Waste-to-Energy Innovation: Harnessing Incinerator Heat for Renewable Power Generation in Nigeria

Submitted by the Research Team

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1. Executive Summary

Nigeria's rapidly growing urban centers face a dual crisis of mounting municipal solid waste and chronic electricity shortages. This project introduces a Waste-to-Energy (WtE) innovation that transforms incinerator heat into renewable electricity through advanced thermal energy recovery. By integrating a high-efficiency incinerator, heat recovery steam generator (HRSG), and steam turbine-generator, the system will convert waste into wealth, transforming dumpsites into decentralized clean power plants.

The project is led by Engr. Dr Agbadua Segun Afokhainu and a team of seasoned engineers and technologists with expertise in renewable energy, engineering design, electronics, materials, thermodynamic simulation, and environmental compliance. Collectively, the team has the technical depth and vision to deliver a scalable solution that supports NASENI's Renewable Energy and Sustainability thematic area and Nigeria's Renewed Hope Agenda.

This project delivers a **triple-impact strategy**:

- **Environmental**: reducing landfill waste and greenhouse gas emissions.
- **Energy**: supplying decentralized electricity to underserved communities.
- **Economic**: creating jobs, advancing industrialization, and generating new green revenue streams.

2. Problem Statement

Nigeria faces two interconnected national challenges:

A. Waste Management Crisis

- 32+ million tonnes of municipal solid waste generated annually.
- Over 70% inadequately disposed, leading to pollution, flooding, and health hazards.
- Landfills emit methane — 25 times more potent than CO_2 — while consuming valuable land.

B. Electricity Deficit

- 85 million Nigerians lack reliable electricity access.
- National grid capacity lags behind demand, restricting industrial growth and social well-being.

This project addresses both crises by turning waste into a renewable energy resource.

3. Project Objectives

1. Design & Develop a high-efficiency waste incinerator integrated with a heat recovery steam generator (HRSG).
2. Generate Renewable Electricity through steam turbine-generator technology.
3. Reduce Environmental Impact by minimizing landfill waste and methane emissions.

4. Prove Commercial Viability through scalable pilot plants and partnerships with municipalities.

4. Innovativeness & Novelty

- 30% Higher Efficiency: Advanced flue gas heat recovery boosts energy conversion.
- Next-Generation Emission Controls: Scrubbers, fabric filters, and catalytic converters ensure compliance with international standards.
- Scalable & Modular: Deployable from 500 kW to 10 MW, adaptable for urban and rural needs.
- Local Content Emphasis: Key components (boilers, turbines, emission units) manufactured domestically.

5. Commercial Viability

Target Customers: Municipal councils, waste firms, industrial clusters, and off-grid communities.

Revenue Streams:

- Sale of electricity under Power Purchase Agreements (PPAs).
- Waste disposal service contracts.
- Sale of carbon credits through international climate finance.

Market Proof: Feasibility studies in Anambra, Lagos and Abuja confirm readiness of municipalities to adopt WtE solutions.

6. Preliminary Results

- **Feasibility Study (2024):** Demonstrated 5 MW potential from processing 150 tonnes/day.
- **Prototype:** Bench-scale system achieved 20% thermal-to-electric efficiency.
- **Partnerships:** Waste supply agreements initiated with (Anambra State Waste Management Authority, Waste Point Limited, Lagos etc).

7. Alignment with NASENI Objectives

- Industrialization: Local manufacturing of key components.
- Renewable Energy & Sustainability: Reduced fossil fuel dependency.
- Job Creation: Engineering, fabrication, and operational employment.
- Urban Development: Smart city integration of WtE plants.

8. Technology Readiness Level (TRL)

- Current TRL: **6** – pilot validated in relevant environment.
- Next: Full-scale demonstration in partnership with municipal authority.
- Documentation: CAD, process flow, thermodynamic simulations, emission compliance.

9. Scale & Sustainability

- Flexible Scaling: From 500 kW community plants to 10 MW municipal systems.
- Feedstock Security: Continuous municipal waste supply.
- Replicability: Model adaptable to all 36 states of Nigeria.

10. Thematic Areas

- **Primary:** Renewable Energy and Sustainability
- **Secondary:** Smart City Infrastructure & Sustainable Urban Development

11. Table 1: Implementation Plan

S/N	PHASES	ACTIVITIES	DURATION	OUTPUT
1	**Phase 1**	Engineering design & procurement	Months 1–4	Final plant design
2	**Phase 2**	Fabrication of incinerator & HRSG	Months 5–8	Manufactured components
4	**Phase 3**	Assembly & installation	Months 9–12	Operational pilot plant
5	**Phase4**	Engineering design & procurement	Months 13–15	Final plant design
6	**Phase 5**	Fabrication of incinerator & HRSG	Months 16–24	Reports & compliance

