ASSESSMENT OF THE GRID EMISSION FACTOR OF MOLDOVA'S ELECTRICITY SYSTEM

CASE STUDY

MOLDOVA ENERGY SECURITY ACTIVITY

APRIL 15, 2024

This publication was produced for review by the United States Agency for International Development. It was prepared by the Moldova Energy Security Activity (Tetra Tech ES, Inc., prime contractor)

ASSESSMENT OF THE GRID EMISSION FACTOR OF MOLDOVA'S ELECTRICITY SYSTEM

Case Study

Prepared for:

Ministry of Environment of the Republic of Moldova
Blvd. Stefan cel mare si Sfant 162
MD 2005, mun. Chisinau
Republic of Moldova

Prepared by:

Tetra Tech ES, Inc.
1320 North Courthouse, Suite 600
Arlington, VA 22201
www.tetratech.com

Contract Number: 7200AA19D00029

CONTENTS

ACRONYMS

BM	Build Margin
CDM	Clean Development Mechanism
CHP	Combined Heat and Power (Cogeneration Power Plant)
CM	Combined Margin
CO_2	Carbon Dioxide
ENTSO-E	European Network of Transmission System Operators for Electricity
GEF	Grid Emission Factor
GJ	Gigajoule
HPP	Hydropower Plant
kV	Kilovolt
LCMR	Low-Cost/Must-Run
MESA	Moldova Energy Security Activity
MGRES	Moldovan Thermal Power Plant in Dnestrovsk
MPS	Moldova Power System
MW	Megawatt
MWh	Megawatt-Hour
NCV	Net Calorific Value
OM	Operating Margin
RES	Renewable Energy Sources
Tool	Tool to Calculate the Emission Factor for an Electricity System, Version 07.0, August 31, 2018, Executive Board 100, developed by the UNFCCC for the CDM of the Kyoto Protocol
TSO	Transmission System Operator
UNFCCC	United Nations Framework Climate Change Convention
USAID	U.S. Agency for International Development

EXECUTIVE SUMMARY

A power system's grid emission factor (GEF) determines the carbon dioxide (CO_2) emission factor for the electricity generated by power plants in the system (that is, the amount of emissions produced per unit of electricity generated) by calculating the combined margin (CM) of the system.

The CM is the weighted average of two system emission factors: the operating margin (OM) and the build margin (BM). The OM is the emission factor of the group of existing power plants whose current electricity generation would be affected by proposed Clean Development Mechanism (CDM) project activity. The BM is the emission factor of the group of prospective power plants whose construction and future operation would be affected by proposed CDM project activity.

A power system's GEF is affected by low-cost CDM projects that will top the merit order list and reduce the generation of carbon-emission-intensive power plants.

In 2011 and 2017, GEF values were calculated for Moldova's electricity system. By 2024, it was clear that the value needed to be updated. The U.S. Agency for International Development (USAID) Moldova Energy Security Activity (MESA) used tool and data from various stakeholders to calculate the new GEF: the Tool to Calculate the Emission Factor for an Electricity System, Version 07.0,[1] and the Table to Calculate the Emission Factor for an Electricity System (Version 04.0)[2] developed by the United Nations Framework Climate Change Convention (UNFCCC) for the CDM. The results are comparable with the International Financial Institutions (Interim) Dataset of Grid Factors (Version 3) published in December 2021[3] but are more accurate because of communication with generation companies, sugar industry companies, and the regulatory agency, which improved the quality of input data.

The updated GEF values may be used to measure the greenhouse gas emission reductions from grid-connected projects for renewable energy (increased electricity supply) and energy efficiency (reduced electricity demand). Therefore, they will help the Government of Moldova track its progress against the reduction targets in Moldova's nationally determined contribution. In addition, the GEF will enable affected national companies to report their indirect CO_2 emissions (associated with consumption of electricity from the grid), as required by the newly adopted Carbon Border Adjustment Mechanism (CBAM), with reference to Regulation (EU) 2023/956 as of May 17, 2023, and Implementing Regulation (EU) 2023/1773 as of August 17, 2023.

The following are the results of Moldova's GEF calculation for the crediting period (the period of time for which net greenhouse gas emissions reductions or removals will be verified), starting in 2024:

TABLE 1. MOLDOVA'S GEF CALCULATION FOR THE CREDITING PERIOD, STARTING IN 2024, TONNE CO_2/MWH

SIMPLE OM	BM	CM		
		WIND AND SOLAR	ALL OTHERS FOR THE FIRST CREDITING PERIOD	ALL OTHERS FOR SUBSEQUENT PERIODS
0.5220	0.4926	0.5147	0.5073	0.5000

[1] <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v7.0.pdf>
[2] <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v1.1.pdf/history_view>
[3] Harmonized grid emission factor data set | UNFCCC.

