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Scalable and Characterization Methods and Tools for Remote Monitoring of Off-Grid Technologies: Case Study of 3x15mva Power Distribution Injection Substation in Nigeria

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Abstract: Remote control and monitoring of energy resources are vital for the effective management of electricity in rural areas. Access to electricity in rural areas of Nigeria has grown in recent years. Nigeria appears to be growing rapidly in the electrification of both rural and urban areas through the use of distributed energy resources using renewable energy. Nevertheless, there have been challenges in the remote monitoring of the energy resources in the rural area. The challenges include high cost of implementation, available technology, power consumption, system integration, social-Economic challenge, etc. This paper present a cost-effective concept for remote monitoring systems of distributed energy resources (off-grid/mini-grid) and on-grid/main-grid technologies based on free open-source Supervisory Control and Data Acquisition (SCADA) or vison CC software that runs on a server located at the central station and a robust interface panel where the sensors measure system parameters, which are subsequently analyzed by signal processors before being transferred to a central location, where data is stored on the server's hard drive. The remote monitoring system is for monitoring and collection of energy data such as current, voltage, power, and environmental data such as temperature and humidity. The basic remote monitoring system consists of two components: a transmitter located at a remote site (where the mini-grid is installed) and a receiver located at the central station (where the system monitoring process is done). The proposed concept comprises various means of connecting locally with the remote system, with the connection being through Universal Serial Bus (USB), RS232, RS485, or Ethernet, where this data is stored on a central relational database management system, which makes it possible for posterior analysis.

***Keywords**: Solar PV, Central Monitoring System, Mini-Grid, Remote Technology, Sustainability, Renewable Energy, Sustainability, Vision CC*

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I. INTRODUCTION

In today's market, data collection and processing play a critical role. Depending on the use, such as power or medical applications, system precision and performance are necessary. With the evolution of technology in industries toward communication, real-time monitoring of electrical characteristics is required in addition to excellent measurement performance and precision [1]. A remote control, also known as feed-in management, is required for two obvious reasons. On the one hand, grid assets such as transformers and lines must be protected from overloading. Feed-in management will partially reduce the feed-in of distributed generators if day-ahead grid simulations show that n-1-security is lost during a condition with low load and strong renewable power generation. On the other hand, in the future, if overall production is too great, a power imbalance will arise, causing the frequency to rise[2]. Computer-based control systems monitor and control critical operations in several critical systems and businesses (e.g., the electric grid, factories, petroleum industries, natural gas, and wastewater industries). To implement off-grid systems, there is a drive for connecting remote monitoring systems and communication networks. remote measurement and technical data from remote stations are frequently collected, processed, and displayed by control systems. Relay control commands are sent from the control center to local or remote outstations. Control systems may also conduct other remote functions, including switches control, Isolators, circuit breakers, and regulating valves for fuel management [3]. The architecture of a SCADA system should be able to allow the diverse structure of automation systems as well as the DMS's advanced level applications[4]. Renewable energy resource solutions have risen in importance over time due to continual malfunction and the overall unpredictability of grids. clean/renewable energy sources are the primary source of electricity generation in distributed generation (DG); the electricity generated can be fed into the main grid or utilized in a domestic mini-grid. Despite the abundant and limitless nature of renewable energy sources, climate unpredictability makes their availability in sufficient amounts for power generation uncertain, making the idea of relying on them as the sole energy source in peril. This sparked r&d. in the disciplines of power generation to improve system efficiency.

The announcement of the United Nations Secretary-General on "Energy for All" in 2012 strengthened international enthusiasm toward renewable energy development.

This seeks to give everyone electricity access, double electri city generation efficiency, and double the amount of renewa ble energy production.[5].The focus of energy sector development in African countries has been on improving and expanding the main grid through the integration of renewable energy generating stations to meet the energy demand. [6]. Despite this effort, there are still serious deficiencies. In Sub-Saharan Africa, electrification rates for urban and rural people are respectively 64% and 13%.

