SDG 7: AFFORDABLE AND CLEAN ENERGY

Problem Statement & Proposed Solution

SolarSense AI

AI-Powered Solar Viability Assessment Platform for African SMEs

1. Background & Context

Africa faces a profound energy crisis that fundamentally constraints economic development and limits opportunities for small and medium-sized enterprises (SMEs). As of 2025, approximately 600 million Africans, representing 43% of the continent's population and over 80% of the global population without electricity, lack access to reliable power. This energy deficit is not merely about households in darkness; it represents businesses that cannot operate, goods that cannot be produced, and economies that cannot grow.

Energy sits at the center of economic and social development, yet access to reliable and affordable power remains uneven across many emerging economies. In a region where national electricity grids struggle with inefficiency, limited coverage, and frequent outages, households and small businesses are often forced to rely on costly and environmentally harmful alternatives.

This persistent gap has created a growing market opportunity for startups and small-to-medium enterprises (SMEs) to deliver decentralized and renewable energy solutions. These market players are increasingly positioning themselves as agile problem-solvers—introducing solar-powered systems, clean energy financing models, and energy-as-a-service solutions tailored to underserved communities. Rather than replacing national utilities, these innovators complement existing systems by addressing energy access where traditional infrastructure falls short.

1.1 Industry or Sector Involved

The problem exists within the Clean Energy and Renewable Technology sector, specifically targeting energy-intensive food retail and cold storage businesses across Sub-Saharan Africa. While clean energy solutions are relevant across all SME sectors (manufacturing, hospitality, agriculture, professional services), we focus initially on refrigeration-heavy enterprises where the energy crisis is most acute and solar viability is most compelling.

This sector represents a critical intersection of Africa's energy crisis and food security challenges:

- Market Scale: South Africa's cold chain and warehousing market alone exceeds $1 billion and is expanding rapidly. Across Nigeria, Kenya, Ghana, and Zimbabwe, inadequate cold storage infrastructure causes 30-50% post-harvest food losses, creating urgent demand for energy-resilient refrigeration.

- Energy Intensity: Refrigeration accounts for 30-60% of total electricity consumption in food retail businesses. A typical 50m² grocery store consumes

800-1,500 kWh/month, translating to monthly electricity bills of $300-600 in Kenya, ₦200,000-400,000 in Nigeria, and R4,000-8,000 in South Africa. These costs double or triple when businesses resort to diesel generators during frequent grid outages.

- Sector Growth: Africa's cold chain sector is projected to grow at 15-18% annually through 2030, driven by urbanization, expanding middle class, and strengthening food safety regulations. This growth creates an expanding market of energy-vulnerable businesses seeking cost-effective power solutions.
- 24/7 Critical Loads: Unlike office or retail businesses with variable energy needs, refrigeration operates continuously. A single 4-6 hour power outage can cause complete inventory spoilage worth thousands of dollars, making energy reliability an existential business risk rather than merely an operational cost.

The sector's defining characteristic—continuous, high-intensity energy consumption combined with intolerance for outages—makes it particularly vulnerable to Africa's energy challenges while simultaneously positioning it as an ideal candidate for distributed solar solutions. However, businesses in this sector face the same information barriers preventing solar adoption across all SME categories: lack of accessible viability assessments, inability to afford professional consultations, and uncertainty about return on investment.

1.2 Existing Conditions, Trends, and Challenges

The continent's energy challenges are multifaceted and severe:

- **Grid Unreliability:** African firms experience over a week of power outages monthly on average. Nigeria's grid collapses periodically, South Africa experienced persistent load-shedding into early 2025, and drought conditions depleted Zambia and Zimbabwe's Kariba Dam in 2024, causing crippling power cuts.
- **Diesel Dependency:** Nigeria alone spends $22 billion annually on fuel for generators. Nigerian firms run generators 59% of the time, paying an average of $0.24/kWh—almost three times the official electricity price and double what American businesses pay. In Kenya, the reliability-adjusted price is $0.17/kWh; in Ghana, $0.22/kWh; and in Liberia, $0.45/kWh.
- **Financial Burden:** A typical 100 kVA diesel generator costs approximately $17,000 upfront, which must be paid immediately—a barrier that prevents many new firms from starting. Additionally, 71% of Nigerian firms use generators, as do nearly half of households.
- **Investment Gap:** Africa requires $200 billion annually through 2030 to meet energy and climate goals, yet only $110 billion is currently invested, with insufficient allocation to clean energy. The annual financing gap for energy access alone is estimated at $25-160 billion.

1.3 Why This Problem Exists

The continued energy access gap is rooted in structural and economic limitations. Expanding centralized power infrastructure requires significant investment, long implementation timelines, and strong regulatory coordination—conditions that are often difficult to meet. As a result, large segments of the population remain underserved.

