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Infrastructure Development and Economic Assessment of a Smart Mini-grid Photo-Voltaic Power System for a Strategic Information and Communication Technology Park in Lagos State, Nigeria

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Abstract

This study assessed the technical and design specifications of a proposed smart mini-grid photovoltaic (PV) system for the strategic Katangua Information & Communication Technology (ICT) Park in Lagos State. It also analyzed the system's techno-economic and environmental viability compared to a diesel generator alternative using an energy technology foresight framework. The smart PV system was designed to support a 4.911 MW power load, featuring a peak PV module size of 15.35 MW, 34,111 PV panel modules, a 10,000 W/48V inverter, and a 10 kWh/48V lithium battery. In contrast, a 250 kVA diesel generator consumed 540 liters daily and emitted 1.5 tonnes of CO2. Life cycle cost analysis revealed that the PV system had a significantly lower cost (N 91.17/kWh) than the diesel generator (N 365.51/kWh), and would eliminate the production of 217,080 tonnes of CO2 over 20 years. The study concluded that the smart PV system is a viable solution with clear technological, economic, and environmental advantages, recommending its implementation for the proposed ICT Hub.

Keywords: Infrastructure; Techno-economic analysis; Smart mini-grid; Photovoltaic; Power system

INTRODUCTION

The nature and extent of energy demand and utilization in a national or regional economy is, to a large extent, indicative of its level of economic development (Akinwale *et al*., 2014; Ogundari, 2023). In Lagos State, socio-economic development, both for the present and the future, is dependent on the availability of energy. Electricity is recognized as a significant energy source, and its availability has been acknowledged as critical to the development of the Lagos State economy (Atanda *et al*., 2017). Lagos State regrettably has been in an energy crisis for many years, with national grid power supply being about 1,000 MW, power deficit being in the range of 9,000 – 10,000 MW, and prevalent crisis of low installed capacity utilization (Somoye, 2023). As shown by the strategic influences of Silicon Valley in the US, the development of a vibrant technology and innovation hub is vital to the techno-economic advancement of a regional and national economy. The region's plethora of high-tech companies, innovation and productivity significantly adds almost 10.5% of US GDP as at 2022 (this is a staggering US$ 2.55 trillion) (Ahmadirad, 2024). The Computer Village in Ikeja, Lagos State is a vibrant technology market in Nigeria and one of the largest in Africa. It is estimated to generate annual revenues in the range of US$ 1.3 – 2.6 billion (0.95 – 1.9% of Lagos State GDP of US$ 136.6 billion and 0.27 – 0.55 % of Nigeria's GDP of US$ 477 billion in 2023). The operation of this ICT business hub is greatly dependent on the availability of electricity; thus, the provision of adequate electric power supply is imperative for its effective functioning (Adebanji *et al*., 2017)

The Lagos State Government's development initiative to increase the ICT sector's contribution to domestic GDP has necessitated the relocation of the extant Computer Village in Ikeja to a new location – the Katangua Market area of Abule Egba, along the Lagos-Abeokuta Expressway. The relocation rationale being the provision of greater space and more robust infrastructure for the ever-increasing ICT business hub, and greater access from other areas of the State. Ideally, an ICT business hub initiative should have uninterrupted power supply to enable robust business operations; however, the reality in the Ikeja Computer Village is a fragile electricity infrastructure, with grid electric power supply of only 4 hours out of a 10-hour workday, and extended periods of time (average of 10 days each month) where no grid power is even supplied (Babatunde *et al*., 2020). Consequently, operators are compelled to resort to private electric power provision via petrol/diesel generators. Nigerian law, up till 2023, made electric power provision the exclusive preserve of the Federal Government, advertently hindering interventions by the sub-national governments (the Lagos State and/or Local Government Councils) and private sector actors on the erratic grid power supply. The existing Ikeja Computer Village, over time, has suffered the inadequacies of electric power supply to Lagos State; records show poor and erratic power supply to the market, and operator dependence on electric power self-generation. The consequent disconcerting environmental and economic implications of this electricity self-generation include pollution via noise (cacophony of multiple generators working), air (carbon-dioxide emissions), and land (oil and fuel spills), the high costs of generator purchase/maintenance and fuel procurement, and the substantial energy intensity (energy cost per dollar of domestic revenue) (Heinemann *et al*., 2022). Regrettably, inaction on sustainable electric power supply to the strategic ICT Park would, most likely, not only accentuate the observed limitations (energy crisis, energy security, environmental safety and cost concerns) but also stifle industrial/innovation capacities in the novel ICT hub, as well as limit socio-economic benefits accruable to Lagos State and Nigeria.