DEFINITIONS

Power plant/unit: A facility that generates electric power. Several power units at one site comprise one power plant, and a power unit is characterized by the fact that it can operate independently from other power units at the same site. Where several identical power units (i.e., with the same capacity, age, and efficiency) are installed at one site, they may be considered one single power unit.

Grid power plant/unit: A power plant/unit that supplies electricity to an electricity grid and, if applicable, to specific consumers. This means that power plants supplying electricity to the grid and specific captive consumers at the project are considered grid power plant/units, while power plants that serve only captive consumers and do not supply electricity to the grid are not considered grid power plant/units.

Off-grid power plant/unit: A power plant/unit that supplies electricity to specific consumers through a dedicated distribution network that is not used by any other power plants. For a power plant to be categorized as off-grid, the following conditions need be fulfilled:

- There is a contract specifying the service between the power plant and the isolated user (indicating time of service and conditions of supply).
- There is a grid (or grids) that is capable of supplying power to the specific consumer(s) to which the off-grid facility is connected.
- The off-grid facility is not connected to the grid(s) and cannot supply power to the grid(s), but only to the consumer(s) to which it is connected.
- Under normal conditions, the consumer(s) are supplied their power requirements from the grid only; that is, the off-grid plant(s) that is connected to the consumer(s) is a standby on-site facility(ies) that is only used when power supply from the grid fails (or in many cases, when the quality of power supply to the end user is below acceptable quality).
- To ensure a proper shift from the grid supply to the off-grid supply, the consumer has in place a change-over switch system (which may be manual or automatic).

Net electricity generation: The difference between the total quantity of electricity generated by the power plant/unit and the auxiliary electricity consumption (also known as parasitic load) of the power plant/unit (e.g., for pumps, fans, control).

Project electricity system: A system 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 are covered by either a single or layered dispatch area.

Isolated grid system: An electricity system that supplies electricity to household users and, if applicable, industries and commercial areas; is not connected to any other electrical network (e.g., national/regional or interconnected power system); and meets one of the following conditions:

- Sixty-five percent of the installed power capacity is based on liquid fossil fuel sources; or

- The maximum installed power capacity is 1,000 MW, and at least 80 percent of that capacity is based on fossil fuel sources—solid, liquid, or gaseous.

Connected electricity system: An electricity system that is connected by transmission lines to the project electricity system.

Dispatch center: An entity responsible for keeping the electricity system synchronized within its dispatch area. The dispatch center's responsibilities include scheduling generation and dispatching electricity from power plants to customers and, where applicable, to the connected electricity system(s).

Dispatch area: An electricity system or a part of the electricity system controlled by a dispatch center. A national electricity system could be controlled by multiple dispatch centers, which can be organized either into a layered dispatch area or into independent dispatch areas. An example of a layered dispatch area is one where regional dispatch centers are required to comply with orders of the national dispatch center.

Low-cost/must-run (LCMR) resources: Power plants with low marginal generation costs or those dispatched independently of the daily or seasonal load of the grid. They include hydro, geothermal, wind, low-cost biomass, nuclear, and solar generation. If a fossil fuel plant is dispatched independently of the daily or seasonal load of the grid and if this can be demonstrated based on publicly available data, it should be considered an LCMR resource. Electricity imports shall be treated as one LCMR power plant.

Load-shedding program: A planned action that consists of the deliberate switching off of electrical supply to parts of the electricity system. Switching off is required when there is an imbalance between electricity demand and electricity supply.

Lowest annual system load: The minimum recorded value of hourly load in MW in a grid over a calendar year.

Highest annual system load: The maximum recorded value of hourly load in MW in a grid over a calendar year.

Grid emission factor: A power system's grid emission factor (GEF) determines the carbon dioxide (CO_2) emission factor for the electricity generated by power plants in the system (that is, the amount of emissions produced per unit of electricity generated) by calculating the combined margin (CM) of the system.

Operating margin: The operating margin is the emission factor of the group of existing power plants whose current electricity generation would be affected by proposed Clean Development Mechanism (CDM) project activity.

