

Country	Tanzania
Request ID#	2023000014
Title	Carbon Reduction and Health Improvement by Retrofitting Biogas Plant in Tanzania
NDE	Tanzania Commission for Science and Technology Name: Dr. Gerald Majella Kafuku Position: Manager of Innovation and Technology Email: kafukugm@gmail.com, gerald.kafuku@costech.or.tz Address: P.O. Box 4302, Ali Hassan Mwinyi Road, Kijitonyama (Saynasi) COSTECH Building, Dar es Salaam, Tanzania
Proponent	Nelson Mandela African Institute of Science and Technology, Tanzania

Summary of the CTCN technical assistance

Challenges

Tanzania aims to meet 60% of its energy needs from renewable sources by 2026, but rural areas still rely heavily on biomass, causing pollution and health issues. Additionally, improper disposal of cattle waste contributes to soil pollution and greenhouse gas (GHG) emissions. To address this, a biogas plant was set up in Arusha, Tanzania having a capacity of 10 m³, using locally sourced cattle manure. However, the efficiency of the biogas plant is low due to sludge accumulation, temperature fluctuations (20-40°C), an unoptimized manure-water mixing ratio, and biogas leakage. During the technical assistance accumulated sludge cleaning with overall retrofitting of the digester tank, methane potential of feedstock, process optimization such as feed rate and interval of feeding will be designed. All these efforts will be made for proper functioning of biogas plant and data collection on a daily basis. This will help to optimize the process for further enhancement and future suggestions. Here it has been cut short since it as a summary. A detailed explanation has been made in Section 3 with anticipated timeline. The proposed activities aim to resolve these technical challenges and improve the plant's performance to support Tanzania's energy goals.

Technical Assistance

Biogas retrofitting and data collection

Jun-Aug 2024 →

- Kick-off meeting and technical assistance proposal plan
- Onsite inspection of the biogas plant and current status of biogas generation and utilization in Arusha, Tanzania

Sept-Nov 2024 →

- Cleaning of accumulated sludge in the digester tank
- Biochemical CH₄ potential (BMP) test based on temperature variation and cattle manure-water mixing ratio
- Change in feeding pattern to maximize digestion process during the daytime

Oct-Dec 2024 →

- Continuous data collection for performance optimization
- Estimation of GHG reduction by using biogas

- Utilization of sludge digestate as fertilizer for plant growth

Health improvement by biogas burning

Aug 2024 →

- Initial indoor air quality monitoring
- Research on current health situation in Tanzania

Sept-Nov 2024 →

- Comparison regarding the change in air quality after biomass and biogas utilization
- Survey on health conditions depending on utilization of various energy source of local resident
- Improved biogas plant survey results by collecting residents' opinions

Increase the awareness on biogas technology and GHG emissions

Aug 2024 →

- Lecture on importance of biogas technology for clean energy
- Benefits of biogas for GHG reduction
- Teaching the basics of anaerobic digestion process

Oct-Nov 2024 →

- BMP experiment, carbon emission and reduction calculation and sludge utilization

Intended impact

- Clean and renewable energy production
- Reduce GHG emissions
- Improve the local and personal hygiene
- Improve indoor air quality thus overall health improvement
- Reduce the burden due to high fuel costs (firewood, charcoal, etc.)
- Digested sludge as fertilizer will enhance sludge disposal and soil quality

The key stakeholders involved

- (1) Tanzania Science and Technology Commission (NDE), Tanzania
- (2) Nelson Mandela African Institute of Science and Technology, Tanzania
- (3) Gongali Model Co. Ltd, Tanzania
- (4) Tanzania Human Development Foundation, Tanzania
- (5) Inha University, South Korea (International Academic Institutions)
- (6) Dongkuk University, South Korea (International Academic Institutions)
- (7) R.E.D Corp., South Korea

Agreement:

(If possible, please use electronic signatures in Microsoft Word file format)

**National Designated Entity to the UNFCCC
Technology Mechanism**

Name: Dr. Gerald Majella Kafuku

Title: Manager of Innovation and Technology

Date: 23rd April 2025

Signature: 

Proponent (signature of the Proponent is optional)

Name: Prof. Askwar Hilonga

Title: Professor

Date: 7th May 2025


Signature: 

UNFCCC Climate Technology Centre and Network (CTCN)

Name: Ariesta Ningrum

Title: Director

Date: 09.05.2025

Signature: 

1. Background and context

Biogas is a composition of CH₄, CO₂ with small amount of H₂S and water vapor produced by degradation of organic matter in an anaerobic environment. The CH₄ content in biogas generally varies from 55-70%, with most of the remainder being CO₂. It makes biogas a flammable gas with an energy content of 28MJ/m³. Biogas can be used as cooking gas, transportation fuel, electricity and heat generation. It is considered as a clean source of energy since burning biogas produces CO₂ and water vapor.

