The Republic of Moldova

Ministry of Environment

Climate Change Office

MOLDOVA

GRID EMISSION FACTOR ASSESSMENT

Chisinau 2017

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Acronyms and Abbreviations

BGP	Biogas Plant
BM	Build Margin
CDM	Clean Development Mechanism
CERs	Certified Emission Reductions
CES	Connected Electricity System
CFU	Moldova Carbon Finance Unit
CHP	Combined Heat & Power (Cogeneration Power Plant)
CM	Combined Margin
CO_2	Carbon dioxide
EB	Executive Board
EBRD	European Bank for Reconstruction and Development
Energy Community	Energy Community of South East Europe (ECSEE) and European Energy Community (EEC)
ERPA	Emission Reduction Purchase Agreement
GHG	Greenhouse gas
HPP	Hydropower plant
kWh	Kilowatt hour
LCD	Load Duration Curve
MW	Megawatt
MWh	Megawatt hour
MGRES	Condensing Power Plant located in Transnistria
MPS	Moldova Power System
OM	Operation Margin
PDD	Project Design Document
PES	Project Electricity System
PhP	Photovoltaic Plant
pmr	pridnestrovian moldavian republic
PP	Power Plant
PU	Power Unit
ANRE	National Energy Regulatory Agency
Moldelectrica	National System Operator and Transport of Electricity
t.c.e.	tone coal equivalent, 1 t.c.e. = 7000 Gcal
HSP	Hydro Storage power plant
Tool	"Tool to calculate the emission factor for an electricity system", Version 2, October 16 2009, EB 50
TSO	Transport and System Operator
MPS	Moldova Power System

Executive Summary

In 2011 GEFs were calculated for Moldova electricity system. By 2016 the need of GEFs updating appeared. Following the Guidance for Moldova Grid Emission Factor updating, developed in 2011 and published on www.clima.md the appropriate calculations have been done below, using the data provided by IS Moldelectrica.

The updated GEFs may be used by CDM and NAMA project developers to calculate CO2eq Emission Reductions.

The following are the results of Moldova GEF calculation for the crediting period starting at the beginning of 2017:

Simple OM	**BM**	**CM**		
		Wind and solar	**All other, for the first crediting period**	**All other, for the second and third crediting period**
0.4333	0.4651	0.4413	0.4492	0.4572

Definitions

Build Margin (BM) is the emission factor that refers to a cohort of power units that reflect the type of power units whose construction would be affected by the proposed CDM project activity. It is a reflection of the likely future power plants being built.

Combined margin (CM) is defined as weighted average of the build margin and the operational margin.

Connected Electricity System (CES) defined as an electricity system that is connected by transmission lines to the project electricity system. Power plants within the connected electricity system can be dispatched without significant transmission constraints but transmission to the project electricity system has significant transmission constraint.

Crediting period is the time from CDM project registration until the end of the specified time when emission reductions can be claimed on the project.

Electricity imports are defined as electricity transfers from connected electricity systems to the project electricity system

Electricity exports are defined as electricity transfers to connected electricity systems

Ex-ante is defined as a calculation based on historic data referring to the future applying the ceteris paribus clause. E.g. the host country's future emissions are calculated by the host country's historic fuel consumption – assuming that everything stays the same.

Low-cost/must-run resources are defined as power plants with low marginal generation costs or power plants that are dispatched independently of the daily or seasonal load of the grid. They typically include hydro, geothermal, wind, low-cost biomass, nuclear and solar generation. If coal is obviously used as must-run, it should also be included in this list.

Net electricity generation refers to the difference between the total quantity of electricity generated by the power plant / unit and the auxiliary electricity consumption of the power plant / unit (e.g. for pumps, vans, controlling, etc).

Operation Margin (OM) is the emission factor that refers to a cohort of power plants that reflects the existing power plants whose electricity generation would be affected by the proposed CDM project activity.

Project Electricity System (PES) defined by the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity (e.g. the renewable power plant location or the consumers where electricity is being saved) and that can be dispatched without significant transmission constraints.

Power plant/unit: A power plant / unit is a facility for the generation of electric power. Several power units at one site comprise one power plant, whereby it is characteristic for a power unit that it can be operated independently of the other power units at the same site. If several identical power units (i.e. with the same capacity, age and efficiency) are installed at one site, they may be considered as one single power unit.

1. Introduction

The determination of emission reductions from energy efficiency and renewable energy CDM projects involving the electricity grid (supply of electricity and/or reduction of demand) is based on the calculation of the grid emission factor (GEF). The experience gained from the Clean Development Mechanism/Joint Implementation (CDM/JI) projects under the Kyoto Protocol indicates that most individual project developers have limited capacities to calculate the emission factors for national (and/or relevant sub-national) power grids, especially in countries like Moldova. This is due to limited access to relevant information and data to carry out the calculation. In order to facilitate, increase efficiency and reduce the costs of CDM and NAMA PDD elaboration the developers of such projects should either know beforehand the values of GEF or have available a simple instrument or procedure to determine it.

