Balikpapan City, Indonesia

Pilot Testing Indonesia's Measurement, Reporting, and Verification (MRV) Framework on Waste Sector in Manggar Landfill, Balikpapan City

Manggar Landfill in Balikpapan City, East Kalimantan, was chosen as a suitable site for pilot testing the Landfill Gas (LFG) Recovery Methodology developed by the Ministry of Environment and Forestry (MoEF) and supported by Urban-LEDS II project. This also supports MoEF Regulation No. 72 of 2017 on the Guidelines for the Implementation of Measurement, Reporting and Verification (MRV) of Action and Resources for Climate Change Control.

ICLEI Case Study June 2021

Summary

Balikpapan City has a vision to be a leading, comfortable, and sustainable city in Indonesia. This vision is also associated with the city's aspirations to pursue low emission development as an effort to reduce greenhouse gas (GHG) emissions through several priority sectors - one of them is waste management, where the city aimed to reduce the total of 45,155 ton CO_2e equivalent (tCO_2e) of GHG emission by 2020 from baseline year 2010. The city's sanitary landfill, locally named Tempat Pembuangan Akhir (TPA) Manggar, has integrated gas networking pipelines and wastewater treatment units that allow them to capture methane gas released in the landfill and use it for cooking and street lighting of nearby communities. The MoEF and ICLEI Indonesia chose TPA Manggar as a pilot project site to test the LFG Recovery Methodology to measure and estimate the emission reduction of a mitigation action in the waste sector. By applying this methodology, the estimated GHG emissions reduction from this pilot project is 505 tCO_2e annually. Therefore, this pilot project will support the implementation of the Measurement, Reporting, and Verification (MRV) Framework of Indonesia's Nationally Determined Contribution (NDC) target by offering local governments a methodology that will allow them to quantify their GHG emissions reduction contribution.

Vertical and Horizontal Governance and Provision of MRV in National Policy

Law No. 16 of 2016 ratified Indonesia's commitment to the Paris Agreement. In November 2016, the Indonesian government submitted its first Nationally Determined Contribution (NDC) to the UNFCCC which outlined the country's commitment to transition to a low carbon and climate resilient future. The country had set an unconditional GHG reduction target of 29% and a conditional target of up to 41% by 2030 against 2010 levels under the BAU scenario.[3]

Therefore, in order to orchestrate a multi-level governance approach to meeting the NDC, the Presidential Regulation No. 61 of 2011 stated that provincial governments are mandated to prepare the regional action plans in reducing GHG emissions (locally named *Rencana Aksi Daerah Penurunan Emisi Gas Rumah Kaca* or RAD-GRK).[4] Meanwhile, cities and districts are only encouraged to prepare their action plans.

Hence, East Kalimantan has declared the province's commitment to reducing its GHG emissions by 19.07% from 2010 levels under BAU scenario by 2020 in its RAD-GRK and institutionalized through Governor Regulation No. 39/2014.[5] The RAD-GRK document, however, is currently under process to renew the planning period and the projected GHG emissions period from 2010-2020 to 2010-2030 to align with Indonesia's NDC.[6]

Facts & Figures

Population and Land Area

2020: 688,318 people and 503.3 km^2 [1]

Population Growth Rate

2010-2020: 2.06% [1]

Waste sector GHG Emission Reduction Target in 2020:

45,155 tCO_2e (using 2010 baseline)[2]

URBAN LEDS
URBAN LOW EMISSION DEVELOPMENT STRATEGIES

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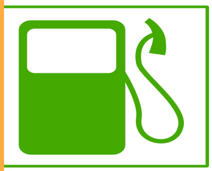
To facilitate an effective and transparent NDC implementation, an Integrated National Transparency Framework was also adopted. This framework is applied through the following mitigation-specific interventions: National Registry System (NRS) for mitigation and adaptation initiatives, National GHGs Inventory System (SIGN-SMART), and MRV system for mitigation including REDD+. [3]

The MoEF Ministerial Act No. 72/2017 or the Guidelines for Implementing MRV Action and Resources of Climate Change Control also instructs local governments to measure their GHG emissions using appropriate methodologies and report these to the NRS.[7] These reports will eventually be verified by MoEF and will be used for the Biennial Update Report (BUR) of Indonesia which will be submitted to the UNFCCC.

