CLEAN DEVELOPMENT MECHANISM
PROPOSED NEW METHODOLOGY: BASELINE (CDM-NMB)
Version 01 - in effect as of: 1 July 2004

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SECTION A. Identification of methodology

A.1. Proposed methodology title:

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Energy Efficiency improvements in district heating production and distribution

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

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Energy
Energy Efficiency in Heat Production
Heat and Hot Tap Water Supply to buildings

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

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The proposed new base line methodology is a general method, applicable for development of the base line scenario and calculation of the CO_2 emission in the base line scenario in situations where the project activity involves energy efficiency improvements in district heating production and distribution.

The proposed new methodology is applicable in project activities in which:

- The project activity involves substitution of heat (and hot tap water (HTW)) produced by small individual boilers, stoves, and block heat systems by a more efficient method of supply (district heating possibly also involving co-generation);

- The project activity involves efficiency improvements in heat production and heat distribution in existing district heating systems (improved heat production efficiency and / or reduction of losses from the distribution system);

- The project activity involves energy efficiency improvements in heat production and heat distribution in introduction of district heating systems to new buildings.

The proposed new base line methodology is applicable for project activities which include:
- 1) heat produced by heat only boilers (HOBs) fired by coal or natural gas, and
- 2) utilisation of surplus heat from existing thermal power plants or industrial power production (co-generation), fired by coal or natural gas.

Accordingly, the proposed new methodology is **not** applicable for project activities involving e.g. additional power production capacity (e.g. green-filed co-generation plants) or heat production based on bio-mass, solid waste incineration or other fuels.

The proposed new base line methodology is applicable for project activities in which the **heat consumption** (heating and HTW) is identical in the base line scenario and in the project scenario, i.e. the proposed new base line methodology is **not** applicable in project activities in which the energy savings (emission reductions) are only related to improved building insulation, reduced energy consumption in buildings (e.g. installation of automatic controls, etc.).

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

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The main strength of the proposed new methodology is that it is a relatively simple way to calculate the CO_2 emission in the project and base line scenarios. It is also considered a main strength that the methodology is transparent and does not require specialist knowledge on e.g. boiler technology and heating technology to be applied. The data required for the estimates are relatively easy to retrieve and be confirmed through other sources, through historical data, etc.

The methodology is based on calculating the emission reductions and calculating the specific emission reduction (the emission reduction per unit of heat supplied).

The main weakness in the proposed new methodology (base line scenario) is that it includes project specific assumptions, e.g. assumptions on replacement of existing, individual boilers by new (individual) boilers with improved efficiency or assumptions on introduction of alternative heat supply technologies (e.g. natural gas fired boilers or surplus heat).

Justification of the base line scenario (analysing and choosing the most likely base line scenario is not a straightforward task). The weight of various arguments and the subsequent selection of the most likely base line scenario vary for each individual case and can thus give cause for disputes.

SECTION B. Overall summary description:

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Main principles:

The principle in the methodology is to calculate how much fuel is needed for heating and hot tap water supply in the base line and the project scenarios and subsequently the emissions and **emission reductions**.

The emission reductions are obtained by a decrease in fuel consumption (in the project scenario less fuel is used compared to the base line scenario caused by a more efficient manner to produce and distribute the heat) for heating of the same floor area. The heated floor area (and HTW consumption) is identical in the baseline scenario and the project scenario (year by year).

The **specific emission reduction factors** (an individual factor for each year) are calculated as tons CO_2 emission reduction per GJ heat supplied to the district heating system in the project scenario. (The emission reduction (for a specific year) is divided by the total heat supplied to the district heating system (for a specific year) in the project scenario).

The specific emission reduction factors (i.e. a table listing specific emission factors for each year) shall be agreed by the involved parties at the start of the project activity and form the future basis for calculation of emission reductions.

When the project activity is actually implemented, the only data needed to be monitored is the **actual heat supplied** to the district heating system. The CO_2 emission reduction is directly calculated by multiplying the specific emission reduction factor (for a specific year) by the (monitored) actual quantity of heat supplied.

By applying the above principles, the monitoring methodology becomes very simple and easy to administrate. Only the quantity of actual heat supplied to the district heating system shall be monitored. The calculation of **emission reductions** is based on the quantity of heat supplied to the district heating systems and accordingly will adjust for e.g. changes in climate (year by year), changed behaviour of consumers, changes in the time schedule for implementation of the district heating system. Accordingly, there is no need for monitoring of data in the baseline scenario as the **emission reductions** are calculated directly from the data monitored in the project activity.

Calculation of fuel consumption and emissions in the baseline and the project scenario

As mentioned above, the key factor for calculation of the emission reductions is the fuel consumption in the baseline and the project scenarios. The proposed new methodology provides the basis for how the fuel consumption shall be calculated.

In **Step 1,** the annual **demand** for heat and hot tap water is calculated.

The key data are:

- The heated floor area (m^2)
- Annual energy demand per m^2.

In **Step 2,** the annual fuel demand and the emissions in the base line scenario (the scenario representing the base line, identified by application of the additionality test tool) are calculated.

The key data are:

- Average annual efficiency of the assumed (base line) heating technology
- Applied fuel(s) in the assumed (base line) heating technology
- CO_2 emission factor(s) applicable for the (assume) fuel(s) in the base line scenario.

The basic principle is to calculate the annual fuel consumption (for heating and HTW) in the base line scenario. Assuming a specific fuel (e.g. coal), the corresponding CO_2 emission is calculated.

In **Step 3,** the annual fuel demand and the emissions in the project activity scenario (for covering the identical demand as applied in the baseline scenario) are calculated.

The key data are:

- Average annual efficiency of the (project scenario) heating technology
- Applied fuel(s) in the assumed (project scenario) heating technology
- CO_2 emission factor(s) applicable for the (project scenario) fuel(s) in the base line scenario.

In the project scenario, also losses from the (new) district heating pipe network are taken into account.

In **Step 4,** the annual emission reductions are calculated (base line scenario emissions subtracted project activity scenario emissions).

In **Step 5,** emission reduction factors (ton CO_2 emission reduction per supplied GJ) for each year are calculated. The emission reduction factors are the emission reductions (for each year) divided by the supplied energy (for each year) to the district heating system.

In **Step 6,** the calculated emission reduction factors (ton CO_2 emission reduction per supplied GJ) are updated (for each year) based on monitored data. The actual annual average boiler efficiencies and the actual marginal heat production efficiency (for co-generation) are calculated based on monitored data, and the emission reduction factor for the specific year is calculated.

Further comments

The methodology includes that the project developer can apply project specific assumptions in respect of development over time in heated floor area, i.e. construction of new buildings, and takes into account the technology applied for heating of such new buildings.

In addition, the project developer can also apply project specific parameters such as replacement of existing boilers and stoves with low efficiency by boilers with improved efficiency.

The methodology takes into account switch of primary fuel (e.g. switch from coal to natural gas or surplus heat).

The proposed new baseline methodology is prepared together with the proposed new monitoring methodology.

In the proposed new monitoring methodology, the only data required to be monitored is the actual energy supply to the district heating system. By application of the **emission reduction factors** (ref. Step 5 above) and the **actual energy supplied** to the district heating network, the emission reductions are directly calculated. By this method, there is no need to keep track of e.g. climatic data, actual progress in the development of the district heating system, changed consumer habits, etc., as the methodology is made to compensate for such changes.

The methodology and especially the future activities in connection with monitoring of the emission reductions are simple and transparent.

SECTION C. Choice of and justification as to why one of the baseline approaches listed in paragraph 48 of CDM modalities and procedures is considered to be the most appropriate:

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C.1. General baseline approach:

? Existing actual or historical emissions, as applicable;

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

? The average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category.

C.2. Justification of why the approach chosen in C.1 above is considered the most appropriate:

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In the process of preparing the alternatives and subsequently evaluating and selecting the base line scenario found to represent the most likely and justifiable scenario, it is essential that all evaluated scenarios are prepared and evaluated with application of similar assumptions. This means that e.g. the heat demand, heated floor area and HTW demand shall be identical in all the evaluated scenarios.

The proposed new base line methodology for estimation of the CO_2 emission in the baseline scenario is considered a feasible, easy and transparent manner to assess the baseline emissions.