The enactment of the Electricity Act 2023 has decentralized the electric power supply in Nigeria, granting devolved public and private sector actors the legal authority to participate effectively in the electricity market (Adeyemi, 2024). This law strengthens the capabilities of the Lagos State and/or Local Government authorities and any other private sector player to intervene in electricity provision for the State in general and specific strategic technology-based economic stimulus initiatives like the novel ICT hub/cluster market in the Katangua market area.

The ideal situation would be for the novel Katangua ICT hub/cluster market (the hopeful 'Silicon Valley' of Nigeria) to have a reliable, affordable, and clean power supply for its industrial activities and wealth creation potential. A plausible electric Power initiative for this strategic ICT business initiative is the smart photo-voltaic mini-grid system. The success of the sustainable deployment of this strategic energy infrastructure is dependent on robust techno-economic analyses which are vital to infrastructure planning and implementation (Heidari *et al*., 2024). Inopportunely, the requisite techno-economic analyses are not readily available in the literature, probably due to domestic limited capabilities to develop and deploy innovative distributed power technologies in Lagos State (Abonyi, 2019). Consequently, this study provides a viable assessment for the development of a smart photovoltaic mini-grid system for the Katangua ICT hub. This techno-economic analysis entailed determining the technical/design specifications for the smart photo-voltaic mini-grid system of the ICT market premised on obtained data on the extant power demand of the Ikeja ICT market, and analyzing the techno-economic and environmental viability of the designed PV power system relative to the alternate diesel generator system. The analysis constitutes policy insight on the technological, environmental, and economic specifications and implications of the development of a smart photovoltaic power system for the Katangua ICT Business Park initiative in Lagos State which is strategic for regional power sector investment and power infrastructure planning for other cluster markets in Lagos State and Nigeria in general.

METHODOLOGY

The study employed an energy technology foresight analysis framework. This was used in this study for a robust project investment analysis. The framework is a structured, collaborative process that leverages collective intelligence to facilitate evidence-based decision-making for envisioning a preferred energy future for a region (Lee, 2015; Gibson *et al*., 2018). Methods may be quantitative (extrapolation, modelling-simulation, benchmarking, etc.), semi-quantitative (Delphi technique, strategic assessment, gaming-simulation, etc.), and qualitative (expert panels, SWOT scanning, back-casting, genius-forecasting, etc.) (Lee, 2015; Gibson *et al*., 2018). These methods can be utilized either individually or collectively.

The Study Location

The novel ICT hub/cluster market is proposed for the Katangua market area of Abule-Egba, Lagos State, along the Lagos-Abeokuta Expressway. This location was selected consequent to constraints identified in the erstwhile Computer Village at Ikeja. Factors influencing the Katangua area selection include space availability for expansion, transportation accessibility, and robust infrastructure development. The Katangua market area is situated at coordinates 6.64° N 3.30° E, in the Abule-Egba neighbourhood, Alimosho Local Government Area of Lagos State (Akinpelu *et al*., 2017). The location is easily accessible to other parts of Lagos State due to the several major roads passing through it, including the Lagos-Abeokuta Expressway.

