Computing, Information Systems, Development Informatics & Allied Research Journal
Vol. 7 No. 3, September, 2016 - www.cisdijournal.net

The Optimization of SCADA on Renewable Energy: An Approach to Sustainable Development in Nigeria

[1]**Adenle Bamidele. J**
Department of Computer Hardware Engineering
DOTS Institute of Technology
Abeokuta, Nigeria
bamidelejohnson2@gmail.com

[2]**Adekusibe Kehinde. G & [3]Akinrogunde Oluwadare. O**
[2]Department of Computer Engineering
[3]Department of Electrical and Electronics Engineering
Institute of Technology
Igbesa, Nigeria
kusibus@yahoo.com; akinrogunde60@gmail.com

[4]**Alashiri Olaitan. A**
Department of Computer Engineering
Kalac Christal Polytechnic
Sangotedo Aja Lagos, Nigeria
olaitanalashiri@yahoo.com

ABSTRACT

The penetration of renewable energy is on the rise worldwide. When interconnecting renewable energy sources with grids, various problems in rotor angle stability and voltage stability could occur. As penetration of renewable energy becomes increasingly larger in energy sources, the potential for sustainable energy that leads to major power outages increases, creating a need for heightened awareness. This paper is an attempt to optimize SCADA, which is a revolutionary development in grid network monitoring and control of processes, automation of energy distribution systems, generation of electricity, customer information system and engineering analysis.[11]

Keywords: Optimization, Network, Sustainable Energy, Substation, Scada, Renewable Energy

---

CISDI Journal Reference Format
Adenle B.J,, Adekusibe, K.G., Akinrogunde, O.O. & Alashiri, O.A. (2016): The Optimization of SCADA on Renewable Energy: An Approach to Sustainable Development In Nigeria. Computing, Information Systems, Development Informatics & Allied Research Journal. Vol 7 No 3. Pp 29-38. Available online at www.cisdijournal.net

---

1. INTRODUCTION

The development and diversification of the equipment's, appliances and power supply devices has led to the increase of energy consumption and to the diversification of problems and phenomena in the systems of production, distribution and use of electricity. Thus it was necessary to introduce new energy sources and new elements of automation and control in order to improve management control, monitoring systems and power supply devices both with electricity producers and carriers, distributors and consumers. This determines the power quality and safety in electric power supply, but at the same time the customer use of certain facilities in order to cover the increasingly complex and high standard electricity needs by Bonnano, F. and Patane, G., 1998.[12]

Industry must overcome a number of technical issues to deliver renewable energy in significant quantities. Control is one of the key enabling technologies for the deployment of renewable energy systems. Solar and wind power require effective use of advanced control techniques. In addition, smart grids cannot be achieved without extensive use of control technologies at all levels. Today, unprecedented use of energy which began with the industrial revolution certainly brought about massive increase in productivity and change in lifestyle. Since then energy demand has been in the increase- to produce more products, travel further and faster or to be more comfortable. Physically, energy is defined as the capacity for doing work. The capacities of energy to do work are inherent properties of energy carriers. Although energy cannot be created nor destroyed according to classical thermodynamics, its capacity for doing work can be degraded and destroyed due to system irreversibility in line with the logic of the second law of thermodynamics.

Some of the common energy carriers or sources are coal, petroleum, natural gas, nuclear fuels, biomass etc. Of all these, the most widely used energy sources are the hydrocarbon compounds or fossil fuels which account for more than 80% of global primary energy consumption. For instance, fossil energies provide about 67% of the energy needed to produce electricity - a veritable and the most terminal form of energy for transmission and distribution for industrial production processes. Energy usage has become an important concern in the past years and there has been growth awareness and an increase in taking personal responsibilities in preventing environmental pollution by minimizing energy waste. Energy has been the key to economic development worldwide, but in the way it is sourced, produced and used, two major drawbacks have emerged. First, the overall energy system has been very inefficient.[14]

And second, major environmental and social problems, both local and global, have been associated with the energy system .Climate change and environmental externalities associated with energy consumption have become a major international issue. It has been observed that among the various sectors contributing to green house gas (GHG) emissions, industrial sector contribution was significant; thus mitigating GHG emissions from the sector offers one of the best ways of confronting the climate change problem. Energy efficiency is a major key in this regard. An estimated 10-30% reduction can be achieved at little or no cost by improving efficiency of energy use in the industry.

