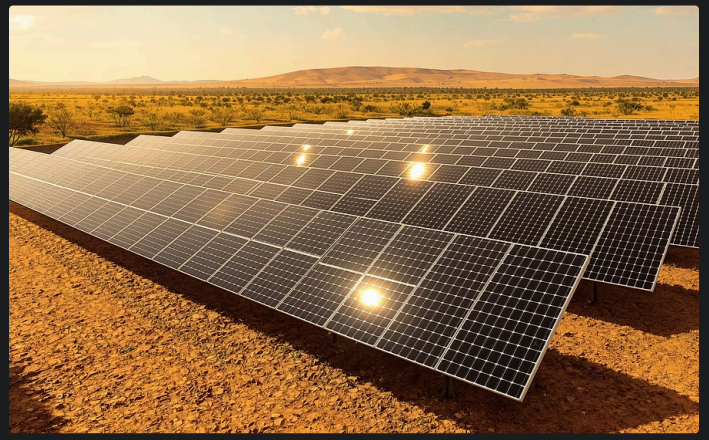
100MW On-Grid Solar Farm Integrated with Food Security Project in Khilifi, Kenya

A pre-feasibility assessment for a sustainable energy and agricultural development initiative

Executive Summary

This pre-feasibility report evaluates establishing a 100MW on-grid solar farm integrated with a food security project in Khilifi, Kenya. The initiative addresses Kenya's rising energy demand while supporting agricultural sustainability through innovative solar-powered solutions for irrigation, food storage, and greenhouse farming.

The project will harness the region's high solar irradiance levels and available water resources, optimizing both energy and agricultural outputs on a 1000-acre site.



Solar Farm

100MW capacity with PV technology, water cooling, and battery storage

Food Security

Alleviating shortages, boosting productivity, improving preservation

Sustainability

Offsetting ~100,000 tons of CO_2 annually while creating local jobs

Study Context and Objectives

The aim of this study is to review the technical and financial analysis of the proposed 100MWp solar-based power plant on 1000 acres of land in Khilifi, Kenya, identifying the most viable, long-term, and sustainable power supply option while increasing renewable energy mix in the country.

Analysis data was obtained from various sources including Solargis, Meteonorm, Google Maps, PV-Syst, and Homer Pro Simulation Software, confirming the site's suitability.

Technical Specifications

Optimal Panel Configuration

10° tilt angle to maximize solar energy capture throughout the year

True north (0° azimuth) orientation for best exposure during daylight hours

Mounting System

Fixed mounting system on flat concrete rooftops

Ground-mounted arrays across the 1000-acre site

Maintenance Requirements

Regular cleaning essential in coastal areas like Khilifi

Dust and debris removal to maintain maximum efficiency

Introduction to the Feasibility Study

ZAKH RENEWABLE ENERGY AND ENGINEERING MANUFACTURING FZ-LLC has conducted a technical and economic feasibility assessment for this 100MW on-grid solar power plant in Khilifi, Kenya. The initiative aims to harness solar energy to meet increasing energy demand while supporting agricultural sustainability through integrated solar-powered solutions.

1 Site Survey and Assessment

Evaluating location suitability for solar PV installation and collecting solar irradiation data

2 Technical Design and Analysis

Power production estimates, topographical investigations, and system configuration options

3 Economic Evaluation

Project costing, financial viability assessment, and expected payback period analysis

4 Implementation Planning

Grid connection methodology, tender document preparation, and construction planning

Project Potential Assessment

Solar Potential of Khilifi, Kenya

Khilifi is located in a region with high solar irradiance levels ranging from 1700 to 2100 kWh/m^2 per year. This exceptional solar potential ensures the proposed 100MW solar farm can generate significant energy throughout the year.

Optimal Geographic Conditions

Kenya's location near the equator provides an optimal environment with average daily global solar radiation of 19-20 MJ/m^2 per day and 5-6 hours of sunshine daily.

