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AutaNet: AI-Based Predictive Energy Management for Net Billing in Distributed Energy Systems Using MATLAB

Name: Fadekemi Zainab Haruna, Ridwan Nasirudeen Kehinde, Muhammad Tariq Abdulraheem, Ademola Stephen Babalola, Ummi Ahmed Kure

Affiliation: Dept. of Mechatronics Engineering & Dept. of Computer Engineering, Federal University of Technology, Minna, Nigeria

Proposed Solution

The rapid integration of distributed energy resources (DER) and prosumer-based electricity markets has intensified the need for intelligent energy management. Net billing — where consumers export surplus PV generation to the grid at a fixed tariff — introduces bidirectional power flows, intermittent generation, and fluctuating demand that complicate dispatch decisions.

Most studies address load forecasting or energy management optimisation in isolation. Dual-model frameworks that simultaneously forecast PV generation and household load within a unified net billing dispatch architecture remain scarce.

AutaNet addresses this by providing a unified dual-LSTM predictive Energy Management System (EMS) embedded in MATLAB/Simulink, simultaneously forecasting PV output and household load to drive a three-way dispatch strategy under net billing.

Objectives: (1) Model a DER system under net billing. (2) Develop dual LSTM forecasters for PV output and household load. (3) Simulate a three-way predictive dispatch: consume | store | export.

Technical Design

System Architecture (3 components): Dual-channel LSTM forecasting module | Predictive Decision Control layer | MATLAB/Simulink simulation with battery SOC integrator.

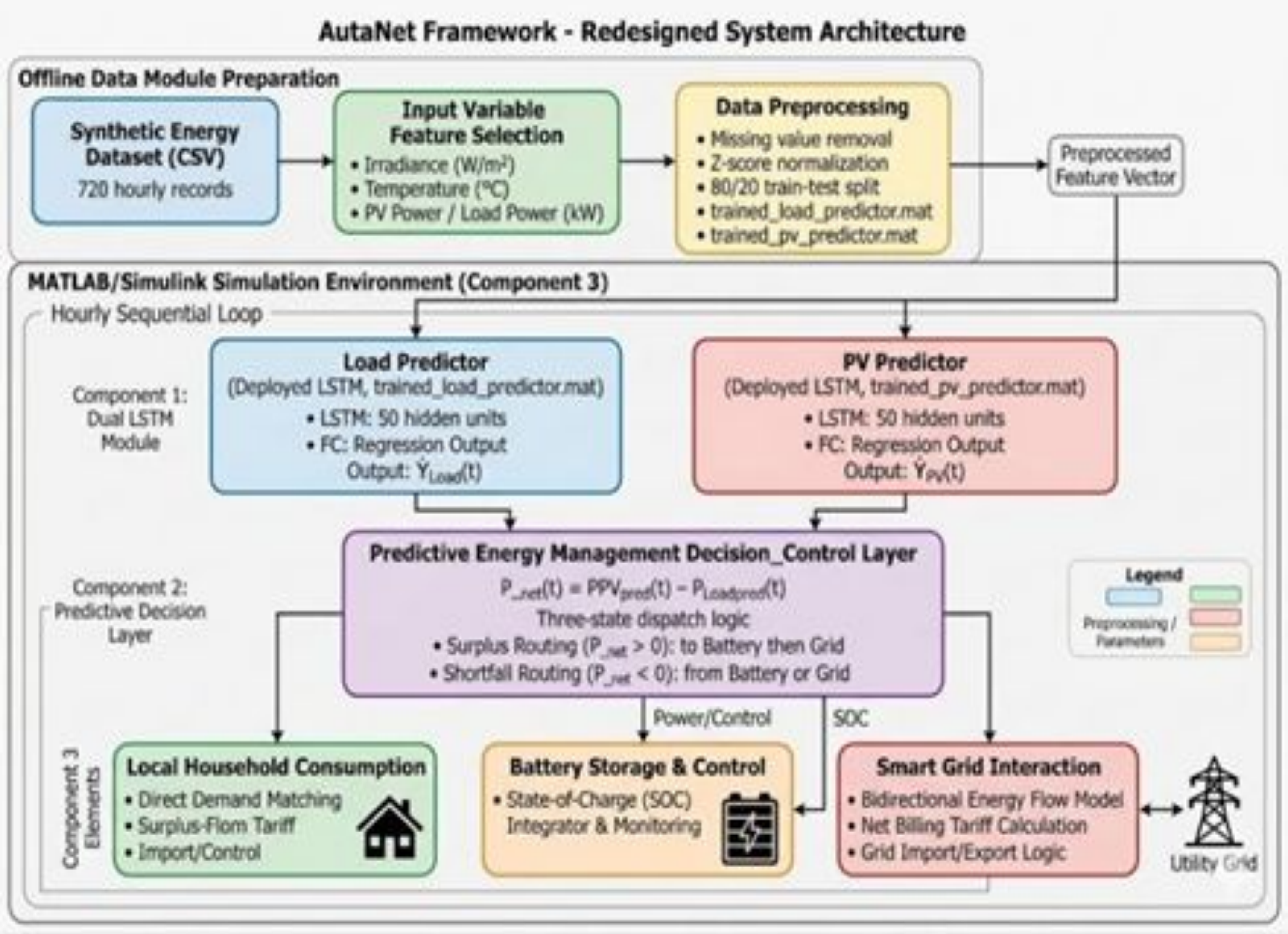

Fig. 1: AutaNet Framework — Dual-LSTM Predictive EMS Architecture with three-way dispatch (consume | store | export)

Dataset: 720 synthetic hourly records (30-day); 80/20 train-test split; 144-step held-out test set. Variables: irradiance (W/m²), temperature (°C), PV power (kW), load power (kW).

PV Predictor: Inputs: irradiance + temperature. 50-unit LSTM → FC regression output. Adam optimizer, lr=0.005, 80 epochs, gradient clip=1.

Load Predictor: Inputs: irradiance + temperature + PV output. Same architecture. Exploits cross-variable co-movement in prosumer households.

Dispatch Logic: P□e□(t) = PV□red(t) − Load□red(t). If P□e□ > 0: charge battery → export surplus to grid. If P□e□ < 0: discharge battery or import from grid.