Although Nigeria is relatively endowed with abundant fossil fuels and other renewable energy sources, the energy situation in the country is yet to be structured and managed in such a way as to ensure sustainable energy development, most especially in the industrial sector. Nigeria as a nation is passing through a serious energy crisis and it has been even more affected not by a lack of energy resources, but largely due to poor resource and financial management, a crippling dependence on imports particularly second-hand goods built with out-dated, inefficient technology etc . As a nation that has limited technological capacity but sees industrialization as constituting a crucial leverage and pre-condition for meaningful development, Nigeria should be wise enough to manage her scarce energy resources judiciously.

The use of energy pervades every aspect of modern society but it is not efficiently used in many industries. In view of the fact that there is an incessant increase in fuel costs, energy efficiency studies are thus rapidly becoming more important. Several millions of dollar can be saved in accumulated energy cost when energy is properly managed. Based on this fact, several researchers have reported on the energy consumption, conservation potential and environmental impact of energy use of different industrial process operations both within and outside Nigeria. Nagesha presented the energy consumption pattern in a textile dyeing industrial cluster and environmental implications in terms of emission of GHGs due to energy use. The study identified substantial scope for energy efficiency and analysed energy consumption in the cluster from an economic perspective. All the economic performance indicators adopted in the study seemed to have significant association with energy efficiency in the cluster. Also, it was observed that the small scale industries which are energy efficient performed better on the economic front and experienced ‘higher returns to scale’.

The study concluded that the firms in the energy intensive product clusters must aim at enhancing their energy efficiency as it leads to multiple benefits and ensures sustainable development in the long run. Fawkes investigated energy efficiency in South African Industry. This study showed that strong incentives exist for energy efficiency improvement in South African industry, in particular, the potential for increasing profit, the need to reduce greenhouse gas (GHG) emissions, the need to maintain economic competitiveness, and the need to delay the cost of new peak-load electricity generation facilities. In their study, Lung et al investigated the impacts that several emerging technologies have had in the U.S food processing industry. This paper assessed the energy efficiency potential for four of these technologies in the U.S. food processing industry. Based on the assessments of these four emerging and newly commercialized technologies, the potential for energy savings in the U.S. food industry is quite strong. In

addition, these technologies have yielded important productivity and other benefits. Depending on the available market portions in which these technologies can be implemented, sector -wide energy savings could range from 1572 GJ and 134 million kWh to 2342 GJ and 186 million kWh. In addition, non-energy benefits such as improved product quality, better production and reduced greenhouse gas emissions are likely. According to Aiyedun assessed the energy efficiency in Nigerian Eagle Flour Mills Limited, Ibadan. The study which is limited based on the available years of data collected (1996-2000) analyzed the energy consumption, productivity and efficiency of the company. The results of the study showed that energy is not quite efficiently utilized in this industry because the energy productivity increased substantially from 0.369 MJkg–1 in 1996 to 0.716 MJkg–1 in the year 2000. An average of 47,810.59 GJ of energy was consumed annually within this period with 44.68%, 0.23%, 42.16% and 12.93% of this energy accruing from electricity, lubricants, diesel and petrol, respectively. The average energy productivity, the average intensity of energy and the average cost of energy input per unit kg are 0.527 MJkg–1, 1.084 GJm–2 and 28 kobo/kg, respectively. The average value of the normalized performance indicator (NPI) obtained is 0.199 GJm–2 which indicates substantial energy consumption for the building type. The areas where the industry uses and wastes energy, and where actions for energy conservation can be implemented were identified.

