Empowered lives.
Resilient nations.

Ministerul Mediului

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

Chisinau • December 2016

Contact Information
Climate Change Office, Ministry of Environment / clima@clima.md
Silvia Pana-Carp, United Nations Development Programme (UNDP), Programme Analyst, Sustainable Development Cluster / silvia.pana-carp@undp.org

Technical Oversight and Guidance
Dr. Vasile Scorpan, Senior Project Manager, Project UNDP "Moldova LECBP", Climate Change Office of Ministry of Environment
Sergiu Ungureanu, Manager, Project " Moldova LECBP"

Authors
Carbon Partners Asiatica Co., Ltd; Tatiana Tugui, National Consultant

Contributors
Dr. Ion Comendant, National consultants

Acknowledgements
We would like to acknowledge the following stakeholders for their participation in the NAMA process: Ministry of Environment; Ministry of Economy; Energy Efficiency Agency; Moldova Technical University; Institute of Power Engineering ASM; "Termoelectrica" S.A.
Special thanks to James Vener, Technical Specialist, LECBP Climate Change & Disaster Risk Reduction, Bureau for Policy and Programme Support, UNDP for valuable comments and recommendations on NAMA design document improvement

Disclaimer: The views expressed in this publication are those of the author(s) and do not necessarily express the views of the United Nations Development Programme or its Executive Board.

FORWARD

The UNDP Low Emission Capacity Building (LECB) Programme is a country-driven initiative that promotes essential cooperation between relevant institutions, engaging the public sector and industry in a concerted effort to design and implement approaches to low emission development that are consistent with national development priorities. National counterparts are supported to strengthen technical and institutional capacities to identify and formulate Nationally Appropriate Mitigation Actions (NAMAs) and Low Emission Development Strategies (LEDS) in the public and private sectors, and to strengthen the underlying greenhouse gas inventory management and Measurement, Reporting and Verification (MRV) systems.

The LECB Programme runs through 2016 and is active in 25 countries: Argentina, Bhutan, Chile, China, Colombia, Costa Rica, the Democratic Republic of Congo (DRC), Ecuador, Egypt, Ghana, Indonesia, Kenya, Lebanon, Malaysia, Mexico, Moldova, Morocco, Peru, Philippines, Tanzania, Thailand, Trinidad and Tobago, Uganda, Vietnam and Zambia.

The programme is supported through generous contributions from the European Commission, the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), and the Government of Australia.

More information can be found at www.lowemissiondevelopment.org

Contents

List of Boxes ..... *Error! Bookmark not defined.*

List of Figures ***6***

List of Tables ***6***

Executive Summary ***8***

Abbreviations and Acronyms ***10***

1. Introduction to a waste to energy NAMA ***11***

2. Background of the waste sector in the Republic of Moldova ***13***

2.1 Current situation and trends of the Sector **13**

2.2 Relevant Stakeholders **16**

2.3 Purpose and Objectives of the NAMA **17**

3. Policy Analysis ***19***

3.1 Relevant National and Sector Strategies and Policies **19**

3.2 Alignment with National and Sector Strategies and Policies **20**

4. Baseline Information and NAMA Targets ***22***

4.1 Baseline boundary and scenario **22**

4.2 GHG baseline and mitigation targets **25**

4.2.1 Calculation for collection of LFG and the destruction of the methane contained within the LFG (Element 1) 25

4.2.2 Calculation for RE electricity generation (Element 2) 29

4.2.3 Totals for baseline and project emissions 30

4.2.4 Baseline and mitigation target for the RP 31

4.2.5 Baseline and mitigation target for the NAMA 32

4.3 SD baseline and co-benefit targets **32**

4.4 Transformational Change **34**

5. Measures & Interventions under the NAMA ***36***

5.1 Representative project **36**

5.2 Replication **37**

5.3 Total NAMA **37**

5.4 Gap and barrier analyses and identification of measures **38**

5.5 Further details about RP **38**

6. Capacity Development ***48***

7. NAMA Financial Requirements and Mechanisms ***50***

7.1 National and International Finance: Sources and Distribution Mechanisms **54**

7.2 National finance sources **54**

7.3 Financial distribution mechanisms **54**

7.4 Indicative NAMA financing needs 55

7.5 Budgeting and cash flow modelling 61

7.5.1 Budget for the RP without financing factors 61

7.5.2 Budget for the Central NAMA Unit (BCNU) 73

7.5.3 Cash flow modelling and analysis 73

8. NAMA Implementation Structure 75

8.1 Phased implementation plan 76

8.2 Implementation schedule 77

9. Measuring, Reporting & Verification 79

9.1 Measurement 80

9.1.1 Emission Reductions 80

9.1.2 Sustainable Development 86

9.1.3 Support 92

9.1.4 This will be gauged by the amounts of public sector financial assistance provided in response the financial needs identified in Section 7.4.Transformative Change 92

9.2 Reporting 92

9.3 Verification & Evaluation 93

10. Risk Management 95

11. Conclusion 98

References 99

Annex 1: NAMA Measures & Interventions and their Outputs, Activities, and Inputs 100

Annex 2: Identified Risks and Risk Mitigation Options 102

Annex 3: Stakeholder consultations during the design phase 104

List of Figures

Figure 4-1: Diagrammatic representation of the BAU and NAMA scenarios.
Figure 9-1: Overall reporting and management structure of the NAMA.
Figure 9-2: List of parameters to calculate GHG emission reductions *ex post.*
Figure 9-3: Line diagram with all relevant measurement points.

List of Tables

Table 1-1: SWDS parameters of the **RP.**
Table 4-1: Identification of the most plausible baseline scenario option for the destruction of LFG (Element 1).
Table 4-2: Identification of the most plausible baseline scenario option for the use of LFG for electricity generation (Element 2).
Table 4-3: A summary of the expected GHG mitigation targets to be achieved by the RP.
Table 4-4: A summary of the expected GHG mitigation targets to be achieved by the NAMA.
Table 4-5: List of SD domains and performance indicators selected for the NAMA.
Table 4-6: Selection of a parameter for each chosen indicator for the WTE NAMA.
Table 5-2: SWDS parameters of the **RP.**
Table 5-3: Waste composition.

Table 5-4: Annual quantity and density of the disposal **waste.**
Table 5-5: Amounts of methane collection **(ex ante estimation).**

Table 5-6: Amounts of annual gross electricity **generation.**
Table 5-7: Amounts of internal power consumption and annual net electricity generation.
Table 7-9: Total investment costs of the LFG C&F systems for the RP.
Table 7-10: Total costs of the power generation facility for the RP.
Table 7-11: Total initial investment costs of the RP. **Unit: USD**
Error! Reference source not found.
Table 7-12: Total O&M costs for the RP. **Unit: USD**
Error! Reference source not found.
Table 7-14: Key budgeting parameters for the RP.
Table 7-15: Core Budget (i.e. without financing factors) for the RP.
Unit: USD
Table 7-16: Cash flow model for the RP without financing factors.
Table 7-3: Summary of national and international financial sources.
Error! Reference source not found.
Table 7-4: Cash flow model for the RP with financing factors.
Table 7-5: Cash flow model for the total NAMA with financing factors.
Table 8-1: Phased implementation plan of the NAMA.
Table 8-2: Gantt chart for Phases 1 and 2 of **the NAMA**
Table 9-1: Roles and responsibilities of MRV management and operational team.
Table 9-2: Measurement procedures for parameter "Wx" (ID 1).
Table 9-3: Measurement procedures for parameter "$LFGc_{,y}$" (ID 2).
Table 9-4: Measurement procedures for parameter "$LFGi_{,y}$" (ID 3).
Table 9-5: Measurement procedures for parameter "WCH4,y" (ID 4).
Table 9-6: Measurement procedures for parameter "Tt" (ID 5).
Table 9-7: Measurement procedures for parameter "Pt" (ID 6).
Table 9-8: Measurement procedures for parameter "EGy" (ID 7).
Table 9-9: Measurement procedures for parameter "EGgrid" (ID 8).
Table 9-10: Measurement procedures for parameter "Flamem" (ID 9).
Table 9-11: MRV procedures for parameter "Odour".
Table 9-12: MRV procedures for parameter "Mitigation – Number of ERs accumulated".
Table 9-13: MRV procedures for parameter "Skill level (number of training sessions)".
Table 9-14: MRV procedures for parameter "Quantity of net electricity supplied by the project to the grid ($EGP_{,y}$)".
Table 9-15: MRV procedures for parameter "Remuneration paid to employees (income generation)".
Table 9-16: MRV procedures for parameter "Number of jobs created during construction and operation phases".
Table 9-17: MRV procedures for parameter "Implementation, processes and compliance with the SD tool".
Table 9-18: Summary of SD evaluation at an individual project level.
Table 9-19: The overall ambition and success of the NAMA (at an individual project level).

Executive Summary

This Project Design Document (PDD) is prepared for a waste to energy (WTE) NAMA in Moldova, which is expected to be implemented in phases. The data for its technical details are mainly based on a feasibility study carried out by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) for waste management zone 3 (WMZ 3) in southern Moldova. Besides the initial WTE facility that is analyzed in detail in this document, the NAMA expects replicability for up to nine (9) similar projects, bringing the total to ten (10).

1. Background

   According to Moldova's National Inventory Report 1990-2010, the waste sector accounted for 11.9% of the country's greenhouse gas (GHG) emissions in 2010, with estimated emissions of 1,578,304 tCO_2e. The waste sector was the third largest national source of emissions after the energy and agriculture sectors. The bulk of the sector's emissions came from solid waste.

   From a public services viewpoint, increased attention is being paid to improve overall municipal waste management, with the Moldovan government recognizing the need for improvement of the entire system, including the collection, transfer, treatment and disposal of waste in regional landfills and closure of existing dumpsites. The effort to improve the system has been supported by numerous international agencies with GIZ, European Investment Bank (EIB) and Czech Development Agency (CDA) funding feasibility studies for all eight (8) waste management regions of the country. The NAMA's WTE facilities will be installed at the solid waste disposal sites (SWDS) that reflect these efforts, though the scope of the NAMA does not include improvement of waste management public services per se.

   Against this background, the WTE NAMA has been selected by the Moldovan government as one of four (4) NAMAs to be put forward for international support.

2. WTE NAMA

   The NAMA, to take place in SWDS, involves installation of systems of equipment to achieve two elements in relation to GHG mitigation:

   Element 1: Collection of landfill gas (LFG) and destruction of the methane contained in it; and
   Element 2: Use of the collected LFG for renewable electricity generation without reliance on fossil fuel.

   The investment cost of each individual intervention is estimated as USD 1,502,798, and USD 15,027,976 for the full NAMA. At full deployment with 4 MW installed capacity, the NAMA will achieve GHG emission reduction of an annual average of 109,262 tCO_2e (a total of 3,387,114 tCO_2e during the NAMA's lifetime), and serve 492,500 tonnes of waste annually. Whilst small in absolute terms, the NAMA constitutes a major undertaking in Moldova, a country with a small population under 4 million, and will make a solid contribution to an important service affecting the daily lives of the Moldovan people.

   In addition to support for the individual interventions, the NAMA will include overall support for: (a) capacity building related to LFG collection and utilization, in particular measurement, reporting and verification (MRV), and (b) a detailed feasibility study specifically for the WTE component of the waste management system. The feasibility study is essential in that the abovementioned feasibility studies (the existing one by GIZ and those planned for other waste management zones) are for broader regional waste management improvements with an emphasis on upstream efforts such as waste collection.

   The NAMA also aims at accelerating policy discussions in Moldova regarding LFG collection and utilization, by way of providing successful examples.

3. Financial Structure

Explained in detail in Section 0, the financial plan developed for the NAMA involves the public sector providing interest-free bridge loans initially, on the understanding that they will be refinanced by national finance sources after three years of successful WTE operation at each SWDS. The amount of bridge loans required for full implementation is USD 7,449,675.

Added to the cost for the NAMA intervention are the estimated one-off cost (a grant) of USD 150,000 for a WTE feasibility study discussed in Section 2, as well as an estimated USD 750,000 for NAMA management, capacity building and awareness building.

It is noteworthy that the financial structure involves only a small amount of grant, in a marked departure from typical NAMA financial structures. Consequently, the cost of international NAMA support per tCO_2e of emission reduction is low, calculated to be USD 0.63 - USD 2.24 / tCO_2e, depending on how the cost of bridge loans is accounted for. This assumes that the USD 750,000 for NAMA management, capacity building and awareness building will be borne by the Moldovan government as part of the country's national ambition potentially with funding support from other programmes. Without such an assumption, the cost of international NAMA support will increase to USD 0.85 - USD 2.46 / tCO_2e, still representing a reasonable level. Please refer to Table 7-8 for details of calculation.

Abbreviations and Acronyms

ANRE	Administration Council of the National Agency Energy Regulation
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
CDA	Czech Development Agency
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
E5P	The Eastern Europe Energy Efficiency and Environmental Partnership
FIT/FiT	Feed-in Tariff
FOD	First Order Decay
Genset	Gas Engine and Generator
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
INDC	Intended Nationally Determined Contributions
IP	Individual Projects
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
NIF	Neighbourhood Investment Facility
NPV	Net Present Value
O&M	Operation and Maintenance
PDD	Project Design Document
RE	Renewable Energy
RP	Representative Project
SD	Sustainable Development
SIDA	Swedish International Development Cooperation Agency
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
WMZ 3	Waste Management Zone 3
WTE	Waste to Energy

1. Introduction to a waste to energy NAMA

The WTE NAMA for municipal solid waste (MSW) in the Republic of Moldova is composed of a number of individual projects[1], each of which involves the installation and operation of a LFG collection system and a renewable energy power plant fuelled with the methane in the collected LFG. After a small amount for internal consumption (for the LFG collection system, the office building of the power plant, etc.), the electricity will be exported to the grid[2].

The NAMA will contribute not only to greenhouse gases GHG mitigation, but also to national sustainable development (SD).

In the absence of this WTE NAMA, the atmospheric release of the LFG from the SWDS would be the Business as Usual (BAU) scenario in the Republic of Moldova, without being used to generate renewable fuel-based electricity to displace fossil fuel-based electricity.

It is clarified that this NAMA follows on the plans for improved MSW management being developed by the Moldovan government with the assistance of GIZ. However, consistent with the notion of "Nationally Appropriate Mitigation Action", the primary focus of the NAMA intervention is GHG mitigation aspects of MSW management. Thus, the scope of the NAMA intervention does not include MSW management activities unrelated to GHG mitigation.

Pending a thorough feasibility study associated with this NAMA, the following stepwise approach is taken for NAMA design development:

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 the RP based on the results obtained in Step 1.

As explained in Section 5.2, this NAMA PDD anticipates that a further study will find the feasibility of 9 replication projects – a total to 10 when combined with the RP.

Based on the information provided by the Moldova country team, the selected RP for Step 1 will be implemented at a new sanitary landfill to be constructed pursuant to a GIZ feasibility study, though a small part of the RP will also include an existing site adjacent to the new site. The key features of the RP are summarized in table below and detailed in Section 5.10, which will also discuss the extent of variability in replication.

In relation to emission reduction estimation in Section 4, it is relevant that the feasibility study prepared for the RP by GIZ calls for a managed SWDS, with controlled placement of waste (i.e. waste directed to specific deposition areas) as well as use of equipment for landfill compaction and daily top layer covering (Section 9.4.12.3 of the Feasibility Study).

Table 1-1: SWDS parameters 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	$m^{(a)}$	ft	m^3/y	y		
Existing site	154,000	11,000	14.0	45.93	37,000	-	2017 is the last year of waste	2018

[1] In this PDD, the terms "project" and "intervention" are used interchangeably.
[2] The NAMA, however, does not exclude the possibility of captive plants, whereby the electricity is used for displacing grid import at a separate facility (typically a factory) owned by the investor.

							acceptance	
New site								
Cell 1	289,000	19,800	14.6	47.89	49,250	6	2018	2020
Cell 2	362,500	17,000	21.3	69.96	49,250	8	2024	2026
Cell 3	432,500	26,000	16.6	54.57	49,250	7	2032	2034
Sub-total	1,084,000	62,800	17.3	172.42	-	21	-	-

(a) Calculated based on the provided data for the area and capacity.

