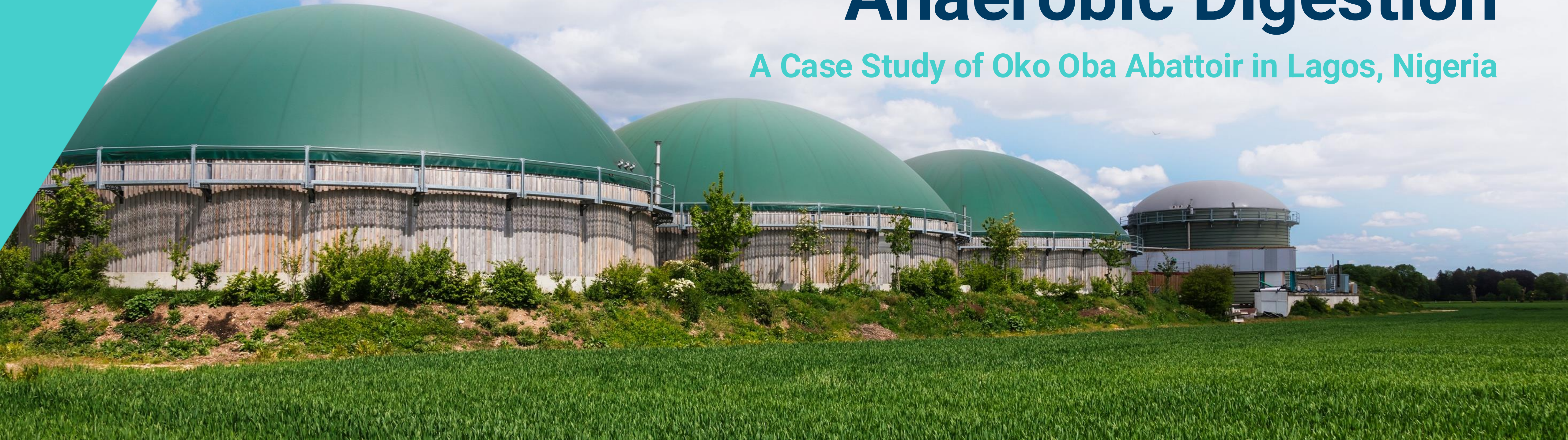
Assessing the Economic Viability and Environmental Benefits of Treating Organic Waste Using Anaerobic Digestion

A Case Study of Oko Oba Abattoir in Lagos, Nigeria



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About Us

RMI is an independent nonprofit, founded in 1982 as Rocky Mountain Institute, that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and nongovernmental organizations to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; Abuja, Nigeria; and Beijing.

The Waste Methane Assessment Platform (WasteMAP), a joint initiative by RMI and Clean Air Task Force, is an open online platform that brings together waste methane emissions data with decision support tools for stakeholders in the waste sector. The platform is supported by country engagement that involves collaboration with national and subnational governments, waste management officials, and other key decision makers to provide capacity building and technical assistance — providing a pathway to reduce solid waste methane emissions. Please visit our website https://www.wastemap.earth/ to learn more.

The Global Methane Hub organizes the field of philanthropists, experts, nonprofits, and government organizations to ensure we unite around a strategy to maximize methane reductions. We have raised over $200 million in pooled funds from more than 20 of the largest climate philanthropies to accelerate methane mitigation across the globe. Visit www.globalmethanehub.org to learn more about organizations that support the commitment.

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Introduction

The waste sector is a major contributor to methane emissions, a powerful climate pollutant generated by organic matter as it decomposes without oxygen at dumpsites and landfills. In Lagos, it is estimated that more than 13,000 tons of solid waste are generated daily, the majority of which is sent to dumpsites.[1] More than 40% of this waste is organic, presenting a clear opportunity for methane mitigation from increased diversion.[2]

Diverting this organic waste from the dumpsite for alternative end uses such as biogas for cooking or organic fertilizers, helps to reduce the amount of waste going to final disposal, thereby extending the lifespan of landfills and dumpsites, promotes a circular economy, lowers greenhouse gas emissions, and improves local air quality and public health.

Olusosun dumpsite, Lagos | Source: RMI site visit

About this Case Study

There is a significant untapped opportunity for increasing waste diversion from final disposal sites in Nigeria. Through this case study, we aim to demonstrate the economic viability and environmental benefits of diverting organic waste (animal waste and food waste) to on-site anaerobic digesters, and the potential to scale such projects. We describe project operations, assess business-as-usual (BAU) and alternative scenarios, identify key challenges and barriers that inhibit project scaling, and provide recommendations that could address these challenges.

Identifying technical assistance opportunities for organic waste management in Nigeria

As a signatory of the Global Methane Pledge, Nigeria has committed to reducing methane emissions by 30% by 2030 relative to 2020 levels, targeting key sectors such as waste and agriculture.3 Its involvement in the Lowering Organic Waste Methane (LOW-M) Initiative further underscores the focus on methane reduction within the waste sector.[4] National Climate Change Policy for Nigeria: 2021–2030 also highlights diversion of organic waste from dumpsites as a crucial strategy for reducing methane emissions.[5]

To support Nigeria's climate commitments and reduce methane emissions from waste, RMI worked with local waste experts to identify waste management facilities and large organic waste generators in Lagos, Ogun State, and Abuja. The team visited several sites to better understand existing operations and waste management practices, and to evaluate opportunities to improve organic waste management through technical assistance.

Two of these sites, Oko-Oba Abattoir and Lafenwa Market, were identified as case studies for anaerobically digesting and composting organic waste, respectively. The Oko Oba Abattoir project was selected because preliminary assessment revealed that it was economically viable while operational before experiencing storm damage. Further, the owner expressed interest in resuming operations, replacing existing fuel for his business activities with an environmentally friendly alternative, and building capacity and creating jobs for local youth.