According to Aderemi, examined the pattern of energy consumption in selected food companies in South-western Nigeria; identified the sources of electrical energy waste and assessed the effectiveness of the strategies for electrical energy savings in the industry. Four sub-sectors of food and drinks industry in the category of Small and Medium Enterprises were examined. They include; beverage, bakery and confectionery, grain mills and storage of cold food products. The study revealed that the pattern of electrical energy consumption in the food companies was mainly from generating set; this was due to either low voltage or epileptic power supply from national grid. Also, the study identified 12 direct sources that lead to electrical energy waste and inefficient energy utilization in the food industry. One of these, among others was the energy loss as a result of worn out or slack / misaligned belts that needed timely replacement or tensioning. Other indirect sources identified include lack of training and retraining of staff, power factor of electrical equipment, and equipment age, among others. In their study, Noah et al carried out a comprehensive energy audit of Vitamalt Nigeria Plc, Agbara using portable thermal and electrical instruments with the objective of studying the pattern of energy consumption and identifying the possibilities of saving energy in the plant. A five year (2000-2004) data on energy consumption of Vitamalt Nig. Plc was collected and analysed. The study showed that the Normalized performance indicator (NPI) calculated over the span of five years gave an average of 1.2 GJ/m2 indicating a fair range in energy performance level classification (1.0 - 1.2) while significant savings and improvement in energy usage is achievable.[11]

1.2 Energy Situation in Nigeria

Nigeria has an abundant supply of natural energy sources, both fossil and renewable. Energy plays a double role in Nigeria's economy: as an input into all economic activities and as the mainstay of Nigeria's foreign exchange earnings through the export of crude oil and, more recently, from increasing natural gas exports. Nigeria's economy is heavily dependent on the oil sector and now on gas too, since both together account for 90-95% of export revenues, over 90% of foreign exchange earnings and nearly 80% of government revenues. The majority of Nigeria's exports of crude are destined for markets in the United States and Western Europe with Asia becoming an increasingly important market of late.

The National energy is at present almost entirely dependent on fossil fuels and firewood which are depleting fast. According to Chendo , recent estimates indicated that the reserve for crude oil stood at about 23 billion barrels in 1998, natural gas 4293 billion m3 at the beginning of 1999, made up of 53% associated gas and 47% non associated gas. Coal and lignite stood at 2.7 billion tones, Tar sands at 31 billion barrels of oil equivalent and large-scale hydropower at 10,000 MW [14] Energy efficiency is a term used in different ways, depending on the context and possibly on the person using it. But it is more commonly understood to mean the utilisation of energy in the most cost effective manner to carry out a manufacturing process or provide a service whereby energy waste is minimised and the overall consumption of primary energy resources is reduced. In other words, energy efficient practices or systems will seek to use less energy while conducting any energy-dependent activity; and at the same time, the corresponding (negative) environmental impacts of energy consumption are minimised. According to The Aspen Institute Centre for Business Education , energy efficiency is defined as the ability to generate the same economic output with less energy input.

Industrial energy efficiency or conversely, energy intensity, defined as the amount of energy used to produce one unit of a commodity is determined by the type of processes used to produce the commodity, the vintage of the equipment used, and the efficiency of production, including operating conditions. Energy intensity varies between products, industrial facilities, and countries depending upon these factors. The objective of an energy efficient industrial system is analogous to "just in time" manufacturing—to provide the appropriate level of service needed to support the production process, to have a backup plan to address emergencies, and to keep the entire system well-maintained and well-matched to production needs over time.

Energy efficiency is rising toward the top of many national agendas for a number of compelling reasons that are economic, environmental and intergovernmental in nature. As many industries are energy-intensive, this is resulting in new impetus to industrial energy efficiency policies. The economic reasons are quite clear. Most important has been the rise in energy prices from 2005-2006 and their likely continuation at a high level. Increasing concerns over energy security (reliability of supply) are a second factor. Energy supply in many countries increasingly depends on imported oil and gas, and supply is being constrained by geopolitical events while global economic growth is resulting in greater energy demand. Additionally, in many developing countries energy efficiency is also a way to alleviate the investment costs for expanding energy supply infrastructure in the face of tight fiscal constraints.