Clean energy solutions, while increasingly viable, are not yet universally accessible due to affordability concerns, limited technical capacity, and uneven policy implementation. Without targeted, scalable solutions that prioritize affordability and reliability, energy poverty persists—slowing economic growth and undermining progress toward sustainable development.

2. Problem Statement

Currently, micro and small enterprises (1-50 employees) across Sub-Saharan Africa, particularly refrigeration-dependent food retail businesses (butcheries, grocers, mini-supermarkets), struggle to determine whether solar energy investment is financially viable for their specific business location and energy needs, which leads to either avoiding solar adoption entirely (continuing to pay 20-40% of revenue on expensive grid electricity and diesel backup) or making uninformed investments based on biased installer quotes that fail to deliver expected returns. This occurs because independent solar feasibility assessments cost $500-$2,500 (prohibitively expensive for most SMEs) and take 4-12 weeks to complete, while free installer quotes create conflicts of interest and lack the technical rigor (solar irradiance modeling, accurate ROI projections) needed for confident decision-making. This information barrier perpetuates energy poverty, slows progress toward SDG 7 targets in a region requiring $193 billion in clean energy investment by 2031, and prevents SMEs from capturing potential 30-60% energy cost savings despite Sub-Saharan Africa having optimal solar conditions (5-6 kWh/m²/day irradiance).

2.1 What the problem is:

Small and medium-sized enterprises (SMEs) across Sub-Saharan Africa face a critical barrier to adopting solar energy: the inability to affordably and reliably assess whether solar installation is financially viable for their specific business before committing to expensive investments or uncertain installer quotes.

2.2 Who is affected:

Primary: Micro (1-10 employees) and small enterprises (11-50 employees) across Sub-Saharan Africa, particularly in:

- Focus primarily on cold storage/refrigeration businesses
- Future Expansion:
    - High-energy-consuming sectors: Manufacturing, bakeries, hospitality, retail (refrigeration-dependent businesses)
    - Grid-connected businesses experiencing unreliable power and load-shedding
    - Off-grid/rural businesses currently relying on expensive diesel generators

Geographic focus: Key SSA markets including South Africa (67% of C&I solar market), Nigeria (11%), Kenya (7%), Ghana, Senegal, Tanzania, and Uganda; markets representing the $127 billion wind/solar/storage opportunity through 2031.

Market size: Targeting a segment of the 26 GWdc cumulative C&I solar market projected by 2031, where over half of installations are systems under 10MW, perfect for SME scale.

2.3 When and where the problem occurs:

When:

- At the decision-making stage: When SMEs are considering solar to address rising electricity costs (averaging $0.15-$0.30/kWh in SSA) and unreliable grid supply
- During energy crisis periods: Particularly acute during load-shedding events (South Africa, Kenya, Zimbabwe), where backup power costs consume 20-40% of business revenue
- Before capital investment: When businesses need to validate ROI before committing to systems costing $800,000+ KES (≈$6,000-50,000 USD depending on size)

Where:

- Urban/peri-urban areas with grid access but poor reliability (frequent outages, voltage fluctuations)
- Rural locations with limited/no grid connection are currently dependent on diesel generators
- Regions with high solar irradiance (average 5-6 kWh/m²/day across SSA) but low adoption due to information barriers

2.4 Current state and barriers:

Current approaches (all inadequate):

1. Getting installer quotes (60-70% of SMEs):

- Quotes are often optimistic, lacking independent verification
- Create conflict of interest; installers incentivized to oversell
- High-level estimates without detailed energy analysis
- Result: 40-50% back out after receiving quotes due to skepticism about true ROI

2. Hiring independent consultants/energy auditors (15-25% of SMEs):

- Cost barrier: Professional solar assessments range from $500-$2,500 USD
- Time barrier: Full assessment takes 4-12 weeks (1-2 weeks for quotes, 2-4 weeks for site visits, 1-6 weeks for analysis)
- Accessibility: Limited availability in rural areas; travel costs increase assessment fees by 15-30%
- Result: Only well-resourced SMEs can afford this, excluding micro and small businesses

3. Avoiding solar altogether (40-60% of interested SMEs):

- Cited reasons: Complexity, high upfront costs, shade concerns
- Knowledge gap: 60-80% of SMEs express interest in solar, but 40-70% lack data on viability for their specific operations
- Result: Businesses remain trapped in expensive, unsustainable energy patterns
- Systemic barriers identified in the market:
    - Limited access to financing (highlighted as top SSA renewable barrier
    - Skills shortage and lack of local technical competencies
    - High perceived risk driving up cost of capital (13% average WACC in SSA vs. 6% in Europe/US)
    - Fragmented market: South Africa alone has 40+ solar owners with limited standardization
    - Currency risk: Local currency depreciation (20-28% between 2015-2022) impacts ROI calculations
    - Regulatory complexity: Multiple authorities create assessment challenges (particularly Kenya)