Build margin: The build margin is the emission factor of the group of prospective power plants whose construction and future operation would be affected by proposed CDM project activity.

Combined margin: The combined margin is the weighted average of two system emission factors: the operating margin (OM) and the build margin (BM).

INTRODUCTION

To determine how much emissions fall because of renewable energy and energy efficiency CDM projects involving the electricity grid (by increasing the supply of electricity and/or by reducing demand), a country needs to calculate the grid emission factor (GEF). The GEF measures the amount of greenhouse gas emissions per unit of electricity generated.

The Moldova National Grid has low security of supply because it has so few of its own energy resources and imports significant electricity and natural gas from abroad. Joining the Energy Community in 2010 gave Moldova the opportunity to overcome this problem, including by developing renewable energy and energy efficiency projects. These could be registered as CDM projects, for which a GEF is needed to calculate the CO_2 emission reductions.

In 2011 and 2017, GEF values were calculated for Moldova's electricity system. By 2024, it was clear that the GEF needed updating. The U.S. Agency for International Development (USAID) Moldova Energy Security Activity (MESA) used tool and data from various stakeholders to calculate the new GEF: the Tool to Calculate the Emission Factor for an Electricity System, Version 07.0,[4] and the Table to Calculate the Emission Factor for an Electricity System (Version 04.0)[5] developed by the United Nations Framework Climate Change Convention (UNFCCC) for the CDM.

The updated GEF values may be used to measure the greenhouse gas emission reductions from grid-connected projects for renewable energy (increased electricity supply) and energy efficiency (reduced electricity demand). Therefore, they will help the Government of Moldova track its progress against the reduction targets in Moldova's nationally determined contribution.

In addition, the GEF will enable affected national companies to report their indirect CO_2 emissions (associated with consumption of electricity from the grid), as required by the newly adopted Carbon Border Adjustment Mechanism (CBAM), with reference to Regulation (EU) 2023/956 as of May 17, 2023, and Implementing Regulation (EU) 2023/1773 as of August 17, 2023.

[4] <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v7.0.pdf>

[5] <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v1.1.pdf/history_view>

I. MOLDOVA POWER SYSTEM (MPS)

The main characteristics of the MPS are outlined below:

- Because of secessionism in the Transnistrian Region (Administrative-Territorial Units of the Left Bank of the Dniester River), the MPS is divided into two parts: one on the right bank and one on the left bank of the Dniester River. Nevertheless, the Government of Moldova considers both parts to belong to one system, and thus to the same country.

- Less than 25 percent of the right bank's annual electricity consumption is covered by the power plants located in this territory. The remaining proportion comes from Ukraine, Romania, or the Moldovan Thermal Power Plant (MGRES), which is located on the left bank.

- Most electricity on the right bank (60-65 percent) is generated by combined heat and power plants (CHPs), which are regulated. The remaining part is produced mainly by distributed renewable energy sources (RES) and one hydropower plant (HPP).

- On the left bank, there are three power plants delivering energy to the national grid: MGRES, the industrial CHP of Tirotex Textile Company, and Dubasari HPP.

- All electricity demand is covered by domestic production and electricity imports. Annual local production is around 801–984 GWh, and local (right bank) electricity production remains far below consumption, covering only 21.4 percent of demand in 2021. This denotes a state of high dependence on imports and purchases of electricity from the Transnistrian region, making Moldova's security of supply vulnerable, despite the fact that during period of 2019-2021 domestic production has increased. The 2021 increase in domestic electricity production was due to the increase in production at CHPs and renewables power plants. The main share of local production belongs to CHP producers (more than 70 percent).

- The risk to security of supply is the rather limited technical reliability (and consequently, availability) of power plants and CHPs due to high wear and tear on the installations. All CHPs are at least 30–50 years old. High wear and tear on both electricity generation and delivery (transmission and distribution) installations has severe negative effects on both the technical performance (such as capacity availability, fuel conversion efficiency, and heat load dependency) and economic performance of energy installations.

Although both parts of the MPS are operated by the transmission system operator (TSO) located on the right bank, the left bank is not controlled by the official Moldovan authority. This means that much of the data needed from the left bank to calculate the GEF values cannot be verified, except for meter readings that are available to the TSO.