This paper discusses Remote monitoring systems using remote monitoring systems, their development, and applications in energy monitoring and management, as well as the data acquisition method. It covers WSN elements such as transmitter and receiver. The case study here shows the predicted and realized advantages of this method of remote monitoring system configurations. Section II reviews the opportunities for renewable energy sources in the energy market. It also provides an overview of improved performance and evaluation in rural electrification projects. We look at common sustainability concerns in the grid and mini-grid systems in Section III, as well as a literature review of current remote monitoring implementation in poor countries and an assessment of remote monitoring utility in addressing sustainability challenges. In section IV, a case study of current and continuing remote monitoring deployment is described. The study finishes with a discussion of the case study approaches to sustainability, as well as their merits and flaws, as well as future directions.

II. ELECTRICITY EXPANSION IN RURAL AREA

A. Opportunities For Renewable Energy Sources in The Energy Market

As discussed earlier, it is very imperative that renewables have a place in the market. Otherwise, people will not be willing to invest in the project. The economic interest and some other factors in renewable energy encourage people to use renewable energy. From a consumer's understanding, the economic opportunities within the labor market, other than ordinary generating of electricity, can be expressed as arbitrage, which means taking advantage of a price difference between two or more markets, i.e, the idea of generating or buying and storing electricity when it is cheap and using it later during peak demand hours. supplementary services, which assist power companies in maintaining a reliable electrical supply, are another option. These services are important to the electricity grid because they offer greater stability and reliability by providing operating and spinning reserves. They also correct energy imbalances[7].

B. Essential Of Rural Electrification Projects

The International Energy Agency estimates that achieving universal electricity access by 2030 will cost almost $1 trillion, but SE4ALL has only secured 3% of that at this time.[8] Expanding large grids to provide electricity to metropolitan areas and 30% of rural areas would provide accessibility, with the remaining shared between mini-grids (65%) and stand-alone systems (35 percent). Projects that have a real-world application of Off-grid and mini-grid technologies will provide 55% of additional electricity access. [9]. In African countries, Future accessibility is a high priority in national electrification plans.

The Federal Government of Nigeria's Rural Electrification Goal is to increase electricity supply to 75 percent and 90 percent by 2020 and 2030, respectively, using the Rural Electrification Policy (2005) and the National Electric Power Policy, and to include at least 10% renewable energy in the mix energy by 2025. (2001)[10].

It might take decades for even the most effective rural electrification efforts to achieve high access rates [11]. Lack of oversight and, as a result, a scarcity of evidence on the portfolio's success are factors contributing to the delay [12]. More broadly, it appears that the availability of information and sufficient evaluation of the advantages of rural electrification programs is limited.[13]. While financing for RE programs remains, there is little empirical evidence to support their claimed degree of impact, according to reports[14]

The next section discusses the lack of long-term viability of grid and off-grid rural electrification projects. To prevent repeating mistakes and improve future deployments, researcher need to identify factors needed to ensure sustainable development, and what their proportionate relevance is in numerous regional circumstances

III. PROBLEMS OF REMOTE MONITORING AND SUSTAINABLE DEVELOPMENT

A. Continuous/Sustainability Problems Of Grid And Mini-Grid

Grid and mini-grid remote technology systems have been evaluated and it shows the technical possibility of offering energy services to villages and other rural communities while minimizing climate change impacts [11]. mini-grid has the advantage of serving as a stopgap remedy while rural areas expect the main grid to reach them, a process that may take years. [4]. The main grid extension can provide enough power than mini-grid alternatives can be claimed to be more equal, reaching the poorest most directly.

Solar PV lamps (The smart power box is an inverter system with LEDs and inverter, batteries and solar panel) to bigger scale mini-grids are examples of off-grid electrical RETs, for example, The Nigerian government collaborated with the Kaduna disco and the Torankawa community in Sokoto state in 2019 to develop a 60kW PV hybrid mini-grid with 216kWh batteries and a 100kVA diesel generator as a proof of concept. GVE, Nigeria's largest mini-grid contractor and a participant in the NEP, now operates 14 mini-grids with a total installed capacity of 589kW of PV and 4,200kWh of lead-acid batteries. It is currently being built with 395kW of PV and 670kWh of lithium-ion batteries. [15]. Mid-scale systems, which use either solar PV or wind production usually focus on businesses, home institutions and hospitals.