The Moldova National Grid is distinguished by a very low security of supply due to a lack of own energy resources and high import of electricity & natural gas from abroad. By joining the Energy Community in 2010 Moldova has an opportunity to overcome this problem, including by developing renewable energy and energy efficiency projects. These have the potential to be registered as CDM or NAMA projects for which a grid emission factor is needed to calculate the CO_2 emission reductions.

In 2011 GEFs were calculated for Moldova electricity system. By 2016 the need of GEFs updating appeared. Following the Guidance for Moldova Grid Emission Factor updating, developed in 2011 and published on www.clima.md the appropriate calculations have been done below, using the data provided by IS Moldelectrioca.

The updated GEFs may be used by CDM and NAMA project developers to calculate CO2eq Emission Reductions.

2. Moldova Electricity System

The main characteristics of the Moldova Power System are outlined below:

- Because of Transnistria secessionism, the Moldova Power System (MPS) is divided into two parts: right bank and left bank (Transnistria) of river Nistru. Nevertheless, the Moldova Government considers both parts to belong to one system, i.e. to MPS, and thus to the same host country;
- Less than 20% of right bank annual electricity consumption is covered by the power plants located on this territory. The remaining proportion comes from Ukraine or Transnistria condensing PP (MGRES), which is located on the left bank;
- Most electricity on the right bank is generated by CHPs (92-96%), which are regulated. The remaining part is produced mainly by one hydropower plant;
- On the left bank two PPs delivering the energy in the national grid are operating at the moment: MGRES and Dubasari HPP.

Although both left and right banks of the MPS are operated by the System Operator (TSO) located on right bank, the left bank is not controlled by the Moldova official authority. This means that much of the data needed from the left bank for the calculation of the GEF cannot be obtained or verified, except for meter readings which are available to the TSO.

2.1 The capacity and electricity generated on right and left banks

The maximum load consumed on the right bank is around 870 MW, with own PP available capacity being 280 MW (32%)[1]. Unfortunately not all of the installed capacity on the right bank can be used to satisfy demand. Local CHP's were designed before 1990 to operate at a heat capacity almost twice what is used at present. Since 1990 this capacity dropped significantly which has led to an operation regime for PPs far from one considered as efficient for cogeneration. As a result, local CHP load is below the nominal value, their specific fuel consumption being quite high, and not as it is expected for cogeneration energy production. However, it is mandatory for all electricity produced by CHP-1, CHP-2 and CHP-Nord to be bought on the power market, as established by the National Energy Regulatory Agency (ANRE). As to CHP Sugar Factories, the electricity produced by these PPs is considered to be a by-product of the industrial process, and is sold at a price lower than the cheapest electricity available on the market.

As to the left bank, there is no available data about own electricity consumption, but the power delivered to the grid by PPs (MGRES and Dubasari HPP) located within this part of the country is known. Moldelectrica has access to the load curves for MGRES. For Dubasari HPP, electricity delivered to the grid is only known for the whole year[2].

[1] The information is provided by Ministry of Economy, ANRE and Moldelectrica

[2] http://mer.gospmr.org/gosudarstvennaya-sluzhba-statistiki/informacziya/toplivno-energeticheskie-resursy.html

Table 1 provides basic information on Moldova power units as of 1st January 2016. From the total electricity produced on the right bank in 2016, 7% is generated by renewable sources and 93% by thermal PPs.

With respect to the left bank, because of the lack of data for MGRES, the fuel consumption is calculated applying a conservative approach, using: a) capacity of units; b) default values for efficiency as prescribed in Annex 1 of the "Tool to calculate the emission factor for an electricity system"; c) units merit order loading, i.e. for each concrete hour is dispatched first the unit with the lowest fuel specific consumption.

Table 1: Main data for Moldova power units (2016)

Power Plant	Unit no.	Commissioned	Installed Capacity, MW	Average fuel consumption 2014-2016, tone/ year	Average electricity generated 2013-2015, MWh/year
Right bank					
CHP-1	PU 1	1959	12	4,575	7,325
	PU 2	1961	25	9,532	15,261
	PU 3	1961	5	1,906	3,052
	PU 4	1995	12	4,575	7,325
	PU 5	2001	12	4,575	7,325
	TOTAL		66	25,165	40,289
CHP-2	PU 1	1976	80	43,104	203,884
	PU 2	1978	80	43,104	203,884
	PU 3	1980	80	43,104	203,884
	TOTAL			129,312	611,651
CHP-Nord	PU 1	1995	12	4,670	26,372
	PU 2	2005	12	4,670	26,372
	TOTAL		24	9,340	52,744
CHP Sugar Factories	Cupcini				
	Drochia				
	Glodeni				
	Falesti				
	TOTAL				6,352
Sudzucker	**TOTAL**	2014	2.4	Biogas	8,309
Covoare-Lux	**TOTAL**	2013	0.4	Solar	378
HPP Costesti	**TOTAL**	1973	16	Hydro	48,300
Left bank					
MGRES	PU 1	1964	200		
	PU 2	1965	200		
	PU 3	1965	200		
	PU 4	1967	200		
	PU 5	1968	200		
	PU 6	1969	200		
	PU 7	1970	200		
	PU 8	1971	200		