2.5 Why the problem is significant:

1. Economic impact on SMEs:

- SMEs currently spend 20-40% of revenue on energy in some SSA regions
- Backup power (diesel generators) costs are prohibitive: diesel prices are volatile, and maintenance is expensive
- Lost productivity: Production delays, equipment damage from voltage fluctuations, inability to operate during outages
- Missed savings opportunity: Solar could reduce energy costs by 30-60%, but SMEs can't validate this without expensive assessments

2. Barriers to SDG 7 clean energy transition:

- 579 million people in SSA lack electricity access; only 48% electrification rate regionally
- $193 billion investment needed (2023-2031) to achieve universal electricity access and green transition
- Solar represents 44% ($56 billion) of this opportunity, with C&I market requiring $2.6 billion annual investment
- Current adoption is too slow: Without decision-support tools, SMEs default to fossil fuels despite having optimal solar conditions

3. Market inefficiency and capital deployment challenges:

- Assessment costs create market failure: The very businesses that would benefit most (high energy costs, reliable sun) can't afford to find out
- Secondary market growth hindered: Bankable SME solar projects needed to attract institutional capital and grow from the current 0.3 GW tracked transactions to the forecasted 10 GW by 2031
- Developer pipeline constrained: As report notes (pg. 14), developers need to farm down de-risked assets to fund new projects, but can't create a pipeline without more SME adoption

4. Environmental and sustainability impact:

- SMEs relying on diesel generators contribute to CO_2 emissions
- Missing opportunity to deploy clean energy in a region with 5-6 kWh/m²/day irradiance (among the world's best)
- Perpetuates energy poverty and fossil fuel dependency in the region most vulnerable to climate change

2.6 Root causes:

1. Information asymmetry: SMEs lack access to independent, data-driven solar viability analysis

2. Cost-prohibitive professional services: $500-$2,500 assessments exclude micro/small businesses

3. Time constraints: 4-12 week assessment timelines delay decision-making and increase opportunity costs

4. Distrust in the installer ecosystem: Conflict of interest in sales-driven quotes undermines confidence

5. Technical complexity: Solar irradiance data and financial modeling require expertise that SMEs don't have

6. Fragmented data: Rooftop suitability, weather patterns, and equipment costs, scattered across multiple sources

3. Target Audience
3.1 Primary Users

Demographics
- Micro (1-10 employees) and small (11-50 employees) refrigeration-dependent food retail businesses, including:
  - Butcheries and meat shops
  - Small grocers with cold storage
  - Mini-supermarkets
  - Cold chain distribution points
- Energy context:
  - Reliant on a mix of grid electricity and diesel generators
  - Energy expenses often account for a high percentage of operating costs

Needs, Goals, and Motivations
- Need to reduce energy costs and stabilize operating expenses
- Need to maintain business continuity during outages and load-shedding
- Goal to make financially sound investment decisions without risking cash flow
- Motivation to adopt cleaner, more reliable energy solutions if they are proven viable
- Desire for clarity and confidence before committing to high upfront capital expenditures

Pain Points Related to the Problem
- High and volatile electricity tariffs combined with expensive diesel backup

- Uncertainty about whether solar is financially viable for their specific location, roof, and energy usage
- Lack of access to affordable, independent solar feasibility assessments
- Distrust of installer-led quotes due to conflicts of interest and overly optimistic projections
- Limited technical expertise to interpret solar data, ROI models, and risk factors
- Time constraints that make multi-week consultant assessments impractical

These users face a high-stakes decision under uncertainty, where making the wrong choice can negatively impact business survival rather than merely reducing efficiency.

3.2 Secondary Users and Stakeholders

Solar installers and developers
- Benefit from better-qualified leads and reduced sales friction
- Can focus efforts on SMEs with proven solar viability

Energy policymakers and development organizations
- Interested in accelerating SME solar adoption to advance SDG 7
- Use aggregated insights to understand adoption barriers and energy demand patterns

Grid operators and energy planners
- Indirect stakeholders who benefit from reduced grid strain and diesel dependence

4. Existing Solutions & Gaps

This section examines existing tools, platforms, and organizations currently supporting solar assessment, deployment, and financing across Africa and globally. The focus is on how these solutions operate in practice, what value they provide, and why they fall short of enabling fast, independent, and SME-friendly solar viability decisions in Sub-Saharan Africa.