1.1. CAPACITY AND GENERATION ON THE RIGHT AND LEFT BANKS

In 2023, the maximum gross load consumed on the right bank was around 840 MW. Installed capacity of CHPs is around 360 MW, and these units are considered must-run due to the need for heat production in winter. The capacity of distributed RES is around 220 MW, and with HPP Costesti, these power plants are considered to be low-cost units. CHPs of sugar plants in Drochia and Falesti (IM Südzucker Moldova SA) and Cupcini (ICS Moldova Zahar SRL) are considered to be must-run because power generation is a byproduct of industrial process.

On the left bank, the power delivered to the grid by local power plants (MGRES and Dubasari HPP) is known. The power mix contains coal units (1,600 MW) and gas units (920 MW) at MGRES, the industrial CHP of Tirotex Textile Company (31.3 MW), and HPP Dubasari (48 MW).

Annex 1 provides basic information on Moldovan power units as of January 1, 2024. Of the total electricity produced on the right bank in 2023, 7 percent was generated by renewable sources and 93 percent by thermal power plants.

1.2. DEMAND SATISFACTION

Table 2 and Table 3 show the evolution of electricity sources' participation in meeting demand throughout the MPS (both right and left banks) from 2019 to 2023, in GWh and as a percentage of total generation.

Demand on the left bank is supplied from one or two MGRES units, and the rest of MGRES' production is used to supply demand on the right bank.

On the right bank, RES capacities and must-run capacities are dispatched first. CHP 1 is utilized during summer months to produce hot water for boiler systems in Chisinau. In winter months, CHP 2 and CHP Nord are used to produce heating energy.

TABLE 2: GENERATED NET ELECTRICITY, GWH

Source	2019	2020	2021	2022	2023
CHP 1	18	20	15	22	31
CHP 2	584	601	680	506	493
CHP Nord	58	100	102	84	79
HPP Costesti	64	47	68	41	69
CHPs of sugar plants	23	19	20	17	15
Distributed RES	44	64	99	188	274
Right bank: total	**791**	**851**	**984**	**858**	**961**
MGRES	3,942	4,375	4,653	3,800	4,290
HPP Dubasari	229	225	244	218	250
CHP Tirotex	260	266	262	262	262
Left bank: total	**4,431**	**4,866**	**5,159**	**4,280**	**4,802**
Imports	644	167	161	0	136

As can be seen in Table 3, during the last five years, approximately 15–17 percent of electricity demand was covered by local CHPs, 6–10 percent by renewable sources, 67–74 percent by MGRES, and 2–11 percent by imports from Ukraine and Romania.

TABLE 3: GENERATED NET ELECTRICITY, %					
Source	2019	2020	2021	2022	2023
Local CHPs	16	17	17	17	15
RES	6	6	7	9	10
MGRES	67	74	74	74	73
Imports	11	3	3	0	2
Total	**100**	**100**	**100**	**100**	**100**
Right bank	13	14	16	17	16
Left bank	76	83	82	83	81

1.3. ELECTRICITY TRANSMISSION SYSTEM

Moldova's electricity network includes 6,228.6 km of 400 kV, 330 kV, and 110 kV transmission lines. Additional 6–35 kV lines operate mainly in radial mode. The transmission system operates synchronously with the Ukrainian electricity system and the European Network of Transmission System Operators for Electricity (ENTSO-E). It is connected by eleven 110 kV lines and seven high-voltage 330 kV interconnection lines with Ukraine, while a 400 kV overhead power line and three 110 kV lines connect it to the electricity system of Romania (Figure 1).

Three other 110 kV overhead power lines provide interconnections with the Romanian electricity system. Interconnection lines with Ukraine permit imports of up to 600 MW, while the maximum gross load recorded on the right bank of the Dniester River is around 900 MW, and the maximum load for the whole country is around 1,150 MW.

The high-voltage interconnection between Moldova and Romania consists of the aforementioned 400 kV Vulcanesti–Isaccea overhead power line and four 110 kV lines.

However, these interconnections were previously used only in exceptional cases, in island mode, as the MPS did not operate synchronously with the Romanian power system.

Thus, to increase Moldova's security of electricity supply by diversifying its sources of electricity, the country has been implementing two major projects:

- The synchronous interconnection of the energy systems of Moldova and Ukraine with the ENTSO-E energy system
- The interconnection of the MPS with the Romanian system through the construction of another 400 kV Vulcanesti–Chisinau overhead line.

Since February 24, 2022, the power systems of Ukraine and Moldova have been disconnected from the integrated IPS/UPS system of Russia and parts of Central Asia.