	PU 9	1973	210		
	PU 10	1974	210		
	PU 11	1980	250		
	PU 12	1982	250		
	TOTAL		2520		3,734,580
HPP Dubasari	PU 1	1954	12		
	PU 2	1954	12		
	PU 3	1955	12		
	PU 4	1958	12		
	TOTAL		48	Hydro	242,800

Sources: ANRE, Moldelectrica for all PPs except HPP Dubasari; http://mer.gospmr.org/gosudarstvennaya-sluzhba-statistiki/informacziya/toplivno-energeticheskie-resursy.html - for HPP Dubasari

2.2. Demand satisfaction

Table 2 and Table 3 show the evolution of electricity sources participation for demand satisfaction throughout the MPS (right and left banks) during the years 2012-2016, in mil. kWh and % of total demand.

Table 2: Electricity delivered to Moldova Grid, mill.kWh

Type of Source	**Sources**	**2012**	**2013**	**2014**	**2015**	**2016**	**Average 3 years 2014-2016**	**Average 5 years**
Right bank	CHP-1	43,230	46,090	51,942	35,663	33,263	40,289	42,038
	CHP-2	635,256	597,668	601,097	626,843	607,013	611,651	613,576
	CHP-Nord	54,072	49,417	50,295	53,265	54,674	52,744	52,344
	HPP Costesti	32,600	41,690	56,300	49,860	38,740	48,300	43,838
	Sudzucker	0	0	0	11,157	13,769	8,309	4,985
	Covoare-Lux	0	0	7.08	567.8	560.6	378	227
	CHP Sugar Factories	2,999	3,761	15,200	1,639	2,218	6,352	5,163
	Total right bank	**768,157**	**738,625**	**774,841**	**778,995**	**750,238**	**768,024**	**762,171**
Left bank	Total MGRES	4,093,928	2,786,254	2,786,254	4,315,293	4,102,194	3,734,580	3,616,785
	MGRES for right bank of river Nistru	3,042,339	1,850,195	2,616,896	3,343,027	3,342,584	3,100,836	2,839,008
	Dubasari HPP	249,000	268,551	261,300	218,100	249,000	242,800	249,190
	Total left bank	**4,342,928**	**3,054,805**	**3,047,554**	**4,533,393**	**4,351,194**	**3,977,380**	**3,865,975**
Ukraine	**Import**	**846,763**	**1,459,227**	**743,912**	**105,825**	**91,619**	**313,785**	**649,469**

	TOTAL	**5,957,849**	**5,252,657**	**4,566,307**	**5,418,212**	**5,193,051**	**5,059,190**	**5,277,615**

Source: ANRE, Moldelectrica for all PPs except HPP Dubasari; http://mer.gospmr.org/gosudarstvennaya-sluzhba-statistiki/informacziya/toplivno-energeticheskie-resursy.html - for HPP Dubasari

There is strong competition between Ukraine and MGRES for supplying the Moldova power market, which accounts for the annual fluctuations of supply from these two sources, which reflects which supplier offered the cheapest electricity for each year.

Table 3: Electricity delivered in Moldova Transport Grid, %

	2012	2013	2014	2015	2016
Local CHP	12.3	13.3	15.7	13.4	13.7
Reneable sources	4.7	5.9	7.0	4.9	5.5
MGRES	68.7	53.0	61.0	79.6	79.0
Import	14.2	27.8	16.3	2.0	1.8
Total	**100**	**100**	**100**	**100**	**100**
Right bank	18.5	13.4	13.2	14.4	14.9
Left bank	29.4	43.0	43.5	85.5	84.7
Import	52.1	43.6	43.3	0.1	0.4

As it can be seen from table 3, during the last five years approximately 12% to 16% of electricity demand has been covered by local CHP's located on the right bank, 4.7% to 7% by renewable sources, 53% to 79.6% by MGRES and 0.1% to 52.1% by import from Ukraine.