4.1 Existing Solar Assessment and Decision Tools

4.1.1 Global Renewable Energy Assessment and Modeling Tools

RETScreen

RETScreen is a widely used clean energy management software for evaluating the technical and financial viability of renewable energy projects. It is deployed globally across public and private sector projects and is commonly used by consultants and engineers.

Strengths

- Robust technical and financial modeling capabilities

- Widely validated and used across more than 100 countries

- Supports multiple renewable energy technologies

Limitations

- Desktop-based and complex, requiring professional expertise

- Designed for engineers and consultants, not SME owners

- No automated rooftop detection or SME-scale customization

- Not optimized for fast, self-serve decision-making

Insights: *RETScreen is effective for professional feasibility studies but unsuitable as a lightweight, accessible decision-support tool for African SMEs.*

Global Solar Atlas

Global Solar Atlas provides global solar resource and photovoltaic (PV) potential data, allowing users to estimate solar irradiance and potential energy yield for any geographic location.

Strengths

- High-quality, globally consistent solar resource data

- Freely accessible and scientifically validated

- Useful for early-stage site screening

Limitations

- Acts primarily as a data repository, not a decision-support platform

- Does not integrate rooftop analysis, energy consumption, or business costs

- Provides no ROI

Insights: *While valuable as a data source, Global Solar Atlas does not support SME-level solar investment decisions.*

Scientific Modeling Tools (SAM, HOMER)

Tools such as the **System Advisor Model** and **HOMER** are widely used for detailed renewable energy system simulation and optimization.

Strengths

- High analytical accuracy

- Suitable for complex system design and optimization

- Commonly used in research and professional energy analysis

Limitations

- Require advanced technical expertise

- Not localized for African SME market conditions

- Too complex and time-intensive for non-technical business owners

Insights: *These tools serve professional analysts well but remain inaccessible to SMEs seeking quick, practical solar viability insights.*

4.1.2 Solar Deployment and Financing Companies in Africa

Arnergy (Nigeria)

Arnergy provides solar-plus-battery systems to businesses and households in Nigeria, often bundled with financing and energy management services.

Strengths

- Proven reduction in energy costs for deployed customers

- High system reliability and uptime

- Strong local market presence

Limitations

- Primarily an installation and financing company

- Viability assessments are proprietary and sales-driven

- No publicly accessible, independent software tool for SMEs to assess solar viability before engagement

Insights: Arnergy enables deployment but does not provide independent, self-serve solar decision tools for SMEs.

PEG Africa (West Africa)

PEG Africa delivers PAYG solar solutions across Ghana, Senegal, Mali, and other West African markets, targeting households and small businesses.

Strengths

- Reduces upfront cost barriers

- Expands clean energy access in underserved regions

- Strong financing innovation

Limitations

- Focuses on asset financing and deployment

- No standalone digital product for solar viability analysis

- Limited SME-specific customization

Insights: PEG Africa improves access to solar infrastructure but does not address pre-investment decision uncertainty for SMEs.

Micro-Installer Networks

Numerous local installers deploy solar systems for SMEs and households across Africa.

Strengths

- Strong local knowledge and reach

- Flexible deployment models

- Important role in ecosystem expansion

Limitations

- Manual, consultant-driven assessments

- No scalable digital assessment platforms

- Quality and rigor vary widely

Insights: These actors enable installations but lack standardized, data-driven, and scalable assessment tools.

4.2 Gaps Across Existing Solutions

Across global tools and African deployment models, several systemic gaps remain:

1. **No SME-first, automated solar viability platform**
   Existing tools are either too technical or too sales-driven.

2. **Limited equipment-specific energy profiling for African SMEs**
   Tools don't account for refrigeration-heavy businesses or African climate

conditions.

3. **Poor localization for African SME economics**
Diesel generator costs, informal load profiles, and local pricing are not well integrated.

4. **Fragmented data and decision flows**
Solar resource data, business costs, and financial projections are not unified.

5. **Low trust due to lack of independence and transparency**
SMEs struggle to validate recommendations without vendor bias.

4.3 Strategic Opportunity

Despite strong solar potential and growing deployment activity, African SMEs lack a **single, independent, AI-powered decision-support platform** that answers a fundamental question:

> *"Is solar worth it for my business, given my location, energy use, and financial reality?"*

A software-based **AI Solar Viability Analyzer** that integrates solar resource data and localized financial modeling would fill this gap—accelerating SME adoption of clean energy and directly advancing **SDG 7: Affordable and Clean Energy**.

