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Project Design Document (PDD) for a Waste to Energy (WTE) NAMA in Republic of Moldova

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Technical Oversight and Guidance

Xxx *<To be completed>*

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Executive Summary

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Abbreviations and Acroyms

Asiatica	Carbon Partners Asiatica Co., Ltd.
BAU	Business as Usual
BCNU	Budget for Central NAMA Unit
BNIP	Budget for NAMA Individual Project
BTN	Budget for Total NAMA
BUR	Biennial Update Report
CAPEX	Capital Expenditure
CDM	Clean Development Mechanism
CH_4	Methane
C&F	Collection and Flaring
EBRD	European Bank for Reconstruction and Development
EIB	European Investment Bank
ERs	Emission Reductions
FIT/FiT	Feed-in Tariff
Genset	Gas Engine and Generator
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
kg	Kilogram
kW	Kilowatt
LEDS	Low Emission Development Strategy
LECB	Low Emission Capacity Building
LFG	Landfill Gas
LMOP	Landfill Methane Outreach Program
MoEN	The Ministry of Environment
MoSEFF	Moldovan Sustainable Energy Financing Facility
MRV	Measurement, Reporting and Verification
m^3	Cubic Metre
MR	Monitoring Report
MSW	Municipal Solid Waste
MW	Megawatt
MWh	Megawatt Hour
NAMA	Nationally Appropriate Mitigation Action
NAMA BM	NAMA Budgeting Methodology
O&M	Operation and Maintenance
PDD	Project Design Document
RE	Renewable Energy
RP	Representative Project
SD	Sustainable Development
SWDS	Solid Waste Disposal Site
SWM	Strategy for Waste Management in the Republic of Moldova for the years 2013-2027
tCO_2e	Tonne of Carbon Dioxide Equivalent
tCH_4	Tonne of Methane
tpd	Tonne per Day
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WTE	Waste to Energy

1. Introduction to a waste to energy NAMA

A waste to energy (WTE) NAMA for municipal solid waste (MSW) in the Republic of Moldova is composed of a large number of individual projects[1] and each of them involves the installation and operation of a landfill gas (LFG) collection and flare system and a grid-connected power plant at its solid waste disposal site (SWDS). These individual projects will contribute not only to greenhouse gases (GHG) mitigation, but also to national sustainable development (SD) through NAMA implementation in ways outlined below:

- Collection and destruction of LFG, which is otherwise unabated released into the air at the SWDS.
- Use of the captured LFG for renewable electricity generation without reliance on fossil fuel-based electricity.

In the absence of this contemplated WTE NAMA, the atmospheric release of the LFG from the SWDS would still be the Business as Usual (BAU) scenario in the Republic of Moldova, and no displacement of fossil fuel-based grid electricity by renewable fuel-based electricity is anticipated.

Pending for the thorough feasibility study of this NAMA, the following step-wise approach is taken to estimate the financial support required for implementation of the NAMA:

Step 1: To select one individual project (hereinafter referred to as "representative project" or "RP") and conduct the GHG emission reductions estimation and the financial analyses in detail.

Step 2: To replicate 10 RP equivalents for this WTE NAMA[2] based on the results obtained in Step 1.

The selected RP is composed of an existing site and a new sanitary landfill, adjacent to each other. The key features of the RP are summarized in table below and detailed in Section 5.1.

Table 1-1: Characteristics of the RP.

Landfill site	Capacity	Area	Depth of waste on average		Annual waste disposal quantity	Expected time of operation for waste disposal	First year of waste acceptance	First year when LFG is collected and fed to the generator
	m^3	m^2	m	ft	m^3/y	y		
Existing site	154,000	11,000	14.0[(a)]	45.93	37,000	-	2017 is the last year of waste acceptance	2018
New site								
Cell 1	289,000	19,800	14.6	47.89	59,500	5	2018	2020
Cell 2	362,500	17,000	21.3	69.96	59,500	6	2023	2025
Cell 3	432,500	26,000	16.6	54.57	59,500	6	2029	2031
Sub-total	1,084,000	62,800	17.3	172.42	-	17	-	-

(a) This represents the sum of (i) the 6 m height of the waste disposed on average based on the project information, and (ii) the 8 m depth of the waste disposed on average as per Asiatica's assumption.

[1] In this PDD, the terms "project" and "intervention" are used interchangeably.
[2] Subject to the input from the Moldova team, this PDD tentatively assumes that the WTE NAMA will involve replication of 10 RP equivalents.

2. Background of the waste sector in the Republic of Moldova

2.1 Current situation and trends of the Sector

1. Geographic boundary applicable to the NAMA

   The geographic boundary of the NAMA is the entire country of Moldova, when a full scale NAMA is deployed. The country is divided into 8 regions of waste management. For the representative project, the geographic boundary is expected to be the region of Cahul.

Figure 2-1: Geographic boundary applicable to the NAMA (map source: WMS)

2. Composition of the target sector

According to Moldova's National Inventory Report 1990-2010[3], the waste sector accounted for 11.9% of the country's GHG emissions in 2010, with estimated emissions of 1,578,304 tCO_2eq. It was the third largest source of emissions after the energy and agriculture sectors.

Within the waste sector, solid waste (excluding industrial waste) was estimated to have emitted 66,098 tCH_4 or 1,388,058 tCO_2eq. When industrial waste is excluded, this becomes 42,924 tCH_4 or 901,402 tCO_2eq[4]. After years of decline from this source due to reduced economic output, there has been a steady increase of GHG emissions from solid waste since 2006. Although other sectors started increasing GHG emissions from 2008, the overall trend is in line with other sectors.

One of four mitigation measures put forward as part of the Technology Needs Assessment, and being a part of a crucial public service in pressing need of improvement, the target sector is well within the national emission reduction priorities.

3. Latest trends in the sector

According to the "National Waste Management Strategy of the Republic of Moldova (2013-2027)"[5] ("NWMS"), the "situation of the rural population, mainly in small villages is poor, with few economic prospects and difficult access to relevant public services, including sanitation of territories, waste collection and storage" with the most common method of household waste treatment being "storing waste on the ground".

Increased attention is being "paid to creation of capacities of [solid municipal waste] storage in the district centers". In line with this, studies have been carried out by GIZ for 3 regions, and in 2016 EIB is funding feasibility studies for three other regions[6].

Commented [KT1]: Note to Moldova team: Could you please confirm the number of regions covered by the GIZ studies?

It is noted that while the final versions of the feasibility studies are expected to make mention of landfill gas collection infrastructure, the overwhelming priority will be to increase collection capabilities, set up district collection stations and to construct sanitary landfills.

4. Barriers

While there is much focus on the waste management sector, there are several barriers in implementing a NAMA measure.

a. Technology barrier

The technology to be adopted in the NAMA activity is a standard technology, proven in countries around the globe – North and South America, Western Europe, Asia, and South Africa – with projects in many South American and Asian non-Annex I countries having reported accurate operational data to the UNFCCC as part of the CDM. However, with landfill gas projects depending on decomposition of organic substances to create landfill gas, often the sole fuel source except during startup, the gas quantity is highly dependent on local conditions. Climatic conditions, waste volume and waste composition characteristics all affect landfill gas generation amount and hence the financial bottom line. For this reason, it is insufficient for an investor to be assured, for example, that a landfill

[3] http://unfccc.int/resource/docs/natc/mdanir.pdf
[4] The National Inventory uses a global warming potential of $21tCO_2eq/tCH_4$. When revised to the current $25tCO_2eq/tCH_4$, the figure increases from 901,402 to 1,073,098 tCO_2eq.
[5] *National Waste Management Strategy of the Republic of Moldova (2013-2027)*, Ministry of Environment of the Republic of Moldova, 2013
http://serviciilocale.md/public/files/deseuri/2013_01_24_NATIONAL_WASTE_MANAGEMENT_STRATEGY_2013-27_ENG.pdf
[6] http://www.eib.org/about/procurement/calls-technical-assistance/ta2015020.htm

gas project in Wisconsin[7] has been successful and that a similar project will be successful in Moldova as the climate conditions are comparable.

In this sense, there is a real technology barrier for waste-to-energy in Moldova, where no data is available from the sole WTE project (Tintareni, in Chisinau).

b. Policy barrier

The NAMA measure assumes grid export of the electricity produced, an activity that comes under the purview of the regulator National Energy Regulatory Agency (ANRE), with which a tariff must be individually negotiated. Study of the tariff calculation methodology and extensive discussion with energy experts suggest that the project will not be able to negotiate a tariff that gives the level of profitability or cash flow that equity and debt investors find reasonable.

It is relevant to note that while a new regulation with an accompanying new methodology is expected to be approved in the near future, the tariff calculation methodology is unknown and Moldovan experts believe that the tariff is likely to decrease more than increase.

c. Financial barrier

A waste-to-energy project has a high investment cost per unit installed capacity. Similar to WTE projects in many parts of the world where there are few fiscal support measures, in Moldova two financial barriers are present.

One is the lack of profitability to incentivise investment. In many countries, the reward for taking a higher risk and successfully implementing a project is a handsome profit. However, grid-connected projects in Moldova are required to individually negotiate tariffs with the regulator ANRE. With a new regulation on renewable energy tariffs expected in the imminent future, there is uncertainty as to the new tariff calculation methodology, however, discussions with Moldovan experts suggest that as a rule of thumb, the tariff will be set with a 10-year payback period for the project owner in mind. Such a low profitability will certainly not attract investment, taking into account the higher risk premium in Moldova.

The other is unavailability of debt financing. Debt is extremely expensive in Moldova, with some projects having to pay interest of close to 20% per annum, exacerbating the lack of profitability. A greater problem however may be that commercial banks are unwilling to lend at all. Indeed, an interview carried out with a leading Moldovan commercial bank suggested a negative impression of WTE projects.

d. Other barrier

As mentioned earlier, increasing attention is being paid to the need for waste management public services, with the possibility of large funds being made available to upgrade the current system. Assuming that credit will be approved for these upstream activities up to and including the construction of a landfill, which in turn becomes the host site for the NAMA measure, this presents a practical challenge – the need for synchronization of those waste management projects and NAMA measures so that more affordable horizontal wells can be placed when (the relevant cells of) the landfill is still empty.

[7] A landfill gas project in Wisconsin is a part of the USEPA Landfill Methane Outreach Program http://www.gundersenenvision.org/renewable-energy/using-waste-to-create-energy

2.2 Relevant Stakeholders

Three stakeholder consultations have been conducted during the design phase. Brief summary of consultation and outcomes are summarized in Annex 3.

<This section is to be elaborated.>

2.3 Purpose and Objectives of the NAMA

The purpose of the NAMA is to strive for long-term SD co-benefits in addition to GHG emissions mitigation, with an ultimate goal at catalyzing transformational change towards a low carbon society in Moldova.

In order to achieve this goal, the contemplated WTE NAMA, which is composed of 10 RP equivalents, aims at:

- Collection and destruction of LFG, which is otherwise unabated released into the air at the SWDS; and
- Use of the captured LFG for renewable electricity generation without reliance on fossil fuel-based electricity.

With the implementation of this WTE NAMA, impacts on the following four aspects are anticipated.

1. GHG mitigation potential

   Considering the fact that unabated release of LFG into the atmosphere of the SWDS is identified as the BAU scenario (or baseline scenario) in Moldova, implementation of this NAMA will lead to a positive and direct GHG emissions mitigation via (a) collection and destruction of LFG (or methane-constituted gas) emitted from the MSW at the SWDS, and (b) avoidance of fossil fuel-based electricity generation by using the captured LFG for renewable electricity generation.

2. Sustainable development co-benefits

   This NAMA anticipates to provide additional SD co-benefits beyond the reduction of GHG emissions. Positive contribution on the following areas of SD are expected:

   - Air quality;
   - Climate change adaptation and mitigation;
   - Quality of employment;
   - Access to clean and sustainable energy;
   - Income generation;
   - Job creation; and
   - Compliance with laws and regulation.

3. Potential for transformational change

With the successful implementation of this contemplated NAMA, transformation of the national or sectoral development towards to a low carbon intensive development path is foreseen. These national or sectoral transformational changes include:

- Change the prevailing practices of the waste management (i.e. collection and/or destruction of LFG emitted from MSW) and energy supply (i.e. utilization of captured LFG for electricity generation) sectors.
- Broadening the context of GHG emissions mitigation activities in the energy supply sector.
- Achievement of the higher level emission reduction target through replicating more successful individual projects in other regions.
- Adoption of this innovative waste to energy approach/technology for the GHG emissions reduction to other sectors or industries.

4. Financial diversification

One of the objectives of the NAMA is to attract the investments into this type of GHG mitigation activity by the private sector in future, via demonstration of successful project implementation.

The local communities will be directly benefited from better air quality, clean and sustainable electricity, more job opportunities, better quality of employment, as well as remuneration income.

3. Policy Analysis

3.1 Relevant National and Sector Strategies and Policies

The Republic of Moldova ratified the Kyoto Protocol on February 13, 2003. Though Moldova, being a non-Annex I Party, had no commitments to reduce GHG emissions under the first commitment period of the Kyoto Protocol, it has committed to promote sustainable development, to contribute to the achievement of the United Nations Framework Convention on Climate Change's (UNFCCC) ultimate objective, and to assist Annex I Parties to fulfil their commitments to limit and reduce GHG emissions.

Their efforts are perceived through the developments in both pre- and post- 2020 mitigation policy frameworks[8].

(a) Pre-2020 mitigation policy framework

In 2010, the Republic of Moldova participated in Copenhagen Accord and submitted an emission reduction target that is stated in the Agreement "Nationally Appropriate Mitigation Actions of the Developing Countries" to the UNFCCC, reproduced below:

- *"To reduce, to not less than 25% compared to the base year (1990), the total national level of greenhouse gas emissions by 2020, by implementing economic*

[8] Government of the Republic of Moldova, 2015. *Republic of Moldova's Intended National Determined Contribution*. [pdf] Government of the Republic of Moldova. Available at: < http://www4.unfccc.int/submissions/INDC/Published%20Documents/Republic%20of%20Moldova/1/INDC_Republic_of_Moldova_25.09.2015.pdf > [Accessed 30 March 2016]. (p.8)

mechanisms focused on global climate change mitigation, in accordance with the principles and provisions of the Convention."

In 2014, the Moldovan Government approved the Environmental Protection Strategy for the years 2014-2023 and the Action Plan for its implementation that aim at:

- *"A 20% GHG emissions reduction compared to the BAU scenario has to be reached in the Republic of Moldova by 2020."*
- *"15% GHG emissions reduction compared to BAU scenario has to be achieved by 2020"* for the waste sector.

(b) Post-2020 mitigation policy framework

It is anticipated that a draft Low Emission Development Strategy (LEDS) of the Republic of Moldova for the years 2021-2030 will be prepared for the Government approval by the end of 2016. This draft strategic document will allow the country to adjust its development path towards a low carbon economy and to achieve a green sustainable development concurrently.

In compliance with its national GHG mitigation objectives, the Strategy for Waste Management in the Republic of Moldova for the years 2013-2027 (SWM 2013-2027) and a number of legislative laws in relation to combating GHG emissions for the waste sector have also been approved. However, none of them are focused on collecting and/or recovering the energy stored in MSW, which substitutes the energy obtained by burning fossil fuels, but are instead oriented towards discouraging waste storage in respective landfills and encouraging their recycling[9].

To elaborate, there is currently no national regulation in Moldova requiring municipal owners or operators of landfills or SWDS to install and operate (a) LFG collection and treatment systems, or (b) LFG destruction and/or utilization systems at the sites. Given no regulatory requirements and contractual obligations, the atmospheric release of the LFG is the prevailing waste management practices pertinent to MSW in most landfills or SWDS in Moldova at the present time. This is consistent with the First Biennial Update Report[10] (BUR) that states, "The current Moldovan legal framework related to environmental protection regulates the reduction of GHG emissions in the waste sector only in general terms. It lacks stipulations on equipping the solid waste disposal sites and wastewater treatment plants with biogas recovery systems".

There are however stated policies in relation to waste management and renewable energy, as follows.

Waste management: The SWM 2013-2027 states that Moldova will establish a legal and institutional framework to support the gradual alignment of its waste management practices to those of the European Union, which is to "prevent waste generation and to promote its reuse, recycling and recovery in terms of environmental protection".

Renewable energy: According to the BUR, one of two policies geared towards increasing energy security is "attracting the renewable energy sources into the energy balance", aiming to increase the mix of renewable energy to 20% of demand by 2020.

[9] Ministry of Environment, 2013. *Third National Communication of the Republic of Moldova Under the United Nations Framework Convention on Climate Change*. [pdf] Ministry of Environment. Available at: < http://unfccc.int/resource/docs/natc/mdanc3.pdf > [Accessed 24 March 2016]. (p.145)

[10] Ministry of Environment of the Republic of Moldova / United Nations Environment Programme, 2016, *First Biennial Update Report of the Republic of Moldova under the United Nations Framework Convention on Climate Change*

3.2 Alignment with National and Sector Strategies and Policies

The NAMA measure / intervention will be fully aligned with national and sector strategies and policies.

1. National level

   At the national level, the NAMA is in full alignment with the Environmental Protection Strategy with GHG reductions in the waste sector. The importance of this cannot be overstated. Although the absolute volume of GHG emissions may be small due to the small population, as is also pointed out in Section 2.1, the waste sector is the third largest contributor of GHG emissions in Moldova after the energy and agricultural sectors.

2. Sectoral level

   The NAMA intervention will fall into the category of (energy) "recovery" as mentioned in Section 2.1. Importantly, the project design assumes in the technology and financial assumptions that recyclables will not be a part of the landfill gas-producing waste, thus ensuring that there is no competition between the NAMA intervention and recycling activities.

   Viewed as part of a wider public service, due to the lack of basic waste management services in many rural areas including waste collection that is taken for granted in developed nations, the government estimates that total investments of between 375 and 470 million Euro will be needed solely for the municipal waste sector in the period between 2013 and 2027.

3. Synergies with other relevant projects

   The World Bank, European Investment Bank (EIB), European Bank for Reconstruction and Development (EBRD), and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) are some international organizations that have supported waste management efforts in Moldova.

