <sub>2</sub> e
$LE_y$	Leakage emissions in the year 'y' in tCO <sub>2</sub> e

As stated in the applicability conditions section, emission reductions are only claimed for the period of time not exceeding the remaining lifetime of the existing equipment. Further, emission reductions are only claimed for each year of the crediting period (monitoring intervals) where the steam quality remains the same and start-up fuel consumption is within the conceded limit



### Changes required for methodology implementation in 2<sup>nd</sup> and 3<sup>rd</sup> crediting periods

At validation stage, the remaining lifetime of the existing boilers is determined as outlined in the section “Procedure for estimating the remaining lifetime of the equipment included in the project boundary”. If the remaining lifetime of the existing boilers has been determined to be above 20 years, the project participants may choose to use a renewable crediting period. To apply for the renewal of a crediting period and in order to comply with the applicability conditions, project participants should carry out an assessment of national/local regulations and their enforcement as relates to replacement, retrofit or efficiency requirements for relevant equipment.

### Data and parameters not monitored

The following data and parameters are included in this methodology but do not need to be monitored during the crediting period. These data and parameters mainly describe the baseline equipment. As the calculation of baseline emissions is on the basis of different load classes, the introduction of load classes shall be conducted carefully taking into account project specific conditions such as expected fluctuations in steam production.

Based on the well-recognized norms (ASME PTC 4-1998, or equivalent national and international standards), uncertainty of each parameter has to be calculated resulting into the following 3 values:

- Test result plus uncertainty
- Test result
- Test result minus uncertainty

For each parameter the tables presented below specify which of the three values (the test result plus uncertainty, the test result or the test result minus uncertainty) has to be used for further calculations.

The determination of all parameters shall be conducted in a three-month period preceding the submission of the CDM-PDD to the DOE.

ID Number:	-
Parameter:	CAP
Data unit:	t/h
Description:	Maximum long term load (capacity) of the boiler or steam generation system (tonnes of steam output per hour at full load).
Source of data:	Actual measurement or technical analyses of the system, whichever is lower. Use test result minus uncertainty for calculations
Measurement procedures (if any):	Measurement strictly following international acknowledged norms and guidelines such as ASME PTC 4-1998
Any comment:	Required to cap the baseline emissions.



ID Number:	-
Parameter:	Boiler load class ‘i’
Data unit:	Range, t/h
Description:	Boiler load class
Source of data:	Determination by project participants: The boiler load bandwidth from no operation to full load is subdivided into smaller intervals, each described by an upper and a lower range.
Measurement procedures (if any):	-
Any comment:	The project participants are free to introduce any number of load classes (also just one load class). Note: The more load classes are introduced, the more precise emission reduction calculations are. At the same time calculation of emissions becomes more laborious.

ID Number:	-
Parameter:	Boiler load class ‘i’, ‘j’
Data unit:	Range, t/h
Description:	Boiler load classes in the case of multi-boiler installations. For each boiler ‘j’ load classes ‘i’ are introduced.
Source of data:	Determination by project participants: The boiler load band width from no operation to full load is subdivided into smaller intervals, each described by an upper and a lower range.
Measurement procedures (if any):	-
Any comment:	The project participants are free to introduce any number of load classes (also just one load class). Note: The more load classes are introduced, the more precise emission reduction calculations are. At the same time calculation of emissions becomes more laborious.

ID Number:	-
Parameter:	Steam system load class ‘k’
Data unit:	Range, t/h
Description:	Steam system load class
Source of data:	Determination by project participants: By the combination of the boiler load classes ‘i’ of each boiler ‘j’, the steam system load classes are founded, each described by an upper and a lower range.
Measurement procedures (if any):	-
Any comment:	Steam system load classes automatically result from any possible combination of boiler load classes boiler load classes ‘i’ of each boiler ‘j’