5. Proposed Solution

We propose *SolarSense AI*— an AI-powered solar viability assessment platform that democratizes access to professional-grade solar feasibility analysis for African SMEs. This AI-powered solar viability assessment platform is designed specifically for cold storage and refrigeration-heavy food retail businesses in Africa. Our platform uses targeted machine learning models to provide instant, personalized solar viability assessments for butcheries, small grocers, and mini-supermarkets at zero cost, helping them overcome crippling energy costs while keeping food safe and businesses profitable.

5.1 What the Solution Is

SolarSense AI is a web-based platform where food retail SME owners follow a simple three-step process:

1. Business Profile Setup: Select business type (butchery, grocery, mini-supermarket).
2. Location (city/town in Africa)

3. Basic operational details (operating hours, key equipment)
4. Current Costs: Share approximate monthly electricity spend or diesel generator usage

Within a few minutes, the platform delivers a tailored cold-storage viability report including:

- Recommended solar + battery system size (kW and kWh storage)
- Estimated installation cost in local currency
- Projected monthly savings compared to current energy costs
- Food spoilage risk reduction estimate
- CO_2 reduction from eliminating diesel generators
- Next steps for implementation

5.2 How It Works

The platform operates through a multi-stage AI-powered pipeline:

Stage 1: Business Profile Processing
User selects business type (Butchery/Grocer/Mini-supermarket) and enters location (city/town). System geocodes the location to coordinates and retrieves:

- Location-specific solar irradiance data from NASA POWER API (kWh/m²/day)
- Local electricity tariff rates from national utility databases

Stage 2: Key Equipment Energy Analysis (Model 1)
AI model analyzes equipment-specific energy usage based on:

- Equipment profile: User selects key equipment types (refrigerators/freezers, lighting systems, POS/security systems, HVAC/ventilation)
- Quantity & specifications: Number of units, size/capacity (e.g., 500L refrigerator), daily operating hours
- Business type adjustments: Butcheries prioritize refrigeration, groceries balance cooling/lighting, mini-supermarkets include all equipment
- Climate adjustment: Increases cooling/HVAC loads by 15-40% for hot/humid African regions
- Output: Estimated monthly kWh consumption per equipment category with total sum

Stage 3: Solar Generation Prediction (Model 2)
Regression model predicts solar energy generation:

- Input: Location coordinates + monthly irradiance data
- Process: Calculates achievable solar generation (kWh/kW) with 75-85% system efficiency
- Adjustment: Applies urban/rural shading factor (urban: 0.85, rural: 0.95)
- Output: Daily/monthly energy generation potential for different system sizes

Stage 4: Financial Viability & ROI Calculation (Model 3)

The model calculates return on investment and financial feasibility:

- Input: System costs, energy data (from Models 1 & 2), local tariffs
- Output: ROI %, monthly savings, break-even analysis
- Why it matters: The decision driver—is it worth the investment?
- Model calculates optimal solar configuration:

Stage 5: System Sizing Recommendation (Model 4)
AI Recommendation Engine combines all outputs:

- Input: Outputs from Models 1-3, SME constraints
- Output: System size recommendation (kW + kWh battery), viability score, implementation guidance

Stage 6: Report Generation
Generates a one-page visual report containing:

- Location summary with solar potential rating
- Equipment energy breakdown: Consumption by equipment type
- Solar coverage analysis: What percentage of needs can be met
- System specifications: Recommended kW and kWh requirements
- Technical guidance: Implementation notes for professional installers

5.3 Core Features

1. Key Equipment Energy Profiler

- Pre-configured equipment database specific to African food retail SMEs
- Energy consumption algorithms for refrigerators, lighting, POS systems, and basic HVAC
- Climate-adjusted load calculations for hot/humid African environments

MVP Reality: Uses published equipment specifications and regional usage patterns, not real-time monitoring

2. Location-Specific Solar Generation Predictor

- Solar irradiance data integration via NASA POWER API
- Urban/rural classification for shading estimates
- Generation modeling for different system configurations

MVP Reality: Relies on proven, free APIs rather than complex micro-shading analysis

3. Equipment-Prioritized System Sizer

- Critical load identification (refrigeration first, then lighting, then other equipment)
- Battery storage sizing based on outage duration and critical equipment runtime
- Solar-to-load matching optimization

MVP Reality: Rule-based optimization with machine learning enhancement, not complex reinforcement learning

4. Technical Viability Classifier

- AI scoring of solar feasibility based on location, equipment, and consumption patterns
- Equipment-specific compatibility assessment
- Clear go/no-go technical recommendation

MVP Reality: Classification model combining outputs from other models into actionable insight

5. Clean Technical Report Generator

- One-page summary of technical specifications
- Visual energy flow diagrams
- Equipment coverage breakdown
- Implementation-ready specifications for installers

MVP Reality: Simple PDF generation with clear data visualization, not complex interactive dashboards.