   Of particular relevance to the NAMA measure / intervention is EIB's and EBRD's recent efforts to fund feasibility studies for three of eight waste management regions, with possibilities to extend credit subsequent to the studies' completion, as well as similar potential for credit for other waste management regions whose studies have already been completed. As mentioned elsewhere in this document, the NAMA project concept relies on there being in place a landfill with a certain waste volume to generate the necessary biogas, which presumes that credit will indeed be extended to the broader waste management project by international supporters such as EIB and/or EBRD, and such credit will be availed of by the Moldovan government. As the choice of gas piping technology (vertical versus horizontal wells) will depend on the timing of the installation relative to the timing of waste disposal, it is all the more important that there be linkages with other international donors.

4. Baseline Information and NAMA Targets

4.1 Baseline boundary and scenario

The contemplated NAMA, which will take place at the SWDS in Moldova, involves two elements in relation to GHG mitigation contribution as outlined in sections above:

Element 1: LFG collection and destruction; and

Element 2: Use of the captured LFG for renewable electricity generation without reliance on fossil fuel.

Several baseline scenario options for Elements 1 and 2 are investigated and the most plausible option is identified as the NAMA baseline scenario with reasons listed below.

Table 4-1: Identification of the most plausible baseline scenario option for the destruction of LFG (Element 1).

Baseline scenario options	Is this the most plausible option?
LFG1: The project activity implemented without being supported by NAMA funding	**No.** This option is a technically feasible. However, taking into account the high capital investment and implementation costs, this is unlikely happened in the absence of any national or international supports.
LFG2: Atmospheric release of the LFG or capture of LFG and destruction through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons	**Yes, this is the most plausible option and also the BAU scenario in Moldova.** In the absence of any national policy or measure in Moldova in regulating municipal owners or operators of landfills or SWDS to install and operate (a) LFG collection and treatment systems, or (b) LFG destruction and/or utilization systems at the sites, the atmospheric release of the LFG is still the prevailing waste management practices in most landfills or SWDS in Moldova nowadays.
LFG3: LFG generation is partially avoided because part of the organic fraction of the solid waste is recycled and not disposed in the SWDS	**No.** This option is a technically feasible and encouraged by the Moldovan government. However, the actions taken so far have not been sufficiently successful[11] that led to the atmospheric release of the LFG still being the BAU scenario in Moldova.
LFG4: LFG generation is partially avoided because part of the organic fraction of the solid waste is treated aerobically and not disposed in the SWDS	**No.** This option is a technically feasible, but not a prevailing practice in Moldova, as additional investment and operational costs are incurred.
LFG5: LFG generation is partially avoided because part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS	**No.** This option is a technically feasible, but not a prevailing practice in Moldova, as additional investment and operational costs are incurred.

Table 4-2: Identification of the most plausible baseline scenario option for the use of LFG for electricity generation (Element 2).

Baseline scenario options	Is this the most plausible option?

[11] Ministry of Environment, 2013. *Third National Communication of the Republic of Moldova Under the United Nations Framework Convention on Climate Change*. [pdf] Ministry of Environment. Available at: < http://unfccc.int/resource/docs/natc/mdanc3.pdf > [Accessed 24 March 2016]. (p.26)

E1: Electricity generation from LFG, undertaken without being supported by NAMA funding	**No.** This option is a technically feasible. However, taking into account the high capital investment and implementation costs, even with the small revenues generated from electricity sales, this is unlikely happened in the absence of any national or international supports.
E2: Electricity generation in existing or new renewable or fossil fuel based captive power plant(s)	**No.** This option is a technically feasible, but unlikely to be occurred.
E3: Electricity generation in existing and/or new grid-connected power plants	**Yes, this is the most plausible option and also the BAU scenario in Moldova.** In the absence of any national policy or measure in Moldova in regulating municipal owners or operators of landfills or SWDS to install and operate (a) LFG collection and treatment systems, or (b) LFG destruction and/or utilization systems at the sites, the atmospheric release of the LFG is still the prevailing waste management practices in most landfills or SWDS in Moldova nowadays. As such, no displacement of grid electricity by LFG-based electricity is anticipated.

The NAMA baseline (or BAU in this case) emissions and emissions under the NAMA scenario for each of the aforementioned elements of the WTE NAMA are summarized as:

1. Element 1

   - NAMA baseline (or BAU) emissions: Unabated release into the air of the methane originating from the SWDS.

   - Emissions under the NAMA scenario: (i) Methane that remains uncollected by the NAMA activity and continues to be release into the air, and (ii) imperfect destruction of the collected SWDS methane.

2. Element 2

   - NAMA baseline (or BAU) emissions: Carbon dioxide (CO_2) emissions generated from fossil fuel-based electricity generation.

   - Emissions under the NAMA scenario: No CO_2 emissions generated from renewable electricity generation from the captured LFG.

Figure 4-1 below shows emission sources by highlighting them in pink and orange for Element 1 and Element 2 respectively.

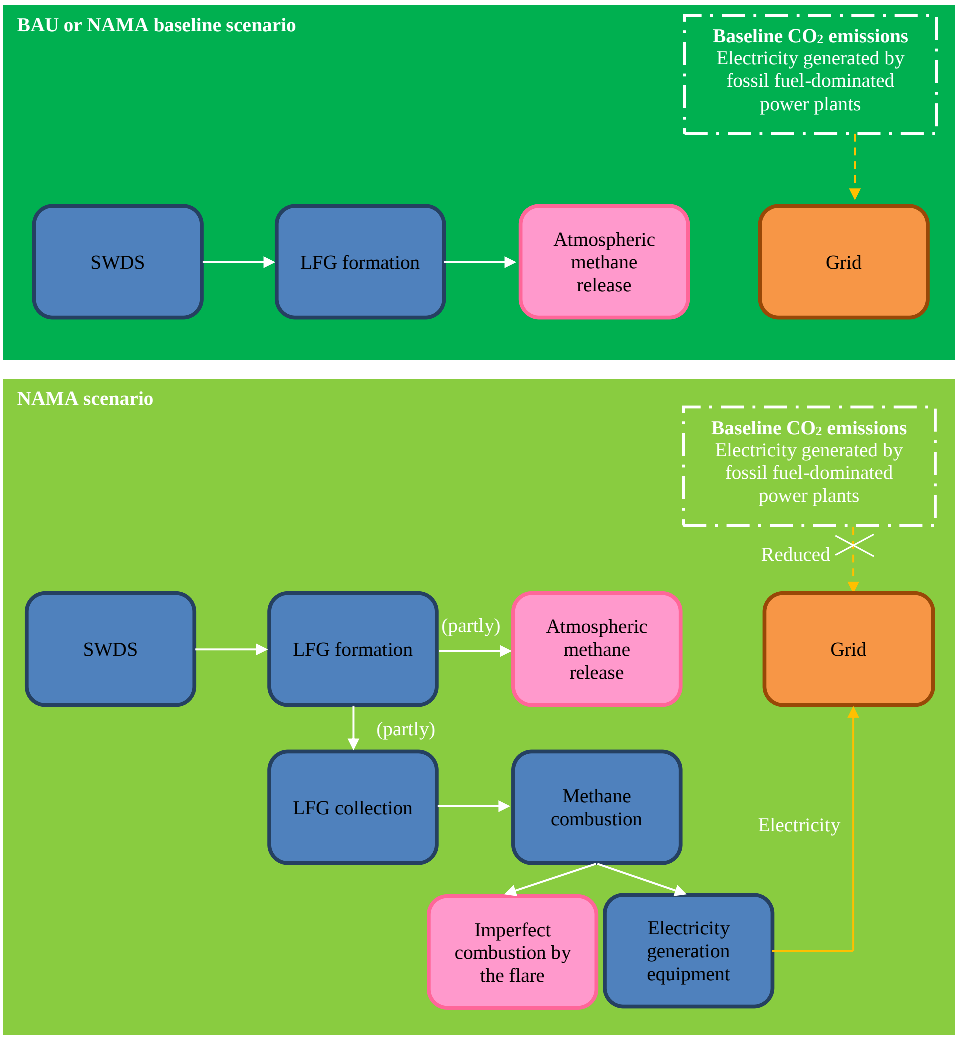

Figure 4-1: Diagrammatic representation of the BAU and NAMA scenarios.

4.2 GHG baseline and mitigation targets

For the contemplated NAMA, both baseline emissions and GHG emissions for the NAMA can only be determined by aggregating corresponding values calculated for each individual project to be undertaken by the NAMA. For this reason, the ensuing sections of this PDD focus on project-based calculations, to avoid excessive complexity.

Section 4.1 above can be expressed in equation form as follows:

Equation 1

$$ER_y = BE_y - PE_y - LE_y$$

Where

ER_y = Emission reduction in year y (t CO_2e)

BE_y = Baseline emissions in year y (t CO_2e)

PE_y = Project emissions[12] in the year y (t CO_2e)

LE_y = Leakage emission in the year y (t CO_2e)[13]

The Equation 1 calculation needs to be conducted for each of the two elements identified in Section 4.1, namely:

Element 1: LFG collection and destruction; and

Element 2: Use of the captured LFG for renewable electricity generation without reliance on fossil fuel.

4.2.1 Calculation for LFG collection and destruction (Element 1)

1. Baseline emissions

Baseline emissions associated with Element 1 consist of methane from the SWDS in the absence of the NAMA intervention, represented by the symbol $BE_{CH4,SWDS,y}$. Thus,

Equation 2

$$BE_{E1,y} = BE_{CH4,SWDS,y}$$

Parameter	Description	Unit	Source
$BE_{E1,y}$	Baseline emissions for Element 1.	tCO_2e/yr	Calculated in accordance with equation 2
$BE_{CH4,SWDS,y}$	Methane emissions occurring in year y generated from waste disposal at a SWDS during a time period ending in year y	tCO_2e/yr	Calculated in accordance with equation 3

The value for $BE_{CH4,SWDS,y}$ is calculated based on the first order decay (FOD) model that is widely used[14]. The model differentiates between the different types of waste j with respective constant decay rates (k_j) and fractions of degradable organic carbon (DOC_j).

[12] The aggregate of this value for all the projects undertaken under the NAMA will constitute "GHG emissions for the NAMA"
[13] This refers to indirect GHG increases attributable to the NAMA. While no such effect is anticipated for the contemplated NAMA (i.e. LEy = 0), parameter is included in the equation for the sake of completeness.
[14] This includes the methodological tool of the CDM entitled "Emissions from solid waste disposal sites".

As shown in Equation 4, the model calculates the methane generation occurring in year y based on the waste streams of waste types j ($W_{j,y}$) disposed in the SWDS over a specified time period.

It is of note that by including parameter OX, Equation 3 takes account of the effect of naturally occurring oxidation.

Equation 3

$$BE_{CH4,SWDS,y} = \varphi \times (1-f) \times GWP_{CH4} \times (1-OX) \times \frac{16}{12} \times F \times DOC_f \times MCF \times \sum_{x=1}^{y} \sum_{j} W_{j,y} \times DOC_j \times e^{-k_j(y-x)} \times \left(1-e^{-k_j}\right)$$

Parameter	Description	Value	Unit	Source
x	Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (x = 1) to year y (x = y)	-	-	-
y	Year of the period for which methane emissions are calculated	-	-	-
$DOC_{f,y}$	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year y (weight fraction)	0.5	-	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
$W_{j,x}$	Amount of solid waste type j disposed in the SWDS in the year x)	Calculated	t	Calculated as W_y x p_j,
W_x	Total amount of solid waste disposed in the SWDS in year x		t	Measured daily and aggregated monthly and annually
p_j	Average fraction of the waste type j in the waste (weight fraction)	**Waste type**: **p_j** Wood, wood products, straw: 1.76 Food, food waste: 56.83 Pulp, paper, cardboard (other than sludge): 5.28 Textiles: 2.59 Non-food organic putrescible garden and park waste: 0 Glass, plastic, metal, other inert waste: 33.54	% wet waste	Estimated once based on information from the SWDS owner/ administrator and from interviews with senior employees.
φ	Model correction factor to account for model uncertainties for year y	0.75	-	Default value in the relevant CDM tool
f_y	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year y	0	-	Based on input from the Moldova team

<table>
<tr><td>GWP_{CH4}</td><td>Global Warming Potential of methane</td><td>25</td><td>tCO_2e/tCH_4</td><td>Paragraph 69 of the Report of the Executive Board of the Clean Development Mechanism Sixty-ninth Meeting</td></tr>
<tr><td>OX</td><td>Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste</td><td>0.1</td><td></td><td>IPCC 2006 Guidelines</td></tr>
<tr><td>F</td><td>Fraction of methane in the SWDS gas (volume fraction)</td><td>0.5[15]</td><td></td><td>IPCC 2006 Guidelines</td></tr>
<tr><td>MCF_y</td><td>Methane correction factor for year y</td><td>0.8 (for existing site)
1.0 (for new site)</td><td></td><td>Relevant values are selected from IPCC 2006 Guidelines based on information from the Moldova team</td></tr>
<tr><td>DOC_j</td><td>Fraction of degradable organic carbon in the waste type j (weight fraction)</td><td><table>
<tr><th>Waste type</th><th>DOC_j</th></tr>
<tr><td>Wood</td><td>43</td></tr>
<tr><td>Pulp, paper and cardboard (other than sludge)</td><td>40</td></tr>
<tr><td>Food, food waste</td><td>15</td></tr>
<tr><td>Textile</td><td>24</td></tr>
<tr><td>Non-food organic putrescible garden and park waste</td><td>20</td></tr>
<tr><td>Glass, plastic, metal, other inert waste</td><td>0%</td></tr>
</table></td><td>%wet waste</td><td>IPCC 2006 Guidelines</td></tr>
<tr><td>k</td><td>Decay rate for the waste type j</td><td><table>
<tr><th>Waste type</th><th>K_j</th></tr>
<tr><td>Wood</td><td>0.03</td></tr>
<tr><td>Pulp, paper and cardboard (other than sludge)</td><td>0.06</td></tr>
<tr><td>Food, food waste</td><td>0.185</td></tr>
<tr><td>Textile</td><td>0.06</td></tr>
<tr><td>Non-food organic putrescible garden and park waste</td><td>0.10</td></tr>
<tr><td>Glass, plastic, metal, other inert waste</td><td>0</td></tr>
</table></td><td>1/yr</td><td>IPCC 2006 Guidelines -</td></tr>
</table>

[15] To be replaced with measured values in ex post calculation.

j	Type of residual waste or types of waste in the MSW	-	-	-

2. Project emissions

As described in Section 4.1, project emissions for Element 1 comprise the following sources:

a) Methane emission through capture inefficiency

b) Methane emission through imperfect combustion in flaring

The project emissions for Element 1 are thus expressed as:

Equation 4

$$PE_{E1,y} = PE_{CH4\_uncollected} + PE_{CH4\_uncombusted}$$

$PE_{E1,y}$	:	Project emissions in year y (t CO_2e/y)
$PE_{CH4\_uncollected}$	:	LFG methane emission through capture inefficiency in year y (t CO_2e/yr)
$PE_{CH4\_uncombusted}$	:	LFG methane collected but released into the atmosphere without being destroyed (combusted) at the flare (t CO_2e/y)

The two emission sources are calculated by Equation 5 and Equation 7, respectively.

Equation 5

$$PE_{CH4,uncollected} = BE_{CH4,SWDS,y} - LFG_{NETc,y} \times w_{CH4,y} \times \rho_{CH4} \times GWP_{CH4}$$

Parameter	Description	Value	Unit	Source
$PE_{CH4\_uncollected}$	Methane emission through capture inefficiency	**Error! Reference source not found.**	t CO_2e/yr	Calculated in accordance with The two emission sources are calculated by Equation 5 and Equation 7, respectively.
$BE_{CH4,SWDS,y}$	Methane emissions occurring in year y generated from waste disposal at a SWDS during a time period ending in year y	**Error! Reference source not found.**	t CO_2e/yr	Calculated in accordance with 3
$LFG_{NETc,y}$	Landfill gas collected (NET)[16] in year y		m^3/yr	Calculated in accordance with Equation 6
$w_{CH4,y}$	Methane content in landfill gas in the year y		%, volume basis	Measured[17]

[16] This is to take account of the concept stated in paragraph 15 of the relevant CDM methodology (ACM-III.G). The paragraph emphasizes that the part of the total collected LFG ($LFG_{c,y}$) corresponds to the portion of methane that would have been naturally oxidized in the baseline situation. The concept is embodied in Equation 4 of the methodology.

[17] For *ex ante* calculation, a default value of 50% is used.

ρ_{CH4}	Density of methane	0.716	Kg/m^3	CDM tool[18]
GWP_{CH4}	Global warming potential of methane	25	tCO_2e/tCH_4	IPCC guidelines

Equation 6

$$LFG_{NETc,y} = LFG_{c,y} \times (1 - OX)$$

Parameter	Description	Value	Unit	Source
$LFG_{NETc,y}$	Landfill gas collected (NET) in year y	**Error! Reference source not found.**	tCO_2e/yr	Calculated in accordance with **Error! Not a valid bookmark self-reference.**
$LFG_{c,y}$	Landfill gas collected in year y		m^3/yr	Measured[19]
OX	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste	0.1		IPCC 2006 Guidelines

Equation 7

$$PE_{CH4_{uncombusted}} = CH4_{flared}\ x\ (1 - \eta_{flare})\ x\ GWP_{CH4}$$

Parameter	Description	Value	Unit	Source
$PE_{CH4\_uncombusted}$	LFG methane collected but released into the atmosphere without being destroyed (combusted)	**Error! Reference source not found.**	tCO_2e/yr	Calculated in accordance with Equation 6 $LFG_{NETc,y} = LFG_{c,y} \times (1 - OX)$
$CH4_{flared}$	Methane fed to the flare		tCH_4	Calculated from measured data for *ex post* calculation[20]. Estimated for *ex ante* calculation[21].
η_{flare}	Flare efficiency for open flare	0.5	-	Default value in the relevant CDM tool
GWP_{CH4}	tCO_2e/tCH_4	25	tCO_2e/tCH_4	IPCC guidelines

Parameter	Description	Value	Unit	
$LFG_{NETc,y}$	Landfill gas collected (NET) in year y	**Error! Reference source not found.**	tCO_2e/yr	Cal acc Err bo ref
$LFG_{c,y}$	Landfill gas collected in year y		m^3/yr	Me
OX	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste	0.1		IPC

18 Project emissions from flaring" Version 02.0.0) http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v2.0.pdf (p9)
19 For ex ante calculation, estimated as $BE_{CH4,SWDS,y}$ x design efficiency of the installed LFG collection system.
20 ($LFG_{c,y}$ - $LFG_{I,y}$ for gas engine(s)) x $w_{CH4,y}$ x ρ_{CH4}
21 For *ex ante* calculation, estimated based on $LFG_{c,y}$ availability and gas engine capacity.