The data to be applied in the base line methodology are basically the heated floor area, energy consumption per m^2/year and data related to the efficiency of the heat production (and distribution). Through application of the additionality tests, the base line scenario will be defined and justified. Accordingly, the data approach is related to "Emissions from a technology that represents an economic attractive course of action, taking into account barriers to investments". Estimation of this approach is evaluated to be the most feasible approach as the alternatives (e.g. historical data) and average emissions from similar projects will involve a very onerous task in respect of data collection and compilation of data to make the data applicable for a specific project. Further comments on application of historical data are given below.

Comments on application of historical data
Theoretically, the emissions from the existing buildings could be made by collecting information on fuel consumption for existing boilers, stoves and furnaces (historical data) and calculating the corresponding CO_2 emissions. This method will, however, involve a number of constraints, and also assumptions will be required to be made. The major constraints will be to collect and compile data for a large number of existing small boilers, stove and furnaces - some operators may not keep adequate and comprehendible records, e.g. the date of purchase of coal does not necessarily represent consumption at the same date as coal will be stocked in coal yards. It will typically also be very difficult to obtain data on actual calorific value for coal supplied to small boiler houses. The delivered useful heat will furthermore have to be assessed based on assumptions on boiler efficiencies as the actual heat supplied is not metered on the existing old boilers and stoves. The technology in the existing boiler houses (and on the existing stoves) is very basic and typically does not include (reliable) metering of heat supplied. In addition, application of historical data will be complicated in respect of adjustment of data for variations in climatic data, number of people supplied with HTW (number of supplied buildings can change), assumptions on overheating / under-heating of dwellings etc.).

A city in which major infrastructure projects such as a district heating project are considered, typically also is developing its building volume, i.e. a (considerable) number of new buildings are also planned to be supplied through the new district heating system. For preparation of an adequate estimate of the emission in the baseline scenario, assumptions will have to be made in respect of technology, fuel consumption etc. for heating of new buildings (i.e. no historical data can be retrieved for such buildings).

Based on the above consideration, the proposed new base line methodology is found both adequate, practical and justified for the estimate of CO_2 emissions in the base line scenarios (alternatives to be evaluated).

SECTION D. Explanation and justification of the proposed new baseline methodology:

D.1. Explanation of how the methodology determines the baseline scenario (that is, indicate the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases (GHG) that would occur in the absence of the proposed project activity):

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The methodology establishes project additionality by using the approved "Tool for demonstration and assessment of additionality" developed by the CDM Executive Board.

Available from http://cdm.unfccc.int/methodologies/PAmethodologies/Additionality_tool.pdf

In the proposed new methodology, the baseline CO_2 emission is estimated as the CO_2 emission resulting from heat and HTW consumption in the buildings in the project area. The estimate is based on the heated floor area, taking into account that also new buildings will be constructed. In the proposed new methodology, the project developer shall analyse and justify which technology for supply of the required energy for heating of the buildings (and supply of hot tap water) can be determined to represent the base line scenario which would occur in the absence of the proposed project activity. The proposed new base line methodology operates with alternative heat supply technologies and alternative fuels (coal and natural gas), by experience representing the realistic alternative supply options for cities in which the proposed project activities (district heating and / or co-generation) are considered.

Many technologies may be applied for heating and supply of HTW (e.g. solar heat, electrical heating, bio-gas, supply from incineration of solid waste, etc.). In the present proposed new baseline methodology, only three technologies are considered to be realistic baseline technologies, ref. the following sections. The three technologies have been selected based on experience as the realistic alternatives in countries in which heat supply today is based on coal fired boilers and stoves.

The proposed new base line methodology addresses various future development features in cities requiring supply of energy for heating e.g.: New buildings will typically be better insulated than the existing buildings, and the proposed new methodology applies a differentiated annual energy consumption (depending on building type (residential or commercial) and building age).

The proposed new base line methodology furthermore includes that old, existing boilers will gradually be replaced, i.e. at a point in time, the operator would have to replace the existing boiler technology by more modern boiler technology (boilers with higher efficiency), i.e. a development over time shall be elaborated by the project developer.

The proposed new base line methodology includes criteria for establishing if a coal based supply technology or a natural gas based technology shall be assessed to represent the most reasonable base line scenario to be applied. To limit the complexity of the proposed new methodology, it only operates with coal and natural gas, i.e. other fuels such as oil or bio-mass could in some situations be relevant, however, not covered by the proposed new base line methodology.

The realistic alternative baseline scenarios shall be described. The task is to determine whether the proposed project activity (introduction of heat supply through a district heating system and e.g. utilisation of surplus heat from a power plant, i.e. co-generation) is additional to the base line scenarios.

The proposed new base line scenario operates with the following alternatives:

Alternative 01 - Replacement and Technical Enhancement, Existing Supply Concept:
The existing boilers will be kept in operation as long as technically possible, using the same fuel as today. At the end of the technical life span of the existing boiler, new heat only boilers with an efficiency corresponding to the efficiency of a new, typical heat only boiler (fuel specific efficiency) will be installed.

For heat and HTW supply to new buildings, new heat only boilers with an efficiency corresponding to the efficiency of a new, typical heat only boiler (fuel specific efficiency) will be installed.

Alternative 02 - District Heating, Heat Only Boiler Concept:
The existing boilers will be replaced by supply from a district heating pipe network. The replacement will take place in phases in compliance with construction of a distribution pipe network for heating. The heat supply to the district heating network will come from heat only boilers. The fuel used in the heat only boilers will be coal. The methodology can by appropriate modifications be applied to other fuels (e.g. lignite, natural gas or heavy fuel oil; however in proposed new base line methodology is only developed for coal).

For heat and HTW supply to new buildings, the heat supply will be made from the district heating network.

Alternative 03 - Introduction of Natural Gas, Heat Only Boilers:
The existing boilers will be replaced by new boilers (with an efficiency corresponding to a typical, natural gas fired boiler). The replacement will take place in phases in compliance with construction of a natural gas distribution pipe network.

For heat and HTW supply to new buildings, new heat only boilers (natural gas fired) with an efficiency corresponding to the efficiency a new, typical heat only boiler will be installed.

Selection of justifiable and realistic base line scenario

Among the above mentioned alternative scenarios, the most realistic and justifiable scenario shall be selected and defined to be the base line scenario. The task is to identify which of the above mentioned alternatives represent the development in case the proposed project activity (efficiency improvements in the heat production and / or heat distribution in the district heating system) will not be implemented. Criteria for selection of the most likely alternative are elaborated below.

Coal fired concepts
In case the national, regional or city specific legislation specified that the fuel applied for heating and HTW supply shall be coal, the applicable base line scenario will be either:

Base Line Alternative 01 - Replacement and Technical Enhancement, Existing Supply Concept
or
Base Line Alternative 02 - District Heating, Heat Only Boiler Concept

The two above mentioned alternatives are also applicable in case absence of a national, regional or city specific legislation or in a situation where natural gas (in sufficient volume and reasonable distance) is not available. Availability of natural gas is evaluated based on the distance to nearest natural gas transmission line or the required investment in the natural gas system.

Criteria 1: In case the distance between the city in question and the nearest natural gas transmission line exceeds 50 km, it is defined that natural gas is not available for the city in question.

Criteria 2: In case the required investments in natural gas transmission pipe lines, distribution pipe lines and other facilities for the natural gas system increases the total project cost by 50% or more, it is defined that natural gas is not available (cost increase compared to the selected scenario, i.e. base line scenario 01 or base line scenario 02).

The criterion for selection of the appropriate base line scenario is based on the environmental situation in the city in question. The project developer shall justify his selection of base line scenario; however, the

guide line is that in case the city in question is suffering from environmental problems (concentrations of suspended particles and SO_2), the base line scenario will be Alternative 02. Reference is made to e.g. WHO guide lines or national guidelines for recommendations in respect of maximum acceptable concentrations of pollutants.

If this is not the case, the base line scenario will be Alternative 01.

Fuel switch requirements (switch from Coal to Natural Gas)
In case the national, regional or city specific legislation specified that existing coal fired boilers for heating and HTW supply shall be converted / replaced by heating concepts applying an alternative fuel (natural gas), the applicable base line scenario will be:

Base Line Alternative 03 - Introduction of Natural Gas, Heat Only Boilers

Comment:
The criterion for selection of the appropriate base line scenario is based on the technological development in the country in question. In some countries, application of natural gas is made in combination with construction of small scale co-generation (e.g. natural gas fired piston engines and natural gas fired turbines). The project developer shall justify his selection of the base line scenario, however, the guide line is that in case small scale, natural gas fired co-generation schemes are under implementation or have been implemented the in the country in question, the presently proposed new base line methodology is **not** applicable. In case of introduction of natural gas, the presently proposed new base line methodology is only applicable for heat only boiler solutions, i.e. Alternative 03.