A typical system might include a solar panel array or wind turbine, a series or parallel array of 12-volt or 24-volt lead-acid batteries, energy-efficient lighting, an AC inverter, charge controller

Many literatures have recommended methods for improving the long-term viability of mini-grid remote technology for sustainability areas such as economics, institutional, and social, community ownership and engagement, technical.

The significance of each of the aspects of sustainability cannot be overstated., even while the focus of remote monitoring in this work is mostly technical sustainability challenges. Government has an corporate role to play to promote the growth of the individual businesses for small-grid rural energy solutions – This is one of the policy to support small grid energy solutions. Weak policies like solar tariffs that fail to promote mini-grid remote technology can prevent projects from getting off the ground, meanwhile apathetic tariff, such as that used overtime in Kenya in the last 30 years, has allowed the dissemination rates of photovoltaic solar comparable to those in South Africa. To give first access as well as regular service , creative finance approaches are sometimes required[16]. Long payback plans with reduced initial expenses, team financing, and adjustable payment options for quasi-income are just a few examples. While further investigation is necessary to completely know the purpose of these challenges and their links to other sets of factors, the literature related to the research presented in this paper demonstrates that remote monitoring can help with operational resilience.

The following are the primary operational reliability challenges that have been found:

- Nonconformity in operational design, which can lead to a component's systematic bias.
- A forward-looking needs analysis should impact the project's scaling. When there is an increase in demand in a rigid pricing system situation, systems can become overburdened and overworked.
- Lead acid station batteries must be properly maintained, and their longevity can be overestimated, causing them to break much sooner than planned.
- The system must be developed with the operators' and repair professionals' skill sets in mind. When a complex system fails, finding specialists to repair it might be difficult.
- The availability of data (typically derived from nontechnical users) may not be adequate to identify the challenge without a full site assessment, therefore determining the system malfunction cannot be assumed for sure.

B. Importance Of Remote Monitoring For Mini-Grid

wireless networks are the primary communications tools available in underdeveloped nations when it comes to remote monitoring plans for off-grid or mini-grid electricity installations. In Africa, wireless networks have grown at a staggering rate of 44 percent since 2000, with 648.4 million mobile phone subscriptions predicted in 2011 [17][18].

Advanced research on the setups and applications of remote monitoring and wireless sensor networks is available for development projects (WSN).[19] who propose a system using wireless sensor network (WSN) technology, provide a power monitoring design for off grid applications that can compute the power for any load. The monitored power is transmitted to the sink at frequent intervals using WSN technology. While there are other examples apart of electrical projects, the technology is transferable and shows how contemporary communications technology may be used in impoverished countries.

As mentioned in previous sections, off-grid technology systems confront a number of problems in terms of long-term viability. Remote monitoring technology, on the surface, appears to have capabilities that could assist alleviate some of these issues. operational reliability is dependent on a successful technical and maintenance method. Any sign of operational imbalance must be reported, and corrected as quickly as possible.

The input effort required to develop the essential skill in isolated rural villages is a large, delaying process which could take several years. Furthermore, until an acceptable degree and grade of indigenous talent base is formed, there is an essential demand to address the operational issues that systems developed in the provisional face. These urgent maintenance requirements can be met with RM technology. Following the first installation, remote monitoring can assist control/Automation personnel (technicians and engineers) in satisfying a maintenance requirement. With such strained technical resources, time-based maintenance is impracticable, as the expenses and time of traveling to distant places represent a significant burden, which mostly jeopardizes the durability of these systems. Technical assistance can use RM to focus their efforts and resources on the most critical installations[14].