1. Transportation and Energy

Provide additional two school buses and two shuttle buses, initiative from PT Pertamina oil company to use Euro V fuel standards instead of Euro II standards (30% more eco-friendly).



2. Waste Management

Waste-to-Energy (WtE) initiatives that converts methane gas into heat and electricity.

3. Agriculture, Forestry and Other Land Use (AFOLU)

Use of organic fertilizers, development of home garden farming and rainwater harvesting.

Figure 1. Priority sectors and programs included in 5 years-local development planning period 2016-2021.

The Balikpapan City Government firmly supports both national and provincial governments in developing a Local Action Plan – Greenhouse Gas Emission Reduction called *"RAD-GRK Balikpapan City 2010-2020"*[2] to achieve the targets. The city set a target to reduce its GHG emissions by 19.39% by 2020 through three priority sectors (**Figure 1**).

In terms of the waste sector, according to their local action plan, Balikpapan City's total GHG emission reduction target specifically in this sector is 45,155 tCO_2e by 2020 (baseline year: 2010). Moreover, the city included the "Zero Waste to Landfill" concept in their four "Ecological City Concept." This affirms the city's commitment to reduce its waste disposal to landfill and its associated GHG emissions by employing the 3Rs (reuse, reduce, recycle).[9][8]

Manggar Landfill, a semi-sanitary landfill in East Kalimantan.

The Manggar Landfill is located in Balikpapan City, East Kalimantan (1°12'47.1"S and 116°56'18.7"E), and caters to all solid waste disposals of the city since 2008. It is composed of seven zones (total area of 9.1 hectares), of which three recently opened zones were inaugurated by Indonesian President Joko Widodo in December 2019. These zones were added due to overcapacity of the older zones and only one zone is currently operational. According to Mr. Tonny Hartono, Head of the Regional Technical Implementation Unit of the landfill, all zones could reach full capacity in five years depending on the city's efforts in administering the 3Rs which aims to significantly reduce waste disposal.

In a sanitary landfill, solid wastes are buried under the ground to isolate the wastes from the environment and to control odors, vectors, fires, etc. The anaerobic decomposition of the organic waste, resulting from the isolation, produces methane gas that is being recovered and distributed by gas networking pipes for the community (**Figure 2**). Additionally, another source of methane gas is the leachate formation due to liquid passing down through the isolated/buried solid waste. The leachate is processed in the leachate treatment unit where it is treated with the Up Flow Anaerobic Sludge Bank (UASB) technology.

The captured methane gas is converted into an energy source for various uses such as replacement for liquefied petroleum gas (LPG) for household cooking, public street lighting, among others **(Table. 2).** This contributes to the reduction of GHG emissions in the energy sector. The operation of the landfill gas recovery in Balikpapan City is regarded as one of the mitigation actions of the city that they also seek to showcase at the local, provincial, and national levels.

