CLIMATE TECHNOLOGY CENTRE & NETWORK

Feasibility study to use waste as fuel for cement factories

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Output 4:

Report on an approach for MRV system for the production and use of RDF from MSW in cement factories in Mozambique

Contents

List of acronyms

ANAMM	Association of the Mozambican Municipalities
AMOR	Mozambican Association for Recycling
CdM	Cimentos de Moçambique
CDM	Clean Development Mechanism
CTCN	Climate Techonology Centre & Network
EN1	Estrada Nacional N°1 – National Road N°1
FUNAB	Fundo do Ambiente (Environment Fund)
JICA	Japanese Cooperation
LAL	Lei das Autarquias Locais (Law of local autarchies)
MGW	Megawatt
MICOA	Ministry of environmental action and co-ordination
MITADER	Ministry of Land, Rural Development and Environment
MISAU	Ministry of Health
MSW	Municipal Solid Waste
NAMAs	Nationally Appropriate Mitigation Actions
NDE	National Designated Entity
PARPA	Action Plan for the Reduction of Absolute Poverty
RDF	Residue Derived Fuel

1. Review on existing MRV approaches for RDF plants, processing MSW

This section aims at presenting existing approaches and experiences for monitoring, reporting and verification procedures for the production of RDF from MSW. As the scope of this report is to outline a general framework for MRV at RDF plants, this and the subsequent sections will focus on only on the RDF process, starting by the reception of MSW and finishing by the storage of the final product, RDF.

1.1 GHG emissions

The review of literature and case studies did not show any results about an MRV framework specifically for RDF plants. However, a study done by the Carbon Africa (supported by KfW PoA Support Centre) in 2015 proposes a MRV framework for the MSW sector in Mozambique, based on the assessment and comparison of different methodological approaches for MRV of GHG emissions: CDM methodologies for waste, the IPCC guidelines 1996 for waste, the Life Cycle Assessment methodology, the California Environmental Protection Agency, Air Resources Board, the Climate Action Reserve methodologies, and the Gold Standard Methodologies.

For this assessment, Carbon Africa evaluated the general applicability of the tools to emission reduction activities in the waste sector in Mozambique, their international recognition, the balance between standardization and possibility to tailor the approach to the specific circumstances of a country or project, and the existence of associated procedures and governance structures for the verification and certification of emission reductions. After the assessment, Carbon Africa concluded that the CDM methodological approach is the one offering large benefits regarding standardization of methodologies, international recognition, and the presence of an institutional framework and guidelines established; concluding that the CDM can act as an open source of methodologies, modalities and procedures and effectively act as an MRV service provider to other mechanisms, including New Market Mechanisms. Based on this, Carbon Africa proposed a MRV framework for the MSW sector in Mozambique based on the CDM, aiming at removing possible barriers or difficulties of using the CDM approach in Mozambique.

Starting from this CDM based proposal of Carbon Africa, the present report highlights the convenience of using also the CDM methodological tools for defining a general MRV framework for the RDF process in Mozambique. For RDF from waste, the CDM methodologies to be applied would be the ACM0022: Alternative waste treatment processes (for calculating the emissions from the RDF process) and the Methodological Tool: Emissions from solid waste disposal sites, for determining the potentially avoided GHG emissions from deviating MSW to the RDF plant.

1.2 Other environmental aspects

Other environmental aspects monitored at RDF plants are the air emissions, water, soil releases, odors and noise. The air emissions of RDF plants will depend on the types of wastes treated and the processes used. The emissions expected in biodrying plants are mostly CO2 (from the biological fermentation, odors and dust. Odors are usually reduced with biofilters and dust with bag filters. Emissions to water and soil also depend on the on the types of wastes treated and the processes used. According to the degree and nature of the pollution agents and to the output (surface water, on-site water treatment, collective industrial, or urban station), different reduction techniques for water may be used alone or combined: e.g. settling, hydrocarbons/oils/sludge separators, activated carbon (should be sufficient for water with low contamination levels), physical-chemical treatment, biological treatment, thermal treatment (for highly polluted water) (HOLCIM - GIZ, 2010).

The aspect mentioned above should be monitored preferably using emission samples taken by an independent testing laboratory, which should also comply with the legal requirements of competence and reporting. The coverage of the inspection and the frequency of emission testing should be agreed with the environmental authorities of the country. Odor and noise aspects should be also monitored at the plant, involving this health and safety occupational aspects (HOLCIM - GIZ, 2010).

1.3 MRV of other parameters - quality aspects (control and quality assurance)

The MRV concept is not only relevant in regard to climate change, but also very important for the processing and quality control aspects of an RDF plant. There are some experiences and guidelines about RDF production that specify what kind of parameters and indicators should be monitored, reported and verified either internally or externally. Quality standards are important not only for complying with the country´s environmental regulations but also for complying with the quality requirements of the client, in this case the cement plants.

Good examples of international norms and standards focused on the management aspects of MRV are the ISO norms. A good way of developing MRV procedures and management plans may be to implement such standards or to structure the internal MRV system of the RDF plan, following the ISO criteria.

Regarding RDF quality standards and quality assurance procedures, this study identified the European Regulation for RDF/SRF CEN/TC 343 (quality standards for a wide range Solid Recovered Fuels), and the the European quality standard BS EN 15359: 2011 (quality criteria of RDF based on data from large industrial RDF users such as cement kilns and coal fired power plants.). The German RAL-GZ 724 sekundärbrennstoffe - Gütesicherung (secondary raw material - quality assurance) and the BS EN 15358: 2011 – Solid recovered fuels QMS and the BS EN 15234 – 1: 2011 – 'Solid biofuels – Fuel quality assurance' are quality assurance systems for RDF.

Developed by CEN/TC343, the EN15359 - 2011 (Solid Recovered Fuels – specifications and classes) is the most crucial for quality specifications. EN15359 provides a system for specification and classification of SRF. It also provides for a set of compliance rules that points out how SRF can be characterized in a reliable way. The EC 15359 identifies three properties for describing and/or classifying SRF (RDF that fulfils the standards):

- Net calorific value (increasing market value of the fuel)
- Chlorine, unwanted as it contributes to corrosion. High chlorine content will lower the market value.
- Mercury (Hg), of all relevant heavy metals, Hg is selected as an indicator of the environmental quality of a SRF. Because of its high volatility, Hg is the heavy metal most likely to be emitted.

Although the classification system focuses on Hg, all heavy metals according to the Waste Incineration Directive (WID) are obligatory parameters for specification according to EN 15359. Per property mentioned, five classes have been established (see table 1).

Classification characteristic	Statistical measure	Unit	Classes				
			1	2	3	4	5
Net calorific value (NCV)	Mean	MJ/kg (ar)	≥ 25	≥ 20	≥ 15	≥ 10	≥ 3

Classification characteristic	Statistical measure	Unit	Classes				
			1	2	3	4	5
Chlorine (Cl)	Mean	% (d)	≤ 0.2	≤ 0.6	≤ 1.0	≤ 1.5	≤ 3

Classification characteristic	Statistical measure	Unit	Classes				
			1	2	3	4	5
Mercury (Hg)	Median	mg/MJ (ar)	≤ 0.02	≤ 0.03	≤ 0.08	≤ 0.15	≤ 0.50
	80th percentile	mg/MJ (ar)	≤ 0.04	≤ 0.06	≤ 0.16	≤ 0.30	≤ 1.00

Table 1 Classification system for RDF according to the EN 15359:2011 (Glorious, 2014[1])

Besides the EN 15359, there are different initiatives for specifying minimum quality requirements for waste derived fuels. Standards for RDF have been developed in in Finland, Italy, and Netherlands (table 3), while in Germany the certification label RAL is used (RAL-GZ 724). Sweden and UK have developed standards for secondary fuels specifically for the cement industry (table 4). Other countries such as the Flemish Region of Belgium adopted the standards issued by

[1] Production and use of Solid Recovered Fuels – developments and prospects, Glorious Thomas, REMONDIS GmbH, Cologne/Germany, 2014

European Federation for Waste Treatment Plants - EURITS for production and use of waste fuel in clinker production (table 5).