Determining the Technical/Design Specifications for the Proposed Smart PV System

Calculating the technical/design specifications for the proposed smart mini-grid PV system entailed obtaining power supply data to the extant Ikeja ICT market from the Ikeja Electricity Distribution Company (Ikeja DISCO). Subsequently, elicited information from secondary sources such as equipment vendors, manufacturers' manuals, and energy/engineering journal articles on other technical/design specifications for the smart PV power system including the PV module sizes for determining the total number of PV panels required, the battery block sizes (measured in V/Ah) and their days of autonomy, the estimated peak sun hours in Lagos State, the inverter types and sizes available as well as the number of solar charge controllers required (measured in kW). Furthermore, the type, specifications, and comparative costs of an equivalent diesel-powered generator were obtained from equipment vendors, and environmental specifications such as diesel consumption elimination (measured in litres) and carbon dioxide emissions elimination (measured in kg) were ascertained.

The power consumption in the extant Ikeja Computer Village was estimated at 4.912 MW (Ajayi, 2022) premised on data from the Ikeja DISCO and an audit report on capacities of functional generators in the Computer Village. This estimated power consumption was assumed as the initial benchmark for Phase I of the proposed novel Katangua ICT Park.

Determination of Daily Electricity Demand for the Proposed ICT Park

Daily electricity demand for the ICT Park = Estimated power required (W) X Time (h) ____ 1

The total daily electricity demand needed from the PV modules:

Total daily electricity demand = daily electricity demand X system energy loss factor _________ 2

Where, Solar panel efficiency is assumed at 80% (i.e. system energy loss factor is 1.25)

Determining the Size for the PV Module

Electric power delivery is dependent on size of PV modules. For appropriate PV module sizing, the total peak Watt (Wp) produced is required. This Wp is dependent on climate of site location, and the 'power generation factor' or daily sun hours. The power generation factor in Nigeria or daily sun hours is 3.4 to 5 hrs. In Lagos, Nigeria, 4 hours of daily sunlight are used. Thus, PV module sizing would entail:

$$Wpeak = \frac{Total\ Wh/day}{4} \qquad 3$$

Determining the Number of PV Panels for the System

Number of PV panels =

$$\frac{Wpeak}{rated\ output\ Wpeak\ of\ the\ PV\ modules\ available} \qquad 4$$

Determining the Size for the Inverter

For safety, the inverter minimum size should be at least double the size of the total appliances wattage

Number of inverters required

$$= \frac{\text{Total Inverter Capacity (kVA)}}{Capacity\ of\ Unit\ Inverter(kVA)} \qquad 5$$

Determining the Size for the Battery (Deep Cycle)

The battery should be large enough to be store sufficient energy to operate the appliances at night and cloudy days. To find out the size of the battery, calculate as follows:

i. Calculated energy use during cloudy days (total load X Number of hours of use)
ii. Divide (ii) by efficiency of battery which is assumed to be 85%. ie divide by 0.85 for battery loss.
iii. Divide (iii) by 0.9 for depth of discharge (Lithium batteries being used)

Battery capacity

$$= \frac{Total\ Wh\ per\ day\ used\ by\ the\ appliances}{0.85\ x\ 0.9} \qquad 6$$

Determining the Size for the Solar Charge Regulator

The functions of the charge regulator are to stabilize the PV generator output going to the inverter and shield the battery against overcharge and deep discharge. The charge regulator rating is determined by the PV array output and its nominal voltage. Ideally, the charge regulator's rated power should be equal to the PV modules peak power, however it is prudent to make it 10% larger.

Size of Charge Regulator

= [Wp + (Wp × 0.1)] OR 1.1Wp _______________ 7

Smart Electric Metering

Recommended meter is the Echelon MTR 3000 series poly phase meter, to monitor activities of the meters without physically visiting the site, control the time the meter delivers output remotely and restrict supply when power usage exceeds the allocated power rating.

Land Requirement for the Smart PV System

A 1 MW power station requires 5 acres for construction (IEA, 2015)

The PV power plant to support the total power requirement is estimated to have a power factor of 0.8.