D.2. Criteria used in developing the proposed baseline methodology:

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The criterion used in developing the proposed new base line methodology is that data required for estimation of the emissions in the base line scenario must be retrievable, i.e. the proposed methodology is based on data commonly available from city administration offices, heating companies etc.

Another criterion is furthermore that the methodology should be easy to apply, logical and transparent for all parties involved.

In the development of the proposed new base line methodology, it has been a criterion to develop a relatively wide applicability of the methodology, however, at the same not suggesting a very complicated and complex methodology. The presently proposed new base line methodology represents a methodology applicable in cities where heat and hot tap water supply today is covered by coal fired heat only boilers and stoves or a district heating system. The project developer is considering implementation of a collective system such a district heating, possibly supplemented by heat supply from co-generation facilities, i.e. improvements in heat production efficiency and / or distribution efficiency.

The methodology furthermore very closely follows recognized and well proven procedures and principles applied in e.g. feasibility studies of project viability / planning alternatives, analyses of tariff reforms, investment planning etc. A similar methodology for assessment of fuel consumption has been applied for preparation of feasibility studies, appraisal reports etc. for international finance and donor organizations (e.g. Asian Development Bank, World Bank, EBRD, DANIDA, SIDA, etc.).

D.3. Explanation of how, through the methodology, it can be demonstrated that a project activity is additional and therefore not the baseline scenario (section B.3 of the CDM-PDD):

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The methodology demonstrates that the project activity is additional and therefore not the base line scenario by using the "Tool for the demonstration and assessment of additionality" developed by the Executive Board.

Available from http://cdm.unfccc.int/methodologies/PAmethodologies/Additionality_tool.pdf

D.4. How national and/or sectoral policies and circumstances can been taken into account by the methodology:

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The proposed new base line methodology takes national and/or sectorial policies and circumstances into account.

Selection and preparation of the most likely base line scenario is made with due consideration to national and/or sectorial policies. By application of the additionality tests, it will be established if the proposed project activity in fact is the consequential implementation of a project in compliance with the national / sectorial policies, or if the proposed project activity in fact is additional to such national / sectorial policies.

D.5. Project boundary (gases and sources included, physical delineation):

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The project boundary is strictly the district heating project, from the production of heat at the boiler houses to the end user demand for heat and HTW. The project boundary includes only emission reductions obtained from the energy efficiency improvements in supplying (and distributing) heat and HTW to the specified district heating area.

This means that the emission reduction from the project is only based on the difference in fuel (coal and natural gas) consumption per GJ of heat supplied to the project area before and after the implementation of the project activity.

D.6. Elaborate and justify formulae/algorithms used to determine the baseline scenario. Variables, fixed parameters and values have to be reported (e.g. fuel(s) used, fuel consumption rates):

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In the sections below, the methodology and equations applied in the proposed new baseline methodology are explained in detail.

The essential data applied (e.g. heated floor area, design thermal ratings and construction of new buildings in the project area) are all data which typically will be possible to be retrieved from and confirmed by the city authorities and the various design institutes participating in the preparation of the (technical) design of the system, estimation of environmental benefits from the project etc.

The proposed new base line methodology includes default values which may be applied by the project developer (e.g. default values for annual average boiler efficiency), however, also opens for the project developer to apply project specific values providing such values can be documented /justified.

Step 1:
Calculation of annual heat and HTW demand, general for all alternatives and for the project activity scenario

Calculation of heat and HTW demand, (Identical in the Baseline Scenario and the Project Activity Scenario)

The fist step in the proposed new base line methodology is to calculate the demand for heat and hot tap water.

The procedure is:

Specification of design thermal loads
According to the building codes and geographical location of the buildings, design thermal ratings are applied.

The applicable design thermal ratings are geographically specific, specific to type of buildings (e.g. high-rise buildings, individual houses, semi-attached dwellings, etc.) and will typically also be time specific (e.g. old buildings have design thermal ratings differing from new buildings, due to the fact that insulation codes have been modified, practices in respect of glazed area and types of installed windows have been changed, etc.).

To ensure that realistic values have been applied, the project developer shall document that in the PDD identical or smaller values as applied in the design of the technical installations have been applied in compliance with state-of-the-art practices for the country/region in question. (The values applied in the design of the technical installations are essential for determining the required capacity of the new installations and accordingly the magnitude of the required investment).

Example:
In Harbin (Northern China), the following capacities of the heating installations are based on the following design thermal ratings:

	Existing	New
	W/m^2	W/m^2
Residential Buildings	63	48
Commercial Buildings	64	55

Estimation of annual heat demand
The specific annual heat demand (GJ/m^2/year) is estimated by multiplication of the design thermal load by the equivalent number of full load hours as indicated in equation (1).

(1) $$E_{spec} = DTR * T_{eq.\ full,\ heating} * 3{,}600\ sec/h * 10^{-9}$$

where:

E_{spec} :	specific annual heat demand	[GJ/m^2/year]
DTR:	Design Thermal Rating	[W/m^2]
$T_{eq.\ full,\ heating}$:	Equivalent number of full load hours, heating	[h/year]

The applied value for "Equivalent number of full load hours, heating" is essential in respect of determining the above mentioned "Specific annual heat demand". To ensure that realistic values have been applied, the project developer shall document that in the PDD an identical or smaller value than applied in the design of the technical installations (and subsequent financial analyses) has been applied. The value shall be in compliance with state-of-the-art practices for the country / region in question. (The value applied in the design of the technical installations (and subsequent financial analyses) is essential for determining the cost of the heat to be supplied to the buildings (fuel consumption and accordingly operation costs are linked to the applied value).

Example:
In Harbin (Northern China), the average heating season is 4,392 hours per year. For Harbin, it is assessed that the equivalent number of full load hours, heating is 2,749 (i.e. the annul heat consumption can be estimated by multiplying the design thermal rating by equivalent number of full load hours, heating). In the Harbin case, the equivalent number of full load hours, heating corresponds approximately to 63% of the length of the heating season.

The annual heat demand (heating) is calculated as indicated in equation (2), i.e. multiplying the specific annual heat demand by the heated floor area.

(2) $E_{d,\ heating} = E_{spec} * A$

where:

$E_{d,\ heating}$:	Annual Heat Demand, Heating	[GJ/year]
E_{spec}:	Specific Annual Heat Demand	[GJ/m^2/year]
A:	Heated Floor Area	[m^2]

In the preparation of the baseline scenario, the annual heat demand (heating) is calculated for each category of buildings (e.g. existing buildings, new buildings, commercial buildings etc.). In addition, the development over time in respect of construction of new buildings is reflected in the base line scenario. If improvements to buildings (e.g. improved insulation, replacement of windows) or other energy saving measures (e.g. improved heat load control) are anticipated to be implemented, such improvements can be taken into account by multiplication of the annual heat demand ($E_{d,\ heating}$) by a reduction factor. The appropriate magnitude of the reduction factor shall be determined by the project developer.

<u>Estimation of annual energy demand for heating of HTW</u>
In the proposed new methodology, the estimation of energy demand for heating of HTW is based on registration of design thermal rating of the existing (and future) HTW installations.

The annual energy demand for heating of HTW is calculated as indicated in equation (3), i.e. by multiplication of design thermal rating with an equivalent number of full load hours, HTW.

(3) $E_{HTW} = DTR_{HTW} * T_{eq.\ full,\ HTW} * 3{,}600\ sec/h * 10^{-3}$

where

E_{HTW} :	Annual energy demand for HTW	[GJ/year]
DTR_{HTW}:	Design Thermal Rating, HTW	[MW]
$T_{eq.\ full,\ HTW}$:	Equivalent number of full load hours, HTW	[h/year]

The equivalent number of full load hours, HTW is assumed to be 0.5 * 8,760 h/year = 4,380 h/year. This corresponds to the fact that the HTW installations on average are utilised at 50% capacity throughout the full year.

In the preparation of the baseline scenario, the annual energy demand for HTW is calculated for each category of buildings (e.g. existing buildings, new buildings, commercial buildings etc.), reflecting how the HTW installations are linked to the specific types of buildings. In addition, the development over time in respect of construction of new buildings is reflected in the base line scenario.