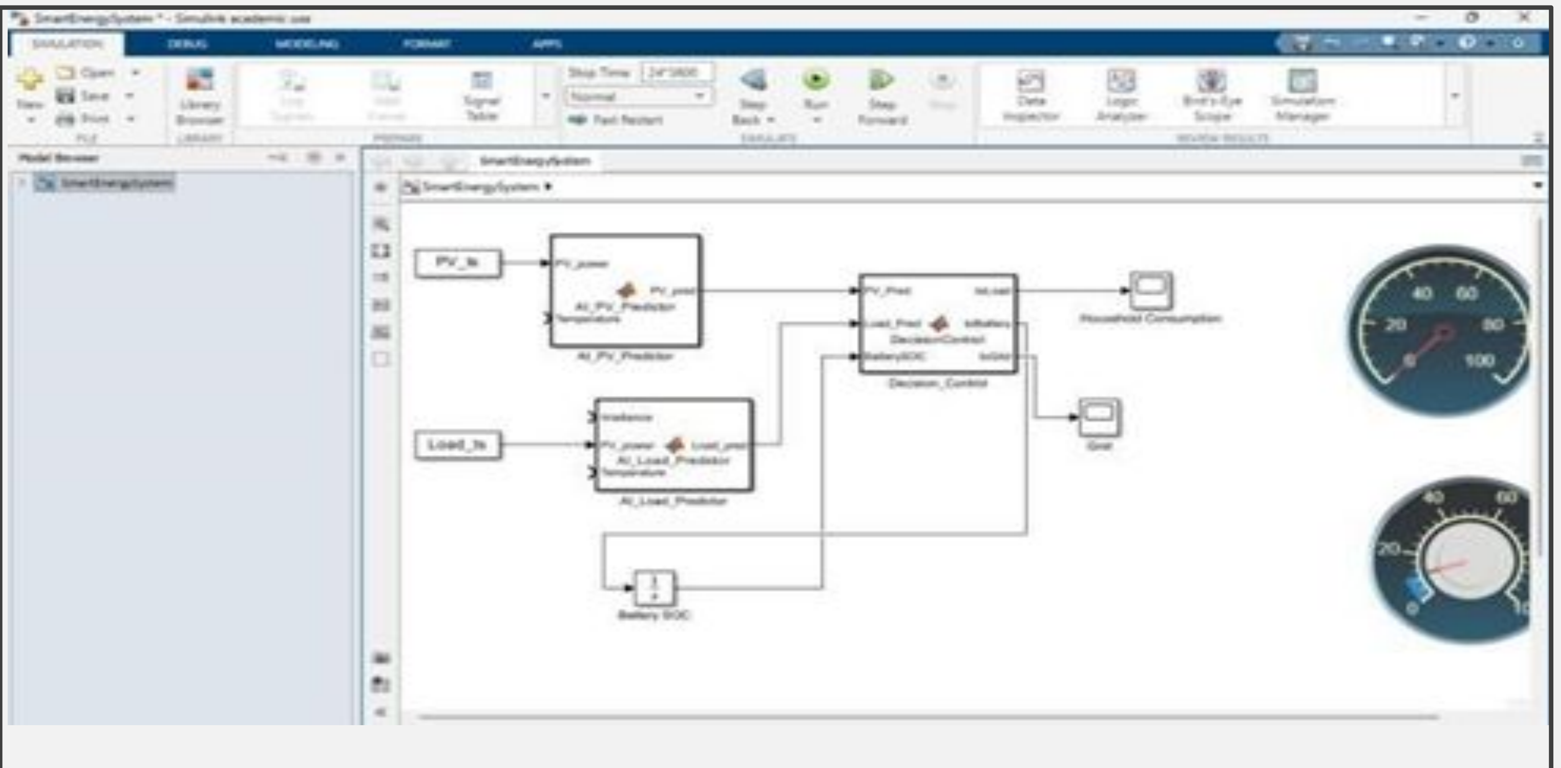

Fig. 2: MATLAB/Simulink Implementation, Smart Energy System Block

Economic Feasibility/Proposed Business Model

Net Billing Value: AutaNet offers a sustainable prosumer-centric business model designed for the rapidly evolving Sub-Saharan African energy landscape, particularly targeting urban Nigerian households with rooftop solar installations, distribution utilities, and mini-grid operators. By leveraging predictive AI, the system maximises financial returns under net-billing frameworks, where the mean generated solar power (3.12 kW) structurally exceeds the mean household load demand (2.08 kW). This consistent generation surplus is strategically monetised: the predictive dispatch model exports electricity to the utility grid during premium tariff windows rather than allowing uncompensated battery overflow. For prosumers, this accelerates the return on investment (ROI) for solar-plus-storage hardware. For utilities and mini-grid operators, widespread AutaNet deployment aggregates distributed energy resources (DERs), reducing peak grid stress, stabilising localised voltage drops, and mitigating the capital expenditure required for central grid infrastructure upgrades.

Relevance to Nigeria: Directly applicable to Nigeria's growing rooftop solar sector and evolving net metering/billing regulatory framework. Supports NERC's metering reform and mini-grid expansion goals.

Timeline for Developing Prototype/Trial

Fig. 3: Gantt chart showing prototype & field trial timeline

Budget & Target User/Market/Scale

TAM: ~4.5 million residential and small commercial grid-connected/off-grid prosumer households experiencing high electricity tariffs and frequent outages in Nigeria (NBS/NERC 2024).

SAM: ~35,000 registered residential clusters, estates, and small business cooperatives using shared solar energy infrastructure across urban hubs in Western and North-Central Nigeria.

SOM: ~450 prosumer households and urban cooperative mini-grid networks within 2 years via NEF and All On acceleration channels.

Grant Budget (₦4,120,000): Hardware Components & Microcontrollers ₦1,250,000 • HIL Testbench Instrumentation ₦450,000 • Software Licenses & Cloud Compute ₦720,000 • Field Installation & Data Acquisition ₦600,000 • Technical Personnel & Logistics ₦500,000 • Publication/IP Filing ₦400,000 • Contingency & Safety Overheads ₦200,000.

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SOLAR-BIOMASS CASSAVA VALUE-ADDITION UNIT

CASSAVAPRO

Turning Nigeria's largest crop — and its own peel waste — into **safe, high-quality cassava flour at the farm gate**, powered by clean energy and owned by women's cooperatives.

THE SOLUTION · IN ONE LINE

A containerised, **off-grid processing unit** that peels, dries and mills fresh cassava on-site — using **solar PV** for power and a **gasifier fired by cassava peels** for heat — cutting spoilage from ~40% to under 10%.

University of Lagos · UNILAG, Nigeria · Engineering · Computer Science · Medicine
FACULTY MENTOR · [Mentor name]   GENDER-BALANCED TEAM · ✓

01 THE PROBLEM

Nigeria is the world's **#1 cassava producer**, yet most of the crop is sold raw and perishes within 48 hours of harvest. Smallholders lose income twice over — to spoilage, and to selling unprocessed roots at a fraction of flour value. Poorly dried cassava also carries **cyanogenic compounds and aflatoxin-producing molds**, a hidden public-health burden.

~40% of harvest lost to spoilage	**₦500B** annual post-harvest loss	**48 hrs** to perish after harvest

04 BUSINESS MODEL

- **Cooperative-owned asset.** A women-led processing cooperative owns and operates each unit as a shared village hub.
- **Processing-as-a-Service.** Farmers pay a per-kg fee to convert roots into flour — no upfront cost, immediate income.
- **HQCF off-take.** High-Quality Cassava Flour sold to bakeries and food processors under a "safe-flour" quality mark.
- **Micro-lease financing.** Pay-as-you-process model lets cooperatives adopt without large capital, de-risking scale-up.

02 TECHNICAL DESIGN

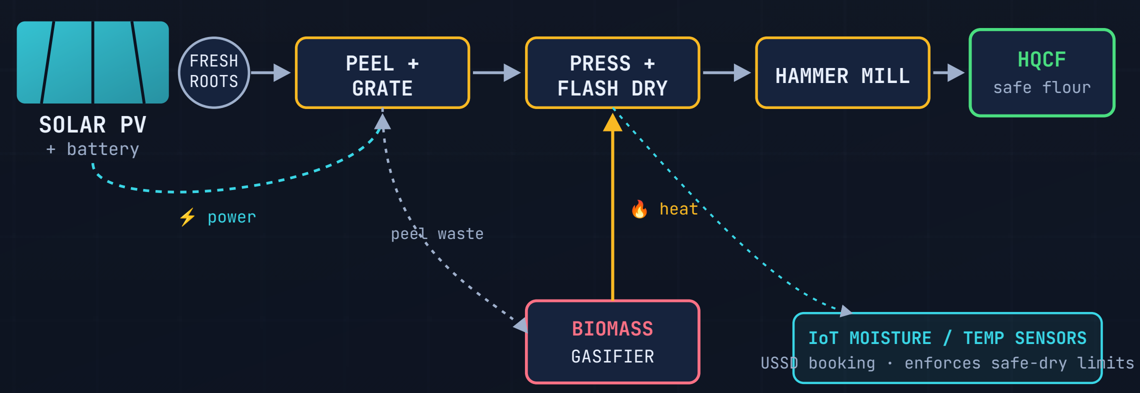
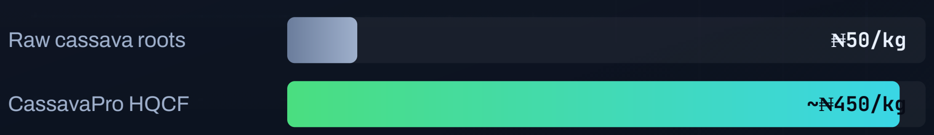


FIG 1 — Solar powers the processing line · cassava peels fuel the dryer · IoT sensors lock in safe drying

- **Hybrid energy core.** Solar PV + battery drives all motors; a peel-fired gasifier supplies drying heat — **zero fuel cost, off-grid.**
- **Circular by design.** The crop's own waste (peels) becomes the energy input, eliminating diesel and disposal.
- **Smart safety [CS].** IoT moisture & temperature sensors enforce drying thresholds that kill aflatoxin mold; a **USSD line** lets low-literacy farmers book slots without a smartphone.
- **Health-validated [Med].** Output tested for residual cyanide & aflatoxin — a quality mark no competitor offers.

03 ECONOMIC FEASIBILITY

₦1.2M build cost / unit	**~₦2.4M** net income / unit / yr	**~6 mo** projected payback



~9× value uplift per kg · figures are projected unit economics, to be validated in field trial

05 TARGET USERS & MARKET

Primary users: smallholder cassava farmers and **women-led processing cooperatives** in rural Nigeria. **Off-takers:** bakeries, flour millers & food processors needing HQCF.

~60M tonnes

Nigeria's annual cassava output — the world's largest, with rising HQCF demand from flour-inclusion policy and import substitution.

06 PROTOTYPE & TRIAL TIMELINE

MONTH 0–2 — Build
Finalise drawings, procure locally-available components, assemble working prototype in the UNILAG workshop.

MONTH 2–4 — Field Trial
Deploy with partner women's cooperative; measure throughput, spoilage reduction & income uplift.

MONTH 4–6 — Smart + Safe
Integrate IoT sensors & USSD booking; validate cyanide/aflatoxin safety with the Medicine team.

MONTH 6–9 — Pilot Fleet
Roll out 3–5 units, refine micro-lease model and prepare for cooperative-led scale-up.

Public-health differentiator: safe-by-design cassava processing — cutting cyanide & aflatoxin exposure.

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4th TERTIARY INSTITUTIONS STUDENT ENERGY CHALLENGE (TIEC4.0)

TIEC Principal Sponsor: ALL ON

NEF 11th NIGERIA ENERGY FORUM 2026

ColdBox — Battery-Free Cold Storage for Smallholder Markets

Team: Samuel-Rotua Richard (Lead) • Ogunsanwo Emmanuel • Chiugo Joy Okpalanedu • Babayanju Covenant Priscilla
Affiliation: Faculty of Engineering & Faculty of Law, University of Lagos, Akoka, Lagos, Nigeria.
Faculty Mentor: ____________________________________

Proposed Solution

Problem: Nigeria loses ₦3.5–5 trillion of horticultural produce annually; up to 48% of tomatoes and peppers spoil before sale because grid power is unreliable, lithium-battery solar fridges are unaffordable (₦500K–1.5M), and ethylene continues to ripen produce even when cooling fails.