As shown in the table, the plans for the RP involve accepting waste over 21 years. Given that LFG continues to be generated after a SWDS is closed, LFG collection activities for the RP is expected to last for 31 years.

On the simplified assumptions that the replication projects start in 3 years from the initiation of the RP and that they will have the same lifetime as the RP, the duration of the NAMA will be 34 years, covering the period from the beginning of the RP to the end of replication projects.

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 the full scale NAMA is deployed. The country is divided into 8 regions of waste management. For the representative project, the geographic boundary will be the southern 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 national 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, two years after 2006, the overall trend is in line with other sectors.

One of five mitigation measures put forward as part of the Technology Needs Assessment [5], 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)"[6] ("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, waste management feasibility studies have been carried out by GIZ for three regions, by the Czech Development Agency for two regions, and EIB is funding feasibility studies this year in 2016 for the remaining three regions[7]. The feasibility studies aim at proposing a system that will improve the management of municipal waste for each region, which includes the collection, transfer, treatment and disposal of waste in a regional landfill and closure of existing dumpsites.

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.

While not a part of a trend, it is notable that there exists one WTE project in Moldova, specifically the Tintareni project in the capital of Chisinau. As a privately-operated project, its exact details are unknown. However, based on the project's latest Clean Development Mechanism (CDM) PDD[8] and discussions with Moldovan stakeholders, it is believed that:

[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] *Technology Needs Assessment for Climate Change Mitigation Report 1 Technology Prioritization*, May 2012, http://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/TNR_CRE/e9067c6e3b97459989b2196f12155ad5/8a56956a4f384bd4a113b7e941f7e992.pdf

[6] *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

[7] http://www.eib.org/about/procurement/calls-technical-assistance/ta2015020.htm

[8] *Landfill Gas Recovery and Energy Production at the Tintareni Landfill Site, Chisinau, Moldova*, 2012, http://cdm.unfccc.int/filestorage/l/u/BFPGMOVQUHTIADYW32RES49NXKL0C5.pdf/PDD_ver_2.0.CDM_1%5B1%

(a) the project received a grant, (b) the project negotiated a grid tariff, (c) the project has been implemented, and (d) the project is presently not producing electricity for export despite the price for export having been agreed to with ANRE[9].

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 gas project in Wisconsin[10] 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). A key strategy of the NAMA is to have the RP act as a model case at the outset of the NAMA to mitigate risks for all subsequent NAMA projects, by acting as an advanced feasibility study on local waste characteristics, and as a model project to reaffirm the suitability of the technology to Moldova. This strategy is elaborated in Section 0.

b. Policy barrier

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

It is relevant to note that the new Renewable Energy Law was approved on 26 February 2016. While an accompanying new methodology is expected to be approved in the near future, the new power tariff calculation methodology is unknown and Moldovan experts believe that the power tariff is more likely to decrease than increase. This is all the more reason why co-financing and NAMA financing are needed for WTE endeavours as the present tariffs are insufficient for commercial sustainability.

c. Financial barrier

Consultations are being conducted with EIB for a Moldova Solid Waste Management Framework Loan, with EIB proposing to loan 100 million Euros of the estimated total cost

5D.pdf?t=ZFB8bzdmNGl6fDAvBIoTMsEJiFWVF55sUQWW. The PDD has been left at validation stage and has not been registered.

[9] Electricity export to the grid was approved by ANRE at a tariff level of 1.73 bani/kWh (ANRE Decree no 519 from 30.05.2013) for a capacity of 320 kW.

[10] 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

of 200 million Euros. It is foreseen that EBRD will co-finance the loan. It is also expected that the programme will benefit from grants in the form of technical assistance and investment grants from the Neighbourhood Investment Facility (NIF), Eastern Europe Energy Efficiency and Environmental Partnership (E5P), and Swedish International Development Cooperation Agency (SIDA), among others, to address affordability constraints. While this is very positive, in the overall scheme, it is expected that the waste to energy component is seen as least crucial, being both capital intensive (elaborated in ensuing paragraphs) and having a less direct impact on the daily lives of residents.

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.

The first barrier 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, based on discussions with local experts, 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 barrier 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 barriers

As mentioned in Section 2.1, increasing attention is being paid to the need for waste management public services. There is a possibility of large funds being made available to upgrade the current system (please refer to Section 3.2), which in itself is an extremely positive outcome for Moldova. 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 possible need for synchronization of those waste management projects and NAMA measures so that, for instance, more affordable horizontal wells[11] can be placed when (the relevant cells of) the landfill is still empty.

2.2 Relevant Stakeholders

Three stakeholder consultations have been conducted during the NAMA design phase between October 2015 and April 2016. Brief summaries of the consultation and outcomes are provided in Annex 3. Stakeholder engagement played a critical role in NAMA design to ensure local experts contributed to all NAMA aspects, notably including collaboration with the Ministry of Environment (MoEN).

[11] In the NAMA financial analysis that includes estimation of initial investment (elaborated in Section 7.5.1), it is assumed that the project employs vertical wells that can be put in place after waste is landfilled, rather than horizontal wells which are placed as the landfill is being filled up.

2.3 Purpose and Objectives of the NAMA

The WTE NAMA aims at:

- Collection of LFG and destruction of the methane contained in it, thereby preventing the GHG emission that would otherwise be unabatedly released into the air at the SWDS; and
- Use of the collected LFG[12] as fuel for renewable electricity generation without reliance on fossil fuel-based electricity.

Specifically, the objectives of the NAMA are two-fold. One is to assist the implementation of actual projects to achieve the activities identified in the two bullet points above. The other is to use successful implementation example(s) to encourage the Moldovan government to introduce policies that mandate collection and utilization of LFG.

With the implementation of this WTE NAMA, it will contribute not only to GHG emissions mitigation, but also to long-term SD co-benefits, with an ultimate goal at catalyzing transformational change towards a low carbon society in Moldova. 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. This will be via: (a) collection of LFG emitted from the MSW at the SWDS and destruction of the methane contained in it, and (b) avoidance of fossil fuel-based electricity generation by using the collected LFG for renewable electricity generation.

2. Sustainable development co-benefits

   This NAMA will provide additional SD co-benefits beyond the reduction of GHG emissions. Positive contribution on the following areas of SD are expected, as elaborated in Section 4.3:

   - 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 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:

[12] Precisely speaking, it is methane contained in LFG that is utilized.

- Change the prevailing practices of the waste management (i.e. collection and/or destruction of methane contained in LFG emitted from MSW) and energy supply (i.e. utilization of collected 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 individual projects in other regions after the successful implementation of the first WTE facility (or RP).

- Adoption of this innovative waste to energy approach/technology 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. Having said that private sector participation in regional waste management infrastructure is not mandatory and is subject to the actual investment conditions in each region.

The local communities will directly benefit 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.

In addition, the Republic of Moldova has communicated their Intended National Determined Contribution (INDC) with the UNFCCC Secretariat and submitted a document entitled "Republic of Moldova's Intended National Determined Contribution"[13] (hereinafter referred to as "INDC document") to the UNFCCC on 25 September 2015. Efforts made by the Government of the Republic of Moldova are perceived through the developments in both pre- and post- 2020 mitigation policy frameworks outlined in this INDC document[14].

(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 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

Relevant legislative acts for the INDC implementation are necessary. Given this, 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.

As noted in the INDC, "the Republic of Moldova intends to achieve an economy-wide unconditional target of reducing its greenhouse gas emissions by 64-67 per cent below its 1990 level in 2030 and to make best efforts to reduce its emissions by 67 per cent. The

[13] 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].

[14] Republic of Moldova's Intended National Determined Contribution, p. 8.

reduction commitment ... could be increased up to 78 per cent below 1990 level conditional to, a global agreement addressing important topics including low-cost financial resources, technology transfer, and technical cooperation, accessible to all at a scale commensurate to the challenge of global climate change." Energy and waste are both sectors noted to be "covered" in the INDC.

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[15].

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 practice pertinent to MSW in most landfills or SWDS in Moldova at the present time. This is consistent with the First Biennial Update Report[16] (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.

It is added that the country experts who participated in the preparation of this NAMA PDD are not aware of any policies or regulations in Moldova that stipulate mandatory LFG collection and destruction/utilization for the sake of safe operation of the SWDS or prevention of environmental degradation of neighbouring areas. This will be rectified as part of the NAMA.

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

[15] 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)

[16] 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*

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 in its NWMS report 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, EIB, European Bank for Reconstruction and Development (EBRD), and 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.

It is also apparent from discussion with Moldovan stakeholders that a cooperative framework should be designed at the outset for cost effectiveness/diffusion and enhanced transparency. This can include the sharing of fiscal and project management resources between donors and between waste management regions.

4. Baseline Information and NAMA Targets

4.1 Baseline boundary and scenario

The NAMA, which will take place at the SWDS in Moldova, involves installation of systems of equipment to achieve two elements in relation to GHG mitigation as outlined in sections above:

Element 1: Collection of LFG and destruction of the methane contained in it; and

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

A few points are added by way of clarification.

- As well as the above two elements, the NAMA includes capacity building related to LFG collection and utilization – technical training, MRV, etc. – as an integral part.
- Waste recycling and reuse, despite its potential contribution to GHG mitigation, is not included. This will be considered as part of MSW management improvements to be carried out as a complementary but separate endeavour from the NAMA.

The NAMA aims at expeditious implementation of LFG collection and utilization activities by concentrating on financial aspects.

With the clarifications above, several baseline scenario options for Elements 1 and 2 have been 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 technically feasible. However, taking into account the high capital investment and implementation costs, this is unlikely to happen 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 at the moment.
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 technically feasible and encouraged by the Moldovan government, which stipulated and approved the Strategy for Waste Management in the Republic of Moldova for 2013-2027, the Law on

	Environment Pollution Fee, the Law on Industrial and Household Waste, the Law on Air Protection, etc., with the aims at discouraging waste disposal in the SWDS and encouraging their recycling. However, the actions taken so far have not been sufficiently successful[17], resulting in the atmospheric release of LFG 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 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 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?
E1: Electricity generation from LFG, undertaken without being supported by NAMA funding	**No.** This option is technically feasible. However, taking into account the high capital investment and implementation costs, even with the revenues generated from electricity sales, this is unlikely happened in the absence of any national or international support.
E2: Electricity generation in existing or new renewable or fossil fuel based captive power plant(s)	**No.** This option is technically feasible, but unlikely to occur.
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 at the moment. 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:

[17] 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)

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 continues to be released into the air, and (ii) Imperfect destruction of the collected SWDS methane and the methane's subsequent emission.

2. Element 2

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

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

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

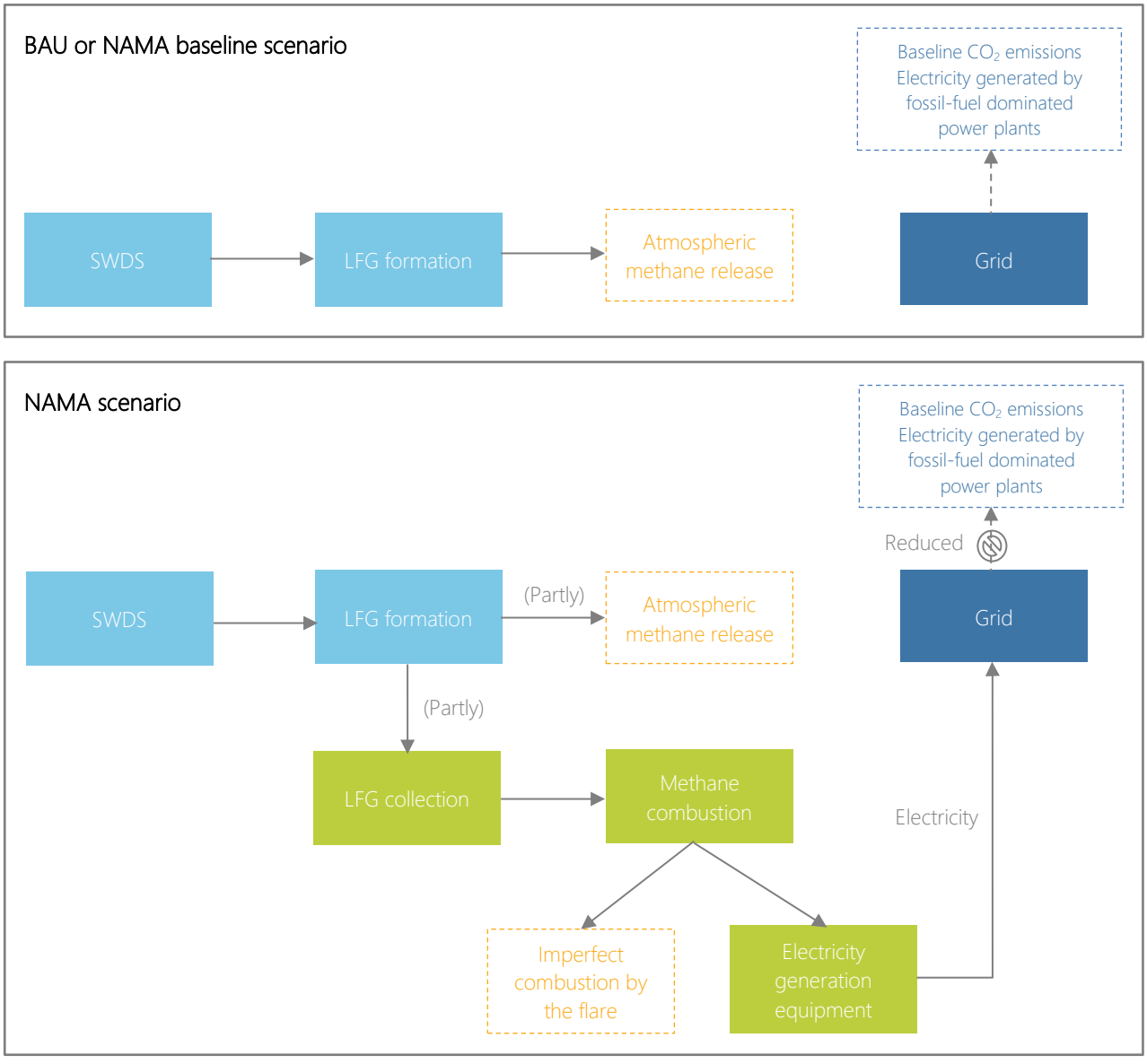

Figure 4-1: Diagrammatic representation of the BAU and NAMA scenarios.

4.2 GHG baseline and mitigation targets

For the NAMA, annual GHG baseline emissions and mitigation targets (i.e. emission reduction) can be expressed in equation 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[18] in the year y (t CO_2e)

LE_y = Leakage emission in the year y (t CO_2e)[19]

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

Element 1: Collection of LFG and the destruction of the methane contained within the LFG through combustion in Gensets or a flare system[20]; and

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

4.2.1 Calculation for collection of LFG and the destruction of the methane contained within the LFG (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

[18] This term is used synonymously with "GHG emissions for the NAMA"

[19] This refers to indirect GHG increases attributable to the NAMA. While no such effect is anticipated for the NAMA (i.e. LEy = 0), parameter is included in the equation for the sake of completeness.

[20] For combustion efficiencies, please refer to footnote 24 for gas engines and to Equation 7 for flaring.

The value for $BE_{CH4,SWDS,y}$ is calculated based on the first order decay (FOD) model that is widely used [21]. 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).

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 in the SWDS.

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_x 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,: 33.54	% wet waste	Estimated based on information from the SWDS owner/ administrator and from interviews with senior employees.

[21] This includes the methodological tool of the CDM entitled "Emissions from solid waste disposal sites". Link to access this CDM tool: http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v7.pdf.