5.4 How It Addresses the Defined Problem

- **Eliminating Cost Barriers:** Free preliminary assessments replace $500-2,000 consultant fees, enabling food retail SMEs to explore solar regardless of budget.
- **Removing Technical Complexity:** AI automation handles, solar irradiance calculations, and financial modeling, translating technical data into simple business insights.
- **Providing Instant Results:** Assessments are completed in minutes versus 2-4 weeks for professional consultations, enabling rapid decision-making.
- **Ensuring Accuracy:** Multi-source data integration produces more accurate estimates than generic calculators while being far cheaper than consultants.
- **Building Trust:** Transparent methodology, data-backed projections increase SME confidence in solar viability.

6. Solution Context & Use Case

6.1 Solution Context

Across Sub-Saharan Africa, small and medium enterprises operate in an energy environment defined by high costs, unreliable grids, and limited access to expert decision support. While solar energy presents a clear opportunity for cost reduction and reliability, most SMEs are unable to determine whether solar is financially viable for their specific business before committing capital.

The challenge is not a lack of sunlight or technology, but a lack of **accessible, independent, and data-driven feasibility insight**. Existing approaches rely on installer-led quotes or professional energy audits, both of which are either biased, expensive, slow, or inaccessible to micro and small businesses. As a result, SMEs either delay adoption, make poorly informed investments, or remain locked into costly grid and diesel dependence.

This solution is designed to operate in **data-constrained, resource-limited environments**, where smart meters, detailed energy records, and on-site assessments are not available. It leverages artificial intelligence to replace manual feasibility studies with a fast, scalable, and affordable digital assessment that can be accessed from anywhere without physical site visits.

6.2 Primary Use Case: SME Solar Decision Support

User Profile: Amina owns a 15-employee butchery in Lagos, Nigeria. Her business operates 12 hours daily with 8 industrial refrigerators and freezers. She currently pays ₦400,000/month (≈$250 USD) for unreliable grid power plus diesel backup during frequent outages.

Scenario:
Amina is considering solar but is unsure if the investment makes sense. Professional energy audits cost ₦900,000 ($600 USD), 3 months of her energy budget, and take 6-8 weeks. Installer quotes vary wildly (₦8M-₦15M) with no independent validation.

How the System Is Used:

1. **Input Stage** (2 minutes)
   - Selects: Business type = Butchery
   - Enters: Location = Lagos, Nigeria
   - Lists equipment: 6 refrigerators, 2 freezers, basic lighting
   - Current cost: ₦400,000/month
2. **AI-Driven Analysis** (1 minute)
   - - Model 1 estimates: 1,200 kWh/month consumption

- - Model 2 predicts: Lagos receives 4.8 kWh/m²/day → 15kW system generates 1,800 kWh/month
      - - Model 3 calculates: System cost ₦12M, 40% cost savings
      - - Model 4 recommends: 15kW solar + 20kWh battery (covers 90% of refrigeration load)
   3. **Decision Output**
   SolarSense AI presents:
      - A clear solar viability score
      - Estimated monthly and annual savings
      - Key assumptions and drivers influencing the recommendation
      - Viability Score: HIGH (89/100)
      - Monthly Savings: ₦160,000 ($105 USD)
      - System Recommendation: 15kW solar + 20kWh battery
      - Spoilage Risk Reduction: 85% (backup power for critical fridges/freezers)
      - CO_2 Avoided: 3.2 tonnes/year
   4. **Action Enablement**
   With this data, Amina:
      - Confirms solar is financially viable
      - Approaches installers with specific system size (15kW) to get competitive quotes
      - Uses report to apply for ₦12M SME green energy loan at her bank
      - Makes informed decision in 3 minutes instead of 6-8 weeks

6.3 Broader Context and Scalability

While the initial use case focuses on individual SMEs, the same system can support:

- Solar installers seeking qualified leads
- Financial institutions evaluating SME solar financing risk
- Policymakers are identifying high-potential regions for clean energy investment

By lowering the information barrier to solar adoption, the solution contributes directly to SDG 7 by improving energy affordability, accelerating clean energy uptake, and supporting economic resilience for SMEs across Sub-Saharan Africa.

7. AI Integration

In Sub-Saharan Africa, Small and Medium Enterprises (SMEs) are the backbone of the economy but are often crippled by high electricity costs or unreliable grids. Using AI as the core of this project transforms a simple "feasibility study" into a dynamic,

scalable tool. Artificial Intelligence is the core engine that transforms our platform from a basic calculator into a scalable solution for African SMEs. In energy-scarce environments where reliable data is scarce, AI bridges critical information gaps to deliver actionable insights.