ID Number:	-
Parameter:	$FC_{BL,i,x}$
Data unit:	t or $m^3$
Description:	Average observed fuel consumption for load x, using repeated performance test for that load, for load class 'i'
Source of data:	Actual measurement. Use test result minus uncertainty for calculations
Measurement procedures (if any):	<p>Measurement following strictly international or national acknowledged norms and guidelines such as ASME PTC 4-1998</p> <p>The measurement has to be conducted together with the measurement of <math>P_{BL,i,x}</math>. Measurement time and conditions shall be chosen in a way to achieve repeatable results at conditions of highest possible stability within the boiler operation. The measurement shall be executed for each load class at the point of load, where lowest specific fuel consumption is expected. The choice of the point of load to measure <math>FC_{BL,i,x}</math> and <math>P_{BL,i,x}</math> has to be justified by either a series of measurements, verifiable manufacturers information or construction-conditioned circumstances. The measurement itself shall be repeated 2 times. The result of the measurement is valid, if repeatability is achieved within the 3 measurements. Repeatability is given, if the 2<sup>nd</sup> and 3<sup>rd</sup> test results are within the uncertainty range of the first measurement. Uncertainty has to be determined according to the consulted norm. In this case the average value of the 3 measurements minus the underlying uncertainty is taken for further calculation.</p>
Any comment:	

ID Number:	-
Parameter:	$FC_{BL,i,j,x}$ (multi-boiler installations)
Data unit:	t or $m^3$
Description:	Average observed fuel consumption for load x, using repeated performance test for that load, within load class 'i' for each boiler 'j'
Source of data:	Actual measurement. Use test result minus uncertainty for calculations
Measurement procedures (if any):	<p>Measurement strictly following international acknowledged norms and guidelines such as ASME PTC 4-1998</p> <p>The measurement has to be conducted together with the measurement of <math>P_{BL,i,x}</math>. Measurement time and conditions shall be chosen in a way to achieve repeatable results at conditions of highest possible stability within the boiler operation. The measurement shall be executed for each load class at the point of load, where lowest specific fuel consumption is expected. The choice of the point of load to measure <math>FC_{BL,i,j,x}</math> and <math>P_{BL,i,j,x}</math> has to be justified by either a series of measurements, verifiable manufacturers information or construction-conditioned circumstances. The measurement itself shall be repeated 2 times. The result of the measurement is valid, if repeatability is achieved within the 3 measurements. Repeatability is given, if the 2<sup>nd</sup> and 3<sup>rd</sup> test results are within the uncertainty range of the first measurement. Uncertainty has to be determined according to the consulted norm. In this case the average value of the 3 measurements minus the underlying uncertainty is taken for further calculation.</p>
Any comment:	



ID Number:	-
Parameter:	$P_{BL,i,x}$
Data unit:	t
Description:	Average observed amount of produced steam (tonnes of generated steam) for load x, using repeated performance test for that load, for load class 'i'.
Source of data:	Actual measurement. Use test result plus uncertainty for calculations
Measurement procedures (if any):	<p>Measurement following strictly international or national acknowledged norms and guidelines such as ASME PTC 4-1998</p> <p>The measurement has to be conducted together with the measurement of <math>FC_{BL,i,x}</math>. Measurement time and conditions shall be chosen in a way to achieve repeatable results at conditions of highest possible stability within the boiler operation.</p> <p>The measurement shall be executed for each load class at the point of load, where lowest specific fuel consumption is expected. The choice of the point of load to measure <math>FC_{BL,i,x}</math> and <math>P_{BL,i,x}</math> has to be justified by either a series of measurements, verifiable manufacturers information or construction-conditioned circumstances. The measurement itself shall be repeated 2 times. The result of the measurement is valid, if repeatability is achieved within the 3 measurements. Repeatability is given, if the 2<sup>nd</sup> and 3<sup>rd</sup> test results are within the uncertainty range of the first measurement. Uncertainty has to be determined according to the consulted norm. In this case the average value of the 3 measurements minus the underlying uncertainty is taken for further calculation.</p>
Any comment:	

ID Number:	-
Parameter:	$P_{BL,i,j,x}$ (multi-boiler installations)
Data unit:	t
Description:	Average observed amount of produced steam for load x, using repeated performance test for that load, within load class 'i' for each boiler 'j'
Source of data:	Actual measurement. Use test result plus uncertainty for calculations
Measurement procedures (if any):	<p>Measurement strictly following international acknowledged norms and guidelines such as ASME PTC 4-1998</p> <p>The measurement has to be conducted together with the measurement of <math>FC_{BL,i,j,x}</math>. Measurement time and conditions shall be chosen in a way to achieve repeatable results at conditions of highest possible stability within the boiler operation.</p> <p>The measurement shall be executed for each load class at the point of load, where lowest specific fuel consumption is expected. The choice of the point of load to measure <math>FC_{BL,i,j,x}</math> and <math>P_{BL,i,j,x}</math> has to be justified by either a series of measurements, verifiable manufacturers information or construction-conditioned circumstances. The measurement itself shall be repeated 2 times. The result of the measurement is valid, if repeatability is achieved within the 3 measurements. Repeatability is given, if the 2<sup>nd</sup> and 3<sup>rd</sup> test results are within the uncertainty range of the first measurement. Uncertainty has to be determined according to the consulted norm. In this case the average value of the 3 measurements minus the underlying uncertainty is taken for further calculation.</p>
Any comment:	