		Italy	Finland[1]			
Characteristic	**Unit**		**DL**	**Quality Class**		
				I	**II**	**III**
Water content	%	<25				
Calorific Value	KJ/kg	15,000				
Ash content	%	20				
Chlorine content	% (m/m)[2]	0.9	0.01	<0.15	<0.50	<1.50
Sulphur Content	% (m/m)[2]	0.6	0.01	<0.20	<0.30	<0.50
Nitrogen Content	% (m/m)[2]	-	0.01	<1.00	<1.50	<2.50
Potassium and sodium content [3]	% (m/m)[2]	-	0.01	<0.20	<0.40	<0.50
Aluminium Content	% (m/m)[2]	-	0.01	[4]	[5]	[6]
Mercury Content	$Mg\ kg^{-1}$	-	0.1	<0.1	<0.2	<0.5
Cadmium Content	$Mg\ kg^{-1}$	-	0.1	<1.0	<4.0	<5.0
Lead	$Mg\ kg^{-1}$	200				
Copper	$Mg\ kg^{-1}$	300				
Manganese	$Mg\ kg^{-1}$	400				
Chromium	$Mg\ kg^{-1}$	100				
Zinc	$Mg\ kg^{-1}$	500				
Nickel	$Mg\ kg^{-1}$	40				
Arsenic	$Mg\ kg^{-1}$	9				
Cadmium+mercury	$Mg\ kg^{-1}$	7				

Table 2 Quality standards for RDF in Italy and Finland (EU Commission, 2003)

Parameter	Criteria	
	"Specialbränsle A"	"Lattbränsle"
Calorific value	23.9 – 31.4 MJ/kg	25.1 – 31.4 MJ/kg
Flash point	< 21°C	< 21°C
Specific density at 15°C	0.9 – 1.1 kg/dm^3	0.80 – 0.95 kg/dm^3
Viscosity	Pumpable	1 – 5 cst at 50°C
Ash content	5 – 10 %	0.6 – 0.8 %
Water	< 30 %	< 10 %
Cl	< 1 %	< 1 %
S	N/A	< 0.5 %
Cr	< 300 ppm	< 30 ppm
V	N/A	< 50 ppm
Z	N/A	< 300 ppm
Zn	< 2000 ppm	N/A
Cd	< 10 ppm	< 5 ppm
Pb	< 350 ppm	< 100 ppm
Ni	N/A	< 10 ppm
Hg	N/A	< 5 ppm
PCB	N/A	< 5 ppm

Table 3 Specification for RDF used in cement plants in Sweden (EU Commission, 2003)

Parameter	Unit	Value
Calorific value	MJ/kg	15
Cl	%	0.5
S	%	0.4
Br/I	%	0.01
N	%	0.7
F	%	0.1
Be	Mg/kg	1
Hg/Ti	Mg/kg	2
As, Se (Te), Cd, Sb	Mg/kg	10
Mo	Mg/kg	20
V, Cr, Co, Ni, Cu, Pb, Mn, Sn	Mg/kg	200
Zn	Mg/kg	500
Ash content (excl Ca, Al, Fe, Si)	%	5

Table 4 EURITS criteria for co-processing of waste in cement kilns (EU Commission, 2003)

	Heavy metal concentrations [4]			
Parameter	Median (mg kg^{-1} DS)		'80th percentile' (mg kg^{-1} DS)	
Cadmium	4		9	
Mercury	0.6		1.2	
Thallium	1		2	
Arsenic	5		13	
Cobalt	6		12	
Nickel	25 [a]	80 [b]	50 [a]	160 [b]
Antimony	50		120	
Lead	70 [a]	190 [b]	200 [a]	400 [c]
Chromium	40 [a]	125 [b]	120 [a]	250 [b]
Copper	200 [a]	400 [b]	500 [c]	1000 [c]
Manganese	50 [a]	250 [b]	100 [a]	500 [b]
Vanadium	10		25	
Tin	30		70	

[a]For solid recovered fuel from production-specific waste.
[b]For solid recovered fuel from high calorific fractions of municipal waste.
[c]Exceedings due to inhomogeneity are acceptable in individual cases.
[d]The heavy metal contents stated above apply for a net calorific value $NCV_{DS} \geq 16$ MJ kg^{-1} for high calorific fractions from municipal solid wastes and for a net calorific value $NCV_{DS} \geq 20$ MJ kg^{-1} for production-specific waste. If these calorific values are not reached, a linear reduction of the values shall be performed. An increase is not permissible.

Table 5 Heavy metal content requirements according to RAL - GZ 724 (Flamme and Geiping, 2012)

The quality control of RDF is very important for the cement plant as well. The RDF has to comply with certain requirements concerning calorific value, ph-value, humidity, chlorine, sulfur content and other physicochemical characteristics. Also the quality and composition of the RDF has an important impact on the air emissions of the cement plant. The quality of the RDF should be tested by an external certified laboratory selected by the RDF plant together with the cement plant. The size of the sampling and the frequency should be also agreed between both parts and if possible, complying an international RDF regulation (such as CEN). The test samples and records of the results of the analysis should be stored for a period of time, for reference purposes (HOLCIM - GIZ, 2010).

While the RDF quality standards set different specifications for RDF, improving the acceptance of Solid Recovered Fuels (SRF) and strengthening the content-related understanding between fuel producers and users for a useful fuel characterization, the quality assurance procedures provide confidence to the end users that the RDF meets the specified requirements of a quality standard.

The RAL-GZ 724 provides stringent guided values and a mandatory verification (external control as well as an external certification). This is still missing on the European level (Glorious et al. 2014).

The following table shows some similarities and differences between both standards regarding the kind of requirements demanded.

Clarified aspects	RAL-GZ 724	CEN/TC 343
Input materials for production described?	EWC-numbers	EWC-groups
External supervision obligatory?	Yes	No
Kind of sampling?	Yes	Yes
Sample preparation?	Yes	Yes
Analytical standards?	Yes	Yes
Limit values?	Yes	No
Statistical evaluation?	Yes	Yes
Classification system for all fuels?	No	Yes
Certification/external supervision obligatory?	Yes	No

Table 6 Relevant aspects of quality assurance (Glorious et al. 2014)

The following figure shows a concept for a comprehensive quality assurance system in a RDF plant. In principle, a QA system should monitor the RDF process (personnel, plant technology, waste input, documentation), and also ensure that the quality of the final RDF is monitored. Fulfilment of operational and organizational criteria can be verified through an inspection (special audit), which many parties have already agreed to do (Flamme and Geiping, 2012).