To ensure that realistic values have been applied, the project developer shall document that in the PDD identical or smaller values than applied in the design of the technical installations (and subsequent financial analyses) have been applied in compliance with state-of-the-art practices for the country/region in question. (The values applied in the design of the technical installations are essential for determining the required capacity of the new installations and accordingly the magnitude of the required investment).

Step 2:
Calculation of the fuel demand and the emissions in the Baseline Scenario

The base line scenario shall be identified (ref. the additionality criteria), and calculations shall be made as stipulated for the alternative representing the base line scenario. Only calculations listed under the alternative representing the base line scenario shall be conducted, i.e.

- in case Alternative 01 represents the base line scenario apply equations (4) and (5)
- in case Alternative 02 represents the base line scenario apply equations (6) and (7)
- in case Alternative 03 represents the base line scenario apply equations (8) through (11).

Calculation of Fuel Consumption and CO_2 emission, Proposed New Baseline Methodology - Alternative 01 - Replacement and Technical Enhancement, Existing Supply Concept

For calculation of the fuel consumption and corresponding CO_2 emission in the base line scenario, three parameters are required:

I: The annual average efficiency of the existing boilers
II: The annual average efficiency of new boilers (replacing existing boilers)
III: Time schedule for replacement of existing boilers by new boilers.

The annual fuel consumption is calculated by dividing the annual heat demand plus the energy demand for HTW by the boiler efficiency.

(4): $E_{fuel,\ baseline} = (E_{d,\ heating} + E_{HTW}) / (?_{baseline}/100)$

where:

$E_{fuel,\ baseline}$:	Annual fuel demand, baseline	[GJ/year]
$E_{d,\ heating}$:	Annual Heat Demand, heating	[GJ/year]
E_{HTW}:	Annual Energy Demand for HTW	[GJ/year]
$?_{baseline}$:	Boiler Efficiency, baseline	[%]

Boiler Efficiency

The project developer may apply documented, annual average boiler efficiencies for the existing boilers and stoves.

The typical project area will comprise many different boilers and stoves (different in respect of age, boiler manufacture, design thermal rating, boiler construction, etc.). The applied annual average efficiencies shall reflect the composition of the boilers and stoves found in the project area, i.e. weighted annual average boiler efficiency shall be applied.

a) In case that historic data (calculated based on records on fuel consumed and energy produced) on boiler (stove) efficiencies are available, such data shall be applied in a conservative manner, i.e. efficiencies equal to or higher than the historic data shall be applied.

b) The applied annual average boiler (stove) efficiencies may be documented according to a recognised standard e.g. DIN 1942 or similar. The measurements of boiler (stove) efficiencies shall be made at the typical load situation for the boiler (stove), and the data shall be applied in a conservative manner, i.e. the annual average boiler (stove) efficiency shall be equal to or higher than the boiler (stove) efficiency measured at the typical load situation for the boiler.

c) Boiler efficiency appearing from boiler manufacturers' data sheets or guaranteed values in contracts may be applied in a conservative manner, i.e. values equal to or higher than the information given by the boiler manufacturers shall be applied.

d) In case that no historical data or measurements are available, the following default values may be applied:

Default values, annual average boiler efficiency, heat only boilers, stoves and furnaces.

PRESENT STATUS OF EXISTING BOILERS				
FUEL	AGE	CONDIITON	REMAINING LIFE (YEARS)	EFFICIENCY %
Coal	Middle	Good	Several	65
Coal	New	Excellent	Many	85
Coal	Old	Poor	Few/none	50
Coal	Old	Fair	Few/none	50
Coal	Old	Fair	Few/none	50
Coal	Stoves and Furnaces 1)		-	40

The above table is based on data from the report: Poland - Coal to Gas Conversion Project, GEF Project Document, Report No: 13054, 1994/10/31
1) The indicted value on efficiency for the stoves and furnaces are made by the consultant.

Emission Factor
Apply the emission factor for the fuel (coal) actually used in the base line scenario. Emission factors can be found on e.g. the IPCC home page.

The project developer shall apply emission factors as applicable to the type of fuel actually used (Anthracite, bituminous coal, sub-bituminous coal, lignite, etc.)

(5): CO_2 emission, baseline = $E_{fuel,\ baseline}$ * $CEF_{baseline}$ /1,000

where:

CO_2 emission, baseline: CO_2 emission in the base line scenario [ton/year]
$E_{fuel,\ baseline}$: Fuel (coal) consumption, baseline [GJ/year]
$CEF_{baseline}$: CO_2 emission factor for the baseline fuel [kg CO_2 / GJ]

In the preparation of the base line scenario, the annual fuel consumption is calculated for each category of buildings (e.g. existing buildings, new buildings, commercial buildings etc.). In addition, the development over time in respect of construction of new buildings and replacement of existing boilers is reflected in the base line scenario.

The total fuel consumption is calculated as the sum of the fuel consumptions for the different categories of buildings. The CO_2 emission is calculated based on the total fuel consumption and application of equation (5).

Calculation of Fuel Consumption and CO_2 emission, Proposed New Baseline Methodology - Alternative 02 - District Heating, Heat Only Boiler Concept

For calculation of the fuel consumption and corresponding CO_2 emission for the proposed new baseline methodology, four parameters are required:

I: The annual average efficiency of the existing boilers
II: The annual average efficiency of new district heating boilers (replacing existing boilers)
III: Time schedule for replacement of existing boilers by new boilers by district heating supply
IV: The annual efficiency of the district heating pipe network.

The annual fuel consumption is calculated by dividing the annual heat demand plus the energy demand for HTW by the boiler efficiency.

(6): $E_{fuel,\ baseline} = (E_{d,\ heating} + E_{HTW}) / ((?_{baseline}/100) * (?_{DH\ Pipe\ Network}/100))$

where:

$E_{fuel,\ baseline}$: Annual fuel demand, baseline [GJ/year]
$E_{d,\ heating}$: Annual Heat Demand, heating [GJ/year]
E_{HTW}: Annual Energy Demand for HTW [GJ/year]
$?_{baseline}$: Boiler Efficiency, baseline [%]
$?_{DH\ Pipe\ Network}$: DH Pipe Network Efficiency, baseline [%]

Boiler Efficiency
Reference is made to earlier comments (Alternative 1) on boiler efficiency.

District Heating Network Efficiency
The project developer may apply annual distribution network efficiency supported by adequate estimations of thermal losses. The estimations shall as a minimum take into consideration the various pipe dimensions in the network, length of the pipe network, insulation coefficients for each specific pipe dimension, operation temperatures and operation patterns, temperature of surrounding soil / air.

The thermal losses from modern district heating distribution pipe networks vary from in the magnitude of 10% up to 30% (percent of the heat input to the distribution pipe network). The annual average efficiency of the distribution pipe network depends on several factors such as heat density in the connected area, operation patter (e.g. stop of network during summer), quality and quantity of pipe insulation material, correct selection of dimensions of pipes, operation temperatures, etc.

Correct estimation of the (annual) thermal losses from the distribution pipe network is in many cases a quite onerous task. The project developer may in such case choose to apply an annual average network efficiency of 90% which in the base line scenario is considered a conservative estimate.

Emission Factor
Apply the emission factor for the fuel (coal) actually used in the base line scenario. Emission factors can be found on e.g. the IPCC home page.

The project developer shall apply emission factors as applicable to the type of fuel actually used (Anthracite, bituminous coal, sub-bituminous coal, lignite, etc.)

(7): CO_2 emission, baseline = $E_{fuel,\ baseline}$ * $CEF_{baseline}$ /1,000

where:
CO_2 emission, baseline: CO_2 emission in the base line scenario [ton/year]
$E_{fuel,\ baseline}$: Fuel (coal) consumption, baseline [GJ/year]
$CEF_{baseline}$: CO_2 emission factor for the baseline fuel [kg CO_2 / GJ]

In the preparation of the base line scenario, the annual fuel consumption is calculated for each category of buildings (e.g. existing buildings, new buildings, commercial buildings etc.). In addition, the development over time in respect of construction of new buildings and replacement of existing boilers is reflected in the base line scenario.

The total fuel consumption is calculated as the sum of the fuel consumptions for the different categories of buildings. The CO_2 emission is calculated based on the total fuel consumption and application of equation (7).