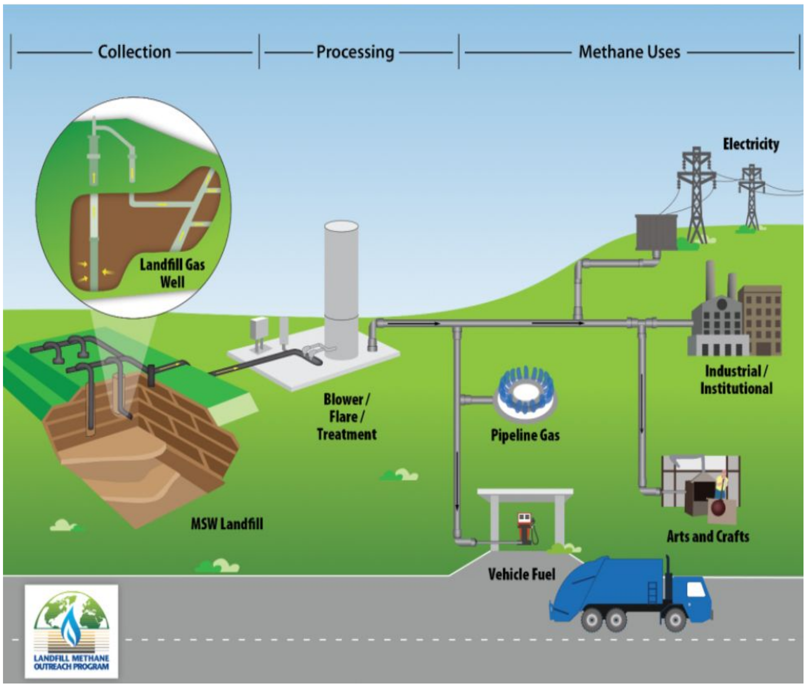


Figure 2. Illustration of process in capturing and distributing methane gas at a sanitary landfill (*Source: United States Environmental Protection Agency*)

Quantifying emission reduction in TPA Manggar

The LFG Recovery Methodology is derived from the CDM AMS-III.G: Landfill Methane Recovery[10][9] and is composed of four (4) modules (**Table 1**). The CH_4 captured from the landfill was being converted and used for electricity of streetlamps and household cooking of a nearby community.

Therefore, because of data limitations, only two modules (Modules 3 and 4) were deemed relevant and appropriate to use to estimate the GHG emissions reduction potential of the LFG recovery and use in Manggar Landfill.

Objective evidence offers a stronger basis for replication and demonstrating impact. Recognizing data availability constraints, the MoEF has developed the LFG Recovery Methodology which is a simplified method of GHG emissions reduction potential calculation of capturing methane gas from the landfill and transforming these into useful energy forms (e.g. household cooking, street lighting). The methodology was developed by MoEF and managed by the methodology team panel of the Directorate General of Climate Change.

The experience of Manggar Landfill in maximizing the socio-economic and GHG reduction benefits of its landfill gas (LFG) recovery provides an attractive case for replication among Indonesian cities that seek to address the equally pressing issues of waste management and climate change.

Figure 3. Gas pipelines for capturing methane gas (left) and *flaring* in nearby area (right) *(Photos from Balikpapan Environmental Agency)*

Table 1. Module criteria & justification of LFG Recovery Methodology

Criteria	Justification
Module 1 is used if flow meter is available in LFG Recovery facility and LFG is used for producing electricity/flaring.	Manggar Landfill has not yet installed the flow meter at the site, albeit the excess of LFG production is also flared. Thus, this module is not applicable for MRV pilot project.
Module 2 is used if LFG is utilized for producing electricity, but the flow meter is unavailable.	Production of LFG is utilized electricity for public street only at the moment and flow meter installation is planned to be carried out in the future. Thus, it is inapplicable for this MRV pilot project.
Module 3 is used if LFG is used for electricity production, specifically for biogas-sourced lamp.	This module is applicable for the reason that the LFG production is also utilized to powering 10 (ten) posts/units of public street lighting in 2020. (see **Table 2).**
Module 4 is used if LFG is used for cooking purposes in houses without calculating the flow rate	This module is applicable because the LFG production is also used for cooking purposes in households even though the LFG flow rate is an assumption data from replacement of LPG consumption.

Table 2. Activities using methane gas from the landfill

Methane Gas Usage	2019 (Unit)	2020 (Unit)
Cooking	71	132
Street Lights	10	10
Flaring	1	7
Sauna	1	1

Landfill Gas Recovery (LFG) methodology as an MRV mechanism

The Landfill Gas Recovery (LFG) methodology was developed by MoEF as part of Indonesia's MRV framework for climate actions. It offers a simplified way for local governments to measure GHG emissions associated with LFG operations and report the results to the SRN. The verification process will be done by the MoEF's methodology panel via interviews and field data gathering.