4.2.2 Calculation for RE electricity generation (Element 2)

1. Baseline emissions

The baseline emissions for Element 2 are derived by Equation 8.

Equation 8

$$BE_{E2,y} = \sum_{k} EG_{grid} \times EF_{EL,k,y}$$

Parameter	Description	Value	Unit	Source
$BE_{E2,y}$	Baseline emissions for Element 2 in year y		tCO_2e/yr	Calculated in accordance with **Error! Reference source not found.**
$EG_{PJ,y}$	Provision of electricity to the grid	**Error! Reference source not found.**	MWh	Measured[22]
$EF_{EL,k,y}$	Emission factor for electricity generation	0.4224	tCO_2/MWh	Based on a World Bank report, which is the most reliable and recent information currently available[23].

2. Project emissions

Not employing fossil fuel for power generation, Element 2 of the project does not involve project emissions.

It is added that electricity demand for the operation of the project (for the power generation facilities and office building, as well as for the LFG collection system) is supplied from the project's own electricity generation. For this reason, the RE generation contribution of the project is gauged by its net grid export, rather than its gross generation.

4.2.3 Totals for the project

The totals are computed as follows:

Equation 9

$$BE_y = BE_{E1,y} + BE_{E2,y}$$

BE_y : Baseline emissions in year y (t CO_2e)
$BE_{E1,y}$: Baseline emissions for element 1 (t CO_2e)
$BE_{E2,y}$: Baseline emissions for element 2 (t CO_2e)

[22] For *ex ante* calculation, estimated as the difference between planned gross electricity generation and expected internal consumption.
[23] http://www.clima.md/lib.php?l=en&idc=243 (p22)

Equation 10

$$PE_y = PE_{E1,y} + PE_{E2,y}$$

PE_y : Project emissions in year y (t CO_2e)
$PE_{E1,y}$: Project emissions for element 1 (t CO_2e)
$PE_{E2,y}$: Project emissions for element 2 (t CO_2e)

Equation 11

$$ER_y = BE_y - PE_{,y}$$

ER_y : Emission reduction in year y in year y (t CO_2e)
BE_{Ey} : Baseline emissions in year y (t CO_2e)
PE_{Ey} : Project emissions in year y (t CO_2e)

Table 4-3 shows the summary of the expected GHG mitigation targets to be achieved by the RP both annually and over the full period of the contemplated NAMA. These mitigation targets were estimated based on the features of the RP delineated in Section 5.1 For detailed ERs calculation, please refer to Annex 5.

Table 4-3: A summary of the expected GHG mitigation targets to be achieved by the RP.

Project year (calendar year)	Baseline emissions (BE_y)	Project emissions (PE_y)	Emission reductions (RE_y)
	tCO_2e	tCO_2e	tCO_2e
1 (2018)	10,668	8,214	2,454
2 (2019)	14,476	12,383	2,093
3 (2020)	18,191	9,001	9,190
4 (2021)	21,143	9,637	11,506
5 (2022)	23,585	10,675	12,910
6 (2023)	25,444	14,491	10,954
7 (2024)	27,037	17,721	9,316
8 (2025)	28,975	12,968	16,007
9 (2026)	30,289	13,528	16,761
10 (2027)	31,424	14,011	17,412
11 (2028)	32,369	14,705	17,665
12 (2029)	33,039	17,726	15,313
13 (2030)	33,598	20,518	13,080
14 (2031)	34,535	16,336	18,199
15 (2032)	35,088	16,753	18,335
16 (2033)	35,577	17,122	18,455
17 (2034)	36,012	17,450	18,562
18 (2035)	27,960	12,406	15,554
19 (2036)	23,886	10,716	13,170
20 (2037)	20,492	9,098	11,395

21 (2038)	17,626	7,828	9,798
22 (2039)	14,807	6,542	8,264
23 (2040)	8,890	4,271	4,620
24 (2041)	7,699	3,402	4,297
25 (2042)	6,657	2,941	3,715
26 (2043)	5,777	2,553	3,225
27 (2044)	5,033	2,224	2,809
28 (2045)	4,403	1,945	2,458
Total	**614,679**	**307,161**	**307,518**
Annual averaged over the full NAMA period achieved by the RP	**21,953**	**10,970**	**10,983**

The expected GHG mitigation targets to be achieved by the NAMA (i.e. 10 RP equivalents) over the full period of the contemplated NAMA are also determined in accordance with the below Step 2 of the step-wise approach mentioned in Section 1:

Step 1: To select one individual project (hereinafter referred to as "representative project" or "RP") and conduct the GHG emission reductions estimation and the financial analyses in detail.

Step 2: To replicate 10 RP equivalents for this WTE NAMA[24] based on the results obtained in Step 1.

Results are shown in Table 4-4.

Table 4-4: A summary of the expected GHG mitigation targets to be achieved by the NAMA.

Item	Baseline emissions (BE_y)	Project emissions (PE_y)	Emission reductions (RE_y)
	tCO_2e	tCO_2e	tCO_2e
Total over the full NAMA period	6,146,791	3,071,612	3,075,178
Annual averaged over the full NAMA period achieved by the NAMA	219,528	109,700	109,828

4.3 SD baseline and co-benefit targets

In addition to GHG mitigation, the WTE NAMA will also contribute to the local SD. The SD co-benefits of the NAMA achieved over its lifetime can be tracked and evaluated by applying the NAMA Sustainable Development Evaluation Tool (NAMA SD Tool) published by the UNDP[25].

The NAMA SD Tool lists 5 domains under the concern of NAMA SD and each domain is composed of a group of SD performance indicators. In accordance with the guidance attached to the NAMA SD Tool[26], only those SD indicators, which are most relevant, specific, meaningful,

[24] Subject to the input from the Moldova team, this PDD tentatively assumes that the WTE NAMA will involve replication of 10 RP equivalents.
[25] Link to access the NAMA SD Tool: http://www.undp.org/content/undp/en/home/librarypage/environment-energy/mdg-carbon/NAMA-sustainable-development-evaluation-tool.html.
[26] *"In order to limit the burden on human and financial resources to measure and report data, policy-makers should select a small, core list of indicators that are specific, meaningful, measurable, and cost-effective to collect. They should also be pertinent and easy to understand."* (Sourced from the "Introduction" tab of NAMA SD Tool).

measurable, and cost-effective to collect, are selected to examine how the WTE NAMA supports sustainable development of the NAMA country. Table 4-5 shows the selected performance indicators of each domain and the reasons for choosing these indicators for the WTE NAMA.

Table 4-5: List of SD domains and performance indicators selected for the NAMA.

Domain	Indicator	Explanation of chosen indicator
Environment	Air pollution/quality	Odour is one of the major concerns of a Solid Waste Disposal Site (SWDS) or landfill, where the wet wastes decompose and release methane that emits a bad odour, in addition to being an explosive gas. This leads to both health and safety impacts on the nearby communities.
	Climate change adaptation and mitigation	The WTE NAMA will achieve GHG mitigation via (a) reduction of methane emissions from the landfill, and (b) displacement of fossil fuel-based electricity generation.
Social	Quality of employment	The skill level of workers/employees will be enhanced through the training sessions provided by the WTE NAMA.
Growth and development	Access to clean and sustainable energy	Clean and sustainable electricity will be generated by using the captured methane gas released from the landfill. This electricity will be exported to the grid to displace the corresponding amount of fossil fuel-based electricity.
Economic	Income generation/ expenditure reduction/ balance of payments	The WTE NAMA will create new job opportunities, thereby increasing income generation by way of remuneration to the employees.
	Job creation (number of men and women employed)	With the presence of the WTE NAMA, both temporary and permanent job opportunities will be created.
Institutional	Laws and regulation	Sustainable development benefits, which is one of the designated goals to be accomplished by a NAMA, can be tracked and evaluated by using the NAMA SD Tool.

After having the relevant SD indicators selected, the next step is to identify the parameter(s) pertinent to the WTE NAMA for each indicator being monitored. One parameter is therefore chosen for each selected indicator, that makes up to seven parameters in total as shown below.

Table 4-6: Selection of a parameter for each chosen indicator for the WTE NAMA.

Indicator	Parameter	Effect on indicator (Positive/ negative/ both)	Monitoring done (Yes/no)
Air pollution/quality	Odour	Positive	Yes
Climate change adaptation and mitigation	Mitigation – Number of ERs accumulated	Positive	No
Quality of employment	Skill level (number of training sessions)	Positive	Yes
Access to clean and sustainable energy	Quantity of net electricity supplied by the project to the grid ($EG_{P,y}$)	Positive	Yes
Income generation/ expenditure reduction/ balance of payments	Remuneration paid to employees (income generation)	Positive	Yes
Job creation (number of men and women employed)	Number of jobs created during construction and operation phases	Positive	Yes

Laws and regulation	Implementation, processes and compliance with the SD tool	Positive	Yes

The measurement, reporting and verification (MRV) procedures for each identified parameter, including how and when to conduct the measurement and the QA/QC procedures, are described Section 9.1.2. Based on the recommended measurement methods for the chosen parameters, the project value of each parameter for an individual project/intervention[27] can be determined ex-post after the project implementation, and then compared with its baseline value which is usually sourced from a feasibility study, literature research, survey, national data, historical project data, data from a similar project, etc. These values serve as the basis for the SD evaluation at an individual project level, followed by an advanced level – a NAMA level, to be discussed in Section 9.1.2 below.

4.4 Transformational Change

The NAMA intervention, coming in a sector with a dire need for improvement, has potential for transformational change.

a. Innovation

Within the context of Moldova waste management, where there is a "lack of equipment for the waste collection and transportation, increasing quantity of waste, lack of capacities for the waste disposal, no organized recycling system for the moment, low level of public awareness about waste management"[28], landfill gas collection and flaring for safety purposes, let alone landfill gas collection and power generation, is innovative technology.

b. Private sector[29] involvement

Being a new type of undertaking in the country, it is expected that the first wave of interventions will be carried out with public sector funding.

Under the financial structure proposed in this document, however, private sector involvement is encouraged to gradually increase as delineated in Section 7.

c. Impact beyond the scope of the project

As mentioned previously, waste management particularly in rural regions are sometimes completely lacking. This poses sanitation problems for the population, and also serious environmental problems including groundwater pollution.

While a downstream activity as compared to non-NAMA interventions[30] such as waste collection improvement and sanitary landfill construction, the NAMA intervention certainly adds to the improvements in the overall waste management system, with health and environmental benefits trickling down to the general population.

[27] In this PDD, the terms "intervention" (which is commonly used in the NAMA SD Tool) and "project" are used interchangeably.
[28] Improvement of solid municipal waste management in the Republic of Moldova, 2014, Osteuropaverein http://www.osteuropaverein.org/media/1547/mda.pdf
[29] In this document, the term "private sector" refers to all entities other than central government units and includes municipalities.
[30] Termed so as there are no GHG reduction aspects to such activities.

Other important impacts include:

- An increase in use of native energy sources in a country which is highly dependent on imported natural gas (Russia) and electricity (Ukraine and Romania).

- Strengthening of the institutional capacities of the national system to bring Moldova onto a low-carbon development path, given that this is one of four priority NAMA measures/interventions chosen by the Moldovan government.

d. Replicability and scaling up

Moldova has a small population, with a total for the entire country being under 4 million[31]. Outside of the capital Chisinau that has a population of 0.7 million, there are only five districts that have a population of over 0.1 million. Scaling up is unlikely, taking into account economically (as well as environmentally) viable transportation distance.

Exact replicability within Moldova will depend on the eventual design of the upstream waste management services, i.e. the number of landfills etc. It is at this stage estimated that the replicability potential is for 9 projects of a similar scale.

It is however of note that waste management issues are not unique to Moldova. While not under the same NAMA umbrella, similar interventions with similar financial structures modified as necessary to suit national circumstances, can be encouraged in other non-Annex I countries, in particular neighbouring countries.

5. Measures & Interventions under the NAMA

The contemplated WTE NAMA, which comprises multiple individual projects, involves the installation and operation of a LFG collection and flare (C&F) system and a grid-connected power plant at its SWDS in Moldova. These individual projects will contribute not only to greenhouse gases (GHG) mitigation, but also to national sustainable development (SD) through NAMA implementation in ways outlined below:

- Collection and destruction of LFG, which is otherwise unabated released into the air at the SWDS.

- Use of the captured LFG for renewable electricity generation without reliance on fossil fuel-based electricity.

Pending for the thorough feasibility study of this NAMA, the following step-wise approach is taken to estimate the GHG ERs achieved by and the financial support required for implementation of the NAMA:

Step 1: To select one individual project (hereinafter referred to as "representative project" or "RP") and conduct the GHG ERs estimation and the financial analyses in detail.

[31] https://en.wikipedia.org/wiki/Demographics_of_Moldova#By_district

Step 2: To replicate 10 RP equivalents for this WTE NAMA[32] based on the results obtained in Step 1.

5.1 At an individual project level

The key features of the RP selected for this NAMA is delineated below:

1. Capacity of the SWDS

The selected RP is composed of an existing site and a new sanitary landfill, adjacent to each other. The solid waste has been disposed in one of the pits at the existing site since the early 1990s and it is expected that all the pits at the existing site, which has a waste disposal capacity of 154,000 m^3 (=11,000 m^2 x 14 m), will be filled completely prior to the operation of the new site.

The new site has a waste disposal capacity of 1,084,000 m^3 and will be divided into 3 cells to be constructed and filled with waste in phases. Cell 1 will be built along with the new site construction in 2018 and started for waste disposal at the same year and in parallel with the installation of the vertical gas wells and pipes. With the annual waste disposal quantity of 59,500 m^3/y, it is anticipated that the lifetime of Cell 1 is approximately 5 years. Cell 2 will then be constructed in-sequence and in parallel with the waste disposal in 2023. Based on the same waste disposal rate, Cell 2 is expected to be fully filled in about 6 years. Following this project implementation plan, Cell 3 will be constructed at the latest and is to be filled from 2029 for another 6 years. This makes up the total lifetime of the new site of 17 years. Table 5-1, which is reproduced from Table 1-1, summarizes the characteristics of the RP.

Table 5-1: Characteristics of the RP.

Landfill site	Capacity	Area	Depth of waste on average		Annual waste disposal quantity	Expected time of operation for waste disposal	First year of waste acceptance	First year when LFG is collected and fed to the generator
	m^3	m^2	m	ft	m^3/y	y		
Existing site	154,000	11,000	14.0[(a)]	45.93	37,000	-	2017 is the last year of waste acceptance	2018
New site								
Cell 1	289,000	19,800	14.6	47.89	59,500	5	2018	2020
Cell 2	362,500	17,000	21.3	69.96	59,500	6	2023	2025
Cell 3	432,500	26,000	16.6	54.57	59,500	6	2029	2031
Sub-total	1,084,000	62,800	17.3	172.42	-	17	-	-

(a) This represents the sum of (i) the 6 m height of the waste disposed on average based on the project information, and (ii) the 8 m depth of the waste disposed on average as per Asiatica's assumption.

2. Waste compositions

Existing site

[32] Subject to the input from the Moldova team, this Report tentatively assumes that the WTE NAMA will involve replication of 10 RP equivalents.

In the absence of site specific data, the composition of municipal solid waste (MSW) sourced from Fourth National Communication[33] is applied in the analysis, pursuant to a suggestion from the Moldova country team.

New site

Site specific data will be used when it is available. In the meantime, National Communication data is used for the new site as well for the purposes of this PDD.

Waste types and composition in accordance with National Communication

This is summarized in the table below. Based on the data, organic components of the waste comprise 66.46% of the total.

Table 5-2: Waste composition.

Waste type		Composition (Wet %)
Organic waste	Food scraps	46.06%
	Waste phyto (food)	10.77%
	Textile	2.59%
	Paper, cardboard	5.28%
	Wood	1.76%
Sub-total for organic		66.46%
Inorganic waste	Furniture	1.95%
	Footwear	0.35%
	Glass	6.12%
	Plastic products	4.66%
	Metal & non-metals	1.67%
	EEE	1.21%
	Other (construction waste)	17.58%
Sub-total for inorganic waste		33.54%
Total		**100.00%**

3. Waste disposal quantity and density

In accordance with the project information provided by the Moldova country team, the annual waste disposal quantity of the existing site and new site are 37,000 m^3/y and 59,500 m^3/y respectively. With the waste density of 0.4 t/m^3 for the existing waste and 1.0 t/m^3 for the new waste, it converts the annual waste disposal quantity to 14,800 t/y and 59,500 t/y respectively.

Table 5-3: Annual quantity and density of the disposal waste.

Landfill site	Annual waste disposal quantity		Waste density
	m^3/y	t/y	t/m^3
Existing site	37,000	14,800	0.4
New site			
Cell 1	59,500	59,500	1.0

[33] This information is provided by the Moldova country team.

Cell 2	59,500	59,500	1.0
Cell 3	59,500	59,500	1.0

4. Gas collection and utilization

LFG will be firstly collected from the waste disposed at the existing site, followed by the new site in accordance with the schedule stated in the last column of Table 5-1 above. Gas collection systems will be built independently at each site and then connected to a gas utilization system where gas engines and generators (Genset) are installed.

Under normal circumstances, the captured LFG, which contains 50% of methane (CH_4) content[34], will be fed to the generators for renewable power generation. The generated power will be exported to the grid, except for a small amount consumed internally.

For the sake of safety, a flare will be installed at the landfill and operated when the gas engines are overloaded with the captured LFG or during maintenance/malfunctioning. Under this arrangement, atmospheric release of the LFG from the landfill sites can be avoided.