Calculation of Fuel Consumption and CO_2 emission, Proposed New Baseline Methodology - Alternative 03 - Introduction of Natural Gas, Heat Only Boilers

For calculation of the fuel consumption and corresponding CO_2 emission for the proposed new baseline methodology, three parameters are required:

I: The annual average efficiency of the existing boilers
II: The annual average efficiency of new boilers (replacing existing boilers)
III: Time schedule for replacement of existing boilers by new boilers

The annual fuel consumption is calculated by dividing the annual heat demand plus the energy demand for HTW by the boiler efficiency.

(8): $E_{fuel,\ baseline} = (E_{d,\ heating} + E_{HTW}) / (?_{baseline}/100)$

where:

$E_{fuel, baseline}$:	Annual fuel demand, baseline	[GJ/year]
$E_{d, heating}$:	Annual Heat Demand, heating	[GJ/year]
E_{HTW}:	Annual Energy Demand for HTW	[GJ/year]
$?_{baseline}$:	Boiler Efficiency, baseline	[%]

Boiler Efficiency
Reference is made to earlier comments (Alternative 1) on boiler efficiency.

Emission Factor
Apply the emission factor for the fuel (coal or natural gas) actually used in the baseline scenario. Emission factors can be found on e.g. the IPCC home page.

The project developer shall apply emission factors as applicable to the type of fuel actually used (Anthracite, bituminous coal, sub-bituminous coal, lignite, etc.)

(9): CO_2 emission, baseline, coal = $E_{coal, baseline}$ * $CEF_{baseline, coal}$ /1,000
(10): CO_2 emission, baseline, n.gas = $E_{n.gas, baseline}$ * $CEF_{baseline, n.gas}$ /1,000

where:

CO_2 emission, baseline, coal:	CO_2 emission in the base line scenario, coal combustion [ton/year]
CO_2 emission, baseline, coal:	CO_2 emission in the base line scenario, n.gas combustion [ton/year]
$E_{coal, baseline}$:	Fuel (coal) consumption, baseline [GJ/year]
$E_{n.gas, baseline}$:	Fuel (n.gas) consumption, baseline [GJ/year]
$CEF_{baseline, coal}$:	CO_2 emission factor for the baseline fuel (coal) [kg CO_2 / GJ]
$CEF_{baseline, n.gas}$:	CO_2 emission factor for the baseline fuel (n.gas) [kg CO_2 / GJ]

The total CO_2 emission in the base line scenario is calculated as the sum of the emissions from the application of the two fuels, i.e.

(11): CO_2 emission, baseline, total = CO_2 emission, baseline, coal + CO_2 emission, baseline, n.gas

where:

CO_2 emission, baseline, total:	CO_2 emission in the base line scenario, total [ton/year]
CO_2 emission, baseline, coal:	CO_2 emission in the base line scenario, coal combustion [ton/year]
CO_2 emission, baseline, coal:	CO_2 emission in the base line scenario, n.gas combustion [ton/year]

In the preparation of the baseline scenario, the annual fuel consumption is calculated for each category of buildings (e.g. existing buildings, new buildings, commercial buildings etc.). In addition, the development over time in respect of construction of new buildings and replacement of existing boilers is reflected in the base line scenario.

The total fuel consumption is calculated as the sum of the fuel consumptions for the different categories of buildings. The CO_2 emission is calculated based on the total fuel consumption for each fuel in question and application of equation (11).

D.7. Elaborate and justify formulae/algorithms used to determine the emissions from the project activity. Variables, fixed parameters and values have to be reported (e.g. fuel(s) used, fuel consumption rates):

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Step 3:
Calculation of the fuel demand and the emissions in the Project Activity Scenario

Below, a description of the applied methodology for estimation of the emission of CO_2 is outlined.

The estimation of annual **demand** for heat and HTW

The methodology and applied data to estimate the demand for heat and HTW in the project scenario are identical to the methodology and applied data in the baseline scenario, i.e. the demand for heat and HTW exactly equation (1) through (3).

Calculation of Fuel Consumption and CO_2 emission, Project Scenario

In the project scenario, the heat supplied to the district heating network can be supplied as:

a) Heat supply from heat only boilers

b) Heat supply from an existing power plant (co-generation plant) possibly combined with heat supply from heat only boilers

c) Heat supply from an existing power plant (co-generation plant) combined with heat supply from heat only boilers.

Instructions on equations to be applied:

- **a)** In case the project activity scenario only is based on heat supply from heat only boilers, calculations shall be made as stipulated in a) below, i.e. equations (20) through (24) shall be applied for calculation of the fuel consumption and the emissions.

- **b)** In case the project activity scenario only is based on co-generated heat, the calculations shall be made as stipulated in b) below, i.e. equations (25) through (29) shall be applied for calculation of the fuel consumption and the emissions.

- **c)** In case the proposed project activity involves heat supply from a co-generation plant in combination with heat supplied from heat only boilers, the project developer shall through preparation of duration curves (or similar) illustrate the proportion of energy to be supplied to the district heating network which will be co-generated heat. Stipulations in a) below, i.e. equations (20) through (24) shall be applied for calculation of the fuel consumption and the emissions for the heat supplied by heat only boilers. Stipulated in b) below, i.e. equations (25) through (29) shall be applied for calculation of the fuel consumption and the emissions for heat supplied as co-generated

heat. The total emissions in the project activity scenario are calculated by application of equation (30).

a) Heat supply from heat only boilers

For calculation of the fuel consumption and corresponding CO_2 emission in the project scenario from the heat only boilers, four parameters are required. (The principles and methodology for the estimates are identical to principles and methodology described for base line scenario, Alternative 02).

I: The annual average efficiency of the existing boilers
II: The annual average efficiency of the district heating boilers
III: The annual average efficiency of the district heating pipe network
IV: Time schedule for replacement of existing boilers by new boilers

The annual fuel consumption for buildings supplied by individual boilers (existing boilers in the project area) is calculated by dividing the annual heat demand plus the energy demand for HTW by the boiler efficiency.

(19): $E_{fuel,\ project\ scenario} = (E_{d,\ heating} + E_{HTW}) / (?_{project\ scenario}/100)$

where:

$E_{fuel,\ project\ scenario}$:	Annual fuel demand, project scenario (existing boilers)	[GJ/year]
$E_{d,\ heating}$:	Annual Heat Demand, heating	[GJ/year]
E_{HTW}:	Annual Energy Demand for HTW	[GJ/year]
$?_{project\ scenario}$:	Boiler Efficiency (existing boilers)	[%]

The annual fuel consumption for buildings supplied by the district heating system (by heat only boilers connected to the district heating system) is calculated by dividing the annual heat demand plus the energy demand for HTW by the boiler efficiency of the district heating boilers multiplied by the district heating network efficiency.

(20): $E_{fuel,\ DH\ -\ HOB,\ project\ scenario} = (E_{d,\ heating} + E_{HTW}) / (?_{DH,\ boilers}/100 * ?_{DH,\ network}/100)$

where:

$E_{fuel,\ DH\text{-}HOB,\ project\ scenario}$:	Annual fuel demand, DH system, project scenario	[GJ/year]
$E_{d,\ heating}$:	Annual Heat Demand, heating	[GJ/year]
E_{HTW}:	Annual Energy Demand for HTW	[GJ/year]
$?_{DH,\ boilers}$:	Annual Average Efficiency, DH boilers	[%]
$?_{DH,\ network}$:	Annual Average Efficiency, DH network	[%]

The heat supplied from the district heating, heat only boilers to the district heating network is calculated as:

(20 a) $E_{DH\ Network,\ HOB,\ project\ scenario} = (E_{d,\ heating} + E_{HTW}) / (?_{DH,\ network}/100)$

where:

$E_{DH\ Network,HOB,\ project\ scenario}$:	Annual heat supplied to the DH network from HOB, project scenario	[GJ/year]
$E_{d,\ heating}$:	Annual Heat Demand, heating	[GJ/year]
E_{HTW}:	Annual Energy Demand for HTW	[GJ/year]

$?_{DH, network}$: Annual Average Efficiency, DH network [%]

The total fuel consumption (e.g. coal consumption) in the project scenario for heat only boilers is calculated as the sum of the fuel (coal consumption) from the buildings heated by individual boilers and the fuel (coal consumption) for the district heating system.