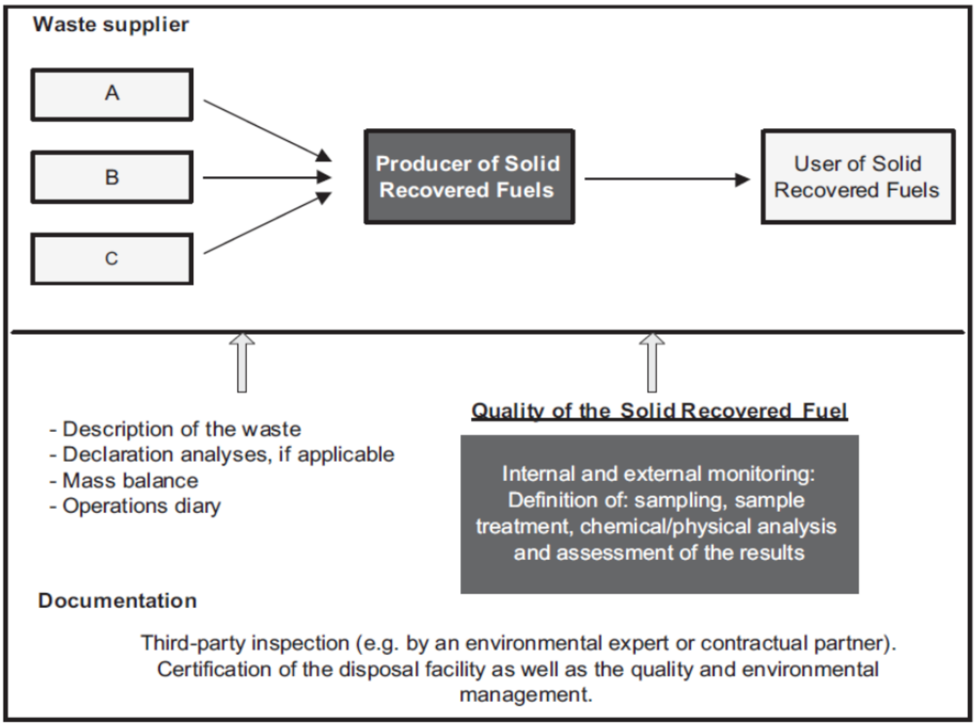

Figure 1 Quality assurance for the producers of RDF (Flamme and Geiping, 2012)

According to the RAF GZ 724, the monitoring of RDF as a product requires an analytical procedure, which should rely on meaningful data. For this, various factors must be considered for the RDF analysis. These include:

The sampling procedures, sample treatment, the analytical method at the laboratory, the interpretation of data and the Choice of quality parameters, used for evaluating the quality of the final RDF. The choice should be based upon consideration of: emission limit values valid in the country, the process technology and the fuel technology. For the case of the RAL GZ 724, the selected parameters are consistent with the parameters in Directive 2010/75/EU of the European Parliament on industrial emissions (Flamme et al. 2012). However, not only regulation should be considered but also the quality criteria of the client,

The RAL GZ 724 requires: humidity, net calorific value (NCV), ash content, chlorine content, cadmium, mercury, thallium, arsenic, cobalt, nickel, antimony, lead, chromium, copper, manganese, vanadium, and tin. No limit value was set for chlorine, which is set individually depending on the requirements of the co-incineration plants (cement plant). There are also no guidance values for calorific value, moisture content, copper and ash content. However, all parameters must be documented.

Implementation of quality assurance of RDF according to the RAL GZ 724

The QA guideline RAL GZ 724 considers the implementation of internal control (monitoring) and external control (verification). For the internal control of the input (MSW), it is stipulated that waste must be documented with reference to the applicable waste code numbers; additionally a mass balance and declaration analysis must be prepared. For the output (RDF) samples should be constantly taken from the output stream every 10 or 20 Tonnes (or depending on the SRF volume produced). A monitoring interval is complete when 21 mixed samples are available, and when the test laboratory takes an additional three mixed samples on three different days.

Following parameters should be analyzed:

- Moisture: [weight-% OS]
- Net calorific value (NCV): [MJ kg-1 DS]
- Net calorific value (NCV): [MJ kg-1 OS]
- Chlorine content: [weight-% DS]
- Two relevant heavy metals

The information gained from internal control measures help both the producer of SRF and the operator of the incineration plant control their respective processes.

External control (verification) should be carried out by an independent expert and a test laboratory approved by the quality association. The expert must carry out an on-site audit to verify the conditions for the manufacturer of SRF. The auditor must also subject the results of the internal control and those of the test laboratory to a plausibility check. The verification intervals for external control would depend on the quantity of SRF manufactured. For instance, if a plant produces less than 30,000 tonnes/year, the RAL recommends two monitoring points per year, if the production is between 30,000 to 40,000 tonnes/year, the verification should be done three times per year. Between 40,000 and 60,000 tonnes/year requires four verifications.

2. Current MRV system in Cimentos de Moçambique, Matola's factory

This section present the current sitiation of the MRV activities at Cimentos de Moçambique, especially about the aspects related to the expected quality and characteristics of RDF and their needs of monitoring processing and outputs parameters that may be affected by burning RDF. Most inputs come from documentation from Cimentos de Moçambique, extracted from the company´s monitoring documents, supported by field visits as well as interviews, emails and phone calls.

The focus of this section is on the monitoring related the production of cement, with focus on material and energy, excluding the financial and human resource monitoring as these are not directly related to co-processing and the use of RDF. To understand better what to monitor, it is important to briefly sum up the different stages of the cement production:

2.1 Production process

The steps necessary to produce cement can be described as following:

- Quarry / Mine - raw materials (limestone, clay, etc.) after extraction quarries, are crushed and undergo a first stage homogenization (called pre-homo). At this stage, the quantity and quality are the main factors monitored.

- Raw Grinding - Those materials with the possible addition of improvers (sand, pyrite ash, high-grade limestone, etc.) are simultaneously dried and milled to obtain a very fine powder (called raw or flour), which is then stored and homogenized. At that stage, the size of the material is a very important factor, looking for homogenization.

- Cooking - A suitable heat treatment at very high temperature turns the so called flour into an intermediate product – the clinker - in which it is possible to find the mineralogical constituents of cement. The flour goes out of the homogenization silos, enters a heat exchanger / heat exchangers (cyclone tower) in counter - current with the hot gases from the kiln (to enjoy the heat), which starts the “decarbonation” process. Then, in the cylindrical rotary kiln (slightly slant to facilitate sliding of the flour inside) where the temperature reaches values above 1450º C, the cooking occurs (clinkering) where the flour transforms into clinker. This is then quenched to stabilize the structure and partially recover of the thermal energy. Having regard to its training mode, the clinker is therefore an artificial igneous rock and the major constituent of the cement. The hot gases leaving the cyclone tower are de-dusted before being returned to the atmosphere During all these stage, the temperature is carefully monitored as well as the emission of gases and particles.

- Cement Mill: Very fine grinding of clinker with a setting regulator (gypsum) and any other additives ("filler" limestone, fly ash, slag steel, etc.) will give rise to the various types of cement, according to the Standards in force.

- Silage and Shipping: Cement is ensiled and can be sold in bulk or packed in paper bags, on pallets or packages. Cement shipment can be made by truck, train or ship, according to their availability.