5. Amounts of LFG collection

Amounts of LFG collection and methane it contains are calculated on the below basis and assumptions:

(a) Expected amounts of LFG generation are estimated by the application of the first order decay model[35] to the situations at the existing and new sites as described in the information/documents provided by the Moldova country team. The key points are summarized in Section 5.1 above and also in the spreadsheets, including the expected waste compositions and relevant values of the Methane Correction Factor (MCF).

(b) LFG collection efficiency is assumed to be 50% for the existing site and 60% or the new site, based on input from GIZ.

(c) The usual IPCC default value of 50% is adopted for the methane content of LFG.

(d) The spreadsheets estimate the annual amounts of methane collection on the basis of (a) in conjunction with assumptions specified in (b) and (c), namely:

$$LFG\ generated \times collection\ efficieny\ (50\%/60\%) \times methane\ content\ (50\%)$$

(e) The amounts of methane collection are summarized in column E of the "Power generation" tab of the spreadsheets and reproduced in the last column of Table 5-4 below.

Table 5-4: Amounts of methane collection.

Project year (calendar year)	Methane captured (tCH_4)		
	Existing site	New site aggregation	Total

[34] This is the IPCC default value sourced from the CDM methodological tool namely *"Emissions from solid waste disposal site (Version 07.0)"* (http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v7.pdf).
[35] Referred in the CDM methodological tool namely *"Emissions from solid waste disposal site (Version 07.0)"*.

1 (2018)	101	-	101
2 (2019)	86	-	86
3 (2020)	74	333	407
4 (2021)	63	412	475
5 (2022)	55	479	533
6 (2023)	47	405	452
7 (2024)	41	344	385
8 (2025)	36	626	661
9 (2026)	31	661	692
10 (2027)	27	692	719
11 (2028)	24	718	742
12 (2029)	21	611	632
13 (2030)	19	521	540
14 (2031)	17	779	796
15 (2032)	15	794	809
16 (2033)	14	808	822
17 (2034)	12	820	832
18 (2035)	11	631	642
19 (2036)	10	539	549
20 (2037)	9	461	471
21 (2038)	9	396	405
22 (2039)	-	341	341
23 (2040)	-	206	206
24 (2041)	-	177	177
25 (2042)	-	153	153
26 (2043)	-	133	133
27 (2044)	-	116	116
28 (2045)	-	102	102
Total	723	12,260	12,983

6. Amounts of gross electricity generation

Amounts of gross electricity generation are then estimated on the following basis and assumptions:

(a) With an assumption of 33% for power generation efficiency and the default heat value of methane of 50.4 MJ/kg CH_4, the following equation shows that 1 tonne of methane is capable of generating 4.62 MWh of electricity.

$$1\ tCH_4 \times 50.4\ MJ/kg\ CH_4 \times 1000\ kg/t \times 33\% \div 3{,}600\ MJ/MWh = 4.62\ MWh$$

(b) Combination of this value with the amounts derived in Section 5.1.5.(e) above allows the calculation of the annual amounts of electricity that can potentially be generated from the methane contained in the collected LFG.

(c) Based on these amounts, installed capacities of gas engines are planned. The capacity starts at 100 kW and reaches 400 kW during the peak years of LFG generation.

(d) Expected gross amounts of annual electricity generation at the planned power generation facility are calculated in column I of the "Power generation" tab of the spreadsheets and reproduced in Table 5-4 below.

Table 5-5: Amounts of annual gross electricity generation.

Project year (calendar year)	Installed power generation capacity	Capacity factor	Annual gross electricity generation
	kW	-	MWh/y
1 (2018)	100	0.53	468
2 (2019)	100	0.46	399
3 (2020)	200	0.95	1,664
4 (2021)	300	0.84	2,195
5 (2022)	300	0.94	2,463
6 (2023)	300	0.80	2,090
7 (2024)	300	0.68	1,778
8 (2025)	400	0.87	3,054
9 (2026)	400	0.91	3,198
10 (2027)	400	0.95	3,323
11 (2028)	400	0.95	3,329
12 (2029)	400	0.83	2,922
13 (2030)	400	0.71	2,496
14 (2031)	400	0.95	3,329
15 (2032)	400	0.95	3,329
16 (2033)	400	0.95	3,329
17 (2034)	400	0.95	3,329
18 (2035)	400	0.85	2,968
19 (2036)	300	0.95	2,497
20 (2037)	300	0.83	2,174
21 (2038)	300	0.71	1,870
22 (2039)	200	0.90	1,577
23 (2040)	100	0.95	832
24 (2041)	100	0.94	820
25 (2042)	100	0.81	709
26 (2043)	100	0.70	615
27 (2044)	100	0.61	536
28 (2045)	100	0.54	469
Total	-	-	57,763

(e) As mentioned in Section 5.1.4 above, excess methane is flared.

7. Amounts of internal power consumption and net electricity generation

(a) Internal power consumption by blowers

(i) The amount of electricity usage by blowers of the C&F system is estimated according to the to the Landfill Methane Outreach Program (LMOP) cost model[36], which has a default value of 0.002 kWh/ft^3.

(ii) The following analysis demonstrates that 1 cubic feet (ft^3) of LFG is capable of generating 0.0468 kWh of electricity:

- As per Section 5.1.6.(a) above, 1 tonne of methane is capable of generating 4.62 MWh of electricity.

- Given that the density of methane is 0.716 kg/m^3, 1 tonne of methane equals to 1,397 m^{3}CH$_4$.

$$1\ tCH_4 \times 1000\ kg/t \div 0.716\ kgCH_4/m^3CH_4 = 1{,}397\ m^3CH_4$$

- With an assumption of 50% methane content of LFG, 2,793 m^3 (or 98,644 ft^3) of LFG is captured.

$$1{,}397\ m^3CH_4 \div 0.5\ m^3CH_4/m^3LFG = 2{,}793\ m^3\ LFG$$

$$2{,}793\ m^3LFG \times 35.315\ ft^3/m^3 = 98{,}644\ ft^3\ LFG$$

- Thus, the electricity generation of 4.62 MWh is derived from 98,644 ft^3 LFG, which translates to 0.0468 kWh/ft^3 LFG captured.

$$4.62\ MWh \div 98{,}644\ ft^3LFG \times\ 1000\ kWh/MWh = 0.0468\ \ kWh/ft^3LFG$$

(iii) Combination of (i) and (ii) above, the internal power consumption by blowers is equivalent to 4.27% of the gross electricity generation, shown in equation below.

$$(0.002\ kWh/ft^3) \div (0.0468\ \ kWh/ft^3) \times 100\% = 4.27\%$$

(b) Internal power consumption by power generation facility

The amount of electricity consumed by power generation facility is calculated as per the LMOP cost model, which has a default value of 8%[37].

(c) Net electricity generation for grid export

Amounts of net electricity generation are therefore calculated in column N of the "Power generation" tab of the spreadsheets based on the below formula and reproduced in the last column of Table 5-6 below.

$$Net\ electricity\ generation = Gross\ electricity\ generation - Internal\ power\ consumption$$

[36] "User's manual of landfill gas energy cost model (version 3.0, August 2014)" for Landfill Methane Outreach Program (LMOP). U.S. Environmental Protection Agency (http://www3.epa.gov/lmop/publications-tools/lfgcost/LFGcost-WebV3_0manual.pdf). (p.21)

[37] Data source: p.30 of the LMOP cost model.

Table 5-6: Amounts of internal power consumption and annual net electricity generation.

Project year (calendar year)	Annual gross electricity generation	Internal power consumption			Annual net electricity generation
		Blowers	Power generation facility	Total	
	MWh/y	MWh/y	MWh/y	MWh/y	MWh/y
1 (2018)	468	20	37	57	411
2 (2019)	399	17	32	49	350
3 (2020)	1,664	71	133	204	1,460
4 (2021)	2,195	94	176	269	1,926
5 (2022)	2,463	105	197	302	2,161
6 (2023)	2,090	89	167	256	1,834
7 (2024)	1,778	76	142	218	1,559
8 (2025)	3,054	130	244	375	2,680
9 (2026)	3,198	137	256	392	2,806
10 (2027)	3,323	142	266	408	2,915
11 (2028)	3,329	142	266	408	2,920
12 (2029)	2,922	125	234	359	2,563
13 (2030)	2,496	107	200	306	2,190
14 (2031)	3,329	142	266	408	2,920
15 (2032)	3,329	142	266	408	2,920
16 (2033)	3,329	142	266	408	2,920
17 (2034)	3,329	142	266	408	2,920
18 (2035)	2,968	127	237	364	2,604
19 (2036)	2,497	107	200	306	2,190
20 (2037)	2,174	93	174	267	1,907
21 (2038)	1,870	80	150	229	1,640
22 (2039)	1,577	67	126	193	1,383
23 (2040)	832	36	67	102	730
24 (2041)	820	35	66	101	719
25 (2042)	709	30	57	87	622
26 (2043)	615	26	49	75	540
27 (2044)	536	23	43	66	470
28 (2045)	469	20	38	58	411
Total	57,763	2,466	4,621	7,087	50,675

The abovementioned features of the selected RP serve the basis for the GHG ERs estimation and the financial analyses conducted in Sections 4.2 and 7.1 respectively.

5.2 At a NAMA level

Subject to the input from the Moldova team, this PDD tentatively assumes that the contemplated WTE NAMA will involves replication of 10 RP equivalents. This can represent not only 10 individual projects of the same size as the RP, but also various other combinations that sum up to 10 RP equivalents. For example, a NAMA that includes 4 individual projects of the same size as the RP, 3 of the size 1.2 times the RP and 3 of the size 0.8 times the RP will be deemed as comprising 10 RP equivalents.

Considering that the measurement activities are to be conducted at the individual project site, measures such as (a) extensive training/capacity building at the initial stage, (b) mandating submission of monthly (or regularly) measurement reports, and (c) regular on-site inspection shall be taken to ensure appropriate measurement and reporting.

6. Capacity Development

Several capacity development needs are identified:

1. Capacity at the central unit

   The NAMA assumes municipality level participation, either as NAMA intervention project owners and/or as the owners of the host landfill. One municipality however will only ever deal with a WTE project once, and it will also be the first time to deal with a NAMA. Central institutional knowhow must be developed for many aspects of the NAMA intervention, including technology, regulation (on the assumption that it is also the first power generation project), and MRV so that the central unit will be able to guide individual NAMA participants..

2. Technology

   Technology capacity building is a built-in component of this NAMA structure, where the first intervention project is intended to serve as a pilot plant for subsequent interventions.

3. Regulatory

   While certainly not intended to hamper investment, the tariff setting mechanism that assumes a project owner must suffer a payback period of as long as 10 years is wanting. This may well be reasonable for a very large power station which are expected to operate for many decades, but is not suited to a small private-owned project subject to a high risk inherent to some types of renewable energy projects, and which typically has a much shorter project lifetime.

   This is exacerbated by the fact that when a project is able to obtain a grant to help alleviate the high investment costs, the tariff calculation is iterated downwards to come get back to the same payback period. While acknowledging that this may be a valid measure when a project's only financial difficulty is high investment cost, this policy is detrimental to a project which faces a profitability as this measure nullifies any improvement in profitability. Again, this is only suitable for very large power stations that are often owned by state or quasi state enterprises.

   Capacity development is required in this sense to formulate an enabling tariff setting methodology, which starts with the understanding and appreciation of the very different nature of investors for different types of power projects.

4. Effective disbursement of international funds

   International funds are typically disbursed through local commercial banks, where bank charges are as high as 20%. There is plenty of room for capacity building, especially in existing entities that already handle international funds, so that there can be less reliance on commercial banks so that more funds can reach the intervention project owner.

5. MRV

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Measurement and reporting requirements for NAMAs are specialized and often baffle even those technically familiar with operation of a landfill or a biogas power plant operation. A capacity building program focused on the MRV activities for NAMAs is essential.

7. NAMA Financial Requirements and Mechanisms

A. Budget for the RP without financing factors

Accurate and dependable budgeting is an indispensable prerequisite for financial planning. At the same time, outcomes of financial planning represent important elements of budgeting, affecting such core NAMA budgeting items as the number of individual projects to be included in the NAMA and public/private funds to be incorporated into a NAMA's budget. To deal with this interaction between budgeting and financial planning, two types budget will be prepared.

Budget 1: A Core Budget to focus on such factors as incomes and costs. This budget does not include financial factors and will serve as a key input for cash flow analysis and financial structuring.

Budget 2: An Augmented Budget that reflects both core factors and outcomes of financial structuring.

These budgets (both Budget 1 and Budget 2) are initially prepared for the RP in accordance with Step 1 of the step-wise approach taken to estimate the financial support required for implementation of the NAMA reproduced below, and called "BNIP (RP)", short for Budget for NAMA Individual Project pertaining to the RP.

Step 1: To select one individual project (hereinafter referred to as "representative project" or "RP") and conduct the GHG emission reductions estimation and the financial analyses in detail.

In relation to the process outlined above, this section focuses on analyzing the budget for the RP without financing factors (i.e. Budget 1 of the RP). Taking into account the following two factors, an approximation on Budget 1 of the RP can only be derived.

- Lack of a detailed feasibility study. The initial investment costs for LFG collection and utilization projects are highly site specific. It is not only subject to the physical conditions and layout (including the size and depth of each pit) of a landfill, but also subject to the compositions of disposal waste, which will determine the LFG generation capacity.
- Lack of updated or sufficient information from precedents in Moldova and in the region. More information and findings about this literature research are summarized in Section 1.2 of Annex 4.

1. Initial investments

The initial investment costs of a WTE technology designed for the LFG collection and utilization at a new sanitary landfill can be classified into three components:

(1) LFG collection and flaring systems

The cost estimation for LFG C&F system refers principally to the Landfill Methane Outreach Program (LMOP) cost model[38] that is arguably the most reliable source for general data.

[38] "User's manual of landfill gas energy cost model (version 3.0, August 2014)" for Landfill Methane Outreach Program (LMOP). U.S. Environmental Protection Agency (http://www3.epa.gov/lmop/publications-tools/lfgcost/LFGcost-WebV3_0manual.pdf).

When deemed appropriate, LMOP default values are modified pursuant to other literature sources and/or author's own experience about similar projects.

The initial investment of LFG C&F systems includes the costs of typical components listed below:

- Engineering, permitting, and administration;
- Wells and wellheads;
- Pipe gathering system (includes additional fittings/installations);
- Condensate knockout system;
- Blowers;
- Instructure controls;
- Flare; and
- Site survey, preparation and utilities.

In view of the staggered installation of the RP, it is expected that four C&F systems are required. One is for the existing site, and the rest of them are for the new site with one system for each cells 1 to 3. Each C&F system includes gas extraction wells, wellheads and pipe gathering system, knockout and blower. However, there will be only one big flare, not for each of the C&F systems, to be shared by two sites.

Table 7-1 summarizes the estimated total investment costs of the LFG C&F systems for the RP as USD 703,655. For detailed cost estimation and its calculation procedures on each typical component, please refer to Section 1.2.2.1 of Annex 4.

Table 7-1: Total investment costs of the LFG C&F systems for the RP.

Landfill site	Cost of vertical gas extraction wells	Cost of wellheads and pipe gathering system	Cost of knockout, blower and flare system	Cost of drilling and pipe crew mobilization	Cost of engineering, permitting and surveying	Total costs
	USD	USD	USD	USD	USD	USD
Existing site	9,162	51,000	27,740	20,000	2,100	110,002
New site						
Cell 1	16,102	85,000	71,502	0	3,500	176,104
Cell 2	25,482	85,000	76,572	0	3,500	190,554
Cell 3	26,522	119,000	76,572	0	4,900	226,994
Sub-total	68,106	289,000	224,646	0	11,900	593,652
Total	77,268	340,000	252,386	20,000	14,000	703,655

<u>Lifetime</u>

The estimated number of years that the LFG energy project will be operating is defined in the LMOP cost model. The default project lifetime is 15 years, which is considered as the average lifetime for the equipment installed in LFG energy projects[39]. In light of this and the expected time of operation for waste disposal for each cell stated in Table 1-1, the lifetime of 15 years will mean that each LFG collection system will have about 10 years after the relevant cell is filled and closed. In 10 years from the closure, LFG generation will be small and the effect will be minimal. Therefore, no replacement of any LFG collection system is planned for the RP.

[39] Data source: p.10 of the LMOP cost model.

Unlike some other LFG projects, the project plan for the RP is to use the flare only when the gas engines are overloaded with the captured LFG or during maintenance/malfunction. According to the estimation, this will not happen often, if at all. This will mean that the flare can expect a long lifetime. In this circumstance, no replacement of the flare is planned for the RP. In the event that its replacement is required, it is reasonable to assume that the replacement cost can be absorbed as part of O&M costs due to the limited cost of an open flare[40].

(2) Power generation facility

The cost estimation for a 400kW power generation facility (4 x 100 kW) is however based on author's own experience gained from CDM registered projects and general opinions of technology providers, after compared it with the default value in literature source detailed in Section 1.2.2.2 of Annex 4.

The power generation facility consists of two components in general:

- Gas engines and accessories, including gas engines, electrical connection, etc.
- Auxiliary equipment, including a compressor, gas treatment system for the LFG, etc.

Based on author's analysis, the total costs for power generation facility of the RP are estimated as USD 658,600 in table below.

Table 7-2: Total costs of the power generation facility for the RP.

Landfill site	Cost of gas engines and accessories	Cost of auxiliary equipment	Total costs
	USD	USD	USD
For both existing site and new site	436,067	222,533	658,600

Lifetime

With the phased implementation plan of the RP, the operation period of the power generation facility will be 28 years from the beginning of power generation with the existing site to the end of the lifetime of the LFG collection system, when power generation ends. This is a fairly long period, even with good maintenance and overhaul of the Gensets. Considering this, the RP adopts the average lifetime of 15 years for the equipment installed in LFG energy projects quoted in the LMOP cost model, with a plan to replace the Gensets. Two out of the four Gensets will be replaced at an assumed cost of USD 75,000 for each 100 kW Genset after 15 operational years[41]. It is noted that this is based on author's contact with reputable gas engine providers who indicate a price of USD 75,000 for a 100 kW gas engine when purchased in a package deal for 4 or more engines. This indicative price will be modified when and if more accurate information for the RP is available.