Ketu Market | Source: RMI site visit

Sites Visited

- Ketu/Ikosi fruit market, Lagos
- Oko-Oba Abattoir, Lagos
- EarthCare Compost Facility, Lagos
- Olusosun dumpsite, Lagos
- West Africa ENRG Material Recovery Facility, Lagos
- Oke Saje Dumpsite, Abeokua
- Lafenwa Market, Abeokuta
- Lafarge Holcim Plant, Ogun State
- Gosa dumpsite, Abuja
- Dei Dei Food Market, Abuja
- Garki Model Market, Abuja

Anaerobic digestion facility at Oko Oba Abattoir
Source: RMI site visit

On-site anaerobic digestion at Oko Oba Abattoir

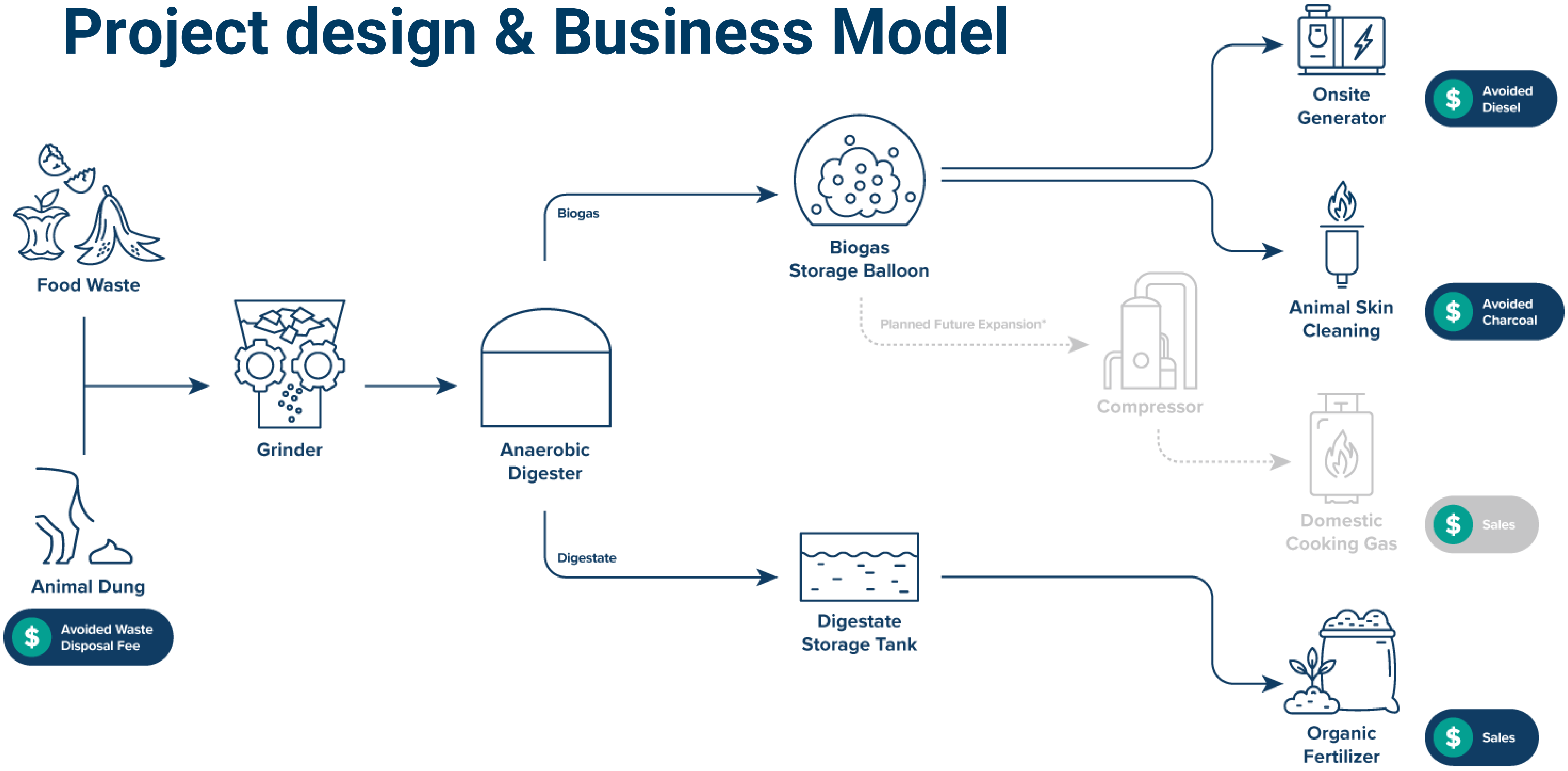
The Oko Oba abattoir, otherwise known as a slaughterhouse, is a facility located in Lagos, Nigeria, where animals (primarily cows and goats) are slaughtered and sold for consumption. Located within the abattoir is a privately-owned anaerobic digestion (AD) facility that is used to treat animal waste (cow and goat dung) from the abattoir, as well as co-digest food waste from a nearby market to produce biogas.

Prior to storm damage in 2022 that halted operations, the AD system was digesting approximately 300 kg of animal waste and 30 kg of food waste daily, with a design capacity to process up to 500 kg of feedstock per day.

About 30% of the biogas generated by the system was used to power a generator on site, providing electricity to satisfy all office and personal use. The remaining biogas was used to produce heat for cleaning the skin of 50 animals per day, which allowed the abattoir to reduce the amount of charcoal that was previously burned for this purpose. The liquid digestate byproduct generated from AD was sold to local farmers as fertilizer.

The project owner expressed interest in expanding the scale of the facility to generate more biogas, aiming to completely eliminate charcoal usage due to its environmental impacts as well the health implication on his employees and use excess supply for domestic cooking.

Project design & Business Model



* Greyed out graphic/text represents planned future expansion.

Scenarios explored in this analysis

In the BAU scenario, the biogas generated meets all on-site electricity needs and is used to clean the skin of some animals, reducing the use of charcoal.

As there is additional food and animal waste at the slaughterhouse and at nearby markets, expanding the capacity of the anaerobic digestion plant will enable the diversion of additional food and animal waste from dumpsites, fuel switching from charcoal, and other end uses for biogas.

This analysis explores four alternative scaling scenarios and their impact on project economics. Scenarios 1 and 2 focus on facility capacity expansion, while scenarios 3 and 4 assess the impact of available policy and financing mechanisms at different capacities.