Remote monitoring can enable the designer oversee the system's utilization remotely, as well as help the consumer learn how to maintain and extend the life of their system and provide them with greater value. The remote monitoring data needs to be delivered to the consumer, but it would have to be distilled in order to avoid enormous operational statistics. This has the potential to have a progressive effect expanding their operational awareness, ensuring that the system is not misused and is used for the functions and cycle of duty for which it was designed, extending the system's lifespan.

RM would make it easier for a single maintenance team at a central location to manage several remote RET installations. The ability to execute early systematic preventive maintenance work is aided by fast communication of the system behavior through the system parameters. The operational data of the system such as depth of discharge of the battery, PV charging capacity, and charge controller performance, would be more widely known, allowing for more systematic evidence production and learning. Adoption of technologies like SIMbaLink [20], which was developed to record basic data on battery and panel health from SHS in Ethiopia, could improve maintenance processes (voltages). A central maintenance organization would review the data before using it. Several scenarios were created to estimate the amount of money that could be saved by using SIMbaLink.

In most poor nations, there is little evidence of the viability of large-scale renewable energy technology implementation. Real performance data for renewable energy technology is scarce. Therefore, most efforts focus on system deployment instead of performance monitoring. Remote monitoring solutions make the collection of data for critical system performance measures easier, allowing for research and development to promote better system standards, design, and implementation, as well as input information into the creation of good energy policies. Furthermore, innovations for remote collection of non-system records such as financial, sociological, and climate data can be used to monitor and review the socio-economic and environmental footprint that these systems have on the local community, traditions, and environment, both positively and negatively, which provides insight into the design and implementation phases to meet the needs of the communities that these systems serve.

IV. THE CASE STUDY OF 3X15MVA POWER DISTRIBUTION INJECTION SUBSTATION IN NIGERIA

This section describes the method of implementing a remote monitoring system of off grid and grid technologies for use in Nigeria and other developing countries. The case study below was chosen to juxtapose various techniques and provide some evidence of the diverse roles' remote plays in grid and off-grid renewable energy initiatives.

The case study is from a 3x15 MVA power distribution injection substation, operated from one of the power distribution companies of Nigeria. This substation has three power transformers that is rated for 15MVA, and nine outgoing feeders. The station supplies electricity to over 10,000 customers that involves both residential and commercial premises. The system is a combination of both software and hardware components. The software is an open-source Supervisory Control and Data Acquisition (Vision CC) software while the hardware is a robust communication panel as show in figure (3).

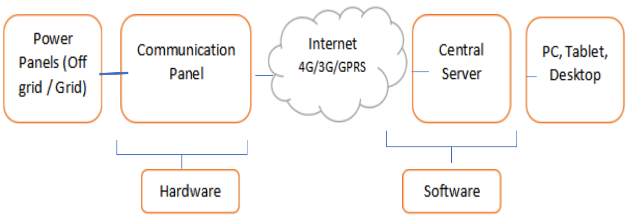

Figure 1: Block diagram of hardware and software components for the remote monitoring system.

Fig 1 shows the complete block diagram of the project. The power panels which are located at the customer premises are connected to the communication panel. The communication panel then connect to the central server via the internet which makes use of a communication protocol as shown in fig 2. The comprehensive components of the system are discussed below:

A. Software: Vision CC (Control Center)

Vision CC is a piece of software that receives input, interacts with controllers, processes it, and then sends it to monitoring engineers. Vision CC supports widely used communication technologies such as the Modbus protocol and OPC, which enable the use of a wide range of devices. Additional drivers can be developed to expand the list of supported devices. It is made up of a collection of applications and libraries. The software is a platform that enables for customized system configuration to fit the needs of the customer. Internal data formats and communication protocols are documented because the software is free and open source. This method makes it easier to integrate with other programs to build complicated enterprise-wide solutions. Custom modules that implement required features can be added to improve its performance.