On March 16 of that year, the Continental European TSOs carried out the emergency synchronization of the ENTSO-E Continental European Power System with the power systems of Ukraine and Moldova.

The new 400 kV interconnection line, from the Balti substation to the Suceava substation, is planned to be built with Romania.

Figure 1. Moldovan Power System interconnections

II. GRID EMISSION FACTOR CALCULATION METHODOLOGY

To calculate Moldova's GEF, MESA used the Tool to Calculate the Emission Factor for an Electricity System, Version 07.0 (the Tool), and the Table to Calculate the Emission Factor for an Electricity System (Version 04.0) developed by the UNFCCC.

For the right bank of the Dniester River, the information needed to calculate the GEF is known. Most of the information was gathered from Termoelectrica, CHP Nord, Moldelectrica, IM Südzucker Moldova SA, ICS Moldova Zahar SRL, the National Agency for Energy Regulation, and the Environment Agency.

For the power sources located on the left bank, only some of the information needed to determine the GEF is known, namely, the total electricity delivered to the grid by MGRES, HPP Dubasari, and the industrial CHP of Tirotex Textile Company. For the rest of the calculation, the team used the following assumptions regarding net calorific value, fuel usage, and CO_2 emissions:

- Fuel consumption was taken from the statistical publication *Socio-Economic Development of the Transnistrian Moldovan Republic"* (Chapter 4) for coal and oil and from Moldovagaz/Tiraspoltransgaz for natural gas.

- The net calorific value of fuel at MGRES for natural gas is based on data received from Moldovagaz, while in the case of fuel oil, the net calorific values are based on data received from Termoelectrica. Net calorific values for coal are based on those available in Statistical Report No. 1, "Energy Balances," produced annually by the National Bureau of Statistics.

- The greenhouse gas emissions factors are those available in Volume 2, "Energy," of the 2006 Intergovernmental Panel on Climate Change's *Guidelines for National Greenhouse Gas Inventories*.[6]

- The distribution of overall gross MGRES generation and fuel consumption to separate units was based on energy balances available in MGRES press releases.[7]

The GEF was determined for the Moldovan grid as a whole, comprising both banks of the Dniester River.

2.1. 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), build margin (BM), and combined margin (CM). The CM is determined as a weighted average of the BM and the OM. The weights of the OM and BM are assigned as prescribed in Step 6 of the Tool.

[6] Intergovernmental Panel on Climate Change, Task Force on National Greenhouse Gas Inventories, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 'Energy',_Chapter 1_'Introduction'_ <https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html>)

[7] Пресс-служба ЗАО «Молдавской государственной районной электростанции» (МГРЭС) <https://moldgres.com/wp-content/uploads/2022/02/proizvodstvennye-pokazateli-zao-moldavskaja-gres-po-itogam-goda.pdf>, <https://moldgres.com/wp-content/uploads/2021/02/proizvodstvennye-pokazateli-zao-moldavskaja-gres-za-2020-god.pdf>

2.2. IDENTIFICATION OF THE RELEVANT ELECTRIC POWER SYSTEM

The MPS can be considered a "project electricity system" within the Tool's classification for the purpose of determining its GEF. It is a relatively small system that has boundaries with the national systems of Ukraine and Romania. The country transmission grid has enough capacity to allow the power system to be dispatched without transmission constraints.

2.3. OFF-GRID POWER PLANTS

The Tool permits including off-grid power plants in the calculation. An off-grid power plant is a power plant/unit that supplies electricity to specific consumers through a dedicated distribution network that is not used by any other power plants.

However, In Moldova, off-grid power plants are used by the consumers requiring the first category of power supply reliability. Usually, such customers have two independent sources of electricity supply, the off-grid power plant being operated when the grid fails. Off-grid power plants are rarely used, and operating data on these power plants are practically unavailable. Therefore, for the purpose of GEF calculation, the Tool's Option I was chosen to determine OM and BM; i.e., only grid power plants were included in the GEF calculation.

2.4. SELECTION OF THE OPERATING MARGIN METHOD

The OM reflects the cohort of existing power plants whose electricity generation would be affected by the proposed CDM project activity. It is calculated as the weighted average CO_2 emissions per unit of electricity generation. The OM is also calculated for the connected electricity system. That system may be a national or international grid, but the Tool states that "for imports from connected electricity systems located in Annex-I countries to UNFCCC, the emission factor is 0 tons CO_2 per MWh."