Parameter	Description	Value	Unit	Source
		other inert waste		
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
GWP_{CH4}	Global Warming Potential of methane	25	tCO_2e/tCH_4	Paragraph 69 of the Report of the Executive Board of the Clean Development Mechanism Sixty-ninth Meeting
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
F	Fraction of methane in the SWDS gas (volume fraction)	0.5[22]		IPCC 2006 Guidelines
MCF_y	Methane correction factor for year y	0.8 (for existing site) 1.0 (for new site)		Relevant values are selected from IPCC 2006 Guidelines based on information from the Moldova team
DOC_j	Fraction of degradable organic carbon in the waste type j (weight fraction)	**Waste type** / DOC_j Wood / 43 Pulp, paper and cardboard (other than sludge) / 40 Food, food waste / 15 Textile / 24 Non-food organic putrescible garden and park waste / 20 Glass, plastic, metal, other inert waste / 0%	%wet waste	IPCC 2006 Guidelines
k	Decay rate for the waste type j	**Waste type** / **K_j** Wood / 0.03 Pulp, paper and cardboard (other than sludge) / 0.06 Food, food waste / 0.185 Textile / 0.06 Non-food / 0.10	1/yr	IPCC 2006 Guidelines

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

Parameter	Description	Value	Unit	Source
		organic putrescible garden and park waste		
		Glass, plastic, metal, other inert waste	0	
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[23]:

a) Methane emission through inefficiency

b) Methane emission through imperfect combustion in flaring and Gensets

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)[24]

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.

[23] Electricity required for the LFG collection system is supplied by the electricity generated through Element 2 and does not incur project emissions. Please refer to Section 4.2.2.2.

[24] It is noted that the combustion efficiency of gas engines is assumed to be 100% (i.e. no incomplete combustion) in accordance with the relevant CDM methodology AMS-III.G "Landfill methane recovery" (http://cdm.unfccc.int/filestorage/E/K/A/EKA6GXDLB5TNYVCIJP0S3O9HQ8UW7F/EB81_repan32_AMS-III%20G_ver09.0.pdf?t=VUN8bzd6OWJlfDDJYRDoMIlcrOJ9U_3yIWVH).

Parameter	Description	Value	Unit	Source
$BE_{CH4,SWDS,y}$	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)[25] 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[26]
ρ_{CH4}	Density of methane	0.716	Kg/m^3	CDM tool[27]
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[28]
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 $LFG_{NETc} = LFG_{c,} \times (1 - OX)$ Paramet $LFG_{NETc,y}$

[25] This is to take account of the concept stated in paragraph 15 of the relevant CDM methodology (AMS-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.

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

[27] "Project emissions from flaring" (Version 02.0.0) http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v2.0.pdf (p9)

[28] For ex ante calculation, estimated as $BE_{CH4,SWDS,y}$ x design efficiency of the installed LFG collection system.

$LFG_{c,y}$	Landfill gas collecte
OX	Oxidation factor (r methane from SW soil or other mater

$CH4_{flared}$	Methane fed to the flare		tCH_4	Calculated from measured data for *ex post* calculation[29]. Estimated for *ex ante* calculation[30].
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

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[31]
$EF_{EL,k,y}$	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[32].

2. Project emissions

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

29 $(LFG_{c,y} - LFG_{l,y}$ for gas engine(s)) x $w_{CH4,y}$ x ρ_{CH4}
30 For *ex ante* calculation, estimated based on $LFG_{c,y}$ availability and gas engine capacity.
31 For *ex ante* calculation, estimated as the difference between planned gross electricity generation and expected internal consumption.
32 http://www.clima.md/lib.php?l=en&idc=243 (p22)

A point that needs elaboration in relation to project emissions is the treatment of internal demand – consumption of electricity for the operation of the project (e.g. for the LFG collection system and in the building used for the project). If a project generates 100 units of renewable energy (RE) and devotes 10 of the 100 to internal consumption, the project's genuine contribution to RE power generation is not represented by its gross generation of 100 units (i.e. before internal consumption) but by its net generation of 90 (i.e. after internal consumption).

It is added that for this reason, the RE generation contribution of the project is gauged by its net grid export (i.e. after deducting internal consumption), rather than its gross generation (i.e. before the deduction of internal consumption).

4.2.3 Totals for baseline and project emissions

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)

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)

4.2.4 Baseline and mitigation target for the RP

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 NAMA. These mitigation targets were estimated based on the features of the RP delineated in Section 5.5 and the application of Equations 1 – 11. For detailed ER 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)	9,733	7,279	2,454
2 (2019)	12,753	10,659	2,093

3 (2020)	15,782	7,317	8,465
4 (2021)	18,066	8,277	9,788
5 (2022)	20,008	9,095	10,914
6 (2023)	21,666	9,792	11,873
7 (2024)	22,899	12,815	10,084
8 (2025)	23,960	15,375	8,585
9 (2026)	25,348	11,345	14,004
10 (2027)	26,253	11,727	14,527
11 (2028)	27,038	12,058	14,980
12 (2029)	27,721	12,347	15,374
13 (2030)	28,318	12,600	15,718
14 (2031)	28,842	12,822	16,020
15 (2032)	29,120	15,444	13,676
16 (2033)	29,372	17,664	11,709
17 (2034)	30,076	13,346	16,730
18 (2035)	30,274	13,484	16,790
19 (2036)	30,408	14,859	15,549
20 (2037)	30,659	15,141	15,519
21 (2038)	30,887	15,391	15,495
22 (2039)	26,209	11,887	14,321
23 (2040)	22,533	9,987	12,546
24 (2041)	19,214	8,604	10,609
25 (2042)	16,607	7,439	9,168
26 (2043)	13,136	5,871	7,265
27 (2044)	11,388	5,091	6,297
28 (2045)	9,910	4,431	5,478
29 (2046)	8,658	3,873	4,786
30 (2047)	7,596	3,399	4,198
31 (2048)	6,692	2,995	3,697
Total	**661,128**	**322,417**	**338,711**
Annual averaged over the full NAMA period achieved by the RP	**21,327**	**10,401**	**10,926**

4.2.5 Baseline and mitigation target for the NAMA

The expected GHG mitigation targets to be achieved by the NAMA (i.e. 10 RP equivalents) over the full period of the NAMA are also determined in accordance with the below Step 2 of the stepwise 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 the RP based on the results obtained in Step 1, in accordance with the analyses delineated in Section 0 (Measures & Interventions under the NAMA).

Subject to input from the Moldova team, this PDD assumes that the WTE NAMA will involve a total of 10 RP equivalents (the RP + replication of 9 RP equivalents).

Results indicating the multiplication of Table 4-3 figures by 10 to show full NAMA results are provided 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	6,611,282	3,224,168	3,387,114
Annual averaged over the full NAMA period achieved by the NAMA	213,267	104,005	109,262

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 are divided into 5 domains: environment, social, growth and development, economic, and institutional based on the UNDP NAMA Sustainable Development Evaluation Tool (NAMA SD Tool). Only those SD indicators, which are most relevant, specific, meaningful, 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 (Relevance to SDG)[33]	Explanation of chosen indicator
Environment	Air pollution/quality (SDG 11: Make cities inclusive, safe, resilient and sustainable)	Odour is one of the major concerns of a Solid Waste Disposal Site (SWDS) or landfill, where the wet wastes decompose and release methane (an explosive gas) and odour-causing gases (e.g. sulfides and ammonia) that emit a distinctive odour[34]. This leads to both health and safety impacts on the nearby communities.
	Climate change adaptation and mitigation (SDG 13: Take urgent action to combat climate change and its impacts)	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 (SDG 8: Promote inclusive and sustainable economic growth, employment and decent work for all)	The skill level of workers/employees will be enhanced through the training sessions about methane collection and power generation technologies provided by the WTE NAMA.
Growth and development	Access to clean and sustainable energy (SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all)	Clean and sustainable electricity will be generated by using the collected 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 during construction (i.e. temporary basis) and operation

[33] For details of sustainable development goals (SDGs) and their relevant targets, please refer to the NAMA SD Tool (http://www.undp.org/content/undp/en/home/librarypage/environment-energy/mdg-carbon/NAMA-sustainable-development-evaluation-tool.html).

[34] Data source: "Landfill Gas Control Measures" (http://www.atsdr.cdc.gov/HAC/landfill/html/ch5.html).

Domain	Indicator (Relevance to SDG)[33]	Explanation of chosen indicator
	(SDG 8: Ditto)	phases (i.e. permanent basis), thereby increasing income generation by way of remuneration to the employees.
	Job creation (number of men and women employed) (SDG 8: Ditto)	With the presence of the WTE NAMA, both temporary and permanent job opportunities will be created.
Institutional	Laws and regulation (SDG 16: Promote just, peaceful and inclusive societies, and SDG 17: Revitalize the global partnership for sustainable development)	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 selecting the relevant SD indicators, 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	Yes
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 MRV procedures for each identified parameter, including how and when to conduct the measurement and the QA/QC procedures, are described in 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[35] 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 – a RP, followed by an advanced level – Total NAMA, to be discussed in Section 9.1.2 below.

[35] In this PDD, the terms "intervention" (which is commonly used in the NAMA SD Tool) and "project" are used interchangeably.

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, there currently 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, and a low level of public awareness about waste management"[36], landfill gas collection and flaring for safety purposes. The NAMA activities consisting of landfill gas collection and power generation are innovative technologies in that they offer significant leaps in reuse of waste material to help satisfy a growing national energy demand.

b. Private sector[37] involvement

Private sector can have various roles in a NAMA, including as equity investor, debt investor, technology provider and formulator of a NAMA. Involvement of private sector is seen as having a catalytic effect on transformational change[38]. Mobilization of private sector financing in particular is seen as important for scaling up of climate change mitigation efforts.

Being a new type of undertaking in the country and as part of a public service sector, it is expected that the first wave of interventions for this WTE NAMA will be carried out with domestic and international public sector funding.

Under the financial structure proposed in this document, however, private sector involvement is encouraged to gradually increase as delineated in Section 0.

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.

Waste collection improvement and sanitary landfill construction planned under the GIZ Feasibility Study will transform such waste management practices entirely. However, these are considered non-NAMA interventions in that there are no GHG reduction aspects to these activities.

The NAMA intervention, which is landfill gas capture and power generation, is downstream of the abovementioned activities, and may have less direct transformational impacts. Nevertheless, the NAMA will certainly add to the improvements in the overall waste management system, with health and environmental benefits trickling down to the general population. Specifically, the NAMA provides (a) enhanced safety due to the combustion of landfill gas, (b) improved odour and sanitation around the landfill site are direct positive impacts often cited by residents surrounding existing landfill sites, (c) increased

[36] Improvement of solid municipal waste management in the Republic of Moldova, 2014, Osteuropaverein http://www.osteuropaverein.org/media/1547/mda.pdf

[37] In this document, the term "private sector" refers to all entities other than central government units and includes municipalities.

[38] Potential for Transformational Change, NAMA Facility, 2015, http://www.nama-facility.org/fileadmin/user_upload/pdf/NAMA_Facility_factsheet_transformational_change_potential.pdf

electricity supply, and (d) depending on the overall system design, better leachate management.

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[39]. 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.

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

It is of note, however, 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.

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

5. Measures & Interventions under the NAMA

- As stated in Section 2.3, the objectives of the NAMA are: Collection of LFG and destruction of the methane contained in it, thereby preventing the GHG emission that would otherwise be unabatedly released into the air at the SWDS; and

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

The analysis in Section 4.1 on the baseline demonstrated that these activities will not be undertaken on a BAU basis, due to the presence of gaps, to be elaborated in Section 5.4. The NAMA measures aim at filling these gaps.

It is added that for the sake of risk mitigation, the NAMA will adopt a phased approach consisting of:

- Phase 1: Feasibility study production. This will commence and finish in NAMA Year 0.

- Phase 2: Implementation of the RP as the first WTE installation. This phase is expected to commence in NAMA Year 0 and complete in NAMA Year 31.

- Phase 3: Full implementation, consisting of further projects whose number is analyzed in Section 5.2. The schedule for Phase 3 is undecided, as preliminary results from Phase 2 are to be sought prior to implementation.

This schedule ensures solid site-specific costing in Phase 1 and a first actual installation in Phase 2 before major part of the investment is made in Phase 3.

5.1 Representative project

As mentioned in Section 1, the individual project selected as the RP will be implemented at a new sanitary landfill to be constructed pursuant to a GIZ feasibility study, though a small part of the RP will also include an existing site adjacent to the new site, which will be closed when the new site commences its operation. Based on GIZ's feasibility study, Table 5-1 summarizes the parameters of the SWDS for the RP[40].

Table 5-1: SWDS parameters 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	$m^{(a)}$	ft	m^3/y		y		
Existing site	154,000	11,000	14.0	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	49,250		6	2018	2020
Cell 2	362,500	17,000	21.3	69.96	49,250		8	2024	2026
Cell 3	432,500	26,000	16.6	54.57	49,250		7	2032	2034
Sub-total	1,084,000	62,800	17.3	172.42	-		21	-	-

[40] It is added that GIZ' feasibility study does not include the existing site and that the information about it in the table has been provided by Moldova representatives for the sake of the NAMA PDD.

(a) Calculated by Asiatica based on the provided data for the area and capacity.

It is of note that while GIZ's feasibility study for the new site does not involve LFG collection and utilization per se, it includes some information about the activity. However, this is technical/operational, without providing financial information. The technical/operational recommendations in the GIZ feasibility study are followed for the NAMA, to the extent appropriate.

According to the detailed analysis about the RP summarized in Section 5.5, the RP can expect 338,711 tCO_2e emission reduction during its lifetime of 31 years and an annual average of 10,926 tCO_2e/y.

5.2 Replication

The NAMA follows on Moldova's plan, to be achieved with international support, that aims at upgrading the country's waste management practice and reducing waste currently disposed of without proper collection and management. As such, the replicability of the NAMA depends on the number of new SWDS to be created with progress in upstream waste management services. Thus, the exact extent of replicability will be known only after thorough studies about improved waste management services.

Pending the completion of such studies, this NAMA PDD has tentatively assumed that: (1) Each of the eight waste management regions of the country will have at least one individual project similar to the RP and (2) two of the eight waste management regions will have another individual project. This will result in 10 RP equivalents in total (i.e. the RP plus 9 replication individual projects). Similar interventions with similar financial structures can also be encouraged in other non-Annex I countries, in particular neighbouring countries, as noted earlier.

5.3 Total NAMA

The assumption of 10 RP equivalents mentioned in the preceding section does not mean 10 individual projects exactly of the same size as the RP. It can be 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.

It is expected that the SWDS for some of the replication projects are built adjacent to an existing site (as is the case for the RP), allowing the LFG collection and utilization activity for both the existing and new site. While this is desirable for an early start of LFG collection and utilization activity on the basis of the LFG from an existing site, it is not an absolute requirement for a replication project to include an existing site.

The renewable energy (RE) electricity produced by NAMA's individual projects is expected to be grid connected (i.e. exporting electricity to the grid except for a small amount used internally). However, the use of the RE electricity for displacement of grid import is not excluded.

When the NAMA achieves 10 RP equivalents, the NAMA's GHG mitigation contribution will be 3,387,114 tCO_2e during its lifetime and an annual average of approximately[41] 109,262 tCO2e/y.

[41] The exact figure for the annual average will depend on the implementation schedules of the replication projects.

5.4 Gap and barrier analyses and identification of measures

The analysis in Section 4.1 on the baseline demonstrated that these activities will not be undertaken on a BAU basis, due to presence of gaps. One of them is financial as delineated in Section 0. The other is capacity building / awareness building needs discussed in Section 0.

By filling these gaps through NAMA measures, the NAMA aims at enabling the implementation of the afore-mentioned activities, thereby mitigating GHG emissions via: (a) collection of LFG emitted from the MSW at the SWDS and destruction of the methane contained in it, and (b) reduction of fossil fuel-based electricity generation by using the collected LFG for renewable electricity generation. The NAMA will also provide SD co-benefits in addition to the reduction of GHG emissions, as elaborated in Section 4.3.

5.5 Further details about RP

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 49,250 m^3/y, it is anticipated that the lifetime of Cell 1 is approximately 6 years. Cell 2 will then be constructed in-sequence and in parallel with the waste disposal in 2024. Based on the same waste disposal rate, Cell 2 is expected to be fully filled in about 8 years. Following this project implementation plan, Cell 3 will be constructed at the latest and is to be filled from 2032 for another 7 years. This makes up the total lifetime of the new site of 21 years. Table 5-2, which is reproduced from Table 1-1, summarizes the SWDS parameters of the RP.

Table 5-2: SWDS parameters 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	$m^{(a)}$	ft	m^3/y		y		
Existing site	154,000	11,000	14.0	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	49,250		6	2018	2020
Cell 2	362,500	17,000	21.3	69.96	49,250		8	2024	2026
Cell 3	432,500	26,000	16.6	54.57	49,250		7	2032	2034
Sub-total	1,084,000	62,800	17.3	172.42	-		21	-	-

(a) Calculated based on the provided data for the area and capacity.

