Feasibility Study Report

FOR

THE DEVELOPMENT AND COMMERCIALISATION OF SMART SOLAR-POWERED COLD STORAGE UNITS IN NIGERIA

Prepared for:

The NASENI Research Commercialization Grant

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1.0 Introduction

1.1 Background and Problem Statement

Nigeria’s agricultural sector is critically constrained by post-harvest losses, estimated at over ₦3.5 trillion annually. These losses affect 40–50% of perishable crops such as fruits, vegetables, dairy, and fish, undermining national food security and eroding the livelihoods of the country’s 93 million smallholder farmers. Smallholders, who produce more than 80% of Nigeria’s food supply, lose an estimated 25% of their income to spoilage, often compelled to sell produce at depressed prices during peak harvests.

The primary drivers of this challenge are the absence of adequate cold storage infrastructure and unreliable electricity supply, with rural access rates as low as 55%. Existing cold storage options—largely diesel-powered, urban-based, and expensive to operate—remain inaccessible to rural producers and environmentally unsustainable. Moreover, their dependence on fossil fuels contributes significantly to carbon emissions, further exacerbating climate and environmental pressures.

1.2 Proposed Solution

This study evaluates the feasibility of designing, locally fabricating, and commercialising smart, modular, solar-powered cold storage units. The proposed solution is an off-grid system enhanced with innovative technologies, including Phase Change Materials (PCM) for extended thermal storage and integrated IoT/Industry 4.0 capabilities for real-time remote monitoring and predictive maintenance.

By leveraging over 70% local content in fabrication, this project aims to create an affordable, accessible, and environmentally sustainable alternative tailored for Nigeria's off-grid and weak-grid settings. The initiative directly aligns with the mandate of the National Agency for Science and Engineering Infrastructure (NASENI) to promote renewable energy and local manufacturing, supports Nigeria's "Renewed Hope Agenda" for food security, and contributes to several UN Sustainable Development Goals (SDGs 2, 7, 9, 12, and 13).

2.0 Market Feasibility

2.1 Market Need and Opportunity

The market for cold storage in Nigeria is vast and critically underserved. Industry estimates suggest that addressing the current infrastructure gaps could create a market exceeding ₦160 billion annually. The demand is driven by several factors, including Nigeria's rising population (over 225 million in 2025), escalating diesel costs, government policies favouring renewable energy, and growing consumer preference for fresh, refrigerated foods.

2.2 Target Market Segments

The solution is designed for a diverse customer base across all six geopolitical zones of Nigeria:

- Smallholder Farmers and Cooperatives: Representing a base of approximately 38 million farmers who require smaller units (2 - 5 metric tons) for preserving fruits, vegetables, and fish.
- Agri-SMEs and Aggregators: Businesses requiring medium-sized units (5 - 10 metric tons) to support logistics and supply chains.
- Urban Food Markets and Retailers: Needing larger hubs (10+ metric tons) for bulk preservation.
- Export-Oriented Agribusinesses: Requiring standardized cold chain solutions to meet international quality standards.
- Fisheries and Aquaculture: A key market in both coastal and inland communities.
- Healthcare and Pharmaceuticals: A secondary market for the storage of vaccines and medicines.

2.3 Competitive Landscape

- Existing Competition: The primary competitors are conventional diesel-powered cold rooms. A typical 5 - 10 MT unit costs ₦6 million - ₦12 million and incurs annual operating expenses of ₦1.5 million - ₦3 million, driven by diesel consumption and maintenance. Their reliance on fossil fuels and high running costs make them unsustainable and unsuitable for rural smallholders.
- Emerging Competition: Several providers, such as Cold Hubs and Kool Boks, are entering the solar-powered market, indicating growing adoption in Southwest, North-Central, and Southeast Nigeria.
- Our Competitive Advantage: The proposed solution offers distinct advantages:
    - Sustainability: 100% solar-powered, eliminating diesel costs and reducing carbon emissions by over 70% compared to diesel alternatives.
    - Local Content: A commitment to using over 70% local materials for fabrication ensures lower costs, availability of spare parts, and stimulation of the local economy.
    - Smart Technology: IoT integration for remote monitoring, predictive maintenance, and usage analytics provides a significant technological edge over competitors.
    - Accessibility: A modular design and flexible business models, including pay-per-use, make the technology accessible to rural users.

3.0 Technical Feasibility

3.1 Technology and Innovation

The system integrates proven technologies in a novel, Nigeria-centric approach designed to maintain temperatures between +2°C and +8°C. Key components include:

- Solar Energy System: High-efficiency, locally assembled PV panels, MPPT controllers, and lithium-ion batteries.
- Cooling System: A high-efficiency vapour compression refrigeration unit using eco-friendly refrigerants.
- Thermal Storage: Phase Change Materials (PCM) are integrated to extend cooling time during non-solar hours, reducing battery dependence by 20 - 30% and lowering lifecycle costs.
- Smart System: IoT sensors (temperature, humidity, voltage) connected to a cloud dashboard enable real-time monitoring and predictive analytics.
- Structure: The modular units are built with locally sourced mild steel or aluminium frames and polyurethane foam insulated panels.

3.2 Resource Availability

The project is well-supported by available resources:

- Human Resources: The project will leverage the expertise of PEDI engineers (mechanical, electrical, ICT) and fabrication technicians.
- Infrastructure: Fabrication will occur at PEDI workshops, utilizing NASENI's solar PV assembly lines and testing facilities.
- Materials: Key structural materials are sourced locally, while critical components like compressors and batteries are available through established supply chains.