(3) Other

It is assumed that costs other than C&F systems and power generation facility, such as office building construction, planning and designing, project management, etc., are already

[40] The indicative price of an open flare with 1,000 nM^3/h is USD 36,000, sourced from a technology provider, who Asiatica has in contact with.
[41] The lifetime of 15 operational years is sourced from a technology provider, who author has in contact with.

included in the default values applied above. As such, no other costs have to be considered separately.

<u>Total initial investment costs</u>

To sum up, the total initial investment costs of the RP are USD 1,512,254, with the investment payment schedule based on its implementation plan delineated in Table 7-3 below.

Table 7-3: Total initial investment costs of the RP. **Unit: USD**

Project year (calendar year)	Total costs of C&F systems				Total costs of power generation facility				Total initial investment costs
	Existing site	New site			Genset 1	Genset 2	Genset 3	Genset 4	
		Cell 1	Cell 2	Cell 3	100 kW	100 kW	100 kW	100 kW	
0 (2017)	II[a] 110,002 (100%)				II 433,600[b] (65.8%)				543,602
1 (2018)	OY[c]	II 104,602 (59%)			OY				104,602
2 (2019)		II 71,502 (41%)				II 75,000 (11.4%)			146,502
3 (2020)		OY				OY	II 75,000 (11.4%)		75,000
4 (2021)							OY		-
5 (2022)									-
6 (2023)			II 113,982 (60%)						113,982
7 (2024)			II 76,572 (40%)					II 75,000 (11.4%)	151,572
8 (2025)			OY					OY	-
9 (2026)									-
10 (2027)									-
11 (2028)									-
12 (2029)				II 150,422 (66%)					150,422
13 (2030)				II 76,572 (34%)					76,572
14 (2031)				OY					-
15 (2032)					RI[d] (Genset 5) 75,000				75,000
16 (2033)					ROY[e] (Genset 5)				-
17 (2034)						RI (Genset 6) 75,000			75,000
18 (2035)						ROY (Genset 6)			-

19 (2036)									-
20 (2037)									-
21 (2038)									-
22 (2039)									-
23 (2040)									-
24 (2041)									-
25 (2042)									-
26 (2043)									-
27 (2044)									-
28 (2045)									-
Total	110,002	176,104	190,554	226,994	808,600				1,512,254

(a) II – Initial investment
(b) $USD\ 658{,}600 - (75{,}000\ USD/engine * 3\ engines) = USD\ 433{,}600$
(c) OY – Operational year
(d) RI – Replacement investment
(e) ROY – Replacement operational year

2. Revenues

Consistent with Section 5.1.4 above, the electricity generated from the RP will be exported to the grid except for a small amount consumed internally. With this concept, the revenue generated from electricity sale will be calculated as per the below equation:

$$Revenue\ from\ electricity\ sale = Net\ electricity\ generation \times Electricity\ tariff$$

After extensive discussions with the Moldova team, an electricity tariff of USD 113 / MWh is recommended for the purposes of this PDD, in view of three factors:

- The average of formula-based annual tariffs is USD 130 / MWh. This is determined based on a document provided by the Moldova country team[42]. For detailed tariff estimation, please refer to Section 2.1.1 of Annex 4.
- At USD 113/MWh, the project has a payback period of 10 years.
- The recommended tariff level is not out of line with the EU practices.

On this basis, the following Table 7-4 shows the revenues from electricity sale.

Table 7-4: Revenues from electricity sale of the RP.

Project year (calendar year)	Annual net electricity generation	Electricity tariff	Annual revenues from electricity sale
	MWh/y	USD/MWh	USD/y
1 (2018)	411	113	46,420
2 (2019)	350		39,595
3 (2020)	1,460		165,000

[42] "METHODOLOGY FOR THE DETERMINATION, APPROVAL AND APPLICATION OF TARIFFS FOR THE ELECTRICITY GENERATED FROM RENEWABLE ELECTRIC ENERGY AND FUEL"

4 (2021)	1,926		217,647
5 (2022)	2,161		244,209
6 (2023)	1,834		207,204
7 (2024)	1,559		176,222
8 (2025)	2,680		302,796
9 (2026)	2,806		317,066
10 (2027)	2,915		329,380
11 (2028)	2,920		330,000
12 (2029)	2,563		289,672
13 (2030)	2,190		247,429
14 (2031)	2,920		330,000
15 (2032)	2,920		330,000
16 (2033)	2,920		330,000
17 (2034)	2,920		330,000
18 (2035)	2,604		294,222
19 (2036)	2,190		247,500
20 (2037)	1,907		215,543
21 (2038)	1,640		185,350
22 (2039)	1,383		156,332
23 (2040)	730		82,500
24 (2041)	719		81,283
25 (2042)	622		70,283
26 (2043)	540		60,997
27 (2044)	470		53,144
28 (2045)	411		46,488
Total	50,675	-	5,726,285

3. O&M costs

The annual operation and maintenance (O&M) costs of the RP are mainly composed of the annual O&M expenses for its two major facilities. They are:

(1) Costs for C&F systems

Consistent with the initial investment costs estimation of the C&F systems, the annual O&M costs for the C&F systems are also calculated pursuant to the LMOP cost model[43]. It consists of (a) annual O&M costs excluding energy costs, and (b) annual energy costs for electricity usage by blowers.

For item (a), the costs are determined based on the number of wells in operation using the formula below. The total annual O&M costs excluding energy costs for C&F systems of the RP over the full NAMA period is USD 922,800. For detailed breakdown, please see Table 7-5 below or Section 1.2.4.1 of Annex 4.

$$Annual\ O\&M\ costs\ excluding\ energy\ costs = (2{,}600\ USD/well \times No.of\ wells) + USD\ 5{,}100\ for\ flare$$

[43] Data source: p.21 of the LMOP cost model.

For item (b), as per the LMOP cost model, the electricity usage by blowers is subject to the quantity of LFG generated and captured, with the default value of 0.002 kWh/ft^3.

The project plan for the RP involves LFG collection and its utilization whereby electricity is produced for grid export as well as for the plant's internal power consumption. Thus, it is assumed that no power will be imported from the grid for the usage by blowers, and in turn the annual energy costs for electricity usage by blowers are assumed as zero in this initial financial analysis.

(2) Costs for power generation facility

Author recommends to use the value of 0.025 EUR/kWh-generated (i.e. equivalent to 0.027 USD/kWh-generated)[44], which is provided by a reputable technology provider in relation to a very similar project – registered CDM project activity namely "Magenko IYO Alam Sekitar Bercham Landfill Gas to Energy Project in Ipoh, Malaysia (Ref. 6812)"[45], in this initial financial analysis.

Annual O&M costs

The annual O&M costs for the RP, which exclude the major overhaul costs described in the ensuing section, are summarized in column 4 of Table 7-5 below, whereas the total O&M costs for the RP, which is calculated as per the following formulae, are shown in column 6 of Table 7-5.

$$Total\ O\&M\ costs = Annual\ O\&M\ costs + Major\ overhaul\ costs$$

Table 7-5: Total O&M costs for the RP. **Unit: USD**

1	2	3	4	5	6
Project year (calendar year)	Annual O&M costs			Major overhaul costs	Total O&M costs
	C&F systems excluding energy costs	Power generation facility	Total		
1 (2018)	12,900	12,760	25,660		25,660
2 (2019)	12,900	10,884	23,784		23,784
3 (2020)	25,900	45,355	71,255		71,255
4 (2021)	25,900	59,826	85,726		85,726
5 (2022)	25,900	67,128	93,028		93,028
6 (2023)	25,900	56,956	82,856		82,856
7 (2024)	25,900	48,440	74,340		74,340
8 (2025)	38,900	83,232	122,132	37,500	159,632
9 (2026)	38,900	87,154	126,054		126,054
10 (2027)	38,900	90,539	129,439	37,500	166,939
11 (2028)	38,900	90,710	129,610	37,500	167,110
12 (2029)	38,900	79,624	118,524		118,524
13 (2030)	38,900	68,013	106,913		106,913
14 (2031)	57,100	90,710	147,810		147,810
15 (2032)	57,100	90,710	147,810	37,500	185,310
16 (2033)	49,300	90,710	140,010		140,010

[44] The exchange rate, sourced from the Hongkong and Shanghai Banking Corporation Limited on 18/11/2015, is 1.073 USD/EUR.
[45] Link of the CDM project: http://cdm.unfccc.int/Projects/DB/DNV-CUK1343113895.99/view.

17 (2034)	49,300	90,710	140,010		140,010
18 (2035)	36,300	80,875	117,175		117,175
19 (2036)	36,300	68,032	104,332		104,332
20 (2037)	36,300	59,248	95,548		95,548
21 (2038)	36,300	50,949	87,249		87,249
22 (2039)	36,300	42,972	79,272		79,272
23 (2040)	23,300	22,677	45,977		45,977
24 (2041)	23,300	22,343	45,643		45,643
25 (2042)	23,300	19,319	42,619	37,500	80,119
26 (2043)	23,300	16,767	40,067		40,067
27 (2044)	23,300	14,608	37,908		37,908
28 (2045)	23,300	12,778	36,078		36,078
Total	922,800	1,574,030	2,496,830	187,500	2,684,330

4. Overhaul costs

Overhaul of the C&F systems and power generation facility are anticipated to be taken place during the project lifetime. The following two overhaul costs are considered in general:

(1) Minor/regular overhaul costs

It is assumed that costs for minor overhaul or regular repair and maintenance of the C&F systems and power generation facility are already included as a part of the annual O&M costs discussed above. As such, no additional costs are required to be considered.

(2) Major overhaul costs

In accordance with the information sourced from the technology provider, each gas engine will be overhauled after 60,000 hours of operation[46] (i.e. about 7.5 years at a 90% capacity factor) and required to be undergone a thorough overhaul at a cost of 50% of the original cost (i.e. USD 37,500)[47]. It is noted that the timing of an overhaul largely depends on the engine itself, however, it is thought that this assumption is reasonable as going hand in hand with the cost (and thereby class) of engine used. Since the expected lifetime of each gas engine is 15 years, there will be one major overhaul activity for each of the Gensets, except Genset 5. It is noted that overhaul of Genset 5 in year 2040 is deemed unnecessary due to the diminished generation rate of the LFG from year 2035 onwards. As per the project implementation plan, there is only 1 engine in operation in year 2040 onwards. The schedule and costs of major overhaul are summarized in Table 7-6 below.

Table 7-6: Major overhaul costs for the RP. **Unit: USD**

Project year (calendar year)	Major overhaul costs			
	Genset 1	Genset 2	Genset 3	Genset 4
	100 kW	100 kW	100 kW	100 kW
8 (2025)	37,500			
10 (2027)		37,500		
11 (2028)			37,500	

[46] The major overhaul at 60,000 operation hours is sourced from a technology provider, who author has contact with.
[47] The ratio of overhaul cost to the original cost may be higher depending on the manufacturer's specifications.

15 (2032)				37,500
23 (2040)	Overhaul of Genset 5 is unnecessary			
25 (2042)		Overhaul of Genset 6 37,500		
Total	187,500			

5. Budget for the RP without financing factors

(1) Summary of budget items

Error! Reference source not found. summarizes the key budget items discussed in the foregoing sections.

Table 7-7: Key budgeting parameters for the RP.

Parameter	Unit	Value	Source
Plant capacity	kW	400	The maximum installed capacity throughout the project lifetime.
Capacity factor	%	95	The highest value assumed in the calculation of the gross power generation, summarized in Table 5-5 above.
Gross electricity generated	kWh/y	3,328,800	The maximum gross electricity generated throughout the project lifetime. For details of annual gross electricity generation, please refer to Table 5-5 above.
Internal power consumption	kWh/y	408,444	Equivalent to 12.27% (=8%+4.27%) of gross electricity generated, as referred in Table 5-6 above. For the sake of conservatism, this is multiplied by the maximum gross electricity generated throughout the project lifetime.
Power for sale	kWh/y	2,920,356	The maximum net electricity generated throughout the project lifetime. For details of annual gross electricity generation, please refer to Table 5-6 above.
Per unit revenue	USD/MWh	113	The flat rate electricity tariff based on the extensive discussions with the Moldova team.
Cash in-flow from electricity sale	USD/y	330,000	The maximum revenue earned throughout the project lifetime, summarized in Table 7-4 above.
Initial investment costs - WTE facility	USD	1,512,254	For details of initial investment costs, please refer to Table 7-3 above.
Total O&M costs			
Annual O&M costs	USD/y	147,810	The maximum annual O&M costs, which are for C&F systems and power generation facility, expensed throughout the project lifetime, listed in Table 7-5 above.
Major overhaul costs	USD	187,500	Total major overhaul costs of the project. For detailed breakdown, please see Table 7-6 above.

(2) Budget without financing factors

The budget corresponding to these input parameters is summarized in Table 7-8 that constitutes the Core Budget of the RP (i.e. Budget 1).

Table 7-8: Core Budget (i.e. without financing factors) for the RP. **Unit: USD**

Project year (calendar year)	Investment in fixed assets A	Intangible assets B	Pre-production expenditures C	Total investment costs D=A+B+C	Total O&M costs E	Income F	Annual BNIP surplus / deficit G=F-D-E	Aggregated annual BNIP surplus / deficit up to year $H_y=H_{y-1}+G_y$
0 (2017)	543,602			543,602	0	0	-543,602	-543,602
1 (2018)	104,602			104,602	25,660	46,420	-83,841	-627,444
2 (2019)	146,502			146,502	23,784	39,595	-130,691	-758,134
3 (2020)	75,000			75,000	71,255	165,000	18,745	-739,389
4 (2021)	0			0	85,726	217,647	131,921	-607,469
5 (2022)	0			0	93,028	244,209	151,181	-456,287
6 (2023)	113,982			113,982	82,856	207,204	10,366	-445,922
7 (2024)	151,572			151,572	74,340	176,222	-49,690	-495,611
8 (2025)	0			0	159,632	302,796	143,164	-352,447
9 (2026)	0			0	126,054	317,066	191,011	-161,436
10 (2027)	0			0	166,939	329,380	162,441	1,005
11 (2028)	0			0	167,110	330,000	162,890	163,895
12 (2029)	150,422			150,422	118,524	289,672	20,725	184,621
13 (2030)	76,572			76,572	106,913	247,429	63,945	248,565
14 (2031)	0			0	147,810	330,000	182,190	430,756
15 (2032)	75,000			75,000	185,310	330,000	69,690	500,446
16 (2033)	0			0	140,010	330,000	189,990	690,437
17 (2034)	75,000			75,000	140,010	330,000	114,990	805,427
18 (2035)	0			0	117,175	294,222	177,047	982,474
19 (2036)	0			0	104,332	247,500	143,168	1,125,642
20 (2037)	0			0	95,548	215,543	119,995	1,245,637
21 (2038)	0			0	87,249	185,350	98,101	1,343,738
22 (2039)	0			0	79,272	156,332	77,060	1,420,798

23 (2040)	0			0	45,977	82,500	36,523	1,457,321
24 (2041)	0			0	45,643	81,283	35,640	1,492,961
25 (2042)	0			0	80,119	70,283	-9,836	1,483,125
26 (2043)	0			0	40,067	60,997	20,931	1,504,056
27 (2044)	0			0	37,908	53,144	15,236	1,519,291
28 (2045)	0			0	36,078	46,488	10,409	1,529,701
Total	1,512,255			1,512,255	2,684,330	5,726,285	**1,529,701**	1,529,701

B. Budget for the Central NAMA Unit (BCNU)

On assumption that the costs for the NAMA central unit – management of the NAMA, provision of capacity building training, etc. – will be borne by the Moldovan government as part of the country's national ambition and thus neutralized in terms of the NAMA's budget, they are not taken account of in the budgeting analysis.

C. Cash flow modelling and analysis

This PDD conducts cash flow modelling at two levels. One is without financing factors and the other with them. The former is carried out in this section while the latter in Section 7.4 below.

Based on the Core Budget of the RP developed above and summarized in Table 7-8, Table 7-9 represents the cash flow model for the RP without financial factors.

Table 7-9: Cash flow model for the RP without financing factors.

Project year (calendar year)	Total investment costs (USD)	Operating cash flow (USD)				Total net cash flow (USD)
		Income (Revenue)	O&M costs	Operating net cash flow	Cumulative operating net cash flow	
	A	B	C	D=B-C	$E=E_{y-1}+D$	F=D-A
0 (2017)	543,602			-		-543,602
1 (2018)	104,602	46,420	25,660	20,761	20,761	-83,841
2 (2019)	146,502	39,595	23,784	15,812	36,572	-130,691
3 (2020)	75,000	165,000	71,255	93,745	130,317	18,745
4 (2021)	-	217,647	85,726	131,921	262,238	131,921
5 (2022)	-	244,209	93,028	151,181	413,419	151,181
6 (2023)	113,982	207,204	82,856	124,348	537,767	10,366
7 (2024)	151,572	176,222	74,340	101,882	639,650	-49,690
8 (2025)	-	302,796	159,632	143,164	782,813	143,164
9 (2026)	-	317,066	126,054	191,011	973,825	191,011
10 (2027)	-	329,380	166,939	162,441	1,136,266	162,441
11 (2028)	-	330,000	167,110	162,890	1,299,156	162,890
12 (2029)	150,422	289,672	118,524	171,147	1,470,303	20,725
13 (2030)	76,572	247,429	106,913	140,517	1,610,820	63,945
14 (2031)	-	330,000	147,810	182,190	1,793,010	182,190
15 (2032)	75,000	330,000	185,310	144,690	1,937,701	69,690
16 (2033)	-	330,000	140,010	189,990	2,127,691	189,990
17 (2034)	75,000	330,000	140,010	189,990	2,317,682	114,990
18 (2035)	-	294,222	117,175	177,047	2,494,729	177,047
19 (2036)	-	247,500	104,332	143,168	2,637,897	143,168
20 (2037)	-	215,543	95,548	119,995	2,757,892	119,995

21 (2038)	-	185,350	87,249	98,101	2,855,993	98,101
22 (2039)	-	156,332	79,272	77,060	2,933,053	77,060
23 (2040)	-	82,500	45,977	36,523	2,969,576	36,523
24 (2041)	-	81,283	45,643	35,640	3,005,216	35,640
25 (2042)	-	70,283	80,119	(9,836)	2,995,380	-9,836
26 (2043)	-	60,997	40,067	20,931	3,016,310	20,931
27 (2044)	-	53,144	37,908	15,236	3,031,546	15,236
28 (2045)	-	46,488	36,078	10,409	3,041,955	10,409

With the plans to make investments over a number of years (instead of concentrating them in year 0), the RP defies the application of the typical analytical tool for the cash flow model – the project IRR. For this project, the payback period analysis offers the best framework for assessing the inherent profitability of the project under consideration.