2. Waste composition

In the absence of site specific data, the composition of municipal solid waste (MSW) sourced from the Fourth National Communication [42] is applied in the analysis, pursuant to a suggestion made by the Moldova country team, based on their view that the data in the National Communication was most representative and reliable when site specific data was not available.

It is added that for the new site of the RP, the plan is to use site-specific data when it becomes available in future. This is for the sake of increased accuracy of *ex ante* estimation of LFG generation that depends on waste composition.

Waste types and composition in accordance with the first paragraph are summarized in the table below. Based on the data, organic components of the waste comprise 66.46% of the total. This figure will be combined with the measured amounts of *total* waste acceptance to estimate the types and mass of organic waste from which LFG is to be generated.

Table 5-3: Waste composition.

Waste type		Composition (Wet % by mass)
Organic waste	Food scraps	46.06%
	Phytotechnical waste	10.77%
	Paper, cardboard	5.28%
	Textile	2.59%
	Wood	1.76%
Sub-total for organic		66.46%
Inorganic waste	Other (construction waste)	17.58%
	Glass	6.12%
	Plastic products	4.66%
	Furniture	1.95%
	Metal & non-metals	1.67%
	Electrical and electronic equipment	1.21%
	Footwear	0.35%
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 49,250 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 49,250 t/y respectively.

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

Table 5-4: Annual quantity and density of the disposal waste.

Landfill site	Waste density	Annual waste disposal quantity		
	t/m^3	m^3/y	t/y	
Existing site	0.4	37,000	14,800	
New site				
Cell 1	1.0	49,250	49,250	
Cell 2	1.0	49,250	49,250	
Cell 3	1.0	49,250	49,250	

4. Gas collection and utilization

The key components of LFG collection systems consist of gas wells comprised of solid and perforated pipes, well heads, a collection station (including blowers to extract gas from the landfill and condensate collection equipment) and an LFG treatment process to prepare the collected LFG ready for use (dewatering and filtration to remove moisture and particulates, etc.)[43].

The design of the LFG collection system for the RP includes the considerations as noted below.

Waste acceptance

Waste placement in the landfill cells will be sequential without overlapping. Thus, the existing site will be closed when Cell 1 of the new site opens to waste disposal. Cell 1 in turn will be closed when Cell 2 starts accepting waste, and Cell 2 will no longer accept new waste when Cell 3 opens. LFG will be produced starting approximately 6-12 months after waste acceptance.

LFG collection

LFG generation continues long after the closure of a SWDS, resulting in LFG collection activities in multiple cells despite the sequential waste acceptance mentioned above. This requires the installation of a total of four LFG collection systems – one for the existing site as well as one each for Cells 1, 2 and 3 of the new site. In the context of this WTE NAMA, sometimes, the four systems are conceived as a group and referred to as "an" LFG collection system for the RP.

LFG utilization

The LFG collected by the LFG collection systems will be connected to one gas utilization system and fed as fuel to gas engines for power generation without reliance on fossil fuel (i.e. renewable energy (RE) electricity generation). After allocating a small amount for internal consumption (for the LFG collection system, the office building of the power plant, etc.), the electricity will be exported to the grid.

For the sake of safety, a flare will be installed at the LFG power plant and operated when the gas engines are overloaded with the captured LFG or during maintenance/malfunctioning.

[43] US EPA presentation at a LMOP workshop http://www3.epa.gov/lmop/documents/pdfs/conf/tx-workshop/2LMOPLFGCollectionandLFGEnergyTechnologies.pdf and Global Methane Initiative https://www.globalmethane.org/documents/toolsres_lfg_ibpgch3.pdf (p21)

When this occurs, partial atmospheric release of the LFG collected from the landfill sites cannot be avoided.

5. Amounts of LFG collection

Amounts of LFG collection and methane contained in the LFG are calculated based on the following assumptions:

(a) Expected amounts of LFG generation are estimated by the application of the first order decay (FOD) model[44] to the situations at the existing and new sites as described in the information/documents provided by the Moldova country team. This FOD method is widely used by the IPCC for estimating LFG or methane emissions from SWDS. It assumes that the degradable organic carbon in waste decays slowly throughout a few decades, during which methane and CO_2 are formed. LFG emissions from SWDS are highest in the first few years after waste deposition, before gradually declining as the degradable organic carbon in waste is consumed by the bacteria responsible for the decay[45].

The key factors that affect LFG generation, such as waste quantity (in weight) and waste composition (in weight fraction), are summarized in Sections 5.1.1 and 5.1.2 above. They are combined with the calculation method detailed in Section 4 and also in the ex-ante ER calculation excel spreadsheets attached to Annex 5.

In accordance with the IPCC Guidelines and the CDM Tool, the spreadsheets estimate the amount of degradable organic carbon in terms of in mass.

(b) For the methane content of LFG, both the IPCC Guidelines and the CDM Tool provide the default value of 50%[46] as a volume fraction. They apply it to the amount of degradable organic carbon estimated in mass in (a) and, by introducing the molecule weight ratio for CH_4/C (i.e. 16/12), arrive at the value in mass for the methane emitted from the SWDS. This approach is followed in our spreadsheets.

It is of note that this default value for methane content (50% in volume) is employed only for *ex ante* calculation and will be replaced with actually measured volume fractions for *ex post* calculation.

(c) LFG collection efficiency is assumed to be 50% for the existing site and 60% for the new site[47]. This parameter is defined as dimensionless in CDM methodology ACM0001 (p.29) and used in conjunction with a value in mass in Equation (5) of the methodology.

(d) The annual amounts of methane to be collected (in mass), calculated from (a), (b) and (c) are summarized in column E of the "Power generation" tab of the ex-ante ER calculation excel spreadsheets attached to Annex 5 and reproduced in the last column of Table 5-5 below.

(e) It will be important to clarify that the process outlined in (a) – (d) above is for *ex ante* estimation. For *ex post* calculation, the volume of actually collected LFG (measured with

[44] Referred in the CDM methodological tool, namely *"Emissions from solid waste disposal site (Version 07.0)"*. ('CDM Tool")

[45] Data source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories "Solid Waste Disposal" (http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf).

[46] The CDM Tool (p.14)

[47] This is based on based on input from a Moldovan expert intimately involved with the planning for the new site. The use of such input as the basis of calculation is allowed by the relevant CDM methodology (ACM0001) that says as follows about the efficiency of the LFG capture system: "Technical specifications of the LFG capture system to be installed (if available) or a default value of 50 per cent".

a flow meter) is multiplied by its methane content (volume fraction based on methane analyzer measurement) to derive the *volume* of methane collected. This data will then be coupled with the density of methane to obtain a value in mass required for emission reduction calculation.

Table 5-5: Amounts of methane collection (*ex ante* estimation).

Project year	Calendar year	Methane captured (tCH_4)		
		Existing site	New site	Total
1	2018	101	-	101
2	2019	86	-	86
3	2020	74	276	350
4	2021	63	341	404
5	2022	55	396	451
6	2023	47	443	490
7	2024	41	376	416
8	2025	36	319	355
9	2026	31	547	578
10	2027	27	573	600
11	2028	24	595	619
12	2029	21	614	635
13	2030	19	630	649
14	2031	17	645	662
15	2032	15	550	565
16	2033	14	470	484
17	2034	12	679	691
18	2035	11	614	625
19	2036	10	630	640
20	2037	9	645	654
21	2038	9	658	666
22	2039	-	561	561
23	2040	-	480	480
24	2041	-	297	297
25	2042	-	254	254
26	2043	-	218	218
27	2044	-	187	187
28	2045	-	161	161
29	2046	-	140	140
30	2047	-	121	121
31	2048	-	106	106
Total		723	12,524	13,247

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 5.5.5.(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, required capacities of gas engines to be installed were determined. Taking project year 1 as an example, the potential amount of power generation is calculated by multiplying the total methane capture in year 1 (101 tCH_4) and the power generation capability from a unit of methane (4.62 MWh/tCH_4) as follows:

$$101 tCH_4 \times 4.62\ MWh/tCH_4 = 468\ MWh/y$$

With the power generation capacity of a 100 kW (or 0.1 MW) gas engine being equivalent to 876 MWh/y (=0.1 MW x 8760 h/y), the capacity factor[48] of the power generation facility for year 1 equals to 0.53, as calculated below:

$$468\ MWh/y \div 876\ MWh/y = 0.53$$

Following the same calculation approach for other years, the engine capacity should have a minimum level of 100 kW up to a maximum of 400 kW during the peak years of LFG generation.

(d) Expected gross amounts of annual electricity generation at the planned power generation facility correspond to smaller of the following two values:

Value 1 (MWh/y): Methane collected in the year (tCH_4) x 4.62 MWh/tCH_4
Value 2 (MWh/y): Installed capacity (kW) x 0.001MW/kW x 8,760 h/y x 0.95[49]

They are calculated in column I of the "Power generation" tab of the ex-ante ER calculation excel spreadsheets attached to Annex 5 and reproduced in

[48] Actual output divided by potential output at full capacity. Please see the following link for more detail. https://en.wikipedia.org/wiki/Capacity_factor

[49] Considered by many as the maximum capacity factor achievable on an annual basis.

Table ***5-6*** below.

Table 5-6: Amounts of annual gross electricity generation.

Project year (calendar year)	Installed power generation capacity		Annual gross electricity generation	Capacity factor
	kW		MWh/y	-
	A		Smaller of Values 1 and 2 above B	C=B/ (A x 0.001 x 8,760)
1 (2018)	100		468	0.53
2 (2019)	100		399	0.46
3 (2020)	200		1,615	0.92
4 (2021)	300		1,868	0.71
5 (2022)	300		2,082	0.79
6 (2023)	300		2,266	0.86
7 (2024)	300		1,924	0.73
8 (2025)	300		1,638	0.62
9 (2026)	400		2,672	0.76
10 (2027)	400		2,772	0.79
11 (2028)	400		2,858	0.82
12 (2029)	400		2,934	0.84
13 (2030)	400		2,999	0.86
14 (2031)	400		3,057	0.87
15 (2032)	400		2,610	0.74
16 (2033)	400		2,234	0.64
17 (2034)	400		3,192	0.91
18 (2035)	400		2,887	0.82
19 (2036)	300		2,497	0.95
20 (2037)	300		2,497	0.95
21 (2038)	300		2,497	0.95
22 (2039)	300		2,497	0.95
23 (2040)	300		2,217	0.84
24 (2041)	200		1,372	0.78
25 (2042)	200		1,173	0.67
26 (2043)	200		1,005	0.57
27 (2044)	200		864	0.49
28 (2045)	100		746	0.85
29 (2046)	100		646	0.74
30 (2047)	100		561	0.64
31 (2048)	100		490	0.56
Total	-		59,536	-

(e) As mentioned in Section 5.5.4 above, excess methane (which occurs when Value 1 in (d) above is greater than Value 2) will be flared.

7. Amounts of internal power consumption and net electricity generation

Internal power consumption relates to (1) electricity required for blowers[50] of the C&F systems and (2) electricity for the power generation facility where power is generated by using the collected methane as fuel, in accordance with the basic concept of the NAMA outlined in Section 1 (Introduction) and Section 2.3 (Purpose and Objectives of the NAMA). It is assumed that both of these electricity demands are met by the electricity generated at the power generation facility. The amounts of internal consumption are elaborated below.

(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[51], which has a default value of 0.002 kWh/ft^3 LFG.

(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 5.5.6.(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, this requires that 2,793 m^3 (or 98,644 ft^3 in terms of the unit adopted by the LMOP model) 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) Combining (i) and (ii) above, the internal power consumption required by the blowers is equivalent to 4.27% of the gross electricity generation, shown in equation below.

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

[50] Blowers are required to pull the landfill gas from the gas collection wells to the gas collection header and further downstream.

[51] "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)

(b) Internal power consumption by power generation facility

The amount of electricity consumed by the power generation facility is calculated as per the LMOP cost model, which has a default value of 8% of the gross electricity generation[52].

(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 5-7 below.

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

Table 5-7: 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)	1,615	69	129	198	1,417
4 (2021)	1,868	80	149	229	1,639
5 (2022)	2,082	89	167	256	1,827
6 (2023)	2,266	97	181	278	1,988
7 (2024)	1,924	82	154	236	1,688
8 (2025)	1,638	70	131	201	1,437
9 (2026)	2,672	114	214	328	2,344
10 (2027)	2,772	118	222	340	2,432
11 (2028)	2,858	122	229	351	2,508
12 (2029)	2,934	125	235	360	2,574
13 (2030)	2,999	128	240	368	2,631
14 (2031)	3,057	131	245	375	2,682
15 (2032)	2,610	111	209	320	2,289
16 (2033)	2,234	95	179	274	1,960
17 (2034)	3,192	136	255	392	2,801
18 (2035)	2,887	123	231	354	2,533
19 (2036)	2,497	107	200	306	2,190
20 (2037)	2,497	107	200	306	2,190
21 (2038)	2,497	107	200	306	2,190
22 (2039)	2,497	107	200	306	2,190
23 (2040)	2,217	95	177	272	1,945
24 (2041)	1,372	59	110	168	1,204
25 (2042)	1,173	50	94	144	1,029
26 (2043)	1,005	43	80	123	882

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

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
27 (2044)	864	37	69	106	758
28 (2045)	746	32	60	91	654
29 (2046)	646	28	52	79	566
30 (2047)	561	24	45	69	492
31 (2048)	490	21	39	60	430
Total	61,199	2,542	4,763	7,305	52,231

The abovementioned features of the selected RP serve as the basis for the GHG emission reductions estimation and the financial analyses conducted in Sections 4.2 and 0 respectively.

6. Capacity Development

Several capacity development needs have been identified:

1. Capacity at the NAMA central coordinating 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 so that the central unit will be able to share their knowledge base to guide individual NAMA participants. Specifically, these skills to be transferred include:

   a. Basic WTE technology knowledge, including a database of potential technology providers. Many first timers require a dedicated procurement specialist / engineer for this purpose.

   b. On the assumption that the intervention will also represent a municipality's first endeavour at negotiating a renewable energy tariff, intimate knowledge of the latest relevant regulations, as well as knowledge of tariff negotiating procedures. Due to the current regulatory uncertainty as mentioned in Section 2.1, a key component of the RP is the feasibility study that will include initiation of tariff negotiations with ANRE. The knowhow and lessons learned from this activity will be shared.

   c. MRV requirements and procedures. While much of the data to be reported by the intervention project owners will be collected in the course of usual business, depending on the final MRV requirements there may be information considered unimportant for day to day operations but which are crucial for climate change accounting. As with CDM project owners, this knowledge will need to be shared at the outset of a new intervention.

2. Technology

   As mentioned in Section 2.1, the technology in itself is proven in many parts of the world. The capacity to be developed here through the implementation of the RP in addition to nine replicated units is first-hand knowledge of the application of WTE technologies in the local context – a combination of climatic conditions, waste volume and waste composition – and possible improvements to be shared with subsequent replication projects from lessons learned.

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 achieve 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. The NAMA financial requirements are discussed in Section 7.

5. MRV

Measurement and reporting requirements for NAMAs, geared towards GHG and SD accounting, 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

Budgeting and cash flow modelling are essential prerequisites for financial structuring discussions in Sections 0 to 7.4. Based on the detailed analyses outlined in Section 7.5, the following tables provide the summary of the Core Budget of the RP and the cash flow model for the RP without financial factors.