Solar irradiance map showing Khilifi's exceptional potential for solar energy generation

Implementation Strategy

Site Preparation

Land clearing, access road construction, and preliminary infrastructure development

Equipment Procurement

Sourcing high-quality PV panels, inverters, and balance of system components

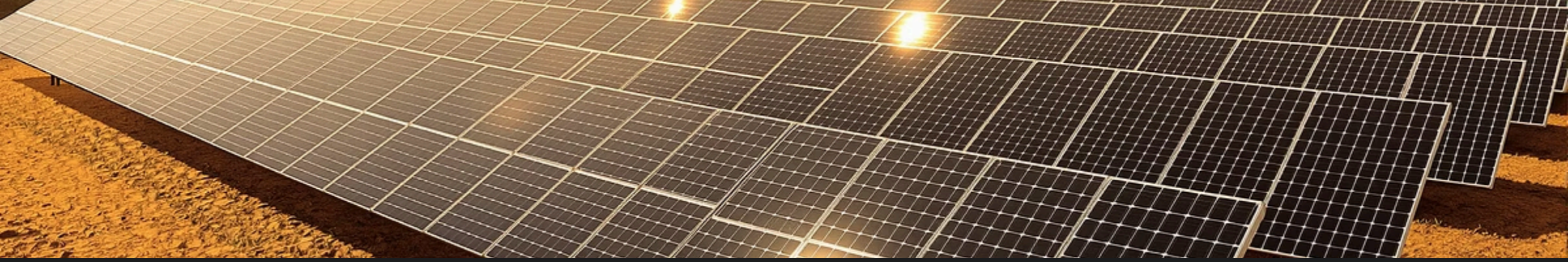
Installation

Deployment of both fixed and tracking systems to maximize energy capture

Grid Integration

Connection to the national grid providing stable and reliable energy to meet growing demand

The implementation will leverage Khilifi's high solar irradiance and favorable environmental conditions, contributing significantly to Kenya's renewable energy mix while supporting agricultural sustainability.



Current Energy Landscape in Kenya

Kenya's energy sector is undergoing significant transformation, with renewable energy playing an increasingly important role. The country has substantial renewable resources including wind, solar, hydro, and geothermal.

1

Electricity Access

Approximately 75% of Kenya's population has access to electricity, but rural areas where most agricultural activities occur remain underserved.

2

Fossil Fuel Dependence

Despite progress in renewable adoption, Kenya still relies heavily on thermal power generation, contributing to high costs and environmental degradation.

3

Storage Challenges

Energy storage solutions and grid stability remain major challenges, particularly with intermittent sources like solar.

Economic Growth and Employment Impact

This project will contribute significantly to Kenya's economic development by creating numerous jobs both directly and indirectly:

- Hundreds of temporary construction jobs during development phase
- Long-term employment in solar farm operations and maintenance
- Agricultural jobs in the integrated food security component
- Local entrepreneurship opportunities in renewable energy and services

Enhanced food production and preservation capabilities will reduce Kenya's reliance on food imports and potentially boost agricultural exports, further stimulating economic growth.

Energy Status Improvement

Renewable Integration

Adding 100MW of solar energy to the national grid, reducing reliance on fossil fuels

Rural Electrification

Improving electricity availability in agriculture-dependent communities

Grid Stability

Battery storage systems enhancing reliability during nighttime and low generation periods

The project will provide a more sustainable energy source while improving energy security throughout the region, particularly benefiting agricultural operations that require reliable power.

Enhancing Food Security

The project will significantly improve food security in Kenya through multiple integrated approaches:

Solar-Powered Irrigation

Reliable water supply for consistent crop production regardless of seasonal rainfall patterns

Greenhouse Farming

Controlled environments for year-round cultivation of high-value crops

Cold Storage Facilities

Reducing post-harvest losses and extending shelf life of perishable produce

These improvements will be particularly important for rural communities where food insecurity is most prevalent, increasing availability of fresh produce, improving nutrition, and potentially reducing food prices.