ColdBox is a battery-free, three-layer cold-storage unit engineered for the off-grid Nigerian market trader:

• Thermal layer — phase-change material (salt-hydrate, Tm ≈ 8–12 °C) holds chamber temperature for 48–72 hrs without power.
• Chemical layer — $KMnO_4$ ethylene scrubber + silica gel + KOH-zeolite trap suspends ripening even when cooling lapses ("Eco-Survival Mode").
• Energy layer — CarbonVolt supercapacitor module (activated carbon from palm-kernel-shell waste) buffers compressor inrush, enabling a 50–60% smaller solar array and eliminating the imported Li-ion battery.

Outcome: 10–14 days of usable shelf life (vs. 2 days unrefrigerated), at ~₦85K–120K per unit, locally assembled with a clear path to domestic component sourcing.

Technical Design

Insulated chamber: 60 L food-grade liner inside PU-foam-lined sheet-metal shell (U ≤ 0.6 W/m²K). Cooled by a 12 V DC compressor driven by a right-sized 100 W solar PV panel + CarbonVolt supercapacitor module.

Energy buffering: CarbonVolt cells use KOH-activated carbon electrodes derived from carbonised palm-kernel shells (aqueous electrolyte). The supercapacitor absorbs compressor surge currents at start-up, extending compressor life and removing the need for a lead-acid or Li-ion battery bank.

Thermal storage: salt-hydrate eutectic ($CaCl_2$-based blend with nucleating agent) tuned to Tm ≈ 8–12 °C — matched to the chilling-injury-safe range for tomatoes and peppers. Stored in 20 kg sealed HDPE pouches around the chamber walls.

Ethylene control: PVC cartridge holding three stages — silica-gel desiccant → $KMnO_4$ on inert pellets (oxidises C_2H_4 to CO_2 + H_2O) → KOH-zeolite trap (captures MnO_2 and trace by-products). Swappable, designed for ~30-day field service life.

Telemetry: ESP32 + DHT22 (T, RH) + MQ-135 (gas) + SIM800L for SMS alerts on temperature excursion or cartridge exhaustion. A Python digital-twin simulates 72 h of operation in < 5 s, used for design validation and field-data calibration.

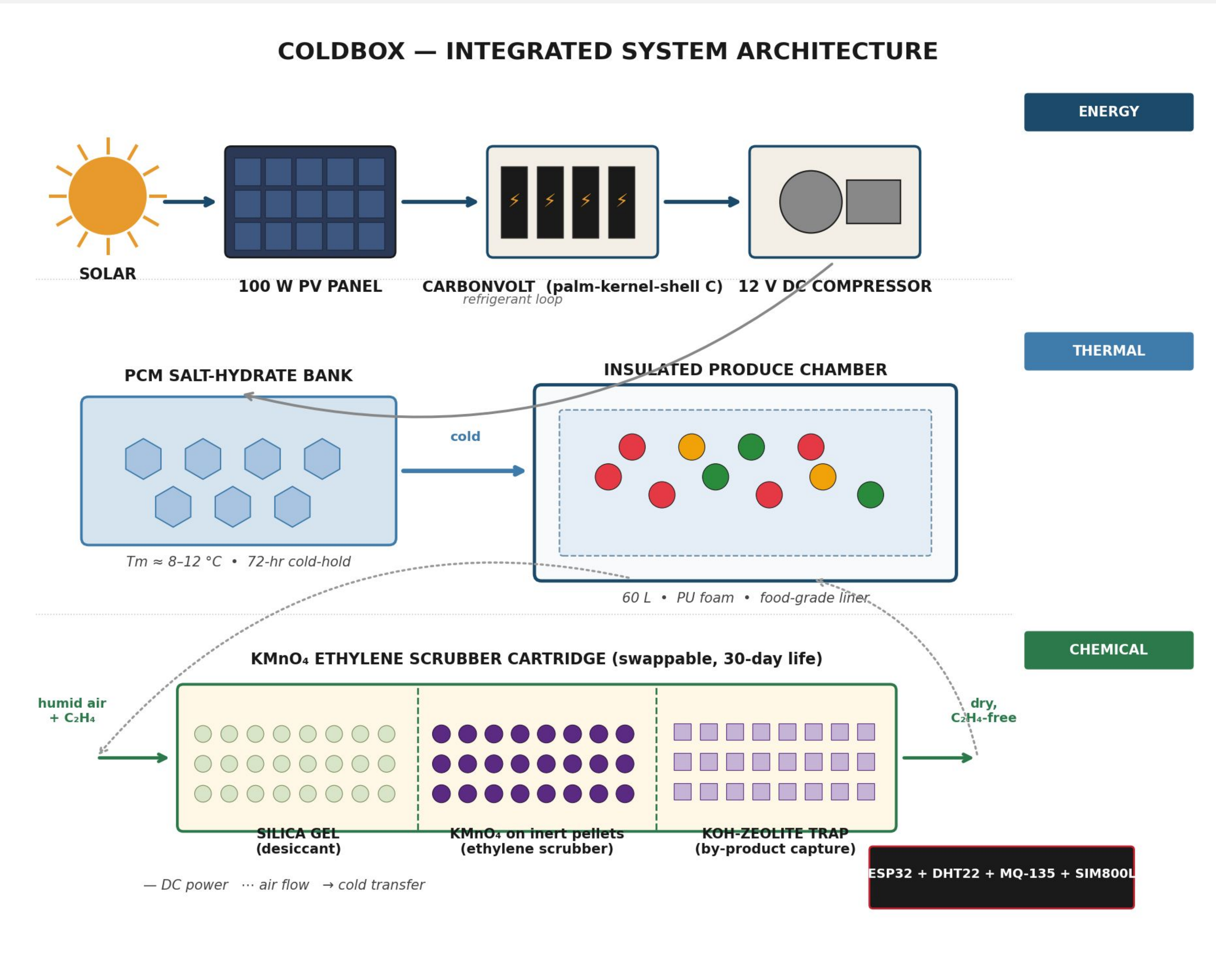

Fig. 1: ColdBox system schematic — three-layer architecture (Energy | Thermal | Chemical) integrating solar PV, palm-kernel-shell supercapacitor, salt-hydrate PCM cold store, $KMnO_4$ ethylene scrubber, and ESP32 telemetry.

Economic Feasibility & Business Model

Unit economics (per smallholder trader):
• System cost: ₦85K–120K (vs ₦500K–1.5M for solar fridge + Li-ion battery).
• Daily spoilage avoided: ₦16K–36K based on FAO/OTACCWA 2023 trader survey.
• Simple payback: 5–8 days at median daily turnover.
• Hardware lifespan: 15–20 yrs — no battery to replace.
• Cartridge service revenue: ₦1,500–3,500/month (recurring).

Revenue streams:
(1) Unit sale + USSD micro-finance (₦5K deposit + ₦5K/month over 18 mo) — captures price-sensitive traders.
(2) Cartridge subscription — locally assembled, swap-and-pay; gross margin ~55%.
(3) Shared "Hub" rental in market clusters — pay-per-day USSD access for the lowest-income tier.

Margins: unit gross margin ~35% at scale; cartridge gross margin ~55%. Break-even ≈ 400 units deployed.

Timeline for Prototype / Trial

Phase 1 — Months 1–3: Lab Prototype
PCM formulation finalised + freeze-thaw cycle testing (UNILAG ChemEng lab); $KMnO_4$ cartridge sized for 30-day life; CarbonVolt cell fabrication and characterisation; digital-twin model validated against bench data.
Phase 2 — Months 4–6: Field Prototype
Build 5 instrumented units; deploy to traders at Mile-12, Mushin, and Oyingbo markets in Lagos for a 60-day field trial. Track produce weight loss, spoilage rate, internal temperature profile, and trader satisfaction via ESP32 telemetry.
Phase 3 — Months 7–9: Pilot Deployment
Scale to 25 units across 3 Lagos markets; integrate USSD payments with a partner micro-finance institution; trial the Hub rental model in one market cluster; file provisional IP through NOTAP.
Phase 4 — Months 10–12: Scale-up
Train 3 fabrication workshops (Lagos, Ibadan, Onitsha); production run of 100 units; cross-state expansion to Ibadan and Abeokuta; finalise cartridge-supply licensing model.

Budget & Target User / Market / Scale

Budget (₦M): Prototyping 4 | Field trial 6 | Pilot 15 | Workshop fit-out 8 | Working capital 5 | TOTAL: ₦38M.
Primary user: smallholder tomato/pepper traders (₦5K–40K daily turnover) in major urban wet markets — Lagos, Ibadan, Onitsha, Kano. 70%+ are women.
Market size: ~2.4M traders nationally handle perishable horticulture; Lagos-only SAM ≈ 180,000 traders. Initial SOM (Years 1–2): 500 units across 5 Lagos markets; Year 3 target: 3,000 units across 6 states with pan-African pilots in Ghana and Kenya.
Impact: each 100-unit deployment saves ~₦1.6–3.6 Bn of produce per year and creates ~16–25 local fabrication jobs (≥50% women).