Table 7-1: Core Budget (i.e. without financing factors) for the RP. **Unit: USD**

Project year (calendar year)	Investment in fixed assets[53] 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	51,761	-78,501	-622,103
2 (2019)	143,231			143,231	23,784	44,151	-122,864	-744,967
3 (2020)	75,000			75,000	69,916	178,551	33,635	-711,333
4 (2021)	0			0	76,796	206,460	129,664	-581,668
5 (2022)	0			0	82,648	230,199	147,551	-434,117
6 (2023)	0			0	87,638	250,441	162,803	-271,314
7 (2024)	113,982			113,982	78,334	212,700	20,384	-250,931
8 (2025)	150,019			150,019	70,542	181,089	-39,471	-290,402
9 (2026)	0			0	111,715	295,373	183,658	-106,743
10 (2027)	0			0	114,434	306,403	191,969	85,226
11 (2028)	0			0	116,790	315,962	199,172	284,398
12 (2029)	0			0	118,840	324,276	205,436	489,834
13 (2030)	0			0	120,630	331,537	210,908	700,742
14 (2031)	0			0	122,199	337,905	215,705	916,447
15 (2032)	225,422			225,422	110,011	288,461	-46,972	869,475
16 (2033)	71,940			71,940	91,981	246,963	83,043	952,518
17 (2034)	75,000			75,000	136,290	352,876	141,586	1,094,104
18 (2035)	0			0	114,968	319,117	204,149	1,298,253
19 (2036)	0			0	104,332	275,974	171,641	1,469,894
20 (2037)	0			0	104,332	275,974	171,641	1,641,535

[53] In financial discussions about climate change projects, the concept of "incremental cost" is important. This is the additional cost to be incurred for mitigating GHG emissions. For the NAMA, the baseline is not to install a LFG collection and utilization equipment. Thus, all the costs for the LFG collection and utilization equipment are incremental costs.

Project year (calendar year)	Investment in fixed assets[53] 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 $H_y=H_{y-1}+G_y$
21 (2038)	0			0	104,332	275,974	171,641	1,813,177
22 (2039)	0			0	104,332	275,974	171,641	1,984,818
23 (2040)	0			0	96,719	245,088	148,370	2,133,188
24 (2041)	0			0	60,694	151,689	90,995	2,224,183
25 (2042)	0			0	55,256	129,632	74,375	2,298,558
26 (2043)	0			0	50,691	111,110	60,419	2,358,977
27 (2044)	0			0	46,852	95,537	48,686	2,407,663
28 (2045)	0			0	43,619	82,426	38,806	2,446,469
29 (2046)	0			0	40,894	71,368	30,475	2,476,944
30 (2047)	0			0	38,591	62,028	23,437	2,500,381
31 (2048)	0			0	36,642	54,122	17,480	2,517,861
Total	1,502,798			1,502,798	2,560,462	6,581,120	2,517,861	2,517,861

Table 7-2: 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	51,761	25,660	26,101	26,101	-78,501
2 (2019)	143,231	44,151	23,784	20,367	46,468	-122,864
3 (2020)	75,000	178,551	69,916	108,635	155,103	33,635
4 (2021)	-	206,460	76,796	129,664	284,767	129,664
5 (2022)	-	230,199	82,648	147,551	432,318	147,551
6 (2023)	-	250,441	87,638	162,803	595,121	162,803
7 (2024)	113,982	212,700	78,334	134,366	729,487	20,384
8 (2025)	150,019	181,089	70,542	110,548	840,034	-39,471
9 (2026)	-	295,373	111,715	183,658	1,023,693	183,658
10 (2027)	-	306,403	114,434	191,969	1,215,662	191,969
11 (2028)	-	315,962	116,790	199,172	1,414,834	199,172
12 (2029)	-	324,276	118,840	205,436	1,620,270	205,436
13 (2030)	-	331,537	120,630	210,908	1,831,178	210,908
14 (2031)	-	337,905	122,199	215,705	2,046,883	215,705
15 (2032)	225,422	288,461	110,011	178,450	2,225,333	-46,972
16 (2033)	71,940	246,963	91,981	154,982	2,380,315	83,043
17 (2034)	75,000	352,876	136,290	216,586	2,596,901	141,586
18 (2035)	-	319,117	114,968	204,149	2,801,050	204,149
19 (2036)	-	275,974	104,332	171,641	2,972,692	171,641
20 (2037)	-	275,974	104,332	171,641	3,144,333	171,641
21 (2038)	-	275,974	104,332	171,641	3,315,974	171,641
22 (2039)	-	275,974	104,332	171,641	3,487,616	171,641
23 (2040)	-	245,088	96,719	148,370	3,635,985	148,370
24 (2041)	-	151,689	60,694	90,995	3,726,980	90,995
25 (2042)	-	129,632	55,256	74,375	3,801,355	74,375
26 (2043)	-	111,110	50,691	60,419	3,861,775	60,419
27 (2044)	-	95,537	46,852	48,686	3,910,460	48,686
28 (2045)	-	82,426	43,619	38,806	3,949,267	38,806
29 (2046)	-	71,368	40,894	30,475	3,979,741	30,475
30 (2047)	-	62,028	38,591	23,437	4,003,178	23,437
31 (2048)	-	54,122	36,642	17,480	4,020,658	17,480

7.1 National and International Finance: Sources and Distribution Mechanisms

One of the key objectives of the 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 7-3: 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 7-4 below and Section 3.1 of Annex 4 for details.)
	2. Grant for a detailed technical feasibility study (Please refer to Section 7.3)

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 electricity tariff awarded under the feed-in tariff (FiT) system. In Moldova, the revised FiT system, instituted in 2016, continues to grant support on the basis of a case-by-case approach, and tariffs are calculated also case by case according to methodology determined by the Moldavian National Energy Regulatory Authority. Based on extensive discussions with the Moldova team, an electricity tariff of USD 126 / MWh is recommended for the purposes of this PDD. Reasons for choosing this electricity tariff are elaborated in Section 7.5.1.3 of this PDD and Section 2.1 of Annex 4.

The second source is in-kind contribution by the central Moldovan government for the management of the NAMA, provision of capacity building training, awareness building, etc.

7.3 Financial distribution mechanisms

A primary objective of this section is elaborate how the financial mechanism identified in Section 0 serves as a good measure to help the NAMA overcome the investment barriers it faces.

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 in addition to existing sites, to be created as part of internationally assisted effort at improved waste management. As pointed out in Section 5.4, this absence of historical data as the basis for future projections creates a major financial barrier for the NAMA, with a result that 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. It is imperative to develop a measure to help the NAMA overcome this barrier.

- It is equally important to note that based on the cash flow analysis, the return on investment for the NAMA's individual projects will not be discouragingly low when the new site performs as planned and a reasonable FiT is granted. This enables the development of a viable financial plan for the NAMA with some international support that will not be prohibitively costly.

In the light of these two factors, the financial plan that was developed for the NAMA 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, as elaborated in Section 7.4 and illustrated for the RP in column 6 of Table 7-4.

Obviously, provision of such a loan involves risk for the public sector supporter. How to mitigate this risk, briefly discussed in Section 5, is addressed in Section 0 on risk management.

One of the key points in developing a financial mechanism for NAMAs is the respective contributions by international and domestic financing. It is of note that the structure outlined above represents co-finance between international funding and national funding and that this co-finance 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 relatively small amount (up to USD 150,000) for a detailed technical feasibility study. This in part is due to a reduced tariff through the FiT system for projects in receipt of international funding grants.

7.4 Indicative NAMA financing needs

This section is composed of two components. The first is to identify the financial needs required by the NAMA, followed by a cost estimation for tCO_2e of emission reduction.

1. Summary of the NAMA's indicative financial needs

The financial needs for the NAMA can be identified by integrating the budget and cash flow model mentioned in Section 7.5 with the framework of financial mechanism discussed in Section 7.3. In summary, they consist of (a) a grant of USD 150,000 for a detailed technical feasibility study, (b) a grant of USD 750,000 for capacity building and NAMA management, and (c) public sector loans with the following features.

(i) The loans will fully address the cash flow needs of the design and installation of the 10 WTE systems (or NAMA individual projects (IP)), including construction (year 0) and the first three years of the new site's operation (years 1 – 3).

(ii) The loans will be project-based and of non-recourse[54] type to ensure that the borrower will not be left with liability in case the IP fails to perform as planned.

(iii) At the end of year 3, 1/3 of the loans will be repaid with capital injection from an investor (who may or may not be the same institution as the site owner).

[54] For a precise definition of "non-recourse", please see http://www.investopedia.com/terms/n/nonrecoursedebt.asp as a good example.

(iv) The remaining 2/3 of the loans will be repaid in 10 equal annual installments, using the cash flow generated by the IP.

(v) The loans will be interest-free.

Generous as the loans may seem, they actually represent a reasonable level of international support per tCO_2e of emission reduction, as seen in Section 7.4.2.

The following two tables present financial needs for the NAMA in specific numerical terms for the RP and for the Total NAMA[55]. As the title of this section indicates, they are indicative pending a detailed feasibility study.

(a) The RP

The following table shows the cash flow model for the RP with financing factors. It is prepared on the basis of Table 7-16 (dealing with the cash flow model for the RP without financing factors) and adding financial factors pursuant to the financial mechanism described above. The cost of a detailed technical feasibility study (USD 150,000) and the cost for capacity building and NAMA management (USD 750,000) are discussed below in relation to the cash flow for the BCNU, given that the output of the feasibility study and the grants for capacity building and NAMA management will be shared with replication projects.

[55] As mentioned in Section 8.2 and Section 0, 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 first WTE facility).

Table 7-4: Cash flow model for the RP with financing factors.

1	2	3	4	5	6					7	8
Project year (calendar year)	Cash Flow (USD)[56]	Grants (USD)	Funds from investor (USD)	Public sector loans[57] (USD)	Public sector loan repayment[58] (USD)					Cash flow after financial transactions (USD)	Accumulated cash flow (USD)
0 (2017)	-543,602			543,602						0	0
1 (2018)	-78,501			78,501						0	0
2 (2019)	-122,864			122,864						0	0
3 (2020)	33,635		214,688		248,322					0	0
4 (2021)	129,664				49,664					80,000	80,000
5 (2022)	147,551				49,664					97,886	177,886
6 (2023)	162,803				49,664					113,139	291,025
7 (2024)	20,384				49,664					-29,281	261,744
8 (2025)	-39,471				49,664					-89,135	172,608
9 (2026)	183,658				49,664					133,994	306,602
10 (2027)	191,969				49,664					142,305	448,907
11 (2028)	199,172				49,664					149,507	598,414
12 (2029)	205,436				49,664					155,772	754,186
13 (2030)	210,908				49,664					161,243	915,429
14 (2031)	215,705									215,705	1,131,135
15 (2032)	-46,972									-46,972	1,084,163
16 (2033)	83,043									83,043	1,167,205
17 (2034)	141,586									141,586	1,308,791
18 (2035)	204,149									204,149	1,512,940
19 (2036)	171,641									171,641	1,684,582

[56] This column is identical to the last column of Table 7-16.
[57] 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).
[58] The loan will be repaid at the end of year 3 and onwards with capital injection from an investor and with the cash flow generated from operation of the LFG activity. To elaborate, 1/3 of the bridge loan (i.e. USD 248,322) will be repaid at the end of year 3, with the remaining 2/3 (i.e. USD 496,645) to be repaid in 10 equal annual instalments starting in year 4.

1	2	3	4	5	6					7	8
Project year (calendar year)	Cash Flow (USD)[56]	Grants (USD)	Funds from investor (USD)	Public sector loans[57] (USD)	Public sector loan repayment[58] (USD)					Cash flow after financial transactions (USD)	Accumulated cash flow (USD)
20 (2037)	171,641									171,641	1,856,223
21 (2038)	171,641									171,641	2,027,864
22 (2039)	171,641									171,641	2,199,506
23 (2040)	148,370									148,370	2,347,875
24 (2041)	90,995									90,995	2,438,870
25 (2042)	74,375									74,375	2,513,245
26 (2043)	60,419									60,419	2,573,665
27 (2044)	48,686									48,686	2,622,350
28 (2045)	38,806									38,806	2,661,156
29 (2046)	30,475									30,475	2,691,631
30 (2047)	23,437									23,437	2,715,068
31 (2048)	17,480									17,480	2,732,548

(a) The total NAMA[59]

Table 7-5 below shows the cash flow model with financial factors for the total NAMA (i.e. 10 RP equivalents, including the RP that will be the first WTE installation under the NAMA). It is noted that, except for the two factors mentioned below, Table 7-5 is prepared by multiplying by 10 the corresponding RP values, derived from Table 7-15 for costs and from Table 7-4 for financing.

There are two special items.

- Cost of detailed technical feasibility study: USD 150,000 (included in column L of Table 7-5)

  This cost is to be funded a NAMA international supporter.

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

- Cost for the NAMA central unit: USD 750,000 (included in column L of Table 7-5)

  This cost (pertaining to management of the NAMA, provision of capacity building training, awareness building, etc.) is expected to be USD 750,000 – approximately 5% of the total investment cost of USD 15,027,976.

  As mentioned in Section 7.2, this is assumed to be borne by the Moldovan government as part of the country's national ambition potentially with funding support from other programmes.

Table 7-5: Cash flow model for the total NAMA with financing factors.

Total $BNIP_k$										**BCNU**			**BTN**
Total investment costs	O&M costs	Income	Subtotal	Grants	Funds contributed by equity investors	Loans borrowed	Loans repayment	Interest payments	Annual BNIP surplus / deficit	Cash inflow	Cash outflow	Annual BCNU surplus / deficit	Annual BTN surplus / deficit
A	B	C	D=C-A-B	E	F	G	H	I	J=D+E+F+G-H-I	L	M	N=L-M	O=J+N
15,027,976	25,604,615	65,811,200	25,178,608	0	2,146,876	7,449,675	7,449,675	0	27,325,484	900,000[60]	900,000[61]	0	27,325,484

[60] USD 150,000 from an international NAMA supporter and USD 750,000 from the Moldova central government and/or from an international donor other than the NAMA supporter.

[61] USD 150,000 for a detailed technical feasibility study and USD 750,000 for NAMA management, capacity building and awareness building.

2. Estimated cost for tCO_2e of emission reduction for the total NAMA

The calculation of USD per ton of CO_2-equivalent emission reductions would be straightforward if the international support consisted of grants. However, the major part of the planned financial support for the NAMA consists of concessionary international loans, raising the issue of how to gauge their cost.

Cost of the concessionary international loans

Fully recognizing that each potential NAMA funding source will have its own method of assessing the cost of loans it makes, two approaches are taken by this NAMA PDD.

- Approach 1: Treat loans as if they were grants and consider the amount of loans as the cost of NAMA support.
- Approach 2: Consider the cost as the net present value (NPV) of the loans, calculated as the difference between the NPV of loans made and the NPV of the loans repaid, as shown in Table 7-7. Pursuant to the suggestion from the Moldova Team, a discount rate of 9% is used.

Obviously, neither of the approaches is fully adequate. Approach 1 is overly conservative in equating loans to be repaid with grants that are not. Approach 2 is the opposite and results in underestimated *ex ante* evaluation of the cost in failing to include the cost of possible default[62].

It will nevertheless be relevant to analyze the two ends of the conservativeness spectrum. Table 7-6 shows the cost of international loans for the NAMA.

Table 7-6: Cost of international loans

Approach	Cost (USD)
Approach 1	7,449,675 (Table 7-5, column G)
Approach 2	1,988,025 (Please refer to Table 7-7, column D)

Table 7-7: NPV approach for the cost of public sector loans[63].

Assumed discount rate for public loans A	NPV of loans borrowed (USD) B	NPV of loans repayment (USD) C	NPV of the loans from supporter (USD) D=B-C
9%	7,190,339	5,202,314	1,988,025

[62] It is of note that *ex post* assessment under Approach 2 includes as cost the loans that have failed to be repaid.
[63] For details of the calculation, please refer to Table 4d of NAMA BM spreadsheet attached to Annex 4.

Emission reductions during the lifetime of the NAMA

This is estimated to be 3,387,114 tCO_2e based on Table 4-4.

Summary

Table 7-8 provides the summary. As row (VII) shows, Approaches 1 and 2 yield a range of USD 0.631 and USD 2.244 as international support for tCO_2e of emission reduction. Even when the presumptive costs for capacity building and NAMA management are included, the range will be USD 0.853 – USD 2.465 per tCO_2e of emission reduction.

