

## Implementation of a Nationally Appropriate Mitigation Action (NAMA) in the building (and construction) sector in Mongolia

Methodology Review and Assessment for the Estimation of GHGs Emissions in the Building Sector in Mongolia



7/31/2018

In case any questions please contact NIRAS att.: Morten Pedersen e-mail mop@niras.dk

## **Table of Contents**

1	Intr	oduction	.8
	1.1	Background on Mongolia's Building Sector	8
	1.2	Methodology Review and Assessment	9
2	Rev	view of the Relevant IPCC Guidelines for GHG Emissions from Buildings.1	LO
	2.1	Category 1A1-Energy Industries	10
	2.2	Category 1A4-Other Sectors	10
	2.2.1	L Scope of 1A4a	10
	2.2.2	2 Scope of 1A4b	11
	2.3	Approach for Calculation of GHG Emissions	11
	2.4	Assessment and Applicability to Mongolia:	13
3	CDI	V Methodologies1	14
4	Rev	view of the International Performance Measurement and Verification	
Pr	otoco	ol for GHG Emissions from Buildings1	16
	4.1	Scope and Applicability	16
	4.1.1	Volume I: Concepts and Options for Determining Energy and Water Savings	16
	4.1.2	2 Volume II: Improved Indoor Environmental Quality	17
	4.1.3	3 Volume III: Applications	17
	4.2	Estimating Energy Savings	17
	4.2.1	L Existing Buildings	17
	4.2.2	2 New Buildings	17
	4.2.3	3 Different Options for Energy Savings for both New and Existing Buildings	18
	4.	2.3.1 Option A	18
	4.	2.3.2 Option B	18
	4.	2.3.3 Option C	19
		Existing buildings	19
		New buildings	19
	4.	2.3.4 Option D	20
		Existing buildings	20
		New buildings	21
	4.2.4	Comparison between the Different Options	21
	4.3	Recommended Option for Mongolia	23
5	Rev	view of NAMAs, NIRs, BURs and NCs from Other Countries for GHG	
Er	nissio	ons from Buildings	24

6	Est	imation of Grid Emission Factor	30
	6.1	Approach followed in the submitted Mongolian Standardized Baseline for the emission factor	or
	of the	national electricity grid	.30
	6.2	CDM Tool to Calculate the Emission Factor for an Electricity System	.30
	6.3	Review of Joint Crediting Mechanism (JCM) Approved Methodology	.36
	6.4	Recommended grid emission factor value	.37
7	Wa	y Forward for Data Collection and Emissions Reduction Estimation	38
	7.1	Proposed Estimation Methodology	. 38
	7.2	Proposed Way forward	. 38
	7.2.	1 Boundary of methodology	.38
	7.2.	2 Scope of methodology	.38
	7.2.	3 Key analysis	. 39
	7.2.	4 Methodology	. 39
	7.2.	5 Documentation	.44
8	Ass	essment of Data Availability for GHG Emissions from Buildings	45
	8.1	Validation of Data Availability	.45
	8.2	Verification of Data Availability	.48
9	Сог	nclusions and Recommended Methodology	52
Α	nnex	I: Assessment of Existing CDM Methodologies	53
	CDM A	M0091: Energy efficiency technologies and fuel switching in new buildings	.53
	Sco	be and Applicability of AM0091	.53
	Gen	eral Approach of AM0091 for baseline emissions calculations	.55
	D	efining the project boundary and type	.55
	Base	eline Emissions Calculation for Existing Buildings	.56
	Base	eline Emissions Calculation for New Buildings	.56
	0	ption 1 for New Buildings:	.56
		Identification of baseline building units (Step 2)	. 59
		Calculations of Baseline Emissions (Step 3)	. 59
		Calculation of Top 20 per Cent Benchmark for Specific Emissions of Baseline Building Units (Step 4)	.63
		Calculation of Baseline Emissions based on the Top 20 per Cent Benchmark (Step 5)	.63
		Updating Baseline Emissions (Step 6)	.64
	0	ption 2 for New Buildings	.64
			<b>C</b> A

Existing Buildings65
New Buildings65
Option 1:
Option 2:
Calculating Leakage Emissions
Emission Reductions Determination67
Assessment of Methodology Requirements and Applicability to Mongolia
CDM AMS-II.R Energy Efficiency Space Heating Measures for Residential Buildings68
Scope and Applicability
Approach
Assessment of Methodology Requirements and Applicability to Mongolia
CDM AMS-II.E: Energy Efficiency and Fuel Switching Measures for Buildings
Scope and Applicability Conditions71
Approach71
Assessment of Methodology Requirements and Applicability to Mongolia
CDM AMS-II.Q.: Energy Efficiency and/or Energy Supply Projects in Commercial Buildings
Scope and Applicability
Assessment of Methodology Requirements and Applicability to Mongolia
CDM AMS-III.AE: Energy Efficiency and Renewable Energy Measures in New Residential Buildings74
Scope and Applicability74
Assessment of Methodology Requirements and Applicability to Mongolia
Annex II: Various Methodologies for Allocating Energy Consumption and
Associated CO <sub>2</sub> Emissions from Cogeneration Plants77
Annex III: Sampling Plan91
Annex IV Detailed Assessment of Methodologies
References 101
Nelelence?

## List of Figures

Figure 4-1 Guide for selecting IPMVP options for existing buildings	. 22
Figure 4-2 Guide for selecting IPMVP options for new buildings	.23
Figure 0-1: Applicable chilled/hot water configuration	.55
Figure 0-2: Approaches to calculating baseline emissions for existing and new buildings according to	
AM0091	.55
Figure 0-3 Steps to calculate baseline emissions for new construction using Option 1	.57
Figure 0-4: Approach to calculating project emissions for existing and new building according to AMOO	)91
	.65
Figure 0-5 Steps to calculate project emissions for new construction using Option 1	.66

## List of Tables

Table 2-1: Data required for the application of IPCC Tier 1, 2, and 3	12
Table 3-1: Summary of methodologies and assessment criteria for applicability in Mongolia	15
Table 5-1 Comparison of estimation methodologies employed by various countries	25
Table 8-1: Data availability and Sources of Data	46
Table 0-1: Applicability conditions of AM0091	53
Table 0-2 Summary of the data required to calculate the baseline emissions from the different source	es
under Option 1	58
Table 0-3: Harmonized efficiency reference values for separate production of electricity	81
Table 0-4: Harmonized efficiency reference values for separate production of heat	83
Table 0-5: Summary of emissions allocation methods	88
Table 0-6: Summary of various sampling methods	94
Table 0-7: Assessment of methodologies for estimation of baseline emissions against context in	
Mongolia	97

#### List of abbreviations

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers **BM** Build margin **BUR** Biennial Update Report **CDD** Cooling degree days **CDM** Clean Development Mechanism **CHPs** Combined Heat and Power plant **CM** Combined margin ECM Energy conservation measure **EF**Emission factor **GCF** Green Climate Fund **GEF** Global Environment Facility **GFA** Gross floor area **GHGs** Greenhouse gases **HDD** Heating degree days **IPCC** Intergovernmental Panel on Climate Change **IPMVP** International Performance Measurement Verification Protocol **JCM** Japanese Crediting Mechanism M&V Measurement and Verfification NAMA Nationally Appropriate Mitigation Action **NC** National communication **NIR** National Inventory Report **OM** Operating margin **PDD** Project Design Document **POA** Programmes of Activities **TNA** Technical Needs Assessment **UNFCCC** United Nations Framework Convention on Climate Change

## 1 Introduction

The objective of this project is to measure emission reductions that would result from the implementation of energy efficiency measures in the building sector in Mongolia. To this end, GHGs emissions must be measured in buildings before and after measures, i.e., a methodology for the calculations of GHGs emitted from buildings before and after implementation of measures. A secondary objective of the project is developing a standardized baseline for the building sector in Mongolia.

This document describes and assesses methodologies pertaining to estimating GHG emission reductions from the building sector in Mongolia as the first component in the implementation of NAMA for energy efficiency in buildings.

In chapters 2-4, the principal methodologies that can and have been used to calculate GHG emissions (in general) are described in terms of goal, scope, and applicability. Following each description, an assessment of the applicability of the methodology for the estimation of GHG baseline emissions, which represents the GHG inventory before implementing any energy efficiency measures is carried out.

To illustrate the practical use of methodologies, a review of methodologies implemented for calculations and reporting of GHGs emissions in various countries is presented in chapter 5.

Chapter 6 presents a brief description of the methodology to be used for the determination of a crucial parameter: the emission factor of an electricity system.

In chapter 7, full details of the selected methodology is discussed while Chapter 8 provides assessment of data availability for data to be used for the selected methodology.

The document has been prepared by NIRAS with Integral as sub-consultant.

## 1.1 Background on Mongolia's Building Sector

According to the document "Climate Change Mitigation in Mongolia" developed under the Technology Needs Assessment (TNA) project funded by GEF<sup>1</sup> [1], the fourth largest GHG emitting subsector is the energy consumption in the commercial and residential subsector for heat and electricity supplying purposes. According to the TNA document, CHPs produce 70 percent of the total country's heat supply, while small and medium capacity boilers and home stoves produce 20 percent and 10 percent, respectively. According to the TNA document as well, most of the district heating systems are highly deteriorated and operate with very low efficiency.

Reducing emissions has thus become a national objective to be implemented via efficiency measures in the building sector for existing and newly constructed buildings. The scope of energy efficiency measures for emissions reduction in existing buildings considered in this document consist of retrofitting measures. In order to measure emissions reduction of energy efficiency measures, calculations of baseline emissions from existing and new buildings and project buildings (where efficiency measures are

<sup>&</sup>lt;sup>1</sup> Ministry of Environment and Green Development, 2013: 5,16,17

implemented) are required. To this end, different methodologies under different schemes relevant to calculations of GHGs are reviewed.

## 1.2 Methodology Review and Assessment

Methodologies from IPCC guidelines, Clean Development Mechanism (CDM), Japanese Crediting Mechanism, and International Performance Measurement Verification Protocol (IPMVP) were reviewed. Moreover, methodologies included in building NAMAs in some countries were also reviewed.

The following specific methodologies reviewed:

 IPCC Guidelines for GHG inventory estimations of emissions from the Energy Industries sector (1A1): Main Activity Electricity and Heat Production (Subsector 1A1a) Others sector (1A4): Commercial/ institutional buildings (Subsector 1A4a) and residential buildings (1A4b)<sup>2</sup>[2]

### 2- CDM methodologies

Large scale: AM0091: Energy efficiency technologies and fuel switching in new and existing buildings<sup>3</sup>[3]

**ACM0022:** Alternative waste treatment processes<sup>4</sup>[4] **AM0107:** New natural gas based cogeneration plant<sup>5</sup>[5] **Small scale methodologies:** 

- AMS-II.E: Energy efficiency and fuel switching measures for buildings<sup>6</sup>[6]
- AMS-II.R: Energy efficiency space heating measures for residential buildings<sup>7</sup>[7]
- AMS-II.Q: Energy efficiency and/or energy supply projects in commercial buildings<sup>8</sup>[8]
- AMS-III.AE: Energy efficiency and renewable energy measures in new residential buildings<sup>9</sup>[9]
- **3-** International Performance Measurement Verification Protocol (IPMVP): Volumes 1<sup>10</sup> and 3<sup>11</sup>[10, 11]
- 4- Japanese Crediting Mechanism (JCM)- MN\_AM003 "Installation of Solar PV System"<sup>12</sup>[12]

The following chapters provide detailed analysis of these methodologies, assessment of needed data and proposed methodology to be used. The document also presents an analysis for the estimation of the electricity grid emission factor and thermal energy production emission factor using different methodologies with focus on the estimation methods in case of CHPs.

- <sup>7</sup> UNFCCC, 2013: 3-9.
- <sup>8</sup> UNFCCC, 2012: 1-15.
- <sup>9</sup> UNFCCC, 2009: 1-7.

<sup>&</sup>lt;sup>2</sup> Darío R. Gómez, et al., 2006: 2.7-2.24.

<sup>&</sup>lt;sup>3</sup> UNFCCC, 2015: 4-107.

<sup>&</sup>lt;sup>4</sup> UNFCCC, 2014: 31.

<sup>&</sup>lt;sup>5</sup> UNFCCC, 2014: 1-12.

<sup>&</sup>lt;sup>6</sup> UNFCCC, 2007: 1-6.

<sup>&</sup>lt;sup>10</sup> International Performance Measurement and Verification Protocol, 2012: 7-35.

<sup>&</sup>lt;sup>11</sup> International Performance Measurement & Verification Protocol, 2003: 11-23.

<sup>&</sup>lt;sup>12</sup> Institute for Global Environmental Strategies, 2017: 1-4.

## 2 Review of the Relevant IPCC Guidelines for GHG Emissions from Buildings

In this section, the relevant IPCC guidelines contained in Volume 2<sup>13</sup>, Chapter 2: Stationary Combustion are reviewed[2]; the relevant categories are:

- Category 1A1 (Energy Industries); mainly subcategory 1A1a (Main Activity Electricity and Heat Production)
- Category 1A4 (other sectors). This includes subcategory 1A4a (emissions from fuel combustion activities in commercial/ institutional buildings) and subcategory 1A4b (emissions from fuel combustion activities in residential buildings).

## 2.1 Category 1A1-Energy Industries

## Scope of subcategory 1A1a- Main Activity Electricity and Heat Production

This category applies to fuel combustion activities consisting of activities with main purpose to supply energy as electricity, heat or both to the public. Captive energy generation is known as Autoproducers in the IPCC guidelines. They are defined as "undertakings which generate electricity/heat wholly or partly for their own use" are not included in this category. "Emissions from autoproducers should be assigned to the sector where they were generated and not under 1 A 1 a". Autoproducers may be in public or private ownership.

In the case of Mongolia, CHPs producing electricity and heat and supplying to the grid and district heating system belong to this category since the main purpose is to generate heat and power.

## 2.2 Category 1A4-Other Sectors

This category applies to combustion activities that result in the generation and use of the generated energy, including electricity and heat, by the same entity/within the same sector, i.e., autoproducers. This category is further subdivided for commercial/institutional (subdivision **1A4a**) and residential (subdivision **1A4b.**)

Applicability of 1A4-Other Sectors to Mongolia: In the case of Mongolia, this source category applies to small and medium boilers generating hot water and/or space heating for buildings not connected to district heating network. Also, it applies to stoves burning coal used in rural areas and GERs for cooking and heating purposes.

### 2.2.1 Scope of 1A4a

This subdivision applies to fuel combustion in commercial and institutional buildings. All activities included in International Standard Industrial Classification of All Economic Activities (ISIC Divisions 41, 50, 51, 52, 55, 63-67, 70-75, 80, 85, 90-93 and 99) are applicable to this source category.

<sup>&</sup>lt;sup>13</sup> Darío R. Gómez, et al., 2006: 2.7-2.24

#### 2.2.2 Scope of 1A4b

This source category applies to fuel combustion in households.

## 2.3 Approach for Calculation of GHG Emissions

Emissions of greenhouse gases from stationary sources are calculated by multiplying fuel consumption by the corresponding emission factor for each type of fuel according to:

#### Equation 2-1

Emissions GHG, fuel = Fuel Consumption fuel • Emission Factor GHG, fuel
---

Where:	
Emissions <sub>GHG, fuel</sub>	= emissions of a given GHG by type of fuel (kg GHG)
Fuel Consumption fuel	= Amount of fuel combusted (TJ)
Emission Factor GHG, fuel	= default emission factor of a given GHG by type of fuel (kg gas/TJ). For
	$CO_2$ , it includes the carbon oxidation factor, assumed to be 1.

In other words, fuel consumption data (amount and type) constitute activity data. The total emissions due to combustion activities are determined by summing emissions (calculated according to Equation 1) of all fuels by:

#### Equation 2-2

## Emissions <sub>GHG</sub> = $\sum_{fuel} Emissions_{GHG,fuel}$

For the determination of emissions in the sector, "Fuel Consumption" is estimated from energy use statistics and is measured in Terajoules. Fuel consumption data in mass or volume units must first be converted into the energy content of these fuels.

The IPCC guidelines define three approaches, namely, Tier 1, 2 and 3, for the calculation of GHG emissions. The 3 Tiers depend on the level and specificity of activity data available, namely fuel consumption and emission factors (EF). Tier 1 requires general data (e.g., national statistics and IPCC EF default values), Tier 2 requires country-specific data (EF derived from national fuel characteristics), and Tier 3 requires country-specific (EF derived from national fuel characteristics) and technology specific data (combustion technology, facility level emissions data.)

The approaches are not applicable to biomass. In the case of mix use of biofuel and fossil fuel, 'the split between the fossil and non-fossil fraction of the fuel should be established and the emission factors applied to the appropriate fractions.'

GHG emissions include CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O. CO<sub>2</sub> emissions are largely fuel-dependent, while CH<sub>4</sub> and N<sub>2</sub>O are technology dependent. Therefore, emissions of CH<sub>4</sub> and N<sub>2</sub>O will be relevant only if technology characteristics are available. The following table outlines data required for the application of each Tier.

## Table 2-1: Data required for the application of IPCC Tier 1, 2, and 3

Tier
Tier 1: Activity data:
Data on the amount and type of fuel combuste

• Data on the amount and type of fuel combusted in the source category determined from national statistics

• IPCC default emission factor for  $CO_2$ ,  $CH_4$ , and  $N_2O$ - default emission factors are provided for aforementioned subdivision (1A1a, 1A4a, and 1A4b) using an average carbon content value for fuel

- Default emission factor for stationary combustion in energy industry (Table 2.2)
- Default emission factor for stationary combustion in commercial/institutional category (Table 2.4)
- Default emission factor for stationary combustion in residential category (Table 2.5)

Default emission factors for  $N_2O$  and  $CH_4$  are not applicable to technologies with emission controls

**Tier 2:** Activity data-approach is fuel-based (fuel-based disaggregation)

• Data on the amount and type of fuel combusted in the source category;

• A country-specific emission factor for the source category and fuel for each gas.

Country specific data is derived from national/regional measurements (fuel characteristics), where carbon content and oxidation factor of each fuel is used.

**Tier 3:** This approach is fuel and combustion technology based with corresponding emission factors. Technology encompasses 'any device, combustion process or fuel property that might influence the emissions.'

## Fuel characteristics amount used and type

- Combustion technology,
- Operating conditions,
- Control technology,
- Quality of maintenance,
- Age of the equipment used to burn the fuel.

**Technology characteristics** to determine specific emission factor: fuel type used, combustion technology, operating conditions, control technology, oxidation factor, and maintenance and age of the equipment

Facility level measurements if available

Applicable to non-CO $_2$  GHG: CH $_4$  and  $N_2O$ 

Applicable for systems with  $CO_2$  storage

Greenhouse Gas Emissions By Technology are determined by the following equation:

## Equation 2-3

Emissions  $_{GHG, fuel, technology} = Fuel Consumption_{fuel technology}$ . Emission Factor<sub>GHG, fuel technology</sub>

To minimize uncertainties pertinent to fuel consumption data, data on fuel supply and deliveries should be collected to serve as a cross checking tool.

## 2.4 Assessment and Applicability to Mongolia:

The IPCC methodology cannot isolate emissions attributed to buildings from those of other sectors. If the power and heat generation plants supply electricity and heat to other sectors e.g., agriculture or industry, it would not be possible to isolate emissions generated from the building sector from the total emissions of the CHP plants. Therefore, the IPCC methodologies are not applicable to estimate inventory emissions from the building sector.

## 3 CDM Methodologies

CDM methodologies were developed with the objective of helping developed countries reduce their emissions by earning certified emissions reductions (CERs) that can be sold. CDM methodologies were specifically developed to provide stringent guidelines for the calculations of emissions reductions. Another objective of CDM is to serve as basis for the development of standardized baselines. The methodologies relevant to the present project and reviewed consist of the following:

## Large scale methodologies:

- AM0091: Energy efficiency technologies and fuel switching in new and existing buildings
- ACM0022: Alternative waste treatment processes
- AM0107: New natural gas based cogeneration plant

### Small scale methodologies:

- AMS-II.E: Energy efficiency and fuel switching measures for buildings
- AMS-II.R: Energy efficiency space heating measures for residential buildings
- AMS-II.Q: Energy efficiency and/or energy supply projects in commercial buildings
- AMS-II.AE: Energy efficiency and renewable energy measures in new residential buildings

The applicability of methodologies was assessed according to 6 principal criteria. The selection criteria are as follows:

- Emissions reduction isolation
- Building status: new and existing
- Building types: categories to be covered: residential, commercial, hospitals, hotels, education building
- Energy source (CHPs, boilers, stoves)
- Ease of implementation-not data exhaustive, no computer simulations required etc.
- Data availability (data available should be consistent and accurate)

Detailed evaluations of the aforementioned methodologies are presented in Annex I: Assessment of Existing CDM Methodologies. These Methodologies were assessed according to 6 criteria presented in Table 3-1.

In light of the assessment, AMS II.E was selected. AMS II.E is general and refers to AM00091 for specific calculations of emissions. Since several parts of AM00091 are detailed to levels not required and/or not applicable for Mongolia, e.g., extensive building categories, modification were made to tailor-fit the methodology to Mongolia's context. The recommended modified methodology is presented in Chapter 7. As AM0091 references tools for the calculation of emission factor from an electricity system, Chapter 7 is dedicated to the description of methodology against the context in Mongolia, i.e., the available data, and summarized in the matrix below are presented in Annex I and Annex IV.