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Acknowledgements

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4th TERTIARY INSTITUTIONS STUDENT ENERGY CHALLENGE (TIEC4.0)

TIEC Principal Sponsor: ALL ON

NEF 11th NIGERIA ENERGY FORUM 2026

P2P Solar Energy Trading for Shared Agricultural Dryers

Name: Muhammad Tariq Abdulraheem

Affiliation: Mechatronics Engineering, Federal University of Technology, Minna

Proposed Solution

The Gap: A 300 W solar array shared among five 100–200 W agricultural dryers currently meets less than 33% of peak demand, causing manual allocation conflicts.

The Solution: An offline, decentralised P2P auction where five ESP32 agents bid via an ESP-NOW WiFi mesh network every 10 seconds.

Dual-Path Priority: Auto-assigns "CRITICAL" status at ₦100/kWh for wet crops (RH ≥ 80%). Manual overrides incur a 20% premium to deter strategic gaming.

Ledger: Transactions are debited in real-time via an NVS flash ledger and logged to an SD card for auditing.

Technical Design

3-Layer Architecture: Sensing layer (INA219 + DHT22), Auction layer (ESP32 NVS + ESP-NOW), Billing layer (SD card + coordinator consensus).

Auction Algorithm: Each ESP32 runs identical firmware. Bids: {priority, price, timestamp}. CRITICAL bids (sensor or paid override) ranked first; ties broken by price then timestamp.

Incentive Compatibility: Gaming costs ₦9/session with no guaranteed win. Genuine urgency is free via sensor. A documented first for agricultural microgrids in sub-Saharan Africa.

Simulation Results: MATLAB/Simulink confirms ≥15% capacity utilisation gain vs. first-come-first-served. BOM finalised at ₦89,000 per node cluster using locally sourced components.

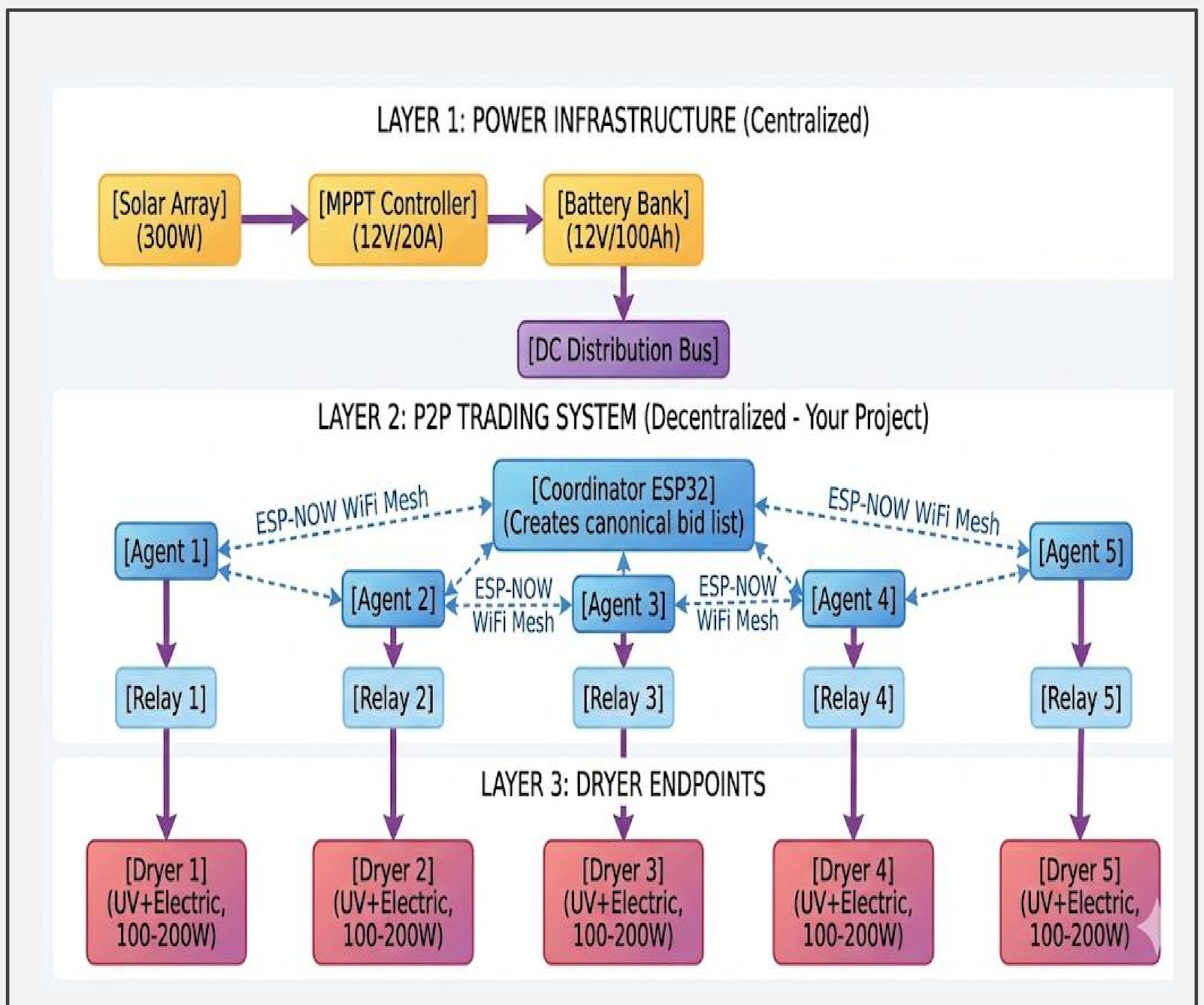


Fig. 1: SYSTEM ARCHITECTURE

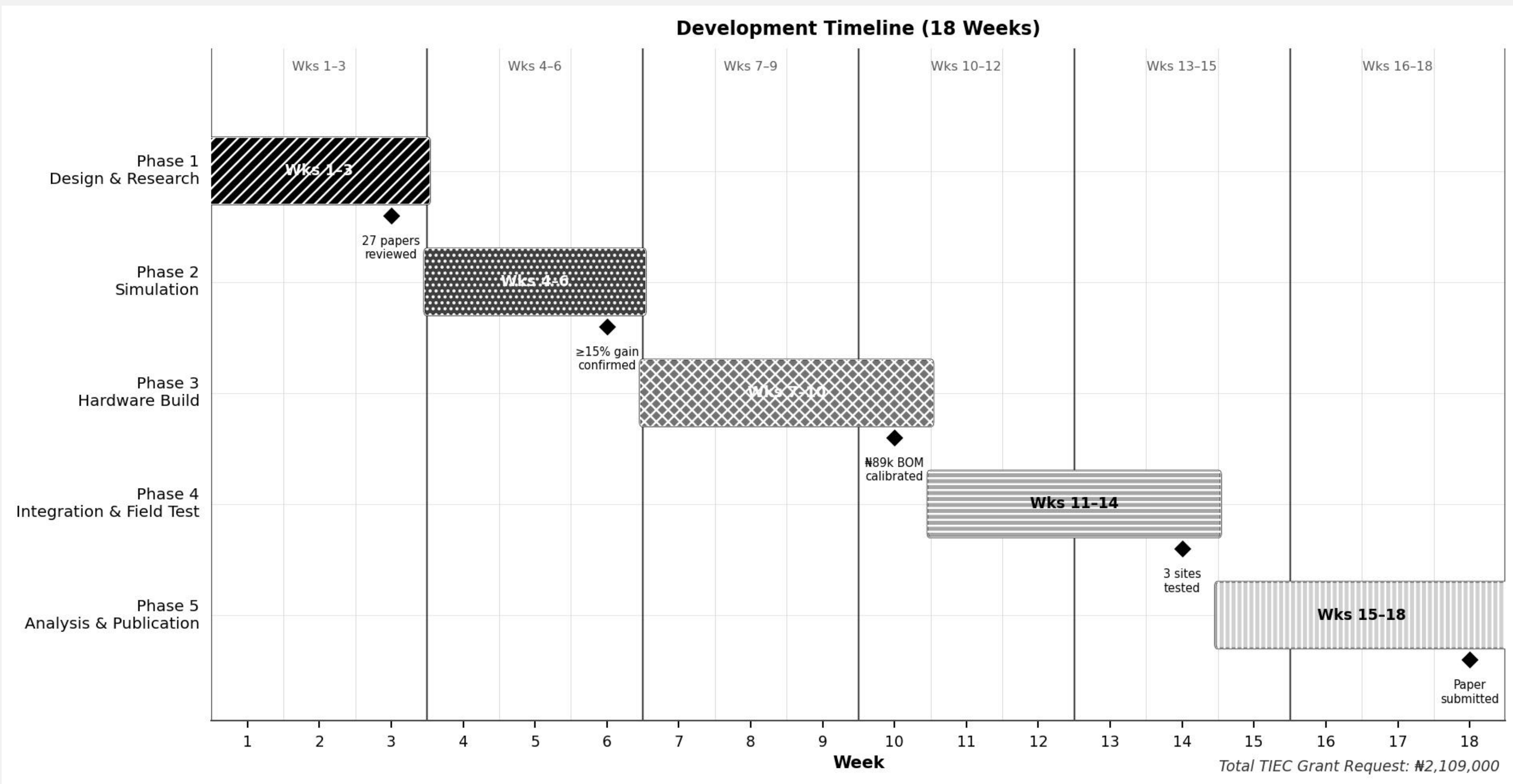
Economic Feasibility/Proposed Business Model

85% cheaper than individual battery upgrades. Estimated payback period <3 months (conservative ₦300/kg farm-gate price; pending field validation).