Table 7-8: Cost effectiveness of the NAMA

Item	Approach 1	Approach 2
(I) Grant for detailed feasibility study (USD)	150,000	150,000
(II) Cost of public sector loans (USD)	7,449,675	1,988,025
(III) Subtotal: (I) + (II) (USD)	7,599,675	2,138,025
(IV) Grants for capacity building and NAMA management (USD)	750,000	750,000
(v) Grand total: (III) + (IV) (USD)	8,349,675	2,888,025
(VI) Emission reductions (tCO_2e)	3,387,114	3,387,114
(VII) Narrowly defined cost effectiveness: **(III) / (VI) (USD/ tCO_2e)**	2.244	0.631
(VIII) Broadly defined cost effectiveness: **(V) / (VI) (USD/ tCO_2e)**	2.465	0.853

7.5 Budgeting and cash flow modelling

7.5.1 Budget for the RP without financing factors

Accurate and dependable budgeting is an indispensable prerequisite for financial planning. 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.

Due to the lack of a detailed feasibility study, these budgets are estimated based on certain assumptions delineated below.

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:

(a) LFG collection and flaring systems

The cost estimation for LFG C&F system refers principally to the Landfill Methane Outreach Program (LMOP) cost model[64] that, prepared by U.S. Environmental Protection Agency (USEPA), is deemed a reliable source for general data. When appropriate, LMOP default values are modified pursuant to other literature sources and/or author's own experience about similar projects as noted.

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

- Engineering, permitting (as applicable), and administration;
- Wells and wellheads;
- Pipe gathering[65] system (includes additional fittings/installations);
- Condensate knockout system;
- Blowers;
- Instrument controls;
- Flaring equipment; and
- Site surveys, preparation and utilities.

The plans for the selected RP is based on a study conducted by GIZ. As stated in Section 5.1, the selected RP relates to an existing site and a new sanitary landfill, adjacent to each other. The existing site has accepted solid waste disposal since the early 1990s, but the installation of gas extraction wells and pipes will be started in project year 0. As per the GIZ report, the new landfill site will be divided into 3 cells to be constructed and filled with waste in different years as follows:

- Cell 1 will be constructed in project year 1 and started for waste disposal at the same year and in parallel with the installation of gas extraction wells and pipes.
- The same approach will be applied to Cell 2 in project year 7.
- The same approach will be applied to Cell 3 in project year 15.

In view of the above construction and installation plans of the selected 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 of the 3 new cells. Each C&F system includes gas extraction wells, wellheads and pipe gathering system, knockout and blower. One flare will be shared by the new and existing sites.

Table 7-9 summarizes the estimated total investment costs of the LFG C&F systems for the RP as USD 694,198. For detailed cost estimation and its calculation procedures on each typical component, please refer to Section 1.2.2.1 of Annex 4.

[64] "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).
[65] The term "gathering", employed for the LMOP cost model, is used in this Report synonymously with "collection" and sometimes "capture" in relation to LFG C&F systems.

Table 7-9: 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	68,231	0	3,500	172,833
Cell 2	25,482	85,000	75,019	0	3,500	189,001
Cell 3	26,522	119,000	71,940	0	4,900	222,362
Sub-total	68,106	289,000	215,189	0	11,900	584,195
Total	77,268	340,000	242,929	20,000	14,000	694,198

Lifetime

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[66]. 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. 10 years after landfill closure, LFG generation will be small. Therefore, no replacement of any LFG collection system is planned for the RP.

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[67].

(b) 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.

[66] Data source: p.10 of the LMOP cost model.
[67] 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.

Table 7-10: 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 implementation plan of the RP to install gas engines at different years, the operation period of the power generation facility will be 31 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[68]. This is based on the past experience in the sector that the price for a 100 kW gas engine is approximately USD 75,000 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.

(c) Other

It is noted that as per the document for the LMOP cost model[69], the default values applied above include direct costs for equipment and installation, and indirect costs associated with project design and administration, mobilization/demobilization of construction equipment, etc.

Total initial investment costs

In summary, the total initial investment costs of the RP are USD 1,502,798, with the investment payment schedule based on its implementation plan delineated in Table 7-11 below.

Table 7-11: 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 (61%)			OY				104,602
2 (2019)		II 68,231 (39%)				II 75,000 (11.4%)			143,231

[68] The lifetime of 15 operational years is sourced from a technology provider, who author has in contact with.
[69] Data source: p.4-5 of the LMOP cost model.

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	
3 (2020)		OY				OY	II 75,000 (11.4%)		75,000
4 (2021)							OY		-
5 (2022)									-
6 (2023)									-
7 (2024)			II 113,982 (60%)						113,982
8 (2025)			II 75,019 (40%)					II 75,000 (11.4%)	150,019
9 (2026)			OY					OY	-
10 (2027)									-
11 (2028)									-
12 (2029)									-
13 (2030)									-
14 (2031)									-
15 (2032)				II 150,422 (68%)	RI[(d)] (Genset 5) 75,000				-225,422
16 (2033)				II 71,940 (32%)	ROY[(e)] (Genset 5)				71,940
17 (2034)				OY		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)									-
29 (2046)									-
30 (2047)									-
31 (2048)									-
Total	110,002	172,833	189,001	222,362	808,600				1,502,798

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

2. Total O&M costs

The total operation and maintenance O&M costs of the RP are composed of annual expenses for its two major components. They are:

(a) 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[70]. The model classifies annual O&M costs into two categories: (i) all annual operating and maintenance costs excluding energy costs, and (ii) annual energy costs for electricity usage by blowers.

For item (i), 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 938,100. This is equal to an annual average of USD 30,261 (=USD 938,100 / 31). For detailed breakdown, please see column 2 of Table 7-12 below or Section 1.2.4.1 of Annex 4.

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

For item (ii), 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.

(b) 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)[71] for maintenance, including overhaul costs. This value 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)"[72], in this initial financial analysis. These costs are shown in column 3 of Table 7-12.

The total O&M costs for the RP are summarized in Table 7-12.

Table 7-12: Total O&M costs for the RP. **Unit: USD**

1	2	3	4
Project year (calendar year)	O&M costs		
	C&F systems excluding energy costs	Power generation facility	Total

[70] Data source: p.21 of the LMOP cost model.
[71] The exchange rate, sourced from the Hongkong and Shanghai Banking Corporation Limited on 18/11/2015, is 1.073 USD/EUR.
[72] Link of the CDM project: http://cdm.unfccc.int/Projects/DB/DNV-CUK1343113895.99/view.

1	2	3	4
Project year (calendar year)	O&M costs		
	C&F systems excluding energy costs	Power generation facility	Total
1 (2018)	12,900	12,760	25,660
2 (2019)	12,900	10,884	23,784
3 (2020)	25,900	44,016	69,916
4 (2021)	25,900	50,896	76,796
5 (2022)	25,900	56,748	82,648
6 (2023)	25,900	61,738	87,638
7 (2024)	25,900	52,434	78,334
8 (2025)	25,900	44,642	70,542
9 (2026)	38,900	72,815	111,715
10 (2027)	38,900	75,534	114,434
11 (2028)	38,900	77,890	116,790
12 (2029)	38,900	79,940	118,840
13 (2030)	38,900	81,730	120,630
14 (2031)	38,900	83,299	122,199
15 (2032)	38,900	71,111	110,011
16 (2033)	31,100	60,881	91,981
17 (2034)	49,300	86,990	136,290
18 (2035)	36,300	78,668	114,968
19 (2036)	36,300	68,032	104,332
20 (2037)	36,300	68,032	104,332
21 (2038)	36,300	68,032	104,332
22 (2039)	36,300	68,032	104,332
23 (2040)	36,300	60,419	96,719
24 (2041)	23,300	37,394	60,694
25 (2042)	23,300	31,956	55,256
26 (2043)	23,300	27,391	50,691
27 (2044)	23,300	23,552	46,852
28 (2045)	23,300	20,319	43,619
29 (2046)	23,300	17,594	40,894
30 (2047)	23,300	15,291	38,591
31 (2048)	23,300	13,342	36,642
Total	938,100	1,622,362	2,560,462

3. Revenues

Consistent with Section 5.5.4 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 126 / 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 the following documents provided by the Moldova country team:

  (i) "Methodology for the Determination, Approval and Application of Tariffs for the Electricity Generated from Renewable Electric Energy and Fuel" – This methodology is developed according to the provisions of the Renewable Energy Act (No. 160-XVI of 12.07.2007) and the National Accounting Standard (NAS) of the Moldova and aims at establishing a methodology for the determination, approval and application of regulated tariffs for all producers of electric energy generated from renewable sources. It is stipulated that the producers shall determine the Feed-in Tariff (FiT) every year and submit it to the Administration Council of the National Agency Energy Regulation (ANRE) for approval.

  (ii) "Development of Renewable Energy Support Mechanisms for Moldova – Task 2 Final Report: Development of Methodology for Feed-in Tariffs" – This EBRD-funded report includes a chapter entitled "Evaluation of Current Feed-in Tariff Methodology in Moldova" that provides a good summary of the current FiT system in the country.

  For detailed tariff estimation, please refer to Section 2.1.1 of Annex 4.

- At USD 126/MWh, the project has a payback period of 10 years. As mentioned in Section 2.1, separate to the formula-based tariff, energy experts say ANRE uses a 10 year payback period as rule-of-thumb payback for approving tariffs.

- The recommended tariff level is consistent with the EU practices. According to one authoritative report on biogas utilization in Central and Eastern Europe[73], the FiT for a biogas power plant of 150 kW ~ 500 kW is EUR 123/MWh in Germany and EUR 119.7 for Bulgaria.

On this basis, and based on the electricity generation estimates provided in Section 5.5.7, the following Table 7-13shows the revenues from electricity sale.

Table 7-13: 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	126	51,761
2 (2019)	350		44,151
3 (2020)	1,417		178,551

[73] Sustainable biogas market development in Central and Eastern Europe https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/biogasin_publishable_final_report.pdf (p22 for Germany and p12 for Bulgaria)

Project year (calendar year)	Annual net electricity generation	Electricity tariff	Annual revenues from electricity sale
	MWh/y	USD/MWh	USD/y
4 (2021)	1,639		206,460
5 (2022)	1,827		230,199
6 (2023)	1,988		250,441
7 (2024)	1,688		212,700
8 (2025)	1,437		181,089
9 (2026)	2,344		295,373
10 (2027)	2,432		306,403
11 (2028)	2,508		315,962
12 (2029)	2,574		324,276
13 (2030)	2,631		331,537
14 (2031)	2,682		337,905
15 (2032)	2,289		288,461
16 (2033)	1,960		246,963
17 (2034)	2,801		352,876
18 (2035)	2,533		319,117
19 (2036)	2,190		275,974
20 (2037)	2,190		275,974
21 (2038)	2,190		275,974
22 (2039)	2,190		275,974
23 (2040)	1,945		245,088
24 (2041)	1,204		151,689
25 (2042)	1,029		129,632
26 (2043)	882		111,110
27 (2044)	758		95,537
28 (2045)	654		82,426
29 (2046)	566		71,368
30 (2047)	492		62,028
31 (2048)	430		54,122
Total	52,231	-	6,581,120

4. Budget for the RP without financing factors

(a) Summary of budget items

Table 7-14 summarizes the key budget items discussed in the foregoing sections.

Table 7-14: Key budgeting parameters for the RP.

Parameter	Unit	Value	Source
Cash in-flow from electricity sale	USD/y	352,876	The maximum revenue earned throughout the project lifetime, summarized in Table 7-13.
Initial investment costs - WTE facility	USD	1,502,798	For details of initial investment costs, please refer to Table 7-11.
Total O&M costs	USD/y	136,290	The maximum annual O&M costs, which are for C&F systems and power generation facility, expensed throughout

			the project lifetime, listed in Table 7-12.

(b) Budget without financing factors

The budget corresponding to these input parameters is summarized in Table 7-15 that constitutes the Core Budget of the RP (i.e. Budget 1).

Table 7-15: Core Budget (i.e. without financing factors) for the RP. **Unit: USD**

Project year (calendar year)	Investment in fixed assets[74] 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	51,761	-78,501	-622,103
2 (2019)	143,231			143,231	23,784	44,151	-122,864	-744,967
3 (2020)	75,000			75,000	69,916	178,551	33,635	-711,333
4 (2021)	0			0	76,796	206,460	129,664	-581,668
5 (2022)	0			0	82,648	230,199	147,551	-434,117
6 (2023)	0			0	87,638	250,441	162,803	-271,314
7 (2024)	113,982			113,982	78,334	212,700	20,384	-250,931
8 (2025)	150,019			150,019	70,542	181,089	-39,471	-290,402
9 (2026)	0			0	111,715	295,373	183,658	-106,743
10 (2027)	0			0	114,434	306,403	191,969	85,226
11 (2028)	0			0	116,790	315,962	199,172	284,398
12 (2029)	0			0	118,840	324,276	205,436	489,834
13 (2030)	0			0	120,630	331,537	210,908	700,742
14 (2031)	0			0	122,199	337,905	215,705	916,447
15 (2032)	225,422			225,422	110,011	288,461	-46,972	869,475
16 (2033)	71,940			71,940	91,981	246,963	83,043	952,518
17 (2034)	75,000			75,000	136,290	352,876	141,586	1,094,104
18 (2035)	0			0	114,968	319,117	204,149	1,298,253
19 (2036)	0			0	104,332	275,974	171,641	1,469,894
20 (2037)	0			0	104,332	275,974	171,641	1,641,535

[74] In financial discussions about climate change projects, the concept of "incremental cost" is important. This is the additional cost to be incurred for mitigating GHG emissions. For the NAMA, the baseline is not to install a LFG collection and utilization equipment. Thus, all the costs for the LFG collection and utilization equipment are incremental costs.

Project year (calendar year)	Investment in fixed assets[74] 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 $H_y=H_{y-1}+G_y$
21 (2038)	0			0	104,332	275,974	171,641	1,813,177
22 (2039)	0			0	104,332	275,974	171,641	1,984,818
23 (2040)	0			0	96,719	245,088	148,370	2,133,188
24 (2041)	0			0	60,694	151,689	90,995	2,224,183
25 (2042)	0			0	55,256	129,632	74,375	2,298,558
26 (2043)	0			0	50,691	111,110	60,419	2,358,977
27 (2044)	0			0	46,852	95,537	48,686	2,407,663
28 (2045)	0			0	43,619	82,426	38,806	2,446,469
29 (2046)	0			0	40,894	71,368	30,475	2,476,944
30 (2047)	0			0	38,591	62,028	23,437	2,500,381
31 (2048)	0			0	36,642	54,122	17,480	2,517,861
Total	1,502,798			1,502,798	2,560,462	6,581,120	2,517,861	2,517,861

7.5.2 Budget for the Central NAMA Unit (BCNU)

It is assumed 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 potentially with funding support from other programmes.

The specific budget amount for the NAMA central unit costs is discussed in relation to the total NAMA cash flow shown in Table 7-5.

7.5.3 Cash flow modelling and analysis

Based on the Core Budget of the RP developed above and summarized in Table 7-15, Table 7-16 represents the cash flow model for the RP without financial factors.

Table 7-16: 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	51,761	25,660	26,101	26,101	-78,501
2 (2019)	143,231	44,151	23,784	20,367	46,468	-122,864
3 (2020)	75,000	178,551	69,916	108,635	155,103	33,635
4 (2021)	-	206,460	76,796	129,664	284,767	129,664
5 (2022)	-	230,199	82,648	147,551	432,318	147,551
6 (2023)	-	250,441	87,638	162,803	595,121	162,803
7 (2024)	113,982	212,700	78,334	134,366	729,487	20,384
8 (2025)	150,019	181,089	70,542	110,548	840,034	-39,471
9 (2026)	-	295,373	111,715	183,658	1,023,693	183,658
10 (2027)	-	306,403	114,434	191,969	1,215,662	191,969
11 (2028)	-	315,962	116,790	199,172	1,414,834	199,172
12 (2029)	-	324,276	118,840	205,436	1,620,270	205,436
13 (2030)	-	331,537	120,630	210,908	1,831,178	210,908
14 (2031)	-	337,905	122,199	215,705	2,046,883	215,705
15 (2032)	225,422	288,461	110,011	178,450	2,225,333	-46,972
16 (2033)	71,940	246,963	91,981	154,982	2,380,315	83,043
17 (2034)	75,000	352,876	136,290	216,586	2,596,901	141,586
18 (2035)	-	319,117	114,968	204,149	2,801,050	204,149
19 (2036)	-	275,974	104,332	171,641	2,972,692	171,641
20 (2037)	-	275,974	104,332	171,641	3,144,333	171,641
21 (2038)	-	275,974	104,332	171,641	3,315,974	171,641
22 (2039)	-	275,974	104,332	171,641	3,487,616	171,641
23 (2040)	-	245,088	96,719	148,370	3,635,985	148,370
24 (2041)	-	151,689	60,694	90,995	3,726,980	90,995
25 (2042)	-	129,632	55,256	74,375	3,801,355	74,375
26 (2043)	-	111,110	50,691	60,419	3,861,775	60,419

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
27 (2044)	-	95,537	46,852	48,686	3,910,460	48,686
28 (2045)	-	82,426	43,619	38,806	3,949,267	38,806
29 (2046)	-	71,368	40,894	30,475	3,979,741	30,475
30 (2047)	-	62,028	38,591	23,437	4,003,178	23,437
31 (2048)	-	54,122	36,642	17,480	4,020,658	17,480

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 Internal Rate of Return (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 column H of Table 7-15, it is in the 10th year when the cumulative total of net operating cash flows turns to a positive figure (USD 85,226). Thus, the RP has a payback period of 10 years with a tariff of USD 126/MWh.

