Monitoring & Evaluation (M&E) Plan and Impact Statement Form

Objective of the M&E Plan and Impact Statement:

- The M&E Plan and Impact Statement must be designed based on the Technical Assistance Response Plan and must enable the Implementer to complete the Closure Report at the end of the assistance.

Process for filling in the form:

- The Implementer must identify relevant quantitative and qualitative indicators as specified in the Closure Report. A sub-set of indicators to monitor and assess must be chosen among these.
- The Implementer may also identify other specific, measurable, achievable, relevant, and time-bound indicators suitable to monitor Activities, Outputs and anticipated Outcomes from the technical assistance and add to the M&E Plan and Impact Statement.
- During implementation of the TA or FTA, the Implementer must collect all relevant data as described in the Monitoring & Evaluation Plan. Aggregated data on selected indicators as well as an updated version of the Impact Statement will be presented in the Closure Report at the end of the assistance.

Basic Information	
Title of response plan	Development of a technical and economic feasibility study for anaerobic digestion of the organic fraction of solid waste from households, hotels and markets in Mauritius
Technical assistance reference number	2020000014
Country/ countries	Mauritius
NDE focal point and organisation	Mr. Jogeeswar Seewoobaduth Ag. Director, Department of Environment Ministry of Environment, Solid Waste Management and Climate Change Phone: +230 210 56 20, +230 203 62 00 Email: jseewoobaduth@govmu.org
Sector(s) addressed	Renewable Energy, Waste Management
Technologies supported	Electricity generation via Biogas, anaerobic digestion
Implementation period and total duration	12 months (end 28 February 2022)
Total budget for implementation	USD 126 040

Designer of the response plan	CTCN + Mauritius NDE
Implementer of response plan	Council for Scientific and Industrial Research (CSIR), South Africa

(A) Outputs and Activities as described in the Response Plan	(B) Indicator	(C) Expected results	(D) Method and frequency for data collection	(F) Comments
General indicators for technical assistance				
	Anticipated number of direct and indirect beneficiaries as a result of the TA	**Direct – Around 20 persons** **Organisations** Solid Waste Management Division (5-6 persons) Department of Environment – Climate Change Division (7 persons) Central Electricity Board (2 persons) Ministry of Energy and Public Utilities (2 persons) Ministry of Agro-Industry and Food Security (2-3 persons) **Indirect - General Public** ~5,000 persons will benefit from the electricity produced from the biogas plant	**Organisations** Estimation made on number of officers from different organisation potentially involved in the project **General Public** Based on calculation. By determining the electricity production from the biogas plant and the electricity consumption per household in Mauritius, the no. of households benefitting from the biogas plant can then be determined. On average, a household in Mauritius has 4 persons. With the no.	**Organisations** Indicative at this point in time. This will be refined when all stakeholders are on board for the project. **General Public** Assumptions made: Plant capacity: 30,000 tonnes/annum (or 100 tonnes/day)

			of households known, the total no. of persons benefitting from the biogas plant can then be determined.	
	Anticipated amount of solid organic wastes diverted from landfilling as a result of CTCN TA	100 tonnes/day	Data to be obtained from weighbridge records at the entrance of the biogas plant	The capacity of 100 tonnes per day is only indicative. This will be refined as the feasibility study proceeds to completion.
	Anticipated metric tons of CO_2 equivalent (CO_2e) emissions reduced or avoided as a result of CTCN TA	Approximately 5,000 metric tons CO_2e avoided per year	Based on calculations - – This will be estimated using the amount of electricity produced and its equivalent amount of coal avoided. The CO_{2e} from the coal avoided will be calculated	Assumption: Plant capacity: 30,000 tonnes/annum (or 100 tonnes/day) Only CO_2 avoidance due to substitution of fossil fuels for electricity production has been considered.
	Electricity contribution to the grid network	12 MWh/day	Determined from calculations based on a methane yield of 0.3 m^3/kg VS, a VS content of 85%, a TS content of 30%, a plant capacity of 100 tonnes per day, a heating value of methane of 55,500 kJ/kg and an electrical efficiency of	Assumption: Plant capacity: 100 tonnes/day. The calculated data are only indicative and will be refined as the study proceeds.
	Anticipated increased economic, health, well-being, infrastructure and built environment, and ecosystems resilience to climate change impacts as a result of technical assistance	**Economic:** Increased resilience due to renewable electricity production and less dependent on the international volatile prices of fossil fuels **Health:** Increased resilience due to better management of solid organic wastes and less	Data from Statistics Mauritius will confirm the contribution of anaerobic digestion to electricity production Could be done through a survey (after completion of the project)	Not Applicable This may present some challenges as people will need to be sensitised about the impacts of