This OM was calculated under the assumption that the project electricity system encompasses the whole MPS (both right and left banks). Imports of electricity to Moldova during the last ten years have come from Ukraine and Romania, which are Annex-I countries to UNFCCC. 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:

- Simple OM is calculated as the generation weighted average CO_2 emission per unit of net electricity (tCO_2/MWh) of all generating power plants serving the system, excluding LCMR plants/units.

- Simple adjusted OM is a variation of simple OM wherein the power plants/units (including imports) are separated into LCMR power sources and other sources.

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

- Average OM is calculated as the 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 LCMR resources (including imports) constitute less than 50 percent of total grid generation in the average of the five most recent years or based on long-term averages for hydroelectricity production.

According to 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 this definition, Costesti HPP (16 MW), Dubasari HPP (48 MW), and other renewable power plants connected to the distribution grid could be treated as LCMR resources. However, four cogeneration power plants (CHP 1, CHP 2, CHP Nord, CHP Tirotex) and MGRES G11 should be identified as must-run because of heat production during winter. In other words, these CHPs cannot be displaced by a CDM project and thus should be examined as must-run as per the Tool.

The other CHPs, i.e., CHPs of sugar plants (IM Südzucker Moldova SA and ICS Moldova Zahar SRL), can be considered low-cost power plants, as they sell their (byproduct) electricity at a lower price than any other on the power market.

Table 4 presents LCMRs' percentage contribution to Moldova's total grid generation mix. These resources constitute 47.9 percent of total grid generation, and because it is below 50 percent, the simple OM method can be used to calculate Moldova's GEF. (Compared to simple OM, simple adjusted OM is too data intensive, which is why preference was given to the former method. Average OM can also be used for Moldova, but it would be considered a backup to simple OM and only used when data availability would require it.)

TABLE 4: SHARE OF LOW-COST/MUST-RUN RESOURCES IN THE TOTAL GRID GENERATION MIX

YEAR	2019	2020	2021	2022	2023
LCMR generation [GWh]	3,027.1	2,734.0	2,955.5	2,401.5	2,810.3
Other generation [GWh]	2,838.4	3,149.9	3,349.9	2,736.0	3,088.7
LCMR [%]	51.6	46.5	46.9	46.7	47.6
Total generation [GWh]	**5,865.5**	**5,883.9**	**6,305.4**	**5,137.5**	**5,899.0**

2.4.1. SIMPLE OPERATING MARGIN METHOD

According to the Tool, the simple OM emission factor is calculated as the generation-weighted average CO_2 emissions per unit of net electricity generation (tCO_2/MWh) of all generating power plants serving the system, not including LCMR power plants/units (but including imports).

The simple OM may be calculated applying one of two options:

- Option A: Based on the net electricity generation and the CO_2 emission factor of each power unit

- 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

This report uses Option A, because Option B can only be used if:

- The necessary data for Option A are not available; and
- Only nuclear and renewable power generation are considered LCMR power sources and the quantity of electricity these sources supply to the grid 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)

$EF_{EL,m,y}$ – 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 LCMR 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[8] if, for power unit *m*, data on fuel consumption and electricity generation are 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)

---

[8] In the Tool there are three approaches (Option A1-3) of how to calculate the emission factor.

$EG_{m,y}$ – 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 LCMR 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

2.4.2. 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 three-year 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 recalculating the emission factor during the crediting period (the period of time for which net greenhouse gas emissions reductions or removals will be verified).

2. **Ex-post option:** The ex-post option requires calculating 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 three-year generation-weighted average data are available, the ex-ante option was chosen to calculate the OM for the MPS.

2.4.3. OPERATING MARGIN CALCULATION

TABLE 5: INPUT DATA FOR CALCULATION OF OM

Year	Unit name	Net generated electricity [MWh]	Fossil fuel type	Amount of fuel [oil, coal – kt; gas – million m^3]	NCV [GJ/unit]	Fuel emission factor [tCO_2/GJ]
2021	Import of electricity	161,394.0				
2021	TPP MGRES G8	213,695.9	Coal	88.62	25,440	0.095
2021	TPP MGRES G9 oil	209,924.3	Gas Oil	1.00	40,200	0.077
2021	TPP MGRES G9 gas	706,775.7	Natural Gas	297.81	34,371	0.056
2021	TPP MGRES G10 oil	209,924.3	Gas Oil	0.51	40,200	0.077
2021	TPP MGRES G10 gas	706,775.7	Natural Gas	297.81	34,371	0.056
2021	TPP MGRES G12	1,302,752.5	Natural Gas	379.04	34,371	0.056
2022	TPP MGRES G9 gas	835,998.7	Natural Gas	179.00	34,442	0.056