As displayed in Table 7-9, it is in the 10^{th} year when the cumulative total of net operating cash flows (USD 1,136,266) exceeds the cumulative total of investments to be made by that year (USD 1,135,260Thus, the RP has a payback period of 10 years with a tariff of USD 113/MWh assumed for **Table 7-4**.

D. Financial structuring

The financial structuring of the RP is elaborated in ensuing sections below.

7.1 National and International Finance: Sources and Distribution Mechanisms

One of the key objectives of the proposed NAMA is to create an enabling environment for mobilizing national finance sources. With this, the planned financial structure for the NAMA involves the combination of an initial bridge loan by an international NAMA supporter, to be refinanced by national finance sources, primarily municipalities. More details of the proposed mechanism are provided in Sections 7.3 and 7.4 and further elaborated in Section 3 of Annex 4.

The following table provides the summary of national and international financial sources.

Table 7-10: Summary of national and international financial sources.

Finance	Sources
National	1. Bridge loan refinancing, principally with funds from municipality investors
	2. Tariff subsidy (Please refer to Section 7.2)
	3. In-kind contribution to the management of the NAMA, provided by the Moldovan government as part of the country's national ambition (Please refer to Section 7.2)
International	1. Initial bridge loan (Please refer to column 5 of Table 7-12 below and Section 3.1 of Annex 4 for details.)

7.2 National finance sources

As well as the refinancing of the initial bridge loan, there are two other significant national finance sources. One is the FiT system that is a pillar for creating an enabling environment.

Based on extensive discussions with the Moldova team, an electricity tariff of USD 113 / MWh is recommended for the purposes of this PDD. Reasons for choosing this electricity tariff are elaborated in item A.2 of Section 7 and Section 2.1 of Annex 4.

The other is in-kind contribution by the central Moldovan government for the management of the NAMA.

7.3 Financial distribution mechanisms

The investment barriers for the NAMA projects have two distinct features.

- The cash flow analysis for the NAMA reveals that unlike most other LFG collection and utilization projects, the LFG to be collected and utilized by the NAMA projects will come very heavily from a new site, to be created as part of internationally assisted effort at improved waste management. In view of this, no national investment (either from municipalities or pure private sector investors) can be expected for the NAMA until it is fully demonstrated that the new site will receive the anticipated amount of waste.

- The return on investment will not be discouragingly low when the new site performs as planned and a reasonable FiT is granted.

In the light of these two factors, the financial plan that was developed involves the public sector providing a bridge loan initially, on the understanding that it will be refinanced by national finance sources when the performance of the new site is convincingly established. The refinancing is scheduled to start at the end of year 3. Please refer to column 6 of Table 7-12

Obviously, provision of such a loan involves risk for the public sector supporter. How to mitigate the risk is addressed in Section 10 on risk management.

It is of note that under the structure outlined above, co-finance between international funding and national funding takes place sequentially, rather than simultaneously as is usually the case.

The proposed financial structure is not expected to require international grants, except for a small amount (up to USD 150,000) for a detailed technical feasibility study.

7.4 Indicative NAMA financing needs

1. Summary of the NAMA's indicative financial needs

Believing that this can be most succinctly presented in table form, the following two tables are provided, one for the pilot project and the other for the entire NAMA[48].

(a) The RP (serving as the pilot project)

The following table represents the cash flow model for the RP without financing factors, which is the identical to Table 7-9 and reproduced here for easy reference.

Table 7-11: Cash flow model for the RP without financing factors.

Project year		Operating cash flow (USD)	

[48] As mentioned in Section 8.4 and Section 10, the implementation of the NAMA will be phased out for the sake of risk mitigation, with Phase 1 consisting of the implementation of the representative project (the initial project serving as the pilot project).

(calendar year)	Total investment costs (USD)	Income (Revenue)	O&M costs	Operating net cash flow	Cumulative operating net cash flow	Total net cash flow (USD)
	A	B	C	D=B-C	$E=E_{y-1}+D$	F=D-A
0 (2017)	543,602			-		-543,602
1 (2018)	104,602	46,420	25,660	20,761	20,761	-83,841
2 (2019)	146,502	39,595	23,784	15,812	36,572	-130,691
3 (2020)	75,000	165,000	71,255	93,745	130,317	18,745
4 (2021)	-	217,647	85,726	131,921	262,238	131,921
5 (2022)	-	244,209	93,028	151,181	413,419	151,181
6 (2023)	113,982	207,204	82,856	124,348	537,767	10,366
7 (2024)	151,572	176,222	74,340	101,882	639,650	-49,690
8 (2025)	-	302,796	159,632	143,164	782,813	143,164
9 (2026)	-	317,066	126,054	191,011	973,825	191,011
10 (2027)	-	329,380	166,939	162,441	1,136,266	162,441
11 (2028)	-	330,000	167,110	162,890	1,299,156	162,890
12 (2029)	150,422	289,672	118,524	171,147	1,470,303	20,725
13 (2030)	76,572	247,429	106,913	140,517	1,610,820	63,945
14 (2031)	-	330,000	147,810	182,190	1,793,010	182,190
15 (2032)	75,000	330,000	185,310	144,690	1,937,701	69,690
16 (2033)	-	330,000	140,010	189,990	2,127,691	189,990
17 (2034)	75,000	330,000	140,010	189,990	2,317,682	114,990
18 (2035)	-	294,222	117,175	177,047	2,494,729	177,047
19 (2036)	-	247,500	104,332	143,168	2,637,897	143,168
20 (2037)	-	215,543	95,548	119,995	2,757,892	119,995
21 (2038)	-	185,350	87,249	98,101	2,855,993	98,101
22 (2039)	-	156,332	79,272	77,060	2,933,053	77,060
23 (2040)	-	82,500	45,977	36,523	2,969,576	36,523
24 (2041)	-	81,283	45,643	35,640	3,005,216	35,640
25 (2042)	-	70,283	80,119	(9,836)	2,995,380	-9,836
26 (2043)	-	60,997	40,067	20,931	3,016,310	20,931
27 (2044)	-	53,144	37,908	15,236	3,031,546	15,236
28 (2045)	-	46,488	36,078	10,409	3,041,955	10,409

The following table shows the cash flow model for the RP with financing factors.

Table 7-12: Cash flow model for the RP with financing factors.

1	2	3	4	5	6	7	8	9	10	11	12
Project year (calendar year)	Cash Flow (USD)[49]	Grants (USD)	Funds from investor (USD)	Public sector loans[50] (USD)	Public sector loan repayment[51] (USD)	Private sector loans (USD)	Private sector loan repayment (USD)	Private sector loans outstanding (USD)	Interest payment (USD)	Cash flow after financial transactions (USD)	Accumulated cash flow (USD)
0 (2017)	-543,602			543,602						0	0
1 (2018)	-83,841			83,841						0	0
2 (2019)	-130,691			130,691						0	0
3 (2020)	18,745		233,966		252,711					0	0
4 (2021)	131,921				50,542					81,378	81,378
5 (2022)	151,181				50,542					100,639	182,017
6 (2023)	10,366				50,542					-40,176	141,841
7 (2024)	-49,690				50,542					-100,232	41,609
8 (2025)	143,164				50,542					92,622	134,230
9 (2026)	191,011				50,542					140,469	274,699
10 (2027)	162,441				50,542					111,899	386,598
11 (2028)	162,890				50,542					112,348	498,946
12 (2029)	20,725				50,542					-29,817	469,129
13 (2030)	63,945				50,542					13,402	482,531
14 (2031)	182,190									182,190	664,722
15 (2032)	69,690									69,690	734,412
16 (2033)	189,990									189,990	924,403

[49] This column is identical to the last column of Table 7-11.
[50] An initial bridge loan to fund the project during construction (year 0) and the first two years of the new site's operation (years 1-3).
[51] The loan will be repaid at the end of year 3 and onwards with capital injection from an investor. To elaborate, 1/3 of the bridge loan (i.e. USD 252,711) will be repaid at the end of year 3, with the remaining 2/3 (i.e. USD 505,423) to be repaid in 10 equal annual instalments starting in year 4.

17 (2034)	114,990									114,990	1,039,393
18 (2035)	177,047									177,047	1,216,440
19 (2036)	143,168									143,168	1,359,608
20 (2037)	119,995									119,995	1,479,604
21 (2038)	98,101									98,101	1,577,705
22 (2039)	77,060									77,060	1,654,765
23 (2040)	36,523									36,523	1,691,287
24 (2041)	35,640									35,640	1,726,927
25 (2042)	-9,836									-9,836	1,717,091
26 (2043)	20,931									20,931	1,738,022
27 (2044)	15,236									15,236	1,753,257
28 (2045)	10,409									10,409	1,763,667

(b) The total NAMA[52]

The following table shows the cash flow model for the total NAMA with financing factors.

Table 7-13: Cash flow model for the total NAMA with financing factors.

Total $BNIP_k$										BCNU	BTN
Total investment costs A	O&M costs B	Income C	Subtotal D=C-A-B	Grants E	Funds contributed by equity investors F	Loans borrowed G	Loans repayment H	Interest payments I	Annual BNIP surplus / deficit J=D+E+F+G-H-I	Annual BCNU surplus / deficit L	Annual BTN surplus / deficit M=J+L
15,122,550	26,843,300	57,262,850	15,297,010	0	7,393,890	7,581,340	7,581,340	0	22,690,900	0	22,690,900

52 In the light of uncertainty as to when the full implementation will begin and the extent of synchronization of the large number of individual projects, no year-by-year breakdown is given for the total NAMA.

2. Estimated cost for tCO_2e of emission reduction

This would be easy to calculate when international support consisted of grants. But the planned financial structuring involves only loans, except for USD 150,000 for a feasibility study. However, counting all international loans as costs to be conservative, the cost tCO_2e of emission reduction is calculated as follows:

(USD 150,000 + USD 7,581,340) /3,075,180 tCO_2e[53]= USD 2.514 / tCO_2e

The funds to be provided by investors are not included in the calculation for two reasons.

- To avoid double-counting with the funds provided by the international supporter.
- The funds are provided only when the investment is considered economically viable.

8. NAMA Implementation Structure

8.1 Description of key operation bodies and implementing partners

At this point in time, the key operational body and implementing partner for the NAMA is The Ministry of Environment (MoEN), which is the ministry responsible both for NAMA and for waste management.

Contact information is as follows:

Commented [KT5]: Note to Moldova team: Please insert.

Name	
Title	
Role	
Responsibility	
Address	
Email	

The central coordination unit is to be finally decided after the international funds are approved. Assuming that the financial structure is accepted as is, one possibility for the central coordination unit will be organizations such as Moldovan Sustainable Energy Financing Facility (MoSEFF), which has experience in acting in a similar capacity for other initiatives with international funds.

Commented [KT6]: Note to Moldova team: This came up in our discussions. If you consider it premature to name anyone at this point in time, please feel free to delete.

Other important partners will be local municipalities who are expected to be the project owners and operators for at least the RP. Also, it will be necessary for the NAMA operational body to liaise closely with institutions such as EBRD and EIB who have supported feasibility studies for waste management projects in several waste management regions and who may extend credit for the upstream activities not covered by the NAMA intervention.

[53] Please refer to Table 4-4.

8.2 NAMA operational & management system

<To be further discussed.>

8.3 Phased implementation plan

In relation to risk mitigation discussed in Section 10, implementing the NAMA in three phases is planned. The table below summarizes objectives for each phase.

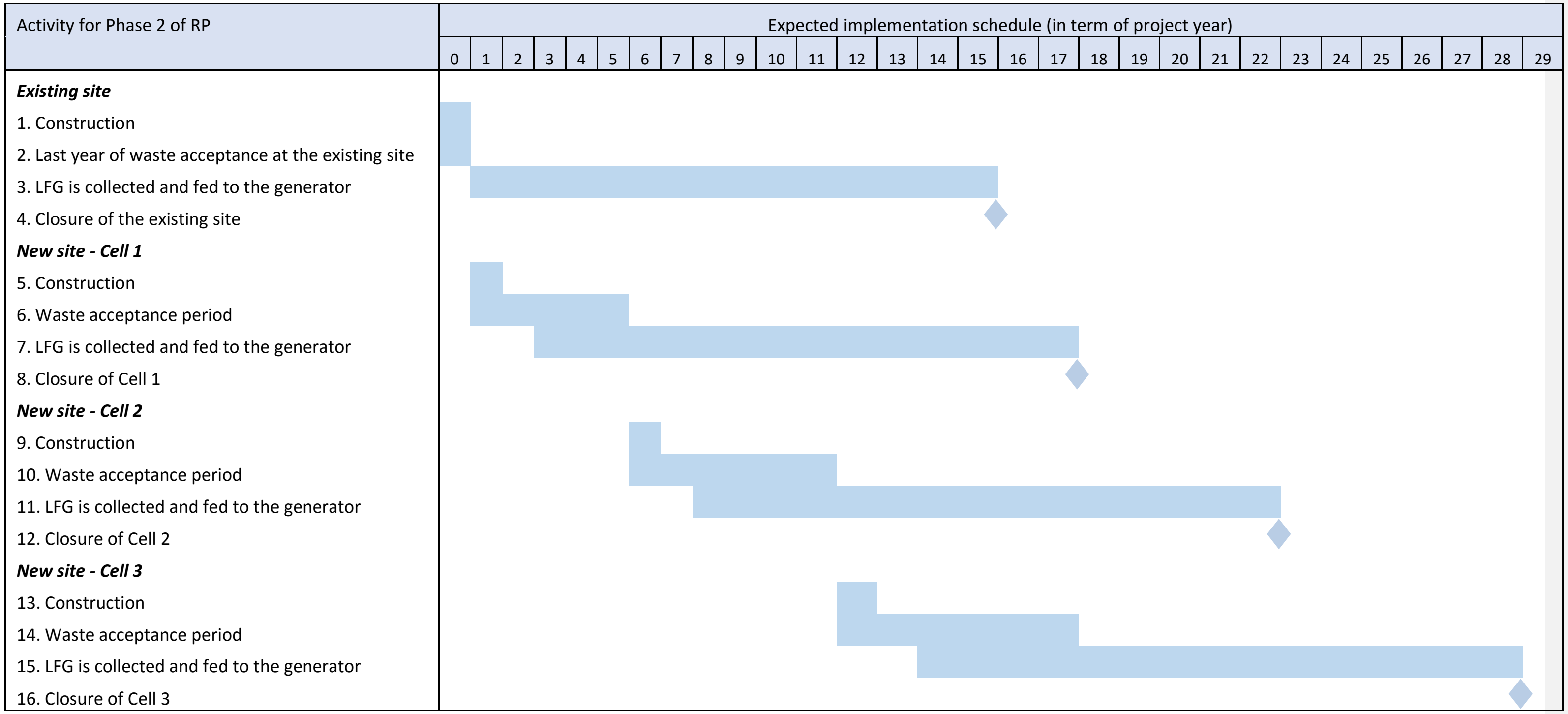
Table 8-1: Phased implementation plan of the NAMA.

Phase	To begin in	Characterization	Planned activities
1	As soon as possible	Feasibility study	▪ Conduct detailed costing estimation. ▪ Initiate discussion on the FiT with the regulator, ANRE on the basis of the above costing estimation.
2	2017	Implementation of the RP as a pilot project	▪ Check the accuracy of waste delivery projection. ▪ Confirm all equipment works properly, with the planned level of efficiency. ▪ Ascertain the actual costs incurred (investment as well as operating). ▪ Secure one FiT precedent for future similar projects. ▪ Ascertain the proper functioning of the flow of international funds in a timely and inexpensive manner.
3	To be decided	Full implementation, consisting of 9 further projects	

8.4 Implementation schedule

Owing to the lack of a definite implementation schedules for Phases 1 and 3 as stated in Section 8.3 above, a realistic Gantt chart cannot be produced for all the phases or for the entire NAMA. With this background, a Gantt chart is depicted for Phase 2 (i.e. the implementation of a pilot project) only.

Table 8-2: Gantt chart for Phase 2 of the RP.



9. Measuring, Reporting & Verification

The contemplated NAMA comprises multiple individual projects. Its measurement activities shall be carried out at each individual project site, considering complexity of the individual projects and that verification will be conducted on an individual project basis. Given this, establishing a robust MRV management and operational team for each individual project is crucial. The roles and responsibilities for relevant members of the MRV management and operational team are listed in Table 9-1.

Table 9-1: Roles and responsibilities of MRV management and operational team.

#	Tasks description	Operator(s)	Supervisor(s)	Plant manager
Measurement activity				
1	Recording of measured data	✓		
Quality Assurance & Quality Control				
2	Verification of data measured (consistency and completeness)		✓	
3	Ensuring adequate training of staff		✓	
4	Ensuring adequate maintenance		✓	
	Ensuring calibration of measurement instruments			✓
5	Data archiving: ensuring adequate storage of data measured (integrity and backup)		✓	
6	Identification of non-conformance and corrective/preventive actions and measurement plan improvement		✓	
7	Emergency procedures		✓	
Measurement report				
8	Preparation of measurement report (MRV report, SD report, etc.)		✓	
9	Management review of measurement report (internal audit)			✓
Reporting flow				
10	Reporting to	Supervisor(s)	Plant manager	NAMA implementer

In order to ensure the measurement activities are conducted appropriately at the individual project site, measures such as (a) extensive training/capacity building at the initial stage, (b) mandating submission of monthly (or regularly) measurement reports, and (c) regular on-site inspection shall be taken. This is under the oversight of MRV Aggregator, who is usually part of the NAMA central unit (NAMA implementer). The relationships between the project implementer and NAMA implementer are diagrammatically shown in Figure 9-1. This figure also presents the overall management structure of the NAMA that includes other interested parties, such as national government, international supporter(s), etc.