BAU — Replace 16% of the charcoal used for animal skin cleaning with biogas

Scenario 1 — Proportionally increase food and animal waste feedstock to enable 100% fuel switch

Scenario 2 — Diversify biogas end use

Scenario 3 — Include grants and low-interest loans

Scenario 4 — Include tax credits to improve project economics

BAU

The BAU scenario, which replaces 16% charcoal usage with biogas, is economically viable

Expected Project Life: 20 years

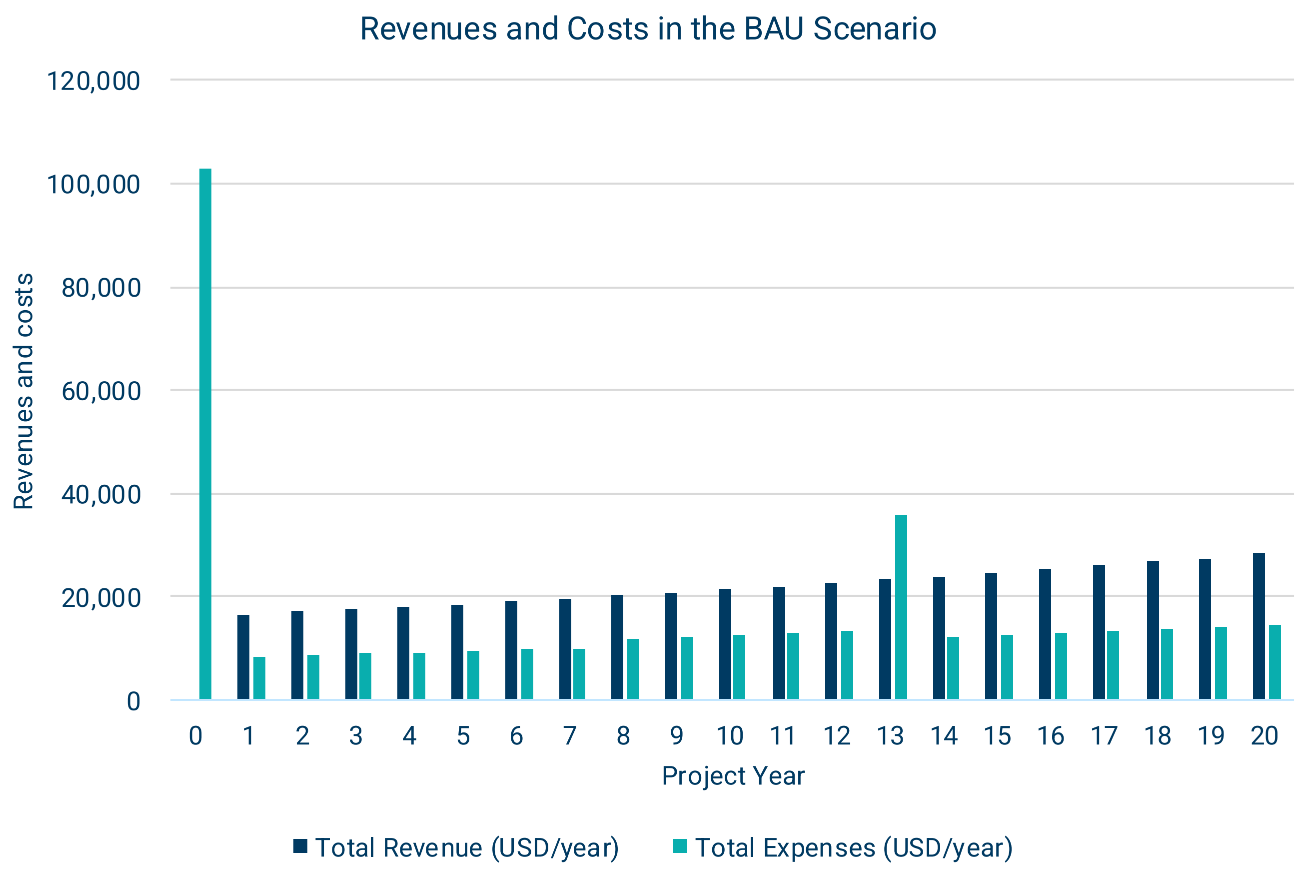
Project IRR: **~6%**

Payback Period: **~12 years**

Financing mechanism: **100% equity** using personal finances, no loan or grant

Within the project life, total revenue is higher than total expenses each year the project is in operation other than in year 13 when a major renovation is planned to address potential equipment damage.

** Note that this analysis uses 2022 U.S. dollars (USD) as base currency to address the currently unusually high volatility of the Naira. All charts in this publication will be in USD*



BAU

However, the high investment outlay may deter private sector investment for similar projects

Although the BAU scenario, in which biogas replaces 16% of the charcoal used for business activities, is economically viable, the high up-front cost may limit private sector investment in similar projects.

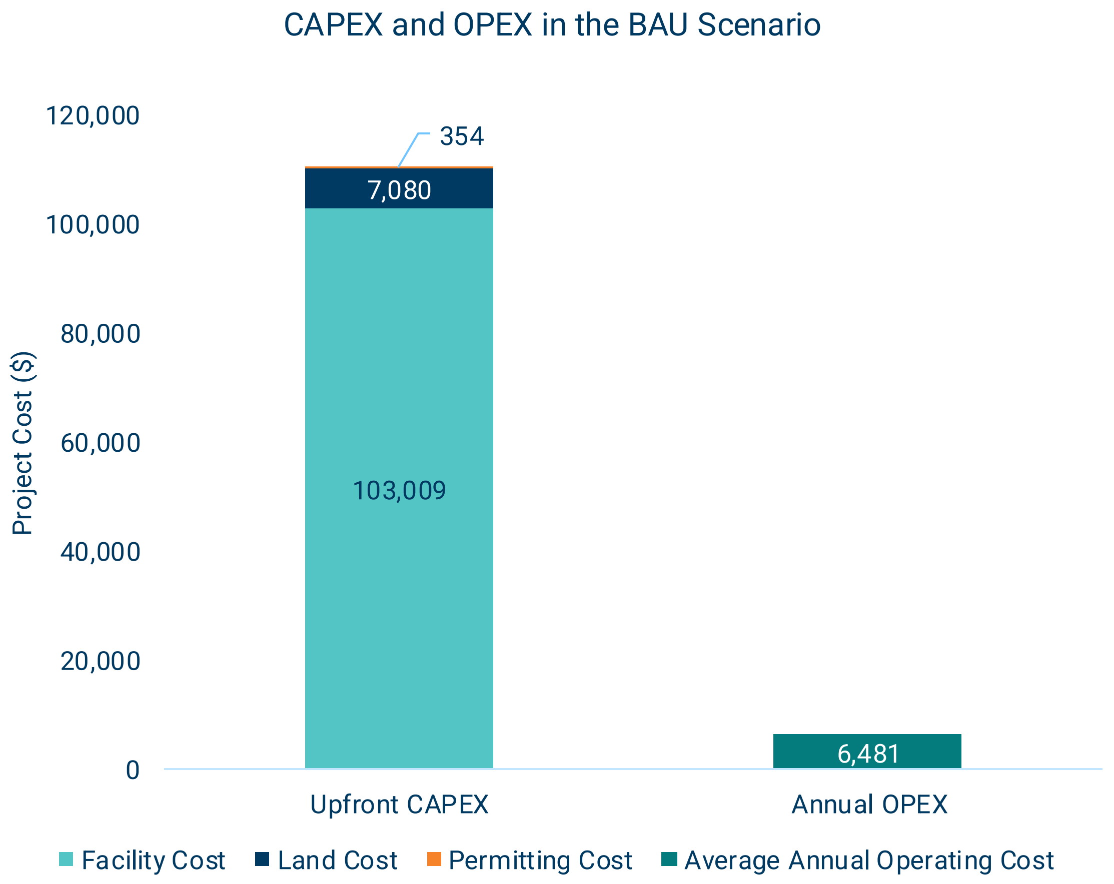
For this project: Up-front CAPEX investment: **₦ 43,650,000 (~$103,000)**