Cattle manure not only is one of the major sources of biogas generation, but it is also rich in valuable nutrients such as nitrogen and phosphorous. Tanzania has the third largest livestock population in Africa, with about 30 million cattle (1 million tons of manure per day) kept by 2.3 million households (TDBP). In addition, 620,000 farmers keep over 2 million pigs (6,600 tons of manure per day). In 2016, the Tanzania domestic biogas project (TDBP) received nine billion Tanzanian shilling (\$3.9 million) worth of funding from the governments of Tanzania, Netherlands and Norway for the TDBP (Hewitt et al., 2022). However, in Tanzania, around 12,000 biogas plant installations were planned, but the initiative was somewhat undermined by the lack of sustained use of many small-scale biogas systems or their subsequent failure or abandonment. Since, Tanzania has a made target to reduce the GHG emissions by 20% by 2030 and increase the electricity generation capacity from 1,500 MW to 4,910 MW, while achieving 60% energy from renewable sources by 2026 (Tanzania energy outlook 2019).

To achieve this goal, it becomes necessary to address the biogas technology from installation to proper maintenance. It can be illustrated through a study example, an average animal (cattle+other domesticated animals) manure produced is 10,365 kg/d with 60% collection efficiency almost 6,295 kg/d can be used for biogas plant and with 67% conversion efficiency almost 4,255 kg/d of animal manure would provide 153 m³/d (1 kg animal manure = 0.036 m³ of biogas). An average biogas consumption for cooking per household is 0.32 m³/d, considering the amount the generated biogas can fulfill the energy demand of 478 families (Mwakitalima et al., 2022). Considering the current GDP per capita of Tanzania, which is \$1,211 (World Bank, 2024), and an average cost for biogas construction \$ 2,000, it seems very difficult to popularize the concept of biogas among local citizens. Therefore, it is necessary to build an effective biogas plant at a lower cost which can be easily supported by residents.

Sources:

Hewitt, J., Holden, M., Robinson, B. L., Jewitt, S., & Clifford, M. J. (2022). Not quite cooking on gas: Understanding biogas plant failure and abandonment in Northern Tanzania. *Renewable and Sustainable Energy Reviews*, 165, 112600.

Tanzania Energy Outlook (<https://www.iea.org/articles/tanzania-energy-outlook#>)

Mwakitalima, I. J., Rizwan, M., & Kumar, N. (2022). Integrating Solar Photovoltaic Power Source and Biogas Energy-Based System for Increasing Access to Electricity in Rural Areas of Tanzania. *International Journal of Photoenergy*, 2023(1), 7950699. <https://doi.org/10.1155/2023/7950699>

2. Problem statement

According to Tanzania's national energy policy, it is proposing a policy aimed at 60% of renewable energy as a whole by 2026. However, Tanzania uses fuel such as liquified petroleum gas (LPG), natural gas, biomass and charcoal as its primary source of energy. In rural Tanzania almost 92% homes still use biomass and charcoal as fuels. And the use of biomass and charcoal is one of the main CO₂ and GHG emitters. Therefore, as mentioned in request form, in rural Tanzania, GHG emission is higher than cities.

Furthermore, biomass and charcoal does not only responsible for GHG emission, but they are also responsible for smoke, toxic gases such as CO, NO_x, VOC, black carbon and PM_{2.5} (Jiang et al., 2024). It deteriorates the woman health mostly, since they expose themselves for longer period of time affecting the respiratory system. According to Ahamad et al., (2021), Tanzania's smoke exposure risk (SER) is 84.3% and it belongs to high SER countries. Therefore, usage of biogas that meets the WHO's standards can lower the SER to 14.6%. To reduce the use of biomass, a biogas plant was set up in Arusha, Tanzania by feeding livestock manure collected locally. This project is targeted in Arusha, since biomass burning for cooking is still a common practice due to low cost compared to (LPG). As mentioned in the request form, since the currently running biogas plant is not working well, the local population has again shifted to biomass such as wood and charcoal as their main fuel source.

The specific technical barriers of the currently running biogas plant in Arusha are having low CH₄ efficiency and sludge accumulation inside the anaerobic digester. Other problems are temperature fluctuation between 20-40°C. Anaerobic digestion is a temperature sensitive process and works better at stable temperatures above 35-37°C, so maintaining the temperature or minimizing the fluctuation would enhance the process. As mentioned in the request form, cattle manure to water mixing ratio has not been optimized accurately, which shall be followed a 3:4 ratio. Feedstock injection rate has not been optimized into the digester, as overfeeding can seize the working efficiency of the digester leading to failure of the biogas plant. In addition to that, per day biogas generation and consumption is unknown since pressure gauges and flowmeter have not been installed.

Sources:

Ahamad, M. G., Tanin, F., & Shrestha, N. (2021). Household smoke-exposure risks associated with cooking fuels and cooking places in Tanzania: a cross-sectional analysis of demographic and health survey data. *International Journal of Environmental Research and Public Health*, 18(5), 2534.

Jiang, K., Xing, R., Luo, Z., Huang, W., Yi, F., Men, Y., ... & Shen, G. (2024). Pollutant emissions from biomass burning: A review on emission characteristics, environmental impacts, and research perspectives. *Particuology*, 85, 296-309.