Despite the potential, policy makers frequently overlook the opportunities presented by industrial energy efficiency to have a significant impact on climate change mitigation, security of energy supply, and sustainability. The common perception holds that energy efficiency of the industrial sector is too complex to be addressed through public policy and, further, that industrial facilities will achieve energy efficiency through the competitive pressures of the marketplace alone. Neither premise is supported by the evidence from countries that have implemented industrial energy efficiency programs. The opportunities for improving the efficiency of industrial facilities are substantial, on the order of 20-30% , even in markets with mature industries that are relatively open to competition.

Industrial energy efficiency is dependent on operational practices, which change in response to variations in production volumes and product types. Due to this dependence, industrial energy efficiency cannot be fully realized through policies and programs that focus solely on equipment components or specific technologies. Companies that actively manage their energy use seek out opportunities to upgrade the efficiency of equipment and processes because they have an organizational context that supports doing this wherever cost effective, while companies without energy management policies do not. Providing technology-based financial incentives in the absence of energy management will not result in significant market shifts because there is no organizational context to respond to and integrate the opportunity into ongoing business practice. There are many benefits of increased energy efficiency. These can broadly be categorized into financial/economic, environmental and social benefits. The relative importance of each of these benefits depends on the actual situation in a given country or area, including for example the prices of different types of energy, the cost of energy efficiency measures and equipment, the tax regime and the current levels of energy efficiency already being achieved. For private companies, the most important benefits of higher energy efficiency will be linked to the financial.

2. GRID MONITORING/CONTROL SYSTEM TECHNOLOGIES

Power grid transmission lines must be operated within their total transfer capability (TTC) limits. Using PMU measurement information to monitor phase, voltage stability, frequency and power flow in real time enables the current grid status to be viewed in detail and can assist transmission line operation.

- ✓ Wide area grid monitoring PMUs enable easy measurement of information from wide areas spanning multiple operating areas, enabling tracking of status changes in external grids.

- ✓ Oscillation monitoring since short-cycle waveform information can be visualized in real time, oscillations difficult to track with conventional systems can be monitored and reported to operators.

- ✓ Failure analysis of waveform information when external disturbances such as grid failures occur enables visual display of accident phenomena and rapid feedback into preventive measures.

- ✓ State estimation precision improvement Measurement data can be acquired from multiple measurement points without time lags, and phase data not measurable by SCADA systems can be measured, enabling state estimation with greater precision.

- ✓ Comparative verification of power grid models Actual data can be compared and verified against existing power grid models used in analysis tools.

This enables parameter adjustments for correction of analysis tool simulation results.

Although hardware for monitoring power flow and voltage is needed when the application is preventing overloading or maintaining grid voltage, PMUs are extremely effective since they enable short-cycle measurement. PMUs also enable actual phase measurement and data measurement ensuring synchronization, so they support high-precision state estimation.[11] Sustainable energy can be defined as energy which provides affordable, accessible and reliable energy services that meet economic, social and environmental needs within the overall developmental context of society, while recognizing equitable distribution in meeting those needs. In practice, sustainable energy has meant different things to different people. Some think of it as the energy related to renewable energy and energy efficiency. Some include natural gas under the heading of sustainable energy because of its more favorable environmental quality. Whatever approach is used, sustainable energy always implies a broad context which covers resource endowment, existing energy infrastructure, and development needs. Sustainable energy will, however, require new approaches in the mobilization of energy resources for development. This would involve: shifts to renewable energy sources; development and wide dissemination of sustainable and renewable energy technologies; energy efficiency and conservation; and technological developments that allow the use of fossil fuels in a cleaner way. Sustainable development is defined as development that meets the present needs and goals of the population without compromising the ability of future generations to meet theirs.