Financing mechanism: **100% equity**

Several factors contributed to its economic viability including:

- Stable feedstock supply at no cost
- Minimal cost for transporting food waste from the nearby market to the biogas plant
- Low operating expenditure (mainly employee labor and land cost)
- Negligible permitting cost

** Exchange rate: $1 = ₦424 (based on 2022 exchange rate)*



Gas pipe at AD facility | Source: RMI site visit

Replacing charcoal fuel with biogas derived from organic waste has significant environmental and health benefits

Reduces emissions and improves air quality

- Using charcoal to produce heat to clean animal skin involves open burning, which emits various pollutants including $PM_{2.5}$, carbon monoxide, and volatile organic compounds. Consistent and direct exposure to these pollutants can cause health issues such as respiratory and cardiovascular diseases. Replacing charcoal fuel with biogas improves local air quality and worker health.

- Diverting organic waste from dumpsites reduces methane emissions, a climate pollutant that is 80 times more effective at trapping heat in the atmosphere than CO_2 on a 20-year time horizon.[6]

Produces clean fuel and enables nutrient recovery

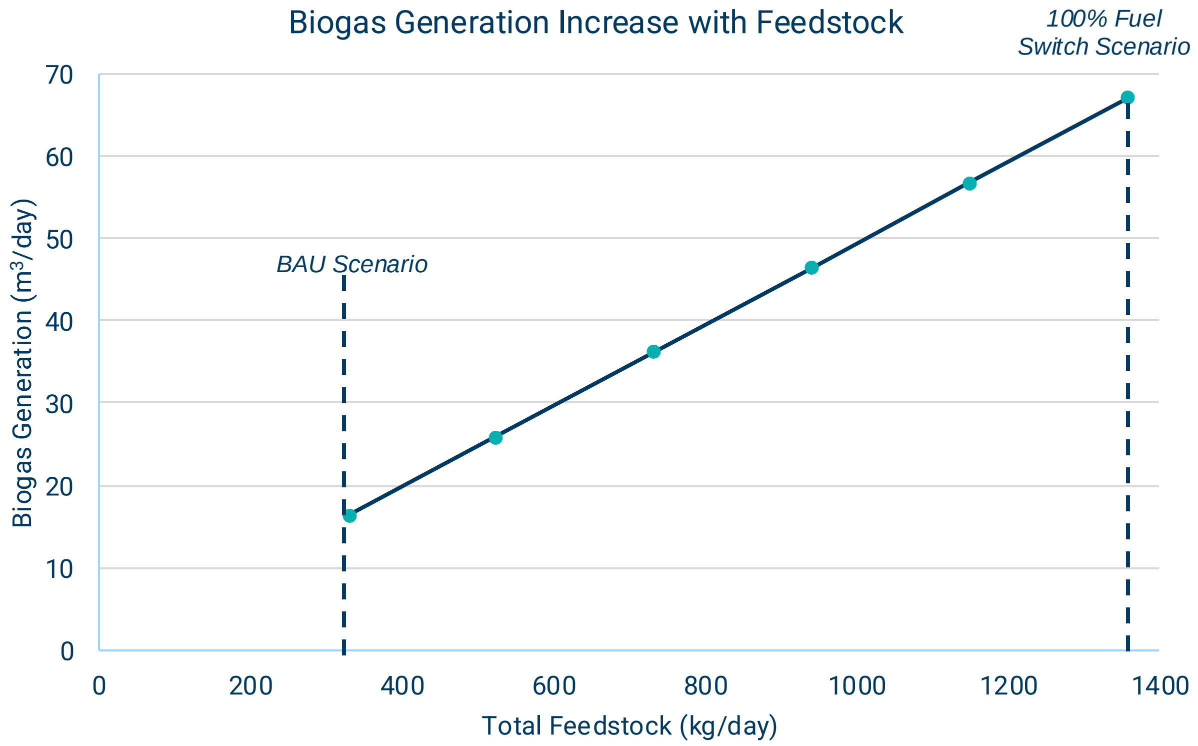
- Co-digesting animal waste and food waste to produce biogas can meet multiple energy needs including animal skin cleaning and on-site electricity demand. If the project scale expands, excess biogas can replace liquified petroleum gas and be used for domestic cooking.

- The digestate byproduct can be used as organic fertilizer to enrich soil since it's a rich source of carbon and nutrients

Scenario 1

To enable a complete fuel switch and avoid charcoal use, the co-digested feedstock must proportionally increase by 400%

- This scenario adds minimal cost for feedstock because food and animal waste can be secured locally for free
- Replacing charcoal fuel completely with biogas to meet the daily cleaning needs of 300 animals requires a total biogas generation of 67 m^3/day (4 times the BAU scenario)
- This is equivalent to increasing feedstock in the BAU scenario by 400% which produces an equivalent amount of digestate
- Additional digestate byproduct can be sold to farmers for higher revenue



Scenario 1

Scaling the AD facility to achieve 100% fuel switch more than doubles the IRR, although an additional 125% of the upfront CAPEX is required for expansion