Thus, the PV power plant set rating (MW)

$$= \frac{Power\ Load}{0.8} \qquad 8$$

Determining the Technical/Design Specifications for the Alternate Diesel Generator System

In Nigeria, the diesel generator is widely used by households and businesses for power generation consequent to the erratic grid power supply

(Ogundari *et al*., 2017; Salu, 2021). The diesel-power generator system size required for the estimated power load is determined.
Diesel generators are rated in Watts with a power factor of 0.8

The diesel generator set rating (kVA)

$$= \frac{Power\ Load\ Demand}{0.8} \qquad 9$$

Ascertaining the Techno-economic and Environmental Viability of the Proposed Smart PV System

Information on engineering economic specifications of the smart PV power system and the alternate diesel generator system were obtained from equipment vendors, manufacturers' manuals, and energy projects' financial reports. The information included the useful lifespans for the PV and extant diesel generator systems, as well as their costs for capital, life operations, maintenance and replacement. Furthermore, the diesel consumption specifications of the diesel generator were also obtained, and the carbon dioxide conversion factors elicited process design reports. Data analysis entailed using Life Cycle Cost Analysis technique and industrial process calculations.
The life cycle cost analyses for the smart PV and Diesel generator power systems were executed over a period of 20 years.

Life Cycle Costs Analysis for the smart PV and diesel generator power systems

Initial Investment = PV panels + Inverters + Lithium Battery + Solar mounting system + Balance of Plant + Mounting Accessories + Installation cost ________ 10

Annual Operations Costs (To be determined in study), which is Annual Maintenance Costs plus Annual Replacement Costs

Total Costs = Initial Investment + Operations Costs over Project Lifespan ______________________________ 11

Total Costs = Initial Investment + Lifespan (Maintenance Cost + Replacement Costs) ________ 12

Therefore, Life Cycle Costs (LCC) for the Power System are:
LCC (₦/KWh) =

$$\frac{Costs\ over\ the\ project\ lifespan}{Lifespan \times Number\ go\ working\ days/year \times kWh/day} \qquad 13$$

Diesel consumption and carbon dioxide emissions from the diesel power-generator option

Assumptions: The 250 kVA Caterpillar model diesel generator consumes approximately 54 litres of diesel per hour at full load.
A litre of diesel used for power generation emits 2.68 kg of carbon dioxide (CO_2).

Consequently:
Diesel consumption by generator
= total litre of diesel X Time __________________ 14

CO_2 emission
= diesel consumption X CO_2 conversion factor ____15

RESULTS AND DISCUSSIONS

This section presented the key findings of the research and their interpretation.

Determination of the Technical/Design Specifications for the Proposed Smart PV System

Determination of daily electricity demand for the proposed ICT Park
Daily electricity demand for the ICT Park = Estimated power required (W) X Time (h) _____ 1
Where;

Estimated power required = 4.912 MW
Time = 10 h (8.00 am – 6.00 pm)

Thus,

Daily electricity demand for the ICT Park = 4.912 MW X 10 hours = 49.12 MWh

N.B Security lights at night are independent of the smart PV system, and will be provided from multiple 300 W solar street lights/flood lights.

The total daily electricity demand needed from the PV modules:
Solar panel efficiency is assumed at 80%
Total Wh/day
= total appliances Wh/day x 1.25 ____________ 2

Where 1.25 is the energy lost in the system (panel efficiency is 80%)
Thus,
Total daily electricity demand
= 49.12 MWh x 1.25 = 61.40 MWh

Determining the size for the PV module
Electric power delivery is dependent on size of PV modules. For appropriate PV module sizing, the total peak Watt (Wp) produced is required. This Wp is dependent on climate of site location, and the 'power generation factor' or daily sun hours. In Nigeria, the power generation factor or daily sun hours is in the range 3.4 to 5 hrs. In Lagos, Nigeria 4 hours of daily sun supply is used. Thus, PV modules sizing would entail:

$$Wpeak = \frac{Total\, Wh/day}{4} \quad \text{3}$$

Total W_{peak} rating needed for the PV module

$$= \frac{61.40}{4}$$

PV module W_{peak} = 15.35 MW (or 15,350,000 W)