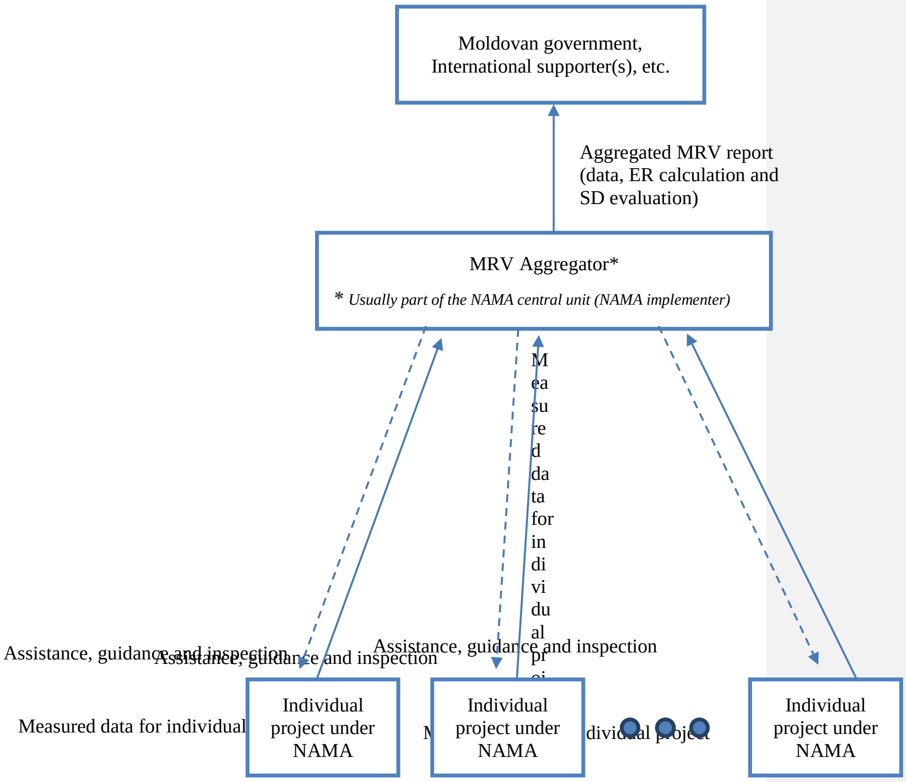


Figure 9-1: Overall reporting and management structure of the contemplated NAMA.

9.1 Measurement

9.1.1 Emission Reductions

The method for calculation of GHG ERs explained in Section 4.2 involves three categories of parameters.

Category 1: Parameters for which an authoritative default value relevant to the NAMA or an estimate by a reliable source is adopted;

Category 2: Parameters to be measured; and

Category 3: Parameters whose values are calculated based on Category 1 and Category 2 parameters.

Naturally, the MRV system focuses on Category 2 parameters. Nonetheless, parameters for all the three categories are listed below for the sake of providing a comprehensive picture.

Category 1:

- Model correction factor to account for model uncertainties (φ).
- Oxidation factor (***OX***).
- Weight fraction of the waste type *j* in the sample *n* collected during the year *x* ($p_{n,j,x}$).
- Fraction of methane captured at the SWDS and flared, combusted of used in another manner (***fy***).
- Global warming potential of methane (GWP_{CH4}).
- Fraction of degradable organic carbon that can decompose (DOC_f).
- Methane correction factor (***MCF***)
- Fraction of degradable organic carbon in the waste type *j* (DOC_j).
- Decay rate for the waste type *j* (K_j).
- Density of methane (ρ_{CH4}).
- Flare efficiency for open flare (η_{flare}).
- Emission factor for electricity generation ($EF_{EL,k,y}$).

Category 2:

- Total amount of waste disposed in a SWDS in year *x* (W_x).
- Landfill gas collected in year *y* ($LFG_{c,y}$).
- Landfill gas destroyed via method *I* in year *y* ($LFG_{i,y}$).
- Methane content in landfill gas in the year *y* ($w_{CH4,y}$).
- Temperature of the landfill gas at time *t* (T_t).
- Pressure of the landfill gas at time *t* (P_t).
- Electricity generation in year *y* (EG_y).
- Provision of electricity to the grid (EG_{grid}).
- Flame detection of flare in the minute *m* ($Flame_m$).

Category 3:

- Emission reduction in year *y* (ER_y).
- Baseline emissions in year *y* (BE_y).
- Baseline emissions of methane from the SWDS in year *y* ($BE_{CH4,y}$).
- Methane emissions occurring in year *y* generated from waste disposal at a SWDS during a time period ending in year *y* ($BE_{CH4,SWDS,y}$).
- Baseline emission associated with electricity generated (BE_{elec}).
- Project activity emissions in year *y* (PE_y).
- Methane emission through capture inefficiency in year *y* ($PE_{CH4\_uncollected}$).
- LFG methane collected but released into the atmosphere without being destroyed ($PE_{CH4\_uncombusted}$).

Figure 9-2: List of parameters to calculate GHG emission reductions *ex post*.

The measurement methods, frequency, and QA/QC procedures for each of Category 2 parameters are summarized in Table 9-2 to Table 9-10[54].

Table 9-2: Measurement procedures for parameter "W_x" (ID 1).

Data / Parameter:	***W_x***
Data unit:	T
Description:	Total amount of waste disposed in a SWDS in year *x*
Measurement procedures:	Measure on wet basis
Measuring frequency:	Continuously, aggregated at least annually for year *x*
QA/QC procedures:	The measuring equipment will be maintained and calibrated in accordance with manufacturer's recommendations or internationally accepted standards
Any comment:	-

Table 9-3: Measurement procedures for parameter "$LFG_{c,y}$" (ID 2).

Data / Parameter:	***$LFG_{c,y}$***
Data unit:	m^3
Description:	Landfill gas collected (recovered) in year *y*
Measurement procedures:	The amount of landfill gas recovered shall be monitored *ex post*, using continuous flow meters.
Measuring frequency:	Continuous flow measurement with accumulated volume recording (e.g. hourly/daily accumulated reading)
QA/QC procedures:	The measuring equipment will be maintained and calibrated in accordance with manufacturer's recommendations or internationally accepted standards
Any comment:	-

Table 9-4: Measurement procedures for parameter "$LFG_{i,y}$" (ID 3).

Data / Parameter:	***$LFG_{i,y}$***
Data unit:	m^3
Description:	Landfill gas destroyed via method *i* (combustion in a gas engine or flare) in year *y*
Measurement procedures:	The amount of landfill gas fuelled or flared shall be monitored *ex post*, using continuous flow meters. The measurement shall be carried out close to a location in the system where the landfill gas is utilized or destroyed.
Measuring frequency:	Continuous flow measurement with accumulated volume recording (e.g. hourly/daily accumulated reading)
QA/QC procedures:	The measuring equipment will be maintained and calibrated in accordance with manufacturer's recommendations or internationally accepted standards
Any comment:	$LFG_{i,y}$ for flare can be calculated as the difference between $LFG_{c,y}$ (ID3) and $LFG_{i,y}$ for gas engine.

[54] For clarity sake, the table format in Annex 6 is applied instead of the table format given in this PDD template.

Table 9-5: Measurement procedures for parameter "$W_{CH4,y}$" (ID 4).

Data / Parameter:	$w_{CH4,y}$
Data unit:	%, volume basis
Description:	Methane content in landfill gas in the year *y*
Measurement procedures:	This parameter will be measured using a continuous analyzer. This methane content measurement shall be carried out close to a location in the system where the landfill gas flow measurement takes places
Measuring frequency:	Continuously. Daily aggregated data will be used for emission reduction calculation.
QA/QC procedures:	The measuring equipment will be maintained and calibrated in accordance with manufacturer's recommendations or internationally accepted standards
Any comment:	-

Table 9-6: Measurement procedures for parameter "T_t" (ID 5).

Data / Parameter:	T_t
Data unit:	ºC
Description:	Temperature of the landfill gas at time *t*
Measurement procedures:	The temperature of the gas is required to determine the density of the methane combusted. If the landfill gas flow meter employed measures flow, pressure and temperature and displays or outputs the normalised flow of landfill gas, then there is no need for separate monitoring of pressure and temperature of the landfill gas. Otherwise, landfill gas temperature measurement shall be made close to where the gas flow is measured
Measuring frequency:	Shall be measured at the same time when methane content in landfill gas ($w_{CH4,y}$) is measured
QA/QC procedures:	The measuring equipment will be maintained and calibrated in accordance with manufacturer's recommendations or internationally accepted standards
Any comment:	-

Table 9-7: Measurement procedures for parameter "P_t" (ID 6).

Data / Parameter:	P_t
Data unit:	Pa
Description:	Pressure of the landfill gas at time *t*
Measurement procedures:	The pressure of the gas is required to determine the density of the methane combusted. If the landfill gas flow meter employed measures flow, pressure and temperature and displays or outputs the normalised flow of landfill gas, then there is no need for separate monitoring of pressure and temperature of the landfill gas. Otherwise, landfill gas pressure measurement shall be made close to where the gas flow is measured
Measuring frequency:	Shall be measured at the same time when methane content in landfill gas ($w_{CH4,y}$) is measured

QA/QC procedures:	The measuring equipment will be maintained and calibrated in accordance with manufacturer's recommendations or internationally accepted standards
Any comment:	-

Table 9-8: Measurement procedures for parameter "EG_y" (ID 7).

Data / Parameter:	EG_y
Data unit:	MWh
Description:	Electricity generation in year *y*
Measurement procedures:	Measured using electricity meter
Measuring frequency:	Continuously measured and recorded daily in a logbook or electronic log file
QA/QC procedures:	The measuring equipment will be maintained and calibrated in accordance with manufacturer's recommendations or internationally accepted standards
Any comment:	-

Table 9-9: Measurement procedures for parameter "EG_{grid}" (ID 8).

Data / Parameter:	EG_{grid}
Data unit:	MWh
Description:	Provision of electricity to the grid
Measurement procedures:	Measured using electricity meter
Measuring frequency:	Continuously measured and recorded daily in a logbook or electronic log file
QA/QC procedures:	The measuring equipment will be maintained and calibrated in accordance with manufacturer's recommendations or internationally accepted standards
Any comment:	-

Table 9-10: Measurement procedures for parameter "$Flame_m$" (ID 9).

Data / Parameter:	$Flame_m$
Data unit:	Flame on or Flame off
Description:	Flame detection of flare in the minute *m*
Measurement procedures:	Measure using a fixed installation optical flame detector: Ultra Violet detector or Infra Red or both
Measuring frequency:	Once per minute. Detection of flame recorded as a minute that the flame was on, otherwise recorded as a minute that the flame was off
QA/QC procedures:	The measuring equipment will be maintained and calibrated in accordance with manufacturer's recommendations or internationally accepted standards

Any comment:	In the case of open flares, the flare efficiency in the minute *m* ($\eta_{flare,m}$) is 50% when the flame is detected in the minute *m* ($Flame_m$), otherwise $\eta_{flare,m}$ is 0%[55]

Accurate data can be obtained only when measurement is conducted at the correct points. Figure 9-3 describes the measuring points of each parameter for the contemplated NAMA projects.

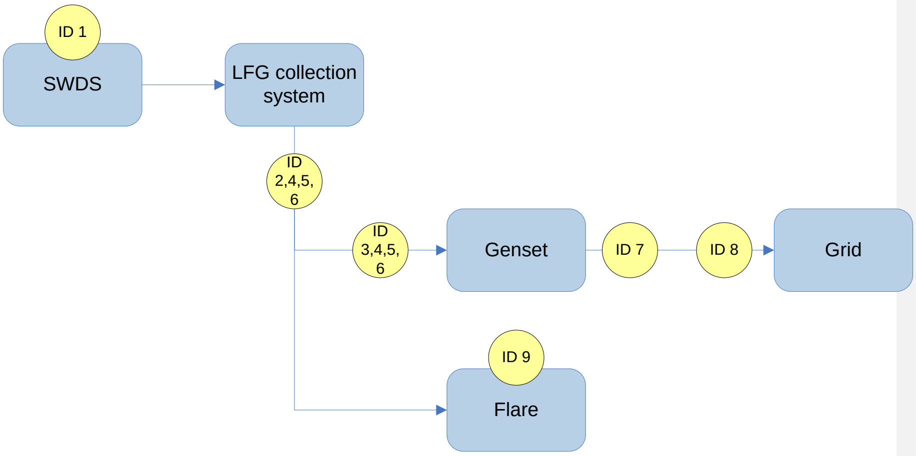


Figure 9-3: Line diagram with all relevant measurement points.

ID No.	Parameter	Nomenclature
ID 1	Total amount of waste disposed in a SWDS in year *y*	Wy
ID 2	Landfill gas collected (recovered) in year *y*	$LFG_{c,y}$
ID 3	Landfill gas destroyed via method *i* (combustion in a gas engine or flare) in year *y*	$LFG_{i,y}$
ID 4	Methane content in landfill gas in the year y	$w_{CH4,y}$
ID 5	Temperature of the landfill gas at time *t*	T_t
ID 6	Pressure of the landfill gas at time *t*	P_t
ID 7	Electricity generation in year *y*	EG_y
ID 8	Provision of electricity to the grid	EG_{grid}
ID 9	Flame detection of flare in the minute m	$Flame_m$

More detailed information on the MRV system in relation to emission reductions, including an illustrative example of a monitoring report, are provided in Annex 6.

[55] Methodological tool "Project emissions from flaring" (Version 02.0.0), https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v2.0.pdf

In addition, an *ex-post* calculation spreadsheet, which is designed to facilitate the NAMA implementer to conduct *ex-post* ERs calculation on their own, is attached to Annex 5. When the input sheet is filled in pursuant to measured values, the spreadsheet will automatically calculate *ex-post* values for (i) BAU emissions, (ii) emissions after project implementation, and (iii) emission reductions calculated as the difference between (i) and (ii). For details, please refer to Annex 5.

9.1.2 Sustainable Development

Methodology for measuring and determining SD impacts are provided in this section. Table 9-11 to Table 9-17[56] describe the MRV procedures for each parameter identified in Section 4.3 above, including how and when to conduct the measurement and the QA/QC procedures.

Table 9-11: MRV procedures for parameter "Odour".

Serial number 1		
Indicator name	Air pollution/quality	
Domain	Environment	
Parameter name	Odour	
Baseline value	0 (tCH_4)	
Way of monitoring	How	This parameter will be measured indirectly by monitoring the quantity of methane (CH_4) collected and destructed by the intervention using an appropriate meter(s).
	Frequency	Once in 3 years[57]
	By whom	Project implementer
Project value	96[58] (tCH_4)	
QA/QC procedures	The measuring equipment will be maintained and calibrated in accordance with manufacturer's recommendations, internationally accepted standards, or local practices.	
	QC check done	NAMA implementer

Table 9-12: MRV procedures for parameter "Mitigation – Number of ERs accumulated".

Serial number 2		
Indicator name	Climate change adaptation and mitigation	
Domain	Environment	
Parameter name	Mitigation – Number of ERs accumulated	
Baseline value	0 (tCO_2e)	
Way of monitoring	How	This parameter will be calculated based on the measured data recorded in a report namely "Estimation of Emission Reductions for a Waste to Energy (WTE) NAMA in Republic of Moldova".
	Frequency	Once in 3 years
	By whom	Project implementer

[56] For clarity sake, the table format in Annex 6 is applied instead of the table format given in this PDD template.
[57] The NAMA SD Tool stipulates the monitoring frequency for all the parameters fixed at 3 years, except that the first SD evaluation must be submitted at the end of year 1. This set monitoring frequency applies to all selected parameters of the WTE NAMA.
[58] For illustrative purposes, this is the assumed quantity of methane collected and destructed by the intervention at the end of year 1.

Project value	2,300[59] (tCO_2e)	
QA/QC procedures	-	
	QC check done	-

Table 9-13: MRV procedures for parameter "Skill level (number of training sessions)".

Serial number 3		
Indicator name	Quality of employment	
Domain	Social	
Parameter name	Skill level (number of training sessions)	
Baseline value	0	
Way of monitoring	How	This parameter will be measured by means of the number of training sessions provided to the employees.
	Frequency	Once in 3 years
	By whom	Project implementer
Project value	1[60]	
QA/QC procedures	This will be cross-checked against the training materials provided and/or training attendance records.	
	QC check done	NAMA implementer

Table 9-14: MRV procedures for parameter "Quantity of net electricity supplied by the project to the grid ($EG_{P,y}$)".

Serial number 4		
Indicator name	Access to clean and sustainable energy	
Domain	Growth and development	
Parameter name	Quantity of net electricity supplied by the project to the grid ($EG_{P,y}$)	
Baseline value	0 (MWh)	
Way of monitoring	How	This parameter will be measured by an electricity meter(s).
	Frequency	Once in 3 years
	By whom	Project implementer
Project value	385[61] (MWh)	
QA/QC procedures	The measuring equipment will be maintained and calibrated in accordance with manufacturer's recommendations, internationally accepted standards, or local practices.	
	QC check done	NAMA implementer

Table 9-15: MRV procedures for parameter "Remuneration paid to employees (income generation)".

Serial number 5

59 For illustrative purposes, this is the assumed number of ERs accumulated by the intervention at the end of year 1.
60 It is assumed that a training session is provided once per year.
61 For illustrative purposes, this is the assumed quantity of net electricity supplied by the project to the grid at the end of year 1.

Indicator name	Income generation/ expenditure reduction/ balance of payments	
Domain	Economic	
Parameter name	Remuneration paid to employees (income generation)	
Baseline value	0 (USD)	
Way of monitoring	How	The remuneration paid to employees will be measured.
	Frequency	Once in 3 years
	By whom	Project implementer
Project value	13,200[62] (USD)	
QA/QC procedures	This will be cross-checked against the remuneration receipts/records.	
	QC check done	NAMA implementer

Table 9-16: MRV procedures for parameter "Number of jobs created during construction and operation phases".