3. Logical Framework for the CTCN Technical Assistance:

(Guidance: Please note that multiple activities lead to one Output, and multiple Outputs lead to one Outcome. There can be several Outputs, but only one Outcome description capturing the CTCN technical assistance. Deliverables are the products or services to be delivered to the NDE/Proponent/CTCN based on the Activities and the Outputs.)

Objective: A technological feasibility study for improving CH ₄ collection efficiency and responding to climate change through structural design improvement of biogas plants.																				
Outcome: Improve CH ₄ collection efficiency by fully retrofitting the biogas plant, collecting digestate for use as fertilizer, and monitoring plant growth to detect any potential toxicity or inhibition. Additionally, provide biogas to local residents for collective use to reduce biomass burning, thereby improving air quality. These actions will help lower GHG emissions and positively impact climate change.																				
										Month (June 2024-Feb 2025)										
										1	2	3	4	5	6	7	8	9		
Mandatory Output: Project management <i>All implementers must undertake the following project management activities at the beginning of, during and at the end of the CTCN technical assistance.</i>																				
Activity A: Pre-implementation																				
<ul style="list-style-type: none"> • Kick-off meeting to discuss the ongoing problems for which request was made and technical assistance proposal • Onsite inspection of the biogas plant and lecture regarding the importance of biogas for GHG reduction and social hygiene • A complete retrofitting of the biogas plant which includes sludge removal, optimization of operational plan and data collection • Carbon reduction calculation and Indoor air quality monitoring • Health report survey of the local population • Improved biogas plant survey results by collecting residents' opinions • Utilization of sludge digestate as fertilizer for agricultural purposes • A co-benefit for each gender will be progressed after the outcomes and evaluated through social surveys 																				
Activity B: Implementation																				
<ul style="list-style-type: none"> • Kick-off will be organized to discuss the ongoing problem in the biogas plant Arusha, Tanzania and a technical assistance proposal will be discussed (June 2024). 																				

<ul style="list-style-type: none"> A review meeting will be held to discuss the overall progress of the project along with challenges and future scope. 									
<p>Activity C: Post-implementation</p> <p>At the end of the project a closure report will be submitted which will discuss the expected and achievable output. A final report, outcomes of all the previous activities, data based concluding remarks efficiency of biogas increased. The project work and outcomes will be presented in the domestic/international conferences. Research articles will be published for each journal domestic and international showcasing the work as a case studies.</p>									
<p>Mandatory deliverables:</p> <p>Deliverable 1: Detailed work plan</p> <p>Deliverable 2: Closure and data collection report, M&E plan (final)</p>									
<p>Output 1: Meeting to discuss the problems mentioned in the CTCN request form and highlight the causes behind the low CH₄ efficiency of the biogas plant. Preparing a plan to visit Arusha, Tanzania and onsite biogas plant observations.</p> <p><i>(Guidance: Outputs are new products and/or services that are produced by the implementers of the technical assistance, through completion of activities, and within the control of the CTCN technical assistance).</i></p>									
<p>Activity 1.1: Problem identification of biogas plant in Tanzania</p> <p><i>(Guidance: Work performed towards production of a specific output. Please add as many rows with activities as required)</i></p>									
<p>Activity 1.2: Checking the possibilities of importing samples from Tanzania to South Korea for analysis</p>									
<p>Activity 1.3: Buying chemicals and sensors to export from South Korea to Tanzania</p>									
<p>Deliverables 1: Meeting over the problem discussion related to low CH₄ efficiency of biogas plant in Arusha, Tanzania. As per the discussion based on the CTCN request form the actual problem was sludge accumulation, temperature fluctuations, and biogas leakage.</p> <p>At first analysis of samples from the digester tank would be the priority, which means import of samples from Tanzania to South Korea. To import the samples approach to Logistics company in Tanzania and provide import clearance certificate to get the custom clearance. In South Korea approach to Animal and Plant quarantine agency (APQA) for manure samples clearance certificate. Following that, contact the logistics company for analytical chemical export from South Korea and provide them clearance certificate by obtaining from Tanzania medical devices authority (TMDA).</p> <p>- Summary report for Output 1.</p>									

4. Resources required and itemized budget:

Please provide an indicative overview of the resources required and itemized budget required to implement the CTCN technical assistance, including for M&E-related activities, using the table below. Important to note that minimum 5% of the budget should explicitly target gender specific activities related to the technical assistance (please see section 10 for further information on gender). Once the Response Plan is completed, a Response Implementation partner(s) will be selected by the Climate Technology Centre (CTC). A detailed activity-based budget for the CTCN assistance will be finalized by the CTCN and selected Implementer.