B. Software Internal Applications

1) Server Application:

The server application handles the data archives, does mathematical calculations, and transmits information to the customer applications. At the same time, the server sends data to the primary archive and creates a backup copy. The server functions as a service. It lacks a graphical user interface. Regardless of whether or not a user logs in or exits, the server continues to run in the background. The Administrator application includes a graphical terminal for customizing the server. While processing requests and passing commands, the application monitors user connections and checks user permissions. Textual log files store information about the application's current status and actions. The server is built to run continuously.

2) The Communication application

It interacts with the controllers and sends data to the Server application. Multiple lines are used to communicate with controllers connected to a system in parallel. Controllers provide commands to the Communicator, which gets current data, archive data, and events. The application aids in the diagnosis of communication cables and devices. Communicator is a service that you can use. The Administrator program includes a graphical terminal for setting Communicator. Log files record information about the application, communication channels, and each connected device. The Communicator is made to run continuously.

3) Webstation Application:

Webstation is a web application that permits delivering orders and displays information to a dispatcher in various forms like tabular, schematic, diagrams, reports, etc. via a browser. Reports are created in HTML and Microsoft Excel, which are both widely used formats. Webstation is accessible without the need for software installation from any computer or tablet linked to an organization's network. A system administrator controls access and assigns user permissions.

4) Agent Application:

Agent Application: The Agent application transfers configuration from Vision CC to the Administrator application. The Agent also provides records that can be seen by the Administrator. The Agent operates as a program on a server that hosts a Vision CC instance that is managed by the Agent.

All or a portion of the Server, Communicator, and Webstation programs are included in a Vision CC instance. As seen in Figure 2, the agent communicates with the administrator using TCP. As a result, the Administrator can be installed on the same computer as the Agent or on another service computer. The Agent uses TPC port 10002 by default. In the case of remote access, the server must allow incoming connections on this port.

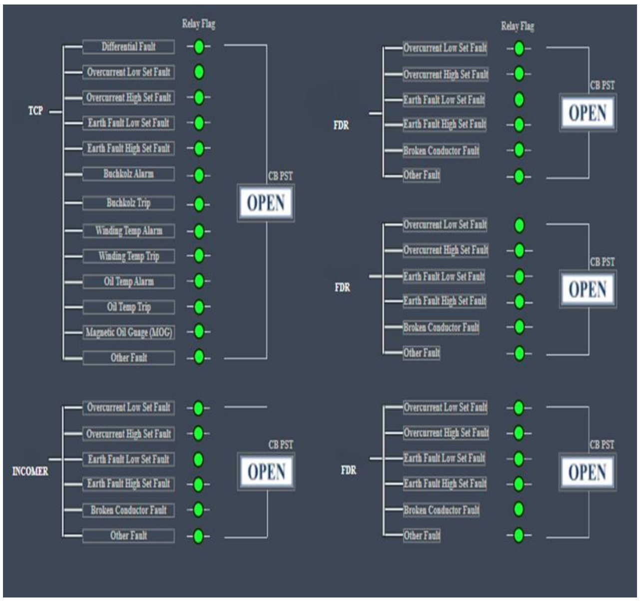

Fig 2: TCP Communication

5) Operator Application:

The Operator application is used to create Vision CC projects and keep track of the automated system's status. Operation is an integrated development environment that allows you to edit the configuration database as well as configure the core Vision CC apps, Server modules, and device drivers. To make the configuration process go faster, the administrator can use the appropriate techniques:

- Transfer of configuration database tables enabling project-to-project collaboration.
- Input and output lines are automatically created using a wizard.
- Practical input is minimized with the channel cloning feature.

A project consists of a collection of system settings, most of which are in XML format. Copying projects from one computer to the other is simple with this method. Git is the greatest option for managing project versions and collaboration.