The “clinkerization” requires that the temperature of the solids reach approximately 1480 °C. To heat the material until it reaches this temperature the flame must reach at least the 1930 °C. These temperatures and gas velocity, combined with a residence time to temperatures above 1200 °C exceed the necessary conditions for the destruction of organic and inorganic components of even the most difficult components, and exceed the operating conditions of incinerator of hazardous waste. This is why the use of waste as RDF, when properly monitored, can be considered as an environmentally friendly treatment for most kind of waste, as the temperature and the residence time to these temperature is higher than in normal waste incineration.

2.2 Material needed to produce cement

Cement manufacturing is a material-intensive process. After mining, grinding and homogenization of raw materials (mostly limestone and clay), the next step in cement manufacturing is calcination of calcium carbonate, followed by sintering the resulting calcium oxide with silica, alumina, and iron oxide at high temperatures to form clinker.

The clinker is then ground or milled with gypsum and other constituents to produce cement. Naturally occurring calcareous deposits such as limestone, marl, or chalk provide the source for calcium carbonate. Silica, iron oxide and alumina are found in various ores and minerals, such as sand, shale, clay, and iron ore. However, process residues are more and more used as replacements for the natural raw materials.

Producing one ton of clinker requires an average of 1,5 – 1,6 tons of raw materials.

2.3 Energy requirements

Cement production also has high energy requirements, which typically account for 30-40% of the production costs (excluding capital costs). Traditionally, the primary fuel has been coal, but a wide range of other fuels is also used, including petroleum coke, natural gas and oil. In addition to these fuels, various types of waste are used as fuel. Modern cement plants have an energy consumption of 3,000-3,300 MJ per ton of clinker, whereas the wet process with long kilns consumes up to 6,000 MJ per ton.

Clinker is burned in a rotary kiln that can be part of a wet or dry long kiln system, a semi-wet or semi-dry grate preheater (Lepol) kiln system, a dry suspension preheater kiln system, or a preheater/precalciner kiln system. The best available technique for the production of cement clinker is a dry process kiln with multi-stage suspension preheating and precalcination.

2.4 Parameters currently monitored

As a matter of fact, a number of factors are monitored from the first to the last stages of the production to get an accurate idea of the on-going production as well as the costs. Cimentos de Mozambique uses a rigorous system of daily monitoring, which is then compiled in a monthly table, which leads to annual figures.

The following tables are extracts of monitoring documents provided by Cimento de Moçambique. All the tables are from the 31st of December. They show the needs in term of material as calculated by Cimentos de Moçambique on 31st of December 2015. The first column represents the daily measurement, the second the monthly measurement (in our case, valid for the 1st of December until the 31st of December) and the third column the yearly data (in our case, valid from 1st of January 2015 to 31st of December 2015).

	Mês	Ano	Dia	Mês	Ano	Dia	Mês	Ano	Dia	Mês	Ano	Dia	Mês	Ano	Dia	Mês	Ano
Argila Adquirida			Big-Bag			Calcário Britado			Calcário Ferrovia			Calcário Rodovia Britado			Carvão		
3,69	6109,85		6180,00	2180,00		196311,00	212410,08		0,00	0,00		0,00	0,00		4115,13	4115,13	
0,00	0,00	35839,70	0,00	4000,00	19971,00	330,00	55275,00	769263,00	330,00	55275,00	769263,00	0,00	0,00	13663,23	0,00	0,00	0,00
0,00	4186,16	40186,43	0,00	0,00	14634,00	64,84	71374,08	647318,14	330,00	55275,00	769263,00	0,00	0,00	20550,17	0,00	0,00	0,00
Cinzas (gas/bot/unc)			Cinzas Pirite			Cinzas Volantes			Clinquer			Clinquer Adquirido			Clinquer Transferido		
0,00	150,00		-0,02	-0,02		92,81	92,81		70183,29	55600,87		5153,37	34302,62		1638,62	1,00	
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	35404,83	322065,63	199,54	318,32	287042,78	584,57	4888,11	44471,16
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	20822,41	274101,58	0,00	29467,57	301889,41	0,00	3250,49	42832,54
Crude Oil Sólido			Depósito CEM II/B L 32.5N			Diatomito adquirido			Gasóleo			Gasóleo Viaturas			Gesso		
0,28	56,94		2643,00	2643,00		3212,14	4799,89		2005,00	2005,00		18046,96	18046,96		22629,42	26326,53	
0,00	20,74	706,56	0,00	0,00	2286,00	0,00	0,00	11017,63	0,00	0,00	0,00	0,00	0,00	2044,00	0,00	0,00	25015,81
0,00	7,40	688,08	0,00	0,00	0,00	0,00	1587,75	13319,40	0,00	0,00	0,00	0,00	0,00	2376,00	0,00	3697,12	38196,01
aco 002 CEM II/A-L 42,5			Saco 003 II/A-L 32,5 N 2 Fls			Saco 040 S/TIMBRE			Saco 096 CEM II/B-L 32,5N			Saco 102 CEM II/B-L 32,5N			Saco2X85 II/B-L32,5N 490X640X110		
0,00	1330,00		342853,00	342853,00		480,00	480,00		226204,00	226204,00		0,00	0,00		936562,00	967254,00	
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	226204,00	0,00	0,00	3049792,00	421920,00	703200,00	5769756,00
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3600,00	0,00	0,00	0,00	0,00	0,00	3429878,00	152366,00	733892,00	4833194,00
2X85 II/A-L42,5 495X590X110			Terras de Cobertura			TOTAL Cimento			TOTAL Clinquer			TOTAL Clinquer Prod.					
6,00	597682,00		0,01	0,01		22073,91	21174,51		76975,28	89904,49		70183,29	55600,87				
0,00	421920,00	2886496,00	0,00	0,00	0,00	0,00	67650,43	659777,21	784,11	40611,25	653579,57	0,00	35404,83	322065,63			
8,00	369526,00	2236420,00	0,00	0,00	0,00	1221,55	66751,03	643687,67	0,00	53540,47	618823,53	0,00	20822,41	274101,58			

Table 7 Extract of the Material monitoring table, 31st of December 2015

Note that the quality of clinker and the concentrations of gases in the kiln as well as emitted into the atmosphere are strictly monitored so that it does not exceed the permissible limits established by national legislation but also to ensure the quality of the clinker. Monitoring is made from the cement plant control room.

As it is observable in the table for energy consumption that energy measurements are made frequently in order to get the daily, monthly and annual consumption. Therefore their costs are as shown in the second table.

Centro de Custo		Energia Dia	Mês	Ano
Valores de Registo de Consumo				
125300	BAIRROS			318.556
128100	EDIFICIOS		2.044	2.044
128300	ILUMINAÇÃO DA FÁBRICA	113	152.334	1.066.891
138000	OFICINAS	900	27.900	324.900
		1.013	**182.278**	**1.712.391**
Valores de Registo de Produção				
153100	BRITADOR 4	724	37.211	890.411
165100	MOINHO CRU 4	3.886	1.271.986	12.870.158
176100	FORNO 4	9.718	2.246.062	16.560.351
185100	MOINHO CIMENTO 6	0	0	0
185200	MOINHO CIMENTO 7	2.150	1.143.655	11.731.388
185300	MOINHO CIMENTO 8	2.440	1.698.984	16.441.885
194120	ENSACADEIRA 5	1.061	66.579	483.147
194150	ENSACADEIRA 7	3.594	72.866	646.507
194160	ENSACADEIRA 6	3.026	67.099	723.579
		26.599	**6.604.442**	**60.347.426**
Total:		**27.612**	**6.786.720**	**62.059.817**

Nota: Valores totalizados relativos ao mês selecionado.