Energy is related to the multidimensional aspects of sustainable development: the economic social and environmental perspectives. Adequate and affordable energy supplies have been the key to economic development and the transition from subsistence agricultural economies to modern industrial and service-oriented societies. Energy is central to improved social and economic well-being, and is indispensable to most industrial and commercial wealth generation. It is the key to relieving poverty, improving human welfare and raising living standards. But no matter how essential it may be for development, energy is only a means to an end. The end is good health, high living standards, a sustainable economy and a clean environment. No form of energy — coal, solar, nuclear, wind or any other — is good or bad in itself, and each is only valuable in as far as it can deliver this end.

The requisite of sustainable development is that the production and use of energy should not endanger the quality of life of current and future generations and should not exceed the carrying capacity of ecosystems. Of all the measures that will contribute to meeting this requisite and/or of challenge of sustainable development and limiting climate change, one obvious solution is to use energy more efficiently. That means consuming less energy to produce goods and services, Environmental- friendly new behaviors and working methods, coupled with the use of new technologies that offer better energy performance. Energy-use efficiency is the fastest, cheapest, cleanest way to address these challenges. The efficient use of energy and supplies that are reliable, affordable and less-polluting are widely acknowledged as important and even indispensable components of sustainable development. For the future, the use of PMUs for more detailed monitoring will enable power grids to support large penetration of renewable energy sources. But although PMU-driven grid monitoring technology is on the rise worldwide, the only application that PMUs are currently being used for is grid status monitoring. Hitachi is planning to build on this status monitoring application with work on supervisory control applications that make effective use of PMU measurement information.[12]

3. FINDINGS AND DISCUSSION

In this paper, the management of renewable energy systems was achieved by placing certain measuring instruments served by human operators in the key points of the network. The operators read the values of the measuring instruments located in the system or made the measurements with handheld meters, communicated these values to those responsible for network management and performed the demanded operations. The communication of values or orders was made by phone or walkie-talkie. This process is slow and requires human presence, but most importantly, it can be an important source of errors.Currently, the development of microelectronics has enabled on a large scale the design and implementation in industry of the monitoring, control and numerical control systems.

Due to the constant technological changes that occur in systems based on renewable energy sources, an important requirement for monitoring and control systems would be the possibility to adapt them to new situations and equipment. The systems that allow the extension or altering without requiring reimplementation of the system are named open systems. The key element that allows monitoring systems to have this feature is the adoption of some interconnection standards concerning the module components. The possibility of easy reconfiguration is also given by the use of devices or equipment reconfigured by reprogramming. Thus, the software plays an important role not only in the adaptation of the system but also in its evolution, meaning the modifying or total or partial replacement of existing functions with more important ones. This extensibility has become possible with the development of real-time systems which, in the present context, become the core of any monitoring and control application. The SCADA systems can be viewed as a set of software and equipment destined to data acquisition and transmission of commands from and toward the process. The SCADA systems also inform the operator or the management level on the current functioning state of the surveyed equipments and processes. In other words, the main function of SCADA systems is the automatic generation of commands, the ensuring of the dialogue between operator and surveyed system, the creating of a database for the monitored system and the alarming of the operator in case of important events.

With an application based on renewable energy sources, the SCADA system gathers information such as technical failure in electrical equipment, transfers the information to the central system, generates an alert signaling the failure, and conducts the analysis and the control of the operations to determine if the failure is critical, displays the information in a logical and organized manner according to the time report between the way in which the processes inside the monitored system are performed and the making of operational decisions Moga, M., 2000: on-line (real time), together with the processes in the system (power and voltage settings, data recording, system reconfiguration, etc...). in-line (real time extended), through decisions based on data processing collected in real time but previous to the decision (determining optimal system configuration, optimization of operating parameters, setting the parameters for automation and protection systems, etc). off-line (outside of real time), through activities of planning future developments (off-line analysis of events, training operators, etc).