		health-related issues		mismanagement of solid wastes
Output 0: Planning and preparation CSIR	-	-	-	-
Output 1: (Implementation plan and communication documents)	Anticipated completion date	28 February 2022	Based on current work plan	This may be tight but the Consultants will do their utmost best.
Output 2: Status quo and baseline analysis of organic waste	Amount of solid organic wastes from households, hotels and markets available for anaerobic digestion	~300,000 tonnes per annum	Data collection from Solid Waste Management Division and Waste Characterisation Studies	Not all of the estimated 300,000 tonnes of organic wastes will be subjected to anaerobic digestion
Activity 2.1: Kick-off meeting	No. of participants in the meeting/ presentation of the technical assistance plan	20 participants - Kick off meeting report	Based on list of invitees during the presentation of the way forward of the project	Not Applicable
Activity 2.2: Analysis of current organic waste value chain	Establishing information on the waste generation, collection, transfer and transportation and disposal	Report on the analysis of the current value chain for organic waste across collection, transport, treatment and disposal	Data and information will be gathered from the SWMD	Information will be collected through meeting (physical or virtual) and discussion on email
	% of women involved in the waste management system	~10%	Through designed survey form/table submitted to the Solid Waste Management Division for onward transmission to the Local Authorities and Scavenging Contractors/ Operators of disposal sites	Some of the Local Authorities and Scavenging Contractors may not reply. As such, gender analysis will be made only on the response received.
Activity 2.3: Baseline analysis of organic waste	Amount of solid waste generated Composition of solid waste Solid Organic Wastes Characterisation	Report on analysis of the organic waste from markets, household and hotels including waste composition, characterization and quantification	Data and information will be gathered from the SWMD and relevant publications. Laboratory analysis will be conducted to characterise the solid waste	Sample will be collected and experimental analysis will be done

Output 3: Anaerobic digestion analysis with biogas potential	Anticipated no. of output revenue streams	4	Potential output streams for which revenue could be generated include electricity from biogas, compost, liquid fertiliser and CO_2.	To be further detailed out in the section on revenue analysis.
Activity 3.1: Quantification of biogas potential	Amount of methane produced from solid organic wastes processed	Estimated metric tons of biogas produced	Determined from calculations based on a methane yield of 0.3 m^3/kg VS, a VS content of 85%, a TS content of 30% and a plant capacity of 100 tonnes per day	This is highly indicative and will be refined as more accurate data are gathered, assessed and worked out.
Activity 3.2: Identification of by-products	Number of potential by-products	3 (Compost, liquid fertiliser and CO_2 from biogas)	From literature review	Not applicable
	Amount of by-product produced	Estimated tons of by-product and its potential use	The quality of by-product produced and its potential use as fertiliser will be investigated through published data	
Output 4: Identification of technologies on site	No. of technologies most probably adapted for Mauritius	2	Single stage high solids or multi stage high solids are probably more appropriate for Mauritius considering that the solids content of organic wastes is around 25%.	This will be refined as the study proceeds.
Activity 4.1: Identification of appropriate technologies and processes	Number of biodigester models assessed	5 technologies will be identified	Databases and reports	The following main types of anaerobic digestion systems will be considered: single stage low solids, single stage high solids, multi stage low solids, multi stage high solids and batch systems (single stage, sequential batch and hybrid batch-upflow