Table 8 Extracts of the energy costs monitoring sheet, 31st of December 2015

A Cost center monitors all the costs related to the different stages of the production. As shown here for the energy costs, the costs are broken down to the different stages of production:

britador (crushing), moinho (grinding), forno (cooking), ensacadeira (bagging unit) : for each unit, costs in Meticais are calculated.

2.5 Monitoring for current and future co-processing

At Cimentos de Moçambique, in 2015, 32 tons of shredded paper (mainly old banknotes coming from Bank of Mozambique) have been burnt in the main burner. To do so, the waste is put in big bags and manually pulled up onto a conveyor belt from where it goes into a pipe which connects to the last cyclone of the preheater tower.

Apart from shredded paper, the factory also burnt a few tons of medical waste. CdM also receives some carbon dust from Mozal (the Mozamican factory producing Aluminium) with a calorific value of 5,000 kCal/kg. The carbon dust is mixed with the raw material to increase its calorific value. Note that paper only has a calorific value of 1,500-1,800 kCal per ton, whereas a good RDF mix should have 4,000 kCal/kg.

Because of the labor involved and the low energy value, CdM charges for incinerating waste approximately 3,000 MZN/ton. At the moment, only solid waste (motor oils, with very high calorific power) is co-processed directly in the main burner: the liquid waste is injected through a pipe connecting the storage tank to the main burner of the clinker kiln. For this process, the temperature monitoring is extremely important, as the temperature has to stay stable. As such, as oil is fed into the kiln, the quantity of gas is reduced in order to keep the temperature to the needed levels.

Note that in order to use RDF at a bigger scale; the plant will have to feed (solid) RDF directly into the main burner, which means that CdM will have to make adjustments.

In terms of monitoring, the RDF project (using RDF at a much bigger scale, up to 180t of RDF/day) will imply a strict monitoring for the following steps: identification of the waste acceptance of the RDF; transport of RDF from suppliers to the plant; reception and temporary storage of RDF in the manufacturing plants; embedding the RDF in the feedstock and / or injection in the clinker kiln for cement production, as well as a global monitoring of operation. These steps are presented below:

Actually, the proper kiln (= the burner) might not need to be changed. But the plant will need to be adapted to receive the RDF, i.e. there is a need for an installation to bring the RDF to the kiln.

2.5.1 Waste identification and acceptance of RDF

This phase consists of identifying the types of waste that the plant is interested in co-processing and registering possible suppliers of these wastes. CdM will establish the conditions under which waste will be delivered to the factory.

Note here that some waste can also be co-processed as feedstock substitutes to produce clinker (and not as fuel): in that case, they substitutes must have a chemical composition similar to the raw materials normally used to produce clinker such as oxides of calcium, silicon, aluminum and iron as well as mineralizing elements (zinc, fluoride, barium and phosphates), which facilitate the clinkering reactions. We will here focus on co-processing considering the RDF, meaning the use of waste as fuel.

2.5.2 Transportation

The waste to be received in the cement factory in Matola must be transported in accordance with the national regulations for waste management (Decree No. 13/2006 of 15 June).

2.5.3 Reception and storage of waste in the manufacturing plants

The waste to be received in the cement factory in Matola should meet the acceptance conditions (composition and calorific value suitable). Here too, the storage will be done in suitable conditions, as recommended by the national regulations for waste management (Decree No. 13/2006 of 15 June), in tightness and hygiene. Solid waste must be temporarily stored in sheds with waterproof cover and surface and the liquid will be stored in closed tanks.

2.5.4 Fuel injection of the RDF in the clinker kiln for cement production

The liquid fuel substitutes waste will be injected through pipe connecting the storage tank to the main burner clinker kiln (as already happening). Solid waste may be introduced into the preheating tower (as already happening in small quantities) or directly into the main burner of the kiln.

Different points of injection / power can be used to insert the waste in cement production process. The most common issues are:

- via main burner at the outlet end of the rotary kiln;
- Via feeder in the transient chamber of the rotary kiln inlet end;
- Via secondary burners in the ascending cyclone towers;
- Via burners pre-calciner;
- Via pre-calciner feeder;

• Via an access along the pre-heating tower for introducing solid waste (as already happening).

2.5.5 Monitoring the operation

At this stage, the quality of clinker and the concentrations of gases emitted into the atmosphere must be strictly monitored so that it does not exceed the permissible limits established by national legislation. Frequent environmental monitoring of air emissions and waste water is needed. Production monitoring is made from the cement plant control room.

Cimentos de Moçambique does monitor the following gases : CO, NOx, SO2, O2, CO2 HCl, TOC, HF. However, it was not possible to have max nor minimal values.

The following table presents the main gases monitored and the purpose of the monitoring :

Emission	Monitoring point	Why is it monitored
CO, O2 , NO, CO2, CH4, SO2	Kiln gas outlet	– Optimization of primary firing – Lower fuel consumption – Maintain clinker quality
CO, O2	Calciner	– Optimization of secondary firing – Lower fuel consumption
CO, O2	Preheater	– Prevention of explosion in ESP – Control of false air in preheater
CO, (O2)	Coal bin	– Prevention of smoldering (Monitor of air entrance)
CO, O2	Coal mill	– Prevention of smoldering – Monitor of air entrance
CO, O2	Emission (global)	– Emission monitoring
CO, NOx, SO2, O2, CO2 HCl, TOC, HF	Emission (global)	– Emission monitoring

2.5.6 Special focus on emissions and dangerous components

The emissions from cement plants that cause concern are nitrogen oxides (NO_x), sulfur dioxide - (SO_2) and dust. Other issues to consider are: carbon oxides (CO and CO_2) Volatile organic compounds (VOC), dioxins (PCDDs) and furans (PCDFs) and metals.

These components are monitored by Cimentos de Moçambique in real time, with a report on daily basis.

The amount of emission depends primarily on the used materials (raw materials and fuels), the temperature level and the oxygen content during all phases of combustion, as well as the shape and flame temperature, geometry of the combustion chamber, the fuel reactivity, and the moisture.

2.5.7 Dust and water

Dusts are released from the cement production process in two ways: as specific emissions (furnace chimney, cooler stack, cement mill chimney), or as fugitive emissions (dispersed powder from the storage area of raw materials, from the transfer points and transport by road).

Cement production generally (except in exceptional cases) does not produce liquid effluents; all water consumed (mainly for cooling purposes) is released into the atmosphere as water vapor.

The quality of surface waters may be affected if large amounts of rainwater dragging large amounts of powder or dust based on the factory grounds directly to a watercourse adjacent. This is relevant for Cimentos de Moçambique, located relatively close to the Bay of Maputo.

The optimization of the clinker burning process as well as the development and introduction of control techniques (such as dust filters) can reduce considerably certain emissions from cement kilns. As such, Cimentos de Moçambique invested in 2015 in a bag filter (of a total cost of 8,9 million EUR) which reduced drastically the dust level coming from the kilns.