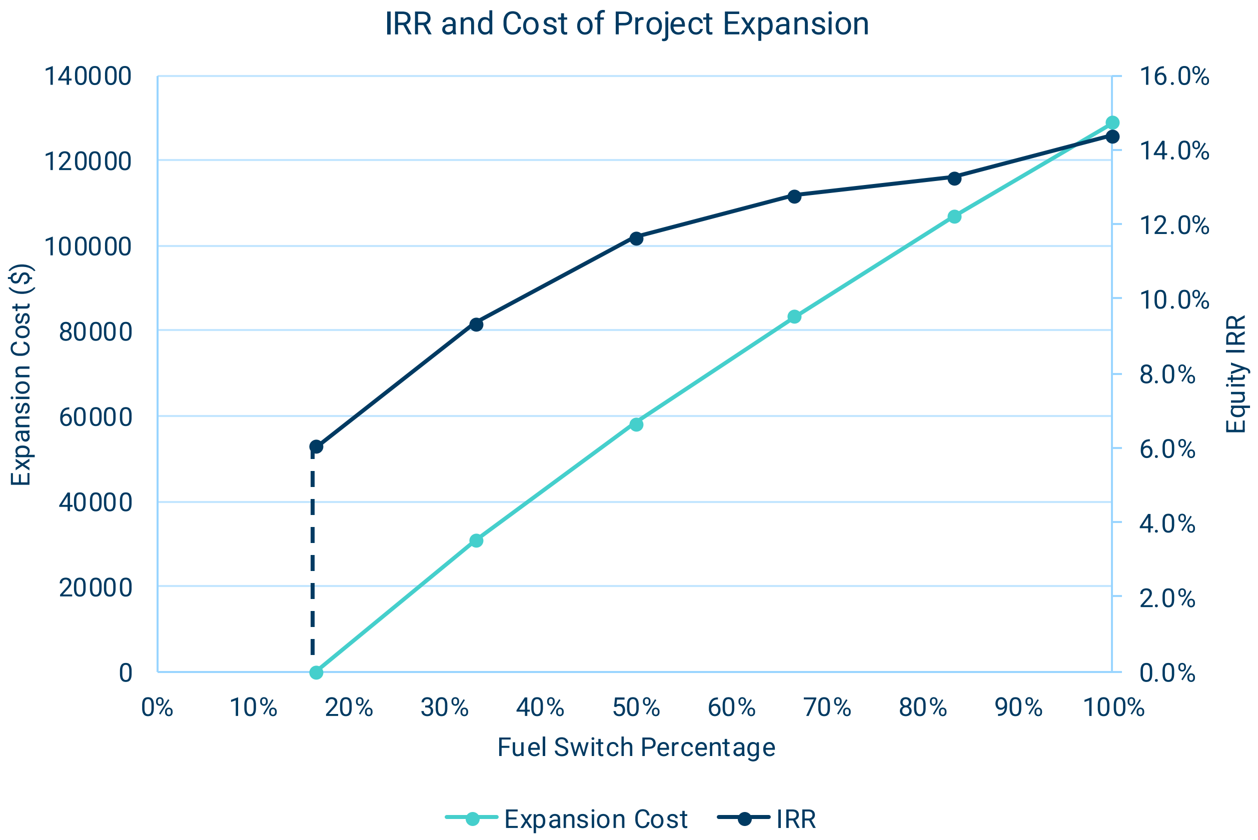
A complete fuel switch to biogas would boost project **IRR to 14% from 6% in the BAU**. However, this requires an additional CAPEX investment of ~$129,000 (**₦ 45,798,000**) during the expansion year

Cost increase in this scaling scenario is driven by

- Facility expansion cost
- Additional labor cost for feedstock collection
- Facility maintenance cost

Revenue increase in this scenario is driven by

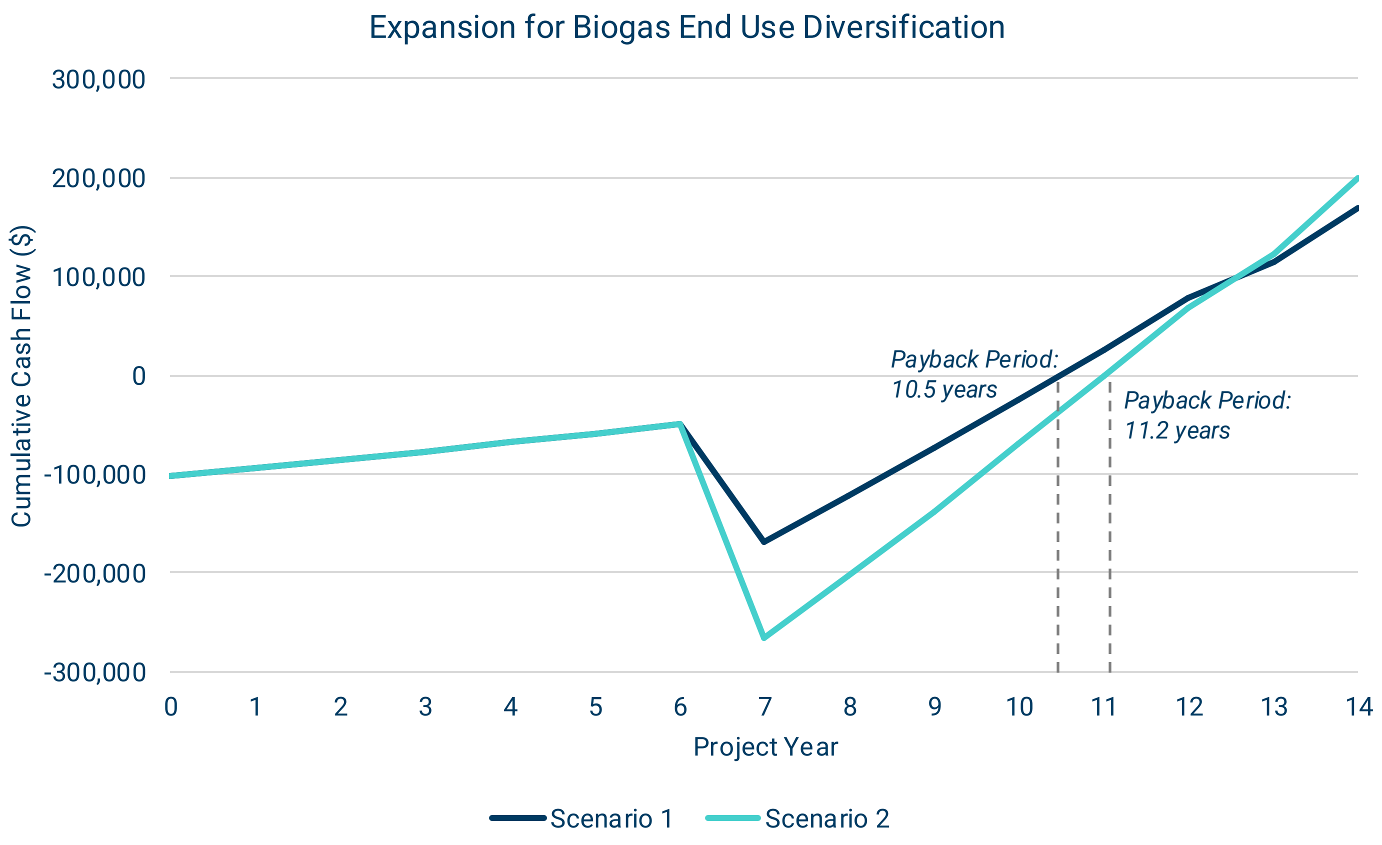
- Increased digestate sales to farmers
- Higher avoided waste disposal fee
- Higher avoided cost for charcoal purchase