ID Number:	-
Parameter:	$NCV_{FF,BL}$
Data unit:	GJ/t or GJ/m <sup>3</sup>
Description:	Net caloric value of fossil fuel used in the baseline boiler
Source of data:	Actual measured or local data is to be used. If not available, regional data should be used and, in its absence, IPCC defaults can be used from the most recent version of IPCC Guidelines for National Greenhouse Gas Inventories.
Measurement procedures (if any):	Measurements according to best international practices.
Any comment:	

ID Number:	-
Parameter:	$EF_{C,FF,BL}$
Data unit:	tC/GJ
Description:	Carbon emission factor for the fossil fuel used in the baseline boiler
Source of data:	Actual measured or local data is to be used. If not available, regional data should be used and, in its absence, IPCC defaults can be used from the most recent version of IPCC Guidelines for National Greenhouse Gas Inventories.
Measurement procedures (if any):	Measurements according to best international practices.
Any comment:	

ID Number:	-
Parameter:	$OXID_{FF,BL}$
Data unit:	Fraction
Description:	Oxidation factor for the fossil fuel used in the baseline boiler.
Source of data:	Actual measured or local data is to be used. If not available, regional data should be used and, in its absence, IPCC defaults can be used from the most recent version of IPCC Guidelines for National Greenhouse Gas Inventories.
Measurement procedures (if any):	Measurements according to best international practices.
Any comment:	

Parameter:	$PRESS_{BL,MIN}$
Data unit:	bar
Description:	Lowest measured pressure of the generated steam during determination of the specific energy consumption.
Source of data:	Measurement. Use test result for calculations.
Measurement procedures (if any):	Measurement strictly following international acknowledged norms and guidelines such as ASME PTC 4-1998 .
Any comment:	



<b>Parameter:</b>	PRESS <sub>BL,MAX</sub>
Data unit:	bar
Description:	Highest measured pressure of the generated steam during determination of the specific energy consumption.
Source of data:	Measurement. Use test result for calculations.
Measurement procedures (if any):	Measurement strictly following international acknowledged norms and guidelines such as ASME PTC 4-1998 .
Any comment:	

<b>Parameter:</b>	TEMP <sub>BL,MIN</sub>
Data unit:	K
Description:	Lowest measured temperature of the generated steam during determination of the specific energy consumption.
Source of data:	Measurement. Use test result for calculations.
Measurement procedures (if any):	Measurement strictly following international acknowledged norms and guidelines such as ASME PTC 4-1998 .
Any comment:	Only required in the case of superheated steam

<b>Parameter:</b>	TEMP <sub>BL,MAX</sub>
Data unit:	K
Description:	Highest measured temperature of the generated steam during determination of the specific energy consumption.
Source of data:	Measurement. Use test result for calculations.
Measurement procedures (if any):	Measurement strictly following international acknowledged norms and guidelines such as ASME PTC 4-1998 .
Any comment:	Only required in the case of superheated steam



### III. MONITORING METHODOLOGY

#### Monitoring procedures

The following data are required to be monitored throughout the crediting period.

For monitoring project emissions from combustion of fossil fuels in the project activity the guidance in the latest approved version of the “*Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion*” should be applied.

Baseline emissions are calculated using the following data:

- Steam generation

Based on well-recognized norms (e.g. ASME PTC 4-1998) uncertainty of each parameter has to be calculated resulting into the following 3 values:

- Test result plus uncertainty
- Test result
- Test result minus uncertainty

For each parameter the tables presented below specify which of the three values (the test result plus uncertainty, the test result or the test result minus uncertainty) has to be used for further calculations.