Activities and Outputs	Input: Human Resources (Title, role, estimated number of days)	Input: Travel (Purpose, national vs. international, number of days)	Inputs: Meetings/events (Meeting title, number of participants, number of days)	Input: Equipment/Material (Item, purpose, buy/rent, quantity)	Estimated cost (USD) <i>Please accumulate the costing at Activity and Output level and provide an estimated costing range for each activity and the total Response Plan</i>	
					Minimum	Maximum
Mandatory Output: Project Management						
Mandatory Activities: A: Pre-implementation B: Implementation C : Post-implementation	Please allocate 1-5 working days for each of the mandatory reports under Activities A-C					
A : Pre-Implementation						
Output 1: Meeting to discuss the problems mentioned in the CTCN request form and preparing a plan to visit Arusha, Tanzania for onsite biogas plant observations.						
Activity 1.1: Problem Identification of biogas plant		Travel to Seoul (National) No. of days: 1	Kick-off meeting to discuss the problems		2,000	2,500

			related to biogas plant in Arusha, Tanzania No. of meeting: 1 Participants: 6 (\$500)			
Activity 1.2: Checking the possibilities of importing samples				To Arusha, Tanzania (International) Buy and Ship (\$1,500)	1,000	1,500
Activity 1.3: Buying chemicals and sensors to export to Tanzania				Travel to Arusha, Tanzania (International) Buy and Ship (\$7,000-8,000)	7,000	8,000
Output 2: Plan to visit Tanzania: Onsite biogas plant inspection and giving lecture regarding biogas						
Activity 2.1: On-site biogas plant inspection and real time monitoring	South Korean team visited Arusha, Tanzania for onsite inspection for 7-8 days (\$5,500)	Travel to Arusha, Tanzania (International) No. of days: 6-7 (\$7,000-8,000)	Meeting with Tanzania group regarding biogas plants problems and biogas utilization in Arusha, Tanzania No. of days: 7 Participants: 4 (\$500-1,000)	Installation of gas sensors at the biogas production site Buy and carry (\$5,000-6,000)	22,000	30,000
Activity 2.2: Lecture at Nelson Mandela African Institution of Science and Technology (NM-AIST)					2,000	3,000
Activity 2.3: Comparison of indoor dust concentration					2,000	3,000

Activity 2.4: Actual gas utilization in Tanzania					2,000	3,000
Output 3: Second visit to Tanzania: Retrofitting of digester tank and lecture regarding experimental procedure	<p>A team of two people visited to inspect the retrofitting work and to perform analytical task for 10 days (\$ 5,500)</p> <p>Retrofitting work was done by labors (including cleaning the digester tank and installing the pipeline and fixing the damaged portion of the digester) (\$2,500)</p>	<p>Travel to Arusha, Tanzania (International) No. of days: 10</p>	<p>Meeting related to biogas retrofitting, operational plan, biogas utilization rate, and taking classes to university students for teaching experimental lessons (\$7,000-8,000)</p>			
Activity 3.1: Preparation for buying chemicals for physico-chemical analysis, biochemical methane potential (BMP) test of feedstock samples.				<p>Purchase chemicals for COD, Nitrogen, and ammonia analysis, Kits for BMP tests, and Gas sensors Buy and install (\$8,000-10,000)</p>	22,000	30,000

Activity 3.2: Data accumulation				Data acquisition system Buy and install (\$2,500-3,000)	2,500	3,000
Activity 3.3: Complete retrofitting of digester tank				Materials requirement for retrofitting works Buy and install (\$9,000-10,000)	9,000	10,000
Activity 3.4: Lecture to NM-AIST students					1,500	2,500
Activity 3.5: Sample collection for COD, TN, and ammonia analysis					5,000	6,000
Activity 3.6: Utilization of sludge waste for fertilizer				Sludge collection equipment Buy/Rent whichever possible	1,500	2,000
B: Implementation						
Output 4: Continuous data collection for performance analysis of retrofitted biogas plant in terms of CH ₄ yield and carbon reduction calculation						
Activity 4.1: Continuous data collection from retrofitted biogas plants				Chemicals and BMP for temperature variation and with different mixing ratio	2,000	3,000
Activity 4.2: Collaborative biogas experiment				Buy and use (\$2,000-3,000)	3,000	3,500

Activity 4.3: Survey on health issue in Tanzania with utilization of biomass			Meetings related to health survey No. of days: 7 Participants: 4 (\$1,000-1,500)		1,000	1,500
Activity 4.4: Carbon reduction calculation					2,000	3,000
Activity 4.5: Data analysis for further suggestions					1,000	1,500
Activity 4.6: Business model establishment					2,000	2,500
C: Post-Implementation						
Output 5: Closure report: Concluding results and future suggestions						
Activity 5.1: Prepare a final report showing the conclusion and future suggestions		Meeting related to closure report (National/International) (\$2,000-2,500)	Discussion related to Closure report and future suggestions (\$500-1,000)		2,000	3,000
Activity 5.2: Presentation at conference and research article writing (Domestic)					5,000	6,000
Activity 5.3: Presentation at conference and research article writing (International)					5,000	6,000
Total budget estimated (USD)					103,000	134,500
Gender and social benefits allocations (5% of the total budget) (USD)					5,150	6,725
Estimated range of costing for the entire Response Plan (USD)					108,150	141,225