(21) $E_{fuel, HOB, total} = E_{fuel, project scenario} + E_{fuel, DH - HOB, project scenario}$

where:

$E_{fuel,,HOB, total}$: Total annual fuel consumption, HOB, project scenario [GJ/year]

$E_{fuel, project scenario}$: Annual fuel demand, project scenario (existing boilers) [GJ/year]

$E_{fuel, DH - HOB, project scenario}$: Annual fuel demand, DH system, project scenario (HOBs) [GJ/year]

Apply the emission factor for the fuel (coal or natural gas) actually used in the project activity scenario. Emission factors can be found on e.g. the IPCC home page.

The project developer shall apply emission factors as applicable to the type of fuel actually used (Anthracite, bituminous coal, sub-bituminous coal, lignite, etc.)

(22): CO_2 emission HOB, project scenario, coal $= E_{coal HOB, project sc.} * CEF_{project, coal} /1,000$

(23): CO_2 emission HOB, project scenario, n.gas $= E_{n.gas HOB, project sc.} * CEF_{project, n.ga} /1,000$

where:

CO_2 emission HOB, project scenario, coal: CO_2 emission in the project scenario from coal fired HOBs, [ton/year]

CO_2 emission HOB, project scenario, n.gas: CO_2 emission in the project scenario from n.gas fired HOBs, [ton/year]

$E_{coal HOB, project sc.}$ Energy consumption by coal fired heat only boilers, project scenario [GJ/year]

$E_{n.gas HOB, project sc.}$ Energy consumption by natural gas fired heat only boilers, project scenario [GJ/year]

$CEF_{project, coal}$: CO_2 emission factor for the project activity fuel (coal) [kg CO_2 / GJ]

$CEF_{project, n.gas}$: CO_2 emission factor for the project activity fuel (n.gas) [kg CO_2 / GJ]

The total CO_2 emission from the heat only boilers in the project scenario is calculated as the sum of the CO_2 emissions from the heat only boilers fired by coal and the CO_2 emission from the heat only boilers fired by natural gas.

$E_{coal HOB, project sc.}$ and $E_{n.gas HOB, project sc.}$ shall be calculated with due consideration to the fuel applied in the existing heat only boilers (in the project scenario) and the fuel to be applied in the HOBs connected to the district heating network (in the project scenario).

Example: The existing heat only boilers may be fired by coal and the new heat only boilers connected to the district heating network may be fired by natural gas.

(24) CO_2 emission HOB, project scenario, total =
CO_2 emission HOB, project scenario, coal +
CO_2 emission HOB, project scenario, n.gas

where:

CO_2 emission HOB, project scenario, total: Total CO_2 emission from HOBs in the project scenario [ton/year]

CO_2 emission HOB, project scenario, coal: CO_2 emission in the project scenario from coal fired HOBs, [ton/year]

CO_2 emission HOB, project scenario, n.gas: CO_2 emission in the project scenario from n.gas fired HOBs, [ton/year]

Boiler Efficiency

Reference is made to earlier comments (Alternative 1) on boiler efficiency.

District Heating Network Efficiency

The project developer may apply annual distribution network efficiency supported by adequate estimations of thermal losses. The estimations shall as a minimum take into consideration the various pipe dimensions in the network, length of the pipe network, insulation coefficients for each specific pipe dimension, operation temperatures and operation patterns, temperature of surrounding soil / air.

The thermal losses from modern district heating distribution pipe networks vary from in the magnitude of 10% up to 30% (percent of the heat input to the distribution pipe network). The annual average efficiency of the distribution pipe network depends on several factors such as heat density in the connected area, operation pattern (e.g. stop of network during summer), quality and quantity of pipe insulation material, correct selection of dimensions of pipes, operation temperatures, etc.

Correct estimation of the (annual) thermal losses from the distribution pipe network is in many cases a quite onerous task. The project developer may in such case choose to apply annual average network efficiency of 90% which in the base line scenario is considered a conservative estimate. A similar value shall be applied in the project scenario.

In the preparation of the project scenario, the annual fuel consumption is calculated for each category of buildings (e.g. existing buildings, new buildings, commercial buildings etc.). In addition, the development over time in respect of construction of new buildings and replacement of existing boilers connected to the district heating system is reflected in the project scenario.

The total fuel consumption for heat only boilers (split on coal and natural gas) is calculated as the sum of the fuel consumptions for the different categories of buildings. The CO_2 emission from the heat only boilers is calculated based on the total fuel consumption (split on coal and natural gas) and application of equation (24).

b) Heat supplied as co-generated heat

In case the proposed project activity involves heat supply from a co-generation plant (or plants) operated in combination with heat only boilers, the project developer shall illustrate through preparation of duration curves (or similar) the proportion of energy to be supplied to the district heating network which will be useful, co-generated heat supplied to the district heating network.

The heat supplied from the co-generation facility to the district heating network is calculated as:

(20 b) $Q_{Heat\ co\text{-}gen} = (E_{d,\ heating} + E_{HTW}) / (?_{DH,\ network}/100) * F_{co\text{-}gen}/100$

where:

$Q_{Heat\ co\text{-}gen}$:	Annual heat supplied to the DH network from co-generation, project scenario [GJ/year]	
$E_{d,\ heating}$:	Annual Heat Demand, heating	[GJ/year]
E_{HTW}:	Annual Energy Demand for HTW	[GJ/year]
$?_{DH,\ network}$:	Annual Average Efficiency, DH network	[%]
$F_{co\text{-}gen}$:	Factor, project and time specific	[%]

The $F_{co\text{-}gen}$ factor is a project specific factor (between 0% and 100%), which determines the proportion of the total heat supply to the district heating network which is produced as co-generated heat. In case the co-generation plant is operated in combination with heat only boilers The project developer shall justify the selected factor through preparation of duration curves (or similar).

In projects where the connected heat demand is large compared to the thermal rating of the co-generation facility, a $F_{co\text{-}gen}$ factor of close to 100% can be expected, however, the project developer shall make due considerations to scheduled (and unscheduled) interruptions to the supply of co-generated heat, e.g. time for maintenance and inspections activities shall be considered.

The basis for the calculation of the CO_2 emission is the **additional fuel** consumption at the co-generation plant for extraction of useful heat to be supplied to the district heating system, i.e. the present new base line methodology is based on the assumption that the co-generation facility is a thermal power plant furnished with extraction type steam turbines.

For calculation of the **additional fuel** consumption and corresponding CO_2 emission in the project scenario from the heat co-generation plant, the following parameters are required:

I) Fuel efficiency for electricity production when the power plant is operated in condensing mode (no supply of useful heat)

II) The C_v-value represents the decline in power production for each extra unit of heat extracted from the turbine.

III) Heat supplied as co-generated heat.

The calculation of the **additional fuel** consumption at the power plant is based upon the marginal fuel efficiency for heat production. The marginal fuel consumption is calculated as follows:

(25) $Q_{Fuel,\ marginal} = Q_{Heat\ co\text{-}gen} / \eta_{h,m}$

where:

$Q_{Fuel,\ marginal}$	: the marginal fuel consumption at the power plant [GJ/year]
$Q_{Heat,\ co\text{-}gen}$	: Annual heat supplied to the DH network from co-generation, project scenario [GJ/year]
$\eta_{h,m}$	: the marginal fuel efficiency for heat production [-]

The marginal fuel efficiency for heat production of the power station can be calculated as follows:

(26) $\eta_{h,m} = \eta_{elec} / C_v\text{-value}$

where:

η_{elec} the fuel efficiency for electricity generation in condensing mode (when the power plant (block) generates electricity without also producing heat) [-]

C_v-value The C_v-value represents the decline in power production for each extra unit of heat output [MW_{el} / $MW_{thermal}$]

I) In case plant (equipment) specific data are available on C_v-value for the turbine(s) and the η_{elec}, such data shall be applied. η_{elec} shall be calculated based on historical data (3 years data) on electric power production (electric power supplied to the grid) and fuel consumption. The applied C_v-value shall be the value guaranteed by the turbine manufacturer, obtained by direct measurements on an identical turbine, or through computer simulations of the impact of extracting thermal energy from the turbine in question.

II) In case the C_v-value or data on electric power production are not available, a default value for the marginal fuel efficiency for heat production of 200% shall be applied. This value is considered a conservative estimate, ref. the example below.

The additional fuel consumption (and marginal fuel efficiency for heat production) is subject to verification during the project activity.