#### Data and parameters monitored

<b>Data / Parameter:</b>	P <sub>PJ,i,y</sub>
<b>Data unit:</b>	t/yr
<b>Description:</b>	Generated steam in the year ‘y’ subdivided into load classes in the case of single boiler installations
<b>Source of data:</b>	Measurement, calculation. Use test result minus uncertainty for calculations.
<b>Measurement procedures (if any):</b>	Measurement (every 15 minutes) of the mass flow rate of generated steam (t/h) following international acknowledged norms and guidelines such as ASME PTC 4-1998. Steam generation is allocated to the associated load class by comparison of measured steam mass flow and the range of the load classes. By multiplication of every 15-minutes-value with 0.25 hours the amount of generated steam is determined. At the end of each year the steam generation within each load class is aggregated.
<b>Monitoring frequency:</b>	Every 15 minutes, allocated and aggregated into load classes
<b>QA/QC procedures:</b>	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards.
<b>Any comment:</b>	



<b>Data / Parameter:</b>	P <sub>PJ,k,y</sub>
Data unit:	t/yr
Description:	Generated steam in the year ‘y’ subdivided into load classes in the case of multi boiler installations
Source of data:	Measurement, calculation. Use test result minus uncertainty for calculations.
Measurement procedures (if any):	Measurement (every 15 minutes) of the mass flow rate of generated steam (t/h) following international or national acknowledged norms and guidelines such as ASME PTC 4-1998. Steam generation is allocated to the associated load class by comparison of measured steam mass flow and the range of the load classes. By multiplication of every 15-minutes-value with 0.25 hours the amount of generated steam is determined. At the end of each year the steam generation within each load class is aggregated.
Monitoring frequency:	Every 15 minutes, allocated and aggregated into load classes
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards.
Any comment:	

<b>Data / Parameter:</b>	EF <sub>PJ,upstream,CH4</sub>
Data unit:	t CH <sub>4</sub> /GJ Fuel
Description:	Emission factor for upstream fugitive methane emissions of fossil fuel used in the project activity from production, transportation, distribution, and, in the case of LNG, liquefaction, transportation, re-gasification and compression into a transmission or distribution system, in t CH <sub>4</sub> per GJ fuel supplied to final consumers
Source of data:	Local data is to be used. If not available, regional data should be used and, in its absence, IPCC defaults can be used from the most recent version of IPCC Guidelines for National Greenhouse Gas Inventories.
Measurement procedures (if any):	
Monitoring frequency:	Yearly
QA/QC procedures:	
Any comment:	Refer to most recent version of AM0029 for further guidance

<b>Data / Parameter:</b>	EF <sub>BL,upstream,CH4</sub>
Data unit:	t CH <sub>4</sub> /GJ Fuel
Description:	Emission factor for upstream fugitive methane emissions of fossil fuel used in the baseline equipment from production, transportation, distribution, and, in the case of LNG, liquefaction, transportation, re-gasification and compression into a transmission or distribution system, in t CH <sub>4</sub> per GJ fuel supplied to final consumers
Source of data:	Local data is to be used. If not available, regional data should be used and, in its absence, IPCC defaults can be used from the most recent version of IPCC Guidelines for National Greenhouse Gas Inventories.
Measurement procedures (if any):	
Monitoring frequency:	Yearly
QA/QC procedures:	



Any comment:	Refer to most recent version of AM0029 for further guidance
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<b>Data / Parameter:</b>	EF <sub>CO<sub>2</sub>,upstream,LNG</sub>
Data unit:	t CO <sub>2</sub> /GJ Fuel
Description:	Emission factor for upstream CO <sub>2</sub> emissions due to fossil fuel combustion / electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system
Source of data:	Local data is to be used. If not available, regional data should be used and, in its absence, IPCC defaults can be used from the most recent version of IPCC Guidelines for National Greenhouse Gas Inventories.
Measurement procedures (if any):	
Monitoring frequency:	Yearly
QA/QC procedures:	
Any comment:	Refer to most recent version of AM0029 for further guidance

<b>Data / Parameter:</b>	PRESS <sub>pj</sub>
Data unit:	bar
Description:	Pressure of the generated steam.
Source of data:	Measurement. Use test result for calculations.
Measurement procedures (if any):	Measurement (every 15 minutes) following international acknowledged norms and guidelines such as ASME PTC 4-1998 .
Monitoring frequency:	Every 15 minutes
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards.
Any comment:	

<b>Data / Parameter:</b>	TEMP <sub>pj</sub>
Data unit:	K
Description:	Temperature of the generated steam
Source of data:	Measurement. Use test result for calculations.
Measurement procedures (if any):	Measurement (every 15 minutes) following international acknowledged norms and guidelines such as ASME PTC 4-1998 .
Monitoring frequency:	Every 15 minutes
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards.
Any comment:	Only required in the case of superheated steam

For parameters to be monitored for the calculation of project emissions please refer to the latest approved version of the “*Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion*”.