Determining the number of PV panels for the system

Number of PV panels =

$$\frac{Wpeak}{rated\ output\ Wpeak\ of\ the\ PV\ modules\ available} \quad \text{4}$$

$$\text{Number of PV panels} = \frac{15{,}350{,}000\ W}{450\ W}$$

= 34,111 modules

Determining the size for the inverter
Total Watt of all appliances = 4.912 MW
For safety, the inverter minimum size should be at least double the size of the total appliances wattage
Thus, minimum inverter size = 4.912 MW X 2 = 9.824 MW ~ 10 MW (10,000 kW or

10,000 kVA)
A 1,000 kVA inverter will be adopted due to manufacturer's inverter specification.

Number of inverters required

$$= \frac{\text{Total Inverter Capacity (kVA)}}{Capacity\ of\ Unit\ Inverter (kVA)} \quad \text{5}$$

$$= \frac{10{,}000\ \text{kVA}}{1{,}000\ \text{KVA}}$$

= 10 units

Determining the size for the battery (deep cycle)
The battery should be large enough to be store sufficient energy to operate the appliances at night and cloudy days. To find out the size of the battery, calculate as follows:

i. Calculated energy use during cloudy days (total load X Number of hours of use)
ii. Divide (ii) by efficiency of battery which is assumed to be 85%. i.e. divide by 0.85 for battery loss.
iii. Divide (iii) by 0.9 for depth of discharge (Lithium batteries being used)

Battery capacity

$$= \frac{Total\ Wh\ per\ day\ used\ by\ the\ appliances}{0.85\ x\ 0.9} \quad \text{6}$$

$$\text{Battery capacity} = \frac{49{,}120{,}000.00}{0.85\ X\ 0.9}$$

= 64,209,150.33 Wh

= 64.21 MWh

The available battery, according to manufacturer's specification, is the 10 kWh Lithium battery type; consequently, 6400 units will be procured for use (ie, 6400 units of 10 kWh/48 V Lithium battery).
The summary of the selected module technical specifications for the smart PV power system as calculated are presented in Table 1.

Determining the Size for the Solar Charge Regulator
The functions of the charge regulator are to stabilize the PV generator output going to the inverter and shield the battery against overcharge and deep discharge. The charge regulator rating is determined by the PV array output and its nominal voltage. Ideally, the charge regulator's rated power should be equal to the PV modules peak power, however it is prudent to make it 10% larger.

Size of Charge Regulator
= [Wp + (Wp × 0.1)] OR 1.1Wp ______ 7

Size of Charge Regulator = 1.1*15.35 MW
= 16.885 MW

The charge regulator should be about 17 MW.

Smart Electric Metering

Recommended meter is the Echelon MTR 3000 series poly phase meter, to monitor activities of the meters without physically visiting the site, control the time the meter delivers output remotely and restrict supply when power usage exceeds the allocated power rating.

Land Requirement for the Smart PV System

A 1 MW power station requires 5 acres for construction (IEA, 2015)

The PV power plant to support the total power requirement of 4911 MW is estimated to have a power factor of 0.8.

Thus, the PV power plant set rating (MW)

$$= \frac{4911}{0.8} = 6{,}138.75 \text{ MW}$$

Consequently,

A 6,138.75 MW power station (Approximately 6 MW power station) would require

= (6 X 5) Acres

= 30 acres of land

Table 1: Technical Specifications for the smart Mini-grid PV System

Indicator	Specification
The Determined Power Load	4.911 MW
The Determined Electricity Consumption	49.11 MWh/day
Daily total electricity supply needed from the PV modules	61.40 MWh
PV Module Size	15.35 MW
Number of PV panels for the system	34,111 modules
PV module Type	N-type mono-crystalline 156 (2 X 78) rectangular cells module type, with dimensions of 2182X1029X40 mm, weight of 26.1 kg, Maximum power (STC) of 450 Wp
Inverter Size	10,000 W/48 V
Battery Size	10 kWh/48 V Lithium battery
Solar Charge Controller Size	8,000 W with acceptable PV voltage range of 85 – 500 V