Based on historical data (3 years data prior to the start of the project activity) on electric power production (electric power supplied to the grid) and fuel consumption, the fuel consumption per unit of electric power supplied shall be calculated as:

26 a) Spec. Fuel con. per MWh $_{(historic)}$ = Fuel consumption $_{(historic)}$ / Elec. power to grid $_{(historic)}$

where:

Spec. Fuel per MWh $_{(historic)}$:	Specific Fuel consumption for electric power production [GJ/MWh] (historic data)
Elec. power to grid $_{(historic)}$	Electric power Supplied to grid [MWh/year] (historic data)
Fuel consumption $_{(historic)}$	Fuel consumption at power plant [GJ/year] (historical data)

The average value of the 3 years shall be applied.

During the project activity, data on electric power production (electric power supplied to the grid), thermal energy extracted from the turbine and fuel consumption shall be monitored. For each year during the project activity, the fuel consumption per unit of electric power supplied (during the project activity) shall be calculated as:

26 b) Spec. Fuel con. per MWh $_{(project)}$ = Fuel consumption $_{(project)}$ / Elec. power to grid $_{(project)}$

where:

Spec. Fuel per MWh $_{(project)}$:	Specific Fuel consumption for electric power production [GJ/MWh] (project data)
Elec. power to grid $_{(project)}$	Electric power Supplied to grid [MWh/year] (project data)

Fuel consumption $_{(project)}$ Fuel consumption at power plant [GJ/year] (project data)

The additional fuel consumption is calculated as:

26 c) $Q_{Fuel,\ marginal}$ = Elec. power to grid $_{(project)}$* (Spec. Fuel per MWh $_{(project)}$ - Spec. Fuel per MWh $_{(historic)}$)

where:

$Q_{Fuel,\ marginal}$: the marginal fuel consumption at the power plant [GJ/year]

Elec. power to grid $_{(project)}$ Electric power Supplied to grid [MWh/year] (project data)

Spec. Fuel per MWh $_{(project)}$: Specific Fuel consumption for electric power production [GJ/MWh] (project data)

Spec. Fuel per MWh $_{(historic)}$: Specific Fuel consumption for electric power production [GJ/MWh] (historic data)

The actual marginal efficiency for co-generation is calculated as:

26 d) $\eta_{h,m\ (actual)} = Q_{Heat,\ co\text{-}gen\ (act)} / Q_{Fuel,\ marginal} * 100\%$

where:

$\eta_{h,m\ (actual)}$ marginal heat production efficiency (actual)

$Q_{Heat,\ co\text{-}gen\ (act)}$: Annual heat supplied to the DH network from co-generation, actual [GJ/year]

$Q_{Fuel,\ marginal}$: the marginal fuel consumption at the power plant [GJ/year]

Example:

Efficiency for electric power production and C_v-value

For a condensing power station using coal, the electric power production efficiency is typically in the range of 30-45% (for older plants). For newer plants higher electric power efficiencies are found.

The C_v-value is normally plant specific. For older plants (and turbines), the C_v-value will typically be in the range of 0.15 $MW_{electric}$ per $MW_{thermal}$.

At a typical fuel efficiency for power production at 35% and a C_v-value of 0.15, the marginal fuel efficiency for heat production can be calculated by application of equation (26) as:

$$\eta_{h,m} = 0.35 / 0.15 = 233\%.$$

A default value for the marginal fuel efficiency of 200% may be applied in the project activity scenario. This value is considered a conservative estimate.

The CO_2 emission from the heat co-generated heat in the project scenario shall be calculated matching the fuel allocated in the project scenario. Apply the emission factor for the fuel (coal or natural gas) actually used in the project activity scenario. Emission factors can be found on e.g. the IPCC home page.

The calculation shall take the applied fuel at the co-generation plant into account.

(27): CO_2 emission co-gen, project scenario, coal = $E_{coal\ mar.,\ co\text{-}gen,\ project\ sc.}$ * $CEF_{project,\ coal}$ /1,000
(28): CO_2 emission co-gen, project scenario, n.gas = $E_{n.gas\ mar.,\ co\text{-}gen,\ project\ sc.}$ * $CEF_{project,\ n.gas}$ /1,000

where:
CO_2 emission co-gen, project scenario, coal: CO_2 emission in the project scenario from coal fired co-generation, [ton/year]
CO_2 emission co.gen, project scenario, n.gas: CO_2 emission in the project scenario from n.gas fired co-generation, [ton/year]
$E_{coal\ mar.\ co\text{-}gen,\ project\ sc.}$ Marginal energy consumption by coal fired co-generation, project scenario [GJ/year]
$E_{n.gas\ mar.,\ co\text{-}gen,\ project\ sc.}$ Marginal energy consumption by natural gas co-generation, project scenario [GJ/year]
$CEF_{project,\ coal}$: CO_2 emission factor for the project activity fuel (coal) [kg CO_2 / GJ]
$CEF_{project,\ n.gas}$: CO_2 emission factor for the project activity fuel (n.gas) [kg CO_2 / GJ]

The total CO_2 emission from co-generation in the project scenario is calculated as the sum of the CO_2 emissions from co-generated heat based on coal and the CO_2 emission from the co-generated heat based on natural gas.

(29) CO_2 emission co-gen, project scenario, total =
CO_2 emission co-gen, project scenario, coal +
CO_2 emission co-gen, project scenario, n.gas

where:
CO_2 emission co-gen, project scenario, total: Total CO_2 emission from co-generation in the project scenario [ton/year]
CO_2 emission co-gen, project scenario, coal: CO_2 emission in the project scenario from coal fired co-generation, [ton/year]
CO_2 emission co-gen, project scenario, n.gas: CO_2 emission in the project scenario from n.gas fired co-generation, [ton/year]

c) Heat supplied by heat only boilers in combination with co-generated heat

For project activities involving heat supply by both heat only boilers and co-generated heat, the total CO_2 emission in the project scenario is calculated as the sum of CO_2 emission from the heat only boilers and the CO_2 emission from co-generation. The emissions from the heat only boilers are calculated based on the proportion of heat supplied by the heat only boilers, and stipulations as indicated in a) above are applied. The emissions from the heat supplied as co-generated heat are calculated based on the proportion of heat supplied as co-generated heat, and stipulations as indicated in b) above are applied.

(30) CO_2 emission, project scenario, total =
CO_2 emission HOB, project scenario, total
CO_2 emission co-gen, project scenario, total

where:

CO_2 emission, project scenario, total: Total CO_2 emission in the project scenario [ton/year]

CO_2 emission HOB, project scenario, total: Total CO_2 emission from HOBs in the project scenario [ton/year]

CO_2 emission co-gen, project scenario, total: Total CO_2 emission from co-generation in the project scenario [ton/year]

D.8. Description of how the baseline methodology addresses any potential leakage of the project activity:

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The methodology does not include emissions of GHG from mining of coal. The emission reduction is outside the direct scope of the project activity and thus too difficult to encompass even though emissions of GHG from coal mining are likely to decrease as a result of the project.

The reductions of emission of GHG caused by reduced transport of coal (and ash) are not taken into account.

By not taking the above emission reductions into account, the methodology is considered to be a conservative approach.

The project activity includes construction work (e.g. new boilers, new district heating pipe network, etc.). The emissions caused by the production and transportation of the materials (e.g. steel) have not been considered and are evaluated to be minor compared to the emission savings obtained by the project activity.

D.9. Elaborate and justify formulae/algorithms used to determine the emissions reductions from the project activity. Variables, fixed parameters and values have to be reported (e.g. fuel(s) used, fuel consumption rates):

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Step 4:
Calculation of the Emission Reductions

The emissions reductions from the project activity are calculated as the CO_2 emission estimated in the project scenario deducted the CO_2 emission in the base line scenario.

(31): CO_2 emission, reduction = CO_2 emission, project scenario, total - CO_2 emission, baseline

where:

CO_2 emission, reduction: CO_2 emission reduction [ton/year]

CO_2 emission, project scenario, total: CO_2 emission in the project scenario (ref. eq. (30)) [ton/year]

CO_2 emission, baseline: CO_2 emission in the selected and justified baseline scenario (ref. eq. (5), (7) or (11)) [ton/year]

Step 5:
Calculation of the Emission Reduction Factor

For each year of the crediting period, the **emission reduction factor** per supplied energy unit is calculated.