	Emissions	Applicability conditions			Ease of	Data
Methodology	reductions isolation (to specific measures)	<b>Building</b> New-N Existing-E	<b>Category</b> Residential-R Commercial-C Institutional-I	Energy source CHP/ boilers	implementation Computer simulation-CS, expert assess-S	availability, consistent, accurate
IPCC	x	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	√ т1,т2 <b>Х</b> т3
CDM -AM0091	V	V	V	X no CHP	√*	✔ if no CS
CDM -AMS II.R	X Space heating only	X N-anly	X R-only			X Building/tenancy
CDM -AMS II.E	√	$\checkmark$	√	√	$\checkmark$	$\checkmark$
CDM -AMS-III.AE	$\checkmark$	x	<b>X</b> R-only	X No fossil fuel	X -Approach 1 CS √- Approach 2	X Building/tenancy
CDM -AMS II.Q	$\checkmark$	$\checkmark$	X C-only	$\checkmark$	X CS	x
IPMVP-A	<b>√</b> ES	$\checkmark$	$\checkmark$		X S	$\checkmark$
IPMVP-B	<b>√</b> ES	$\checkmark$	$\checkmark$		$\checkmark$	X Full measurement
IPMVP-C	<b>√</b> ES	$\checkmark$	$\checkmark$		$\checkmark$	√ Existing-Energy data X New-building data
IPMVP-D	<b>√</b> ES	$\checkmark$	$\checkmark$		X CS	x

## Table 3-1: Summary of methodologies and assessment criteria for applicability in Mongolia

✓ covered by the methodology
 X Not covered by the methodology

# 4 Review of the International Performance Measurement and Verification Protocol for GHG Emissions from Buildings

In this chapter, the International Performance Measurement Verification Protocol (IPMVP) was reviewed and the main outcomes summarized. The IPMVP provides an overview of current best practice techniques available for verifying results of energy efficiency, water efficiency, and renewable energy projects with the objective of increasing investments in efficiency projects. The IPMVP is used when payments or contracts need to be issued on the basis of performance. In that respect, the IPMVP acts as trusted source outlining good practice for estimating savings. For example, using the IPMVP as a basis to design measurement and verification for projects or to generate energy-savings reports can facilitate acquisition of energy performance contracts and payments (if dependent on performance.)<sup>14,15</sup> [13, 14]

The International Performance Measurement and Verification Protocol consists of Volumes I, II, III. Volume I pertains to Concepts and Options for Determining Energy and Water Savings with focus on retrofitting existing buildings. Volume 2 addresses Improved Indoor Environmental Quality. Volume 3 addresses Concepts and Options for Determining Energy Savings in New Construction.

## 4.1 Scope and Applicability

## 4.1.1 Volume I: Concepts and Options for Determining Energy and Water Savings

Volume 1 is mainly for retrofitting existing buildings. The main features of Volume 1 are summarized in the following points<sup>16</sup>[10]:

- Provides energy efficiency project buyers, sellers and financiers a common set of terms to discuss key M&V project-related issues and establishes methods which can be used in energy performance contracts.
- Defines broad techniques for determining savings from both a "whole facility" and an individual technology.
- Applies to a variety of facilities including residential, commercial, institutional and industrial buildings, and industrial processes.
- Provides outline procedures which i) can be applied to similar projects throughout all geographic regions, and ii) are internationally accepted, impartial and reliable.
- Presents procedures, with varying levels of accuracy and cost, for measuring and/or verifying: i) baseline and project installation conditions, and ii) long-term energy savings.
- Provides a comprehensive approach to ensuring that building indoor environmental quality issues are addressed in all phases of ECM design, implementation and maintenance.
- Creates a living document that includes a set of methodologies and procedures that enable the document to evolve over time.

<sup>&</sup>lt;sup>14</sup> Efficiency Valuation Organization, 2018. <u>https://evo-world.org/en/products-services-mainmenu-</u> en/protocols/ipmvp, accessed: 25.06.2018

<sup>&</sup>lt;sup>15</sup> International Performance Measurement & Verification Protocol, 2002:17-35

<sup>&</sup>lt;sup>16</sup> Efficiency Valuation Organization, 2012: 7-35.

### 4.1.2 Volume II: Improved Indoor Environmental Quality.

This document provides more detailed information on indoor air pollution than on thermal comfort and lighting, which is not within the scope of measuring baseline GHG emissions due to energy consumption and is therefore not addressed further.

## 4.1.3 Volume III: Applications

This document<sup>17</sup>[11] is mainly addressing the energy efficiency measures in new buildings. It is broadly consistent with IPMVP Volume I and uses the same format and key terms, some concepts and definitions have been modified to suit new construction. It should not be applied to retrofit savings determination. This document also does not address sampling methodologies for large-scale programs involving multiple buildings.

## 4.2 Estimating Energy Savings

## 4.2.1 Existing Buildings

The following equation is used to estimate energy savings:

### Energy Savings = Base year Energy Use - Post-Retrofit Energy Use ± Adjustments

This "Adjustments" term distinguishes proper savings reports from a simple comparison of cost or usage before and after implementation of an energy conservation measure. "Adjustments" can be classified into:

- Routine Adjustments: for any energy-governing factors, expected to change routinely during the reporting period, such as weather and occupancy. A variety of techniques can be used to define the adjustment methodology. Techniques may be as simple as a constant value (no adjustment) or as complex as a several multiple parameter non-linear equations each correlating energy with one or more independent variables.
- Non-Routine Adjustments: for those energy-governing factors which are not usually expected to change, such as the facility size and the design and operation of installed equipment.

### 4.2.2 New Buildings

The baseline for new construction M&V is usually hypothetical - it cannot be measured or monitored in the same way that a retrofit baseline can be physically documented. The baseline for new construction must therefore be postulated, defined, and developed.

The following equation is used to estimate energy savings:

### Energy Savings = Projected Baseline year Energy Use - Post-Construction Energy Use

<sup>&</sup>lt;sup>17</sup> International Performance Measurement & Verification Protocol, 2003: 11-23.

In new construction there is no "adjustments". Instead, the baseline is adjusted to account for operating conditions during the M&V period and the Projected Baseline Energy Use is generated. The adjustments are derived from identifiable physical facts such as weather, occupancy, and system operating parameters.

## 4.2.3 Different Options for Energy Savings for both New and Existing Buildings

There are four options for estimating energy savings; Option A, B, C and D). If it is decided to determine savings at the facility level (whole-building approach), Option C or D is favored. However if only the performance of the energy conservation measure (ECM) itself is of concern, a component-based technique may be more suitable, then Option A or B is preferred. The following sub-sections provide a brief on each option.

## 4.2.3.1 Option A

Option A involves isolation of the energy use of the equipment affected by an ECM from the energy use of the rest of the facility. Measurement equipment is used to isolate all relevant energy flows pre and post the project. Only partial measurement is used under Option A, with some parameter(s) being stipulated rather than measured. Factors beyond the control of the equipment manufacturer and not relevant to the performance guarantee (e.g. operating hours) should be considered for stipulation. Option A is applicable in the following cases:

- The performance of only the systems affected by the ECM is of concern
- For ECMs and systems with constant and/or predictable loads such as fixed-speed motors and lighting equipment
- Where the additional cost of performing a Whole Building Calibrated Simulation cannot be justified.
- The stipulations can be readily reviewed and confirmed.

In case of new buildings, the projection of baseline can be based on:

- Energy codes and standards.
- In the absence of codes or standards, a baseline can be developed from a proposed design by removing the pertinent ECMs or design features.

## 4.2.3.2 **Option B**

The savings determination techniques of Option B are identical to those of Option A except that no stipulations are allowed under Option B. In other words, **full measurement is required**. Short term or continuous metering may be used under Option B. Continuous metering provides greater certainty in reported savings and more data about equipment operation. Option B is applicable in the following cases:

- The performance of only the systems affected by the ECM is of concern
- ECMs and systems with variable loads such as variable speed fan and pump drives, chillers, boilers, etc. and where the additional cost of performing a whole building calibrated simulation cannot be justified.
- The uncertainty created by stipulations is unacceptable.

In case of new buildings, the projection of baseline can be based on:

- Energy codes and standards.
- In the absence of codes or standards, a baseline can be developed from a proposed design by removing the pertinent ECMs or design features.

## 4.2.3.3 Option C

This option involves use of utility meters, whole-facility meters, or sub-meters to assess the energy performance of a total facility.

## Existing buildings

Option C usually requires 12, 24, or 36 months (i.e., one full year or multiple years) of continuous base year daily or monthly energy data, and continuous data during the post-retrofit period. Hourly data should be aggregated at least to the daily level to control the number of independent variables required to produce a reasonable model of the base year, without significant impact on the uncertainty in computed savings. The "Adjustments" referred to in the equation above will be determined using regression analysis of the relevant independent variables

Option C is best applied in the following cases:

- The energy performance of the whole facility will be assessed, not just the ECMs.
- There are many types of ECMs in one facility.
- The ECMs involve activities whose individual energy use is difficult to separately measure (operator training, wall or window upgrades, for example).
- When Retrofit-Isolation techniques (Option A or B) are excessively complex. For example, when interactive effects or interactions between ECMs are substantial.
- Reasonable correlations can be found between energy use and other independent variables.

### New buildings

The Projected Baseline Energy Use is the energy use of a "control group" of similar buildings without the ECMs or design enhancements. For "new buildings", regression equation is not used to project the performance of the baseline buildings throughout the project/programme period. Hence, the successful application of Option C depends on identifying buildings that are as similar as possible to the subject building. Minimum considerations in identifying Baseline buildings should include:

- Location and/or climate
- Use, occupancy, and operational scheduling
- General configuration e.g. floor area, shape, orientation
- Envelope configuration and construction e.g. R-value, fenestration type and
- area, mass
- Lighting, plug, and miscellaneous electrical power densities
- HVAC configuration and operation
- Operational stability

### Option C is best applied where:

- The M&V focus is on whole building performance rather than individual ECMs.
- A high level of savings accuracy is not required.
- An appropriate population of potential Baseline buildings is available.

• The budget for M&V is limited.

## 4.2.3.4 Option D

Option D involves the use of computer simulation software to predict facility energy use for baseline and project scenarios. Such *simulation model* must be "calibrated" so that it predicts an energy use and demand pattern that reasonably matches actual energy consumption data.

Option D may be used to assess the performance of all ECMs in a facility, similar to Option C. However, different from Option C, multiple runs of the simulation tool in Option D allow estimates of the savings attributable to each ECM within a multiple ECM project.

Option D may also be used to assess just the performance of individual systems within a facility, similar to Options A and B. In this case, the system's energy use must be isolated from that of the rest of the facility by appropriate meters.

The following steps are used to calibrate the simulation model:

- 1. Get the energy bills
- 2. Get as much as possible of detailed operating data from the facility. These data might include operating characteristics, occupancy, weather, loads and equipment efficiency.
- 3. Assume other necessary input parameters, and document them.
- 4. Whenever possible, gather actual weather data from the calibration period
- 5. Run the simulation and verify that it predicts operating parameters such as temperature and humidity.
- 6. Compare the simulated energy results with the metered energy data from the calibration period, on an hourly or monthly basis.
- 7. Evaluate patterns in the differences between simulation results and calibration data.
- 8. Revise input data in step 3 and repeat steps 5 and 6 to bring predicted results within the calibration specifications in 7, above. Collect more actual operating data from the facility to meet the calibration specification if necessary.

### Existing buildings

Option D is especially useful where Baseline energy data do not exist or are unavailable. It is also useful when it is too difficult to predict how future facility changes might affect energy use; hence, using Options A, B or C would create excessive error in the savings determination.

Option D is best applied where:

- Either baseline energy data or reporting-period energy data, but not both, is unavailable or unreliable.
- There are too many ECMs to assess using Options A or B.
- The ECMs involve diffuse activities, which cannot easily be isolated from the rest of the facility, such as operator training or wall and window upgrades.
- The performance of each ECM will be estimated individually within a multiple-ECM project, but the costs of Options A or B are excessive.
- Interactions between ECMs or ECM interactive effects are complex, making the isolation techniques of Options A and B impractical.

- An experienced energy-simulation professional is able to gather appropriate input data to calibrate the simulation model.
- Simulation software predicts metered calibration data with acceptable accuracy.

### New buildings

Option D involves computer simulation of whole building energy use. The Post-Construction Energy Use is determined by utility metering and/or sub-metering or by using an energy simulation model of the asbuilt building calibrated to metered energy use data. The Projected Baseline Energy Use is determined by energy simulation of the baseline under the climatic and operating conditions of the M&V period.

Option D is best applied where:

• The M&V focus is on interrelated ECMs and systems, or whole building performance rather than simple individual ECMs.

- A high degree of accuracy in savings determination is required.
- The budget for M&V is generous.

## 4.2.4 Comparison between the Different Options

The following two figures Figure 4-1 and Figure 4-2 present a guide for selecting the appropriate option for existing and new buildings respectively.



Figure 4-1 Guide for selecting IPMVP options for existing buildings<sup>18</sup>[10]

<sup>&</sup>lt;sup>18</sup> Efficiency Valuation Organization, 2012: 33.



Figure 4-2 Guide for selecting IPMVP options for new buildings<sup>19</sup>[11]

## 4.3 Recommended Option for Mongolia

Following the flow chart in Figure 4-1, it is recommended to use Option C, which is based on using utility meters (electricity and fuel bills can also be used) for the whole building. This is because this approach can measure the emission reduction as a result of group of measures in a building. The data requirements are fairly simple and not as complex as in the case of modeling. Modeling is also not required since there is no specific need to estimate emission reduction for each measure but rather for the whole building.

<sup>&</sup>lt;sup>19</sup> International Performance Measurement & Verification Protocol, 2003: 11-23.

## 5 Review of NAMAs, NIRs, BURs and NCs from Other Countries for GHG Emissions from Buildings

The practical experience of Annex I countries can be utilized by checking the estimation methodologies used in their national inventory reports (NIRs). In addition, the practical experience of other non-Annex I countries (including countries with similar national circumstances to Mongolia) can be utilized by checking estimation methodologies used in their NCs, BURs and NAMAs. The main relevant outcomes of the review of such methodologies are categorized and summarized in Table 5-1.

Source	Category	Estimation methodology	Parameters monitored	
<b>Sweden</b> NIR 2017 <sup>20</sup> [15]	IPCC category: 1A1a	IPCC-Tier 2	Quarterly fuel statistics, country specific emission factors	
	IPCC category: 1A4a	IPCC-Tier 2	National level by fuel type	
	IPCC category: 1A4b	IPCC-Tier 2	National level by fuel type	
<b>Netherlands NIR</b> <b>2017<sup>21</sup></b> [16]	IPCC category: 1A1a	IPCC-Tier 2	Fuel statistics, country specific emission factors	
	IPCC category: 1A4a	IPCC-Tier 2	National level by fuel type	
	IPCC category: 1A4b	IPCC-Tier 2	National level by fuel type	
Georgia NAMA for energy efficient refurbishment in the public building sector in Georgia <sup>22</sup> [17]	<u>Building Category:</u> <u>existing</u> <u>residential building</u> s	Not defined	<ul> <li>Number of residences/buildings renovated (Database to be developed)</li> <li>Historic annual electricity and primary thermal energy consumption (kWh/m<sup>2</sup>). Energy auditors will estimate this using the corresponding energy bills</li> <li>Annual Energy savings</li> <li>Buildings age groups (construction year)</li> <li>Floor area</li> </ul>	
Georgia NIR <sup>23</sup> [18]	IPCC category: 1A1	IPCC-Tier 1	<ul> <li>Annual national level data by fuel type</li> <li>IPCC default emission factors</li> </ul>	
	IPCC category: 1A4	IPCC-Tier 1	<ul> <li>Annual national level data by fuel type</li> <li>IPCC default emission factors</li> </ul>	

Table 5-1 Comparison of estimation methodologies employed by various countries

 <sup>&</sup>lt;sup>20</sup> Swedish Environmental Protection Agency, 2017: 127-132, 175-182
 <sup>21</sup> National Institute for Public Health and the Environment (RIVM), 2017: 73, 279
 <sup>22</sup> Mitigation Momentum, 2016 :57-58
 <sup>23</sup> Ministry of Environment and Natural Resources Protection of Georgia, et al., 2016: 42-48

Source	Category	Estimation methodology	Parameters monitored
Mexico Third NC <sup>24</sup> [19]	IPCC category: 1A4b	IPCC-Tier 1	<ul> <li>Annual national level data by fuel type</li> <li>IPCC default emission factors</li> </ul>
Mexico NAMA Design working paper <sup>25</sup> [20]	Building Category: new residential building	<ul> <li>Whole building Benchmarking approach for determining the baseline conditions based on energy consumption per gross floor area.</li> <li>Benchmark will be created only for primary, year-round residence and for buildings built in the recent 5 years. The following aggregation will also be considered:</li> <li>Building type</li> <li>Climate condition</li> <li>Building size:</li> </ul>	<ul> <li>Electricity consumption-Direct and continuous metering, if available utility billing records</li> <li>Emission factor of electricity grid</li> <li>Transmission/distribution loss</li> <li>Fuel consumption- Direct and continuous metering and if available utility billing records or fuel purchase invoices</li> <li>Net calorific value of fuel</li> <li>CO<sub>2</sub> fuel emission factor (fuel supplier invoices, own measurement, or regional or national default value)</li> <li>Refrigerant leakage from refrigerators and air-conditioners (IPCC default value or manufacturer specifications.)</li> <li>Gross floor area of a building unit (Building plan, or onsite measurement.)</li> </ul>

 <sup>&</sup>lt;sup>24</sup> Ministry of Environment and Natural Resources, 2007: 34-43, 61
 <sup>25</sup> Stefan, W., et al., 2010: 57-58

Source	Category	Estimation methodology	Parameters monitored
Mexico	Building Category:	'Whole house' approach. The energy	• Energy consumption data (billing)
NAMA for	Existing residential buildings	consumption of the baseline is then	(gas, water and electricity
Sustainable		continuously updated based on the same	consumption) prior to programme
Housing		comfort conditions of	
Retrofit <sup>26</sup> [21]		improved housing (improved housing indoor temperature and external climate conditions will be monitored) using a calculation tool. Sampling will be used to estimate emission	<ul> <li>Energy consumption data (billing) (gas, water and electricity consumption) of the programme buildings</li> <li>Room temperature</li> <li>External climate conditions</li> </ul>

<sup>&</sup>lt;sup>26</sup> Susanne Theumer, et al., 2014: 17-22, 31-33

Mexico <sup>27</sup> [22]       Building Category: New residential building       Whole building Benchmarking approach for determining the baseline conditions based on energy consumption per gross floor area.       • Electricity consumption (kWh) by metered measurement (bimonthly and aggregated annually)         Gas consumption (L) (gas meter or simulation)       • Benchmark will be created only for buildings built in the recent 5 years, assuming 2 occupants per house <sup>28</sup> , and assuming range for the comfort temperature. The following aggregation will also be considered:       • Water consumption (L) (water meter-aggregated annually)         • Building type       • Climate condition       • Building type         • Climate condition       • Climate condition       • Belectricity consumption (L) (water meter-aggregated annually)         Sampling will be used to estimate emission reductions       • Building type       • Climate condition         • Climate condition       • Building type       • Climate condition         • Climate conditions       • Building type       • Electricity consumption: Housing, heating, refrigerator, lighting, appliances among others (AC etc.)         • Water consumption: Housing, heating, refrigerator, lighting, appliances among others (AC etc.)       • Water consumption: shower, washing machines, toilets (monthly/annually)         • Relative humidity: interior wall, exterior       • Relative humidity: interior wall, exterior

<sup>&</sup>lt;sup>27</sup> Robert, K., et al., 2012: 36-43
<sup>28</sup> Occupants are not using the property 100% of the time

Source	Category	Estimation methodology	Parameters monitored
Mexico Small and Medium Business (SME) NAMA <sup>29</sup> [23]	Building Category: Commercial- Small and medium enterprises	energy/GHG savings due to substitution of equipment are estimated using IT system which tracks all equipment substitutions (refrigerators, air conditioners, etc.) taking place nationwide. The IT system is calibrated through field measurements. It estimates average savings to be realized from the substitution, taking into account the working hours and climatic region of the SME.	<ul> <li>Obsolete equipment specifications based on catalogues (commercial refrigerators, air conditioners, lighting, etc.)</li> <li>New units (brand, model, capacity)</li> <li>Working hours of SME</li> <li>climatic region of the SME.</li> </ul>
Bosnia- Herzegovina GCF funding proposal <sup>30</sup> [24]	Building Category: Existing residential buildings	Emission reductions are calculated based on avoided quantity of fuel consumption (as a result of energy efficiency and fuel switching measures) by multiplying baseline energy use by relevant GHG Emission. Energy management information system (EMIS) has been used to record the baseline performance factor	<ul> <li>Energy use (Energy management information system) of the project buildings</li> <li>Energy sources (Energy management information system) of the project buildings</li> </ul>

<sup>&</sup>lt;sup>29</sup> Ministry of Energy (SENER) and GIZ, 2017, <u>http://www.nama-database.org/index.php/Small\_and\_Medium\_Business\_(SME)\_NAMA</u> accessed: 25.06.2018 <sup>30</sup> Green Climate Fund, 2017: 39,75

## 6 Estimation of Grid Emission Factor

There are several approaches for the calculation of grid emission factors for power plants. Those approaches include the CDM methodological tool to calculate the emission factor for an electricity system and the JCM Approved Methodology MN\_AM003.

In case of the existence of CHP plants as suppliers of electricity to the grid, an approach to apportion the fuel consumption between electricity and heat is needed. Various methods for the allocation of emissions from CHPs are grouped into three principal approaches: efficiency, energy, and exergy based methods. A detailed description of each approach is provided in Annex II: Various Methodologies for Allocating Energy Consumption and Associated CO<sub>2</sub> Emissions from Cogeneration Plants.

The following sections present a summary of the different approaches for the calculation of grid emission factors for power plants, which is required for the estimation of emissions due to electricity consumption.