Determination of the Technical/Design Specifications for the Alternate Diesel Generator System

$$\text{The diesel generator set rating (kVA)} = \frac{Power\ Load\ Requirement}{0.8}$$

$$\text{The diesel generator set rating (kVA)} = \frac{4.911\ kVA}{0.8}$$

= 6,138.75 kVA

The projection of the deployment of 25 units of 250 kVA generator sets (giving a total capacity of 6,250 kVA) is deemed suitable.

A 15 kVA diesel generator is assumed suitable for procurement. This generator consumes approximately 4 litres of diesel per hour.

Techno-Economic Specifications for the PV System

This section presents the parameters of the pre-investment analysis of the PV system project and the Life Cycle cost analysis of the PV system and diesel generator system, as well as the diesel consumption costs for the diesel generator system. The life cycle cost analyses for the smart PV and Diesel generator power systems were executed over a period of 20 years:

A. LCC for 6 MW PV Power Station

LCC for One 5.8 KW PV Power System

Initial Investment:

1. PV panels (12, 450 W) = ₦1,560,000.00
2. Inverter (2) = ₦1,462,000.00
3. Lithium Battery (10 kWh) = ₦2,300,000.00
4. Solar mounting system = ₦ 180,000.00
5. Balance of Plant = ₦ 424,300.00
6. Mounting Accessories = ₦ 368,000.00
7. Installation cost = ₦ 416,100.00

TOTAL = ₦6,728,400.00

Annual Maintenance Costs = ₦250,000.00
Maintenance costs over 20 years
= ₦250,000.00 X 20 = ₦5,000,000.00

Replacement Costs Over Project Lifespan

PV Sytem (1ce) = ₦6,728,400.00
Inverter (2ce) = ₦2,924,000.00
Battery (2ce) = ₦4,600,000.00
Total = ₦14,252,000