5. Profile and experience of experts

Experts required	Brief description of required profile
<i>Please use the same titles for all experts as applied in section 4.</i>	<i>Please provide a short description of expertise and experience needed (education, sectors of expertise, years of experience, country experience, language requirements, etc.).</i>
Dong-Hoon Kim Professor Inha university South Korea Lead Investigator	Ph.D. (2008) Anaerobic Digestion of Organic Solid Wastes Expertise in anaerobic digestion process, biogas production, dark fermentation, GHG reductions. Korean representatives on IEA-HIA Task 34 on biohydrogen. Experience: >10 years of teaching/research experience Language fluency: Korean and English. Country : South Korea, France, China
Si-Kyung Cho Professor Dongguk University South Korea Co-Team Investigator 1	Ph.D. (2013) Anaerobic Digestion, Environmental Engineering Expertise in anaerobic digestion process, resource recovery, wastewater treatment, wet electrostatic precipitator, biogas production, microplastic and ARGs. Korean representatives Technical Advisory committee of Korea Environment Corporation Experience: >10 years of teaching/research experience Language fluency: Korean and English.
Chang-Kyu Lee CEO and Founder R.E.D. Corp. South Korea Co-Team Investigator 2	Environmental facilities manufacture company's CEO Experience: >10 years of environmental engineering experience Language fluency: Korean and English. Country : South Korea, Spain, Saudi Arabia
Seongwon Im Assistant Professor Suchon University	Ph.D. (2020) Anaerobic digestion, animal manure storage and GHG reduction Experience: >5 years of experience in research and development Language fluency: Korean and English.
Om Prakash Post-Doc fellow Inha University	Ph.D. (2024) Anaerobic digestion and biomethanation Research experience: 4 years Language fluency: Hindi and English
Ali Ashraf Joolaei Ph.D. student Inha University	Ph.D. (2024) Anaerobic digestion of bioplastics and Machine learning Research experience: 2 years Language fluency: Persian and English
Min-sang Kim	Ph.D. (2025) Anaerobic digestion and Machine learning

Ph.D. student
Dongguk University

Research experience: 4 years
Language fluency: Korean and English

6. Intended contribution to impact over time

The anticipated benefits of biogas will be reduction of GHG emissions which usually happens during cattle manure storage and biomass burning.

Since biogas is considered as a cleaner fuel and produces significantly less smoke compared to wood and charcoal. Indoor air quality will be improved (SER<15%) thus improving the health of residents. In addition, an awareness program will be run among the village about personal and social hygiene which overall improves the quality life of villagers. Lectures about the basics of anaerobic digestion, carbon reduction and technical training related to biogas plants will be provided to students. As discussed in section 1, a small biogas plant with a feed around 7000 kg cattle manure/day as mentioned can benefit almost 500 families which could be an average village population in Tanzania. The current project will not have immediate impact on the GDP contribution of the focus sector. However, slow and steady progress in biogas technology in Arusha and other cities will have greater impact on the national economy. An estimated carbon emission reduction from 3-10 m³ biogas plant would be almost 55.4 ton CO₂ eq./y (51.8 ton CO₂ eq./y from CH₄ recovery + 3.6 ton CO₂ eq./y due to renewable energy generation).

Please provide a brief description of the intended contribution to impact over time of the outcome and outputs provided by this technical assistance on resilience to climate change and/or carbon abatement. To the extent possible, please quantify the intended impact contribution, for example by indicated estimated number of people potentially impacted over time, GDP contribution of the focus sector, carbon emissions by the focus sector, etc. This intended contribution to impact is what will happen if the objective (as articulated in section 3) is met. Please ensure relevant complementarity with text in sections 7 to 12. (maximum 1250 characters including spaces)

7. Relevance to NDCs and other national priorities

Biogas generation from organic waste like cattle manure not only generates clean energy but also reduces the GHG emissions if left untreated. With biogas the cost of energy production and supply will be minimized as the infrastructure and distribution can be decentralized. Recently South Korea has taken a pledge reach net zero carbon emissions by 2050 through various means. And among them one of the strategies is to reduce dependency on fossil fuels instead finding renewable and low carbon emission based fuels. Currently, South Korea has 110 biogas plants and aims to build 140 biogas plants which will increase the biogas production by 40% and lower the annual energy cost by about \$136 million and reducing the 1.1 million tons of GHG. Similarly, Tanzania can harvest its biogas potential and reduce the carbon emissions. Tanzania has the third largest livestock population with 30 million cattle which means almost 300,000 tons of cattle dung generates daily (1 cattle = 10 kg dung /d). In total approx. 10,800 m³ of biogas can be produced on daily basis (1 kg cattle dung = 0.036 m³ biogas). Technical assistance related to biogas plant retrofitting and awareness will help to reach the NDCs to reduce the GHG emissions and adapt to climate change. As the goal of the Paris Agreement is to hold the increase in the global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the increase to 1.5°C above pre-industrial levels.