## 6.1 Approach followed in the submitted Mongolian Standardized Baseline for the emission factor of the national electricity grid

Mongolia has submitted a standardized baseline for its grid emission factor. The methodology used the CDM Tool to calculate the emission factor for an electricity system. Since most of the electricity generation in Mongolia is based on CHPs, the submitted standardized baseline tackled this point by reporting on the use of specific fuel consumption for electricity generation only as opposed to total fuel consumption, which corresponds to consumption for electricity and heat generation. The methodology for apportioning the fuel consumption between electricity and heat is not clear. However, these values are obtained from the "Ministry of Energy" as was the case in the registered Mongolian CDM projects. Such specific fuel consumption is more or less a representation of the reference efficiency for electricity generation. Hence, this approach is similar to the "Shared emissions savings" and "harmonized efficiency reference values" methodologies discussed in Annex II: Various Methodologies for Allocating Energy Consumption and Associated  $CO_2$  Emissions from Cogeneration Plants.

## 6.2 CDM Tool to Calculate the Emission Factor for an Electricity System

This methodological tool<sup>31</sup> [25] determines the CO<sub>2</sub> emission factor for the displacement of electricity generated by power plants in an electricity system, by calculating the "combined margin" emission factor (CM) of the electricity system.

The CM is the result of a weighted average of two emission factors pertaining to the electricity system: the "operating margin" (OM) and the "build margin" (BM).

Where:

**The operating margin:** Is the emission factor that refers to the group of existing power plants whose current electricity generation would be affected by the proposed CDM project activity.

**The build margin:** Is the emission factor that refers to the group of prospective power plants whose construction and future operation would be affected by the proposed CDM project activity.

<sup>&</sup>lt;sup>31</sup> UNFCCC, 2015: 4-31.

## Applicability

This tool may be applied to estimate the **Operating Margin (OM)**, **Building Margin (BM) and/or Combined Margin (CM)** when calculating baseline emissions for a project activity that substitutes grid electricity that is where a project activity supplies electricity to a grid or a project activity that results in savings of electricity that would have been provided by the grid (e.g. demand-side energy efficiency projects).

## **Baseline Methodology Procedure**

Step 1: Identify the relevant electricity systems;

Step 2: Choose whether to include off-grid power plants in the project electricity system (optional);

Step 3: Select a method to determine the operating margin (OM);

Step 4: Calculate the operating margin emission factor according to the selected method;

Step 5: Calculate the build margin (BM) emission factor;

Step 6: Calculate the combined margin (CM) emission factor.

## Step 1: Any connected electricity systems should be identified

If a connected electricity system is located partially or totally in Annex I countries, then the emission factor of that connected electricity system should be considered zero.

## Step 2: Choose whether to include off-grid power plants in the project electricity system (optional)

Project participants may choose between the following two options to calculate the operating margin and build margin emission factor:

Option I	Option II
Only grid power plants are included in the calculation	Both grid power plants and off-grid power plants are included in the calculation

The CDM projects in Mongolia usually chose Option I.

### Step 3: Select a method to determine the operating margin (OM)

The calculation of the operating margin emission factor  $(EF_{grid,OM,y})$  is based on one of the following methods, which are described under Step 4:

(a) Simple OM; or

(b) Simple adjusted OM; or

(c) Dispatch data analysis OM; or

(d) Average OM.

The following figure presents a flow chart OM selection guide. According to the CDM projects in Mongolia, the criteria required for applying the Simple OM are met; hence, it was usually used.



### Step 4: Calculate the operating margin emission factor according to the Simple OM Method

The simple OM emission factor is calculated as the generation-weighted average  $CO_2$  emissions per unit net electricity generation (t $CO_2$ /MWh) of all generating power plants serving the system, not including low-cost/must-run power plants/units.

#### The simple OM may be calculated by one of the following two options:

(a) Option A: Based on the net electricity generation and a  $CO_2$  emission factor of each power unit; or (b) Option B: Based on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system.

According to the CDM projects in Mongolia, the fuel consumption and the total electricity generation of each power plant connected to the grid are available; hence, Option A is applied.

The following equations are used:

#### **Equation 6-1**

$$EF_{grid,OMsimple,y} = \frac{\sum_{m} EG_{m,y} \times EF_{EL,m,y}}{\sum_{m} EG_{m,y}}$$

Where:	
EF <sub>grid,OMsimple,y</sub> =	Simple operating margin CO <sub>2</sub> emission factor in year y (tCO <sub>2</sub> /MWh)
EG <sub>m,y</sub> =	Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
EF <sub>EL,m,y</sub> =	$CO_2$ emission factor of power unit m in year y (tCO <sub>2</sub> /MWh)
M=	All power units serving the grid in year y except low-cost/must-run
	power units
Y=	Relevant year as per the data vintage chosen in Step 3

The emission factor  $(EF_{EL,m,y})$  should be determined as follows (where data on fuel consumption and electricity generation is available for each power plant)

## Equation 6-2

$$EF_{El,m,y} = \frac{\sum_{i} FC_{i,m,y} \times NCV_{i,y} \times EF_{CO2,i,y}}{EG_{m,y}}$$

Where:	
FC <sub>i,m,y</sub> =	Amount of fuel type i consumed by power unit m in year y (Mass or volume unit)
NCV <sub>i,y</sub> =	Net calorific value (energy content) of fuel type i in year y (GJ/mass or volume unit)
EF <sub>CO2,i,y</sub> =	$CO_2$ emission factor of fuel type i in year y (tCO <sub>2</sub> /GJ)
EG <sub>m,y</sub> =	Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
m=	All power units serving the grid in year y except low-cost/must-run power u nits
i=	All fuel types combusted in power unit m in year y
<b>y</b> =	Relevant year as per the data vintage chosen in Step 3

#### Step 5: Calculate the Build Margin (BM) emission factor

In terms of vintage of data, project participants can choose between one of the following two options:

Option 1	Option 2			
For the first crediting period Calculate the build margin emission factor ex ante based on the most recent information available on units already built for sample group m at the time of CDM-PDD submission to the DOE for validation.	For the first crediting period For the first crediting period, the build margin emission factor shall be updated annually, ex post, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available.			
For the second crediting period The build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the	For the second crediting period For the second crediting period, the build margin emissions factor shall be calculated ex ante, as described in Option 1			

Option 1	Option 2
crediting period to the DOE.	
<b>For the third crediting period</b> The build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period	For the third crediting period The build margin emission factor calculated for the second crediting period should be used.

## According to the CDM projects in Mongolia, Option 1 is applied.

- The option chosen should be documented in the CDM-PDD.
- Capacity additions from retrofits of power plants should not be included in the calculation of the build margin emission factor.
- The sample group of power units m used to calculate the build margin should be determined as per the following procedure, consistent with the data vintage selected above:



The build margin emissions factor is the generation-weighted average emission factor ( $tCO_2/MWh$ ) of all power units *m* during the most recent year *y* for which electricity generation data is available, calculated as follows:

#### **Equation 6-3**

$$EF_{grid,BM,y} = \frac{\sum_{m} EG_{m,y} \times EF_{EL,m,y}}{\sum_{m} EG_{m,y}}$$

The CO<sub>2</sub> emission factor of each power unit m ( $EF_{EL,m,y}$ ) should be determined as per the guidance in Step 4 for the simple OM, using Options A1, A2 or A3, using for y the most recent historical year for which electricity generation data is available, and using for 'm' the power units included in the build margin.

If the power units included in the build margin m correspond to the sample group SET<sub>sample</sub>- CDM->10yrs, then, as a conservative approach, only Option A2 from guidance in Step 4 for the simple OM can be used and the default values provided.

## Step 6: Calculate the Combined Margin Emission Factor

The calculation of the combined margin (CM) emission factor (EF<sub>grid,CM,y</sub>) is based on one of the following methods:

Option a: Weighted average CM; or Option b: Simplified CM.



The weighted average CM method (Option a) should be used as the preferred option. The simplified CM method can only be used if the data requirements for the application of Step 5 above cannot be met.

### Weighted average CM

The combined margin emissions factor is calculated as follows:

## **Equation 6-4**

$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$		
Where:		
EF <sub>grid,,</sub> =	Build margin $CO_2$ emission factor in year y (tCO <sub>2</sub> /MWh)	
$EF_{grid_{ii}} =$	Operating margin $CO_2$ emission factor in year y (tCO <sub>2</sub> /MWh)	
<b>W</b> ом =	Weighting of operating margin emissions factor (per cent)	
<i>W<sub>BM</sub></i> =	Weighting of build margin emissions factor (per cent)	

## The following default values should be used for $w_{\text{OM}}$ and $w_{\text{BM}}$ :

(a) Wind and solar power generation project activities:  $w_{OM} = 0.75$  and  $w_{BM} = 0.25$  (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods;

(b) All other projects:  $w_{OM} = 0.5$  and  $w_{BM} = 0.5$  for the first crediting period, and  $w_{OM} = 0.25$  and  $w_{BM} = 0.75$  for the second and third crediting period, unless otherwise specified in the approved methodology which refers to this tool.

Note: Alternative weights can be proposed, as long as  $w_{OM} + w_{BM} = 1$ 

## 6.3 Review of Joint Crediting Mechanism (JCM) Approved Methodology

According to the Joint Crediting Mechanism, there is an Approved Methodology MN\_AM003 "Installation of Solar PV System"<sup>32</sup>[12]. As part of this methodology, an estimation methodology for the Mongolian grid emission factor was developed.

The grid emission factors was set in a very **conservative manner** on the basis of the Mongolian national grid, which consists of Central Energy System (CES), Altai-Uliastai Energy System (AUES), Western Energy System (WES), Eastern Energy System (EES), and Southern (Gobi) Energy System (SES) and on the most efficient heat efficiency of a diesel power generator. This methodology applies the lowest emission factor of coal-fired power plant supplying electricity to the national grid, which is set to be 0.797 tCO<sub>2</sub>/MWh. This value is lower than the grid emission factor for CES, which is 1.154 tCO<sub>2</sub>/MWh (combined margin, 2012) published by the Mongolian government and ensures net emission reductions.

### **Estimation Methodology**

Most of the power results from coal fired CHPs, so this methodology applies the lowest  $CO_2$  emission factor of the coal-fired CHP plant supplying electricity to the main grid.

The calculation of each coal-fired CHP plant emission factors was conducted using the specific fuel consumption of each power plant from the national authority and default values determined by the national authority and IPCC guidelines (shown in the following table)

Item	Value	Refer	Reference		
$CO_2$ emission factor for lignite	90,900 kgCO <sub>2</sub> /TJ	IPCC	guideline	for	National

<sup>&</sup>lt;sup>32</sup> Institute for Global Environmental Strategies, 2017: 1-4
coal		Greenhouse Gas Inventories
		2006, Chapter 2, stationary
		combustion [2]
Net calorific value for lignite coal	29.33 TJ/Gg	Mongolian national standard

The CO<sub>2</sub> emission factors of power generation by each coal-fired CHP plants are obtained using the following equation, applying the values indicated in the previous table.

 $CO_2$  emission factor of power generation [tCO<sub>2</sub>/MWh] = Specific fuel consumption [g/kWh] \* Net calorific value of fuel [TJ/Gg] \* Effective CO<sub>2</sub> emission factor of lignite [kgCO<sub>2</sub>/TJ] \* 3.6 \* 10<sup>-9</sup>

System	Power Plant	Plant emission factor (tCO <sub>2</sub> /MWh)		
		2013	2014	2015
CES	CHP2	1.641	1.669	1.666
	CHP3	0.928	0.965	0.896
	CHP4	0.816	0.808	0.797
	DARKHAN CHP	1.144	1.130	1.178
	ERDENET CHP	0.870	0.866	0.866
EES	Dornod CHP	1.773	1.763	1.714
	(Choibalsan)			
SES	Dalanzadgad	1.822	4.394	4.277
	Ukhaa khudag	2.147	2.082	2.069
	СНР			

The emission factors in the different power plants were found to be as follows

As a result, the most efficient coal-fired CHP plant that supplies electricity to the grid is identified as CHP4, with the lowest power generation emission factor of 0.797 tCO<sub>2</sub>/MWh. This value is lower than the 2013 OM and BM emission factors of the CES grid (1.1542 tCO<sub>2</sub>/MWh and 1.0566 tCO<sub>2</sub>/MWh, respectively) published by the government of Mongolia.

The consultant does not recommend applying the JCM methodology in this NAMA since the emission reductions will be underestimated compared with the values that are obtained by applying the CDM methodological tool discussed above.

# 6.4 Recommended grid emission factor value

National grid emission factors (GEF) for power generation by CHPs in Mongolia have been reported using two methodologies: JCM and CDM. By applying the JCM methodology, the grid emission factor for the most efficient plant was 0.797 tCO<sub>2</sub>/MWh, while values of 1.1542 tCO<sub>2</sub>/MWh and 1.0566 tCO<sub>2</sub>/MWh for OM and BM, respectively, were reported using the CDM tools. The JCM methodology underestimates GEF values, which would result in an underestimation of emissions reduction in comparison with the CDM values. Therefore, the consultant recommends using GEF values obtained by applying the CDM methodological tool.

# 7 Way Forward for Data Collection and Emissions Reduction Estimation

# 7.1 Proposed Estimation Methodology

Based on the assessment of the data received in light of the requirements of the different methodologies, the CDM methodology AMS-II.E is the most suitable to the Mongolian case for the following reasons:

- Can be used for existing buildings
- Can be used for residential, commercial and institutional buildings
- Flexible in estimating the energy savings, so it is not mandating using either data collection surveys or computerized simulation.
- A lot of CDM projects were successfully registered using it including a PoA in Mongolia
- Flexible in utilizing any estimation methodologies for baseline and project emissions.
- Will allow for non-complex preparation for standardized baseline

It is, therefore, proposed to utilize AMS-II.E for the purpose of standardized baseline preparation. The proposed approach to estimate the GHG inventory relies on the approach used in AM0091 but after removing emission sources that are not significant for Mongolia and adjusting the benchmark according to building specification (existing/newly constructed.) For both existing/newly constructed emissions will be determined using the benchmark to the average specific energy  $(tCO_2e/m^2)$ . Moreover, a simplified building categorization is proposed, which was adjusted after discussions with the stakeholders.

# 7.2 Proposed Way forward

# 7.2.1 Boundary of methodology

In the building sector in Mongolia, GHG emissions are attributed to the use of energy, i.e., consumption of fossil fuel and electricity. The project boundary for the proposed methodology consists of emissions of  $CO_2$  resulting from the following:

- 1. Consumption of hot water for heating purposes
- 2. Consumption of electricity in building units
- 3. Consumption of coal by heat only boilers and cooking stoves in the production of heat and for cooking in some specific buildings

In terms of geographical boundary, the project is applicable to the whole country.

# 7.2.2 Scope of methodology

The proposed methodology will apply to newly constructed and existing building units. When sampling for new buildings, all sampled buildings for the baseline emissions estimations should have finalized construction within 5 years prior to start of NAMA activities. When sampling for existing buildings, all sampled buildings for the baseline emissions estimations should have finalized construction for at least 5 years prior to the start of NAMA activities. Both new and existing buildings consist of:

• <u>Residential buildings (apartments and houses)</u>

- <u>Hotels and resorts</u>
- Offices
- <u>Hospitals</u>
- <u>Retail</u>
- Education buildings

The scope of applicable mitigation actions consists of energy efficiency measures resulting in electricity and/or fuel savings, e.g., switching fuels, energy efficient technology such as efficient appliances, efficient thermal envelope, efficient lighting systems, efficient heating, building energy management systems (BEMS), intelligent energy metering etc.

# 7.2.3 Key analysis

The principal parameters required for the analysis of emissions from baseline and NAMA buildings consist of:

- Information on baseline buildings: categorization, total number of buildings within each category and construction date
- Emission factors of fuel used in baseline buildings (stand-alone boilers and stoves)
- Emission factors for electricity and heat production by CHPs on the basis of allocation of fuel consumed for electricity and heat
- Gross floor area of NAMA and baseline buildings;
- Fuel consumption, quantity and energy content of hot water consumed in NAMA and baseline buildings
- Electricity consumption in NAMA and baseline buildings;
- Calorific values of fuels

# 7.2.4 Methodology

The approach proposed in this NAMA is discussed in the following sub-sections:

# **Emissions Reduction Estimation**

1. Classify the project buildings into different categories according to building type, building size, and climate condition. According to the TNA, the building sector in Mongolia is generally composed of old multi-story commercial and residential, and private houses built in 1970's, 1980's and early 1990's and commercial and institutional (referred to as provincial centers in the TNA) buildings[1]. The complexity in the type of buildings is minimal and therefore a simple categorization scheme would be required. The detailed scheme such as that provided by the CDM methodology AM00091 (see section: Scope and Applicability of AM0091) would be not be necessary. Simpler categorization schemes such as that provided in "Edge" building design tool software<sup>33</sup> would be better suited to the type of building sector in Mongolia. The categorization will be based on a modified version of the Edge building design tool software categories:

<sup>&</sup>lt;sup>33</sup> EDGE is a building design tool, it is an innovation of IFC, a member of the World Bank Group. EDGE empowers the discovery of technical solutions at the early design stage to reduce operational expenses and environmental impact. Based on the user's information inputs and selection of green measures, EDGE reveals projected operational savings and reduced carbon emissions.

- a) **<u>Residential buildings</u>**: apartments and houses (assumptions for **area and occupancy** are based on **income categories**)
- b) <u>Hotels:</u> for hotels and resorts (assumptions for **area**, **occupancy** and the type of support services are based on **the star rating of the property**)
- c) Offices: assumptions are based on occupancy density and hours of use
- d) <u>Hospitals</u>: assumptions are based on the **type of hospital** (i.e., nursing home, private or public hospital, clinic or diagnostic center)
- e) <u>Retail:</u> assumptions are based on **the type of retail building** (i.e., department store, mall or supermarket)
- f) Education buildings: assumptions are based on occupancy density and hours of use

For each category, conduct a baseline measurement survey for the buildings which will undergo retrofit. This includes obtaining the energy consumption data (both electricity and fuels) in addition to all the independent variables affecting the energy use. The survey is to be based on at least 12-months data. Such surveys are to be conducted using representative samples. "Guidelines for Sampling and Surveys for CDM Project Activities and Program of Activities" are to be followed in this regards. Annex III: Sampling Plan provides a guide for the sampling techniques that can be followed. The minimum sample size should be determined according to the following equation (reported in AM0091):

## **Equation 7-1**

$$n_{BL\ min,i,y} \geq \frac{cv_{SE,BL,i,y}^2 \times t_{0.05}^2 \times N_{BL,i}}{P_{10\%}^2 \times N_{BL,i} + cv_{SE,BL,i,y}^2 \times t_{0.05}^2}$$

## **Equation 7-2**

$$cv_{SE,BL,i,y}^2 = \frac{\sigma_{POP,SE,BL,i,y}}{\mu_{POP,SE,BL,i,y}}$$

 For the sampled baseline buildings, estimate the baseline emissions from each source of energy consumption, then divide the total baseline emissions for each building unit is divided by the ground floor area to determine the specific baseline emission per building unit

The total baseline emissions for a building unit 'j', in category 'i' for year 'y',  $BE_{i,j,y}$ , will be calculated using the following equation:

#### Equation 7-3

# $BE_{i,j,y} = BE_{EC,i,j,y} + BE_{FC,i,j,y} + BE_{WC,i,j,y}$

a) BE for Electricity Consumption BE EC, i, j, y (apportioning of fuel use between electricity and heat production will be obtained from the Ministry of Energy)

To calculate emissions due to electricity consumption sourced from the grid and accounting for electricity displaced due to efficiency measures, operating and build margins must be considered. Baseline emissions are therefore calculated according to following equation:

#### **Equation 7-4**

# $BE_{EC,i,j,y} = BE_{EC,non-REcaptive,i,j,y}$

Where:

- **BE**<sub>EC,I,j,Y</sub> = Baseline emissions from electricity consumption of baseline building unit *j* in building unit category *i* in year *y* (tCO<sub>2</sub>/yr) for purposes other than hot water production
- **BE** <sub>EC,non-REcaptive,I,j,y</sub> = Baseline emissions from electricity consumption of baseline building unit *j* in building unit category *i* in year *y*, which is supplied by the grid and/or an offgrid fossil-fuel-fired captive power plant(s) (tCO<sub>2</sub>/yr) for purposes other than hot water production

**BE** <sub>EC,non-REcaptive,I,j,y</sub> shall be calculated using the latest approved version of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

#### **Equation 7-5**

 $BE_{EC non-REcaptive, i, j, y} = EC_{BL, i, j, k, y} \times EF_{grid}$ 

EF<sub>grid</sub> shall be obtained from the Ministry of Energy/Ministry of Environment

b) BE for Fuel Consumption (BE FC,<sub>i,j,y</sub>): for stoves usage (hot water production and cooking in rural areas and GERs)

#### **Equation 7-6**

$$BE_{FC,i,j,y} = \sum_{k} FC_{BL,i,j,k,y} \times COEF_{k,y}$$

Where:

BE  $_{FC,i,j,y}$  =Baseline emissions from fossil fuel consumption in baseline building unit j in<br/>building unit category i in year y (tCO2/yr) for purposes other than hot water<br/>productionFC\_{BL,i,j,k,y} =Quantity of fossil fuel type k fired in in baseline building unit j in building unit<br/>category i in year y (mass or volume unit/yr) for purposes other than hot<br/>water productionCOEF\_{k,y} =CO2 emission coefficient of fuel type k in year y (tCO2/mass or volume unit)-<br/>Data will be provided by the Coal Research Institute and/or retrieved from<br/>universities studies