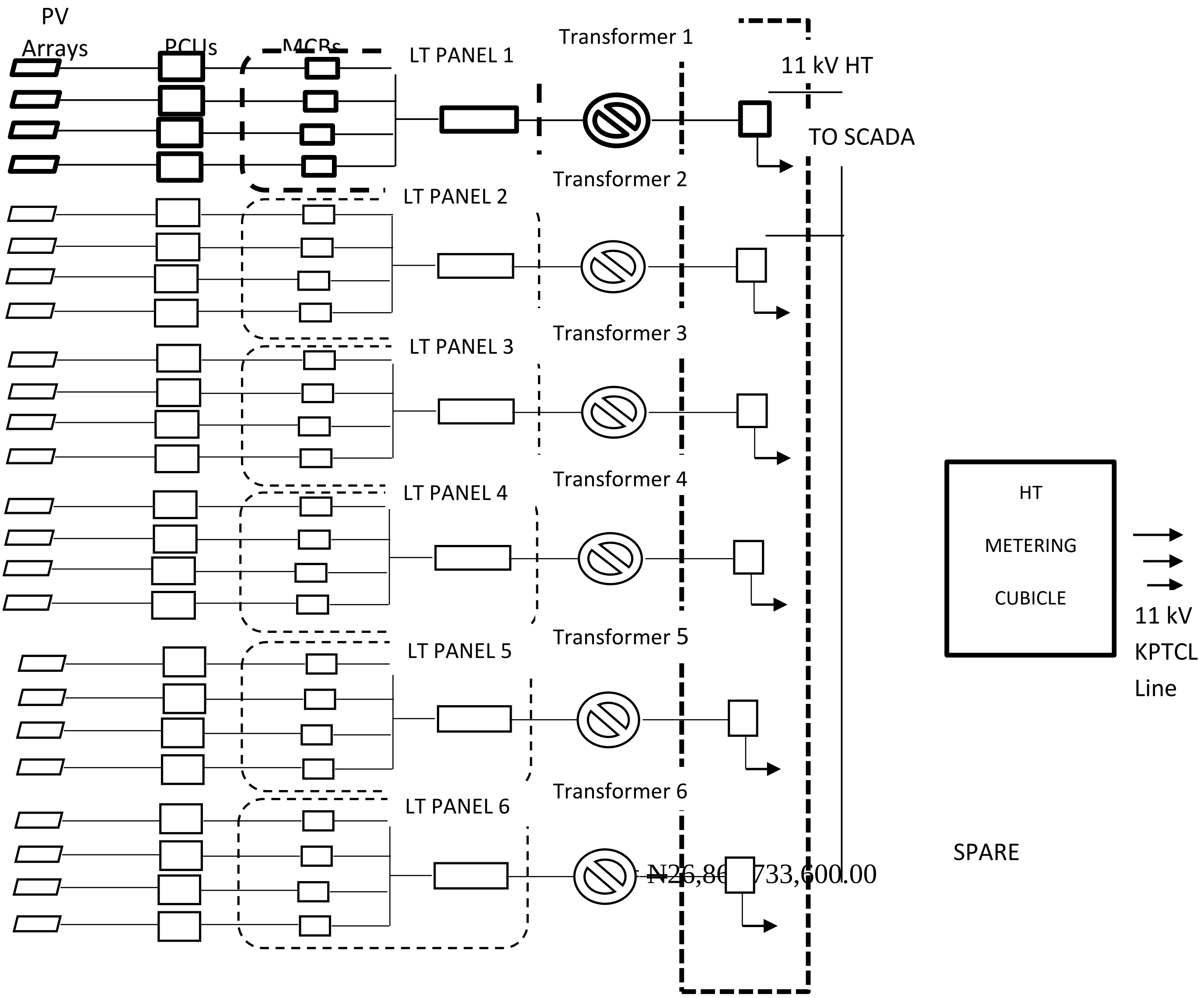

Figure 1: Simple Block Diagram for the 6 MW Smart PV Power System
Source: Lulbadda & Hemapala (2019)

Total Costs for One 5.8 KW PV Power System over Lifespan
= ₦6,728,400.00 + ₦5,000,000.00 + ₦14,252,000.00
= ₦25,980,400.00

Life Cycle Costs for 6 MW PV Power System
= ₦25,980,400.00 X 1,034
= ₦26,863,733,600.00

Therefore, Life Cycle Costs (LCC) for the PV Power System are:

LCC (₦/KWh)

$$= \frac{Costs\ over\ the\ project\ lifespan}{Period \times 365 \times kWh/day} \qquad 23$$

$$= \frac{26{,}863{,}733{,}600}{20\ yrs \times 300\ day/yr \times 49110 kWh/day}$$

$= \frac{26,863,733,600.00}{294,660,000.00}$

= 91.17

LCC for the PV Power System = ₦ 91.17/kWh

B. LCC for Diesel Generator System (25, 250 kVA Caterpillar Diesel Generators)

LCC for One 250 kVA Caterpillar Diesel Generator:

Initial Investment

1. Generator set = ₦ 22,500,000.00
2. Installation + ancillary costs = ₦2,500,000.00
3. Total = ₦25,000,000.00
4. This generator set will be replaced after 10 years, thus initial investments on one 250 kVA Caterpillar Diesel Generator = ₦50,000,000.00

Annual Operating/Maintenance Costs

1. Fuel Consumption = 54 Litres/hour
2. Fuel cost = ₦1,300/L
3. Daily fuel cost = ₦1300/L X 54 L/hr X 10 hr/day = ₦702,000
4. Annual fuel cost = ₦1300/L X 54 L/hr X 10 hr/day X 300 days/Yr = ₦210,600,000
5. Annual Maintenance cost = ₦1,500,000
6. Overhaul cost = ₦4,000,000 every 5 year = ₦16,000,000 for 20 years = ₦800,000/Yr
7. Total = ₦212,900,000/Yr