C. Hardware

The communication panel represents the hardware part of the remote monitoring system. It consists of:

i. The physical enclosure
ii. 4G/3G/GPRS Modem Router
iii. Embedded computer/Server
iv. Remote terminal unit
v. Data exchangers (Ethernet switch)
vi. Uninterrupted power supply
vii. AC distribution board

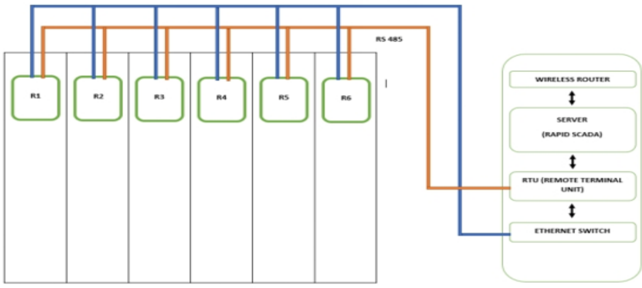

Fig 3: HV Protection panel and Substation Automation Panel

R1,R2,R3,R4,R5 and R6 are protection relays that monitor the supply of electricity. They contain the registers that store the needed data(Current, voltage,power,etc.). They are connected to the substation Automation panel(Also called communication Panel) via ethernet bus to Ethernet switch and via Rs485 to Ethernet as shown in fig 3.

Data can be acquired locally or remotely, and each option has advantages and disadvantages.. The proposed concept comprises of various means of connecting locally with the remote system. Connection could be through USB, RS232, RS485, and Ethernet. This approach is chosen to offer flexibility, expandability and ease of use. For remote data collection, GPRS, 3G and 4G can be used to get the data to the central station. This data is stored on a central relational data base management system which makes it possible for posterior analysis.

This project uses 3G/4G wireless infrastructure to deliver data to a database on a web server, which web applications can access with a simple and consumer data interpretation like an android. Despite the fact that many apps rely on a local base station to collect data and update a web application, the proposed method simplifies system development. The goal of remote monitoring systems is to facilitate the provision and stability of the energy systems they monitor; hence, the complexity of the remote monitoring system should not threaten its own dependability. The remote data collection for this project focuses on physical and operational data, which may be used to determine system usage and asset health. A web application has been designed to present database information in a user-friendly manner (data provided based on viewer, with several levels of information available to system users, operators, maintenance people, and designers), using charts and tables as needed

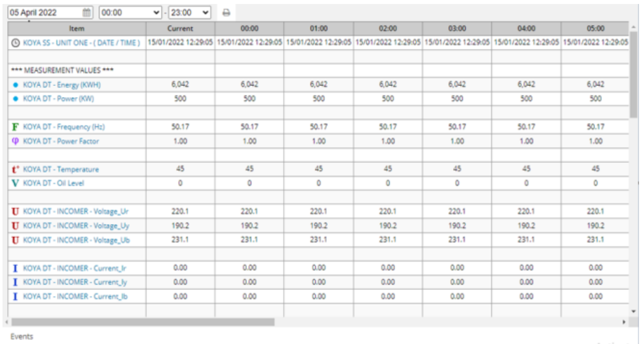

Fig. 4: Displays of System Information

The remote monitoring software which is the Vision CC software runs on both the embedded computer in the hardware communication panel and on a server located at the central station. This enables synchronism of the data recorded at remote location with the data at the central location irrespective of distance and data transmission delay between these two points. Both arrangements would require a dedicated and long-lasting uninterrupted power supply to ensure that the servers and its ancillaries are running 24/7.

For the remote location, an interface panel is used. This panel has the ability to connect to the various controllers and sensors for the different types of distributed generations (PV, Wind and fossil-based generators). The interface panel polls the data from the controllers and sensors, saves this information and transmits the information to the central station for processing and analysis. The interface panel is also capable of conducting basic processes that needs to be performed quickly. These processes are linked with automatic actions and notification. The automatic actions are required to mitigate potential hazards. These actions are carried out without the express permission of the central station. This action also generates an automatic notification to the central station of this anonymous action. In the proposed concept, the variables from the controller or the sensor data are stored in the embedded computer. The embedded computer makes the complete monitoring system cheaper and ensure reliable data storage. Although the embedded system has a smaller capacity when compared to a standard server system, other embedded computer can be placed in parallel in order to increase the storage capacity.