Data Input Requirements

Terminology

Activity Data: the relevant measurement of a GHG generating process taking place during a given period of time (e.g. volume of gas used, electricity used).

Default Value: The values that have been provided by the methodology team panel.

Emission factor: The mass of GHG emitted per unit of activity (e.g. kg of CO2 per kilometer traveled), provided by the methodology team panel.

Estimated Emission Reduction Formula

$$ER_y = BE_y - PE_y$$

ER_y = Emission Reduction

BE_y = Baseline Emission

PE_y = Project Emission

Activity Data Input and Results

The LFG Recovery Methodology uses an excel-based tool that allows the user to input the activity data gathered. The activity data on electricity for street lighting and cooking fuel consumption from the community around the Manggar Landfill were used as inputs to the tool which automatically calculates baseline emissions (BEy) and project emissions (PEy) annually (**Table. 3** and **Figure 4**). The GHG emissions reduction potential (ERy) is also automatically calculated by the tool by subtracting the project emissions from the baseline emissions, as shown in the formula below.

Table 3. Activity Data Required for Module 3 and 4 of LFG Recovery Methodology

Module 3		Module 4	
Parameter	Value	Parameter	Value
Number of Street Lights	10 units	Number of households that utilize LFG (replacing LPG consumption) for cooking purposes	132 Household Connection (SR)
Power Consumption Average	24 watts		
Operation time (average time/day)	12 hours		

Table 4. Default values for the parameter for both modules with the a) indicator of the parameter and b) the source of values for each parameter.

Parameter	Indicator	Unit	Module 3	Module 4	Source of Values
$D_{CH4,y}$	Methane density at LFG temperature and pressure in year y.	ton/m^3	0.000656	0.000656	LPG Gas Unit Conversion Values: kg, Litres, MJ, kWh & m^3
$NCV_{CH4,y}$	Methane NCV in given year y.	MJ/NM^3	35.9	35.9	CDM Small-Scale LFG Recovery Calculation Methodology (AMS-III.G)
Q_{SR}	Average LPG gas consumption per house connection (SR) (kg LPG / SR)	kg/SR*/year	-	144	Pranadji dkk. (2010): *Analisis Perilaku Penggunaan LPG pada RT di kota Bogor*, Jur. Ilm. Kel. & Kons., Vol. 3, No. 2, pp: 173-18
EE_y	Energy conversion efficiency in year y (thermal).	%	40	75	CDM Small-Scale LFG Recovery Calculation Methodology (AMS-III.G)
GWP CH_4,y	Global warming potential for methane in year y.	CO_2e/CH_4	21	21	Second Assessment Report (SAR) IPCC 1995
Lamp use	-	day/yr	365	-	-
$EF_{listrik}$	Emission factor for electricity	ton CO_2e/MWh	1.15	-	Emission Factor for Mahakam Grid year 2018 (source: Ministry of Energy and Mineral Resources)
EF_{LPG}	Emission factor for LPG	ton CO_2e/TJ	-	65	Calculation from Emission Factor of CO_2, CH_4 and N_2O

D. Activity Data		Parameter	Quantity	Unit
	1	Number of Lights	10	Unit
	2	Average Lights Power	24	Watt
	3	Lights usage/day	12	Hour
E. Baseline Emission Estimation:				
Baseline Emission -1: Methane Destruction	1	$BE_{y,1}$	3.630	ton CO_2e
Baseline Emission -2: On-Grid Electricity Substitution	2	$BE_{y,2}$	1.209	ton CO_2e
		Total Baseline Emission	4.839	ton CO_2e
F. Project Emission Estimation:				
	1	$PE_{power,y}$	2.470	ton CO_2e
	2	$PE_{flare,y}$	0	see justification [3]
	3	$PE_{process,y}$	0	see justification [4]
		Total Project Emission	2.470	ton CO_2e
G. Emission Reduction Estimation		$ER_{y,calculated} = (BE_{y,1} + BE_{y,2}) - PE_y - LE_y$		
		$ER_{y,calculated}$	2.370	ton CO_2e

Variables (Module 3)

Activity data (D): At the time that the data was taken, there were 10 units of lights, with average of 24 Watt of power and average use of 12 hr/day.