Revenue Model: Energy billed at ₦100–120/kWh. Cooperative collects revenue; hardware cost recovered in season 1.

Open-Source + Grant Path: Firmware on GitHub. Requesting ₦2.1M TIEC grant for 3 pilot cooperative deployments, field validation and journal publication.

Timeline for developing prototype/trial



Total TIEC Grant Request: ₦2,109,000

Budget & Target User/Market/Scale

TAM: ~3 million smallholder households in Nigeria with post-harvest loss challenges (NBS 2023). SAM: ~25,000 registered cooperatives with shared energy infrastructure in North-Central Nigeria (NAERLS 2022). SOM: ~500 cooperative dryer networks within 2 years via NEF/All On channels.

Budget Category	Cost (₦)
Hardware Components	267,000
Testing & Calibration	150,000
Field Personnel	600,000
Publication & IP	400,000
Training	500,000
Contingency	192,000
Total Grant Request	**2,109,000**

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Team: B.O. Olawoore (Hardware), F.Z. Haruna (Simulation), C.F. Chioma (Field).

Supported by TIEC 4.0 / All On.

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4th TERTIARY INSTITUTIONS STUDENT ENERGY CHALLENGE (TIEC4.0)

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11th NIGERIA ENERGY FORUM 2026

TIEC4.0 Poster Title

Name: **LUMAQ: Smart Energy Gateway Affordable Multi-Source Energy Monitoring for Off-Grid Nigeria**

Affiliation : **Dept. of Mechatronics Engineering, FUT Minna, Niger State**

Proposed Solution

Nigeria's energy deficit costs SMEs an estimated ₦600B annually in generator fuel. Over 90 million citizens lack reliable electricity, yet existing energy monitors cost ₦720,000+, are built for industrial settings, and cannot track solar, battery, and grid sources simultaneously on one affordable device.

LUMAQ is a locally manufacturable smart energy gateway priced below ₦72,000. It monitors voltage, current, power, and temperature across three energy sources in real time, displays live readings on a built-in LCD, and transmits data wirelessly to a remote dashboard. Faults are detected and flagged automatically.

Technical Design

Arduino Mega 2560 (MCU) paired with ACS712 ×3 current sensors (solar/battery/grid), LM35 temperature sensor, 16×2 I2C LCD, and ESP8266 Wi-Fi module. Fully verified in Proteus 8 Professional.

• Arduino Mega 2560 — 54 digital I/O, central processing

• ACS712 ×3 — current sensing, ±30A

• LM35 — temperature, 0–100°C

• ESP8266 — Wi-Fi, 802.11 b/g/n Live test: Solar 18V / 2.1A | Battery 12.6V | Grid 220V

Fig. 1: LUMAQ Prototype v1 — custom enclosure with multi-source energy display

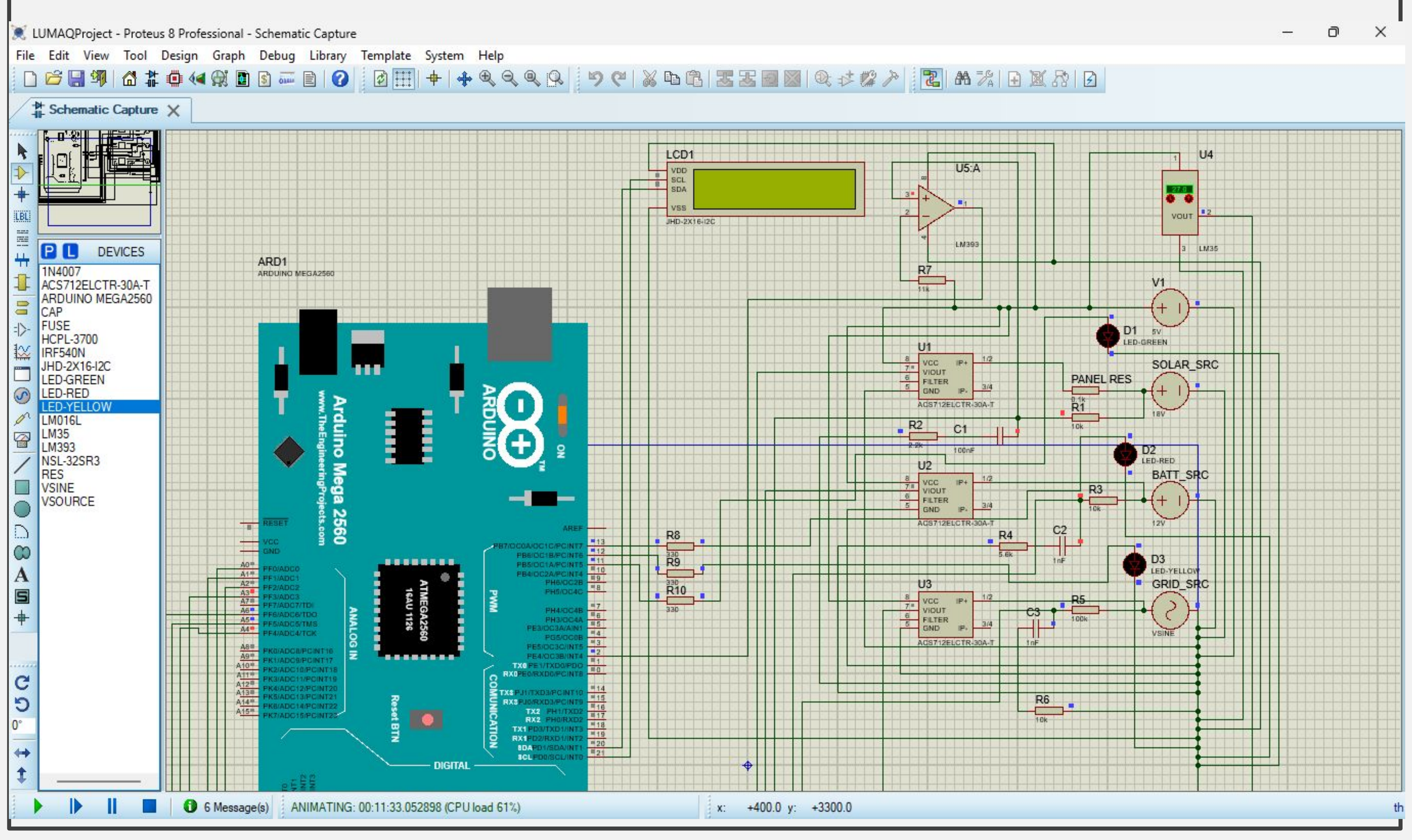

Fig. 2: LUMAQ Prototype v1 — Circuit schematic verified in Proteus 8 Professional

Economic feasibility/Proposed Business Model

BOM: <₦72,000 | Retail: ₦128,000–₦192,000 | Margin: 60–70%
Comparable solutions (Schneider EMS, SolarEdge): ₦720,000–₦3.2M+
LUMAQ delivers equivalent functionality at 10× lower cost, purpose-built for the Nigerian off-grid operator market. Nigeria's renewable energy capacity is projected to grow from 4.51 GW (2026) to 14.07 GW by 2031, creating strong demand for affordable monitoring infrastructure [2].

Revenue streams:

• Hardware sales — mini-grid operators, solar installers, NGOs

• SaaS dashboard — ₦2,500/month per site remote monitoring

• Data licensing — anonymised energy data to grid planners

Timeline for developing prototype/trial

• Q2 2026 Prototype v1 — Arduino + ACS712 ×3 + LCD complete

• Q3 2026 — ESP8266 Wi-Fi dashboard integration & firmware upgrade

• Q4 2026 — 5-unit campus pilot at FUT Minna mini-grid

• Q1 2027 — PCB miniaturisation & enclosure cost reduction

• Q2 2027 — 50-unit commercial production run

• Q3 2027 — West Africa market entry & scale

Budget & Target User/Market/Scale

Seed budget: ₦715,000 total — prototype materials (₦85,000), PCB fabrication batch ×10 (₦150,000), 5-unit pilot deployment (₦360,000), software & cloud infrastructure (₦120,000). Target users: off-grid households, mini-grid operators, SMEs running hybrid power systems, and NGOs delivering rural electrification. Nigeria's off-grid solar industry generated ₦3.5B revenue in 2024, with rapid growth forecast [1].

Scale: FUT Minna → Nigeria → West Africa → Pan-Africa.

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4th TERTIARY INSTITUTIONS STUDENT ENERGY CHALLENGE (TIEC4.0)

TIEC Principal Sponsor: ALL ON

NEF 11th NIGERIA ENERGY FORUM 2026

TIEC4.0 Poster Title

Name: GRID GUARD A
Affiliation : Ladoke Akintola University of Technology (LAUTECH)
Team: Adetayo Saka · Ojuawo Rosemary · Ojiaku Precious, Olusanya Samson
Faculty Mentor: Prof. T. B. Asafa

Proposed solution

GridGuard AI is a hardware-software layer for DISCOs. It reconciles feeder-level energy input against metered customer consumption, estimates technical loss, and flags suspicious loss gaps.

1 Feeder Sensor Node → 2 Edge Gateway → 3 Meter Data → 4 ML Engine → 5 DISCO Dashboard

Detection logic

NTL Index = Feeder Input - Metered Energy - Estimated Technical Loss.
If the residual exceeds threshold, GridGuard raises a bypass flag.