**ANNEX I**

## Step 2: Determination of the load classes of the baseline boiler(s)

**Case A: Single-boiler installation**

For a boiler capable of a maximum long term load (rated steam generation capacity) of 500 tonnes of steam per hour the following load classes could be presented:

Table 1: Exemplified load classes for a single boiler

Load class 'i'	Lower range	Upper range
1	0 t/h	100 t/h
2	101 t/h	200 t/h
3	201 t/h	300 t/h
4	301 t/h	400 t/h
5 <sup>6</sup>	401 t/h	500 t/h

**Case B: Multi-boiler installation**

Table 2: Illustration of selection of load classes for a multi-boiler steam generation system

Steam system:		Upper range of load class, where each load class has a range of 3 t/h		Upper range of load class, where each load has a range of 5 t/h	
Boilers:	CAP:	Valid:	Ineligible load class:	Valid:	Ineligible load class:
Boiler No. 1	20 t/h	0-3; 3-6; 6-9; 9-12; 12-15; 15-18	18-21	0-5; 5-10; 10-15; 15-20	20-25
Boiler No. 2	24 t/h	0-3; 3-6; 6-9; 9-12; 12-15; 15-18; 18-21; 21-24	24-27	0-5; 5-10; 10-15; 15-20	20-25
Boiler No. 3	26 t/h	0-3 ;3-6; 6-9; 9-12; 12-15; 15-18; 18-21; 21-24	24-27	0-5; 5-10; 10-15; 15-20; 20-25	25-30

For the purpose of additional illustration, we assume that for a steam generation system including 2 boilers (each capable of delivering a CAP of 500 tonnes of steam per hour), the following load classes have been introduced.

Table 3: Illustration of selection of boiler load classes in a multi-boiler steam generation system

Boiler 'j'	Load class 'i'	Lower range	Upper range
1	1	0 t/h	100 t/h
1	2	101 t/h	200 t/h
1	3	201 t/h	300 t/h
1	4	301 t/h	400 t/h
1	5	401 t/h	500 t/h

<sup>6</sup> In this example final the upper range of final load class is the maximum rated steam generation capacity of the boiler.



2	1	0 t/h	100 t/h
2	2	101 t/h	200 t/h
2	3	201 t/h	300 t/h
2	4	301 t/h	400 t/h
2	5	401 t/h	500 t/h

To calculate steam system baseline emissions additionally load classes for the steam generation system have to be introduced. The system load classes is defined by dividing the maximum load of the system by the number of load class for the system.

Table 4: Resulting steam system load classes from Table 4

Load class 'k'	Lower range	Upper range
1	0 t/h	100 t/h
2	101 t/h	200 t/h
3	201 t/h	300 t/h
4	301 t/h	400 t/h
5	401 t/h	500 t/h
6	501 t/h	600 t/h
7	601 t/h	700 t/h
8	701 t/h	800 t/h
9	801 t/h	900 t/h
10	901 t/h	1,000 t/h

For example, the system load is 1000 ts/h and is dividing into 10 load classes. As given in Table 4 above. For each system load class there can be one or more than one combination of operation of individual boilers in different boiler load class. For example, for system load class '2' of the boiler system can be achieved through 3 combinations: operating boiler 1 in boiler load class '2' and not operating boiler 2; or operating boiler 1 and 2 in boiler load class '1'; or not operating boiler 1 and operating boiler 2 in load class 2. This combination are shown in Table 5 below. Each cell represents the combination of boiler load class operation for boiler 1 and 2. The number in the cell represents the system load class 'k'.

Table 5: Determination of steam generation system load classes 'k' based upon boiler load classes 'i' 'k' is the number of the matrix.