# c) BE for hot water consumption (BE WC,i,j,y)

To estimate baseline emissions from hot water production:

#### **Equation 7-7**

	$\mathbf{DF} = - W C_{BL,i,j,y} \times EF_{BL,WP,i,j,y}$
	$\frac{BE_{WC,i,j,y}}{1-\eta_{BL,dist,l,y}}$
Where:	
BE <sub>wc,i,j,y</sub> =	Baseline emissions from hot water consumption of baseline building unit <i>j</i> in building unit category <i>i</i> in year <i>y</i> (tCO <sub>2</sub> /yr)
WC <sub>BL,i,j,y</sub> =	Energy content of annual hot water consumption in baseline building unit j in building unit category I in year y (GJ/yr)
EF <sub>BL,WP,I,j,y</sub> =	Emission factor for production of hot water that is supplied to baseline building unit <i>j</i> in building unit category <i>i</i> in year <i>y</i> ( $tCO_2/GJ$ )
η <sub>BL,dist,l,y</sub> =	Average technical distribution losses of the hot water system <i>I</i> network serving baseline building unit <i>j</i> in building unit category <i>i</i> in year <i>y</i> (GJ of technical thermal energy losses in the hot water distribution network divided by GJ of thermal energy supplied to the building units) – data will be provided by Energy Regulatory Commission

 $WC_{BLIIV} \times EF_{BLWPIIV}$ 

**Equation 7-8** 

$$EF_{BL,WP,i,j,y} = \frac{BE_{WP,EC,l,y} + BE_{WP,FC,l,y}}{WP_{BL,l,y}}$$

Where:	
EF <sub>BL,WP,i,j,y</sub> =	Emission factor for production of hot water that is supplied to baseline building unit <i>j</i> in building unit category <i>i</i> in year <i>y</i> ( $tCO_2/GJ$ )
BE <sub>WP,EC,I,y</sub> =	Baseline emissions from electricity consumption of hot water system / in year y ( $tCO_2$ /yr). To be calculated in a similar way to Equation 7-4- Data on CHP will be provided by the Energy Regulatory Commission
BE <sub>WP,FC,I,y</sub> =	Baseline emissions from fuel consumption of hot water system / in year $y$ (tCO <sub>2</sub> /yr) (in case all or part of the heat consumed in hot water system is supplied by fossil fuel). To be calculated in a similar way to Equation 7-6-
WP <sub>BL,I,y</sub> =	Energy content of annual hot water produced by hot water system in year y (GJ/yr)- Water consumption data for production of hot water and technical distribution losses will be provided by the Energy Regulatory Commission

d) Calculate specific baseline emission per building unit I in category j for year y (SE), which is given by:

**Equation 7-9** 

$$SE_{BL,i,j,y} = \frac{BE_{i,j,y}}{GFA_{BL,i,j,y}}$$

3. Estimate the average specific emissions per building category.

In CDM methodologies, the specific baseline emissions is calculated based on the top 20% performers for conservativeness and for minimizing free riders. In this methodology, however, it is

recommended to calculate the specific baseline emissions based on the average value since the emission reductions are estimated based on the whole sector and not for specific buildings. In this case, there is no room for free riders as the whole sector moves towards better efficiency and the averages of the energy consumption of different building categories within the whole sector after implementing the measures are compared to corresponding averages before implementing the measures. This proposed approach will allow for more emission reductions for Mongolia and will avoid penalizing Mongolia when using the strict benchmark under the CDM.

Specific emissions per building category determined from the average of sampled buildings:

#### **Equation 7-10**

$$SE = \frac{\sum_{j} SE_{i,j,y}}{J_{i,y}}$$

J<sub>i,y</sub>: Number of building units

4. Estimate the baseline emissions of the NAMA buildings

# Equation 7-11

$$BE_y = \sum_i SE_{i,y} \times GFA_{PJ,i,y}$$

Where:

**BE**  $_{y}$  = Baseline emissions in year y (tCO<sub>2</sub>e/yr)

 $SE_{i,y}$  = Benchmark Specific emissions of building units in building unit category i in year y (tCO<sub>2</sub>e/(m<sup>2</sup>·yr))

**GFA**  $_{PJ,i,y}$  = Total GFA of NAMA building units in building unit category i in year y (m<sup>2</sup>)

- 5. After the implementation of the NAMA, for each category, identify representative samples as per the "Guidelines for Sampling and Surveys for CDM Project Activities and Program of Activities" are to be followed in this regard (Annex III: Sampling Plan provides a guide for the sampling techniques that can be followed).
- 6. For the sampled NAMA buildings, estimate the NAMA emissions from each source of energy consumption (Use Equation 7-3-Equation 7-8), then divide the total emissions for each building unit by GFA to determine the specific NAMA emission per building unit.
- 7. Estimate the NAMA emissions using the following equation

# Equation 7-12

$$PE_{y} = \sum_{i} SE_{i,y} \times GFA_{PJ,i,y}$$

Where: PE<sub>v</sub> =

NAMA emissions in year y (tCO<sub>2</sub>e/yr)

 $\begin{aligned} \textbf{SE}_{i,y} = & & \text{Specific NAMA emissions per building unit obtained from the representative sample for building unit category i in year y (tCO_2e/(m^2 \cdot yr)) \end{aligned}$ 

- **GFA**  $_{PJ,i,y}$  = Total GFA of NAMA building units in building unit category i in year y (m<sup>2</sup>)
- 8. Estimate the emissions reduction as the difference between the baseline emissions obtained from step 4 and NAMA emissions obtained from step 7.

# 7.2.5 Documentation

Documentation required for the application of this modified methodology consists of:

- 1. Data collection forms for parameters outlined in the 'Key Analysis' section 7.2.3
- 2. Calculation sheets for the estimation of baseline and project emissions, and corresponding emissions reduction

# 8 Assessment of Data Availability for GHG Emissions from Buildings

# 8.1 Validation of Data Availability

On the basis of the report prepared by the local consultants named "A Review of Existing System and Data Collection" and the stakeholder meeting held in March 2018, the data available was determined.

The availability of data required for the calculation of baseline emissions using the proposed methodology was verified by designing validation forms consisting of questions, which were presented to stakeholders including local consultants during the Workshop held in March in Ulanbaatar. Questions covered each step of the methodology. The results on data availability, corresponding data providing entity, and proposed way forward are presented in the table below.

# Table 8-1: Data availability and Sources of Data

Recommended methodology steps	Data requirements	Availability	Source of Data
Categorization of buildings	Building category	Yes	Municipalities (Ulaanbaatar and others) (primary source) Public District Heating Companies Housing and Public Utilities Authority
Baseline measurement survey (buildings that will be retrofitted)	Total number of buildings in each category (simple random sampling)	Yes	Municipalities (Ulaanbaatar and others) Housing and Public Utilities Authority
Specific baseline emission per building unit per unit area	<ul> <li>Expected mean emission of CO<sub>2</sub> per m<sup>2</sup></li> <li>Standard deviation of the mean</li> </ul>	No	<b>Way forward:</b> carry out comparative study on emissions of CO <sub>2</sub> /m <sup>2</sup> from countries with similar socio-economic and environmental circumstances
	Gross floor areas (GFA) per building unit per category • Sampled • Non-sampled	Yes	Distribution companies
Baseline emissio	ns calculations		
Flectricity	Monthly metered bills for electricity consumption for each building unit	Yes	Supply service center Housing and Public Utility Authority Private company "Ganbij" LLC.
consumption	Apportioning of fuel use between electricity and heat production	Yes	Energy Regulatory Commission

Recommended methodology steps	Data requirements	Availability	Source of Data
	Grid emission factor update- For all CHPs: Net electricity generated and delivered to grid (MWh) per year •Fuel consumption per year •Fuel net calorific value Fuel CO <sub>2</sub> emission factor (tCO <sub>2</sub> /GJ)	Yes	Ministry of Energy Ministry of Environment
Fuel consumption	Fuel consumption data Monthly bills for each building unit (hot water production by stand-alone boilers, home stoves)	Yes (boilers) No (stoves)	ERC (according to 2016 Statistics on Energy Performance p.11) Potential data providers: National Statistic Office Research Institute Ministry of Nature, Environment and Tourism
	<ul> <li>Fuel characteristics</li> <li>Net calorific values</li> <li>Carbon content</li> </ul>	Yes	National reports Coal research Institute Academic studies
Hot water consumption	Monthly and annual <b>energy</b> <b>content</b> of hot water consumed per building unit (excluding hot water generated from home stoves and stand-alone boilers, e.g., district heating)	Yes*	<ul> <li>Heat meters (GJ) available only for commercial buildings</li> <li>For other buildings, <i>the energy content can be calculated</i>:</li> <li>Meters for hot water and heat are on the substation (on the distribution company side of the substation). Metering of flow (m<sup>3</sup>) for hot water at building level (in and out.)</li> <li>Temperature difference calculation on the basis of assumptions: <ul> <li>inlet to building: 60 °C</li> <li>inlet to substation 5 °C</li> </ul> </li> </ul>

Recommended methodology steps	Data requirements	Availability	Source of Data
	Technical distribution loss of hot water production system	Yes	District heating companies Range: 13- 19 % (company specific)
Hot water production (EF of the hot water production system calculation)	Electricity consumption (MWh) per month and per year for operation of hot water production system	Yes	ERC
	Fuel consumption (FC $_{BL,i,k,y}$ ): mass or volume of fuel per month and year for hot water production system	Yes	ERC
	$\begin{array}{llllllllllllllllllllllllllllllllllll$	Yes	Research Coal Institute Academic studies
Hot water production Water produced energy content	Energy content of the water produced by the hot water production system	Yes	ERC

# 8.2 Verification of Data Availability

Following two missions attended by local and international consultants and members affiliated to the different stakeholders, data required for the application of the proposed methodology were provided by ERC, CHP plants, Public Utilities Authority, and Electricity Network Company.

The data obtained consisted of:

• Annual energy consumption (electricity and hot water) by building units in 6 categories,

- Gross floor areas for building units
- Annual thermal energy produced (hot water) by CHP 2, CHP3, and CHP4 for the years 2013-2017. Total thermal energy (steam and hot water) are provided for 2011-2017.
- Annual electricity produced by CHP 2, CHP3, and CHP4 for the years 2011-2017
- Fuel consumption (kg/Gcal) by CHP 2, CHP3, and CHP4 for thermal energy production for the years 2011-2017.
- Fuel consumption (gr/kWh) by CHP2, CHP3, and CHP4 for electricity production for the years 2011-2017.

The data received allowed the calculations of Emission Factors for hot water production by CHP2, CHP3, and CHP4. Moreover, the provided data verified the fact that it is possible to obtain the required data for application of the methodology as per the validation exercise conducted during the first mission with different stakeholders. A detailed list of data requirements, verification, and source is presented in Table 8-2

Methodology steps	Data requirements	Data Verification	Comments	Data source
Categorization of buildings	Building category	Yes	6 categories: residential, offices, hotels, hospitals, retail, and education	Public Utilities Authority
Baseline measurement survey (buildings to be retrofitted)	Total number of buildings in each category (simple random sampling)			
Specific baseline emission per building unit	<ul> <li>Expected mean emission CO<sub>2</sub>/m<sup>2</sup></li> <li>Standard deviation of mean</li> </ul>			
per unit area	<ul> <li>Gross floor areas per building unit per category</li> <li>Sampled</li> <li>Non-sampled</li> </ul>	Yes	Reported GFA for building units in 6 categories	Public Utilities Authority
Electricity consumption	Monthly metered bills for electricity consumption for each building unit	Yes	Annual consumption provided for building units for 6 categories Note: Data incomplete for several building units in the offices, retail, hotel, hospital, and education categories	Public Utilities Authority

# Table 8-2: Data verification and sources of data

Methodology steps	Data requirements	Data Verification	Comments	Data source
	Apportioning FC: electricity and heat production	Yes	gr/kWh (electricity) and kg/Gcal (heat) for CHP2, CHP3, CHP4 Fuel consumption for generation of electricity and heat corresponds to the total amount of electricity and heat generated with deviations of 13% (CHP2), 10% (CHP3) and 12% (CHP4)	Energy Regulatory Commission (ERC)
	<ul> <li>Grid emission factor</li> <li>Net electricity generated and delivered to grid (MWh/year)</li> <li>Fuel consumption/yr</li> </ul>	Yes Yes	Ministry of Environment (Standardized Baseline Submission to UNFCCC) Annual electricity generated by CHP2, CHP3, CHP4 was provided For CHP2, CHP3, and CHP 4, annual net electricity	Ministry of Environment
	• Fuel NCV/EF	Yes	gr/kWh were provided. Separate fuel consumptions were calculated for CHP2, CHP3, and CHP4. NCV (kcal/kg) for Baganuur and Shivee- Ovoo types of coal were provided	
Fuel consumption	FC monthly bills for each building unit (hot water production by stand-alone boilers, home stoves)	NA	All data on fuel consumption by boilers and home stoves has been reported as 0 ton/yr for the buildings reported for all categories.	Public Utilities Authority
	Fuel characteristics (NCV/C content)	NA		

Methodology	Data requirements	Data	Comments	Data source
steps		Verification		
Hot water consumption	Monthly and annual energy content of hot water consumed per building unit (excluding hot water generated from home stoves and stand-alone boilers, e.g., district heating)	Yes	Annual energy content of hot water consumed for building units in 6 categories provided	Public Utilities Authority
	Technical distribution loss of hot water production system	NA	District heating companies Range: 13- 19 % (company specific)	ERC
Hot water production (EF of the hot water	Electricity consumption (MWh) per month and per year for production of hot water production system	Yes	Yes	CHP Plants
production system calculation)	Fuel consumption (FC <sub>BL,i,k,y</sub> ): mass or volume of fuel per month and year for hot water production system	Yes	For CHP2, CHP3, and CHP 4 annual energy content of hot water produced and kg/Gcal were provided. Separate fuel consumption was calculated for CHP2, CHP3, and CHP4. EF hot water production was determined for CHP2, CHP3, and CHP4	CHP Plants
	$\begin{array}{llllllllllllllllllllllllllllllllllll$	NA	Values determined using EF values retrieved from BUR	BUR
Hot water production	Energy content of water produced by the hot water production system	Yes	Annual energy content of hot water generated by CHP2, CHP3, CHP4 was provided	CHP Plants

# 9 Conclusions and Recommended Methodology

According to the above assessments, a modified version of the CDM methodology AMS-II.E is proposed for estimating emissions from the building sector in Mongolia. Modifications consist of a simplified categorization scheme for buildings. Simplifications in the calculations were made to account for the circumstances of Mongolia, e.g., any terms pertaining to refrigerant use were removed. The modified methodology allows the determination of baseline emissions from the sector, which can be used for the compilation of the inventory from the building sector. The modified methodology further allows the estimation of emissions after the implementation of mitigation measures. In order words, reductions in emissions from mitigation measures can be quantified. Furthermore, the modified methodology can be used for the development of the standardized baseline, a planned task in the project.

# Annex I: Assessment of Existing CDM Methodologies

# CDM AM0091: Energy efficiency technologies and fuel switching in new buildings

# Scope and Applicability of AM0091

Conditions of applicability of AM0091 for the calculation of emissions in buildings are summarized in the following table

# Table 0-1: Applicability conditions of AM0091

Conditions for applicability of AM0091	Situations for non-applicability of AM0091
Project activities that implement energy efficiency measures and/or fuel switching in <b>new or existing</b> <b>building</b> units, which include residential, commercial, and institutional buildings (also named as categories); a summarized list is presented below.	If Biogas systems, biomass systems, <b>cogeneration</b> <b>systems</b> are the source of electrical or thermal energy for <i>project</i> building units and for the corresponding hot/chilled water systems
Calculations of emissions due to:	If chlorofluorocarbon (CFC) are used as a
<ul> <li>Consumption of fossil fuel</li> </ul>	refrigerant
Consumption of electricity	
Consumption of chilled/hot water	
Leakage of refrigerants	
The difference between heating degree days (HDD) and cooling degree days (CDD) between municipalities in which the project building units are located should not be more than +/- 20 per cent	If project building units being credited in other project activities registered as CDM projects.
Hot/chilled water system configuration shown in	Renewable energy technologies that emit a
Figure 0-1	material amount of GHG emissions (e.g.
	geothermal power plants, reservoir-type hydro
	power plants) are captive power source to project building units
Project building units compliant with national building codes	Project activities where only fuel switching measures are implemented in project building units

# Categories of building units to which AM0091 is applicable:

- (a) Residential buildings (low-rise or high-rise): building serving for dwelling purposes
  - i. Single-family.
  - ii. Multi-family
- (b) Commercial building units (low-rise or high-rise): building unit where activities focus on the exchange of goods and/or services for a profit

- i. Office (e.g., administrative and professional offices, government offices, and banks or other financial institutions)
- ii. Hotel (e.g., hotels, motels, and guest houses)
- iii. Warehouse & storage this category includes, for example, distribution and shipping centers;
- iv. Mercantile & service
  - a. Retail (e.g., shopping stores for furniture, cloths, drugs, books etc.)
  - b. Food sales (e.g., grocery stores or food markets etc.)
  - c. Services (e.g., auto repair shops, post offices, photocopy center etc.)
  - d. Other mercantile and service (e.g., mercantile & service building units that belong to none of the above categories)
  - e. Food service (e.g., restaurants or cafeterias etc.)
  - f. Entertainment (e.g., cinemas, night clubs, etc.)
- (c) Institutional building units (low-rise or high-rise): building units used for not-for-profit activities serving public interest)
  - i. Education (e.g., preschools or day-care centers, elementary or middle schools)
  - ii. Public assembly
    - a. Social or meeting (e.g., community centers, lodges, meeting halls etc.)
    - b. Culture (e.g., museums, theaters, operas, and concert halls)
    - c. Religious worship (e.g., temples, mosques, and churches)
    - d. Recreation (e.g., gymnasiums, buildings to serve outdoor recreational facilities etc.)
    - e. Other public assembly (e.g., public assembly building units that belong to none of the above categories)
      - a) Health care (low-rise or high-rise) this category includes the following:
        - Health care this category includes, for example, hospitals, clinics, and rehabilitation centers;
        - Nursing this category includes, for example, nursing homes, assisted living centers, or other residential care buildings;
        - Other health care this category includes health care building units that belong to none of the above categories
      - b) Public order and safety
        - Stations (e.g., police and fire stations, other public service stations for road and park maintenance, civil defense)
        - Prisons (e.g., jails, reformatories, and penitentiaries)
        - Judiciary (e.g., courthouses and probation offices)
        - Other public order and safety (e.g., public order and safety building units that belong to none of the above categories)
          - Institutional lodging (e.g., retirement homes, convent or monastery, shelters, orphanage, or children's homes, halfway houses, and military barracks.)

For emissions due to chilled/hot water consumption, the methodology is applicable to the following configuration



Figure 0-1: Applicable chilled/hot water configuration

## General Approach of AM0091 for baseline emissions calculations

## Defining the project boundary and type

The project boundary includes areas covering the project and building units as well as energy supply systems. Energy supply systems are defined as systems as electricity and chilled/hot water systems where all equipment are used for the supply of energy service through chilled/hot water systems to users that are or will be connected to the chilled/hot water systems.

The methodology for the calculation of baseline emissions depends on whether the building is an existing unit or a new construction; both situations are described in the next section. The approach to methodology selection is illustrated in the following figure.



Figure 0-2: Approaches to calculating baseline emissions for existing and new buildings according to AM0091

# Baseline Emissions Calculation for Existing Buildings

In case of retrofitting existing buildings, the baseline emissions of those buildings are determined using a whole building computerized simulation model. The data required as inputs to the model are:

- Relevant building characteristics (B-settings), which include:
  - Building envelope (e.g. dimensions and building geometry, location of building surfaces such as windows, doors and skylights, orientation of external surfaces, building shades and shading from nearby objects, relative position of the building thermal zones);
  - Thermal properties (layer-by-layer description of the building materials with their conductivity, specific heat and density).
- Energy consumption of the existing building(s) experienced over the recent 12 months prior to its/their retrofit
- Relevant tenancy-related characteristics (T-settings). This include:
  - Occupancy or average number of people per time period (such as population counts in weekdays, weekends and holidays
  - Internal load schedules and plug loads, including their counts, nameplate data, usage schedules and diversity of operations
  - Building operations including control temperatures and hours of operation
- Weather files for the project location with hourly data of temperature, humidity, wind direction and speed, total and diffuse solar radiation;

The model should be calibrated so that its results match the 12-month actual energy consumption data of the existing building(s).

The methodology also necessitates that only the computerized simulation tools that have successfully met the analytical verification and have a current empirical validation requirements as defined in the International Energy Agency's BESTEST protocol shall be used. In addition, project participants shall demonstrate that the building energy simulations and related calibrations have been performed by skilled operator(s) as demonstrated by having at least three years of relevant experience and professional education and/or training.

To calculate the baseline emissions after the project implementation, the model will use the same Bsettings (building characteristics), while the T-settings (tenants' behavior) and weather data will be adjusted to match those obtained from the calibrated project scenario model.

# Baseline Emissions Calculation for New Buildings

# Option 1 for New Buildings:

As shown in **Error! Reference source not found.**, several steps should be followed in order to calculate he baseline emissions for new buildings under option 1. Data are collected for baseline buildings in the project area, and then the top 20% building unit performers are determined. The specific average emissions of these buildings are calculated per gross floor area (GFA) based on the four sources mentioned above. Finally, the baseline emissions are calculated by multiplying the specific emissions by

the total GFA of the project units and correction factors. Actually, there are a lot of important details required in this option, and accordingly the following sub-sections will highlight the key points. Before that, the following table summarizes the key data required for estimating emissions from the baseline building units in case this option will be applied.