Scenario 2

Proportionally scaling the feedstock beyond 100% fuel switch diversifies biogas end use with similar project economics

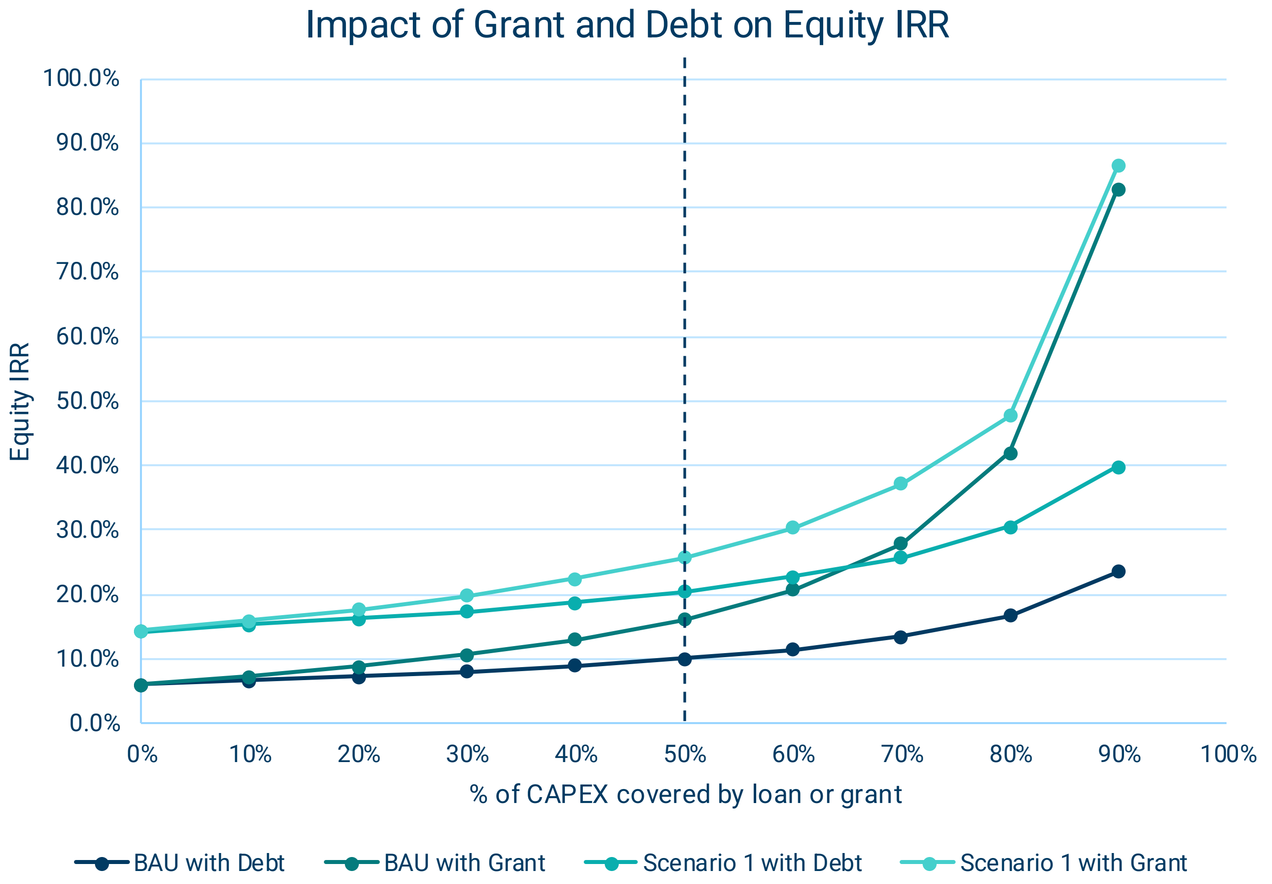
- Further scaling the AD facility to co-digest 2 tons per day (tpd) of animal waste and 200 kg per day of food waste, aligned with the project owner's plan, would enable end-use diversification.
- In this scenario, the additional biogas generated is compressed, purified, and sold for domestic cooking.
- Diversifying end use would require **additional investment** in purchasing bio-CNG compressor and biogas purification equipment. In this scenario, the IRR remains relatively consistent with scenario 1 at **~14%** but the payback period is **8 months shorter**, from 11.2 years to 10.5 years.



Scenario 3

Grants and low-interest loans can lower barrier to entry for new investors and improve project viability

- Grants and low-interest loans that partially cover CAPEX for project start-up and expansion can defray investment needed which can encourage private sector investors to enter the market
- In the BAU Scenario, assuming 50% of the total upfront CAPEX is grant funded, the investment risk is lowered and the return on the remaining equity investment (equity IRR) more than doubles. If the grant is replaced with a 10-year loan with an interest rate of 10%, the equity IRR increases by 70%
- Similarly, for scenario 1, a grant that covers 50% of the CAPEX for expansion would lead to an equity IRR increase of 80%, and if the grant is replaced with a 10-year loan with an interest rate of 10%, the equity IRR increases by 50%
- It is worth noting that low-interest loans in the Nigerian economy can be challenging due to the high inflation and risks of continued Naira devaluation