				anaerobic sludge blanket (UASB))
Activity 4.2: Identification of suitable site	Number of sites identified	2 sites will be identified	Discussion will be held with Ministry of Environment and relevant stakeholders with respect to potential sites	The number of sites is highly indicative and will be refined at a later stage. This will require an important input from the Ministry
Activity 4.3: Stakeholder meeting	Number of meetings held	2 meetings will be held (one meeting of activity 4.1 and 4.2)	Minutes of meeting	
	No. of participants present	~20	Solid Waste Management Division (5-6 persons) Department of Environment – Climate Change Division (7 persons) Central Electricity Board (2 persons) Ministry of Energy and Public Utilities (2 persons) Ministry of Agro-Industry and Food Security (2-3 persons)	Actual no. of participants will be finalised as the study proceeds.
Output 5: Schematic design of the biogas plant	Anticipated no. of drawings	4	Based on experience	List of drawings will include at least the following: 1. Schematic design 2. Material flow 3. Energy flow 4. Process flow diagram (PFD)
Activity 5.1: Development of a schematic design and inventory	No. of major equipment in the biogas plant	6	Based on literature review	Major equipment include: shredder, tank, digester, biogas holder, gas cleaning system, waste heat boiler
	Process flow diagram	Material and energy flow diagram	Material and energy balance	

Activity 5.2: Considerations for supply chain integration	Number of opportunities and requirements	Different requirements and opportunities for the integration into the existing value / supply chain		
Output 6.: Cost & Revenue analysis and business model	Anticipated Internal Rate of Return	10-15%	Feasibility study will determine the exact IRR	A sensitivity analysis will be carried out to determine the impact of other variables on the IRR
Activity 6.1: Cost analysis	Total investment cost	Estimated total capital investment	Using engineering economics tools	
	Cost of operation and maintenance	Estimated cost of operation and maintenance		
	Cost of electricity	Estimated cost of electricity (Rs/kWh)		
Activity 6.2: Revenue analysis	Total revenue from the sale of product and by-products	Estimated revenue from the operation of the biogas	Different components like sales of electricity and by-products, tipping fee, and any other opportunities like carbon credits.	This will be further clarified as the study proceeds.
Activity 6.3: Cost-benefit analysis	NPV, IRR, PB	Estimated net present value (NPV), the internal rate of return (IRR), and the pay-back period (PB)	Using economics tools	
Activity 6.4: Development of a business model	Establishment of a business model	Business model for the biogas plant		
Output 7: Implementation Plan and PPP proposal	Anticipated amount of funding/investment leveraged (USD) as a result of TA (disaggregated by public, private, national, and international sources, as well as between anticipated/confirmed funding)	USD 12 Million (fully private capital investments as foreseen in a potential PPP, with Government only providing tipping fee)	Feasibility study will confirm this anticipated investment costs.	This is based on a rough estimate obtained from: World Biogas Association, 2018. Global Food Waste Management: An implementation guide for cities, pp. 86.
Activity 7.1: Development of	Establishment of implementation plan	Develop an Implementation plan including		

implementation plan		timeline and stakeholder responsibilities.		
Activity 7.2: Development of PPP proposal	Public-Private-Partnership	1 Public-Private-Partnership		
Activity 7.3.: Capacity building on anaerobic digestion	Number of personnel trained	Around 20 trained staff	Through workshop Solid Waste Management Division (5-6 persons) Department of Environment – Climate Change Division (7 persons) Central Electricity Board (2 persons) Ministry of Energy and Public Utilities (2 persons) Ministry of Agro-Industry and Food Security (2-3 persons	Actual no. of participants will be finalised at the end.
Activity 7.4: Closure meeting	Closure meeting	1 closure meeting report	Presentation of the technical and economic feasibility study, business model, implementation plan and draft PPP.	Not Applicable
	No of participants in closure meeting	20	Based on no. participants in kick-off meeting	

Note: The Response Plan may contain information useful for the section below. The information in the table below will be used by the CTCN for public communication of the achieved and expected results of the Technical Assistance through the CTCN website www.ctc-n.org and other communication channels. See for example: https://www.ctc-n.org/sites/www.ctc-n.org/files/benin_a_ag_forestry.final_.pdf

Impact Statement	
Challenge	Increasing solid waste generation is a major issue in Mauritius, with most of the total solid wastes generated being landfilled annually. Although the sole landfill in the island has been ensuring a continuous disposal capacity since 1997, this is not a sustainable approach as the landfill is reaching the end of its lifetime. Besides, Mauritius, being a Small Island Developing State, depends heavily on fossil fuels for meeting its energy requirements. Considering the highly fluctuating prices of fossil fuels on the world market, this does not represent a sustainable solution for the country.