2.3. Electricity Transmission System

The electricity transmission system of the Republic of Moldova operates synchronously with the Ukrainian electricity system with which it is connected by fourteen 110 kV lines and six high voltage interconnection lines of 330 kV, while a 400 kV overhead power line connects it to the electricity systems of Romania and Bulgaria (Fig. 1). Three other overhead power lines of 110 kV provide interconnections with the Romanian electricity system in an "insular regime". Interconnection lines with Ukraine permit import of up to 900 MW, while the maximum load recorded on right bank is around 800 MW[3], and the maximum load for the whole country (right and left banks) being around 1200MW.

In the event of a load deficit in Moldova the demand can be covered by importing electricity from Romania, but no more than 250MW, applying a so-called island principal of network operation (because of the Moldova and Romania power systems frequency discrepancies), using 3 x 110 kV lines (Stinca-Costesti, Tutoara-Ungheni, Cioara-Husi) and the Isaccea (Romania) - Vulcanesti (Moldova) 400kV interconnection. Because this scheme of load satisfaction leads to buying electricity at a price much higher than that supplied from Ukraine and as it cannot ensure a reliable power supply (the

[3] Source: Moldelectrica

electricity for each island is provided through one line, without reserve lines), the above mentioned scheme is not a preferred option and has only been used once during the last 10 years, in 2000.

In order to strengthen the import capacity, new interconnection lines are planned to be built with neighboring countries, as specified in the National Energy Strategy[4]. The most powerful is the 400 kV Transport Network Dnestrovsc (Ukraine) – Balti (Moldova) – Suceava (Romania).

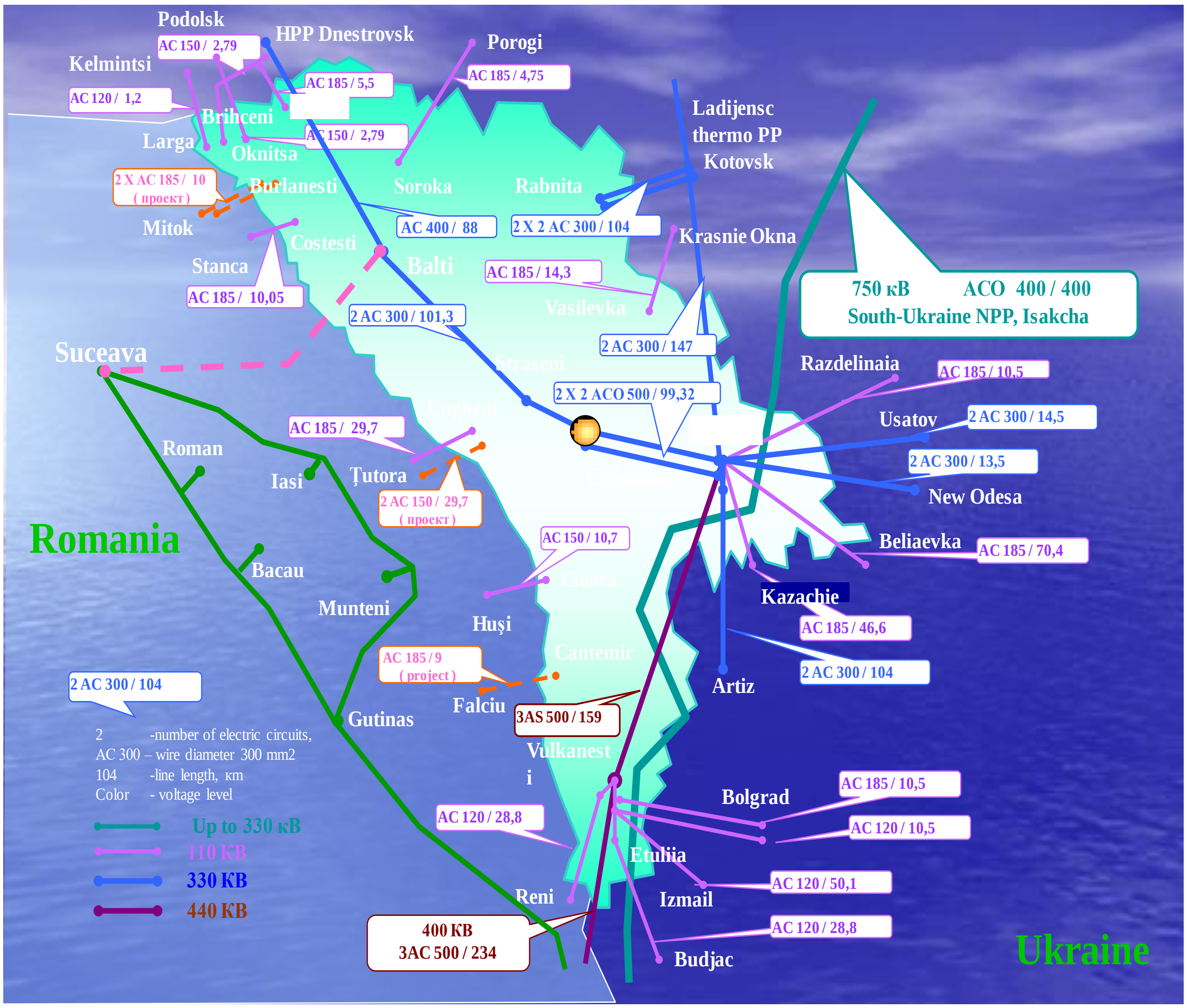

Figure 1. Moldova Power System interconnections

3. GEF calculation Methodology

In order to calculate the Moldova Grid Emission Factor (GEF) the "Tool to calculate the emission factor for an electricity system", Version 02.2.0, EB 61, Annex 12[5] is applied. The steps applied to