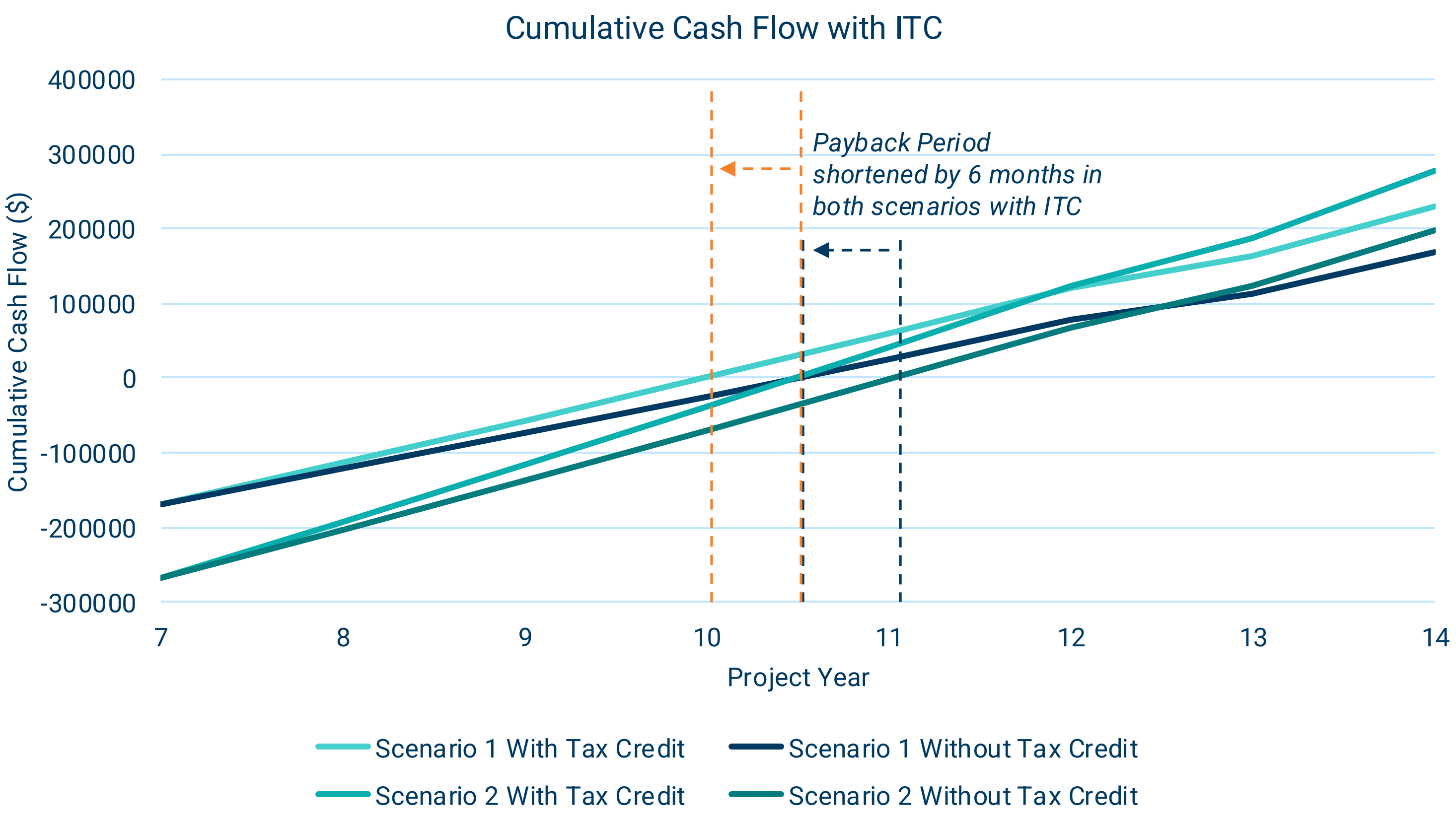


Scenario 4

Policy instruments, such as tax credits, can encourage private sector investment by improving project cash flow

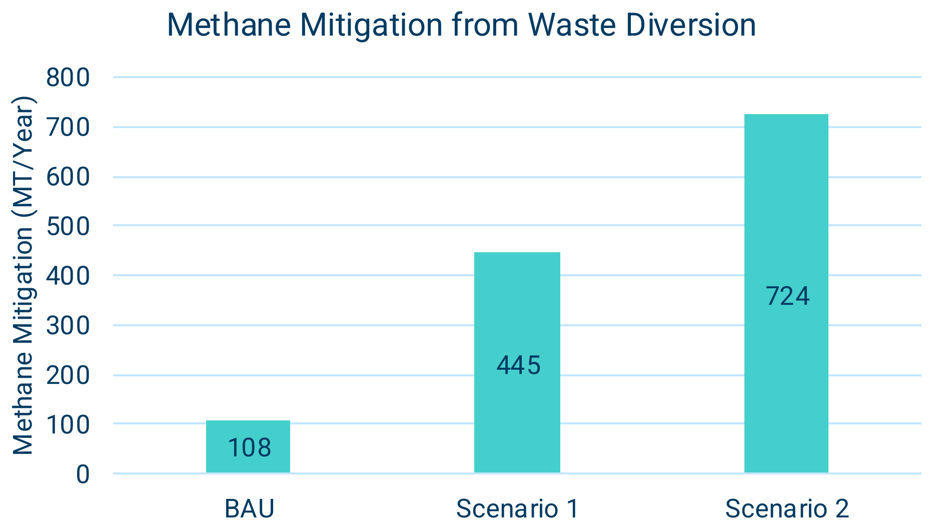
- An investment tax credit (ITC) allows businesses to deduct a certain percentage of the cost of investing in capital assets from their taxes. This mechanism has been implemented to **encourage investment and innovation** in solar and wind projects, green hydrogen, and electric vehicle charging infrastructure and it has also been used to encourage biogas project development in the United States.

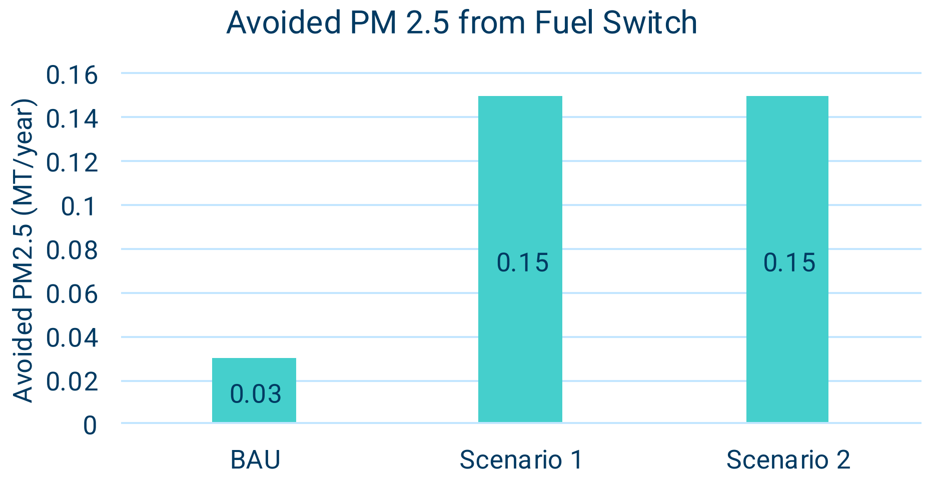
- Similarly, an ITC could **boost cash flows** for biogas projects. With an ITC that covers 30% of the up-front and expansion CAPEX, both scenarios 1 and 2 would achieve a **higher IRR by 2 percentage points and shorter payback period by 6 months**.