- Works with full AMI deployment
- Also supports statistical NTL mode for legacy-meter feeders
- Alerts field officers by dashboard/SMS

Technical design

ML anomaly detection pipeline

1. Read feeder V/I every 60 seconds
2. Compute KCL balance: expected vs actual
3. Feed residual into Isolation Forest
4. Detect sudden time-series load patterns
5. Generate suspect zone + probability score
6. Send alert to dashboard and field team

Prototype demo focus: simulated feeder input + customer readings + injected theft anomalies + live dashboard alerts.

Budget, target users, market & scale

- Target users: DISCO revenue protection, metering, and field inspection teams
- Initial market: Band A feeders with high tariff and high bypass incentive
- Scale path: 1 pilot feeder -> 10 feeders in 1 DISCO -> licensing across 11 Nigerian DISCOs
- Hardware stack: CT/PT clamp sensors, Raspberry Pi gateway, 4G/LoRaWAN, solar enclosure

Item	
Sensor node + enclosure	₦1.20M
Edge gateway + comms	₦0.85M
Installation + calibration	₦0.75M
Dashboard + ML prototype	₦1.20M
Contingency / field ops	₦0.50M
TOTAL	**₦4.50M**

Economic feasibility & business model

Pilot feeder ROI model: Band A feeder with 500 customers

Energy injected / month	150,000 kWh
Assumed bypass loss	20% = 30,000 kWh
Tariff	₦225 / kWh
Monthly lost revenue	₦6.75M
Recovered by GridGuard	30% = ₦2.0M/month
Annual recovery	₦24M+
Payback period	< 3 months

Business model: hardware-enabled SaaS + deployment fees + monthly analytics subscription per feeder, with optional performance-based recovery share.

Timeline for prototype / trial

Month 1-3 — Prototype & Pilot
Build sensor node, dashboard, KCL simulator, and anomaly detection pipeline. Secure 1 DISCO feeder test.

Month 4-8 — Deployment & Validation
Deploy on feeder, collect live data, compare alerts with DISCO inspection records, tune thresholds.

Month 9-12 — Scale & Licensing
Expand to 10 feeders, package dashboard as SaaS, begin licensing discussions with 3 DISCOs.

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TIEC4.0 Poster Title

Name: AGROCOOL+

Affiliation : Olabisi Onabanjo University, Faculty of Engineering, Departments of Mechanical Engineering, Electrical Engineering & Computer Engineering.

Proposed Solution

Nigeria suffers major post-harvest losses due to poor storage systems, unreliable electricity, and limited access to affordable refrigeration in rural areas. **AGROCOOL+** is an AI-optimized, solar-powered multi-compartment cold storage system designed to address this challenge.it uses IoT sensors to monitor temperature, humidity, and energy usage in real time, while embedded AI optimizes cooling cycles to reduce energy waste and maintain ideal storage conditions for different produce types . By combining renewable energy with intelligent control, AGROCOOL+ provides a scalable and cost-effective solution that improves food preservation, increases farmers' income, and strengthens food security.

Technical Design

AGROCOOL+ is a solar-powered cold storage system that integrates sensors, edge AI, and automated cooling control.

An ESP32-S3 processes temperature, humidity, and gas sensor data locally using a TinyML model to estimate spoilage risk and regulate cooling.

A relay-controlled compressor adjusts operation based on AI decisions using optimized duty cycles to reduce energy consumption.

The system runs as a closed loop: sensing, processing, and actuation.

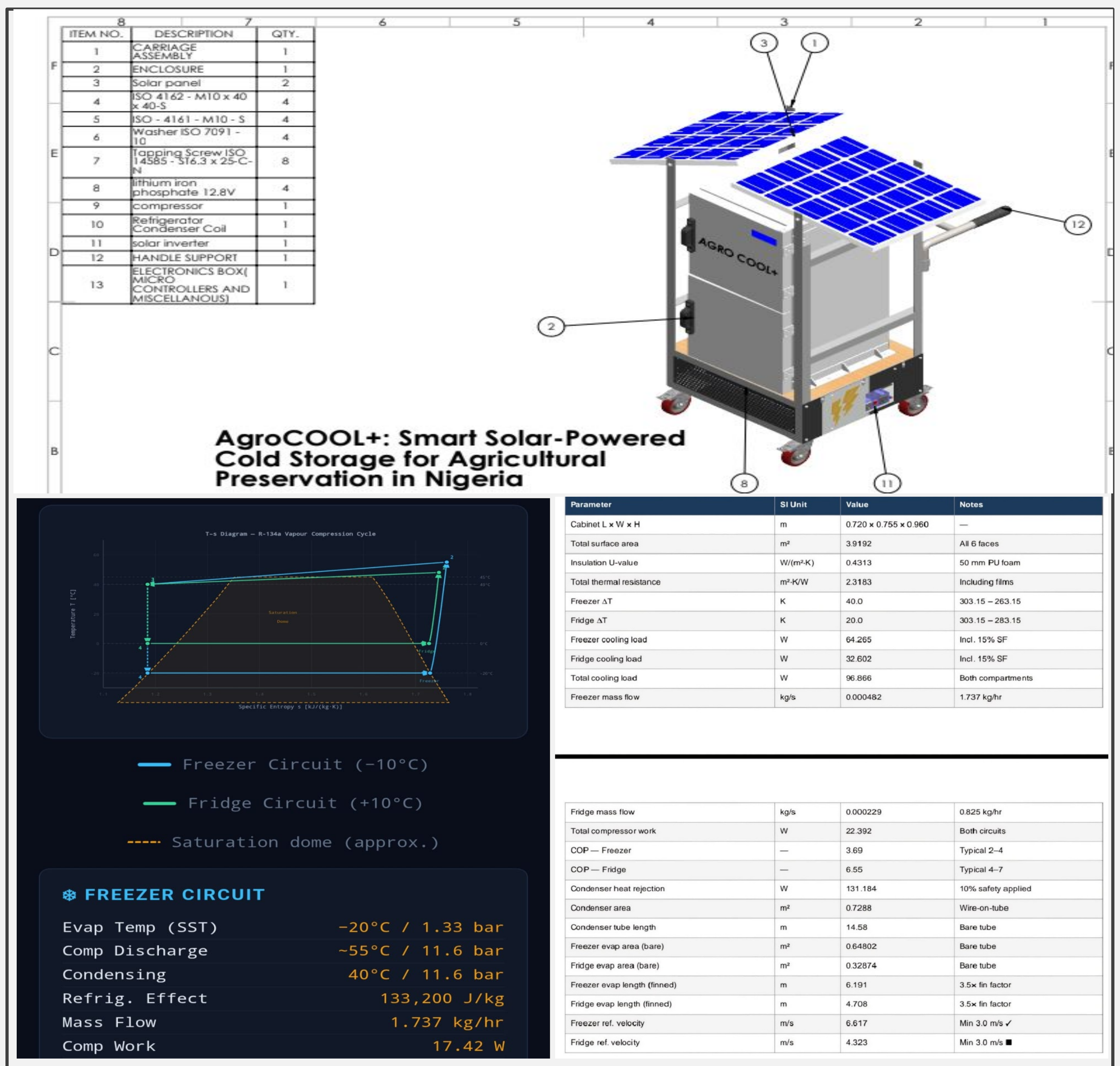
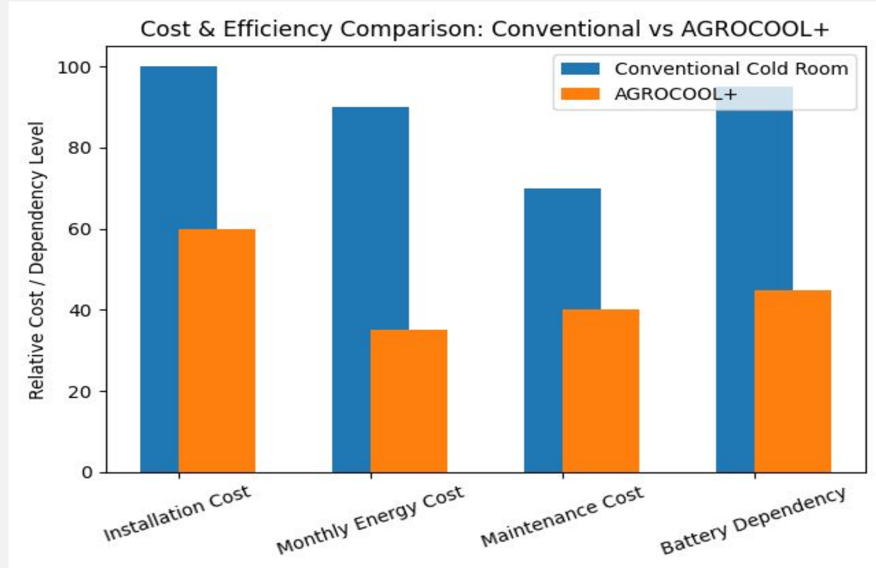


Fig. 1: Technical design

Economic feasibility/Proposed Business Model



AGROCOOL+ is a low-cost cold storage system for farmers and distributors.
It uses pay-per-use, subscriptions, and leasing, with added income from maintenance and monitoring.
Smart cooling reduces energy demand, lowering battery size, installation cost, and overall operating expenses.