The data acquisition module and the pre-processing of the acquired data is carried out in the interface panel where the embedded computer is located. The central station is where the central server is located and the main monitoring activities is carried out.

D. Data Acquisition Module*:*

The communication panel has a remote terminal unit which is also known as the data acquisition module. This module collects two sets of data. The first set is the quantity of fuel available for the off-grid system. For the PV system, this would be in the form of solar intensity. This can give the user information about their battery's health, charge level, remaining charge (in hours or days), and life. Based on the condition and usage information supplied, the charging station operator can also remotely disable batteries. For the wind turbine, the wind speed is the data to be captured while for fossil fuel-based generator, the level of the liquid or gas fuel. The second set of data is the quantity of power and electricity being generated by the off-grid technology. The combination of these two sets of data represents the input and the output of the off-grid technology. This module is connected to various controllers for PV systems controllers, Wind turbine controllers, and fossil fuel-based generators. The link between these devices co be USB, RS485, RS232, and Ethernet. The embedded computer or mini server is connected to this module through an Ethernet cable. This is chosen due to the high speed obtainable for Ethernet transmission. The data is saved in the embedded computer system.

E. Pre-processing:

This is done at the embedded computer of the hardware communication panel which is located at the remote location. This is carried out by the Vision CC software. The software is integrated with various communication protocol such as Modbus, M-Bus, DNP3, IEC 60870, IEC 61850, Profibus, Profinet. Etc. This protocol enable communication with various controllers. Pre-processing is carried to ensure that the data collected are accurate and reliable. This process also gives the remote station some level of autonomy such that when there is loss in communication with the central station, the remote station can operate smartly pending when the communication is restored. This action gives the system a self-healing ability to make decisions and resolved challenges before they escalate and become uncontrollable.

F. Central Server:

This is located at the central station and receives every data transmitted from the remote station. The Vision CC software also runs on the central server. This enables synchronism between the software installation at the remote station and the central station. The data received is backup immediately in a relational database management system. This database is made available to other third-party systems and software's for more comprehensive analysis and decision making in the business process. The central server has a web station that grant the users to view the status of the off-grid technology.

G. Monitoring:

The Vision CC software has a number of notification channels. These include email, SMS, chat group. This enables continuous monitoring of the entire system. Certain thresholds are set in the software and whenever these thresholds are violated, a notification is sent to the technical crew or the managers to attend to that issue. The Vision CC software is an open-source software. Open-source software is software that is released with the source code, usually under a license that restricts modification, reuse, and redistribution. Free software is based on voluntary contributions from a community of geographically dispersed developers through the Internet. When opposed to proprietary software, this freeware frequently provides a more trustworthy alternative, performs better, fosters creativity, and can detect and repair bugs faster. Furthermore, the software is available all around the world, and programmer engagement and market share are increasing. Although the most well-known proponents of free and open-source software are from industrialized countries, support from underdeveloped countries has risen dramatically in recent years.

H. Station Overview

1) Remote Station

The PV installation will be equipped with Wireless Sensor Network (WSN) devices for the remote station. Open-source models have significant cost, customization, and independence from a single entity advantage over proprietary solutions. As a result, the RS will be built around an Open WSN node.

The Wasp mote node by Libelium[21] is used in particular for delivery. This node can be powered by a lithium battery that can be recharged via a solar panel-specific connection. This option will make the RS independent of the PV system, allowing it to operate seamlessly in terms of reporting PV performance parameters to the central monitoring station regardless of the PV system's health.