Environmental and health benefits from waste diversion and fuel switching grow as the project scales

- As discussed on page 12, the two major environmental benefits of this project are methane mitigation through **organic waste diversion** and $PM_{2.5}$ avoidance by replacing charcoal fuel with biogas and **reducing open burning**.
- On average, the BAU scenario reduces methane emissions by 108 MT/year, the complete fuel switch scenario (scenario 1) mitigates 4 times the methane emissions compared with BAU, and scenario 2 would reduce ~7 times the methane emissions compared with BAU.
- In the BAU scenario, replacing 16% of the charcoal usage with biogas avoids 0.03 MT/year of $PM_{2.5}$, and scenarios 2 and 3, where complete fuel switch is achieved, avoids 0.15 MT/year of $PM_{2.5}$.





Summary of Key Findings

- The BAU and all four alternative scenarios in this analysis, across different capacities and biogas end uses, are **economically viable**, but the up-front cost involved, the majority of which is **equipment cost**, can be a barrier for new investors

- In the BAU scenario, which processes 330 kg/day of feedstock, the biogas generated meets all on-site electricity needs and replaces almost 20% of charcoal fuel used for animal skin cleaning. **This scenario is economically viable and generates an IRR of 6%.**

- A complete fuel switch from charcoal to biogas to clean the animal skin (scenario 1) would **require quadrupling biogas generation**. This expansion results in an IRR increase from **6% to 14%** but would require **125%** of the upfront CAPEX investment during expansion year

- Scenario 2 explores further capacity expansion to enable end-use diversification using additional biogas generated for domestic cooking. Due to additional investment needed for biogas compression and purification equipment, increasing feedstock processed by 0.8 tpd beyond scenario 1 wouldn't improve the project IRR, which **remains constant at 14%**, but the payback period would be **~8 months shorter**.

- In scenario 3, the **equity IRR increases significantly regardless of facility capacity** when half of the up-front investment is grant funded or funded by a 10-year loan with a 10% annual interest rate, which demonstrates how grants and low-interest loans can improve project economics.

- Scenario 4 explores how policy incentives, specifically an investment tax credit, can improve project viability. When an ITC is applied against 30% of the capital investment, both scenarios 1and 2 see IRR increase by **2 percentage points** and a shorter payback period by **6 months**. The impact of ITC can be more substantial in larger capital projects.

- This project diverts animal and food waste from the dumpsite, which enables **methane mitigation** up to 726 MT/year depending on the scenario. Fuel switching which avoids the use of charcoal also **reduces local pollution** and improves employee health.

Recommended Next Steps for Project Financing

As demonstrated in this analysis, this on-site anaerobic digestion project at Oko Oba abattoir in Lagos is **economically viable with potential to scale**. This approach also delivers **significant environmental and health benefits** including waste diversion, emissions reduction and nutrient recovery.

However, this facility is currently non-operational due to storm damage, and **securing funds to repair the facility** is the first step toward realizing the environmental and economic benefits.

According to the project owner, a total of **₦ 36 million** (~$21,400 using November 2024 exchange rate) is needed for the full repair to bring the facility back online. This includes:

- Cost of a new storage balloon to replace the damaged one
- Cost of roofing to minimize similar damage in the future
- Labor and miscellaneous costs to fix the treatment plant, generator and other accessories

The project owner is eager to resume operations and expand the scale of the facility in the future to enable a complete fuel switch and sell excess biogas for domestic cooking. However, securing project finance is a challenge.

Funding support from governmental bodies, such as the National Council on Climate Change, and international aid agencies, such as the US Agency for International Development, can eliminate barriers to securing finance. These agencies can also **provide technical assistance** to promote best practices that improve project operations. Such assistance would also **promote private sector participation** and empower new investors in organics waste diversion projects in the country.

Conclusion

There is an untapped opportunity for increasing waste diversion from final disposal sites in Nigeria. This analysis evaluates the economic feasibility and environmental benefits of using on-site anaerobic digestion to process animal and food waste from Oko Oba Abattoir and nearby markets. It is evident that this case study presents a **scalable, economically viable model** for treating organic waste. This approach also delivers **significant environmental and health benefits**, including reducing methane emissions, extending the lifespan of dumpsites through waste diversion, and replacing charcoal fuel with biogas, which prevents harmful open burning.

Like many infrastructure projects, establishing an anaerobic digestion facility involves substantial up-front costs, which can discourage potential investors. To attract investment and ensure long-term project sustainability, **financial and policy incentives** are essential. Options might include **grants, low-interest loans**, and **investment or production tax credits**.

Organic Waste at Ketu Market
Source: RMI site visit

To foster a successful ecosystem for organic waste treatment through anaerobic digestion, it is also crucial to:

- **Secure a reliable, low-cost feedstock supply with minimal contamination**, a key factor that enables the economic viability of this project

- **Provide technical capacity building** for operating and maintaining anaerobic digestion facilities, which would help maximize biogas production, reduce facility downtime, and improve overall project efficiency.

- **Strengthen the end market for biogas and digestate** to secure product offtake: Defining and encouraging diverse use of biogas as fuel replacement based on local context encourages project developers to participate in the market. Broader outreach to educate farmers on the value of using digestate as fertilizer would boost digestate demand and enhance the project's overall profitability.

Appendix A: Additional Resources

The following tools and documents may be helpful for developing and operating anaerobic digestion projects.

- U.S. EPA's Biogas Toolkit
- AgSTAR Anaerobic Digester Project Development Handbook
- AgSTAR Anaerobic Digester/Biogas System Operator Guidebook
- U.S. EPA Initial Project Checklist for On-farm Biogas Projects
- Anaerobic Digestion Screening Tool
- Organics Economics (OrganEcs) Screening Tool – Anaerobic Digestion
- World Biogas Association's Biogas Financial Calculator

Appendix B: Modeling Assumptions

The following are common assumptions made during the modelling to assess project economic viability:

- All of the biogas produced is either used for on-site electricity generation, animal cleaning, or domestic cooking. Apart from the the BAU scenario, there is no excess biogas.
- All of the digestate by-product is sold to farmers, which generates revenue
- The project has a 20-year lifespan, with regular maintenance throughout. A major renovation is scheduled for year 13 to address equipment deterioration.
- For all alternative scenarios, expansion happens in year 7 and operation of the expanded facility starts in year 8.
- For alternative scenarios 1 and 2, 25% CAPEX savings is assumed to account for lower equipment cost due to potential local fabrication
- To address the current unusually high currency volatility in Nigeria and model project economics in real purchasing power terms, this model uses 2022 US dollars as base currency. It is worth noting that if local currency continues to be volatile, it is possible that project owners will be limited by decreasing purchasing power and ability to pay. This limitation is not part of our analysis.

Endnotes

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