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[4] Energy Strategy of the Republic of Moldova up to 2030. Official Monitor, no.27-30/146 from 08.02.2013

[5] http://cdm.unfccc.int/filestorage/2/9/L/29LIXUT6W4Z0AKD37RYQ1EVSMG8HBN/eb61_repan12.pdf?t=N3R8MTMwNzQyNDkxMC45OA==|eCBV6uCWxME2DFkb35NqRDHJM4M=

calculate the GEF will be further updated in accordance with any latest version of the Tool that might be issued in the future.

For the right bank of the river Nistru the information needed to calculate GEF is known. As to the power sources located on left bank , only a part of the information for GEF determination according to the Tool is known, namely total electricity delivered to the grid by each PP, as for MGRES the annual load curve and power capacity of each of its units is available. For determining other data needed a conservative approach can be applied as it is recommended in Annex 1 of the Tool. In addition, as the fuel type used by MGRES is not known, the conservative assumption is made that the thermal units are fired with natural gas, which is the fossil fuel with the lowest emission factor. So that hereinafter the GEF is determined for the Moldova country grid taken as a whole, comprising both parts of the river Nistru.

3.1. General Guidance from the Tool

The Tool determines the CO_2 emission factor for the displacement of electricity generated by power plants in an electricity system, by calculating the "operating margin" (OM) and "build margin" (BM) as well as the "combined margin" (CM). The combined margin is determined as a weighted average of the build margin and the operational margin, as defined by the Tool. The weights of OM and BM are assigned as prescribed in Step 6 of the Tool.

3.2. Identification of the relevant electric power system

The Moldova Power System (MPS) can be considered as a project electricity system as per the Tool for the purpose of determining the grid emission factor. MPS is a relatively small system with boundaries with the national systems of Ukraine and Romania (figure 1). The national transmission and distribution networks were designed for the supply corresponding to the 1990 level. This supply has subsequently been more than halved since then due to decreasing demand provoked by the country's transition to a market economy. Therefore at present the country transmission grid has enough capacity which allows the power system to be dispatched without transmission constraints.

3.3. Off-grid power plants

The Tool permits to include in the calculation off-grid power plants. According to the definition, an off-grid power plant is a power plant/unit that supplies electricity to specific consumers through a dedicated **distribution** network which is not used by any other power plants.

In the Republic of Moldova off-grid power plants are used by the consumers requiring first category of power supply reliability. Usually, such customers have two independent sources of electricity supply, the off-grid PP being operated when the grid fails. Because the Moldova System Average Interruption Duration Index (SAIDI) is quite high, being around 3.6 hours[6], off-grid PPs are rarely used, and operating data on these PP is practically unavailable. That's why for the purpose of GEF calculation the Option I, as per the Tool, is chosen for operating and build margin emission factor determination, i.e. only grid power plants are included in the GEF calculation.

3.4. Selection of the operating margin (OM) method

[6] www.anre.md , Annual report 2015

Hereinafter the operating margin (OM) is calculated under the concept that the project electricity system encompasses the totality of the Moldova Power System (both right and left banks of the river Nistru).

The operating margin refers to a cohort of power plants that reflect the existing power plants whose electricity generation would be affected by the proposed CDM project activity.

The OM is calculated as the weighted average CO_2 emissions per unit of electricity generation. The OM is also calculated for the connected electricity grid (CES). The CES may be a national or international grid, but the Tool states that: "For imports from connected electricity systems located in Annex-I country(ies), the emission factor is 0 tons CO_2 per MWh". The import of electricity to Moldova during the last 10 years has come from Ukraine only, which is an Annex-I country. Thus the emission factor of this import is equal to 0 tons CO_2 per MWh.

The Tool proposes four methods to determine the operating margin:

a) **Simple OM** is calculated as the generation weighted average CO_2 emission per unit net electricity (tCO_2/MWh) of all generating power plants serving the system excluding low cost/must run plants/units;

b) **Simple adjusted OM** is a variation of the Simple OM where the power plants/units (including imports) are separated in low cost/must run power sources and other sources;

c) **Dispatch data analysis OM** determined based on the power units that are actually dispatched at the margin during each hour where the project is displacing electricity. This requires annual monitoring and is not applicable to historical data; this option is data intensive.

d) **Average OM is** calculated as an average emission rate of all power plants including must run sources.