Figure 0-3 Steps to calculate baseline emissions for new construction using Option 1

Fossil Fuels	Electricity	Chilled/hot water	Refrigerant use
<ol> <li>Annual consumption of each fossil fuel type used in each baseline building unit (excluding the amount of fossil fuels used for captive power generation).</li> <li>CO<sub>2</sub> emission coefficient of each fossil fuel type</li> <li>Average net calorific value and density of each fossil fuel type</li> </ol>	Electricity consumption of baseline building unit j in building unit category i in year y, which is supplied by the grid and/or an off-grid fossil-fuel-fired or renewable captive power plant(s) and the emission factor of the supplied electricity.	<ol> <li>Energy content of annual chilled/hot water consumption in each baseline building unit (GJ/yr). If there is no energy meter, the following is required:         <ul> <li>Annual chilled/hot water consumption (in mass or volume)</li> <li>Average temperature difference between the outlet and inlet of the heat exchanger used for the cooling/heating of the building unit</li> </ul> </li> <li>Emission factor for production of chilled/hot water that is supplied to each baseline building unit (tCO<sub>2</sub>/GJ). The following data is required:             <ul> <li>Electricity consumption to generate the water and the corresponding emission factor</li> <li>Fuel consumption to generate the water and the corresponding emission factor</li> <li>Annual chilled/hot water consumption (in mass or volume)</li> </ul> </li> <li>Average technical distribution losses of the chilled/hot water system network serving each baseline building unit</li> </ol>	<ol> <li>Annual quantity of refrigerant type m used to replace the refrigerant(s) that has leaked in each baseline building unit and in the corresponding chilled water system (t refrigerant/yr)</li> <li>Global Warming Potential of each refrigerant type (tCO<sub>2</sub>e/t refrigerant)</li> <li>Energy content of annual chilled water consumption in each baseline building unit (GJ/yr)</li> <li>Average technical distribution losses of the chilled water system in each baseline building unit</li> <li>Energy content of annual chilled water produced by chilled water system (GJ/yr)</li> </ol>

# Table 0-2 Summary of the data required to calculate the baseline emissions from the different sources under Option 1<sup>34</sup>

<sup>&</sup>lt;sup>34</sup> The detailed equations will be shown in the following sub-sections

The following sub-sections highlights the key points in some of the steps required under this option.

# Identification of baseline building units (Step 2)

One of the challenges in this option is the identification of the baseline buildings units. The baseline buildings units of each category should fulfill the following conditions:

- Should be located in the same municipality as the project building units. If the minimum sample size of baseline building units cannot be obtained within the municipality, the project boundary should be extended to cover the geographical area of the next higher level of administrative boundary (e.g. group of municipalities, state, province, county); otherwise, the building unit category should be excluded.
- Should have been built and then occupied within the five years prior to the start of the project activity
- Should be located in a region with annual heating degree days (HDD) and cooling degree days (CDD) in a range from 80 per cent to 120 per cent of the average value of the region that the project building units are located in
- Should be located in an area with similar socio-economic conditions to the one in which the project building units are located. A minimum of three socio-economic classes should be defined based on the level of income or property price (e.g. low, middle, and high income/property price groups). Reliable data sources should be referenced; otherwise, a survey should be conducted
- Gross Floor Area (GFA) of a baseline building unit should be in the range from 50 per cent to 150 per cent of the average GFA of the project building units. In addition, they should have similar height or number of floors (low-rise or high-rise), window-to-wall ratio and front façade orientation to the project building units.
- In case of residential building units, they should be used as a primary, year-round residence. On the other hand, for commercial and institutional building units, the minimum occupancy on annual average is at least 30 hours/week

After the determination of all the applicable baseline buildings units for each category, the project developer may either choose to identify the baseline building units from all the building units in the project boundary or use a randomly selected sample of the building units in the project boundary. The latter can be only applied if the sample size is larger than the minimum sample size (the methodology shows the detailed statistical equations to estimate the minimum sample size).

# Calculations of Baseline Emissions (Step 3)

Following that the identification of building units, and for each building unit in each building category, the baseline emissions are calculated based on the addition of emissions resulting from each source of energy consumption, namely, electricity (EC), fuel (FC), water (WC) and from the leakage of refrigerants (REF). The total baseline emissions for a building unit 'j', in category 'i' for year 'y' is given by the following equation:

# Equation 0-1

$$BE_{i,j,y} = BE_{EC_{i,j,y}} + BE_{FC_{i,j,y}} + BE_{WC_{i,j,y}} + BE_{ref_{i,j,y}}$$

Key parameters required for the calculations of baseline emissions from the aforementioned four sources are presented in Table 3.2. The detailed equations are shown below.

# Calculation of Baseline Emissions due to Electricity, Fuel, Water Consumption and Refrigerant Use *1) Emissions due to Electricity Consumption*

The calculation of baseline emissions due to electricity consumption is dependent on the source of the electricity, namely, grid or off-grid fossil fuel fired captive power plant and/or off-grid renewable captive power plant and is given by:

#### **Equation 0-2**

# $BE_{EC,i,j,y} = BE_{EC,non-REcaptive,i,j,y} + BE_{EC,REcaptive,i,j,y}$

Where:	
BE <sub>EC,I,j,y</sub> =	Baseline emissions from electricity consumption of baseline building unit <i>j</i> in building unit category <i>i</i> in year <i>y</i> ( $tCO_2/yr$ )
<b>BE</b> <sub>EC,non-REcaptive,I,J,y</sub> =	Baseline emissions from electricity consumption of baseline building unit <i>j</i> in building unit category <i>i</i> in year <i>y</i> , which is supplied by the grid and/or an off-grid fossil-fuel-fired captive power plant(s) (tCO <sub>2</sub> /yr)
<b>BE</b> <sub>EC</sub> , REcaptive,Ι,j,γ =	Baseline emissions from electricity consumption of baseline building unit <i>j</i> in building unit category <i>i</i> in year <i>y</i> , which is supplied by an off-grid renewable captive power plant(s) ( $tCO_2/yr$ )
BE <sub>EC,non-REcaptive,I,j,y</sub>	shall be calculated using the latest approved version of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".
BE EC, REcaptive, I, j, y	equals 0 (tCO <sub>2</sub> /yr) as a conservative simplification.

For the calculation of  $BE_{EC}$  from electricity consumption of baseline building unit in a building unit category that is supplied by the grid, AM0091 refers to the "Tool to calculate baseline, project, and/or leakage emissions from electricity consumption". As per this tool, the emissions from electricity consumption are estimated by multiplying the energy consumption by the grid emission factor. The latter is estimated using the "Tool to calculate the emission factor for an electricity system".

## 2) Emissions due to Chilled/Hot Water Consumption :

As shown in the following equation, the emissions due to chilled/hot water consumption depend on:

- Energy content of annual water <u>consumption</u> of baseline building unit in building category (Gj/yr). If
  no heat meters are available, mass/volumetric flow rate of water will be required together with the
  temperature difference at outlet and inlet of heat exchanger.
- Average technical distribution losses of chilled/hot water system network
- Emission Factor (EF) for the production of hot/chilled water supplied to baseline building (*applicable to each centralized hot/chilled water system*)

#### **Equation 0-3**

$$BE_{WC,i,j,y} = \frac{WC_{BL,i,j,y} \times EF_{BL,WP,i,j,y}}{1 - \eta_{BL,dist,l,y}}$$

Where:	
BE <sub>wc,i,j,y</sub> =	Baseline emissions from chilled/hot water consumption of baseline
	building unit <i>j</i> in building unit category <i>i</i> in year <i>y</i> (tCO <sub>2</sub> /yr)
WC <sub>BL,i,j,y</sub> =	Energy content of annual chilled/hot water consumption in baseline
	building unit j in building unit category I in year y (GJ/yr)
EF <sub>BL,WP,I,j,y</sub> =	Emission factor for production of chilled/hot water that is supplied to
	baseline building unit <i>j</i> in building unit category <i>i</i> in year y (tCO <sub>2</sub> /GJ)
<b>η</b> <sub>BL,dist,l,y</sub> =	Average technical distribution losses of the chilled/hot water system I
	network serving baseline building unit <i>j</i> in building unit category <i>i</i> in year
	y (GJ of technical thermal energy losses in the chilled/hot water
	distribution network divided by GJ of thermal energy supplied to the
	building units)

As shown in the following equation, the EF for production of chilled/hot water system depends on the (1) fuel consumption (if fuel is used), electricity consumption, or fugitive emissions (if geothermal sources are used) and

(2) energy content of annual chilled/hot water <u>produced</u> by chilled/hot water system. Energy content is determined as shown above (energy, mass, volume of hot/chilled water), but for water production

#### Equation 0-4

$EF_{BL,WP,i,j,y} = \frac{BE_{WP,EC,l,y} + BE_{WP,FC,l,y}}{WP_{BL,l,y}}$
Emission factor for production of chilled/hot water that is supplied to baseline building unit <i>j</i> in building unit category <i>i</i> in year <i>y</i> (tCO <sub>2</sub> /GJ)

Where:

 $EF_{BL,WP,i,i,v} =$ 

BE <sub>WP,EC,I,y</sub> =	Baseline emissions from electricity consumption of chilled/hot water
	system / in year y (tCO <sub>2</sub> /yr)
BE <sub>WP EC Ly</sub> =	Baseline emissions from fuel consumption of chilled/hot water system /

BE <sub>WP,FC,I,y</sub> =	Baselir	ie e	missions fr	om	fuel co	วทรเ	ımp	otion c	of c	hillec	l/hot v	water systei	m /
	in yea	r y	(tCO <sub>2</sub> /yr)	(in	case	all	or	part	of	the	heat	consumed	in
	chilled	/hot	t water sys	tem	l is su	pplie	ed k	by fos	sil f	uel)			

BE <sub>WP,FE,I,y</sub> =	Baseline fugitive emissions of CO <sub>2</sub> and methane due to release of non-
	condensable gases from geothermal sources in chilled/hot water
	production in chilled/ hot water system / in year y (tCO <sub>2</sub> /yr) (In case all
	or part of the heat consumed in chilled/hot water system / is supplied by
	a geothermal source)
	For every constant of everyal ability of the sustain every second by ability of the t

WP<sub>BL,Ly</sub> = Energy content of annual chilled/hot water produced by chilled/hot water system in year y (GJ/yr)

As mentioned above, the emissions for electricity consumption can be determined using 'Tool to calculate baseline, project, and/ or leakage emissions from electricity consumption.' On the other hand, the emissions due to fossil fuel consumption require data on fuel type, amount consumed and the corresponding emission coefficient as shown in the following equation. The same equation can be also used to calculate the baseline emissions due to the fuel consumption in buildings for purposes other than chilled/hot water production.

#### **Equation 0-5**

$$BE_{WP,FC,l,y} = \sum_{k} FC_{BL,l,k,y} \times COEF_{k,y}$$

Where:

BE WP,FC,I,y =	Baseline emissions from fossil fuel consumption of chilled/hot water
-	system / in year y (tCO <sub>2</sub> /yr)
FC <sub>BL,I,k,y</sub> =	Quantity of fossil fuel type <i>k</i> fired in chilled/hot water system / in year <i>y</i> (mass or volume unit/yr)
COEF <sub>k,y</sub> =	$CO_2$ emission coefficient of fuel type k in year y (tCO <sub>2</sub> /mass or volume unit)

#### 3) Emissions due to the Use of Refrigerants :

The emissions due to the use of the refrigerants can be used according to the following two equations. As shown, the equation is divided into 2 parts; the first related to the refrigerants leak in the building units, and the other related to the refrigerants leak in the chilled water system. The main data required are the annual quantity of refrigerants used to replace the leaks, types of used refrigerants, in addition to the energy content of the produced and consumed chilled water.

## **Equation 0-6**

$$BE_{ref,i,j,y} = \sum_{m} Q_{BL,ref,i,j,m,y} \times GWP_{BL,ref,i,j,m,y} + BE_{WP,ref,l,y} \times \frac{WC_{BL,i,j,y}}{(1 - \eta_{BL,dist,l,y}) \times WP_{BL,l,y}}$$

Where:

BE <sub>ref,I,j,y</sub> =	Baseline emissions from the use of a refrigerant(s) in baseline building unit <i>j</i> in building unit category <i>i</i> in year <i>y</i> (tCO <sub>2</sub> e/yr)
<b>Q</b> <sub>BL,ref,i,j,m,y</sub> =	Annual quantity of refrigerant type <i>m</i> used to replace the refrigerant(s) that has leaked in baseline building unit <i>j</i> in building unit category <i>i</i> in year <i>y</i> , excluding refrigerant leakage from chilled water system (t refrigerant/yr).
GWP <sub>BL,ref,i,j,m,y</sub> =	Global Warming Potential of refrigerant type m used in baseline building unit <i>j</i> in building unit category <i>i</i> in year <i>y</i> (GJ/yr)
BE <sub>WP,ref,l,y</sub> =	Baseline emissions from the use of a refrigerant in chilled water system <i>l</i> in year <i>y</i> (tCO <sub>2</sub> /yr)
Ŋ <sub>BL,dist,l,y</sub> =	Average technical distribution losses of the chilled water system $l$ in year $y$ (GJ of technical thermal energy losses in the chilled water distribution network divided by GJ of thermal energy supplied to the building units)
WP <sub>BL,I,y</sub> =	Energy content of annual chilled water produced by chilled water system <i>l</i> in year <i>y</i> (GJ/yr)

## **Equation 0-7**

$$BE_{WP,ref,l,y} = Q_{BL,ref,l,y} \times GWP_{BL,ref,l,y}$$

Where:	
BE <sub>WP,ref,l,y</sub> =	Baseline emissions from the use of a refrigerant in chilled water system I
	in year y (iCO <sub>2</sub> /yr)
$\mathbf{Q}_{BL,ref,l,y} =$	Average annual quantity of the refrigerant used to replace the refrigerant that has leaked in chilled water system / in year y (t refrigerant/yr)
QWP BL,ref,l,y =	Global Warming Potential of the refrigerant used in chilled water system / in year y ( $tCO_2e/t$ refrigerant)

Following calculation of baseline emissions from each source of energy consumption, the total baseline emissions for each building unit is divided by the GFA to determine the **specific baseline emission per building unit I in category j for year y (SE), which is given by:** 

#### Equation 0-8

$$SE_{BL,i,j,y} = \frac{BE_{i,j,y}}{GFA_{BL,i,j,y}}$$

Calculation of Top 20 per Cent Benchmark for Specific Emissions of Baseline Building Units (Step 4)

Following the determination of the specific baseline emission, building units are arranged according to the SE and the top 20% building unit performers 'J'.

In **the absence of enforceable standards on building efficiency** in the host country, the top 20% benchmark level of SE for building units in category 'i' is simply calculated as the average SE value given by:

#### Equation 0-9

$$SE_{Top\ 20\%,i,y} = \frac{\sum_{j} SE_{top\ 20\%,i,j,y}}{J_{i,y}}$$

In **the presence of enforceable standards on building efficiency** in the host country, the top 20% benchmark level of SE for building units in category 'i' given by the following equation. In this case, the value of the energy efficiency used in the standard (EI) will be used together with the average carbon intensity (CI) and the specific emissions from the refrigerant use (REFI) of the top 20 per cent performer building units.

#### Equation 0-10

$$SE_{Top20\%,i,y} = El_{standard,i,y} \times Cl_{top20\%,i,y} + REFl_{top20\%,i,y}$$

Calculation of Baseline Emissions based on the Top 20 per Cent Benchmark (Step 5)

#### Equation 0-11

$$BE_{y} = \sum_{i} SE_{Top20\%,i,y} \times GFA_{PJ,i,y} \times CF_{BL,i,y}$$

Where:	
BE <sub>y</sub> =	Baseline emissions of baseline building units in year y (tCO <sub>2</sub> e/yr)
SE <sub>Top20%,i,y</sub> =	Specific emissions of top 20 per cent performer building units in building
	unit category i in year y (tCO <sub>2</sub> e/(m <sup>2</sup> ·yr))
GFA <sub>PJ,i,y</sub> =	Total GFA of project building units in building unit category i in year y $(m^2)$
CF <sub>BL,i,y</sub> =	Baseline correction factor for occupancy of project building units in building unit category i in year y

## Updating Baseline Emissions (Step 6)

The baseline emissions should be updated after project implementation. Under Option 1, the same baseline buildings (or the selected sample) will remain to be monitored annually throughout the project period, where the emissions from the electricity consumption, fuel consumption, chilled/hot water consumption and refrigerant use will be calculated based on the relevant monitoring parameters.

## **Option 2 for New Buildings**

As illustrated in Figure 2.2, the other option for estimating the baseline emissions from new buildings is based on computer modeling. There are two relevant sub-options:

- Option 2a: Modeling baseline emissions based on the building characteristics (B-settings building physical characteristics e.g. thermal properties of materials, building envelope dimensions, orientation, etc.) of the top 20 per cent benchmark buildings.
- Option 2b: Modeling baseline emissions based on the building characteristics (B-settings) obtained from interviews with 5 construction companies/experts.
   This information shall be supported by evidence (such as studies conducted by third party or construction documentation). If different construction companies or experts provide different quotes of most commonly used materials and construction practices, the most conservative option shall be selected as the baseline characteristic.

For Option 2a and Option 2b, the T-settings (e.g. occupancy, control temperature, etc.) as well as weather data shall match those in the calibrated model of the project building units. As mentioned above, the methodology necessitates that only the computerized simulation tools that have successfully met the analytical verification and have a current empirical validation requirements as defined in the International Energy Agency's BESTEST protocol shall be used. In addition, project participants shall demonstrate that the building energy simulations and related calibrations have been performed by skilled operator(s) as demonstrated by having at least three years of relevant experience and professional education and/or training.

## Calculating Project Emissions for Building Units within a Category

The methodology for the calculation of project emissions depends on whether the building is an existing unit or a new construction; both situations are described in the next section. The approach to methodology selection is illustrated in Figure 0-4.



Figure 0-4: Approach to calculating project emissions for existing and new building according to AM0091

# **Existing Buildings**

As was the case with the baseline emissions of the existing buildings which will undergo retrofitting, the project emissions will be obtained through whole building computer model. The latter will be established based on the following:

- As-built project building characteristics
- Weather, building operating characteristics, building control strategies and settings and building occupancy experienced during the same 12 month period for which energy use data under expected (full) operations are available
- Actual annual energy used in the building during the first full year of project building operation

The building model is then calibrated following the "Whole Building Calibrated Simulation" path in ASHRAE Guideline 14-2002. As mentioned above, the T-settings of the calibrated project model are copied to the baseline model so as to get the corresponding baseline emissions.

# **New Buildings**

## Option 1:

As shown in **Error! Reference source not found.**, several steps should be followed in order to calculate he project emissions for new buildings under option 1. In short, data are collected for all the project buildings in the project area (or selected sample). The project emissions of each building are calculated based on the same four sources mentioned above. For each source, the equations to be used are the same as those used for the estimation of the baseline emissions.



Figure 0-5 Steps to calculate project emissions for new construction using Option 1

## Option 2:

In this option, whole building computer model will be used. The same details mentioned in the 'Baseline Emissions Calculation for Existing Buildings' section **Error! Reference source not found.** apply.

## Calculating Leakage Emissions

- If fossil fuel switching is involved, the upstream leakage emissions associated with fossil fuel use should be calculated.
- In case the project activity involves the replacement of equipment, and the leakage effect of the use of the replaced equipment in another activity is neglected because the replaced equipment is scrapped, an independent monitoring of scrapping of replaced equipment needs to be implemented. The monitoring should include a check if the number of project activity equipment distributed by the project and the number of scrapped equipment correspond with each other. For this purpose, scrapped equipment should be stored until

such correspondence has been checked. The scrapping of replaced equipment should be documented and independently verified.

## **Emission Reductions Determination**

Emission reductions due to the implementation of energy efficient measures are calculated from the difference between baseline emissions, project activities emissions, and leakage emissions.

# Assessment of Methodology Requirements and Applicability to Mongolia

According to the "Review of Existing System and Data Collection" document submitted by the local consultants, electricity is mainly supplied by 3 CHPs. Therefore, the methodology would not be applicable since it does not allow for estimation of emissions from electricity grid and district heating system supplied by cogeneration plants. However, the approach used in this methodology can be used if it is possible to estimate a separate emission factor for electricity and for heat. If the fuel used in the cogeneration plant can be apportioned between electricity and heat, then it would be possible to utilize the approach used in this methodology. In addition, an adjustment for buildings utilizing stand-alone medium or small boilers for heat should be done.

Modeling requirement include actual data on specific building characteristics (see section Baseline Emissions Calculation for Existing Buildings). According to the Technology Needs Assessment (TNA), large energy consumption in the building sector is due to poorly insulated homes constructed in 1970s, 1980s, and 1990's without compliance with any codes or standards. Therefore, collecting the complex data required for modeling would require extensive field measurements, which would not be possible. Therefore, utilizing the approaches in the methodology that are based on surveys for historical electricity and heat consumption would be the recommended approach.

With respect to estimating emissions from refrigerants, it is proposed to neglect this emission source as it is not expected that this source will be significant. The calculations of upstream leakage emissions from fossil fuel extraction and transportation are complex and are therefore recommended to be excluded as well.

# CDM AMS-II.R Energy Efficiency Space Heating Measures for Residential Buildings

# Scope and Applicability

The methodology applies to energy efficiency and fuel switching measures within existing residential buildings to improve space heating. Energy efficiency activities involve installation of new equipment, products, or modifications of existing equipment (e.g., cooking stoves) or changes to building characteristics such as building insulation, enhancing glazing of windows etc.