8. NAMA Implementation Structure

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

Contact information for the NAMA is as follows:

Name	Dr. Tatiana Tugui
Title	Manager, Environmental Pollution Prevention Office, Ministry of Environment
Role	Project Management Unit
Responsibility	NAMA focal point
Address	9 Cosmonautilor St, Office 736, Chisinau
Email	TBD (info@eppo.md)

The exact composition and members of the NAMA central coordination unit will be confirmed after the international funds are approved.

The Government will set up an organizational structure for the development of the WTE NAMA project. The key operation bodies and implementing partners which constitute the framework are shown in

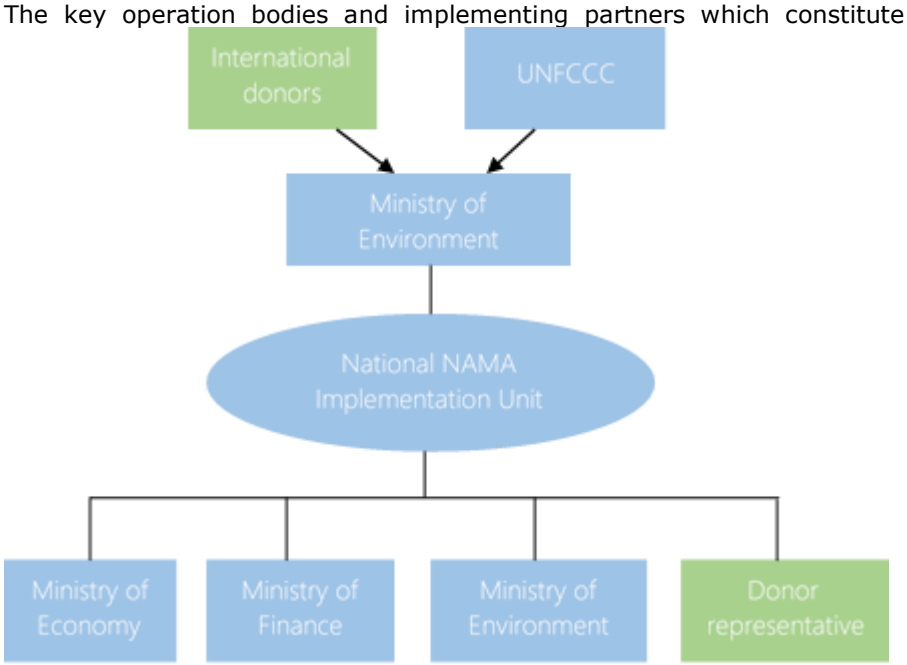

Figure 8-1.

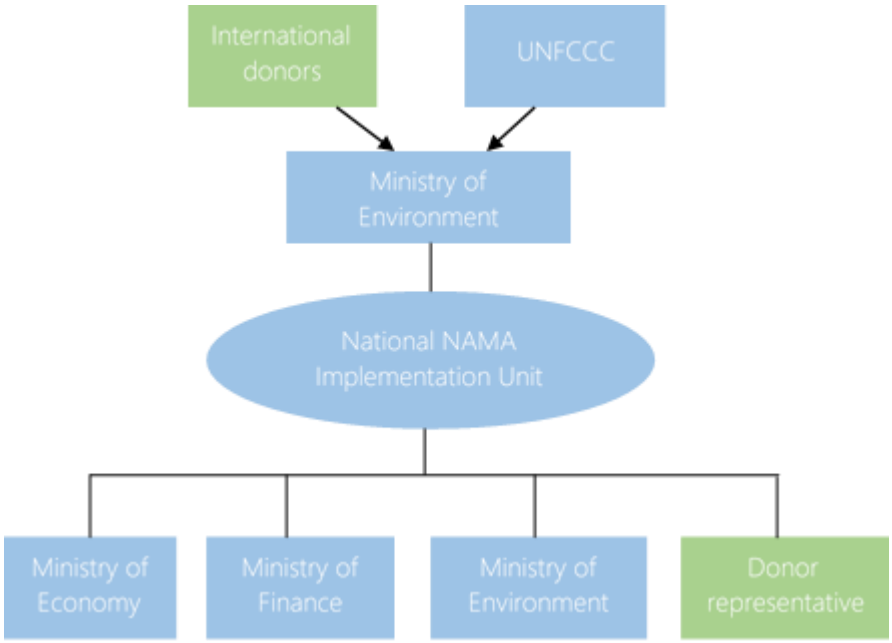

Figure 8-1: NAMA implementation framework

The framework involves all institutions that are needed to develop, implement and manage the implementation of the WTE NAMA. It will have to reflect the complexity of the NAMA programme which is cross-sectoral and covers a broad range of topics such as renewable energy, mitigation of climate change, market development and financing. In the context of the NAMA, the institution could divide tasks and responsibilities as follows:

1. National NAMA Implementation Unit

   Since the NAMA will be implemented within the framework of international climate policy, the MoEN will lead and supervise the NAMA implementation process through a National NAMA Implementation Unit. The Implementation Unit will be created by Government Decree.

   The Climate Change Office of the MoEN has the mandate to promote and implement climate change related programmes and projects and will be responsible for communicating and reporting NAMA relevant activities at the international level, for example, to the UNFCCC.

   The National NAMA Implementation Unit will be responsible for negotiating international support for NAMA implementation with international donors. If financial support is granted, the NAMA Implementation Unit will be the recipient and responsible for channeling resources to the implementers of the NAMA components, local governments, project developers, etc.

2. Supporting ministries and stakeholders

   The Ministry of Economy, the Ministry of Finance and Donors' representatives will support the NAMA implementation process where necessary, which may include, among other activities, the setting of objectives, approving and monitoring the implementation plans in their respective fields of activity.

   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.

8.1 Phased implementation plan

In relation to risk mitigation discussed in Section 0, the NAMA will be implemented in three phases. 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 (Project year 0 or earlier)	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 (Project year 0)	Implementation of the RP as a first WTE facility	▪ 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	

8.2 Implementation schedule

A Gantt chart is depicted for Phase 2 (i.e. the implementation of the RP) in Table 8-2. In the light of uncertainty as to when the full implementation (i.e. the 9 further projects) will begin and the extent of synchronization of the number of individual projects, no implementation schedule is given for Phase 3 of the NAMA.

Table 8-2: Gantt chart for Phases 1 and 2 of the NAMA

Activity for Phases 1 and 2 of the NAMA	Expected implementation schedule (in terms of project year)
	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
PHASE 1	
Feasibility Study	
PHASE 2	
Existing site	
1. Construction	
2. Last year of waste acceptance at existing site	
3. LFG is collected and fed to the generator	
4. Closure of the existing site	
New site - Cell 1	
5. Construction	
6. Waste acceptance period	
7. LFG is collected and fed to the generator	
8. Closure of Cell 1	
New site - Cell 2	
9. Construction	
10. Waste acceptance period	
11. LFG is collected and fed to the generator	
12. Closure of Cell 2	
New site - Cell 3	
13. Construction	
14. Waste acceptance period	
15. LFG is collected and fed to the generator	
16. Closure of Cell 3	

9. Measuring, Reporting & Verification

The NAMA comprises multiple individual projects. Its data measurement activities shall be carried out at each individual project site, considering complexity of the individual projects. 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 central coordinating unit

In order to ensure measurement activities are conducted appropriately at the RP and other individual project sites, measures such as (a) extensive training/capacity building at the initial stage, (b) mandating submission of monthly (or otherwise regularly) measurement reports, and (c) regular on-site inspection shall be taken. This is under the oversight of MRV Aggregator, who will be part of the NAMA central coordinating unit. The relationships between the project implementer and NAMA central coordinating unit 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.

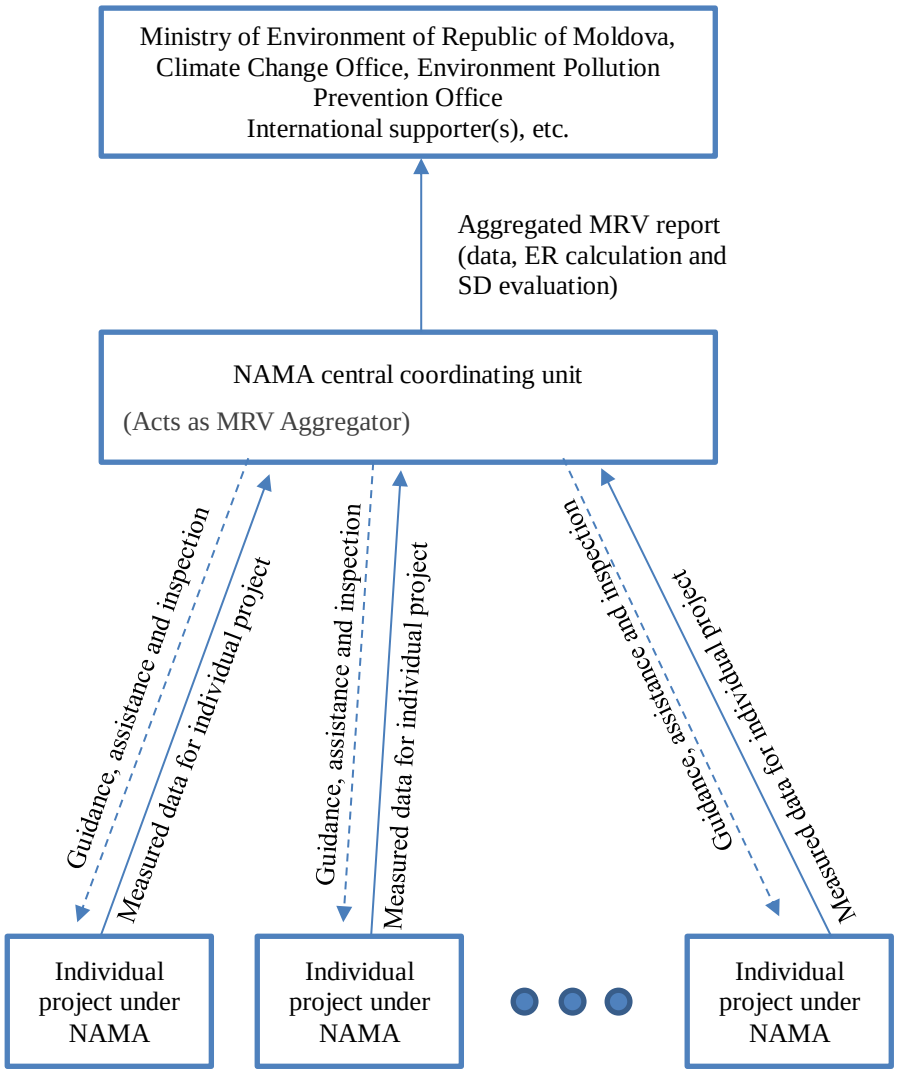

Figure 9-1: Overall reporting and management structure of the NAMA.

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.

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.

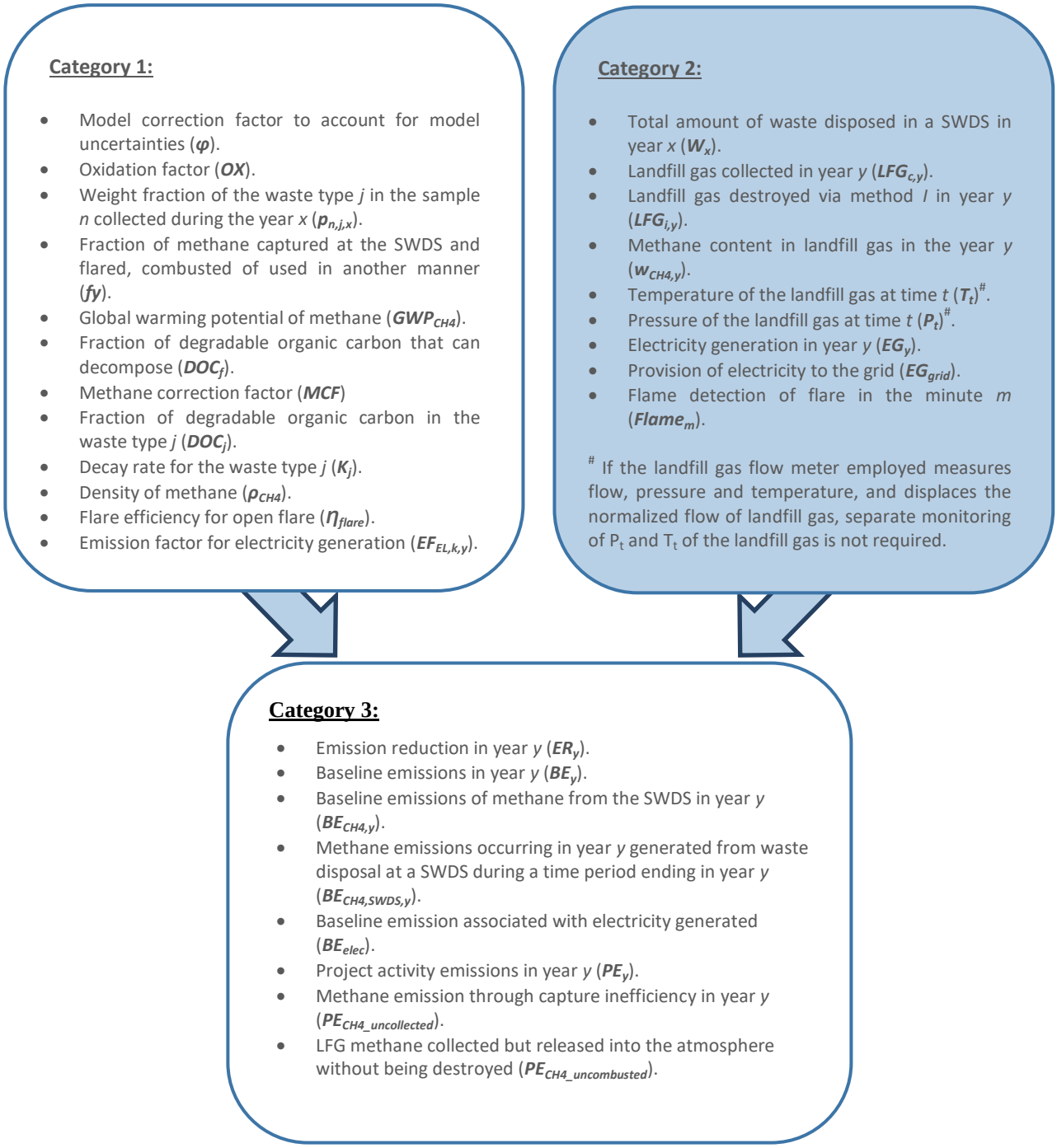

Figure 9-2: List of parameters to calculate GHG emission reductions *ex post*.

The measurement methods, frequency, and QA/QC procedures for each of Category 2 parameters are summarized in Table 9-2 to Table 9-10[75].

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

Data / Parameter:	W_x
Data unit:	T

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

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.

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%[76]

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 NAMA projects.