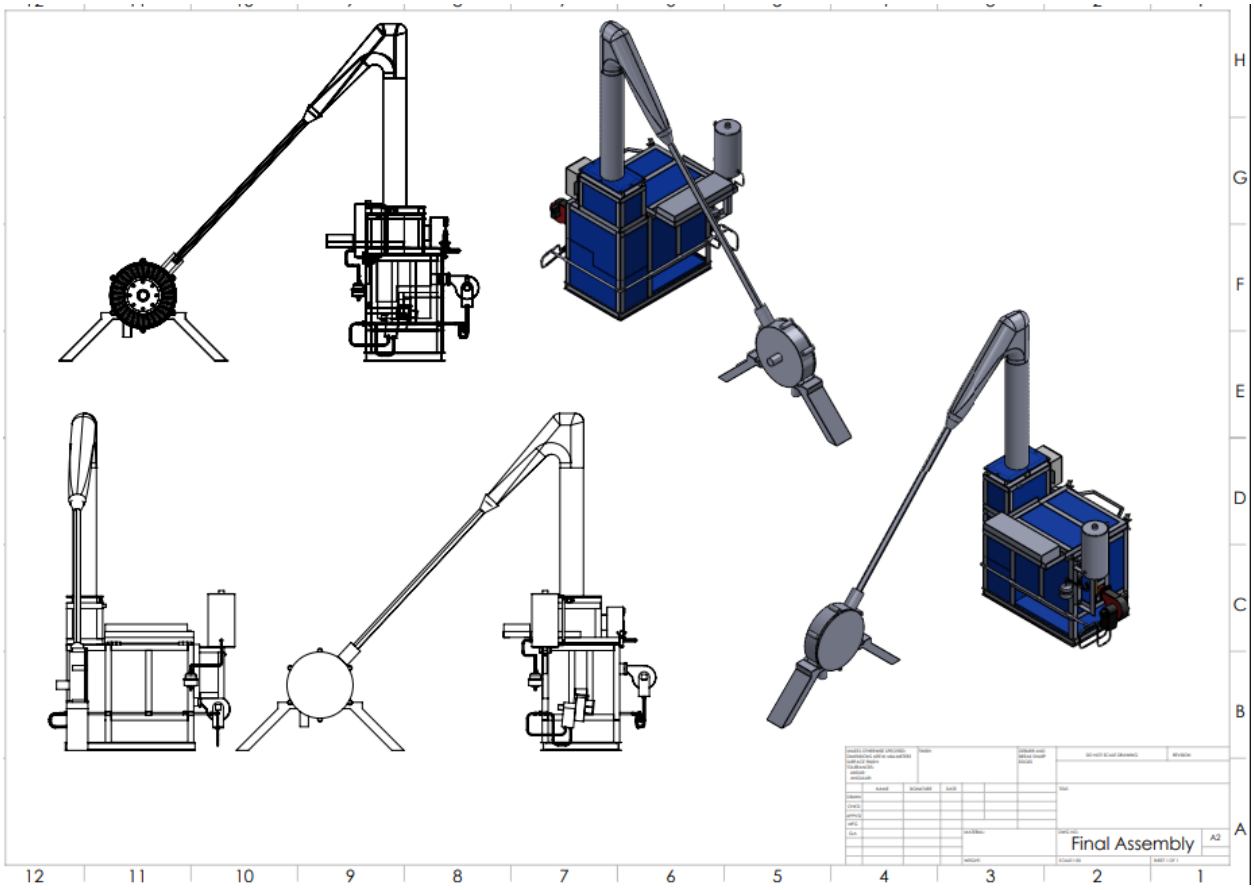

Figure 1; the design concept of the waste to energy system

12. Table 2: Budget Summary

S/N	Item Description	Amount (#)
1	Engineering design & simulations	10,000,000
2	Fabrication of incinerator	10,000,000
3	Heat recovery steam generator	15,000,000
4	Steam turbine-generator	25,000,000
5	Emission control systems	10,000,000
6	Installation & commissioning	10,000,000
7	Testing & certification	5,000,000
8	Project management & personnel	10,000,000

9	Contingency 10%	9,500,000
	TOTAL	**104,500,000**

13. Expected Outcomes

- Energy Access: 5 MW per plant (~10,000 homes powered).
- Waste Reduction: 150 tonnes/day diverted from landfills.
- Employment: 50+ direct jobs, 200+ indirect jobs.
- Climate Impact: 80% reduction in methane emissions.
- Economic Impact: Carbon credit revenues and local manufacturing boosted.

14. Conclusion

This project is a transformative innovation in Nigeria's waste and energy sectors. By converting waste into clean electricity, it creates environmental, energy, and economic dividends while advancing Nigeria's Renewed Hope Agenda. With NASENI's grant support, the project will move from pilot to commercial scale, positioning Nigeria as a continental leader in waste-to-energy solutions and delivering measurable progress on the SDGs (7, 9, 11, 13).

15. Research Team and Expertise

1. Engr. DR. Agbadua Segun Afokhainu- Principal Investigator, is a seasoned Mechanical Engineer and academic researcher with expertise in materials engineering, sustainable composite development, and thermal–fluid systems**.** His research focus spans the design, analysis, and optimization of advanced engineering materials for automotive and renewable energy applications.
2. Engr. Oghenekaro Peter – Co-Researcher, a Specialist in waste-to-energy conversion and incinerator design optimization.
3. Tgst Agbomabinu Emmanuel – Co-Researcher Focused on energy efficiency, thermodynamic simulation, and environmental compliance.
4. Engr. Erukpe Peter – Co-Researcher Expert in electronics systems and steam turbine integration for decentralized grids.
5. Engr Felix Patrick-Co-Researcher Focused on energy and power, and environmental compliance
6. Engr. Madagwu Lucky – Co-Researcher Experienced in process design, energy audits, and industrial plant operations.
7. Engr. Obumneme Onyedum – Co-Researcher Specialist in materials, emission control technologies, and environmental impact assessments.
8. Engr. Joseph Irabodemeh Michael – Principal Investigator an Engineer with expertise in modeling (CAD design, renewable energy

systems, and composite material applications in sustainable engineering solutions.

9. Engr. Aju Adonis – Co-Researcher
   Skilled in structural design, fabrication, and modular engineering systems.
10. Tgst Udeh Cajethan – Research Associate
    Provides technical support, and prototype testing.