Operating and Maintenance Costs over 20 Years = ₦212,900,000/Yr X 20 Yrs

= ₦4,258,000,000.00

LCC for 250 kVA Caterpillar Diesel Generator Set LCC
= Initial Investment + Annual Operating & Maintenance Costs

= ₦ (50,000,000.00 + 4,258,000,000.00)
= ₦4,308,000,000.00

The LCC for 25 250 kVA Caterpillar Diesel Generators
= ₦4,308,000,000.00 X 25

₦107,700,000,000.00

Therefore, Life Cycle Costs (LCC) for the Diesel Generator System are:

LCC (₦/KWh)

$$= \frac{Costs\ over\ the\ project\ lifespan}{Period \times 365 \times kWh/day} \qquad 23$$

$$= \frac{107,700,000,000.00}{20\ yrs \times 300\ day/yr \times 49110 kWh/day}$$

$$= \frac{107,700,000,000.00}{294,660,000.00}$$

= 365.51

LCC for the Diesel Generator System

= ₦ 365.51/kWh

LCC ratio of Smart PV Power System to Diesel Generator System

LCC Ratio

$$= \frac{LCC\ for\ the\ Diesel\ Generator\ System}{LCC\ for\ the\ Smart\ PV\ Power\ System} \qquad 23$$

$= \frac{365.51}{91.17}$ = 4.009 ~ 4

From this analysis, the diesel generator system is estimated to cost 4 times more than the smart PV Power System, indicating that the smart PV Power System is the better option for utilization in the proposed ICT Park.

Diesel Consumption and Carbon Dioxide Emissions from the Diesel Power-Generator Option

Assumptions**:** The 250 kVA Caterpillar model diesel generator consumes approximately 54 litres of diesel per hour at full load.

A litre of diesel used for power generation emits 2.68 kg of carbon dioxide CO_2) (Guru *et al.*, 2022). Consequently:

One 250 kVA Caterpillar diesel generator is estimated to consume 54 litres of diesel per hour at full capacity.

In 10 hours (daily operation in the ICT Park), (54 X 10) L or 540 litres of diesel will be consumed.

25 units of the 250 kVA Caterpillar diesel generator will consume (540 X 25) L diesel/day

= 13,500 litres of diesel per day
OR 4,050,000 litres of diesel for a 300-day/working year
1 litre of diesel produces 2.68 kg of CO_2
13,500 litres of diesel will produce (13,500 X 2.68) kg of CO_2 = 36,180 kg CO_2
This is approximately 36.2 tonnes of CO_2 per day
OR 10,854 tonnes of CO_2 for a 300-day/working year.
The adoption of the smart PV power system for the strategic ICT Park is projected to eliminate from the atmosphere this estimated 36.2 tonnes of CO2 per day, or 10,854 tonnes of CO_2 for a 300-day working year.

CONCLUSION AND RECOMMENDATION

This study analyzed the technological, environmental, and economic factors essential for developing a smart PV power system for the proposed Katangua ICT Park in Abule Egba, Lagos State. Using an energy technology foresight analysis framework, it aimed to provide key policy insights for advancing critical ICT infrastructure outlined in the Lagos State Development Plan 2050. The study determined a power demand of 4.911 MW and an electricity requirement of 49.11 MWh/day. It estimated a PV module size of 5,295.31 W, requiring 34,111 N-type monocrystalline modules (450 Wp each). The smart PV power system would prevent the annual use of 4.05 million liters of diesel and 10,854 tonnes of CO_2 emissions, highlighting its environmental benefits. Furthermore, the study found that the smart PV system had a lower life cycle cost (₦91.17/kWh) than the diesel generator (₦365.51/kWh) over 20 years, making it four times more cost-effective. The study concluded that the smart PV system was viable and recommended its adoption for the strategic ICT Park.

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