Current climate technology addresses the actions to be taken for reducing GHG emissions by utilizing CH₄, a potential GHG with a 100 year global warming potential of 28. The current climate technologies will lay a groundwork for implementation strategies to improve the biogas efficiency and regular data monitoring. After long term monitoring and evaluating the performance, a new policies can be set to improve the biogas plant further and make aware about

the climate technologies and its benefits among the people so that voluntary actions can be taken to reduce the GHG emissions. In this way other relevant priorities like Technology Needs Assessments (TNAs), Technology Action Plans (TAPs), National Adaptation Plans (NAPs), and Nationally Appropriate Mitigation Actions (NAMAs) can be met.

Sources:

<https://www.korea.net/Government/Briefing-Room/Press-Releases/view?articleId=1533260&insttCode=A260112&type=N>

Mwakitalima, I. J., Rizwan, M., & Kumar, N. (2022). Integrating Solar Photovoltaic Power Source and Biogas Energy-Based System for Increasing Access to Electricity in Rural Areas of Tanzania. *International Journal of Photoenergy*, 2023(1), 7950699.
<https://doi.org/10.1155/2023/7950699>

8. Linkages to relevant parallel on-going activities:

Scientists and Engineers Without Borders (SEWB) is an organization that seeks to provide sustainable scientific technologies to the socially vulnerable groups in developing and third-world nations. Specifically, the organization recognizes the need for availability of technologies in nations with underdeveloped scientific and technological environment and focuses on distribution and proliferation of easily applicable available technology as well as promoting public-private partnerships. As the current research project focuses on distribution of accessible biogas production systems in Tanzania, it coincides with the spirit of SEWB. Participation of SEWB in further distribution and collaboration may ensue.

Furthermore, United African University in Tanzania (UAUT) operated by a nonprofit organization Pan Asia, Africa and America Universities Association (PAUA) is a university located in Dar es Salaam which seeks to train and educate young Tanzanian individuals to benefit the global society. Currently the university has departments in computer engineering, information and communication technology and business and administration. Preparation to establish network with the purpose of training suitable technicians and engineers for future operation of biogas plants is due.

9. Anticipated follow up activities after this technical assistance is completed:

The current technical assistance will contribute to a complete retrofitting of the biogas plant, increase the CH₄ generation efficiency, use of digestate as fertilizer, and improving the air quality of local houses as it is a clean source of energy. In addition to that, an awareness and technical training program which includes basics concept of anaerobic digestion, benefits of biogas technology, experimental procedures, and carbon reduction methodology will also be provided to the university students and technical staffs.

Overall, biogas is a promising solution for rural communities looking to shift away from fossil fuels and reduce their carbon footprint. The outputs can be used by governmental agencies, non-profitable organizations, non-governmental organizations to promote and expand the biogas technology into other rural areas. Using the current biogas operational cost and efficiency new and bigger biogas plant can be built in and around Arusha to support the rural communities and reduce the carbon emissions concomitantly. Tanzania governmental agencies, local governmental agencies can bring the policies related to biogas plant construction and utilization. If possible, they can provide subsidies to local players to ease the financial burden on setting up the biogas plant.

Currently there are no method to dispose sludge waste produced from biogas plant in Tanzania, and utilization of these sludge waste can benefit both environmentally and agriculturally. Anaerobic digestate have been proved useful to be utilized as fertilizer in recent studies and using it as fertilizer will benefit local resident and farmers in rural community. Since fertilizer prices are high, consumption of fertilizer in Tanzania dropped by 38% in 2021. Using anaerobic digestate as fertilizer will ease the financial burden on local farmers and residents with consumption of fertilizer. If Tanzania government agencies can help with distribution of anaerobic digestate to local farmers, then it can benefit both biogas production plant and farmers.

Health monitoring is essential since utilization of biomass causes dust formation and causes lung disease among local households. 50% of people suffered from lung disease using biomass as energy source in cooking. These results were from Arusha, and more rural areas will have higher number. Tanzania government needs to conduct regular health monitoring on cooking environment to bring policies for health and strengthen the policies related to biogas plant construction and utilization.

10. Gender and co-benefits:

Each technical assistance must integrate gender mainstreaming activities and lead to gender and other co-benefits. At least 5% of the technical assistance budget need to be allocated to gender mainstreaming activities.

Imbedded in design of the activities:	<p>In many developing countries like Tanzania, women and girls spend hours collecting firewood for cooking. This reduces the time availability for doing other creative and self-improving activities such as personal hygiene education, learning skills through community involvement.</p> <p>Traditional cooking through firewood and charcoal leads to significant indoor air pollution causing respiratory diseases, eye related problems and other pollution related health complexities to women and children. This reduces an average life expectancy.</p> <p>The responsibility of fuel collection often falls on girls, reducing the time for school attendance and study. In areas without biogas plants, girls are more likely to be pulled out of school to assist with household energy needs, perpetuating gender disparities in education.</p> <p>Women and girls who travel long distances to collect firewood may face heightened risks of violence. This is particularly true in conflict zones or areas with insecure environments.</p>
Gender and co-benefits intended as result of the activities:	<p>Women use biomass such as wood and charcoal for cooking in most of the rural Tanzania suffers lung problems due to toxic smoke and particulate matters comes out from biomass. It increases the burden of social health infrastructure and personal medical expenses which could have been used otherwise for social development or education purposes. Biogas does not produce smoke on burning and release CO₂ and water vapor both are harmless. Thus, save women from getting lung problems and reduce the medical expenses.</p>