The methodology is applicable to:

- Technology or measures for energy efficiency are implemented in existing buildings
- Fuel switching only if resulting from energy efficiency measures
- Direct measurements and recording of energy consumption are possible, i.e., electricity, fossil fuel, non-renewable biomass in the project boundary
- Impacts due to implementation of energy efficiency measures under the project activity are discernable from changes in energy use due to other variables not related to the project activity.
- Annual Aggregated energy savings for a project activity do not exceed 60 GWh<sub>e</sub> or 180 GWh<sub>th</sub>

The methodology (AMS-II.R) is not applicable if "AMS-II.G: Energy efficiency measures in thermal applications of non-renewable biomass" is applied to activities within the physical, geographical site of the building(s) which is/are part of the proposed project activity.

# Approach

# Defining the Project Boundary

The project boundary consists of the physical site of the building unit where energy efficiency measures are implemented.

# **Calculating Baseline Emissions**

The baseline emissions are calculated by multiplying the energy consumption by the corresponding emission factor. Therefore, the first step consists of determining the energy consumption.

# Baseline Energy Consumption Determination

There are 3 approaches to determine the baseline energy consumption:

1- Baseline Measurement Survey

**Data source**: based on direct measurements and recording of (1) energy use of the heating equipment and (2) independent variables that influence energy use such as ambient temperature and occupancy levels (the range of these variables should be accurately determined throughout the survey)

**Requirements for data collection**: (1) Frequency: period of time that allows recording of a representative range of variables (so this may necessitate data collections in multiple seasons). (2) Sampling methodology of the building units used for the baseline measurement should be compliant

with the 'Standard for sampling and surveys for CDM project activities and programme of activities'. According to the methodology, data collection can be carried out prior to or in parallel with the implementation of the project activity.

**Data processing**: mathematical relationship between measurements of energy use and independent variables are then investigated using computational tools such as regression analysis tools to determine an appropriate equation appropriately representing the baseline energy consumption.

# 2- 'Treatment Group vs Control Group Study'

**Data source**: based on measurements of energy use for two groups; "<u>control group</u>" that will not implement the energy efficiency measures during the project period and a "<u>treatment group</u>" that will implement the energy efficiency measures. The selection of residences falling in either group is done by 'random assignment' according to the Standard for sampling and surveys for CDM project activities and programme of activities'.

**Data processing**: energy used for the "<u>treatment group</u>" is subtracted from that of the "<u>control</u> <u>group</u>" to determine energy savings and emission reductions.

Unlike the first approach "Baseline measurement survey", the methodology did not explicitly determine in this approach how to obtain the independent variables that may affect the energy consumption nor how to use such data in modifying the obtained energy consumption values.

# 3- 'Use of Existing Data from Registered CDM Projects'

**Data source**: energy use data is taken from previous CDM projects

This approach is only valid for "suppressed energy demand scenarios", which are defined by the following conditions:

- Projects are implemented in rural areas with a country electrification rate below 20%;
- Animal dung is the prevalent source of fuel in the project area;
- Project activity is in a Least Developed Countries (LDCs) or a Small Island Developing States (SIDs);
- Conditions of special underdeveloped zone as per 'Guidelines for demonstrating additionality of microscale project activities'

# Baseline Emissions Determination

Following determination of energy consumption, the baseline emissions are determined by multiplying the energy consumption with the corresponding emission factor.

- For an electricity system, the emission factor is determined from the 'Tool to calculate emission factor for electricity system'
- If fuel is consumed, the IPCC default emission factor can be used.

# Project Emissions Determination

Emissions from project activities are calculated following the same approach as those outlined above for the baseline emissions calculations. The energy consumption is multiplied by the corresponding emission factor.

# Leakage Emissions Determination

The methodology states that in case it will be applied as a programme of activities (PoA), the upstream leakage emissions associated with fossil fuel use should be calculated. In addition, the leakage emissions

from the scraping of equipment should be monitored the same way as in Methodology AM0091 (see section Calculating Leakage Emissions.)

## Emission Reductions Determination

Emission reductions due to the implementation of energy efficient measures are calculated from the difference between baseline emissions, project activities emissions, and leakage emissions. But, this should be done only for the project equipment which are still operating, the fact that should be verified by a biennial survey.

## Monitoring Requirements:

- Direct energy consumption measurements (on monthly basis at minimum),
- Any other data necessary to document independent variables that influence energy consumption (e.g. ambient temperature measurements indoor and outdoor),
- Equipment surveys to determine what percentage of the equipment is still operating or has been replaced by equivalent equipment (biennial at least). This can be based on a representative sample by following the "Standard for sampling and surveys for CDM project activities and programme of activities".

# Assessment of Methodology Requirements and Applicability to Mongolia

The methodology can be used for the determination of baseline emissions from electricity consumption and fossil fuel consumption for space heating applications. This methodology is not suitable for projects involving electricity efficiency measures, e.g., efficient lighting. In addition, the boundary of this methodology is limited to the buildings, so it doesn't include emissions from the chilled/hot water source.

# CDM AMS-II.E: Energy Efficiency and Fuel Switching Measures for Buildings

# Scope and Applicability Conditions

The methodology can be applied to a single building (residential, commercial, institutional,....etc) or a group of similar buildings (such as school district) involving energy efficiency measures and/or fuel switch if the latter is part of energy efficiency measures within the building(s). In case, fuel switch is the primary measure, methodology AMS-III.B is applicable. Energy efficiency measures include improved insulation, efficient appliances to replace existing equipment or be installed in new facilities. The applicability conditions also include:

- Direct measurement and recording of energy consumption data (electricity/fuel) should be possible.
- Aggregated annual energy savings for a single project activity do not exceed 60 GWh
- Impacts due to implementation of energy efficiency measures under the project activity are discernable from changes in energy use due to other variables not related to the project activity.

# Approach

# Defining the Project Boundary

The project boundary consists of the physical site of the building unit(s) where energy efficiency measures are implemented.

## **Calculating Baseline Emissions**

The methodology does not specify exact equations for emission calculations. It just states that the baseline emissions are determined by multiplying the baseline energy consumption by the applicable emission coefficient. The baseline energy consumption/use pertains to energy consumed by existing equipment that will be replaced in case of retrofit, or by the building that would otherwise be built in case of a new building.

Emission coefficient for electricity displaced is calculated according to the CDM tool "Tool

to calculate the emission factor for an electricity system". For fossil fuels, the methodology permits using default IPCC values.

The methodology does not specify how to select the baseline building (in case of new facilities) and how to obtain its historical energy consumption. The methodology also does not specify whether the baseline emissions should be updated during the crediting period. By reviewing some of the CDM projects/Program of Activities (PoAs), the following approaches have been used:

- Selecting a building similar to the project building, then developing an energy simulation model and calibrating it using historical energy data. The model is then continuously updated during the crediting period to have T-settings similar to the project building (an approach similar to the modeling option in AM0091)
- Selecting conservative building features in ASHRAE guidelines and calibrating it with occupancy data from buildings in the same region of the project building. An energy simulation model for the baseline building is then developed, and the resultant energy consumption values are fixed throughout the crediting period

• Conducting a baseline measurements survey to get the energy consumption values and the variables affecting it using the same approach discussed under AMS-II.R (see section CDM AMS-II.R Energy Efficiency Space Heating Measures for Residential Buildings.)

## **Calculating Project Emissions**

Similar to the baseline emissions, the methodology does not specify exact equations for emission calculations. Accordingly, the projects emissions are determined by multiplying the project energy consumption by the applicable emission coefficient.

## **Calculating Emissions Reductions**

Emission reductions are calculated from the difference between baseline emissions and project activity. Emissions from project activity are calculated from direct measurements of energy consumed multiplied by the applicable emission factor. Leakage emissions should also be taken into consideration in case of fuel switching (upstream emissions if any) and in case of equipment replacement.

**Data Requirement:** direct measurements and recording of energy consumed (e.g., metered bills). In case of retrofits, the replaced equipment specifications should be documented.

# Assessment of Methodology Requirements and Applicability to Mongolia

The methodology is suitable for various energy-efficiency projects (both space heating and efficient appliances). It is applicable to all types of buildings. The boundary of this methodology is limited to the buildings, so it doesn't include emissions from the chilled/hot water source. However, the estimation of the emission factor for heat is very flexible and therefore it is possible to include an approach to estimate an emission factor in case heat is supplied by CHP plants.
# CDM AMS-II.Q.: Energy Efficiency and/or Energy Supply Projects in Commercial Buildings

## Scope and Applicability

The methodology applies to commercial building having an on-site energy supply and whole building energy efficiency projects whose emissions can be determined using a 'whole building computerized tool'.

- Commercial buildings can be retrofitted or newly constructed projects. Allowable projects include one or more of the following: energy efficient building design features; energy efficient appliances, equipment, technologies, energy management controls, on-site renewable energy projects, on-site cogeneration, fossil fuel switching.
- If refrigerants are used, they shall have no Ozone depleting potential.
- Aggregated annual energy savings for a single project activity do not exceed 60 GWh
- All technologies (e.g. equipment or appliances) used in the project activity must be new and not transferred from another project activity
- Only whole building computerized simulation tools that have successfully met the analytical verification and have a current empirical validation requirements as defined in the International Energy Agency's BESTEST protocol can be used. In addition, the simulations should be performed by operators with at least 3 years of relevant experience

The project boundary is the buildings together with its onsite energy generation (heating/cooling). Hence, the methodology is not applicable to project activities that affect **off-site district heating** and/or cooling plants and distribution network even in the event that those sources supply energy to the building.

# **Emission Reduction Calculation**

As mentioned above, the methodology depends on whole building computerized simulation tools. The approach mentioned in the document is the same modeling approach followed by the CDM methodology AM0091 (Section Baseline Emissions Calculation for Existing Buildings.)

# Assessment of Methodology Requirements and Applicability to Mongolia

The methodology is suitable for various energy-efficiency projects (both space heating and efficient appliances). The boundary of this methodology includes the on-site energy generation; hence, emissions from the production of chilled/hot water source can be included (but not for off-site district heating/cooling). However, the methodology only applies to commercial buildings, so residential buildings cannot be included.

# CDM AMS-III.AE: Energy Efficiency and Renewable Energy Measures in New Residential Buildings

# Scope and Applicability

The methodology applies to energy efficiency measures implemented in new residential buildings (single or multiple family residences) connected to the grid. Efficiency measures can be one or more of the following: efficient building design practices, efficiency technologies, or renewable energy technologies (examples include efficient appliances, high efficiency heating and cooling systems, passive solar design, thermal insulation, and solar photovoltaic systems). In this methodology, the word "residence" refers to a single housing unit, so a single building with 10 apartments has ten residences. The methodology also requires the following conditions:

- The methodology is applicable only for emission reductions associated with changes in the grid electricity consumption between project and baseline residences (e.g. for domestic water heating, if baseline residence uses electricity, the project residence should use electricity or renewable energy (no fossil fuel))
- CFC free refrigerant in the project activity
- All equipment and building materials are new
- Aggregated annual energy savings for a single project activity do not exceed 60 GWh

# **Conditions for Baseline Residences:**

- Built and occupied within the prior 5 years (from start of project activity)
- Not part of the project activity
- Located within 100 km from project residences
- Shares similar characteristics to project residences with respect to floor area (± 50%), microclimate (average rainfall, wind, temperature), tenants' socio-economic class
- Compliant with energy standards (e.g., building codes) if any.

The methodology is not applicable to residences using biomass for energy supply.

#### **Emission Reduction Calculations**

Annual electricity savings from project activities is multiplied by the applicable emission factor and the technical grid loss according to the following equation:

$$ER_y = \sum_i ES_{y,j} \times EF_{elec,y} \times (1 + TD_y)$$

Where:	
ER <sub>y</sub> =	emission reductions from electricity savings in year y, tCO <sub>2</sub>
i =	Residence type (e.g., single famiy and multifamily)
<b>y</b> =	crediting period year
ES <sub>y,I</sub> =	Annual electricity saving from project activity residences in year y for residence type i, MWh
EF <sub>elec,y</sub> =	Grid electricity emission factor for year y, as per the procedures of AMS I.D, tCO_2/MWh

**TD**<sub>y</sub> =Average annual technical grid losses (transmission and distribution)<br/>during year y for the grid serving the project residences, expressed as a<br/>fraction.

#### **Calculations of Electricity Savings**

Electricity savings can be calculated following two ex-post options:

- a) Using computer simulation model for the baseline residences to estimate the annual electricity consumption
- b) Comparing actual energy consumption data of sample of project and baseline residences (using regression analysis for both).

#### **Option A:**

The protocol consists of determining the annual baseline residence electricity consumption by computer simulation. The model determines the annual baseline residence electricity consumption value for *an average baseline residence, which is then* multiplied by the number of occupied project residences. The measured annual project residence electricity consumption is then subtracted from the estimated annual baseline residence electricity consumption to obtain the energy savings.

**Data required for modeling:** Input parameters consist of actual weather data, project residence building characteristics such as floor areas, and number of residences.

**Data required for calibration process** consists of monthly electricity consumption of a sample of baseline residences (for a year), building and occupant characteristics, and monthly weather data.

The minimum sample size of occupied residences shall be 100, however if the project has fewer than 100 residences, then all occupied project residences' electricity consumption shall be used.

The methodology refers to Option D of the IPMVP (International Performance Measurement and Verification Protocol, Concepts and Practices for Determining Energy Savings in New Construction) for the calculation of energy savings.

The model shall be calibrated for the first crediting period year and every third year thereafter (e.g., year 4, 7, 10) using data (energy use, weather data, residence characteristics) collected during the same years that the model is calibrated.

# **Option B:**

Energy savings per year (ES) are based on the determination of average daily savings,  $\beta$ , using a regression model. ES is given by:

$$ES_{y,i} = \beta_i \times (365 \ days/years) \times N_i$$

#### **Determination of Average Daily Savings**

Average daily electricity savings per residence for each year are calculated based on average daily consumption of electricity, actual weather data (HDD, CDD), baseload electricity consumption ( $\alpha$ ), other residence and occupancy characteristics (X) including for example number of occupants, occupied floor area, and heating/cooling system type. Such data should be obtained for project and baseline residences. The average daily savings is obtained by solving for  $\beta$  in the following regression equation:

$$ADC_{j,m,y} = \propto + \beta EEj + \lambda_l HDD_{j,m,y} + \lambda_2 CDD_{j,m,y} + \gamma x_j$$

Average daily electricity consumption during the post-treatment year <i>y</i> for both the project and baseline residences (residence <i>j</i> for month m). ADC is computed by dividing the total bill for month m by the number of days in the billing period.
Set to 1 if energy efficiency improvements have been installed and 0 otherwise. (i.e., project residences have a 1 in all months and baseline residences have a 0 in all months.
Non-variable base load electricity consumption, for example electricity consumption associated with appliances in constant operation.
Average daily heating degree days based for residence <i>j</i> in month m
Average daily cooling degree days based for residence <i>j</i> in month m
Important characteristics that need to be included for project and baseline residences (number of occupants, occupied floor area, heating system type, cooling system type)
Estimate of daily electricity savings for a 12 month period.
Number of project residences.

Each year, 12 ADC values are computed and used.

The regression analysis should be based on a minimum sample size of 100 residences, however if the project has fewer than 100 residences, then project residences' electricity consumption and an equal sample of baseline residences shall be used.

Monthly baseline and project residence electricity consumption and weather data for each crediting period year, must be used for the regression analyses. However, new survey data for updating X coefficient(s) and  $\alpha$  are not required for each crediting year. Such data only needs to be collected, and used to update the value for  $\alpha$  and the X coefficient(s), for the first crediting period year and every third year thereafter (e.g., year 4, 7, 10).

**Required data:** actual electricity consumption data for baseline and project residences (monthly metered bills), actual weather data (monthly HDD and CDD), characteristics of residence and occupancy (first year and then every 3 years) for project residences, heating/cooling system type. For renewable energy systems providing electricity to project grid, electricity production provided to the project grid is required (utility revenue meter data or electricity metering equipment.)

# Assessment of Methodology Requirements and Applicability to Mongolia

The methodology is suitable for various energy-efficiency projects (efficient building design practices and efficient appliances). However, it can only be applied to efficiency projects including changes in the grid electricity consumption. The boundary of this methodology is limited to the buildings, so it does not include emissions from the chilled/hot water source. Also the methodology only applies to new residential buildings, so retrofitting activities to existing residential buildings cannot be included, and also commercial buildings cannot be included.

# Annex II: Various Methodologies for Allocating Energy Consumption and Associated CO<sub>2</sub> Emissions from Cogeneration Plants

## General Scientific Approaches

Methods for the allocation of emissions from CHPs are grouped into three principal approaches: efficiency, energy, and exergy based methods

## **Efficiency Methods**

**Efficiency methods** are based on the determination of fuel consumed by each energy stream, namely, electricity and heat. The determination of the share of fuel consumed, therefore, depends on the efficiency of fuel energy to electricity and heat. Efficiency methods differ in the approach to the determination of efficiency values, e.g., source specific, default determination of the share of fuel consumed. Other factors influencing the selection of one method over the other pertain to the type of technology, e.g., high/low thermal system.

The determination of the emissions is provided by World Resources Institute/World Business Council for Sustainable Development<sup>35</sup> [26] according to the following equation:

 $Emissions_{Heat} = Emissions_{Total} \times \frac{\frac{Heat \ Output}{Efficiency_{Heat}}}{\frac{Heat \ Output}{Efficiency_{Heat}}} + \frac{Electricity \ Output}{Efficiency_{Electricity}}$ 

And  $Emissions_{Total} = Emissions_{Heat} + Emissions_{Electricity}$ 

Where:	
Emissions <sub>Total</sub> =	Total emissions from CHP plant
Emissions <sub>Heat</sub> =	Emissions share attributable to heat production
Emissions <sub>Electricity</sub> =	Emissions share attributable to electricity production
Efficiency <sub>Heat</sub> =	Assumed efficiency of typical heat production
Efficiency <sub>Electricity</sub> =	Assumed efficiency of typical electricity production

Heat output and electricity output are reported in the same units (i.e. Joule, Btu, or KWh) Details for the different efficiency approaches are provided below.

# (a) Efficiency approach California Air Resources Board (CARB) [26]<sup>36</sup>

**Approach:** Allocation of energy (and accordingly emissions) is based separate efficiency for both heat and electricity. Actual thermal energy and electricity production efficiencies are recommended to be identified by the CHP power plants; otherwise, there are recommended default values.

# **Efficiency values**

<sup>&</sup>lt;sup>35</sup> Energy Efficiency Council, Combined Heat and Power- Best Practices and Emissions Allocation Protocols. 2015: 20-26

<sup>&</sup>lt;sup>36</sup> Similar approach is also followed by the WRI/WBCSD GHG Protocol Initiative: Allocation of Emissions from Combined Heat and Power (CHP) Plant. 2006

- Default values: 80% for steam and 35% for electricity
- Ratio of 2:1 efficiency for thermal to electrical generation (for low thermal systems)
- For high thermal system, actual efficiencies can be calculated based on the following equations (according to California Cogeneration Council approach))

**Electricity Generation Efficiency** 

$$eP = \frac{P}{F}$$

**Thermal Energy Production Efficiency** 

$$eH=\frac{H}{F-P}$$

Where:

Efficiency of electrical generation
Total electricity output
Total fuel input
Thermal energy efficiency
Total thermal energy output

# (b) EPA CHP Efficiency Metrics<sup>37</sup>

**Approach:** Only one value for efficiency is assumed which is the efficiency of the conventional technology that would be used to produce the useful thermal energy output. The electric generation efficiency is then accordingly calculated using the following equations.

**Electricity Generation Efficiency** 

$$e_{P=\varepsilon_{\varepsilon\varepsilon}} = \frac{W_E}{Q_{FUEL} - \sum(\frac{Q_{TH}}{\alpha})}$$

**Thermal Energy Production Efficiency** 

$$E_H = \frac{Q_{TH}}{\eta_O - \epsilon_{EE}}$$

Where:

**Q**<sub>FUEL</sub> = total fuel energy input

 $W_E$  = Net useful electric output (gross electric output of generator minus any parasitic electric losses)

 $\Sigma Q_{TH}$  = Net useful thermal output (gross thermal output<sup>38</sup> of CHP system minus any thermal output that is not put to a useful purpose.)<sup>39</sup>

<sup>&</sup>lt;sup>37</sup> EPA CHP efficiency metrics- <u>https://www.epa.gov/chp/methods-calculating-chp-efficiency</u>

<sup>&</sup>lt;sup>38</sup> Gross thermal output is the total thermal output of the CHP system.

<sup>&</sup>lt;sup>39</sup> In the case of a CHP system that produces 10,000 pounds of steam per hour, with 90 percent of the steam used for space heating and the remaining 10 percent exhausted in a cooling tower, the energy content of the 9,000 pounds of steam per hour is the net useful thermal output.

**No:** Total system efficiency = 
$$\eta_O = \frac{W_e + \sum Q_{TH}}{Q_{FUEL}}$$
  
**Q:** Efficiency of the conventional technology that would be used to produce the useful thermal energy output if the CHP system did not exist

# (c) Incremental Fuel Consumption to Thermal Energy Production<sup>40</sup> [27]

**Approach:** Only one value for efficiency is assumed which is a **reference efficiency value from a reference CHP** ( $\eta_{pp}$ ). The latter is used to calculate the amount of fuel used to generate electricity (E), and then the amount of fuel used to generate thermal energy is accordingly calculated according to the following equations. This approach assumes that thermal energy is treated as a by-product to electricity generation.