The CO_2 emission reduction per supplied energy unit to the district heating system (i.e. the emission reduction factor) is calculated as:

a) Projects only involving supply of heat by heat only boilers:

(32 a)

CO_2 emission red. factor, supply DH network = CO_2 emission, reduction / $E_{\text{DH network, HOB, Project Scenario}}$

where:

CO_2 emission red. factor, supply DH network: The agreed CO_2 emission reduction factor based on supplied energy to the DH network [ton CO_2/GJ]

CO_2 emission, reduction: CO_2 emission reduction, ref. equation (31) [ton/year]

$E_{\text{DH Network,HOB, project scenario}}$: Annual heat supplied to the DH network from HOBs, project scenario, ref. equation (20 a) [GJ/year]

b) and c) Projects only involving supply of heat by co-generation:

(32 b) CO_2 emission red. factor, supply DH network = CO_2 emission, reduction / $Q_{\text{Heat co-gen}}$

where:

CO_2 emission red. factor, supply DH network: The agreed CO_2 emission reduction factor based on supplied energy to the DH network [ton CO_2/GJ]

CO_2 emission, reduction: CO_2 emission reduction, ref. equation (31) [ton/year]

$Q_{\text{Heat co-gen}}$: Annual heat supplied to the DH network from co-generation, project scenario, ref. equation (20 b) [GJ/year]

The calculation of the emission reductions actually obtained shall be calculated based on the equation below:

(33) CO_2 emission red., actual = CO_2 emission red. factor, supply DH network * $E_{\text{monitored, DH network}}$

where:

CO_2 emission red., actual: The actual obtained CO_2 emission reduction [ton CO_2/year]

CO_2 emission red. factor, supply DH network:	The agreed CO_2 emission reduction factor based on supplied energy to the DH network [ton CO_2/GJ]
$E_{monitored, DH network}$	The monitored energy supply to the district heating network (one year) [GJ/year]

In projects involving supply of heat from both heat only boilers and co-generated heat, equation (33) shall be applied. The heat source operating with the highest heat production efficiency shall be allocated the emission reductions. This principle provides an incentive during the project activity for maximum utilisation of the production unit operating with the highest efficiency.

Step 6:
Updating of emission reduction factors based on monitored data

The emission reduction factors shall be adjusted according to the monitored data. The principle is that the emissions calculated for the baseline scenario are not changed.

The emissions in the project scenario are re-calculated based on actual efficiencies. Step 4 and Step 5 are repeated, and a set of emission reduction factors valid for the specific year are obtained. The actual emission shall be calculated reflecting the actual fuel used (i.e. fuel consumption in terms of coal and gas shall be monitored).

Project involving supply of heat from HOBs
For projects involving heat supply from heat only boilers, the calculation of the actual emissions during the project activity shall be updated by application of the actual annual average boiler efficiency for the specific year. The actual annual average boiler efficiency is defined to be

$\eta_{HOB, actual}$ = Heat Supplied, DH network / Fuel consumed * 100%

where:

$\eta_{HOB, actual}$:	Actual heat only boiler efficiency (annual average) [%]
Heat Supplied, DH network:	Heat supplied to the DH network [GJ/year]
Fuel consumed:	Fuel consumed by the boiler [GJ/year]

Project involving supply of co-generated heat
For each year, the actual marginal heat production efficiency is calculated by application of equations (26 a) through (26 d).

SECTION E. Data sources and assumptions:

E.1. Describe parameters and or assumptions (including emission factors and activity levels):

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<u>Design Thermal Ratings and Annual Energy Consumption</u>
Assumptions have been made in respect of the relationship between design thermal loads and annual energy consumption. Reference is made to Section D, in which comments on the applied data and methodology are given.

Construction of new buildings
The project developer shall, if relevant, include a forecast for development - over time - in respect of construction of new buildings.

Replacement of existing boilers
In the proposed new base line methodology, the project developer shall justify assumptions applied in respect of the remaining technical life span for the existing boilers, i.e. the pace in which existing boilers will be replaced by new boilers with improved efficiency. In a similar manner, the implementation time for any of the (alternative) base line scenarios becomes an important parameter, to be justified and documented by the project developer. In the proposed new base line methodology, a quick implementation schedule (replacement schedule) will typically reduce the emissions in the base line scenario, i.e. a conservative estimate is to apply a relatively quick implementation schedule.

In the project scenario, the replacement of the existing boilers with supply from the district heating system (district heating boilers and / or co-generation) follows the time schedule for implementation of the district heating project. The time schedule for the project scenario shall be documented by the project developer by reference to relevant studies and agreements (e.g. feasibility studies, bidding documents, implementation contracts, etc.)

Boiler efficiency
In Section D, comments are given on applicable boiler efficiencies both for existing heat only boiler and for new district heating boilers.

Efficiency for heat supplied by the District Heating System
In Section D, comments are given on applicable efficiencies of the heat supply through a district heating pipe network.

Hear supplied by co-generation
In the project scenario, the co-generated heat is assumed generated by extraction of thermal energy from a steam turbine, and the estimates of the fuel consumption and subsequent emissions are based on considerations on the marginal efficiency (marginal fuel consumption). In the project scenario, the approach is to calculate the marginal fuel consumption for the steam extraction, assuming that the electric power production is kept at a level so that no useful thermal energy is extracted.

Emission factors
In the calculation of the CO_2 emission, emission factors for coal combustion and combustion of natural gas are applied according to values published by IPCC.

By applying a methodology in which energy units is used, it is necessary to investigate/calculate actual quantity of coal (ton) or volume of natural gas used and the corresponding calorific values of the coal actually used. Calorific value of natural gas used is not required.

E.2. List of data used indicating sources (e.g. official statistics, expert judgement, proprietary data, IPCC, commercial and scientific literature) and precise references and justify the appropriateness of the choice of such data:

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Emission factors for fuel are obtained through the values published by IPCC.

E.3. Vintage of data (e.g. relative to starting date of the project activity):

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For preparation of the Project Design Document (PDD), the project developer should retrieve most recent available data on building stock (e.g. heated floor area), HTW demands and other data applicable both for selecting and developing the base line scenario and the project scenario. The data shall be retrieved prior to the starting date of the project activity. The data shall be of recent vintage, and not older than 5 years, i.e. data shall have been updated / checked within 5 years from the starting date of the project activity.

Technical data on boiler efficiency (e.g. data from boiler test reports) can be applied also in case the data are older than 5 years from the starting date of the project activity, provided that the boilers are in a similar technical condition as when the test was undertaken.

In case data on boiler efficiency are obtained from several boilers and for several different operation conditions, a weighted average shall be applied, i.e. the weight with which a specific type of boiler (or stove) is applicable in the scenarios shall be taken into account.

The requirements to the applied data are that they are consistent with data applied during the technical and financial feasibility studied, e.g. the basis for the technical design of the proposed new system (calculation of capacity and dimensions of various components), assessment of project cost, heat tariff, etc. comply with data used for the estimation of the emission reductions.

The project developer shall in the PDD include relevant references to applied data and sources of data.

E.4. Spatial level of data (local, regional, national):

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The methodology requires that specific data are retrieved for each proposed project (e.g. data on heat demands and HTW demands, applied fuels, and future composition of the heat production must be retrieved by the project developer for each proposed project).

SECTION F. Assessment of uncertainties (sensitivity to key factors and assumptions):

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The estimate of the CO_2 emission reduction is sensitive to applied data on heated floor area and annual energy consumption. However, in the proposed monitoring methodology, a principle is suggested in which the emission reduction is linked to the actual energy supplied to the district heating system or heat produced as co-generation. This methodology means that the calculation of actual emission reductions will (automatically) adjust for e.g. climatic changes (some winters will be colder than others), differences in buildings actually connected to the system, future energy saving measures, etc. Reference is made to the section on monitoring methodology for further details.

SECTION G. Explanation of how the baseline methodology allows for the development of baselines in a transparent and conservative manner:

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The proposed new base line methodology is transparent in the fact that it applies a simple and logical set of equations. The equations are logical and can be comprehended by all professionals working within the energy / environmental sector, i.e. no specialist knowledge on e.g. heating systems or boiler technology is required.

Several of the key data applied in the proposed new methodology can be confirmed by other sources not related to the district heating project (e.g. heated floor area, city development plans), i.e. to the extent possible, the applied date are transparent.

The methodology is conservative in the fact that it only includes emission reductions directly linked to the proposed project. In addition, it is conservative in the fact that default values applicable on e.g. efficiencies are selected to be relatively high, meaning that the emissions in the base line scenarios are relatively high and contrary in the project scenario default values on efficiencies relatively low. This means that the emission reductions estimated by the project activity are made in a conservative manner.

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