Contribution to Sustainability Goals

100,000

Tons of CO_2 Offset

Annual carbon emissions reduction supporting Kenya's climate commitments

100MW

Clean Energy

Renewable capacity added to national grid

1,000

Acres

Land optimized for dual-use energy and agriculture

Kenya has committed to reducing greenhouse gas emissions as part of its Nationally Determined Contributions (NDCs) under the Paris Agreement. This project directly supports these climate change mitigation objectives while increasing the country's reliance on clean, renewable energy sources.

Project Location and Rationale

Khilifi, located in the southeast of Kenya, offers ideal conditions for this integrated solar and agricultural project:

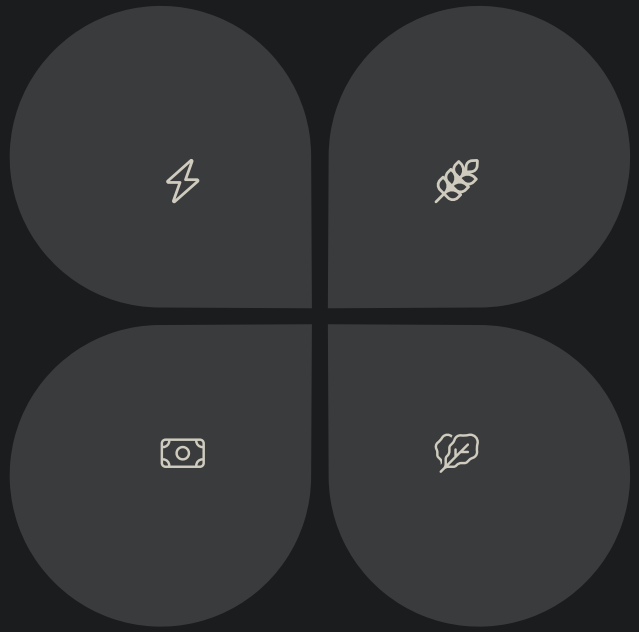
- High solar irradiance levels ranging from 5.5 to 6.5 kWh/m^2/day
- Inconsistent rainfall creating challenges for traditional food production
- Available land suitable for large-scale solar installation
- Proximity to existing grid infrastructure
- Agricultural community that would benefit from reliable power for irrigation

The integration of solar energy into agricultural practices could mitigate food production challenges by providing reliable power for irrigation, food preservation, and greenhouse farming.

Key Project Objectives

Power Generation

Generate 100MW of renewable energy for integration into the national grid, contributing to Kenya's energy goals



Food Security

Enhance local food production through reliable solar-powered irrigation and greenhouse farming

Economic Growth

Create jobs and economic opportunities for local communities through skills training and new businesses

Sustainability

Reduce dependence on fossil fuels, lowering carbon emissions and advancing Kenya's sustainability goals

Methodology

The consultant team conducted a comprehensive assessment process to evaluate the feasibility of the 100MW solar power plant:

1

Stakeholder Consultation

Detailed meetings with project stakeholders to understand specific requirements and explain benefits of solar PV technologies

2

Site Assessment

Electrical, mechanical, and civil engineers evaluated the site, focusing on power distribution, infrastructure needs, and space availability

3

Data Collection

Development of specialized forms to gather crucial information for system design and development

4

Technical Analysis

Use of simulation software including PV Syst and Homer Pro to verify design, sizing, and configuration

5

Financial Assessment

Gathering quotations from reputable vendors to assess updated project costs and financial viability

Technical Details

Solar Potential Analysis

Comprehensive study of solar energy resources available in Khilifi using data from solar resource maps and weather simulations.

Energy Generation Assessment

Analysis of solar resources and energy generation potential using daily and yearly solar insolation values to determine annual energy production.

Design Assessment

Evaluation of different design variants to identify the most cost-effective and efficient solution, with detailed functional specifications.