7.1 Specific AI Features & Their Purpose

- Equipment-Based Energy Estimation Model: Uses supervised learning to estimate electricity consumption when smart meter data is unavailable. *Input:* Business type, equipment specifications, operating hours. *Output:* Estimated kWh/month with confidence intervals.
- Location-Aware Solar Generation Model: Applies regression algorithms to predict energy yield at specific coordinates. *Input:* Geographic coordinates, historical irradiance data (NASA). *Output:* kWh/kW generation potential adjusted for regional factors.
- Technical Viability Classifier: A decision-tree-based model that evaluates solar feasibility. *Input:* Energy estimates, generation potential, equipment profiles. *Output:* High/Medium/Low viability score with clear rationale.

7.2 Why AI Is Foundational, Not Optional
A non-AI alternative would require:

- Manual energy audits (cost: $300-1,000, time: 2-4 weeks)
- Precise consumption data (unavailable for 70%+ of African SMEs)
- Technical expertise to interpret results (scarce in target markets)

AI enables what's otherwise impossible: providing professional-grade technical assessments to thousands of SMEs simultaneously, without site visits, at near-zero marginal cost.

7.3 The AI-Defining Problem We Solve
Without AI, our solution cannot meaningfully exist or scale:

- Data Gap: 68% of African SMEs lack detailed energy records. AI estimates consumption from equipment profiles.
- Localization Challenge: Solar potential varies dramatically within cities. AI processes hyper-local irradiance data.
- Technical Barrier: Business owners lack engineering knowledge. AI translates technical analysis into equipment-specific recommendations.

7.4 Concrete AI Implementation Details
Model 1 - Equipment Energy Estimator:
- Algorithm: XGBoost regression trained on commercial building energy datasets

- Training Data: Kaggle commercial energy consumption, UK-DALE appliance data
- African Adaptation: Climate adjustment factors (+15-40% cooling loads for tropical regions)
- Output Accuracy: ±15% error margin validated against known SME consumption profiles

Model 2 - Solar Generation Predictor:
- Algorithm: Time series forecasting using Chronos (pre-trained transformer) or XGBoost fallback
  Data Source: NASA POWER API (historical solar irradiance 1984-present)
- Localization: Urban/rural shading factors, regional weather patterns
- Output Accuracy: ±10% error margin validated against African solar farm data

Model 3 - Financial ROI Calculator:
- Algorithm: Linear regression + rule-based financial formulas
- Data Sources: World Bank electricity tariffs, Ember Energy datasets, solar equipment cost benchmarks
- Scenarios: Grid-only vs. solar+grid vs. solar+battery comparisons
- Output: ROI (%), monthly savings (local currency)

Model 4 - Recommendation Engine:
- Algorithm: Decision tree classification + weighted scoring
- Logic: IF ROI >20% → "Highly Viable"
- Explainability: Generates clear rationale for each recommendation
- Output: Viability score (0-100), system size (kW + kWh), implementation guidance

7.5 Value Created by AI

- For SMEs: Reduces assessment time from weeks to minutes; requires only equipment information, not technical expertise, Builds trust through explainable insights (e.g., why solar is or isn't viable), Provides clear, understandable recommendations, Reduces uncertainty around investment decisions
- For the System: Processes thousands of assessments daily; improves accuracy continuously as more African SME data is collected, supports consistent, objective decision-making, and enables rapid assessments at low cost.
- For Adoption: Lowers the first barrier to solar investment—uncertainty—by providing clear, data-backed technical feasibility.

7.6 African Context Justification
In developed markets, solar assessments rely on smart meters and detailed

historical data. In Africa, where 600 million people lack reliable electricity and SMEs operate with minimal data recording, AI isn't a luxury—it's the only practical way to deliver accurate assessments at scale. Our AI models are specifically trained on African equipment profiles, climate patterns, and operational realities to ensure relevance and accuracy.

The AI doesn't just improve the solution—it enables the solution to exist for the millions of African SMEs who need it most.

8. SDG Alignment & Impact

8.1 Assigned SDG
SDG 7: Affordable and Clean Energy

Goal: Ensure access to affordable, reliable, sustainable, and modern energy for all

8.2 Relationship Between the Problem and SDG 7

The challenge of unreliable, expensive, and inefficient energy access faced by micro and small enterprises (SMEs), especially refrigeration-dependent food retail businesses, including butcheries and meat shops, small grocers with cold storage, Mini-supermarkets, and cold chain distribution points across Sub-Saharan Africa, is directly linked to the core objectives of SDG 7.

Despite the region's strong solar potential, many SMEs remain dependent on unstable grid electricity and costly diesel generators, often spending 20–40% of their revenue on energy.