These values are then inputted into the yellow boxes. Subsequently, the BEy, PEy and ERy values will be automatically generated and calculated.

D. Activity Data		Parameter	Quantity	Unit
	1	Number of LFG Consumer/Household Connection (SR)	132	Household Connection (SR)
E. Baseline Emission Estimation:				
Baseline Emission -1: Methane Destruction	1	$BE_{y,1}$	448.337	ton CO_2e
Baseline Emission -2: LPG Substitution	2	$BE_{y,2}$	57.354	ton CO_2e
		Total Baseline Emission	505.691	ton CO_2e
F. Project Emission Estimation:				
	1	$PE_{power,y}$	2.470	ton CO_2e
	2	$PE_{flare,y}$	0	see justification [3]
	3	$PE_{process,y}$	0	see justificiation [4]
		Total Project Emission	2.470	ton CO_2e
G. Emission Reduction ($ER_{y,calculated}$)		$ER_{y,calculated} = (BE_{y,1} + BE_{y,2}) - PE_y - LE_y$		
		Total Emission Reduction	503.221	ton CO_2e

Variables (Module 4)

Activity data (D): There were 132 household connections, locally known as *Sambungan Rumah* or SR at the time data was collected which then inputted into the yellow box.

Similarly as module 3, BEy, PEy and ERy values will be generated and calculated automatically after inputting the activity data.

Figure 4. Preview of module 3 (top) and module 4 (bottom) data input requirement (yellow boxes) to obtain emission reduction estimation (G). Additionally, according to the methodology justification, the Leakage Emission (LEy) is ignored (LEy = 0) because this calculation based on methane capture technology and it is negligible for simplification. .

Table 6. Summary of estimated GHG emissions reduction calculated using Module 3 and 4,

No.	Parameter	Module 3 (tCO_2e)	Module 4 (tCO_2e)	Total (tCO_2e)
1.	**Baseline Emission (BE_y)**	4.839	505.591	510.43
2.	**Project Emission (PE_y)**	2.470	2.470	4.94
3.	**Emission Reduction (ER_y)**	**2.370**	**503.221**	**505.691**

Discussion: Methodology Effectiveness and Lesson Learnt

The calculation using both Modules 3 and 4 are found to be useful and effective in calculating the GHG emission reduction of **505.691** tCO_2e from electricity use of 10 street lights in Manggar Landfill and household cooking substituted with methane gas derived from the landfill) for 132 household connections. But, these values are not exact values due to the absence of a gas meter (therefore based on estimation). Regardless, as previously mentioned, this methodology acts as an instrument to track Balikpapan City's progress in GHG emissions reduction in the waste sector. The City is able to see their climate action impacts in numbers and these values may be a valuable reference for project upscaling and replication.

Due to the quantification of the mitigation actions, other Indonesian local governments may be encouraged to duplicate the measurement system of Mangar Landfill and install measurement equipment to obtain more accurate results and improve the effectiveness of this methodology.

Further, the simplification of CDM AMS-III.G.: Landfill Methane Recovery provides opportunities for easy replication in many Indonesian local governments that will institute an effective measure to estimate GHG emissions reduction in landfills and can suit the context of the landfill that does not have measurement tools yet.

Provision of the national default values (**Table. 4**) is significantly beneficial for this pilot project as well as in the further implementation of these modules because they assist the local and national governments in the data filling process and bring about data uniformity which is crucial for producing quality output.