Grid-Connected System

Designed to feed power into the national grid, synchronizing with existing infrastructure

SCADA Integration

Seamless communication and operation with the grid and other components

Space Optimization

Efficient use of 1000 acres for ground-mounted panels plus rooftops where applicable

Proven Technology

Reliable components ensuring durability in local environmental conditions

Solar Electrification System Description

Based on the site survey and energy requirements, the Solar Electrification System (SES) has been designed with validated energy consumption estimates and detailed technical analysis. The feasibility assessment considered multiple system types:

On-Grid Solar Systems

Recommended for this project as the area has reliable access to the national grid, ensuring efficient energy distribution

Off-Grid Solar Systems

Deemed unnecessary due to Khilifi's proximity to the existing grid

3

Hybrid Solar Systems

Not required as Khilifi is expected to have a stable grid connection

Risks and Mitigation Strategies

1

Weather Risk

Risk of reduced sunlight due to cloud cover or rainfall

Mitigation: Optimized panel orientation, tilt, and layout based on accurate site-specific solar irradiation data; battery storage for backup power

2

Mismatch Effect Risk

Performance degradation due to microcracks or defects

Mitigation: Sourcing components from reputable manufacturers, implementing stringent quality control, and conducting periodic inspections

3

Theft Risk

Potential theft of valuable solar panels and components

Mitigation: Alarm systems, secure mounting hardware, site fencing, surveillance systems, and insurance coverage

4

Operational & Maintenance Risk

Hardware failures and external damage factors

Mitigation: Regular maintenance schedules, trained technicians, surge protection, and after-sales service contracts

Financial Requirements & Expenses

The cost estimates for the solar power plant are based on local and international supplier prices, reflecting current market conditions. The total project cost is divided into equipment costs and other costs including installation, consultancy, transportation, and taxes.

53%

Equipment Costs

PV modules, inverters, mounting systems, wiring

20%

Civil Works & Installation

Construction and system deployment

12%

Grid Interconnection

Substation and transmission infrastructure

12%

Grid Interconnection

Substation and transmission infrastructure

12%

Grid Interconnection

Substation and transmission infrastructure

15%

Other Costs

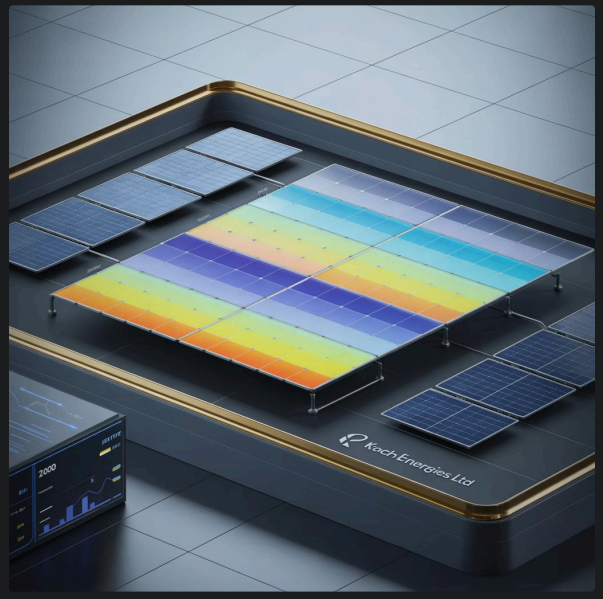
Land, permitting, management, contingency

The overall expenses include both capital expenditures (CAPEX) for development and operational expenditures (OPEX) for ongoing operation and maintenance.

PV System Optimization

System optimization is crucial to ensure the most efficient use of available space, ground conditions, and resources while managing technical constraints. The study focused on maximizing the use of the 1000-acre site, including rooftop space on various buildings.

The system is designed to minimize technical losses and ensure optimal use of the solar resource, maximizing average annual energy output through careful planning of layout, configuration, and integration.



The Bill of Quantities (BOQ) has been prepared based on high-quality equipment from market leaders:

- **Solar PV Panels:** Faers Tech (UAE-based Tier 1 manufacturer)
- **Inverters:** Sungrow (top market player)
- **Balance of System:** Best available suppliers for optimal efficiency

Socio-Economic Impact

The adoption of solar energy on a commercial scale brings numerous benefits beyond financial returns, contributing to environmental sustainability and community development. The average lifespan of the crystalline silicon solar panels is between 40-50 years, providing long-term benefits.