Any of the four methods can be used, however, the simple OM method (option a) can only be used if low-cost/must-run resources constitute less than 50% of total grid generation in: 1) average of the five most recent years, or 2) based on long-term averages for hydroelectricity production, as stated in the Tool.

According to the definition of the Tool "Low-cost/must-run resources are defined as power plants with low marginal generation costs or power plants that are dispatched independently of the daily or seasonal load of the grid. They typically include hydro, geothermal, wind, low-cost biomass, nuclear and solar generation. If coal is obviously used as used as must-run, it should also be included in this list, i.e. excluded from the set of plants."

Strictly following the definition, Costesti HPP (16MW), Dubasari HPP (48MW), Sudzucker BGP (2.4MW), Covoare-Lux PhP (0.4MW), and other renewable PPs connected to distribution grid, could be treated as low-cost/must-run resources. However, there are three cogeneration PPs (CHP-1, CHP-2, CHP-Nord) that should be identified as must-run. Along with the electricity production they provide heating and hot water to Chisinau and Balti households. Even though the price for electricity produced by CHP-1, CHP-2 and CHP-Nord is much higher than that produced by MGRES or PPs in Ukraine, the National Agency for Energy Regulation (Regulator) makes it mandatory for customers to buy all the power produced by these CHPs[7], i.e. these power plants are dispatched independently. In other words, the mentioned CHPs cannot be displaced by a CDM project and thus these sources should be examined

[7] ANRE decision on share of electricity bought from Moldova electricity sources

under the definition of must-run as per the Tool. Such approach is used in the study[8] for determining GEF for the Ukraine Power System.

The other CHPs of MPS, i.e. CHP Sugar Factories, can be considered as low cost PPs, as they sell the (by-product) electricity at a price lower than any other on the power market.
Based on the determined low cost/must run PPs for the case of Moldova,

Table 4 presents their percent contribution to the total Moldova grid generation mix.

Table 4: The share of low cost/must-run resources in the total grid generation mix

Type of PP	Sources	Delivered to the grid	
		MWh average per 2012-2016	% from total
Low cost/must run PPs	CHP-1	42,037.6	0.8
	CHP-2	613,575.6	11.6
	CHP-Nord	52,344.4	1.0
	HPP Costesti	43,838.0	0.8
	Dubasari HPP	249,190.2	4.7
	Sudzucker	4,985.2	0.1
	Covoare-Lux	227	0.0
	CHP Sugar Factories	5,163.4	0.1
	Total low cost/must run PPs	**1,011,361.3**	**19.2**
Non low cost/must run Sources	Total MGRES	3,616,784.7	68.5
	Import	649,469	12.3
	Total non low cost/must run PPs	**4,266,253.8**	**80.8**
	TOTAL	**5,277,615.2**	**100.0**

Sources: ANRE, Moldelectrica for all PPs except HPP Dubasari; http://mer.gospmr.org/gosudarstvennaya-sluzhba-statistiki/informacziya/toplivno-energeticheskie-resursy.html for HPP Dubasari

As it is seen from table 4, low cost/must run resources constitute 19.2% of total grid generation, i.e. it is below 50% and thus Simple OM can be used for Moldova grid GEF calculation.

As to the other methods we can state with certainty that dispatch data analysis OM is not appropriate to the Moldova case as in the Republic of Moldova no merit order is used to involve PPs in the energy balance. Relatively long term power purchase contracts (usually one year contracts) between the customers and traders (PP, independent supplier) are dispatched by the system operator.

[8] EBRD. Development of the electricity carbon emission factor for Ukraine. 2010. http://www.lahmeyer.de/fileadmin/fm-lahmeyer/dokumente/li-aktuell/Draft_Baseline_Study_Ukraine.pdf

Simple adjusted OM is too data intensive in comparison with Simple OM and thus the preference should be given to the latter OM method.

Average OM can be used for Moldova case as well, but it will be considered as a reserve to the use of Simple OM and only for the situation when the data availability would require using it.

3.4.2. Simple OM method

According to the Tool, the simple OM emission factor is calculated as the generation-weighted average CO_2 emissions per unit net electricity generation (tCO_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 applying one of two Options:

Option A: Based on the net electricity generation and a CO_2 emission factor of each power unit; or
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.

In this Report Option A is used, as Option B can only be used if:

(a) The necessary data for Option A is not available; and
(b) Only nuclear and renewable power generation are considered as low-cost/must-run power sources and the quantity of electricity supplied to the grid by these sources is known, which is not the case for Moldova.