2.5.8 Control of emissions and metals.

The polluting gases emitted by kilns are regarded as one of the main environmental concern. The cement plant of Matola carries out monitoring of the level of its air emissions looking specifically at the following pollutants: total suspended particle (TSP), nitrogen oxides, carbon monoxide, sulfur dioxide, total organic compounds, fluoride hydrogen, hydrogen chloride, and cadmium talium, heavy metals, mercury, dioxins and furans, in addition to control the content of chlorine in the dust, SO_3, K_2O and Na_2O.

The emissions of each chimney are monitored in real time in the control room, which allow for immediate adjustment whenever needed.

2.6 Reporting and verification

2.6.1 Internal reporting

The data monitored by Cimentos de Moçambique are shared internally with the staff on site, but also with the group (CIMPOR and Intercement). The monitoring systems have been harmonized within the groups and analysts evaluate the monitoring sheets for the different sectors and source of information to try to improve the efficiency of the activity.

2.6.2 External reporting

The environmental regulations defines the legal mechanisms to inspect public and private activities, which directly or indirectly are likely to cause negative impacts on the environment. The law regulates the supervision of activity, monitoring and enforcement of environmental protection standards at national level. The cement factory is legally supported by an environmental permit of 5 years, renewable upon submission of environmental compliance and its management plan. In addition, CdM has already an EIA licence for RDF co-processing excluding Municipal Solid Waste. The factory communicates on its activities through annual report, either from Cimentos de Moçambique or from Intercement.

2.6.3 External verification

In December 2001, March 2005, July 2008 and April 2009 were held, the first, second, third and fourth public multisectoral environmental audit directed by MITADER (MICOA back then). The plant was audited and after each audit, report with the main findings and recommendations, linked with deadlines were submitted to Cimentos de Moçambique, who then followed the recommendations of the Ministry.

After several meetings held and diverse correspondence at various levels, Cimentos de Moçambique prepared its Environmental Impact Study (EIA) and Environmental Management Plan (EMP), both approved by MITADER. Following the latest action plan, Cimentos de Moçambique receives every year a visit of an external auditor to perform the due Environmental Compliance Annual audit.

As such, Cimentos de Moçambique receives an external auditor every year to check the environmental compliance. The latest environmental audit was finished in December 2015, by the firm EIA & SERVICES, LDA.

It included the relevant document review, reading written materials and verification of available data, site visits, interviews with technicians of the sites visited, laboratory analysis of drinking water as well as analysis of noise and particles produced during the production process. Globally positive, the document gave a few recommendations that must be implemented before the next annual audit (in 2016)

Apart from this annual inspection, the law also foresees extraordinary inspection that can be performed any time achieve certain objectives relating to any public or private activity which could jeopardize the balance of the environment.

3. Outline of a MRV system appropriate for producing RDF from MSW in Mozambique

3.1 Monitoring of GHG emissions

As mentioned in the first section, the CDM methodological tools represent a strong basis for determining GHG emissions reductions of an RDF project. This is not only due to the well-developed methods of estimations, but also due to the recommendations given for structuring the monitoring management plan (including frequency and quality assurance).

3.1.1 Estimations GHG

It is recommended that the RDF project uses the CDM methodologies for establishing first the GHG baseline of the project, subtracting the project emissions and leakage emissions (equation 35, ACM 0022, large-scale consolidated methodology for alternative waste treatment processes).

$$ER_y = BE_y - PE_y - LE_y \qquad \text{Equation (35)}$$

Where:

ER_y	=	Emissions reductions in year *y* (t CO_2e)
BE_y	=	Baseline emissions in year *y* (t CO_2e)
PE_y	=	Project emissions in the year *y* (t CO_2e)
LE_y	=	Leakage emissions in year *y* (t CO_2e)

For the calculation of the baseline

Due to the diversion of MSW from landfills, the baseline emissions are the emissions of methane from the SWDS. These emissions are determined using the methodological tool "Emissions from solid waste disposal sites".

For the calculation of Project emissions:

a) Equation 18 of the ACM 0022, large-scale consolidated methodology for alternative waste treatment processes). This equation assumes that the project combines different alternative waste treatments. For an RDF project, the emissions to be calculated are the ones generated only because of the RDF production.

$$PE_y = PE_{COMP,y} + PE_{AD,y} + PE_{GAS,y} + PE_{RDF\_SB,y} + PE_{INC,y} \qquad \text{Equation (18)}$$

Where:

PE_y	=	Project emissions in year *y* (t CO_2e)
$PE_{COMP,y}$	=	Project emissions from composting or co-composting in year *y* (t CO_2e)
$PE_{AD,y}$	=	Project emissions from anaerobic digestion and biogas combustion in year *y* (t CO_2e)
$PE_{GAS,y}$	=	Project emissions from gasification in year *y* (t CO_2e)
$PE_{RDF\_SB,y}$	=	Project emissions associated with RDF/SB in year *y* (t CO_2e)
$PE_{INC,y}$	=	Project emissions from incineration in year *y* (t CO_2e)

b) Equation 20 of the ACM 0022, large-scale consolidated methodology for alternative waste treatment processes "Project emissions associated with mechanical or thermal production of RDF"

$$PE_{RDF\_SB,y} = PE_{COM,RDF\_SB,y} + PE_{EC,RDF\_SB,y} + PE_{FC,RDF\_SB,y} + PE_{ww,RDF\_SB,y} \quad \text{Equation (20)}$$

Where:

$PE_{RDF\_SB,y}$	=	Project emissions associated with RDF/SB in year *y* (t CO_2e)
$PE_{COM,RDF\_SB,y}$	=	Project emissions from combustion of fossil waste associated with combustion of RDF/SB within the project boundary in year *y* (t CO_2)
$PE_{EC,RDF\_SB,y}$	=	Project emissions from electricity consumption associated with RDF/SB (production and on-site combustion) in year *y* (t CO_2e)
$PE_{FC,RDF\_SB,y}$	=	Project emissions from fossil fuel consumption associated with RDF/SB (production and on-site combustion) in year *y* (t CO_2e)
$PE_{ww,RDF\_SB,y}$	=	Project emissions from the wastewater treatment associated with RDF/SB (production and on-site combustion) in year *y* (t CH_4)

c) The project emissions from combustion of fossil waste associated with the combustion of RDF should be calculated using the equation 22 of the ACM 0022, large-scale consolidated methodology for alternative waste treatment processes: Project emissions from combustion within the project boundary

$$PE_{COM,C,y} = PE_{COM,CO2,c,y} + PE_{COM,CH4,N2O,c,y} \quad \text{Equation (22)}$$

Where:

$PE_{COM,C,y}$	=	Project emissions from combustion within the project boundary associated with combustor *c* in year *y* (t CO_2e)
$PE_{COM,CO2,c,y}$	=	Project emissions of CO_2 from combustion within the project boundary associated with combustor *c* in year *y* (t CO_2)

$PE_{COM,CH4,N2O,c,y}$	=	Project emissions of CH_4 and N_2O from combustion within the project boundary associated with combustor *c* in year *y* (t CO_2)
c	=	Combustor used in the project activity: gasifier or syngas burner, incinerator or RDF/SB combustor

d) The project emissions from electricity consumption due to waste treatment process implemented under the project activity (PEEC,t,y) shall be calculated using the “Methodological Tool to calculate baseline, project and/or leakage emissions from electricity consumption"

e) The project emissions from fossil fuel consumption associated with the RDF/SB process (production and on-site combustion) is determined according to the procedure “Project emissions from fossil fuel use”, where PEFC,RDF_SB,y=PEFC,t,y and the alternative waste treatment option t is the production of RDF/SB. The "Project emissions from fossil fuel use" shall be calculated using the “Methodological Tool to calculate project or leakage CO2 emissions from fossil fuel combustion”

f) The project emissions from the waste water treatment associated with the RDF production *PEww,RDF_SB,*y is determined according to the procedure “Project emissions from wastewater treatment”, where *PEww,RDF_SB,y=PEww,t,y* and the alternative waste treatment option *t* is the production of RDF/SB.