Serial number 6		
Indicator name	Job creation (number of men and women employed)	
Domain	Economic	
Parameter name	Number of jobs created during construction and operation phases	
Baseline value	0	
Way of monitoring	How	The number of jobs created during construction (i.e. temporary basis) and operation (i.e. permanent basis) phases will be measured.
	Frequency	Once in 3 years
	By whom	Project implementer
Project value	28[63]	
QA/QC procedures	This will be cross-checked against the remuneration receipts/records.	
	QC check done	NAMA implementer

Table 9-17: MRV procedures for parameter "Implementation, processes and compliance with the SD tool".

Serial number 7		
Indicator name	Law and regulation	
Domain	Institutional	
Parameter name	Implementation, processes and compliance with the SD tool	
Baseline value	0	
Way of monitoring	How	This parameter will be measured by means of the punctual reporting of SD for the intervention as stipulated in the NAMA SD Tool, i.e. once in every 3 years.
	Frequency	Once in 3 years
	By whom	Project implementer

[62] For illustrative purposes, it is assumed that the total remuneration paid to employees is USD 13,200, of which USD 10,000 is for the construction workers (i.e. 20 temporary workers with USD 500 each) and USD 3,200 is for the permanent employees at the first year of the operation phase (i.e. 6 operators with USD 350 each + 1 supervisor with USD 500 + 1 plant manager with USD 600).
[63] For illustrative purposes, it is assumed that the project creates 20 temporary jobs during construction phase and 8 permanent jobs (i.e. 6 operators in three shifts + 1 supervisor + 1 plant manager) during operation phase.

Project value	1[64]	
QA/QC procedures	This will be cross-checked against the NAMA SD reporting records.	
	QC check done	NAMA implementer

In the absence of a feasibly study for the WTE NAMA under consideration, hypothetical baseline values, which are summarized in the above tables, are applied for illustrative purposes only. These values are subject to change based on input from the Moldova country team.

As delineated in Section 4.3, the project value of each parameter for an individual project will be determined *ex-post* after the project implementation. For illustrative purposes, assumed project values, which are listed in Table 9-11 to Table 9-17 above with explanations, are applied for the SD evaluation of an individual project.

By inputting the baseline value (in column 6 of Table 9-18 below), the target value estimated (ex-ante) (column 7) and the project value (i.e. intervention value monitored (ex-post) in column 8) of each identified parameter into the spreadsheet of the NAMA SD Tool, both of the (ex-ante) estimated Nationally Appropriate Improvements (NAIs) and the (ex-post) monitored NAIs are automatically calculated and shown in the same spreadsheet, as reproduced in columns 10 and 11 of Table 9-18 respectively. In addition, the Project Success can also be determined automatically by the same spreadsheet (in column 12 of Table 9-18) based on the results of estimated NAIs and monitored NAIs.

[64] It is assumed that the first SD evaluation was conducted at the end of year 1, in line with the NAMA SD Tool guidance outlined in footnote 57.

Table 9-18: Summary of SD evaluation at an individual project level.

1	2	3			4	5	6	7	8	9	10	11	12
Domain	Indicator	Parameter Selection			Measurement value[65]	Measure ment type	Baseline Value	Target value estimated (ex-ante)	Intervention Value monitored (ex-post)[66]	Unit	NAIs estimated (ex-ante)	NAIs monitored (ex-post)	Evaluation of Project Success
		Number of parameters selected per indicator	Parameter name	Effect									
Environment	Air pollution/ quality	1	Odour	+	This parameter is measured by means of the quantity of methane (CH_4) collected and destructed by the intervention using an appropriate meter(s)	Direct	0	101	96	tCH_4	1.00	0.95	95%
	Climate Change adaptation & Mitigation	1	Mitigation - Number of ERs accumulated	+	This parameter is calculated based on the measured data recorded in a report namely "Estimation of Emission Reductions for a Waste to Energy (WTE) NAMA in Republic of Moldova".	Indirect	0	2,454	2,300	tCO_2e	1.00	0.94	94%
Social	Quality of employment	1	Skill level (number of training sessions)	+	Number of training sessions provided to employees as per records	Direct	0	1	1	Number	1.00	1.00	100%
Growth and Development	Access to clean and sustainable energy	1	Quantity of net electricity supplied by the project to the grid ($EG_{P,y}$)	+	This parameter is measured by an electricity meter(s)	Direct	0	411	385	MWh	1.00	0.94	94%
Economic	Income generation/ expenditure reduction/	1	Remuneration paid to employees (income generation)	+	Remuneration paid to employees (income generation) as per records	Direct	0	14,200	13,200	USD	1.00	0.93	93%

[65] This column was prepared in accordance with the guidance provided in NAMA SD Tool (Line 36 of "Instructions" tab) reproduced below:
"For the parameter identified, please indicate the measurement value in column G (for example whether it will be measured via a literature value or through a survey, etc.). Intervention implementer can define the best possible way of measurement."
[66] This is equivalent to the project value mentioned in the text.

	Balance of payments												
	Job Creation (number of men and women employed)	1	Number of jobs provided during construction and operation phases	+	Number of jobs provided during construction and operation phases as per records	Direct	0	30	28	Number	1.00	0.93	93%
Institutional	Law and regulation	1	Implementation, Processes and Compliance with the SD tool	+	This parameter is measured by means of the punctual reporting of SD for the intervention as per the NAMA SD Tool, i.e. once in every 3 years.	Direct	0	1	1	Number	1.00	1.00	100%

Based on the monitored NAIs and project success results derived in columns 11 and 12 of Table 9-18, the mean value of them are determined for each domain and the overall ambition and success of the NAMA (at an individual project level) can then be calculated as the mean value over all domains, as summarized in Table 9-19[67].

Table 9-19: The overall ambition and success of the NAMA (at an individual project level).

Domain	Indicator	NAIs monitored (ex-post)	Mean value of NAIs monitored (ex-post)	Evaluation of Project Success	Mean value of evaluation of Project Success
Environment	Air pollution/ quality	0.95	0.94	95%	94%
	Climate Change adaptation & Mitigation	0.94		94%	
Social	Quality of employment	1.00	1.00	100%	100%
Growth and Development	Access to clean and sustainable energy	0.94	0.94	94%	94%
Economic	Income generation/ expenditure reduction/ Balance of payments	0.93	0.93	93%	93%
	Job Creation (number of men and women employed)	0.93		93%	
Institutional	Law and regulation	1.00	1.00	100%	100%
Mean value over all domains		-	**0.96**	-	**96%**

9.1.3 Support

<To be completed.>

9.1.4 Transformative Change

<To be completed.>

9.2 Reporting

"Reporting" in the context of a MRV system is commonly defined as "presenting the measured information in a transparent and standardised manner"[68].

While this seems straightforward, it actually involves a management issue for the contemplated NAMA due to the coexistence of two factors. One is that the only practical approach to measurement with respect to the contemplated NAMA is to have it carried out for

[67] It is noted that this table was prepared according to the instructions of NAMA SD Tool (Line 61 of "Introduction" tab), reproduced below:
"Determination of NAMA ambition and NAMA success with Nationally Appropriate Improvements (NAIs):
NAIs are calculated for each intervention, the mean value is determined for each domain, and the overall ambition and success of the NAMA calculated as the mean value over all domains."

[68] http://namapipeline.org/Publications/Guidance_for_NAMA_Design_2013_.pdf (p53)

each individual project. The other factor is the fact that "reporting" will not be complete without the calculations of ERs or Project Success based on the measured data.

Given this, information on the process and plan for reporting of GHG mitigation and SD benefits are outlined below.

1. GHG mitigation

Two-tier reporting approach is recommended as follows:

Tier 1: Have each individual project implementer conducted measurement outlined in Section 9.1.1.

Tier 2: Let each individual project implementer relay the measured data to the NAMA central unit (or the NAMA implementer) that will perform ER calculation, with the assistance of an outside expert if necessary.

2. SD benefits

Two-tier reporting approach is recommended as follows:

Tier 1: Have each individual project implementer conducted not only measurement but also SD evaluation based on the measured data using the spreadsheet of NAMA SD Tool.

Tier 2: Let each individual project implementer relay its SD evaluation results together with the measured data to the NAMA central unit (or the NAMA implementer) that will provide an overview of the SD evaluation at a NAMA level, with the assistance of an outside expert if necessary.

The reporting flows at an individual project level and at a NAMA level are presented in Table 9-1 and Figure 9-1 respectively.

For the reporting contents of the GHG mitigation and SD benefits, please refer to Appendix C-1 of Annex 6 and the sample SD excel spreadsheet respectively.

For the reporting frequency and the QA/QC processes of the GHG mitigation and SD benefits, please refer to Sections 9.1.1 and 9.1.2 respectively.

9.3 Verification & Evaluation

With there being no rule for NAMA verification, the decision on how exact the verification process for a particular NAMA should be is left to the NAMA implementer, host country government, international supporter(s) and other relevant parties.

At the most rigorous end of the spectrum is verification by an independent third-party authorized by an international organization, typically designated operational entities (DOEs) accredited for verification of CDM project activities. The MRV system outlined in this PDD is designed to pass the verification by a DOE, complying with the CDM modalities most of the time with justifiable deviations from them when appropriate.

As discussed above, the practical approach to measurement with respect to the contemplated NAMA is to have it carried out for each individual project due to the complexity of the individual projects. As such, verification is planned to be conducted on an individual project basis.

The verifying frequency as well as the reporting content are also at the discretion of NAMA implementer, host country government, international supporter(s) and/or other relevant parties. It is however advised that the verifying frequency of SD benefits shall follow the measurement frequency suggested by NAMA SD Tool (i.e. the first SD evaluation must be submitted at the end of year 1, with the subsequent evaluations to be conducted once in every 3 years thereafter), whereas that of GHG mitigation may follow the same verifying pattern as SD benefits or may be set as once a year.

As part of the quality control processes, both of the MRV reports (quoted in Section 9.2) and the verification and evaluation reports (prepared by a verifier or DOE based on a desk review of MRV reports and/or on-site visit) for each individual project and the aggregated report/summary for the contemplated NAMA (prepared by MRV aggregator) shall be reviewed by interested parties, such as the project implementer, NAMA implementer, Moldovan government, international supporter(s), etc.

Under this verification and evaluation arrangement, not only the performance of each individual project, in turn the NAMA, can be tracked, but also the outcomes of GHG mitigation and SD benefits can be quantified.

10. Risk Management

This section identifies the risks the proposed NAMA involves before discussing possible mitigation measures for them.

1. Types of risk of the NAMA

The risks associated with the NAMA under consideration can be broadly classified into three categories.

Category 1: A risk particular to this NAMA;

Category 2: Risks common to all project undertakings; and

Category 3: A type of risk that, albeit less significant for this NAMA than for some WTE NAMAs, still entails careful attention.

Each category is elaborated in reverse order below.

Category 3: A type of risk that, though less significant for this NAMA than for some other WTE NAMAs, still entails careful attention

For the proposed NAMA, technology risk belongs to this category. LFG collection and utilization adopted for the NAMA is a proven technology, functioning well in a great many countries in the world. It is different from newer WTE technologies (such as anaerobic digestion and gasification) which, albeit successful in some countries, cannot claim to have been universally established.

In this sense, the NAMA's technology risk *per se* is limited. Nonetheless, there is a need to be prepared against potential site- specific problems. For example, it is possible that a particular component in the waste delivered to the site causes clogging of the pipes or precipitation pattern at a site has a detrimental effect on the normal functioning of the LFG collection system.

Please note that underperformance issues are discussed in the next section.

Category 2: Risks common to all project undertakings

For this category, three factors most pertinent to the proposed NAMA are highlighted.

Underperformance

This issue, common to all project undertakings, is of particular relevance to the NAMA under consideration, due to the model dependency of the future LFG generation estimation. While the employed model is authoritative and widely used, it is yet to be seen how it fits the specific climatic condition at the planned sites.

An added concern is the amounts of waste and its composition. This is discussed fully in the section on Category 1 risk below.

Cost overrun

In the absence of a specific feasibility study, the present financial analyses have relied on the combination of generic information and data for similar projects Asiatica is familiar with. Considering that the cost of LFG collections systems is highly dependent on the specific circumstances at a particular site, there currently exists uncertainty as to the cost projections.

Revenue shortfall

Revenues for the NAMA projects are dictated by the FiT granted to them. Having extensively discussed the tariff used in the financial analysis, the Moldova team and Asiatica believe that the assumed tariff level (USD 113/MWh) is reasonable. Nonetheless, this is without a confirmation at this time.

Category 1: A risk particular to this NAMA

Most LFG collection and utilization projects are conducted at a well-established site with a proven track record of waste delivery, where future waste volume and composition can be accurately projected on the basis of historical data or by conducting a measurement campaign. In contrast, the vast majority of the LFG that will be utilized by the NAMA projects is generated from a new site to be started as part of Moldova’s effort to improve, with the assistance of an international partner, the quality of waste management in the country.

Until a track record is established, investors could not be blamed for being hesitant.

2. Risk mitigation measures

The most effective way to mitigate the risks enumerated above is to adopt a phased-out implementation plan and proceed with the following three phases.

Phase 1: Detailed feasibility study → This will reduce, though not eliminate, the cost overrun risk. To save time, it is recommended to conceive this phase as the first component of Phase 2.

Phase 2: Implementing the RP that will also serve as the pilot project → The success of the pilot project will significantly lower the risk levels for all the items listed above, for subsequent projects in the NAMA.

Phase 3: Implementing the remaining nine RP-equivalent projects

As regards environmental and social risk, it is believed that the NAMA intervention itself will pose overwhelmingly positive effects.

11. Conclusion

The proposed NAMA has four distinct advantages. It will:

1. Achieve GHG mitigation at a low cost (conservatively estimated to be USD 2.5 / tCO_2e reduction), while delivering a substantial amount of GHG reduction (3,075,178 tCO_2e) throughout the lifetime of the NAMA;

2. Offer significant SD benefits; and

3. Set a good precedent for entities other than the central government to invest in climate change mitigation projects and be instrumental in achieving transformational change.

4. The risks it involves can be controlled by phased implementation. For the first two phases – a feasibility study and the implementation of a pilot project, the amount of international support is limited to less than USD 1 million (USD 150,000 for a feasibility study and USD 758,134 for the pilot project, totalling USD 908,134).

It is recommended to move forward expeditiously with the NAMA and seek international support for the first two phases, in anticipation of full implementation later.

References

Harvard style of referencing should be used along with the Word Citation function (under "References" and "Citations & Bibliography").

Guidance on the Harvard style can be found here http://libweb.anglia.ac.uk/referencing/harvard.htm

<To be completed.>

Annex 1: NAMA Measures & Interventions and their Outputs, Activities, and Inputs

NAMA Measures & Interventions and their Outputs, Activities, and Inputs		
Measure & Intervention Outcome – A :		
Outputs	Activities	Inputs (Technology, Capacity Building, Finance, Other)
1.a. Confirmation of the site specific technical feasibility of the representative project (RP) serving as the pilot project; 1.b. Detailed and site specific cost estimates for the RP	1.1 A full technical feasibility study	1.1.1 Funding for the feasibility study
Measure & Intervention Outcome – B :		
Outputs	Activities	Inputs (Technology, Capacity Building, Finance, Other)
1. Pilot project implementation report	1.1 Implementation of the RP serving as the pilot project	1.1.1 Funding for the pilot project
2 Confirmation that attracting investment from the private sector (including municipalities) is possible.	1.2 Analysis of the results of the pilot project and assessment of their implications for the implementation of the NAMA	1.1.2 Capacity building for MRV
3 ER and SD benefits assuming that the pilot project is successful	1.3 Based on the outcome of the pilot study implementation, revision, if necessary, of the NAMA plans	
Measure & Intervention Outcome – C :		
Outputs	Activities	Inputs (Technology, Capacity Building, Finance, Other)
1. Project implementation (or MRV) reports for 9 further projects	1.1 Implementation of the 9 further projects	1.1.1 Funding for the 9 further projects

2. Aggregated MRV report for the NAMA, including monitored data, ER calculation and SD evaluation	1.2 Analysis of the results of each implemented project and aggregation of the analysed results	1.1.2 Capacity building for MRV
3. Verification and evaluation reports (to be prepared by a verifier based on a desk review of the MRV report and/or on-site visit) for each implemented project or the NAMA	1.3 Verification and evaluation process taken for each implemented project	

Annex 2: Identified Risks and Risk Mitigation Options

Identified Risks and Risk Mitigation Options		
Risk A : [LOW, MEDIUM, or HIGH] *description for the risk in terms of category, level of impact on the NAMA, and probability. As well explain qualitative evaluation.*		
Measure & Outcome Impacted	**Proposed and Planned Risk Mitigation Measures**	**Proposed and Planned Means to Track the Risk**
xxx	xxxx	xxxx
Risk B : [LOW, MEDIUM, or HIGH]		
Measure & Outcome Impacted	**Proposed and Planned Risk Mitigation Measures**	**Proposed and Planned Means to Track the Risk**
xxx	xxx	xxx
Risk C : [LOW, MEDIUM, or HIGH]		
Measure & Outcome Impacted	**Proposed and Planned Risk Mitigation Measures**	**Proposed and Planned Means to Track the Risk**
xxx	xxx	xxx

Annex 3: Stakeholder consultations during the design phase

List of relevant stakeholder consultations		
Dates and consultation topic	Relevant stakeholders attending	Brief summary of consultation and outcomes.
16/03/2015 Project parameters	Ms. Tamara, MoEN	Confirmation of main project parameters.
15 - 18/03/2015 Energy parameters	Dr. Ion Comendant, Mr. Andrei	Discussion on renewable energy laws, tariff calculation mechanisms, regulations relating to use of distribution grid, project boundary, baseline scenarios
18 - 22/03/2015	Mr. Vasile Scorpan, Dr. Ion Comendant, Mr. Sergiu Ungureanu	Confirmation of financial structure

Commented [KT7]: Note to Moldova team: I didn't obtain her last name.

Annex 4: Financial analyses for a waste to energy (WTE) NAMA in Republic of Moldova

<Please refer to the separate file attached to the PDD.>

Annex 5: Estimation of emission reductions for a waste to energy (WTE) NAMA in Republic of Moldova

<Please refer to the separate file attached to the PDD.>

Annex 6: Outline of MRV system for a waste to energy (WTE) NAMA in Republic of Moldova

<Please refer to the separate file attached to the PDD.>