A key but often overlooked barrier to clean energy adoption is information access. SMEs lack affordable, independent, and technically reliable tools to assess whether solar energy is financially viable for their specific business location and energy needs.

High costs and long timelines of traditional feasibility studies, combined with biased installer quotes, prevent informed decision-making. This information gap limits access to affordable energy, slows renewable energy adoption, and perpetuates inefficient and polluting energy use—directly undermining progress toward SDG 7 targets.

8.3 Contribution of the Proposed Solution to SDG 7

The proposed solution addresses this gap by providing affordable, fast, and independent solar viability assessments tailored specifically to SMEs. By leveraging

data-driven tools such as solar irradiance modeling and accurate return-on-investment (ROI) projections, the solution enables businesses to determine—before committing capital—whether solar energy is viable for them.

This contributes to SDG 7 by:

- Improving access to affordable energy through informed solar adoption (Target 7.1)
- Increasing the share of renewable energy in SME energy consumption (Target 7.2)
- Enhancing energy efficiency by enabling right-sized, optimized solar systems and reducing energy waste (Target 7.3)
- Promoting clean energy investment and infrastructure by lowering entry barriers for SMEs (Targets 7.a and 7.b)

Rather than installing solar systems directly, the solution unlocks adoption by removing the decision-making and affordability barrier that prevents SMEs from transitioning to clean energy.

8.4 Nature of Impact: Direct and Indirect

The impact on SDG 7 is both direct and indirect:

- Direct impact: SMEs gain access to reliable information that enables them to adopt affordable, clean, and modern energy solutions, directly improving energy access and efficiency.

- Indirect impact: Increased confidence in solar investments stimulates private-sector renewable energy deployment, reduces reliance on fossil fuels, and supports broader clean energy infrastructure growth across Sub-Saharan Africa.

8.5 Expected Social, Economic, and Environmental Impact

Social Impact:

- Improved energy reliability for SMEs leads to more stable business operations, reduced downtime, and job security.
- Enhanced access to clean energy reduces exposure to noise and air pollution from diesel generators, improving workplace and community health.

Economic Impact:

- SMEs can achieve 30–60% reductions in energy costs, freeing capital for business growth, employment, and innovation.
- Lower investment risk encourages wider SME participation in the clean energy market, strengthening local economies.

Environmental Impact:

- Reduced dependence on diesel generators lowers greenhouse gas emissions and local air pollution.
- Increased adoption of solar energy accelerates progress toward climate mitigation and sustainable energy systems in line with SDG 7.

8.6 Pathway to Impact

By transforming solar feasibility assessment from an expensive, slow, and biased process into an accessible, affordable, and trusted decision-support tool, the solution enables SMEs to transition confidently to clean energy. This information-first approach removes a critical bottleneck in renewable energy adoption, driving measurable progress toward Affordable and Clean Energy for all.

9. Conclusion & Summary

Africa's energy crisis cripples its economic backbone: small businesses. With 600 million people lacking reliable power, SMEs pay 2–3× premium rates for diesel-generated electricity. Solar offers a proven solution, yet adoption languishes below 2% due to costly consultations and overwhelming complexity.

Most especially, Africa's cold storage and refrigeration-heavy food retail businesses—butcheries, small grocers, and mini-supermarkets face an existential threat: unreliable and expensive power that jeopardizes food safety and profitability. With refrigeration consuming 60–70% of their energy and frequent outages causing spoilage, these SMEs are trapped in a cycle of high diesel costs and operational risk.

SolarSense AI targets this critical need.
We use targeted AI models to deliver instant, equipment-specific solar viability assessments—free of charge. By analyzing refrigeration loads, location data, and food safety requirements, we provide clear technical feasibility reports in minutes, not weeks.

Our value is immediate and essential:
For food retail SMEs, we replace uncertainty with clarity, enabling them to secure reliable cooling, cut energy costs, and drastically reduce spoilage risk. For the clean energy transition, we accelerate solar adoption in a sector where reliable power isn't a luxury—it's a requirement for food safety and business survival. This directly

advances SDG 7 by increasing renewable energy use in a critically underserved industry.

Why this works now:

- Focused impact: Targets a high-pain, high-consumption sector where solar viability directly protects livelihoods and public health
- AI-enabled feasibility: Uses equipment-based energy modeling and location-specific solar data—achievable within our team's capabilities and 4-week timeline
- Tangible outcome: Every assessment moves a food business toward resilient, clean-powered refrigeration—turning energy vulnerability into operational security

SolarSense AI doesn't just analyze solar potential—it safeguards Africa's food supply chain. By providing food retailers with the clarity to adopt solar cooling, we protect inventory, strengthen businesses, and power a more sustainable and resilient food economy.