<u>For the calculation of Leakage emissions</u>

If the RDF/SB is disposed of in a solid waste disposal site (SWDS), then this is accounted for as leakage emissions according to the procedure Leakage emissions associated with RDF/SB (equation 32 of the ACM 0022, large-scale consolidated methodology for alternative waste treatment processes)

3.1.2 Monitoring of parameters for GHG emissions of the RDF project

The CDM methodology ACM0022 proposes monitoring plans for the data or parameters needed for the estimations and following up of the GHG emissions of waste projects. With exception of the parameter 17" **RATEcompliance,t,y** " Rate of compliance with a regulatory requirement to implement the alternative waste treatment t implemented in the project activity ", no other input - oriented parameter (MSW) was found in the CDM methodology. However, the RDF project can easily define and monitor parameters such as "quantity of MSW received at the RDF plan and diverted from SWDSs". The list below presents some possible parameters to be included in a monitoring plan.

Parameters related to the input (MSW)

Parameter	Qmsw
Unit	tons
Description	quantity of MSW received at the RDF plan and diverted from SWDSs
Source of data	Municipality, project participants
Measurement procedures (if any)	weightbridge
Monitoring frequency	Continuosly, aggregated at least once a month
QA/QC procedures	Maintenance and calibration of equipment will be carried out according to internationally recognised procedures
Any comment	--

Parameter	MSW_Comp
Unit	GJ/volume or mass unit
Description	Average NCV of the MSW received at the RDF plan
Source of data	Sample taken by a certified laboratory,
Measurement procedures (if any)	Measurements shall be undertaken in line with national or international fuel standards
Monitoring frequency	Every 6 moths
QA/QC procedures	Maintenance and calibration of equipment will be carried out according to internationally recognised procedures
Any comment	--

Parameter	MSW_NCV
Unit	%
Description	Composition of the MSW received at the RDF plan
Source of data	Sample measurements done by the project participants
Measurement procedures (if any)	weightbridge, sampling according to international standards, such as LAGA 98, RAL, etc
Monitoring frequency	Every 6 moths
QA/QC procedures	Maintenance and calibration of equipment will be carried out according to internationally recognised procedures

Any comment	--

Some parameters related to the output (RDF) may be (taken from The CDM methodology ACM0022):

Data / Parameter:	$\mathbf{Q_{RDF\_SB,y}}$
Data unit:	T
Description:	Quantity of RDF/SB produced in year *y*
Source of data:	Project participants
Measurement procedures (if any):	Weighbridge
Monitoring frequency:	Annually
QA/QC procedures:	Weighbridge will be subject to periodic calibration (in accordance with stipulation of the weighbridge supplier)
Any comment:	-

Data / Parameter:	$\mathbf{NCV_{RDF\_SB,y}}$
Data unit:	GJ/mass or volume units
Description:	Weighted average net calorific value of RDF/SB in year *y*
Source of data:	Measurements by the project participants
Measurement procedures (if any):	Measurement is not required for RDF/SB produced wholly from biomass residues, otherwise measurements shall be undertaken in line with national or international fuel standards
Monitoring frequency:	The NCV shall be obtained for each shipment of RDF/SB exported from the project site for which there is documented evidence that it will be combusted, from which weighted average annual values shall be calculated
QA/QC procedures:	-
Any comment:	This parameter is required for the procedure to calculate leakage emissions for the combustion of RDF/SB outside the project boundary

Data / Parameter:	$\mathbf{Q_{waste,c,y}}$
Data unit:	T
Description:	Quantity of fresh waste or RDF/SB fed into combustor *c* in year *y*
Source of data:	Project participants
Measurement procedures (if any):	Measured with calibrated scales or load cells
Monitoring frequency:	Continuously, aggregated at least annually
QA/QC procedures:	-
Any comment:	Parameter required for procedure to calculate project emissions from combustion within the project boundary

Data / Parameter:	$\mathbf{Q_{RDF\_SB,COM,,y}}$
Data unit:	T
Description:	Quantity of RDF/SB exported off-site with potential to be combusted in year *y*
Source of data:	Project site
Measurement procedures (if any):	Sale invoices of the RDF/SB should be kept at the project site. They shall contain customer contact details, physical location of delivery, type, amount (in tons) and purpose of RDF/SB (use as fuel or as material in furniture, etc.). A list of customers and delivered SD amount shall be kept at the project site
Monitoring frequency:	Weekly
QA/QC procedures:	-
Any comment:	See procedure to calculate leakage emissions associated with RDF/SB for further information

<table>
<tr><td>Data / Parameter:</td><td>$EF_{CO2,RDF\_SB,y}$</td></tr>
<tr><td>Data unit:</td><td>t CO_2/GJ</td></tr>
<tr><td>Description:</td><td>Weighted average CO_2 emission factor for RDF/SB in year y</td></tr>
<tr><td>Source of data:</td><td>$EF_{CO2,RDF\_SB,y}$ is zero for biomass residues, otherwise determine from one of the following sources:
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>(a) Measurements by the project participants</td><td>This is the preferred data source</td></tr>
<tr><td>(b) IPCC default values at the upper/lower limit [9] of the uncertainty at a 95 per cent confidence interval as provided in table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If (a) is not available</td></tr>
</table></td></tr>
<tr><td>Measurement procedures (if any):</td><td>For (a): Measurements shall be undertaken in line with national or international fuel standards</td></tr>
<tr><td>Monitoring frequency:</td><td>For (a): the CO_2 emission factor shall be obtained for each shipment of RDF/SB exported from the project site for which there is documented evidence that it will be combusted, from which weighted average annual values shall be calculated.
For (b): any future revision of the IPCC Guidelines shall be taken into account</td></tr>
<tr><td>QA/QC procedures:</td><td>-</td></tr>
<tr><td>Any comment:</td><td>This parameter is required for the procedure to calculate leakage emissions for the combustion of RDF/SB outside the project boundary</td></tr>
</table>

In addition to the parameters mentioned above, the project operators may define further parameters relevant for the estimations of the GHG emissions of the RDF plant.

3.2 Monitoring of other parameters - quality

Considering the quality aspects to be monitored and mentioned in the first section of this report, the RDF project will have to design a monitoring plan, which shall include not only the kind of quality parameters of the MSW and the RDF, but also parameters of the RDF process. It is recommended that the monitoring plan should be design as a component of a quality-environmental management system (such as ISO). This includes not only monitoring processes but also establishes the main procedures and plans for the reporting and verification components of an internal MRV system.