3.3 Estimated Fabrication Costs (2025)

Local fabrication at PEDI/NASENI facilities allows for competitive pricing. Estimated costs are:

- Small Unit (2 - 3 MT): ₦3.8m - ₦4.5m.
- Medium Unit (5 MT): ₦4.8m - ₦6m.
- Large Unit (10 MT): ₦6m - ₦7.2m

4.0 Economic Feasibility

4.1 Cost-Benefit Analysis

A comparative analysis of a 5-metric-ton unit over a five-year period demonstrates a compelling financial case for the solar solution.

System Type	Initial Cost	Annual OPEX	5-Year Total Cost	Key Notes
Diesel Cold Room	₦7,000,000	₦2,000,000	₦17,000,000	High recurring costs, unsustainable.
Solar Cold Room	₦5,500,000	₦400,000	₦7,500,000	56% savings vs. diesel, eco-friendly, payback in 3-4 years.

Each solar-powered unit is projected to save its owner approximately ₦9.5 million over five years compared to a diesel alternative.

4.2 Financial Viability and Projected Benefits

The project is economically viable with significant potential for returns. The estimated cost for a $12m^3$ unit is ₦5,800,000.

Projected benefits include:

- For Farmers: A potential 40% reduction in post-harvest losses, leading to an average income increase of 20-30%.
- Job Creation: Opportunities in fabrication, installation, maintenance, and digital services.
- Local Industry Stimulation: With over 70% local content, the project will ensure capital circulates within the Nigerian economy.
- Environmental Impact: Each unit contributes to reducing CO_2 and methane emissions. The project aims to reduce 50,000–70,000 tons of CO_2-equivalent emissions by year five.
- Revenue Models: A dual model of direct sales and a **Pay-Per-Use** system (₦200–₦400 per crate/day) will lower entry barriers and ensure broad adoption.

5.0 Pilot Phase Budget

A detailed budget has been developed for a pilot phase involving the deployment of three units, targeting 2,000–5,000 farmers. The total estimated budget is **₦36,355,000**.

S/N	Category	Description	Total Cost (₦)
1	R&D and Prototyping	Engineering design, software development, component testing	5,000,000
2	Fabrication & Materials	Structural materials, refrigeration, solar systems, PCM, labour	16,800,000
3	Digital Integration	IoT hardware, cloud dashboard, AI model development	4,250,000
4	Deployment & Operations	Logistics, installation, farmer training, pilot monitoring	7,000,000
5	Contingency (10%)	Provision for unforeseen expenses and overheads	3,305,000
	Total Pilot Budget		**₦36,355,000**

6.0 Operational Feasibility

6.1 Implementation Plan & Timeline

A phased 24-month implementation plan is proposed:

1. **Months 1–6:** Design and Prototyping: Detailed design, component testing, and prototype fabrication.
2. **Months 7–12:** Pilot Deployment: Rollout of three units in diverse agricultural hubs to gather real-world data and user feedback.
3. **Months 13–24:** Scale-Up and Commercialization: Refine the design based on pilot data and begin scaled deployment of over 50 units nationwide. The long-term plan aims to deploy 180 units over four years.

6.2 Scalability

The solution is designed for high scalability:

- **Flexible Deployment:** Units can be deployed individually or linked to create larger systems for cooperatives.
- **Sectoral Versatility:** The technology is transferable to fisheries, pharmaceuticals, and urban food logistics, opening up additional markets.

7.0 Risk Analysis and Mitigation

A thorough risk assessment has identified potential challenges and corresponding mitigation strategies.

Risk Description	Impact	Mitigation Strategy
High Initial Capital Cost	Medium	Introduce flexible financing models (leasing, cooperative pooling), offer pay-as-you-store options, and leverage NASENI grant support.
Currency Fluctuations	High	Maximize local content (≥70%), establish bulk import contracts for critical components (panels, batteries, compressors), and explore local R&D for alternatives.
Maintenance & Technical Skills	Medium	Establish service centres, implement training programmes for local technicians, and use IoT for remote monitoring and predictive alerts.
Adoption Resistance	Low-Medium	Deploy demonstration units in farming clusters, conduct farmer sensitization campaigns, and showcase success stories from pilot projects.
Battery Lifecycle Costs	Medium	Integrate Phase Change Materials (PCM) to reduce battery size and strain
Logistical Challenges	Medium	The modular design facilitates easier transport and on-site assembly in rural areas with poor infrastructure.

8.0 Conclusion and Recommendation

This feasibility study affirms that the Smart Solar-Powered Cold Storage Project is both viable and transformative across all key dimensions—Market, Technical, Economic, and Operational. The project directly responds to Nigeria's urgent food security needs by addressing the ₦3.5 trillion annual burden of post-harvest losses, particularly among smallholder farmers who form the backbone of national food production.

The proposed solution is technically robust, economically competitive, and operationally scalable. By combining local manufacturing capacity with smart, renewable technologies, it will reduce food waste, raise farmer incomes, stimulate local industries, create green jobs, and advance Nigeria's commitments to climate resilience and clean energy adoption.

It is therefore strongly recommended that this project advance to the implementation phase, beginning with the pilot deployment. With NASENI's support and strategic partnerships, the initiative is positioned to catalyze the large-scale adoption of sustainable cold chain infrastructure, transforming Nigeria's agricultural value chains and delivering measurable economic, social, and environmental impact.