Timeline for developing prototype/trial

The prototype will be tested with perishable produce under different conditions to assess cooling efficiency, energy use, and spoilage reduction.

Week 1-2	**Requirement analysis, system design, and feasibility study**
Week 3-4	System design (cooling compartments, and power setup)
Week 5-6	Component sourcing and procurement
Week 7-8	Prototype construction and system integration
Week 9	Software setup (monitoring + smart cooling control system)
Week 10	Testing and performance optimization
Week 11	Pilot deployment in selected rural/farm location
Week 12	Evaluation, feedback collection, and final refinement

Budget & Target User/Market/Scale

Solar Panel & High-Capacity Battery System	₦350,000
Cooling Unit (Efficient Compressor System)	₦250,000
ESP32-S3, Sensors & Control Electronics	₦90,000
Thermal Insulation & Multi-Compartment Fabrication	₦180,000
Wiring, Power Management & Safety Systems	₦70,000
AI/IoT Integration, Testing & Calibration	₦60,000
Miscellaneous & Contingency	₦50,000 Total estimate= ₦1,000,000

AGROCOOL+ is designed for farmers, cooperatives, food distributors, and rural cold-chain operators needing affordable and reliable cold storage.

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Acknowledgements

We appreciate the guidance of our lecturers and the support of our colleagues during the development of this project.

Energy innovations. Powerful collaborations.

4th TERTIARY INSTITUTIONS STUDENT ENERGY CHALLENGE (TIEC4.0)

TIEC Principal Sponsor: ALL ON

11th NIGERIA ENERGY FORUM 2026

SUNPOD

Name: Emmanuel Aanu Ajayi, Mary Ifeoluwa Aderigbigbe, Engr. Michael ibiwoye

Affiliation : Kwara State University, Malete

Proposed Solution

SUNPOD is a cloud-connected smart solar power system that provides affordable, reliable, and sustainable electricity for households, campuses, and businesses. Built from upcycled electronic waste materials, it supports green manufacturing and reduces environmental pollution. The system integrates RFID authentication, IoT monitoring, remote control, and AI-powered energy management to improve efficiency and security. SUNPOD reduces dependence on diesel generators, expands clean energy access, and creates youth employment through local manufacturing, installation, maintenance, and renewable energy entrepreneurship across Nigeria.

Technical Design

SUNPOD consists of a microprocessor, solar photovoltaic panels, a charge controller, lithium battery storage, and an inverter integrated into a smart energy station. The system uses RFID authentication for secure user access and IoT sensors to monitor voltage, current, battery health, and energy consumption in real time. A cloud platform enables remote monitoring and control through mobile devices. Artificial Intelligence algorithms analyze usage patterns, optimize load distribution, and predict battery performance. Upcycled electronic waste materials are incorporated into the housing

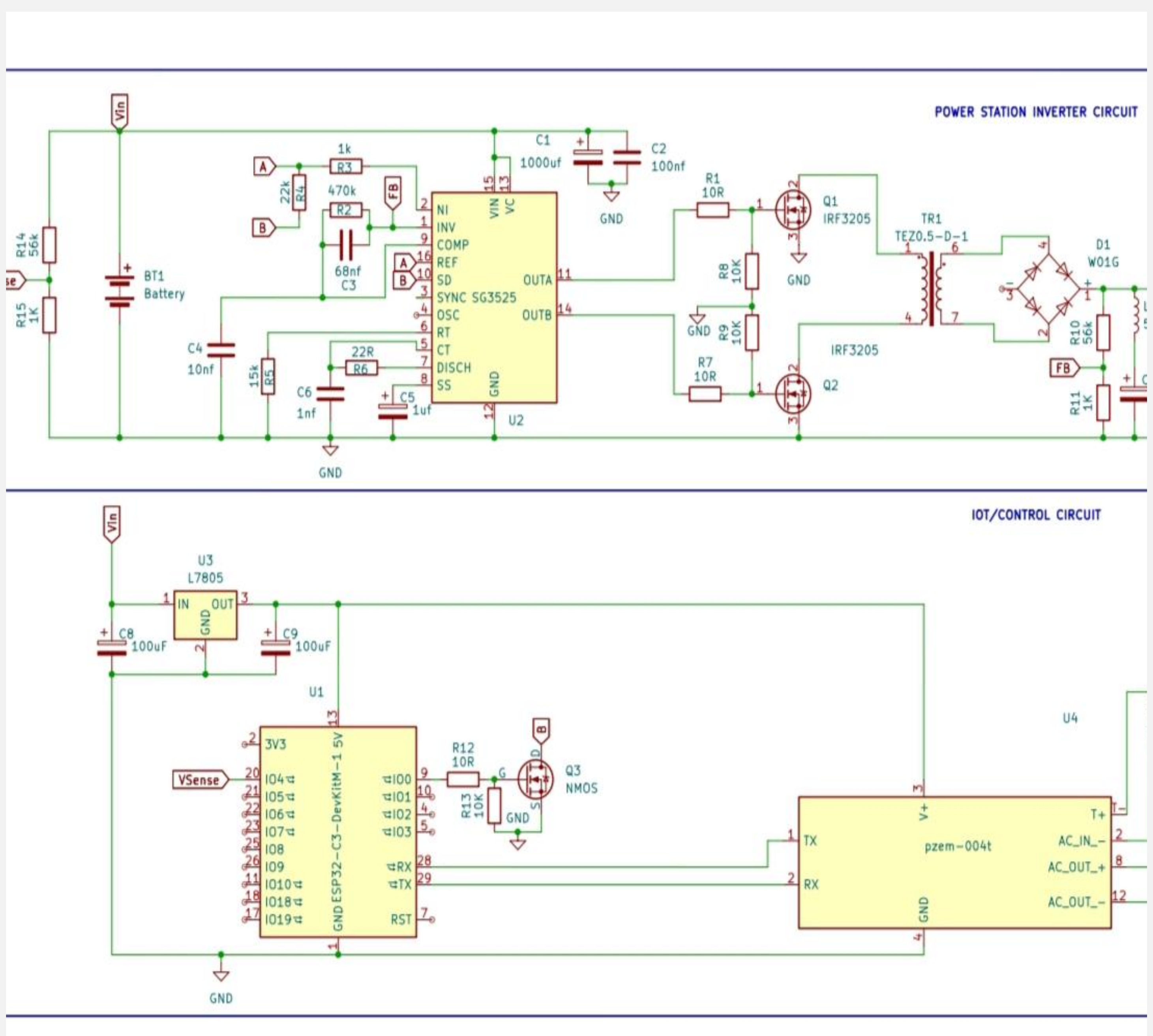

Fig. 1: The Circuit Diagram Design Development of SUNPOD

Economic Feasibility/Proposed Business Model

SUNPOD adopts a scalable business model that combines direct sales, leasing, and pay-as-you-go energy services for households, campuses, and small businesses. Revenue is generated through system sales, subscription-based monitoring, maintenance services, and installation support. By using upcycled electronic waste and local fabrication, production costs are reduced significantly. The model is commercially viable, affordable for end users, and supports long-term profitability. Strategic partnerships with local manufacturers and microfinance providers will enable rapid deployment, market expansion, and sustainable jobs.

Timeline for developing prototype/trial

- Week 1: System design, component sourcing, and collection of upcycled electronic waste materials
- Week 2: Hardware fabrication, solar assembly, RFID integration, and IoT setup
- Week 3: Software programming, AI integration, testing, and pilot trial deployment

Expected outcome: A functional SUNPOD prototype capable of secure energy access, cloud monitoring, remote control, and efficient clean energy delivery for target users. The pilot will serve selected campuses and communities, with scale-up in Nigeria through partnerships with clean energy investors.

Budget & Target User/Market/Scale

The estimated prototype budget for SUNPOD is ₦300,000. Target users include households, tertiary institutions, SMEs, and rural communities with limited electricity access.

References

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Acknowledgements

Support from the Centre for Artificial Intelligence and Machine Learning Systems KWASU is acknowledged.

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4th TERTIARY INSTITUTIONS STUDENT ENERGY CHALLENGE (TIEC4.0)

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11th NIGERIA ENERGY FORUM 2026

The Solar Grating Point

Bringing zero-fuel, industrial-grade cassava processing to the farm gate

Name: Akintunde Abdulrahman · Hajara Kudu Ibrahim

Affiliation: Nile University of Nigeria, Faculty of Engineering, Abuja · Faculty Advisor: Dr. Chibuzor Azodo

Proposed Solution

Nigeria leads the world in cassava production at over 63 million tonnes per year, yet farm-gate losses for roots and tubers run as high as 50–60% [5][1]. Roots rot within 48 hours of being uprooted, mills are too far from the farm gate, and the petrol and diesel engines that power existing graters cut directly into the farmer's already-thin margin.

> We propose the Solar Grating Point — a modular, solar-powered Business-in-a-Box that brings industrial-grade cassava grating directly to the farm gate. A locally-fabricated 1HP stainless-steel grater is powered by a dedicated 3 kVA hybrid solar system and housed in a lockable prefab kiosk that ships flat-packed and deploys in under a day.

Productized service. Farmers pay per bag grated, not for the machinery. No upfront cost barrier.

100% solar. 1.1 kW panel array + $LiFePO_4$ battery — no fuel, no grid, no downtime.