2022	TPP MGRES G10 gas	835,998.7	Natural Gas	179.04	34,442	0.056
2022	TPP MGRES G12	1,063,998.3	Natural Gas	227.87	34,442	0.056
2023	Import of electricity	136,300.0				
2023	TPP MGRES G9 gas	943,775.8	Natural Gas	283.00	34,442	0.056
2023	TPP MGRES G10 gas	943,775.8	Natural Gas	283.07	34,442	0.056
2023	TPP MGRES G12	1,201,169.2	Natural Gas	360.27	34,442	0.056

2.5. CALCULATION OF THE BUILD MARGIN

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

- Option 1 - 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 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 crediting period. For the third crediting period, 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;
- Option 2 - 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 emissions factor shall be calculated ex ante, as described in Option 1 above. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.

The BM reflects 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 whichever of the following two sets has greater annual electricity generation:

- 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

- 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 percent of the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities.

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.

Because the Tool refers to "recent or likely future additions to transmission capacity [that] enable significant increases in imported electricity," and because in the case of Moldova, the increase in import capacity is not expected until 2028, the increase in transmission cannot be integrated into the BM calculation. Therefore, only the most recently built power plants will be taken into consideration.

Because the last five commissioned units do not produce more than 20 percent of overall MPS generation, older units were introduced into the dataset used to calculate the BM.

TABLE 6: INPUT DATA FOR CALCULATION OF BM

Unit name	Commissioning date	Cumulative energy comprising ≤ 20 percent of system generation [%]	Fossil fuel consumed [m^3]	NCV [GJ per unit]	Emission factor [tCO_2 / unit]	Efficiency
Distributed RES	2020–2023	3.8				
CHP North G3 (JMS 620 GS-N.L.)	Oct. 28, 2019	4.0	2,473,908	0.035	0.0561	
CHP North G4 (JMS 620 GS-N.L.)	Oct. 28, 2019	4.1	1,573,428	0.035	0.0561	
CHP North G5 (JMS 620 GS-N.L.)	Oct. 28, 2019	4.3	2,835,145	0.035	0.0561	
CHP North G6 (JMS 620 GS-N.L.)	Oct. 28, 2019	4.5	2,274,677	0.035	0.0561	
Distributed RES	2013–2019	5.5			0.0561	
CHP Tirotex G7 ("Deutz" MWM TCG 2032 V12, V16 Gas Engine)	Jul. 1, 2011	6.0			0.0561	0.4
CHP Tirotex G8 ("Deutz" MWM TCG 2032 V12, V16 Gas Engine)	Jul. 1, 2011	6.6			0.0561	0.4
CHP Tirotex G1 ("Deutz" MWM TCG 2032 V12, V16 Gas Engine)	Jul. 1, 2010	7.2			0.0561	0.4
CHP Tirotex G2 ("Deutz" MWM TCG 2032 V12, V16 Gas Engine)	Jul. 1, 2010	7.7			0.0561	0.4
CHP Tirotex G3 ("Deutz" MWM TCG 2032 V12, V16 Gas Engine)	Jul. 1, 2010	8.3			0.0561	0.4
CHP Tirotex G4 ("Deutz" MWM TCG 2032 V12, V16 Gas Engine)	Jul. 1, 2010	8.8			0.0561	0.4
CHP Tirotex G5 ("Deutz" MWM TCG	Jul. 1, 2010	9.4			0.0561	0.4

2032 V12, V16 Gas Engine)				
CHP Tirotex G6 (“Deutz” MWM TCG 2032 V12, V16 Gas Engine)	Jul. 1, 2010	9.9	0.0561	0.4
CHP North G2 (ПТ-12/13-3.4/1.0-1)	Nov. 10, 2005	10.2	0.0561	0.6
CHP 1 (G2) (ТГ-2 ПТ-12/15-35/10М)	Jul. 1, 2001	10.2		
CHP North G1 (ПТ-12/15-35/10-М)	Nov. 1, 1995	10.6	0.0561	0.46
CHP 1 (G1) (ТГ-1 Р-12-3585м)	Jul. 1, 1994	11.1	0.0561	0.46
TPP MGRES G12	Jul. 1, 1982	31.5	0.0561	0.33

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:

$EF_{grid,BM,y}$ – BM 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 BM

y – Most recent historical year for which power generation data are available

If the power units included in *m* correspond to a dataset that includes units older than ten years, then, as a conservative approach, only Option A2 from guidance in Step 4, section 6.4.1 can be used, and the default values provided in Table 2, Appendix of TOOL 09: “Determining the baseline efficiency of thermal or electric energy generation systems” shall be used to determine the parameter ηm,y for the power units that started to supply electricity to the grid more than ten years ago.