This pilot project offers valuable lessons - one of which is that the MoEF discovered that the LFG utilization for cooking purposes is not only used by the community but also by small and medium enterprises (SMEs). The methodology panel team took into account adding a sub-module called "**Module 4.b**" and considered using kilograms as mass units for annual activity data for small and medium enterprises connections. Additionally, measurement equipment, namely kWh meter and flow meter, shall be installed in order to fulfill the principles of transparency, accuracy, completeness, comparability and consistency (TACCC).

Figure 5. Beneficiary communities using methane gas captured from the landfill for cooking *credit: Balikpapan Environmental Agency*

Recommendation and Replication Going Forward

The testing of LFG Recovery Methodology by the MoEF must be continuously explored. Specifically, consistent monitoring needs to be conducted to ensure that the capacity of Manggar Landfill is increasing. Thus, in the next couple of years, Module 1 can be utilized in calculating GHG emissions reduction in order to get more accurate results. Furthermore, with the simplicity of LFG Recovery Methodology and guidance from the MoEF methodology team panel, each module can be applied and replicated to other landfills in many provinces, cities, and districts in Indonesia, depending on the availability of activity data in a particular landfill.

In this case study, only Modules 3 and 4 have been covered due to some suitability issues of the TPA Manggar. MoEF has implemented Modules 1 and 2 in another landfill, called TPA Bantar Gebang in Bekasi City. Implementation of these modules - Modules 1 and 2 - should be expanded to other areas to further improve and refine the results of the tabulations and mainstream the MRV system in reducing GHG emission especially in the waste sector. more GHG emission from the waste sector .

Figure 6. The MoEF conducts a workshop for the Environmental Agency of Balikpapan City to guide them in filling out the form for the identified mitigation action at Manggar Landfill to National Registry System, as part of the reporting and verification process in the MRV.

A Living Document...

This methodology is a living document, which means that continuous evaluation, comprehensive research, and regular update regarding the documents are needed by adjusting to the relevant project boundary, situations, conditions and technologies which could enhance the quality and effectiveness of the methodology. Therefore, in terms of the replication, further pilot project using similar methodology may have contrasting variables in the measuring process.

For future references, MoEF should seek further and continuing review of the methodology and pilot tests by national and international experts. This action needs to be carried out to ensure technical accuracy of the measurements and can therefore be used to account for local climate actions in the NDC.

Technical Terms

Vertical Integration: *Communication/coordination of different sectors across governance levels in the same state, for instance between the national government to local government. This integration has top-down and bottom-up dynamics.[11][10] For example, bottom-up vertical integration would be between Balikpapan City Environmental Agency and the MoEF and for the top down would be any national institutions informing new policy for local governments in Indonesia to be implemented.*

Horizontal integration: *Unlike vertical integration, horizontal integration refers to interaction of different sector or local government organizations (LGOs) but within same governance level.[11][10] For instance, the waste management in Balikpapan City is between Environmental Agency particularly Manggar Landfill Working Group of Implementation Unit and Local Development Planning Agency to acquire agreement between two parties for a project or consult about their upcoming project.*

Measurement, Reporting, Verification (MRV): *A significant framework coined during Bali Action Plan under COP 13 that associated with national commitment and mitigation actions that can be measured, reported as well as verified and also climate change and supports such as providing funds, provision of technology as well as capacity buildings.[11]*

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Further Reading

1. **Balikpapan City Tests Manggar Landfill Readiness as Clean Energy Source**

1. Testing of National MRV Pilot Project in Balikpapan City's Manggar Landfill completed

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FIGURE

Figure 2. Illustration of process in capturing and distributing methane gas at a sanitary landfill: United States Environmental Protection Agency, 2021. *Basic Information about Landfill Gas | US EPA*. [online] US EPA. Available at: <https://www.epa.gov/lmop/basic-information-about-landfill-gas#collecting> [Accessed 8 June 2021].