Amount of fuel used to generate electricity

$$F_E = \frac{E}{\eta_{PP}}$$

Amount of fuel used to generate heat

$$F_H = F - F_E$$

The fraction of fuel consumed for the production of electrical and thermal energies

$$f_E = \frac{F_E}{F} = \frac{E}{F\eta_{PP}}$$
$$f_H = \frac{F_H}{F} = 1 - f_E$$

#### (d) Shared Emissions Savings [27]

**Approach:** The share of fuel consumed is calculated independently for each energy stream based on **two reference efficiencies (for the boiler and power plant)**. The following equations are used:

Amount of fuel used to generate electricity and heat

$$F_H = \frac{H}{\eta_b}$$

<sup>&</sup>lt;sup>40</sup> Ibrahim, D. and A.R. Marc, Exergy Analysis of Heating, Refrigerating, and Air Conditioning- Methods and Applications. 2015: 350-351

$$F_E = \frac{E}{\eta_{PP}}$$

The fraction of fuel consumed for the production of electrical and thermal energies are got according to the following equations:

$$f_E = \frac{F_E}{F} = \left(\frac{E}{\eta_{PP}}\right) / \left(\frac{E}{\eta_{PP}} + \frac{H}{\eta_b}\right)$$
$$f_H = \frac{F_H}{F} = \left(\frac{H}{\eta_b}\right) / \left(\frac{E}{\eta_{PP}} + \frac{H}{\eta_b}\right)$$

## (e) 'Harmonized Efficiency Reference Values'<sup>41</sup> [28]

**Approach:** Like the previous approach, the share of fuel consumed is calculated independently for each energy stream based on **two reference efficiencies (for the boiler and power plant**). The same equations are used; however, the only difference is that the harmonized efficiency reference values are based on the with EU guidelines (2015/2402 of 12 October 2015) of heating station and power plants. The harmonized efficiency reference values are based on net calorific values and the year of construction of the CHP plant. The following figures respectively present snapshots for the harmonized efficiency values for separate production of electricity and heat.

<sup>&</sup>lt;sup>41</sup> Achim, D., S. Thomas, and R. Steffen, Allocation of CO<sub>2</sub>-Emissions to Power and Heat from CHP-Plants: 3-6.

Category		Type of fuel		Year of construction		
			Before 2012	2012- 2015	From 2016	
Solids	S1	Hard coal including anthracite, bituminous coal, sub-bituminous coal, coke, semi-coke, pet coke	44,2	44,2	44,2	
	S2	Lignite, lignite briquettes, shale oil	41,8	41,8	41,8	
	S3	Peat, peat briquettes	39,0	39,0	39,0	
	S4	Dry biomass including wood and other solid biomass including wood pellets and briquettes, dried woodchips, clean and dry waste wood, nut shells and olive and other stones	33,0	33,0	37,0	
	S5	Other solid biomass including all wood not included under S4 and black and brown liquor.	25,0	25,0	30,0	
	S6	Municipal and industrial waste (non-renewable) and renewable/bio-degradable waste	25,0	25,0	25,0	
Liquids	L7	Heavy fuel oil, gas/diesel oil, other oil products	44,2	44,2	44,2	
	L8	Bio-liquids including bio-methanol, bioethanol, bio-butanol, biodiesel and other bio-liquids	44,2	44,2	44,2	
	L9	Waste liquids including biodegradable and non-renewable waste (including tallow, fat and spent grain).	25,0	25,0	29,0	
Gaseous	G10	Natural gas, LPG, LNG and biomethane	52,5	52,5	53,0	
	G11	Refinery gases hydrogen and synthesis gas	44,2	44,2	44,2	
	G12	Biogas produced from anaerobic digestion, landfill, and sewage treatment	42,0	42,0	42,0	
	G13	Coke oven gas, blast furnace gas, mining gas, and other recovered gases (excluding refinery gas)	35,0	35,0	35,0	
Other	014	Waste heat (including high temperature process exhaust gases, product from exothermic chemical reactions)			30,0	
	015	Nuclear			33,0	
	016	Solar thermal			30,0	

# Table 0-1: Harmonized efficiency reference values for separate production of electricity<sup>42</sup> [29]

<sup>&</sup>lt;sup>42</sup> European Commission, COMMISSION DELEGATED REGULATION (EU) 2015/2402 of 12 October 2015 reviewing harmonised efficiency reference values for separate production of electricity and heat in application of Directive 2012/27/EU of the European Parliament and of the Council and repealing Commission Implementing Decision 2011/877/EU, in Official Journal of the European Union. 2015: L333/58.

Categor	Category Type of fuel		Year of construction		
			Before	2012-	From
			2012	2015	2016
	017	Geothermal			19,5
	018	Other fuels not mentioned above			30,0

	Table 0-2: Harmonized efficienc	v reference values for separate	e production of heat <sup>43</sup> [29]
--	---------------------------------	---------------------------------	---

Categor	у	Type of fuel:	Year of construction						
				Before 2016			From 2016		
			Hot wate r	Steam ( <sup>1</sup> )	Direct use of exhaust gases ( <sup>2</sup> )	Hot water	Steam ( <sup>1</sup> )	Direct use of exhaust gases ( <sup>2</sup> )	
Solids	S1	Hard coal including anthracite, bituminous coal, sub- bituminous coal, coke, semi-coke, pet coke	88	83	80	88	83	80	
	S2	Lignite, lignite briquettes, shale oil	86	81	78	86	81	78	
	S3	Peat, peat briquettes	86	81	78	86	81	78	
	S4	Dry biomass including wood and other solid biomass including wood pellets and briquettes, dried woodchips, clean and dry waste wood, nut shells and olive and other stones	86	81	78	86	81	78	
	S5	Other solid biomass including all wood not included under S4 and black and brown liquor.	80	75	72	80	75	72	
	S6	Municipal and industrial waste (non-renewable) and renewable/bio-degradable waste	80	75	72	80	75	72	
Liquids	L7	Heavy fuel oil, gas/diesel oil, other oil products	89	84	81	85	80	77	
	L8	Bio-liquids including bio-methanol, bioethanol, bio- butanol, biodiesel and other bio-liquids	89	84	81	85	80	77	

<sup>&</sup>lt;sup>43</sup> European Commission, COMMISSION DELEGATED REGULATION (EU) 2015/2402 of 12 October 2015 reviewing harmonised efficiency reference values for separate production of electricity and heat in application of Directive 2012/27/EU of the European Parliament and of the Council and repealing Commission Implementing Decision 2011/877/EU, in Official Journal of the European Union. 2015: L333/58.

Catego	·у	Type of fuel:	Year of construction					
			Before 2016			From 2016		
			Hot wate r	Steam ( <sup>1</sup> )	Direct use of exhaust gases ( <sup>2</sup> )	Hot water	Steam ( <sup>1</sup> )	Direct use of exhaust gases ( <sup>2</sup> )
	L9	Waste liquids including biodegradable and non- renewable waste (including tallow, fat and spent grain).	80	75	72	75	70	67
Gaseou	G10	Natural gas, LPG, LNG and biomethane	90	85	82	92	87	84
S	G11	Refinery gases hydrogen and synthesis gas	89	84	81	90	85	82
	G12	Biogas produced from anaerobic digestion, landfill, and sewage treatment	70	65	62	80	75	72
	G13	Coke oven gas, blast furnace gas, mining gas, and other recovered gases (excluding refinery gas)	80	75	72	80	75	72
Other	014	Waste heat (including high temperature process exhaust gases, product from exothermic chemical reactions)				92	87	_
	O15	Nuclear	_	_		92	87	_
	O16	Solar thermal	_	_	_	92	87	_
	017	Geothermal	_	_	_	92	87	_
	O18	Other fuels not mentioned above		_	_	92	87	_

## **Energy methods**

Energy content methods allocate emissions based on the proportion of produced energy of each stream (electricity and heat) to the total energy produced (by both streams) in BTU or Joules. According to the references, sometimes the assumption is that efficiencies for the production of electrical and thermal energy are equivalent and sometimes not. The energy quality is not put into consideration.

# a) Product Energy Allocation

**Approach:** Allocation of emissions is based on the proportion of produced energy of each stream (electricity and heat) to the total energy produced (by both streams) in BTU or Joules (e.g., CCAR approach [26])<sup>44</sup>. Equal efficiencies for the production electricity and heat is assumed.

 $Emissions_{Heat} = Emissions_{Total} x \frac{Net \ Heat \ Production}{Net \ Heat \ Production + Electricity \ Production}$ 

and

Emissions -	Electricity Production
Emissions <sub>Electricity</sub> =	$Emissions_{Total} \times \frac{1}{Net Heat Production + Electricity Production}$
Where:	
Emissions <sub>Total</sub> =	Total emissions from CHP plant
Emissions <sub>Heat</sub> =	Emissions share attributable to heat production in tonnes
Emissions <sub>Electricity</sub> =	Emissions share attributable to electricity production in tonnes

b) UK Emissions Trading Scheme<sup>45</sup> [26]

**Approach:** Allocation of emissions is based on **the proportion of produced energy of each stream** (electricity and heat) **to the total energy produced** (by both streams) in a BTU or Joules. It is assumed that efficiency for the production of heat **is twice** that of electricity

Hence, the emission factors for each energy stream are determined according to the following equations:

$$CO_2$$
 EF from electricity (lb  $CO_2$ /megawatt-hr) = 
$$\frac{2 x CO_2 \text{ direct emissions (tonnes CO_2)}}{2 x \text{ Electricity produced (megawatt - hr)} + \text{ Steam produced (megawatt - hr)}}$$

Steam emission factor from cogeneration:

 $CO_2 \text{ EF from steam (lb CO_2/megawatt-hr)} = \frac{CO_2 \text{ direct emissions (tonnes CO_2)}}{2 \text{ x Electricity produced (megawatt - hr)} + \text{ Steam produced (megawatt - hr)}}$ 

c) WRI/WBCSD GHG Protocol Initiative<sup>46</sup> [30]

22

23

<sup>&</sup>lt;sup>44</sup> Energy Efficiency Council, Combined Heat and Power- Best Practices and Emissions Allocation Protocols. 2015:

<sup>&</sup>lt;sup>45</sup> Energy Efficiency Council, Combined Heat and Power- Best Practices and Emissions Allocation Protocols. 2015:

<sup>&</sup>lt;sup>46</sup> WRI/WBCSD GHG Protocol Initiative, Allocation of Emissions from Combined Heat and Power (CHP) Plant. 2006: 14

**Approach:** The energy content method allocates emissions based on the amount of energy in each energy output. Losses due to inefficient use of either the electricity or steam outputs are not considered. When steam is used, the enthalpy of the returned condensate is subtracted. The method is well suited for situations in which steam is used for process heat.

# The determination of emissions by energy stream (electricity and heat) is based on:

- Electricity energy content is equal to electrical energy output, P.
- Steam energy content, H , is determined based on *the fraction of the total energy in steam* (or hot water) that can be used for process heating.<sup>47</sup> Steam energy content, E<sub>H</sub>, is determined according to the following equation<sup>48</sup>:

$$Energy = F_i x (h_i - h_{ref})$$

Where:	
<b>F</b> <sub>i</sub> =	Mass of steam in tonnes (1,000 kg)
h <sub>i</sub> =	Specific enthalpy of steam flow I, in kJ/kg
h <sub>ref</sub> =	Specific enthalpy at reference conditions (corresponding to returned
	condensates, assume at 100° C and 1 atm pressure)

Then the fraction of electrical and thermal energy is determined accordingly.

#### **Exergy Methods**

In exergy-based methods, the allocation of emissions is based on the work potential of the products, i.e., the exergy content of the electrical and thermal energies. The exergy content is an indicator for the quality of products such as steam, hot-cold water etc.

## a) Product Exergy Allocation

**Approach:** Electrical energy and electrical exergy, Ex<sub>E</sub>, are equivalent. The determination of thermal exergy depends on reference conditions.

$$f_E = \frac{Ex_E}{Ex_E + Ex_H}$$
$$f_H = \frac{Ex_H}{Ex_E + Ex_H}$$

Thermal energy is converted to thermal exergy by multiplying thermal energy (thermal output) and an exergetic temperature factor. The exergetic temperature factor is determined on the basis of **the** selected reference conditions (e.g., reference conditions (ambient) ( $T_o$ ), process temperature (T))<sup>49</sup> [27].

$$H_t = 1 - \frac{T_o}{T}$$

<sup>&</sup>lt;sup>47</sup> Steam is used for indirect heating, with condensates returned to the CHP system. "If the condensates are not returned or if a hot water output stream is considered in the allocation, applicable reference conditions should be used (e.g., the temperature and pressure of boiler feed water)."

 $<sup>^{48}</sup>$  The values of enthalpy (h<sub>i</sub>, h<sub>ref</sub>) can be found in standard steam tables.

<sup>&</sup>lt;sup>49</sup> Ibrahim, D. and A.R. Marc, Exergy Analysis of Heating, Refrigerating, and Air Conditioning- Methods and Applications. 2015: Elsevier: 346-347

For heat exchangers, thermal exergy is determined from thermal exergies of incoming and outgoing flows.

# b) GHG Protocol<sup>50</sup> [30]

Approach: Allocations based on the work potential of the different energy streams generated. **Assumptions:** useful energy in steam corresponds to the maximum amount of work that could be done by the steam in an open (flow), steady state, and thermodynamically reversible process.

Step 1: Obtain the total emissions,  $E_{T}$ , produced for the generation of electricity and steam based on the total fuel consumption. Obtain or estimate this value for the CHP plant. This can be calculated based on the fuel mix of the CHP plant, and the guidance in the revised GHG Protocol calculation tool for "Direct Emissions from Stationary Combustion", available on the GHG Protocol website, www.ghgprotocol.org.

# Step 2: Calculate the work potential for each energy stream.

- For electricity, the work potential, Wp, is equal to energy output.
- For steam, the work potential is calculated from the specific enthalpy (or heat content) and specific entropy of the stream according to following equation:

$$W_{i} = F_{i} \times \left[ \left( h_{i} - T_{ref} \times S_{i} \right) - \left( h_{ref} - T_{ref} \times S_{ref} \right) \right]$$

Where:

<b>W</b> <sub>i</sub> =	Work potential of stream i (kJ)
<b>F</b> <sub>i</sub> =	Mass of steam (kg)
T <sub>ref</sub> =	Reference temperature (°K)
h <sub>i</sub> =	Specific enthalpy of steam flow i (kJ/kg)
h <sub>ref</sub> =	Specific enthalpy at reference conditions (kJ/kg)
<b>S</b> <sub>i</sub> =	Specific entropy of steam flow i (kJ/kg-°K)
S <sub>ref</sub> =	Specific entropy at reference conditions (kJ/kg-°K)

The values of enthalpy and entropy can be found in standard steam tables. Selection of reference conditions (pertaining to  $T_{ref}$  and  $S_{ref}$ ) are arbitrary (e.g., return condensate temperature or make up water temperature and pressure.)

Steps 3-4: Calculate the total work potential. Determine the fraction of total emissions to allocate to electricity, Fp, and heat,  $F_H$  stream.

$$W_{total} = W_P + W_i; F_P = \frac{W_P}{(W_P + W_i)} \text{ and } F_P = \frac{W_i}{(W_P + W_i)}$$

<sup>&</sup>lt;sup>50</sup> WRI/WBCSD GHG Protocol Initiative, Allocation of Emissions from Combined Heat and Power (CHP) Plant. 2006: 12-13

Step 5: Allocate the total emissions of the CHP facility to the individual streams in proportion to their work potential.

$$E_P = F_P \times E_T$$
 and  $E_H = F_H \times E_T$ 

## Summary

There are several approaches that can be adopted for the allocation of emissions to each energy stream produced. There is no universally accepted method for systems generating electricity and heat (CHPs) [27]. The table below summarizes the main methods.

Table 0-3: Summary of emissions	allocation methods
---------------------------------	--------------------

Approach	Total fuel	Energy	output	Efficien	су	Work potential
		Р	н	Р	н	
Efficiency	Y	Y	Y	Y/N <sup>51</sup>	Y/N <sup>52</sup>	-
Share of fuel consumed by energy stream produced						
determined based on the efficiency of fuel energy						
conversion to each energy stream produced with						
thermal energy conversion being more efficient than						
electrical one.						
Energy	Y	Y	Y	-	-	-
Share of fuel consumed by energy stream produced						
determined from the fraction of output of each						
energy stream to total output (unified energy units)						
Exergy	Y	Y	Y	-	-	Y
Share of fuel consumed by energy stream produced						
determined from the fraction work potential of each						
energy stream to total work potential. Work						
potential of steam is determined based on steam						
tables						

CDM Methodologies for Allocating Energy Consumption and Associated  $CO_2$  Emissions from Cogeneration Plants

The small and large CDM methodologies have been reviewed to check if any has dealt with allocating fuel consumption in CHP plants to the output electrical energy and thermal energy.

# ACM0022: Alternative Waste Treatment Processes

<sup>&</sup>lt;sup>51</sup> Some approaches require a value for this efficiency only, and some others require values for both efficiencies <sup>52</sup> ibid

In this CDM methodology<sup>53</sup>[4], baseline emissions from electricity and heat cogeneration are calculated by multiplying electricity generation ( $EG_{t,y}$ ) and the quantity of heat supplied ( $HG_{PJ,y}$ ) with the CO<sub>2</sub> emission factor of the fuel used by the cogeneration plant, as follows:

	$PF = - (EG_{t,y} \times 3.6) \times 10^{-3} + HG_{PJ,y} \times FF$
	$BE_{EN,y} - \frac{1}{\eta_{cogen}} \times EF_{CO2,BL,CG}$
Where:	
<i>BE<sub>EN,</sub></i> =	Baseline emissions associated with energy generation in year y ( $tCO_2$ )
$EF_{CO_{2,i}} =$	CO <sub>2</sub> emission factor of the fossil fuel type used for energy generation by
	the cogeneration plant in the baseline (tCO <sub>2</sub> /TJ)
HG <sub>PJ,</sub> =	Quantity of heat supplied by the project activity displacing baseline heat
	generation by a fossil fuel cogeneration plant in year y (TJ)
<i>EG<sub>t,</sub></i> =	Electricity generated by the alternative waste treatment option <i>t</i> and
	exported to the grid or displacing fossil fuel fired power-only and/or
	cogeneration captive energy generation in year y
$\eta_{cogen} =$	Efficiency of the cogeneration plant that would have been used in the
	absence of the project activity (ratio)

So, it can be observed that this methodology avoided allocating energy, and it instead estimates the total emissions from fuel combustion in CHP. So, the emissions are allocated to total energy rather than separate allocation to electrical and thermal energy.

# AM0107: New Natural Gas Based Cogeneration Plant

In this CDM methodology<sup>54</sup>[5], baseline emissions were a bit differently calculated compared to the previous methodology. It also depends on the output electrical and thermal energy; however, each of them is divided by its separate efficiency instead of using single efficiency for the cogeneration plant as was the case in the previous methodology.

$$BE_{y} = \left[\frac{HG_{PJ,y}}{\eta_{BL,HG}} + \frac{EG_{PJ,y} \times 3.6}{\eta_{BL,EG}}\right] \times EF_{BL,y}$$

Where:	
BEy =	Baseline emissions in year y (tCO <sub>2</sub> e)
$HG_{P_{ny}} =$	Quantity of heat supplied by the project activity in year y (GJ)
$EG_{P,ry} =$	Quantity of electricity supplied by the project activity in year y (MWh)
$\eta_{BL,HG} =$	Assumed efficiency of heat generation in the baseline cogeneration plant (fraction)
$\eta_{BL,EG}$ =	Assumed efficiency of electricity generation in the baseline cogeneration plant (fraction)
<i>EF<sub>BLy,</sub></i> =	$CO_2$ emission factor of the fuel that would have been used in the baseline cogeneration plant (tCO <sub>2</sub> /GJ)

<sup>&</sup>lt;sup>53</sup> UNFCCC, ACM0022: Alternative waste treatment processes version 02.0 2014: 31.

<sup>&</sup>lt;sup>54</sup> UNFCCC, *AM0107: New natural gas based cogeneration plant version 03.0.* 2014:.1-12.

The assumed efficiencies of heat generation and electricity generation in the baseline cogeneration plant shall correspond to the maximum efficiency of heat production and maximum efficiency of electricity production by the baseline cogeneration plant. The CDM "Tool to determine the baseline efficiency of thermal or electric energy generation systems" has been used in one of the projects in this regards.

It can be observed that the approach followed in this CDM methodology is similar to the "Shared emissions savings" and "harmonized efficiency reference values" discussed above.

# Annex III: Sampling Plan

This annex is based on "Guideline Sampling and surveys for CDM project activities and programmes of activities"<sup>55</sup>[31] and AM0091.

# A) Sampling Plan Components

The recommended sampling plan consists of 3 parts: (a) sampling design; (b) data to be collected; and (C) implementation plan (schedule to implement A and B)

# Sampling design shall consist of the following elements:

- Determining the parameters that will be sampled (e.g., electricity consumption, fuel consumption), and the objectives of each.
- **Identification of sampling requirements** according to applicable CDM methodology or sampling standards and the confidence/precision criteria to be met.
- **Deciding the Target population** (e.g., districts at which NAMA to be implemented, and the corresponding number of buildings)
- **Sampling method selection and description**. The following sections will provide more details about the different methods
- Sample size determination and justification. The following sections will provide more details about the statistical methods to be used. At this stage, the confidence interval and precision should be also decided.
- Sampling frame identifies or describes the sampling frame to be used. This shall agree with the information about the Target Population and Sampling Design above. For instance, if cluster sampling is to be used in a study of equipment in buildings, then the frame should be a listing of the buildings from which the sample will be selected.

# Data to be collected

• Field measurements identify all the variables to be measured and determine appropriate timing and frequency of the measurements.

# Recommended practices for unbiased estimates of sampled parameters

- a) Randomizing cases and drawing sample using random number tables or using the random number generator of appropriate software. If a systematic sampling is chosen: the sample should be random and free of any trend or cyclical pattern;
- b) Selecting the most effective information-gathering method, i.e., the most reliable and cost effective method for collecting the data. The methods of survey and data collection and criteria to be used for selecting an appropriate survey and data collection method by the project implementer are described in the next section.