Under Option A, the simple OM emission factor is calculated based on the net electricity generation of each power unit and an emission factor for each power unit, as follows:

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

Where:

$EF_{grid,OMsimple,y}$	=	Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh) (in the denominator of the formula import from Ukraine is considered as well)
$EF_{EL,m,y}$	=	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
m	=	All power units serving the grid in year *y* except low-cost / must-run power units
y	=	The relevant year as per the data vintage chosen in Step 3

The emission factor of each power unit *m* is determined according to Option A1 of the Tool if for a power unit *m* data on fuel consumption and electricity generation is available:

$$EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{EG_{m,y}}$$

Where:

$EF_{EL,m,y}$	= CO_2 emission factor of power unit *m* in year y (tCO_2/MWh)
$FC_{i,m,y}$	= Amount of fossil fuel type *i* consumed by power unit *m* in year *y* (Mass or volume unit)
$NCV_{i,y}$	=Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ/mass or volume unit)
$EF_{CO2,i,y}$	= CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)
$EG_{m,y}$	= 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 units
i	= All fossil fuel types combusted in power unit *m* in year *y*
y	= The relevant year as per the data vintage chosen in Step 3 of the Tool

If for a power unit *m* only data on electricity generation and the fuel types used is available, the emission factor should be determined according to the Option A2 of the Tool, i.e. based on the CO2 emission factor of the fuel type used and the efficiency of the power unit, as follows:

$$EF_{EL,m,y} = \frac{EF_{CO2,m,i,y} \cdot 3.6}{\eta_{m,y}}$$

Where:

$EF_{EL,m,y}$	= CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
$EF_{CO2,m,i,y}$	= Average CO_2 emission factor of fuel type *i* used in power unit *m* in year *y* (tCO_2/GJ)
$\eta_{m,y}$	= Average net energy conversion efficiency of power unit *m* in year *y* (ratio)
m	= All power units serving the grid in year *y* except low-cost/must-run power units
y	= The relevant year as per the data vintage chosen in Step 3

3.4.3. Data Vintage

The Tool offers two options for collecting the data for OM calculation:

1. **Ex-ante option:** The ex-ante option is based on the 3 years generation-weighted average, based on the most recent data available at the time of validation. Once the project is registered this option does not require monitoring and recalculation of the emission factor during the crediting period.

2. Ex-post option: The ex-post option requires calculation of the GEF for each year in which the project activity displaces grid electricity. This option requires the emission factor to be updated annually during monitoring.

As 3 years generation-weighted average data is available the ex-ante option is chosen to calculate OM for Moldova Power System.

3.5. The Calculation of the Build Margin

The build margin refers to a cohort of power units that reflect the type of power units whose construction would be affected by the proposed CDM project activity. According to the Tool, the BM is calculated as the emission factor of a) the set of five power units, *excluding power units registered as CDM project activities*, that started to supply electricity to the grid most recently or b) the set of power units, *excluding power units registered as CDM project activities*, that started to supply electricity to the grid most recently and that comprise 20% of annual electricity generation of the project electricity system, excluding power units registered as CDM project activities. The BM is calculated based on the set that has the larger annual electricity generation.

The BM is determined for the project electricity system except where recent or likely future additions to transmission capacity enable significant increases in imported electricity. In such cases, the transmission capacity may be considered a BM source[9].

With respect to transmission capacity, the Ukraine-Moldova interconnection lines have been built before 2000, but the increase of supply into Moldova from these lines was implemented during 2007-2009, as a result of power plant capacity increasing in the Odessa region power system (Ukraine) which borders with Moldova power system in the country's southern part. This capacity is determined from the Steady-State Stability Study, respecting the normative level of Stability. Up to 2005-2006 Ukraine-Moldova interconnection capacity, available for import to Moldova, could reach a maximum of 150MW as the majority of the interconnections' line capacity was used to transport electricity to the Odessa region from other parts of Ukraine (via Moldova), whereas this figure was increased to more than 900MW during 2007-2009. The carrying capacity of the lines, however, has not been physically changed. Because the Tool refers to "recent or likely future additions to transmission capacity enable significant increases in imported electricity", and that in the case of Moldova the increase in import capacity was not due to any "recent … addition to transmission capacity" but rather existing capacity being freed up, it is concluded that the increase in transmission cannot be integrated into the BM calculation. For the BM calculation, therefore, only the most recently build PPs will be taken into consideration.

In Table the sets of power units reflecting abovementioned options a) and b) are shown. Because the set b) registers more electricity delivered to the grid it is chosen for BM calculation.