	<p>Biogas operation requires injecting the feedstock, technical support, regular monitoring, digestate handling, and biogas collection and utilization. It requires manpower so in this way, a local job creation is also possible for differently skilled people.</p> <p>Young girls usually skip the schools and walk a long distance into forest for biomass and firewood collection, thus cannot study for longtime and remains uneducated. With biogas availability, they will no longer skip school to bring firewood and educate themselves.</p> <p>Tanzania is an agriculture-based economy, and most farmers buys chemical fertilizer to improve the crop productivity. However, chemical fertilizers are not only expensive but also deteriorate soil health with time. Digestate coming from biogas fertilizer can replace chemical fertilizers and can be cheaper than chemical fertilizer. Another reason is since it is organic it also improves soil health overtime.</p> <p>Cattle manure if left untreated can be nuisance due to odor problem and promotes insects like mosquitoes which can cause different diseases. Run off manure into the field is unhygienic since it mixes with river bodies. Proper treatment of manure through biogas plant reduces the chances of soil and water pollution.</p>
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11. Main in-country stakeholders in implementation of the technical assistance activities:

Using the table below, please list and describe the role of in-country stakeholders, participants and beneficiaries who will be involved in or directly consulted during implementation of the assistance.

In country stakeholder	Role in implementation of the technical assistance
Tanzania Science and Technology Commission (NDE), Tanzania	The Tanzania Science and Technology Commission can provide government policy or administrative support. In addition, public seminars can be held at the government level to publicize the commercialization of the Biogas plant and present the potential spread of the project continuously.
Nelson Mandela African Institute of Science and Technology, Tanzania	Nelson Mandela African Institution of Science and Technology can help the improved Biogas plant operate as a pilot project locally. And research can be supported to leap forward into more efficient technologies through R&D.
Gongali Model Co. Ltd, Tanzania	Since Gongali Model Co. Ltd has experience in building a biogas plant in Tanzania, it can carry out local production of the improved designed biogas plant.
Tanzania Human Development Foundation, Tanzania	The Tanzania Human Development Foundation (TAHUDE Foundation) is a local organization engaged in environmental NGO activities in Tanzania and plans to implement a role in improving awareness and promoting the residents of the Biogas plant. Also TAHUDE has got funds from the United

	States Africa Development Foundation (USADF) to build Biogas systems on flexible loans to the grassroots community. The NGO will support the improved Biogas
Inha University, South Korea (International Academic Institutions)	Participating as an international consulting institution, Inha University conducts a role in reviewing the existing Biogas plant by professional engineers and deriving design conditions for the improved biogas plant. In addition, delivering lectures and conducting scientific experiments, carbon reduction estimation. Professionals have experience in cattle manure handling, reduction in GHG emissions during manure storage, and anaerobic digestion of cattle manure. Biogas upgrading techniques through various means.
Dongguk University, South Korea (International Academic Institutions)	Participating as an international consulting institution, Dongguk University conducts a role in reviewing the existing Biogas plant by professional engineers and deriving design conditions for the improved biogas plant. Air quality monitoring and comparison, digestate treatment and utilization.
R.E.D Corp., South Korea	R.E.D Corp. has experience in conducting R&D work in the environmental field in domestic and overseas projects. Specialization in designing and manufacturing membrane and anaerobic digestion reactors.

12. SDG Contributions:

Instructions: Please complete the grey section below for a maximum of three SDGs that will be advanced through this TA. A complete list of SDGs and their targets is available here:

<https://sustainabledevelopment.un.org/partnership/register/>.

Goal	Sustainable Development Goal	Direct contribution from CTCN TA (1 sentence for top 1-3 SDGs)
1	End poverty in all its forms everywhere	
2	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	
3	Ensure healthy lives and promote well-being for all at all ages	Biogas will improve social hygiene and indoor air quality by minimizing odor and smoke problems.
4	Ensure inclusive and equitable quality education and promote life-long learning opportunities for all	
5	Achieve gender equality and empower all women and girls	
6	Ensure availability and sustainable management of water and sanitation for all	
7	Ensure access to affordable, reliable, sustainable, and modern energy for all (consider adding targets for 7)	
	7.1 - By 2030, ensure universal access to affordable, reliable and modern energy services	
	7.2 - By 2030, increase substantially the share of renewable energy in the global energy mix	
	7.3 - By 2030, double the global rate of improvement in energy efficiency	
	7.a - By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology	
	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	
8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	Biogas plant provides a secure energy system and can be benefits small scale industrialization through innovation.
10	Reduce inequality within and among countries	
11	Make cities and human settlements inclusive, safe, resilient and sustainable	
12	Ensure sustainable consumption and production patterns	
13	Take urgent action to combat climate change and its impacts	<i>All TAs should indicate relevance to Goal 13 and at least one target below (13.1 to 13.b).</i>
	13.1 - Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	
	13.2 - Integrate climate change measures into national policies, strategies and planning	
	13.3 - Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	
	13.a - Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly \$100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible	
	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	Biogas technology can be promoted in least developed countries and rural areas, supporting sustainable energy access while reducing environmental impacts. These initiatives can better indoor quality thus improves women's health. Scaled-up biogas plant requires manpower thus create local jobs and creating awareness about the impact of biogas initiative among young generation will inspire them to take more serious initiative to avoid climate change.
14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development	
15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	Biogas technology helps to restore sustainable growth by avoiding the use of biomass thus combat deforestation and diversity loss.
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	
17	Strengthen the means of implementation and revitalize the global partnership for sustainable development	