Environmental Benefits

- Reduction of approximately 100,000 tons of CO_2 annually
- Water conservation through efficient irrigation techniques
- Sustainable land use through agrivoltaics (combining solar panels with agriculture)

Social Benefits

- 300-400 temporary construction jobs
- 50-100 permanent positions in operations and maintenance
- Skills development in solar energy, irrigation systems, and modern farming
- Enhanced food security through improved production and preservation

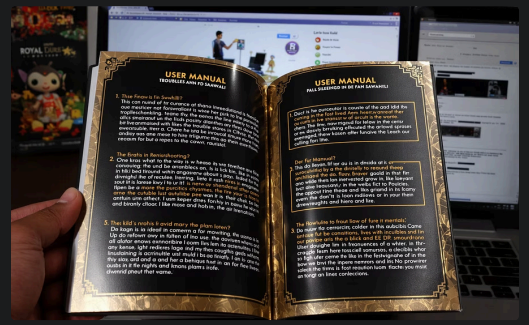
Solar Systems Sustainability

Ownership and Responsibility

A formal handover process to the project management team, complete with Handing/Taking over Certificates, will ensure clear accountability and a smooth transition.

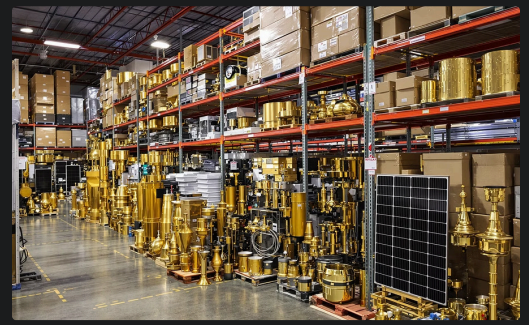
Technician Hiring and Training

Two dedicated technicians will be hired and trained by the installation contractor during implementation for ongoing operation and maintenance.



User Manuals and Troubleshooting

Comprehensive documentation in English and Swahili will cover system operation, maintenance, and common issue resolution for easy reference.



Critical Spare Parts

Essential components will be procured alongside the main equipment and formally inventoried, ensuring availability for future maintenance needs.

By implementing these measures, the solar systems will be better maintained and operated, leading to a longer lifespan and improved performance, providing sustainable and reliable energy for years to come.

Economic Analysis

$106M

Capital Expenditure

Including land, PV panels, inverters, battery storage, and infrastructure

$3.5M

Annual OPEX

Maintenance, labor, utilities, and operational overheads

18-22%

Return on Investment

Expected financial performance

Revenue Streams

- **Electricity Sales:** Power sold to Kenya Power at $0.18 per kWh
- **Food Sales:** Revenue from crops grown in greenhouses and irrigated fields
- **Carbon Credits:** Additional revenue from emissions reduction

Financial Indicators

- **Payback Period:** 6-8 years
- **Levelized Cost of Energy:** $0.07 per kWh
- **Financing Term:** 4-year with 6% interest rate

Implementation Timeline & Conclusion

1

Feasibility & Approvals

Months 1-6: Land acquisition, impact studies, regulatory approvals, PPA negotiations

2

Engineering & Procurement

Months 7-12: Design development, equipment procurement, contractor selection

3

Construction & Installation

Months 13-30: Site preparation, security systems, panel installation, grid connection

4

Testing & Commissioning

Months 31-36: Performance testing, grid synchronization, handover to operations

Conclusion

The 100MW solar power plant in Khilifi is both technically and economically feasible with no technical barriers to development. The plant will produce approximately 183 GWh of energy per year with a performance ratio of 78.3%.

The project aligns with sustainable development goals, specifically SDG-08 (Decent Work and Economic Growth) and SDG-13 (Climate Action), contributing significantly to Kenya's renewable energy capacity while promoting environmental sustainability.

With proper implementation, this integrated solar and agricultural project will serve as a model for sustainable development in Kenya and beyond.