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

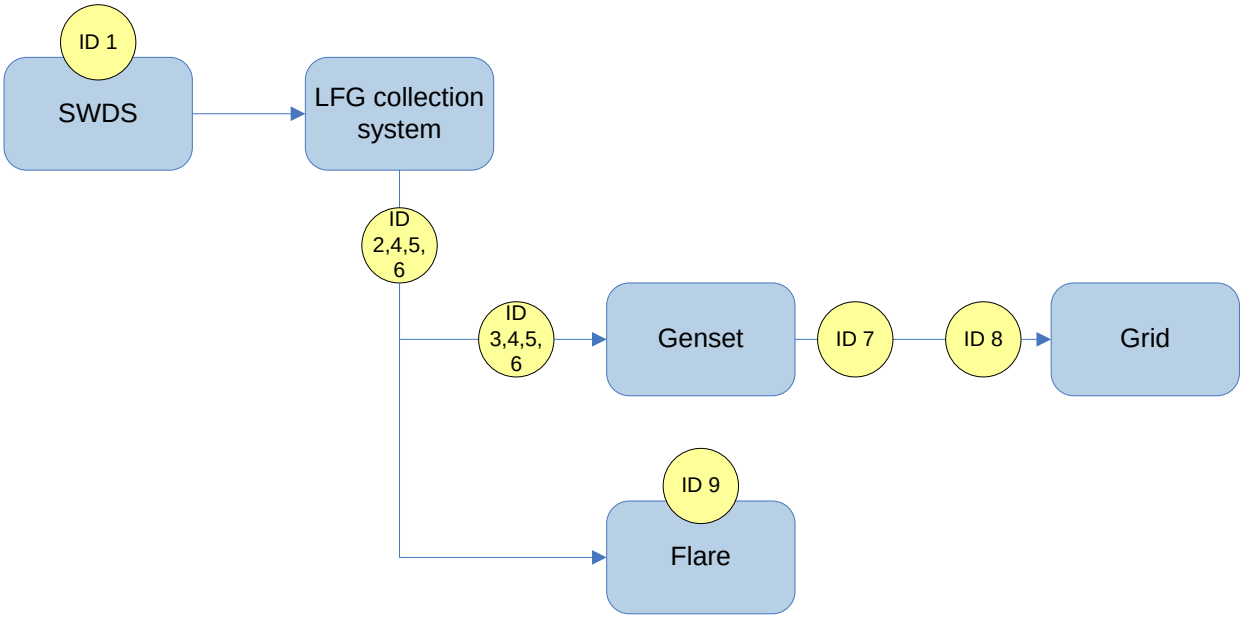

Figure 9-3: Line diagram with all relevant measurement points.

ID No.	Parameter	Nomenclature
ID 1	Total amount of waste disposed in a SWDS in year *x*	W_x
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.

In addition, an *ex-post* calculation spreadsheet, which is designed to facilitate the NAMA central coordinating unit 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**[77] 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 (m^3)	
Way of monitoring	How	This parameter will be measured indirectly by monitoring the quantity of LFG collected and destroyed by the intervention using an appropriate meter(s).
	Frequency	Once in 3 years[78]
	By whom	Project implementer
Project value	268,156[79] (m^3)	
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 central coordinating unit

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
Project value	2,300[80] (tCO_2e)	
QA/QC procedures	-	
	QC check done	-

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

[77] For the sake of clarity, the table format in Annex 6 is applied instead of the table format given in this PDD template.
[78] 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.
[79] For illustrative purposes, this is the assumed quantity of methane collected and destructed by the intervention at the end of year 1.
[80] For illustrative purposes, this is the assumed number of ERs accumulated by the intervention at the end of year 1.

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[81]	
QA/QC procedures	This will be cross-checked against the training materials provided and/or training attendance records.	
	QC check done	NAMA central coordinating unit

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[82] (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 central coordinating unit

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

Serial number 5	
Indicator name	Income generation/ expenditure reduction/ balance of payments
Domain	Economic
Parameter name	Remuneration paid to employees (income generation)
Baseline value	0 (USD)

[81] It is assumed that a training session is provided once per year.
[82] For illustrative purposes, this is the assumed quantity of net electricity supplied by the project to the grid at the end of year 1.

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[83] (USD)	
QA/QC procedures	This will be cross-checked against the remuneration receipts/records.	
	QC check done	NAMA central coordinating unit

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[84]	
QA/QC procedures	This will be cross-checked against the remuneration receipts/records.	
	QC check done	NAMA central coordinating unit

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

[83] 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).

[84] 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[85]	
QA/QC procedures	This will be cross-checked against the NAMA SD reporting records.	
	QC check done	NAMA central coordinating unit

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. These values are subject to change.

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

By inputting the baseline value (in column 6 of Table 9-18), the ex-ante target value is estimated (column 7) and the ex-post project value (i.e. intervention value monitored 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.

[85] 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 78.

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[86]	Measurement type	Baseline Value	Target value estimated (ex-ante)	Intervention Value monitored (ex-post)[87]	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	282,123	268,156	m^3CH_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/ Balance of	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%

[86] 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."

[87] This is equivalent to the project value mentioned in the text.

1	2	3			4	5	6	7	8	9	10	11	12
Domain	Indicator	Parameter Selection			Measurement value[86]	Measurement type	Baseline Value	Target value estimated (ex-ante)	Intervention Value monitored (ex-post)[87]	Unit	NAIs estimated (ex-ante)	NAIs monitored (ex-post)	Evaluation of Project Success
		Number of parameters selected per indicator	Parameter name	Effect									
	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, their mean values 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[88].

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

9.1.4 This will be gauged by the amounts of public sector financial assistance provided in response the financial needs identified in Section 7.4.Transformative Change

This has been discussed fully in Section 4.4. To avoid duplication, it is mentioned in this section that transformative change will be measured by two parameters, namely the number of RP-equivalent projects implemented and the amounts of private sector investment made for them.

9.2 Reporting

Reporting in the context of a NAMA MRV system is commonly defined as "presenting the measured information in a transparent and standardised manner"[89].

While this seems straightforward, it actually involves a management issue for the NAMA due to the coexistence of two factors. One is that the only practical approach to measurement with respect to the NAMA is to have it carried out for each individual project. The other factor is the fact that reporting will not be complete without the calculations of GHG emission reductions or SD benefits based on the measured data.

[88] 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."

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

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

1. GHG emission reductions

A two-tier reporting approach is recommended as follows:

Tier 1: Each individual project implementer conducts measurements as outlined in Section 9.1.1.

Tier 2: Each individual project implementer relays the measured data to the NAMA central coordinating unit that will perform emission reduction calculation, with the assistance of an outside expert if necessary.

2. SD benefits

A two-tier reporting approach is recommended as follows:

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

Tier 2: Each individual project implementer relays its SD evaluation results together with the measured data to the NAMA central coordinating unit that will provide an overview of the SD evaluation at a NAMA level, with the assistance of an outside expert if necessary.

The reporting is provided at an individual project level and at a NAMA-wide level are presented in Table 9-1 and Figure 9-1.

For the reporting contents of the GHG mitigation and SD benefits, please refer to Appendix C-1 and Appendix C-2 of Annex 6 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 official UNFCCC rule for NAMA verification, the decision on how exact the verification process for a particular NAMA is left to the NAMA central coordinating unit, 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 with deviations when appropriate.

As discussed above, the practical approach to measurement with respect to the 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 central coordinating unit, 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 two-tiered MRV reports (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 NAMA (prepared by MRV aggregator) shall be reviewed by interested parties, such as the project implementer, NAMA central coordinating unit, 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 NAMA involves before discussing possible measures for their mitigation and management.

1. Types of risk of the NAMA

Table 10-1 summarizes the risks most pertinent to this NAMA, together with the assessment of their risk levels. Each of the risks is elaborated after the table.

Table 10-1: Summary of the risks and their levels.

No.	Risk level	Risk type
(1)	High	Under performance (waste volume)
(2)	Medium	Under performance (LFG generation)
(3)	Medium	Cost overrun
(4)	Medium	Tariff
(5)	Low	Equipment malfunctioning

(1) Under performance (waste volume)

Most LFG collection and utilization projects are conducted at a well-established site with a proven track record of waste delivery, where future waste volumes and compositions can be projected with reasonable accuracy 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 is generated from new sites to be started as part of Moldova's effort to improve the quality of waste management in the country, with the assistance of an international partner(s).

(2) Under performance (LFG generation)

This issue, common to all LFG collection and utilization projects, is of particular relevance to the NAMA, due to the lack of historical data and complete model dependency for 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.

(3) 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. As seen in Section **Error! Reference source not found.**, generic information about costs is mostly based on the model for the LMOP, prepared by US EPA. While the model's credibility and the data on which it is based is of high quality, the site-specific nature of LFG collection systems requires caution.

(4) Tariff

Revenues for the NAMA are dictated by the FiT granted to it. Having extensively discussed the tariff issues, the Moldova team and Asiatica believe that the assumed tariff level (USD 126/MWh) is reasonable. Nonetheless, this is without a confirmation at this time.

(5) Equipment malfunctioning

LFG collection and utilization activity undertaken by the NAMA applies a proven technology, functioning well in a great many countries in the world. It is different than 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 mindful of the highly site-specific nature of this technology in terms of waste composition, geology, moisture, impurities, etc. in order to ensure proper functioning of the LFG collection system and the electricity generation equipment.

It is added that as regards environmental and social aspects, the NAMA intervention will pose little risk, while producing overwhelmingly positive effects.

2. Risk mitigation measures

The NAMA design includes measures to mitigate two of the five risks.

- A detailed feasibility study planned and funded as an integral part of the NAMA will substantially mitigate, though not eliminate, Risk (3) (i.e., cost overrun).
- The availability of such a feasibility study will help finalize the FiT rate before investments are committed, eliminating Risk (4).

3. Risk management

Unfortunately, the remaining three risks defy definite mitigation measures. Faced with this type of situation, which is not rare in practice, the approach often adopted is to *manage* the risks though financial structuring [90]. For the NAMA under discussion, this entails the development of a financial structure that is agreeable to both an international supporter and private sector investors, in terms of risk benefit comparison. The ensuing sections explain how this is to be achieved.

For the private sector investors, the three risks (as well as the risk of cost overrun in comparison with the detailed feasibility study) will be significantly reduced by the provision of a bridge loan outlined in Section 7.3, which allows them to make investment only after three years of successful operation.

Naturally, the investment is not risk free. For example, after successfully operating for the first three years, the LFG collection system may be impaired by unusually heavy rainfall. It is also possible that at some point after three years, one of the large communities whose waste has been transported to the SWDS may decide to start its own composting programme, greatly reducing the amount of organic waste supplied to the SWDS. Nonetheless, the investor is likely to consider such risks as acceptable, in view of the reasonably good payback period (10 years initially and 7 years when counted from the time private sector investment is made after three years' operation).

[90] Please note the use of the term "manage" as opposed to "mitigate". This is because financial structuring is a zero-sum game, to use the term in game theory, and does not reduce the amount of the total risk. Instead, it attempts to distribute the risks in such a way that will be acceptable to participants.

For the international NAMA supporter, one of the good points of the proposed financial structure is the following phased approach mentioned in Section 0.

- Phase 1: Feasibility study
- Phase 2: Implementation of the RP as the first WTE installation
- Phase 3: Full implementation, consisting of 9 RP equivalents (10 RP equivalents in total, combining Phases 2 and 3)

This phased approach will offer two benefits to the potential international NAMA supporter: (1) Relatively small amounts required for Phase 1 (USD 150,000) and Phase 2 (USD 744,967); and (2) An opportunity to confirm the successful operation of the first WTE installation before making a more substantial amount of commitment for Phase 3.

The proposed financial structure also means a cost effective way to assist GHG mitigation. As shown in line (VII) of Table 7-8 in Section 7.4, the cost for the international NAMA supporter per tCO_2e of reduction is estimated to be between USD 0.631 and USD 2.244, depending on how the costs of loans are calculated.

It is hoped that these two factors will convince the international NAMA supporter that extending the bridge loans is a reasonable risk to assume, despite the presence of Risk (1), Risk (2) and Risk (5).

11. Conclusion

The NAMA has four distinct advantages. It will:

1. Achieve GHG mitigation at a low cost (estimated to be USD 0.63 - USD 2.24 / tCO_2e reduction, depending on how the cost of loans is determined), while delivering a substantial amount of GHG reduction (3,387,114 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 the first WTE facility, the amount of international support is limited to less than USD 1 million (USD 150,000 for a feasibility study and USD 744,967 for the first WTE facility, totalling USD 894,967).

It is recommended to move forward expeditiously with the NAMA and seek international support for the first two phases, in anticipation of full implementation (Phase 3) later.

References

All sources of information referred to in the NAMA PDD are clarified in footnotes.

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 first WTE facility; 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. The first WTE facility implementation report	1.1 Implementation of the RP serving as the first WTE facility	1.1.1 Funding for the first WTE facility
2 Confirmation that attracting investment from the private sector (including municipalities) is possible.	1.2 Analysis of the results of the first WTE facility 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 first WTE facility is successful	1.3 Based on the outcome of the first WTE facility 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: Under performance (waste volume) – High		
Measure & Outcome Impacted	**Proposed and Planned Risk Mitigation Measures**	**Proposed and Planned Means to Track the Risk**
Amount of GHG emission reductions	For the implementer of individual projects: Provision of a public sector bridge loan until a credible track record of waste volume is established. For the provider of the bridge loan: Adoption of a phased implementation plan as delineated in Section 0.	To track the annual waste volume delivered to the landfill sites.
Risk B: Under performance (LFG generation) – Medium		
Measure & Outcome Impacted	**Proposed and Planned Risk Mitigation Measures**	**Proposed and Planned Means to Track the Risk**
Amount of GHG emission reductions	For the implementer of individual projects: Provision of a public sector bridge loan until a credible track record of waste volume is established. For the provider of the bridge loan: Adoption of a phased implementation plan as delineated in Section 0.	To track the quantity of LFG collected per ton of waste received.
Risk C: Cost overrun – Medium		
Measure & Outcome Impacted	**Proposed and Planned Risk Mitigation Measures**	**Proposed and Planned Means to Track the Risk**
Profitability of the intervention(s)	For both the implementer of individual projects and the provider of the bridge loan: Detailed feasibility study as the first step of the NAMA.	To track the actual cost and compare it against the projected cost.
Risk D: Tariff – Medium		
Measure & Outcome Impacted	**Proposed and Planned Risk Mitigation Measures**	**Proposed and Planned Means to Track the Risk**

Economic viability of the intervention(s)	For both the implementer of individual projects and the provider of the bridge loan: Negotiate with the relevant government authorities and agree on the tariff before making commitments on investments.	To track the actual tariff and compare it against the projected tariff.
Risk E: Equipment malfunctioning – Low		
Measure & Outcome Impacted	**Proposed and Planned Risk Mitigation Measures**	**Proposed and Planned Means to Track the Risk**
Amount of GHG emission reductions	For the implementer of individual projects: Provision of a public sector bridge loan until a credible track record of waste volume is established. Regular inspection and maintenance, including major overhauls, are planned. For the provider of the bridge loan: Adoption of a phased implementation plan as delineated in Section 0.	To track the number and length of the downtime occurrences of equipment.

Annex 3: Stakeholder consultations during the design phase

The following table lists stakeholder consultations held with stakeholders during missions. Please refer to the separate file attached to the PDD for a stakeholder consultation report.

List of relevant stakeholder consultations		
Dates and consultation topic	Relevant stakeholders attending	Brief summary of consultation and outcomes.
27 – 31/10/2014 Project design	Ministry of Environment, EIB, Commercial Banks	Confirmation of scope of intervention. Takeaway on financing.
16/03/2016 Project parameters	Ms. Tamara Guvir, MoEN	Confirmation of main project parameters.
15 - 18/03/2016 Energy parameters	Dr. Ion Comendant, Mr. Andrei Sula	Discussion on renewable energy laws, tariff calculation mechanisms, regulations relating to use of distribution grid, project boundary, baseline scenarios
18 - 22/03/2016 Financial structure	Mr. Vasile Scorpan, Dr. Ion Comendant, Mr. Sergiu Ungureanu	Confirmation of financial structure
19 – 22/04/2016 All topics	Dr. Tatiana Tugui, MoEN Ms. Tamara Guvir, MoEN Dr. Ion Comendant Mr. Andrei Sula	Further discussion and confirmation of existing and upcoming renewable energy laws, tariff calculation mechanisms, financial structure.