Local content. 1HP grater fabricated by Nigerian engineers in the Idu Industrial District, Abuja.

Local content (full unit): 100% of grating machinery, kiosk fabrication, and installation labour is Nigerian-sourced; the Operator and Hub Manager are recruited from the host village.

Technical Design

The complete unit is sized for the rural cassava-belt load profile: it must run a 1HP motor at full duty for at least 6 hours per day on solar input alone, with battery storage to cover cloudy mornings and pre-sunrise startup.

Grating machine	1HP (0.75 kW) stainless-steel electric grater · Niji-style fabrication, Abuja
Solar array	2 × 550 W monocrystalline panels (1.1 kW total, ~5 m^2 roof footprint)
Inverter	3 kVA / 24 V hybrid pure sine-wave inverter with LCD load display
Battery storage	24 V · 100 Ah $LiFePO_4$ — rated 6,000 cycles (~10 years), 5× lead-acid life
Enclosure	Lockable prefab metal kiosk; ships flat-packed, deploys in under a day

Daily throughput: 15 bags (50 kg) of cassava roots per kiosk per day at ₦500 per bag — sustained for 25 working days per month.

Cost-Benefit Outlook

Cumulative cash position over the first 60 months of operation. CAPEX of ₦3M is recovered around month 25; thereafter the unit produces ~₦1.4M/year in pure profit with zero fuel cost.

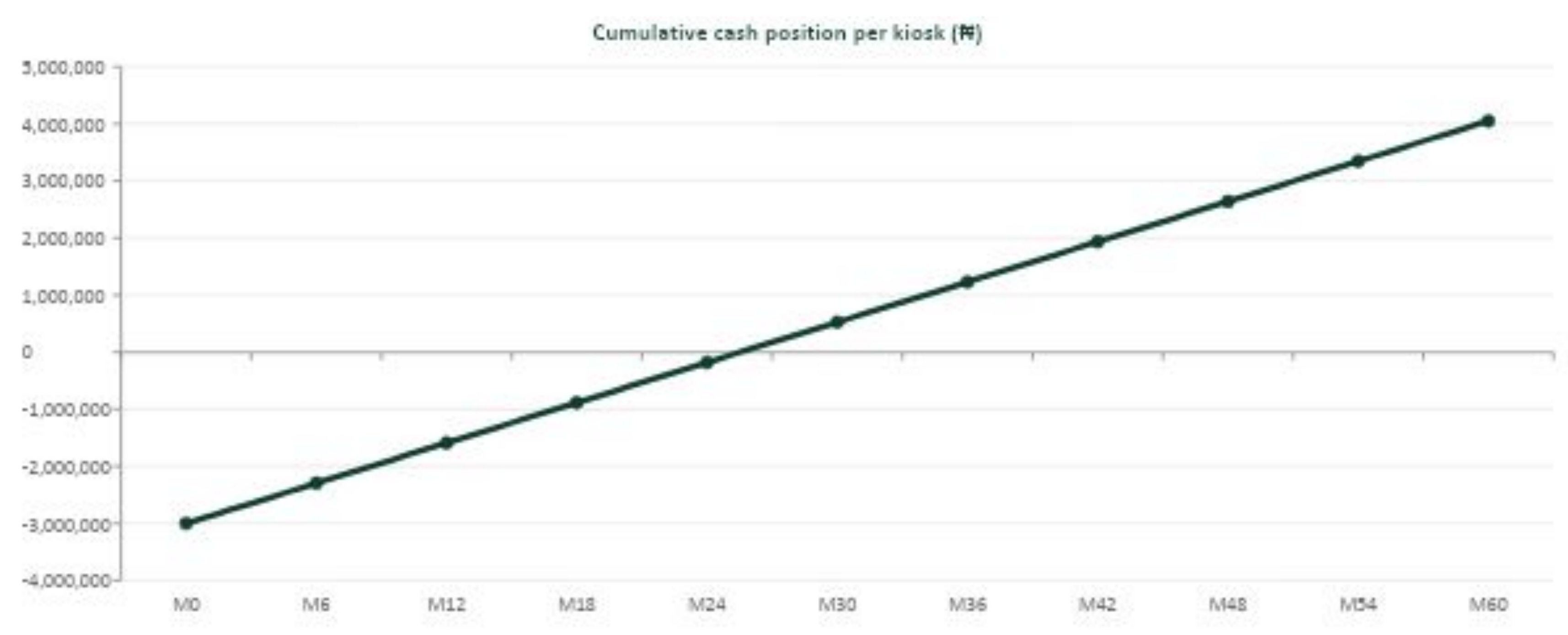

Figure 1: Cumulative profit per Solar Grating Point over a 5-year operating horizon. Breakeven at month 25.

Economic Feasibility / Proposed Business Model

One Solar Grating Point operates as a single-asset micro-enterprise. CAPEX of ₦3M per unit pays back in roughly 25 months and produces ₦1.4M+ in annual profit thereafter, with zero recurring fuel cost.

CAPEX per unit	
3 kVA solar kit *Inverter, panels, $LiFePO_4$ battery*	₦1,600,000
1HP stainless-steel grater *Niji-style fabrication, Abuja*	₦650,000
Prefab lockable kiosk *Secured shop structure*	₦550,000
Installation and logistics *Site setup and transport*	₦200,000
Total CAPEX	**₦3,000,000**

₦187,500
Monthly revenue
15 bags/day × ₦500 × 25 days

₦117,500
Net monthly profit
After ₦70k OPEX

~25 mo
Payback period
Then ₦1.4M+/yr, zero fuel cost

Productized service. Recurring revenue. Eliminates fuel costs entirely.

Timeline for Developing Prototype / Trial

Month 1–2	**Procurement & build**	Source grater and 3 kVA solar kit; fabricate kiosk; finalise BOM and supplier MOUs.
Month 3	**Pilot deployment**	Install first kiosk at a partner village in Kogi or Benue cassava cluster.
Month 4–6	**Field trial**	Operate unit; record daily throughput, revenue, downtime, and farmer satisfaction.
Month 7–9	**Scale validation**	Refine BOM and operating SOP; secure follow-on funding for 10-kiosk rollout.

Budget & Target User / Market / Scale

Target user. Smallholder cassava farmers and rural processors in clusters of 200+ farms within a 5 km radius, currently losing harvest to spoilage or paying premium fees to distant petrol mills.

Market: Nigeria's cassava belt (annual output, million tonnes)

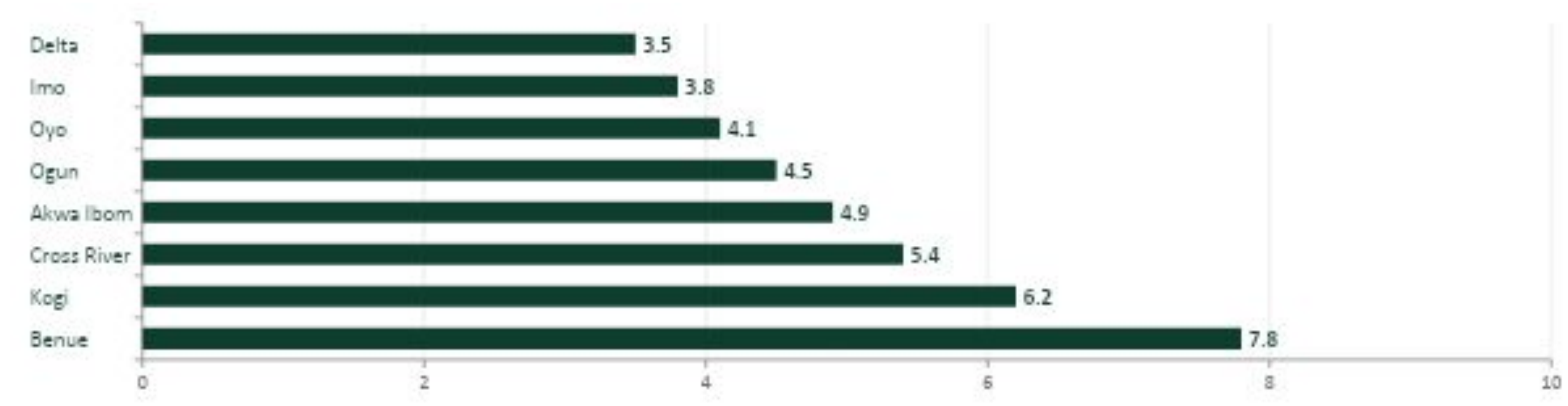

Figure 2: Eight states dominate Nigeria's >63 M-tonne annual cassava output (indicative shares). Each Solar Grating Point targets the farm-gate processing demand within one such cluster.

Scale roadmap

1 PHASE 1 — **1 pilot kiosk**
TIEC-funded pilot at a host village. Validate unit economics.

2 PHASE 2 — **10 kiosks · 3 states**
Cluster rollout: Kogi, Benue, Ogun. Hub Manager model.

3 PHASE 3 — **100 kiosks by 2028**
Full cassava-belt network. ₦140M+ annual ecosystem profit.

Impact

+30%
Farmer income
Reclaimed post-harvest losses

~1.2 t
CO_2 avoided/yr
Per kiosk; displaces petrol grating

2 jobs
Per kiosk
Operator + Hub Manager (local youth)

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Acknowledgements

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