2.6. CALCULATION OF COMBINED MARGIN EMISSIONS FACTOR

The calculation of the CM emission factor ($EF_{grid,CM,y}$) is based on one of the following methods:

- Weighted average CM
- Simplified CM

For the Moldovan case, the weighted average CM was chosen, as Moldova is not a least developed country, 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:

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

$EF_{grid,OM,y}$ – OM CO_2 emission factor in year *y* (tCO_2/MWh)

W_{OM} – Weighting of OM emissions factor (%)

W_{BM} – Weighting of BM emissions factor (%)

The CM was calculated 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 that refers to the Tool.

III. GRID EMISSION FACTOR CALCULATION

Moldova's GEF was calculated based on the Table to Calculate the Emission Factor for an Electricity System (version 04.0).

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

Table 7 shows the results of the calculation of Moldova's GEF values for the crediting period starting in 2024.

TABLE 7. MOLDOVA'S GRID EMISSION FACTORS FOR THE CREDITING PERIOD STARTING IN 2024, TONNE CO_2/MWH

SIMPLE OM	BM	CM		
		WIND AND SOLAR	ALL OTHERS, FOR THE FIRST CREDITING PERIOD	ALL OTHERS, FOR SUBSEQUENT PERIODS
0.5220	0.4926	0.5147	0.5073	0.5000

ANNEX 1. MAIN DATA FOR MOLDOVA'S POWER UNITS, 2023

TABLE 8. MOLDOVA POWER PLANT DATA			
Power plant UNIT	Commissioned	Installed capacity, MW	Net generated electricity, GWh
TPP MGRES G1	1964	200.0	0.0
TPP MGRES G2	1965	200.0	0.0
TPP MGRES G3	1965	200.0	0.0
TPP MGRES G4	1967	200.0	0.0
TPP MGRES G5	1968	200.0	0.0
TPP MGRES G6	1969	200.0	0.0
TPP MGRES G7	1970	200.0	0.0
TPP MGRES G8	1971	200.0	0.0
TPP MGRES G9	1973	210.0	943.8
TPP MGRES G10	1974	210.0	943.8
TPP MGRES G11	1980	250.0	1,201.2
TPP MGRES G12	1982	250.0	1,201.2
CHP 1 (G1) (ТГ-1 Р-12-3585м)	1994	12.0	31.4
CHP 1 (G2) (ТГ-2 ПТ-12/15-35/10М)	2001	12.0	0.0
CHP 1 (G3) (ТГ-5 Р-27-90/1,2)	1958	10.0	0.0
CHP 1 (G4) (ТГ-6 Р-5-90/37)	1960	27.0	0.0
CHP 1 (G5) (ТГ-4 ПТ-10-35/10/1,2)	1961	5.0	0.0
CHP 2 (G1) (ПТ-80/100-130/13)	1976	98.0	245.2
CHP 2 (G2) (ПТ-80/100-130/13)	1978	80.0	126.0
CHP 2 (G3) (ПТ-80/100-130/13)	1980	80.0	121.9

CHP North G1 (ПТ-12/15-35/10-M)	1995	12.0	22.7
CHP North G2 (ПТ-12/13-3.4/1.0-1)	2005	12.0	14.4
CHP North G3 (JMS 620 GS-N.L.)	2019	3.4	11.4
CHP North G4 (JMS 620 GS-N.L.)	2019	3.4	7.1
CHP North G5 (JMS 620 GS-N.L.)	2019	3.4	12.8
CHP North G6 (JMS 620 GS-N.L.)	2019	3.4	10.4
HPP Dubasari G1	1954	12.0	62.5
HPP Dubasari G2	1954	12.0	62.5
HPP Dubasari G3	1955	12.0	62.5
HPP Dubasari G4	1958	12.0	62.5
HPP Costesti	1973	16.0	68.8
Sugar power plants	1958–2014	33.2	14.5
CHP Tirotex	2010–2011	31.3	262.1
Distributed RES	2013–2023	222.0	274.1