CTCN assistance	• Development of a schematic design of a biogas plant • Cost and revenue analysis and development of a business model for the biogas plant • Development of a preliminary proposal for a public-private partnership • Capacity-building on anaerobic digestion
Anticipated impact	• Establishment of a public-private partnership for the setting-up and operation of a biogas plant • Setting-up and operation of the biogas plant • Diversion of a significant fraction of organic wastes from landfilling to the biogas plant • Reduction in greenhouse gas emissions from the solid waste sector.
Anticipated co-benefits from the TA	Anticipated co-benefits linked with the construction and operation of a biogas plant in Mauritius are: 1. reduced environmental impacts resulting from degradation of organic wastes such as greenhouse gas emissions and leachate formation contaminating groundwater, 2. improved health with the reduced environmental impacts, 3. renewable energy exploitation and clean electricity production, *4.* potential use of the digestate from the anaerobic digestion process as organic fertilizer in line with a circular economy approach *5.* creation of green jobs
Gender aspects of the TA	The role of women and youth will be analysed within the current organic waste supply chain in Mauritius from waste generation, collection, transportation to disposal. Opportunities for women and youth will be identified in connection with the future construction and operation of the biogas plant (Deliverables 2 and 5 of the Technical Assistance).
Anticipated contribution to NDC	The Technical Assistance directly supports Mauritius' Nationally Determined Contributions to: • A gradual shift towards the use of cleaner energy technologies, such as biogas • A sustainable and integrated waste management, including waste to energy through anaerobic digestion
The narrative story	Over 500,000 tonnes of solid wastes are landfilled annually in Mauritius, out of which more than 50% are organic wastes, while over 87% of the total primary energy requirements of the island are met through fossil fuels. As a solution to alleviate both issues, anaerobic digestion is proposed as the technology to process organic wastes and simultaneously, produce renewable energy in the form of biogas. Prior to implementation of anaerobic digestion on a large scale, an in-depth feasibility study needs to be carried out. This CTCN Technical Assistance thus addresses this gap through the development of a technical and economic feasibility study for anaerobic digestion of the organic fraction of solid waste from households, hotels and markets in Mauritius. At the end of this Technical Assistance, Mauritius will have a technical and economic feasibility study report as well as a preliminary proposal for a public-private partnership at hand that will allow the country to move towards the implementation phase of the project. The implementation of anaerobic digestion is in line with the mitigation measures listed in the Nationally Determined Contributions submitted by Mauritius.

Contribution to SDGs	• *SDG 7 (Target 7.2) - By 2030, increase substantially the share of renewable energy in the global energy mix* Through the setting-up and operation of the anaerobic digestion plant, biogas will be produced and will be burnt to eventually generate electricity. This will reduce the reliance on fossil fuels for meeting the energy demand in Mauritius. As such, this contributes to target 7.2 having as aim to increase substantially the share of renewable energy in the energy mix for Mauritius. • *SDG 7 (Target 7.b) - By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support* The implementation of a biogas plant expands and upgrades the energy infrastructure of Mauritius in line with target 7.b. • *SDG 12 (Target 12.5) - By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse* Through the setting-up and operation of the biogas plant, organic wastes will be converted into biogas (for electricity generation) and a digestate (with potential for reuse as soil amendment). This is in line with the concept of recycling as specified in Target 12.5. • *SDG 13 (Target 13.3) - Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning* Anaerobic digestion of organic wastes is one of the mitigation measures that a country can take to abate greenhouse gas emissions from the solid waste sector. This Technical Assistance has a component on capacity-building which involves training on anaerobic digestion to relevant national stakeholders, including the Department of Environment and Solid Waste Management Division of the Ministry of Environment, Solid Waste Management & Climate Change and other relevant stakeholders. This is in line with Target 13.3. • *SDG 13 (Target 13.b) - Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.* This Technical Assistance is one of the mechanisms through which Mauritius, as a small island developing State, is receiving technical support for mitigating greenhouse gas emissions from the solid waste sector. This is in line with Indicator 13.b.1.
Reference to knowledge products	No UNFCCC Technology Executive Committee (TEC) knowledge products have been used in the development of the TA request and are envisaged to be used during implementation of the TA.