Table 5: The sets of power units built most recently according to BM calculation procedure

Sets	No	Power Plant	Power Unit	Year of commissioning	TOTAL electricity delivered to the grid in 2010	Electricity delivered to the grid in 2016 by power units, MWh
a)	1	CHP-Nord, unit 1	unit 1	1995		27,337
	2	CHP-1, Unit 5	unit 5	2001		6,048
	3	CHP-Nord, unit 2	unit 2	2005		27,337

[9] Page 4 of the Tool: For the purpose of determining the build margin emission factor, the spatial extent is limited to the project electricity system, except where recent or likely future additions to transmission capacity enable significant increases in imported electricity. In such cases, the transmission capacity may be considered a build margin source.

	4	Covoare-Lux	-	2013		560.6
	5	Sudzucker		2014		13,769
	TOTAL					**75,051**
	Share from TOTAL, %					**1.4**
b)	1	Covoare-Lux		2013		560.6
	2	Sudzucker		2014		13769
	3	CHP-Nord, unit 2	unit 2	2012		27337
	4	CHP-1, Unit 5	unit 5	2005		6048
	5	CHP-Nord, unit 1	unit 1	2001		27337
	6	CHP-1, Unit 4	unit 4	1995		6048
	7	MGRES, unit 12	unit 12	1982		2181606.157
	TOTAL					**2262705**
	Share from TOTAL, %					**44**
TOTAL electricity delivered to the grid in 2016					**5193051**	

It should be mentioned that Sudzucker PP is registered as CDM project and it should not be included in the set of PP for BM. But, if the set of PPs selected comprise PP built more than 10 years ago than plants registered as CDM project activity should be included in the build margin group alternated of the plants built more than 10 years ago, following the rules d), e), f) from the Step 5 of the Tool.

The appropriate changes in the set of plants is introduced in the Sheet BM.

The BM is therefore calculated as follows:

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

Where:

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year *y* (tCO_2/MWh)

$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)

$EF_{EL,m,y}$ = CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)

m = Power units included in the build margin

y = Most recent historical year for which power generation data is available

3.6. The calculation of combined margin emissions factor

According to the Tool the calculation of the combined margin (CM) emission factor ($EF_{grid,CM,y}$) is based on one of the following methods:

(a) Weighted average CM; or
(b) Simplified CM

For the Moldova case, the weighted average CM is chosen as Moldova is not a Least Developed Country (LDC), as the required by the Tool.

The combined margin emissions factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$

Where:

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EF_{grid,OM,y}$ = Operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
w_{OM} = Weighting of operating margin emissions factor (%)
w_{BM} = Weighting of build margin emissions factor (%)

The CM calculation will be done for the following default values of w_{OM} and w_{BM}, as specified in the Tool:

- 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;
- 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.
- Alternative weights can be proposed, as long as w_{OM} + w_{BM} = 1, for consideration by the Executive Board, taking into account the guidance on selecting alternative weights under Step 6 on Calculating the combined emission factor of the latest Methodological Tool version 03.

4. GEF calculation

1. The Moldova GEF calculation Sheet is based on a modified IGES CDM ERs (cdm-info@iges.or.jp) Calculation Sheet to which five sheets are added, reflecting the automatic calculation of net electricity production by MGRES power units for the last 5 years: 2012-2016. The last 5 sheets are completed with data only when the total volume of electricity delivered to the grid by this PP is known. In order to reflect low-cost/must-run PP on conventional fuels appropriate changes are introduced in the IGES Sheet as well;
2. Due to the lack of data on type and fuel consumption per power unit for MGRES the conservative approach is used to determine these parameters, applying the information on type of units built at this PP, the year of their commissioning and the recommended efficiency of such units according to Annex 1 of the Tool;
3. Thus, in the Excel spreadsheet the fuel consumption is calculated applying: a) capacity of units; b) default values for efficiency as prescribed in Annex 1 of the “Tool to calculate the emission factor for an electricity system”; c) units merit order loading, i.e. for each hour of each three most recent years it is charged first the unit with the lowest fuel specific consumption; d) net electricity production of each power unit is calculated;
4. In addition, at MGRES three types of fuels are used - natural gas, heavy fuel oil and coal - but it is not known exactly which ones participate in the electricity production at each power unit. It is

therefore necessary, as the Tool prescribes, to make a conservative assumption, i.e. that the thermal units are fired with natural gas, which is the fossil fuel with the lowest emission factor;

5. The OM, BM and CM are calculated in separate sheets;
6. OM is calculated based on the ex-ante approach; Option 1 for vintage of data is used for BM calculation and standard approach and default values for CM is applied.

The Guidance for subsequent annual updates of the GEF by the DNA or Climate Change Office is presented on www.clima.md site.

5. The results of Moldova Power System GEF calculation

Using the Excel tool the following are the results of Moldova GEF calculation for the crediting period starting with 2017:

Table 6: The results of Moldova Power System GEF calculation, tCO_2/MWh

Simple OM	BM	CM		
		Wind and solar	All other, for the first crediting period	All other, for the second and third crediting period
0.4333	0.4651	0.4413	0.4492	0.4572