Steam system load classes 'k'		Boiler 1					
		No operation	Load class 1	Load class 2	Load class 3	Load class 4	Load class 5
Boiler 2	No operation	-	1	2	3	4	5
	Load class 1	1	2	3	4	5	6
	Load class 2	2	3	4	5	6	7
	Load class 3	3	4	5	6	7	8
	Load class 4	4	5	6	7	8	9
	Load class 5	5	6	7	8	9	10

**ANNEX II****Determination of specific energy consumption in case of a multi-boiler installation**

To illustrate estimation of  $SEC_{SYS,k}$  the example in Table 4 and Table 5 above is used. Table 6 below presents an example of the estimation of  $SEC_{SYS,1}$  and  $SEC_{SYS,2}$ . As can be seen from this table, the steam generation system class '1' be achieved by the combination of the following boiler load class operations:  $\{(1,1), (0,1)\}$ ,  $\{(0,1), (1,2)\}$ . There are only two possible combinations. For the steam generation system class '2' there are three possible combinations:  $\{(2,1), (0,2)\}$ ,  $\{(1,1), (1,2)\}$ ,  $\{(0,1), (2,2)\}$ .

Table 6: Illustration of the determination of specific energy consumption ( $SEC_{SYS,k}$ ) within each steam generation system load class 'k' in case of 2 boilers.

Steam generation system load class k (t/h)	Boiler load class i of boiler 1	Boiler load class i of boiler 2	Columns to be added for further boilers if required	$SEC_{SYS,k}$
1: 0-50	1	No operation	...	$SEC_{SYS,1}$
	No operation	1	...	$SEC_{SYS,1}$
2: 51-100	2	No operation	...	$SEC_{SYS,2}$
	No operation	2	...	$SEC_{SYS,2}$
	1	1	...	$SEC_{SYS,2}$

Therefore, the  $SEC_{SYS,1}$  and  $SEC_{SYS,2}$  shall be estimated as follows:

$$SEC_{SYS,1} = \min \left\{ \left( SEC_{1,1} * \left( \frac{1}{1} \right) + SEC_{0,2} * \left( \frac{0}{1} \right) \right), \left( SEC_{1,0} * \left( \frac{0}{1} \right) + SEC_{1,2} * \left( \frac{1}{1} \right) \right) \right\}$$

$$SEC_{SYS,2} = \min \left\{ \left( SEC_{1,2} * \left( \frac{2}{2} \right) + SEC_{0,2} * \left( \frac{0}{1} \right) \right), \left( SEC_{1,1} * \left( \frac{1}{1} \right) + SEC_{1,2} * \left( \frac{1}{1} \right) \right), \left( SEC_{0,1} * \left( \frac{0}{1} \right) + SEC_{2,2} * \left( \frac{2}{2} \right) \right) \right\}$$



**ANNEX III**

Data required for calculation of baseline emissions within the capacity of the baseline equipment

**Case A: Single-boiler installation**

Table 7: Illustration of data required for calculation of baseline emissions within the capacity of the baseline equipment

Load class 'i'	Exemplified lower range	Exemplified upper range	SEC <sub>i</sub>	P <sub>PJ,i,y</sub>
As shown above	See Step 1	See Step 1	See Step 3 (Eq. 2)	To be monitored during crediting period
1	0 t/h	100 t/h	SEC <sub>1</sub>	P <sub>PJ,1,y</sub>
2	101 t/h	200 t/h	SEC <sub>2</sub>	P <sub>PJ,2,y</sub>
3	201 t/h	300 t/h	SEC <sub>3</sub>	P <sub>PJ,3,y</sub>
4	301 t/h	400 t/h	SEC <sub>4</sub>	P <sub>PJ,4,y</sub>
5	401 t/h	500 t/h	SEC <sub>5</sub>	P <sub>PJ,5,y</sub>

**Case B: Multi-boiler installation**

Table 8: Illustration of data required to calculate baseline emissions within the capacity of the baseline equipment

Load class k	Exemplified lower range	Exemplified upper range	SEC <sub>SYSTEM,k</sub>	P <sub>PJ,k,y</sub>
As shown above	As shown above	As shown above	(See Eq. 9)	To be monitored during crediting period
1	0 t/h	100 t/h	SEC <sub>SYS,1</sub>	P <sub>PJ,1,y</sub>
2	101 t/h	200 t/h	SEC <sub>SYS,2</sub>	P <sub>PJ,2,y</sub>
3	201 t/h	300 t/h	SEC <sub>SYS,3</sub>	P <sub>PJ,3,y</sub>
...	...	...	...	...
10	901 t/h	1,000 t/h	SEC <sub>SYS,10</sub>	P <sub>PJ,10,y</sub>