<sup>&</sup>lt;sup>55</sup> UNFCCC, Guidelines for sampling and surveys for CDM project activities and programmes of activities Version 04.0. 2018: 1-114.

- c) Conducting surveys/measurements.
- d) Minimizing non-response and adjusting for its effects, analyzing potential bias arising from non-response, and correcting for any detected biases or losses in precision due to non-response.

# B) Survey and data collection methods:

This is one of the points that need to be agreed upon before starting the data collection. According to the Guideline Sampling and surveys for CDM project activities and programmes of activities- CDM-EB67-A06-GUID, a survey can be conducted by **physical on-site visit (face-to-face) or remote survey**.

- **Physical on-site visit methodologies for data collection** include hard-copy questionnaires, smartphones or tablet app modules connected to data clouds, data sensors, e-mail or web-based platform or SMS, telephone, mailing (post), etc.
- Remote survey where a surveyor will not physically visit households, data are collected through:
   (i) a data sensor to transmit data including figures and/or images recorded by camera; (ii) e-mail or web-based platform or SMS; (iii) telephone interview; (vi) mail (post).

# C) Sampling Statistical Methods:

# 1) Simple random sampling

This is usually applied when the population is homogeneous. For example, if a mitigation measure related to a cook stove is applied in this NAMA, using this sampling method assumes that the chosen sample size can be anywhere in Mongolia without differentiation between districts.

# 2) Stratified sampling

This is usually applied when the population is not-homogeneous. In other words, subpopulations within the population having similar population characteristics and hence grouped by population elements For example, if a mitigation measure related to a cook stove is applied in this NAMA, using this sampling method assumes that there are some differences between the districts; hence, a different sample size will be calculated for each district.

# 3) Cluster sampling

This method is applied when the population is not-homogeneous and is grouped in various areas. For example, if a mitigation measure related to a cook stove is applied in this NAMA, using this method assumes that the cook stoves are 'clustered' or grouped into lots of villages. Instead of going to numerous individual households in each village, sample size to be defined will be for the number of villages. In this case, each household in the randomly selected village will be part of the survey.

# 4) Multi-stage sampling

Like cluster sampling, this method is applied when the population is not-homogeneous and is grouped in various areas. Applying the same cook stoves example, the difference here is that instead of surveying all households in the randomly selected village, the number of households will be first defined, and then the sample size to be defined will be for the number of villages.

The following table summarizes the various sampling methods and shows the statistical equations used in each.

# Table 0-1: Summary of various sampling methods

Sampling method	Basis	Data requirement
Stratified sampling	Sample size equation:	Same as above, but data to be on group- level (not total population level)
b8	$n \ge \frac{1.645^2 NV}{(N-1) \times 0.1^2 + 1.645^2 V}$	
	Where: $V = \frac{SD^2}{\vec{p}^2} = \frac{overall  variance}{\vec{p}}$	
	$ar{p}$ is the overall proportion	
	$n_i = \frac{g_i}{N} \times n$ where i=1,,k and k is the number of districts Where: $g_i$ = size of the i <sup>th</sup> group (district) where i=1 N = population total	
	$SD^{2} = \frac{(g_{a} \times P_{a}(1-p_{a})) + (g_{b} \times P_{b}(1-P_{b})) + (g_{c} \times P_{c}(1-P_{c})) + \dots + (g_{k} \times p_{k}(1-p_{k}))}{N}$	
	$\overline{p} = \frac{(g_a \times P_a) + (g_b \times p_b) + (g_c \times p_c) + \dots + (g_k \times p_k)}{N}$ Where g <sub>i</sub> and N are as above and p <sub>i</sub> is the proportion for the i <sup>th</sup> group (district); i=1,,k	

Sampling	Basis	Data requirement
method		
Cluster		Same as above, but data to be on cluster-
sampling	$1.645^2 MV$	level (not total population level)
	$C \ge \frac{1}{(M-1) \times 0.1^2 + 1.645^2 V}$	
	Where:	
	$V = \frac{SD_B^2}{2} = \frac{Variance\ between\ clusters\ (villages)}{2}$	
	$\frac{1}{P^2}$ average proportion	
	C = Number of clusters to be sampled (villages)	
	M= Total number of clusters (villages) – this must encompass the entire	
	population	
	1.645 = Represents the 90% confidence required	
	0.1 = Represents the 10% relative precision required	
Multi-stage		Same as above, but data to be on cluster-
sampling	$SD_B^2$ , $M$ , $1$ , $SD_W^2$ , $(\overline{N} - \overline{u})$	level (not total population level)
	$\frac{1}{\overline{n}^2} \times \frac{1}{M-1} + \frac{1}{\overline{u}} \times \frac{1}{\overline{n}^2} \times \frac{1}{(N-1)}$	
	$c \geq \frac{r}{0.1^2} + \frac{r}{1.5D_2^2}$	
	$\frac{0.1}{1.645^2} + \frac{1}{M-1} \frac{5B_B}{\overline{p}^2}$	
	Where:	
	C= number of groups that should be sampled	
	M = total number of groups in the population	
	$\overline{u}$ = number of units to be sampled within each group (prespecific as 10	
	households)	
	$\overline{N}$ = average units per group (50 households per village)	
	$SD_B^2$ = unit variance (variance between villages)	
	$SD_w^2$ =average of the group variances (average within village variation)	
	P= overall proportion	
	1.645 = Represents the 90% confidence required	
	0.1 = Represents the 10% relative precision	
	2	
	$SD_{i}^{2} - \frac{\sum_{i=1}^{n}(p_{i}-\overline{p})^{2}}{\sum_{i=1}^{n}(p_{i}-\overline{p})^{2}}$	
	$SD_B = \frac{n-1}{n-1}$	

# Annex IV Detailed Assessment of Methodologies

# Table 0-1: Assessment of methodologies for estimation of baseline emissions against context in Mongolia

Code	М	ethod	lology	scop	e and	appl	icab	ilitv		Data														
	En	ergy s	source	9	Buil	ding	type	2		Data	requii	remer	nts											Way forward
Assessment criteria	CHPs	Boilers	Electricity grid powered by CHPs	District heating system	New	Existing	Residential	Commercial	Institution	Electricity consumption	Water consumption	Fuel consumption	Fuel characteristics-type. Carbon content, emission factor, NCV,	Technology characteristics- C.combustion	Building setting: envelope, thermal properties,	Tenancy setting: occupancy	Gross floor area	Meteorology: indoor/outdoor T	Water characteristics: mass, volume, T (in/out)	Energy efficiency in electrical appliances	Energy efficiency related to space heating	Whole building simulation	Refrigerant-Type and amount	
Mongolian	Ŷ	Y	Y	YY	Y	Y	Y	Y	Y <sup>56</sup>	Y <sup>57</sup>	Y <sup>58</sup>	Y <sup>59</sup>	Y <sup>60</sup>	TBD	N <sup>61</sup>	N <sup>62</sup>	Y <sup>63</sup>		Y	TBD	TBD		N	FC: stoves
IPCC		l											ļ										ļ	
1A1a	Υ		Y	Y																				_
1A4a		Y						Y	Y															
1A4b		Y		-			Y																	
									T1	Y		Y												- T1: FC

<sup>\*</sup>Y: yes, data is available (Mongolia)/Methodology is applicable; \*\*TBD: to be determined; N: no, data is unavailable (Mongolia)

<sup>&</sup>lt;sup>56</sup> Education buildings data. <u>*References*</u>: (technical data and guidelines for kindergarten and school buildings) (Green Public Buildings /School and Kindergarten/ Green Global Growth Institute)

<sup>&</sup>lt;sup>57</sup> Electricity consumption data for residential and commercial buildings. <u>*Reference:*</u> (Ulaanbaatar Electricity Distribution Network)

<sup>&</sup>lt;sup>58</sup> Heat consumption data. <u>*Reference:*</u> (Ulaanbaatar District Heating Company)

<sup>&</sup>lt;sup>59</sup> Available for CHPs, small and medium boilers in rural areas, but not for stoves used for cooking and heating

<sup>&</sup>lt;sup>60</sup> References for data include national reports, Coal research Institute and academic studies

<sup>&</sup>lt;sup>61</sup> Building structure (clarification needed on what 'structure' entails), Building inventory data: building use, building structure, building height and age (Reference Entity: Master Planning Agency, Municipality of Ulaanbaatar), Building type data (Reference Entity: Construction Development Center, Ministry of Construction and Urban Development)

<sup>&</sup>lt;sup>62</sup> Building database: location and accommodation capacity. <u>*Reference*</u>: (Housing and Public Utilities Authority, Municipality of Ulaanbaatar)

<sup>&</sup>lt;sup>63</sup> Floors (referred to as 'stage', area (referred to as 'space')]

Code	M	ethod	ology	scop	pe	and	appl	icabi	ility		Data														
	En	ergy s	ource			Builc	ling	type			Data	requir	emer	nts											Way forward
Assessment criteria	CHPs	Boilers	Electricity grid powered by CHPs	District heating system	Stoves	New	Existing	Residential	Commercial	Institution	Electricity consumption	Water consumption	Fuel consumption	Fuel characteristics-type. Carbon content, emission factor, NCV,	Technology characteristics- C.combustion.	Building setting: envelope, thermal properties,	Tenancy setting: occupancy	Gross floor area	Meteorology: indoar/outdoor T	Water characteristics: mass, volume, T (in/out)	Energy efficiency in electrical appliances	Energy efficiency related to space heating	Whole building simulation	Refrigerant-Type and amount	
Mongolian Data	Υ*	Y	Y	Y١	Y	Y	Y	Y	Y	Υ <sup>56</sup>	Y <sup>57</sup>	Y <sup>58</sup>	Υ <sup>59</sup>	Y <sup>60</sup>	TBD	N <sup>61</sup>	N <sup>62</sup>	<b>Y</b> <sup>63</sup>		Y	TBD	TBD		N	FC: stoves
Tier levels										T2 T3	Y Y		Y Y	Y Y	Y										_ T2: FC, EFs T3: FC, TC, EFs <sup>64</sup>
CDM Me	thc	odolo	gies								-	-	-	-	-		-	-	-		-	-	-		-
AM0091		Ŷ	65 V	Y	•	Y V	Y V	Y V	Y V	Y	Y v <sup>70</sup>	Y	Y	Y		Y <sup>66</sup>	Y <sup>67</sup>	Y		Y	Y v <sup>71</sup>	Y	Y <sup>68</sup>	Y <sup>69</sup>	verify grid electricity source
AMS-II.R			Y				Y	Y	T	T	Y		Ŷ			Y <sup>73</sup>	Y <sup>74</sup>		Y <sup>75</sup>		1	Y			<ul> <li>Fuel consumption</li> <li>Fuel consumption</li> <li>Confirm availability of B-characteristics</li> <li>Meteorological data</li> </ul>

<sup>64</sup> Fuel consumption (FC) of small and medium boilers for the three tiers, country-specific emission factors of fuels (EFs) for Tier 2 and Tier 3, and technology characteristics (TC) of small and medium boilers for Tier 3

<sup>65</sup> Not applicable to baseline-project buildings supplied with <u>electrical or thermal energy generated from cogeneration plants (CHPs.)</u>

<sup>66</sup> In case of applying the whole building simulation option

67 ibid

<sup>68</sup> Mandatory for existing buildings, and mandatory in one of the options for new buildings

<sup>69</sup> Not applicable in case of using chlorofluorocarbon (CFC) as a refrigerant

<sup>70</sup> For baseline energy consumption estimation, approaches similar to AMS-II.Q or AMS-II.R can be applied.

<sup>71</sup> Applicable for fuel switch if the latter is part of energy efficiency measures within a single building

<sup>72</sup> More data will be needed as the methodology did not explicitly show how to estimate savings. Please refer to the way forward of AMS-II.Q and AMS-II.R

<sup>73</sup> One option under the methodology requires this as an independent variable

74 ibid

75 ibid

Code	M	ethod	ology	sco	pe	and	appl	icabi	lity		Data														
	En	ergy s	source	9		Builc	ling	type			Data r	equir	emer	nts								-			Way forward
Assessment criteria	CHPs	Boilers	Electricity grid powered by CHPs	District heating system	Stoves	New	Existing	Residential	Commercial	Institution	Electricity consumption	Water consumption	Fuel consumption	Fuel characteristics-type. Carbon content, emission factor, NCV,	Technology characteristics- C:combustion.	Building setting: envelope, thermal properties,	Tenancy setting: occupancy	Gross floor area	Meteorology: indoor/outdoor T	Water characteristics: mass, volume, T (in/out)	Energy efficiency in electrical appliances	Energy efficiency related to space heating	Whole building simulation	Refrigerant-Type and amount	
Mongolian Data	Y	Y	Y	Y	Y	Y	Y	Y	Y	Yoo	Υ"	Y°	Y <sup>39</sup>	Y	TBD	N	Nº2	Y		Y	TBD	TBD		N	FC: stoves
AMS-II.Q		Y	Ŷ	<b>Y</b> 76		Y	Y		Y		Y	Y	Y	·		Y	Y	Y	Y	Y	Y	Y	Ŷ	Y <sup>77</sup>	<ul> <li>Fuel consumption</li> <li>Confirm availability of B-characteristics</li> <li>Whole building simulation tool<sup>78</sup></li> </ul>
			Y		-	Y <sup>79</sup>		Y																	
AMS-II.AE						Appro	oach 1	!			Y					Y	Ŷ	Y	Y		Ŷ	Y <sup>80</sup>	Ŷ	Y <sup>81</sup>	<ul> <li>Confirm availability of B-characteristics</li> <li>Meteorological data</li> <li>Whole building computerized simulation tool</li> </ul>
						Appro	ach 2	?			Y					Y	Y		Y		Y	Y <sup>82</sup>		Y <sup>83</sup>	<ul> <li>Confirm availability of B-characteristics</li> <li>Meteorological data</li> </ul>
Internati	ona	al Per	form	anc	e I	Meas	sure	mer	nt an	d Ve	rificati	on Pi	rotoc	ol											

 <sup>&</sup>lt;sup>76</sup> Not applicable to project activities that affect off-site district heating and/or cooling plants
 <sup>77</sup> if refrigerants ae used, they should have no Ozone depleting potential
 <sup>78</sup> Certified model and experienced modeler

 <sup>&</sup>lt;sup>79</sup> Single or multiple family residences
 <sup>80</sup> Provided that savings are just represented in grid electricity savings

<sup>&</sup>lt;sup>81</sup> CFC free refrigerant

<sup>&</sup>lt;sup>82</sup> Provided that savings are just represented in grid electricity savings

<sup>&</sup>lt;sup>83</sup> CFC free refrigerant

Code	M	ethod	ology	sco	pe	and a	appl	icabi	ility		Data														
	En	ergy s	ource	)		Build	ling	type	:		Data ı	requir	emen	its											Way forward
Assessment criteria	CHPs	Boilers	Electricity grid powered by CHPs	District heating system	Stoves	New	Existing	Residential	Commercial	Institution	Electricity consumption	Water consumption	Fuel consumption	Fuel characteristics-type. Carbon content, emission factor, NCV,	Technology characteristics- C:combustion, emission	Building setting: envelope, thermal properties,	Tenancy setting: occupancy	Gross floor area	Meteorology:	Water characteristics: mass, volume. T (in/out)	Energy efficiency in electrical appliances	Energy efficiency related to space heating	Whole building simulation	Refrigerant-Type and amount	
Mongolian Data	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y <sup>56</sup>	Y <sup>57</sup>	Y <sup>58</sup>	Υ <sup>59</sup>	Y <sup>60</sup>	TBD	N <sup>61</sup>	N <sup>62</sup>	<b>Y</b> <sup>63</sup>		Y	TBD	TBD		N	FC: stoves
Vol I and Vol III			Y			Υ <sup>84</sup>	<b>Y</b> <sup>85</sup>	Y	Y	Y	Y	Y	Y				Υ <sup>86</sup>	Y <sup>87</sup>	Y <sup>88</sup>		Y	Ŷ	Y <sup>89</sup>		<ul> <li>Confirm availability of B-characteristics</li> <li>Meteorological data</li> <li>Whole building computerized simulation tool</li> <li>Fuel consumption</li> </ul>

<sup>84</sup> Volume III
<sup>85</sup> Volume I
<sup>86</sup> Option C and D
<sup>87</sup> Option C and D
<sup>88</sup> Option C and D
<sup>99</sup> Option D

# References

- 1. Ministry of Environment and Green Development Mongolia, (2013), *Technology Needs* Assessment: Volume 2 - Climate Change Mitigation in Mongolia. p. 5,16,17.
- 2. Darío R. Gómez, et al., (2006), *Chapter 2: Stationary Combustion*, in *2006 IPCC Guidelines for National Greenhouse Gas Inventories* 2006, Intergovernmental Panel on Climate Change Panel. p. 2.7-2.24.
- 3. UNFCCC, (2015), AM0091: Energy efficiency technologies and fuel switching in new and existing buildings --- Version 3.0.. p. 4-107.
- 4. UNFCCC, (2014), *ACM0022: Alternative waste treatment processes version 02.0.*, p. 31.
- 5. UNFCCC, (2014), AM0107: New natural gas based cogeneration plant version 03.0.: p. 1-12.
- 6. UNFCCC, (2007), AMS-II.E: Energy efficiency and fuel switching measures for buildings --- Version 10.0, in Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories. p. 1-6.
- 7. UNFCCC, (2013), AMS-II.R. Energy efficiency space heating measures for residential buildings ---Version 1.0.. p. 3-9.
- 8. UNFCCC, (2012), AMS-II.Q. Energy efficiency and/or energy supply projects in commercial buildings --- Version 1.0, in Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories. p. 1-15.
- 9. UNFCCC, (2009), AMS III.AE. Energy efficiency and renewable energy measures in new residential buildings --- Version 1.0, in Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories. p. 1-7.
- 10. Efficiency Valuation Organization, (2012), *Concepts and Options for Determining Energy and Water Savings Volume 1*, in *International Performance Measurement and Verification Protocol*. p. 7-35.
- 11. International Performance Measurement & Verification Protocol, (2003), *Concepts and Options for Determining Energy Savings in New Construction Volume 3*. p. 11-23.
- 12. Institute for Global Environmental Strategies, (2017), *Joint Crediting Mechanism Approved Methodology MN\_AM003 "Installation of Solar PV System"*, p. 1-4.
- 13. Efficiency Valuation Organization, (2018), *International Performance Measurement and Verification Protocol*, 25.06.2018].
- 14. U.S. Department of Energy, (2002), International Performance Measurement & Verification Protocol Concepts and Options for Determining Energy and Water Savings Volume I p. 17-35.
- 15. Swedish Environmental Protection Agency, (2017), *National Inventory Report Sweden 2017* p. 127-132, 175-182.
- 16. National Institute for Public Health and the Environment (RIVM), (2017), *Greenhouse gas emissions in the Netherlands 1990–2015 National Inventory Report 2017.* p. 73, 279.
- 17. Mitigation Momentum, (2016), *NAMA for energy efficient refurbishment in the public building sector in Georgia*, p. 57-58.
- 18. Ministry of Environment and Natural Resources Protection of Georgia, "World Experience for Georgia", and Ilia State University, (2016), *GHGs National Inventory Report of Georgia* 2010-2013. p. 42-48.
- 19. Ministry of Environment and Natural Resources, (2007), *Mexico's third national communication to the United Nations Framework Convention on Climate Change*. p. 34-43, 61.
- 20. Stefan, W., et al., (2010), Working Paper For Supported NAMA Design Concept for Energy-Efficiency Measures in the Mexican Residential Building Sector Version 01. p. 57-58.
- 21. Susanne Theumer, et al., (2014), Supported NAMA for sustainable housing retrofit in Mexico Mitigation actions and financing packages. p. 17-22, 31-33.

- 22. Robert, K., et al., (2012), Supported NAMA for Sustainable Housing in Mexico Mitigation Actions and Financing Packages. p. 36-43.
- 23. Ministry of Energy (SENER) and GIZ. (2017), Small and Medium Business (SME) NAMA.
   25.06.2018]; Available from: <u>http://www.nama-</u> database.org/index.php/Small and Medium Business (SME) NAMA.
- 24. Green Climate Fund, (2017), *FP051: Scaling-up Investment in Low-carbon Public Buildings*. p. 39,75.
- 25. UNFCCC, (2015), *Tool 07: Tool to calculate the emission factor for an electricity system Version* 06.0. p. 4-31.
- 26. Energy Efficiency Council, (2015), *Combined Heat and Power- Best Practices and Emissions Allocation Protocols*. p. 20-26.
- 27. Ibrahim, D. and A.R. Marc, (2015), *Exergy Analysis of Heating, Refrigerating, and Air Conditioning- Methods and Applications*. Elsevier.
- 28. Achim, D., S. Thomas, and R. Steffen, *Allocation of CO*<sub>2</sub>-*Emissions to Power and Heat from CHP-Plants.* p. 3-6.
- 29. European Commission, (2015), Commission Delegated Regulation (EU) 2015/2402 of 12 October 2015 reviewing harmonised efficiency reference values for separate production of electricity and heat in application of Directive 2012/27/EU of the European Parliament and of the Council and repealing Commission Implementing Decision 2011/877/EU, in Official Journal of the European Union. p. L333/58.
- 30. WRI/WBCSD GHG Protocol Initiative, (2006), *Allocation of Emissions from Combined Heat and Power (CHP) Plant*. p. 12-14.
- 31. UNFCCC, (2018), *Guidelines for sampling and surveys for CDM project activities and programmes of activities Version 04.0.* p. 1-114.