The RDF project should identify the kind of parameters to monitor, according to the expected quality of the final output, the country regulations for emissions to the air, water and soil, and any other parameter important for ensuring a good performance of the RDF process. As there are not RDF quality standards in Mozambique, this RDF project should adjust its quality MRV to the quality requirements of its current potential client, which is Cimentos de Mozambique. According to Carbon Africa (2016) the quality requirements of the Cimentos Mozambique (CdM) plant would be as follows:

Parameter		Unit	Amount	
	Calorific value	Kcal/kg	≥	4,500
	Ash content	%		---
	Water content	%	≤	10-20
	Sulphur (S)	%	≤	1.2
<<	Chlorine (Cl^-)	%	≤	0.3
	Fluoride (F^-)	%	≤	0.3
	P_2O_5	%	≤	2.0
	Maximum particle size	mm	≤	10.0
	Granulometria-passante P-50 mm	%		100.0
	Flash point	^oC	≥	80.0
General				
	Barium (Ba)	ppm	≤	3.000
(1)	Copper (Cu)	ppm	≤	5.000
(1)	Manganese (Mn)	pmm	≤	10.000
(3)	Cyanides (CN^-)	pmm	≤	100
(2)	Zinc (Zn)	pmm	≤	3.000
(2)	Berilium (Be)	ppm	≤	100
<<	$SiO_2+Al_2O_3+Fe_2O_3+CaO+MgO+SO_3+Na_2O+K_2O+F^-$	%		---
	Radioactive waste	---		Absent
	Medical waste	---		Absent
	Hospital waste	---		Absent
	PVC	---		Absent
<<	PCBs (Polychlorinated Biphenyl)	ppm	≤	50
	Pesticides	---		Absent
	Explosives	---		Absent
	Benzene	ppm	≤	5.000
	SVOC (Semi-volatile Organic Compounds)	ppm	≤	2.000
	PAH (Polycyclic Aromatic Hydrocarbons)	ppm	≤	1.500

Table 9 Quality requirements for RDF to be used at Cimentos de Mozambique (Carbon Africa, 2016)

Then, all the parameters mentioned above should be monitored periodically. An example of a possible monitoring plan is presented below. All activities related to the MRV should be documented through internal or external documentations (procedures, MRV records, legal documentations, certifications, etc.).

Monitoring	
Parameter	
Unit	
Description	
Source of data (who is responsible for providing the data?)	
Measurement procedures (if any)	
Monitoring frequency	
Responsible for monitoring	
QA/QC procedures	
Responsible for QA/QC	
Procedure in case of deviation	
corrective measure	
preventive measure	

Table 10 Proposed aspects to be considered when designing an internal Monitoring plan for an RDF plant in Mozambique, based on a quality and environmental management system

3.3 Reporting and verification: GHG emissions, process, and quality parameters

The means and frequency of the reporting and verification of GHG emissions should be established according to the requirements of the MRV system for GHG emissions of the country (if any). In case that the institutional structure would not be in place, the RDF plant should report their results of the monitoring to the relevant public authorities (municipalities, ministry), coordinating external verification with them. Reporting of GHG emissions may be done, first internally, for instance from the production area responsible for monitoring the GHG parameters to the general production manager; and externally, from the RDF plant to the relevant national MRV authority in Mozambique (probably MITADER).

In case of a lack of general procedures for MRV in the country, the RDF plant could establish intern and extern reporting and verification procedures, as a part of an integrated quality and environmental management system (ISO). In this case, it is important to establish not only the frequency of reporting and verification but also the means for these activities, design of procedures for performing internal reporting and verification, responsible at the internal level, legal framework (air emissions, pollution regulations), resources assigned for the MRV activities, capacity training plan, etc.

The tables below show the possible aspects to be considered in reporting and verification plans, in case of absence of national MRV procedures.

Reporting	
Responsible for internal reporting	
Frequency of the internal reporting	
Internal reporting: to whom	
Responsible for external reporting	
Frequency of the external reporting	
External reporting: to whom	
Legal framework or agreements associated with reporting	
Procedure in case of deviation	
corrective measure	
preventive measure	

Table 11 Proposed aspects to be considered when designing an internal reporting plan for an RDF plant in Mozambique, based on a quality and environmental management system

Verification	
Internal verification: responsible	
Means of verification	
Frequency	
To whom	
External verification: responsible	
Frequency	
To whom	
Means of verification	
Legal framework or agreements associated with verification	

Table 12 Proposed aspects to be considered when designing an internal verification plan for an RDF plant in Mozambique, based on a quality and environmental management system

4. Bibliography

DOCUMENTS

- Auditoria anual privada de conformidade ambiental, Fábrica da matola 1, elaborado por EIA & SERVICES, lda, December 2015
- Assembleia da República. Lei 2/97, de 18 de Fevereiro.
- Conselho Municipal de Maputo (2008) Plano Director- Gestão de Resíduos Urbanos da Cidade de Maputo.
- Conselho de Ministros. Constituição da República de Moçambique de 19 de Novembro 2004.
- Conselho de Ministros. Decreto n.o 11/2006, de 15 de Junho.
- Conselho de Ministros. Decreto n.o 94/2014, de 31 de Dezembro.
- Closing Operation and Concession of Hulene dumpsite, 2014
- Carbon Africa Limited & Associação Moçambicana de Reciclagem (2014) A Comprehensive Reviw of the Municipal solid Wast Sector In Mozambique
- Carbon Africa (2016) Internal report for UDP: Technical requirements and suitable technical options for upgrading Mozambican cement factories (2016)
- Flamme S, Geiping J (2012) Quality standards and requirements for solid recovered fuels: a review. Waste Management & Research 30(4) 335–353. DOI: 10.1177/0734242X12440481
- João Mucavele-Moçambique & Viana Castelo (2015) Gestão De Resíduos Sólidos Urbanos Em Moçambique: O Caso Específico Do Município De Maputo
- Estudo impacto ambiental – Projeto de aterro sanitario
- MICOA (2012) . Estratégia Nacional de Adaptação às Mudanças Climáticas (2013-2015)
- MOÇAMBIQUE. Assembleia Municipal da cidade de Maputo. Resolução no 86/ AM/2008 de 22 de Maio.
- MAPUTO (Município). Plano Director da Gestão de Resíduos Sólidos Urbanos da Cidade de Maputo.Maputo, 2008.
- Projecto do Aterro Sanitário Para as Cidades de Maputo e Matola, March 2016
- Power Point Presentation of João Mucavele, director of Salubrity at International Technological Waste Days, Portugal, September 2015
- RDF – Conceito para Mathlemele – working document by Cimentos de Moçambique, 2015

WEBSITES

- http://citypopulation.de/Mocambique.html accessed on 13th of June 2016
- http://www.edm.co.mz/ accessed on 13th of June 2016

- http://www.noticiasmocambique.com/recolha-residuos-solidos-matola-insatisfeita-os-privados/ accessed on 13th of June 2016
- https://www.aquaporservicos.pt/companies/15-visaqua-gestao-de-infra-estruturas-e-servicos-ambientais-s-a?locale=pt , accessed on 13th of June 2016
- http://asfes.org/files/descargas/PUBdefinitiva.pdf accessed on 13th of June 2016
- http://pt.rfi.fr/africa/20121009-mocambique-luta-contra-pobreza-e-prioridade-do-novo-primeiro-ministro accessed on 13th of June 2016
- http://pt.globalpetrolprices.com/Mozambique/gasoline_prices/ accessed on 13th of June 2016

The Climate Technology Centre and Network (CTCN) fosters technology transfer and deployment in developing countries through three core services: technical assistance, access to information and scaling up international collaboration. The CTCN is the operational arm of the UNFCCC Technology Mechanism.

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