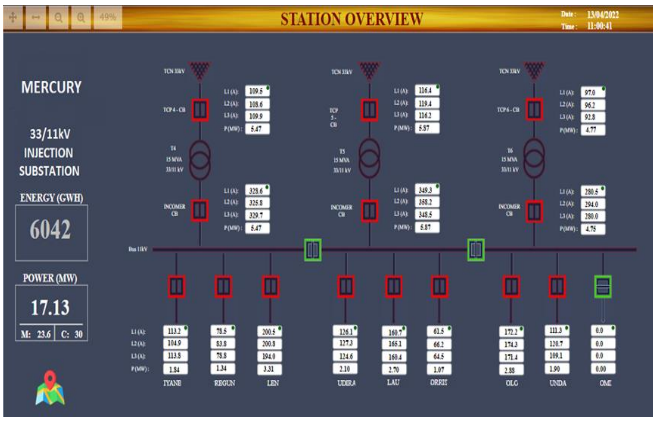

Fig 5: Station Overview

As seen in Fig. 5. Using the cellular network, numerous RSs will be able to connect with the central station. At least one main station will be present in each remote station, analyzing and aggregating data from far-flung sub-stations. The number of remote stations that can be connected to the remote monitoring system is scalable, and the remote stations themselves are customizable in terms of the number of sensors that can be added. A number of sensors, such as current, voltage, sun radiation, and temperature sensors, can be added to the main station node. A ZigBee module will be used to receive data from sub-stations within its locus. This node will also include a GPRS module for sending SMSs to the central monitoring station. The PV system's loading condition will be investigated using the load current sensor. Any system overload will be informed to the individuals in charge of monitoring.

2) Control Station (CS)

The control station is the remote monitoring system's brain. This could include components for aggregating and processing data from all RSs. Defect alarms will be sent directly to the monitoring staff' mobile phones, allowing them to respond immediately to the individual solar PV system. The alarms could come straight from the remote stations or from the control monitoring server. The other component is the server, which is a computer with a broadband connection. This component will collect, save, and present data on present and past PV system performance. Another section is internet connectivity, which will enable users to access system performance data from anywhere on the planet. Control room operators were trained to take daily measurements for a variety of indicators.

This remote system is expected to provide technical, economic, and commercial data to aid in the management of both personal and metropolitan systems' lifecycles and asset condition. Various levels of data and remote monitoring (i.e. enable, disable battery assets) will be supplied based on the log on details (e.g. user, operator or designer). By executing operations on the server using the collected data, the remote monitoring unit's specification, power consumption, and expenses can all be reduced. Another benefit is that control signals can be sent back to specified systems via a bidirectional communications link, with updates conducted when the asset is utilized or charged again.

V. RESULT AND DISCUSSION

Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections A-D below for more information on proofreading, spelling and grammar. Keep The impact is a decrease in the amount of operating these off-grid and grid-connected systems as a result of the following.:

- Lowering the cost of o&m for off-grid installations that are located in remote locations
- Fewer trips to site
- Increased component life span
- Better performance

This project exhibits the ability to remotely monitor off-grid/mini-grid and main-grid projects utilizing free and low-cost services. To see if this technique is more effective in enhancing the sustainability and reliability of similar initiatives, a longer monitoring period was used. The cost savings from the implementation of this remote monitoring system cannot be overstated, with savings reaching as high as 35%. Finally, remote analysis and debugging of situations are archived in fewer travels than delegating to a local professional. A possible lack of precision and gaps in the data collection have all been identified as flaws thus far. The implementation team, on the other hand, reaps the benefits of a practical solution. For example, this allows the project team to collect data from afar if there isn't a designated on-the-ground monitor. In addition, the project team now has a direct route to communicate with the operator, which has enhanced responsibility and participation. Also, clear and real-time data transfers are available; the team can act swiftly if there is a delay in Messages or if an issue arises. finally, the remote monitoring system allows the design which use tools that are normally accessible and inexpensive and data collection costs are substantially lower.

VI. CONCLUSION

Remote control and monitoring of energy resources are vital for the effective management of electricity in rural areas. The current remote monitoring implementations in Nigeria are distinctions on a main topic of establishing suitable technologies to assist in remote technologies in other sub-Saharan Africa countries.

For remote technologies deployments, the requirement of reliable and near actual monitoring system presents a viable way to increased reliability. On a operational level, there are different technology to deploy in remote monitoring, and it is backed by researchers, engineers and specialists around the world.

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