13. Classification of technical assistance:

Please indicate primary type of technical assistance. Optional: If desired, indicate secondary type of technical assistance.

<i>Please tick off the relevant boxes below</i>	<i>Primary</i>	<i>Secondary</i>
<input type="checkbox"/> 1. Decision-making tools and/or information provision	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/> 2. Sectoral roadmaps and strategies	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/> 3. Recommendations for law, policy and regulations	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> 4. Financing facilitation	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> 5. Private sector engagement and market creation	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/> 6. Research and development of technologies	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> 7. Feasibility of technology options	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> 8. Piloting and deployment of technologies in local conditions	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> 9. Technology identification and prioritization	<input type="checkbox"/>	<input type="checkbox"/>

14. Monitoring and Evaluation process

Upon contracting of the implementing partners to implement this Response Plan, the lead implementer will produce a monitoring and evaluation plan for the technical assistance. The monitoring and evaluation plan must include specific, measurable, achievable, relevant, and time-bound indicators that will be used to monitor and evaluate the timeliness and appropriateness of the implementation. The CTCN Technology Manager responsible for the technical assistance will monitor the timeliness and appropriateness of the Response Plan implementation. Upon completion of all activities and outputs, evaluation forms will be completed by the (i) NDE about overall satisfaction level with the technical assistance service provided; and (ii) the Lead Implementer about the knowledge and learning gained through delivery of technical assistance. Furthermore, the NDE together with the project proponent(s) will complete a periodic post-implementation form to track the impact of the activities beyond the technical assistance end date.

Activity	Output/Deliverables	Expected outcome	Objectively verifiable Indicator	Means of verification
Activity 1.	Kick off meeting to discuss the ongoing problem at biogas plant in Arusha, Tanzania.	Understanding of biogas working status and improve the technical assistance plan based on the feedback.	Lack of experimental facility at the research institute in Tanzania, export of necessary chemicals and probes for analytical purpose.	Installation of sensors and probes for continuous data accumulation, sending of chemicals and equipments for various analytical purposes.
Activity 2.	Onsite inspection of the biogas plant for experimental condition check, comparison of indoor air quality and lecture about the benefits of biogas.	Onsite inspection will be helpful for real time check of the working biogas plant and measuring the indoor air quality check will provide an initial data for further evaluation, lecture regarding the benefits of biogas will improve awareness among the university students.	Low biogas production, H ₂ S, ammonia concentration in the biogas, estimation of odor problems, methane content in the biogas will be evaluated. An awareness related to biogas benefits will enhance importance of biogas for GHG reduction.	Retrofitting will be more optimal, operational plan will be optimized easily; temperature fluctuation will be lowered down to avoid any further setback for the biogas plant.
Activity 3.	Complete retrofitting of biogas plant, evaluating the methane potential and measuring the indoor quality improvement. Use of digestate as fertilizers for plant growth	Will enhance biogas production rate, control the biogas leakage problem, cleaning of sludge accumulation, optimizing the temperature variation.	Comparison between earlier and after retrofitting biogas production rate, biogas utilization time, measuring the methane content. Sludge digestate as fertilizers will improve the agricultural productivity.	Utilization of biogas plant for longer period of time, improvement in the biogas production rate, Improved indoor air quality. Growth monitoring of plant after fertilizers use.
Activity 4.	Continuous data collection from the Tanzania group relate to biogas performance and BMP experiment and carbon reduction estimation.	Will help to evaluate the performance stability, BMP setup at different temperature	Based on the BMP results a comparative data can be built up for temperature variation	Further suggestions can be made based on the real data; Estimation of carbon

Annex 1. Guidance Note for the Response Plan template

		for anaerobic digestion for checking the microbial adaptations and its effect of biogas yield	and process optimization can be further enhanced. Also, it will used as a backup for the operational plan.	reduction can be evaluated accurately.
Activity 5.	Closure report citing the final outcomes, sustainability of the projects and future suggestions.	The output will be used in other biogas plants setup and operation, it will also help to guide the sustainability of the future plans for setting up the biogas plants in Arusha and other part of Tanzania.	Report publication in scientific journals and CTCN channel will enhance the reach of this work and results to the global scale.	Presentation of the work in domestic and international conferences will further increase its reach. More countries may come forward to develop the biogas plant by changing in their policies and providing subsidy.