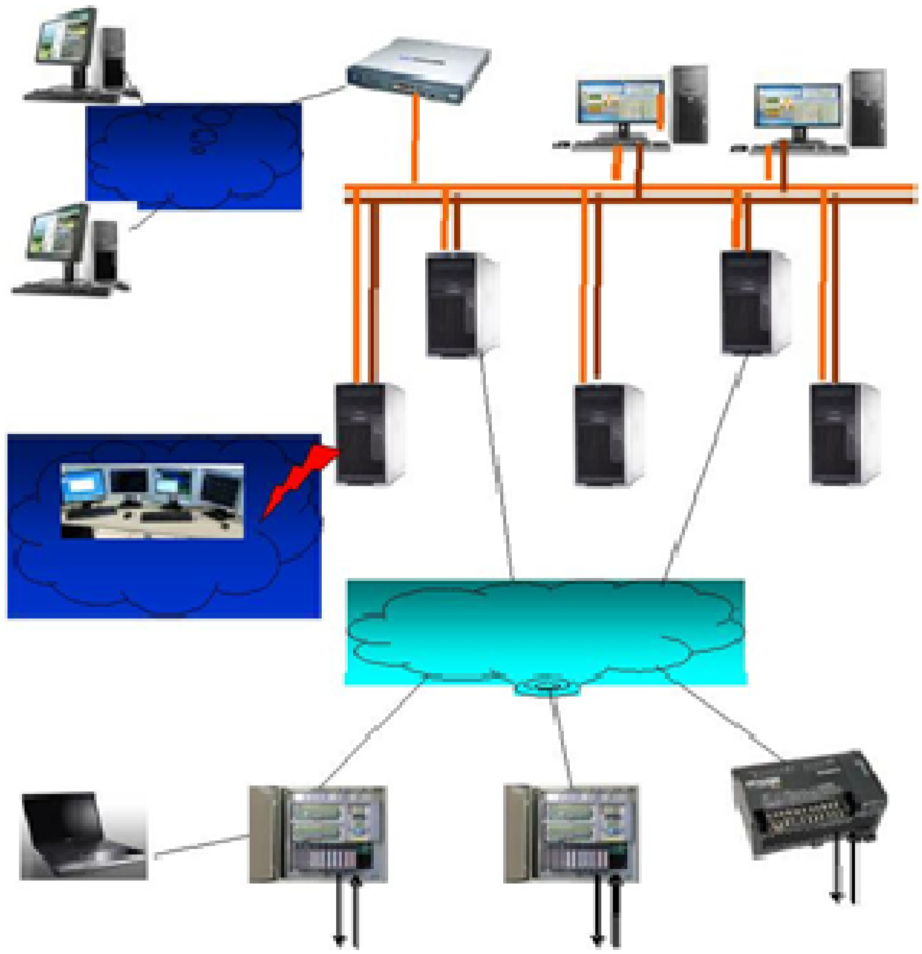

Fig. 1: Topology of a SCADA system for renewable energy based application

A SCADA system typically implements a distributed database that contains elements called points. A point represents a single input or output value, monitored or controlled by the system. Points can be of hard or soft type. A hard point is the representation of an input or output connected to the system and a soft point is the result of mathematical and logical operations applied to other hard and soft points. Point values are usually stored with the time when they were recorded or calculated Zhang, P., 2010. The software component for managing the system should not be neglected in the implementation of such systems. The development and implementation of such applications in different alternatives can be achieved by various methods from those based on simple logic to fuzzy logic-based methods, optimization methods based artificial intelligence, genetic algorithms and intelligent agents.

The development and implementation of a SCADA system based on renewable energy sources for electricity production and consumption means determining and implementing a set of rules and constraints, both for generators and consumers. Fig. 2 shows a summary of these rules. The diagram also illustrates the logic of ongoing processes in a power generation system based on renewable energy.

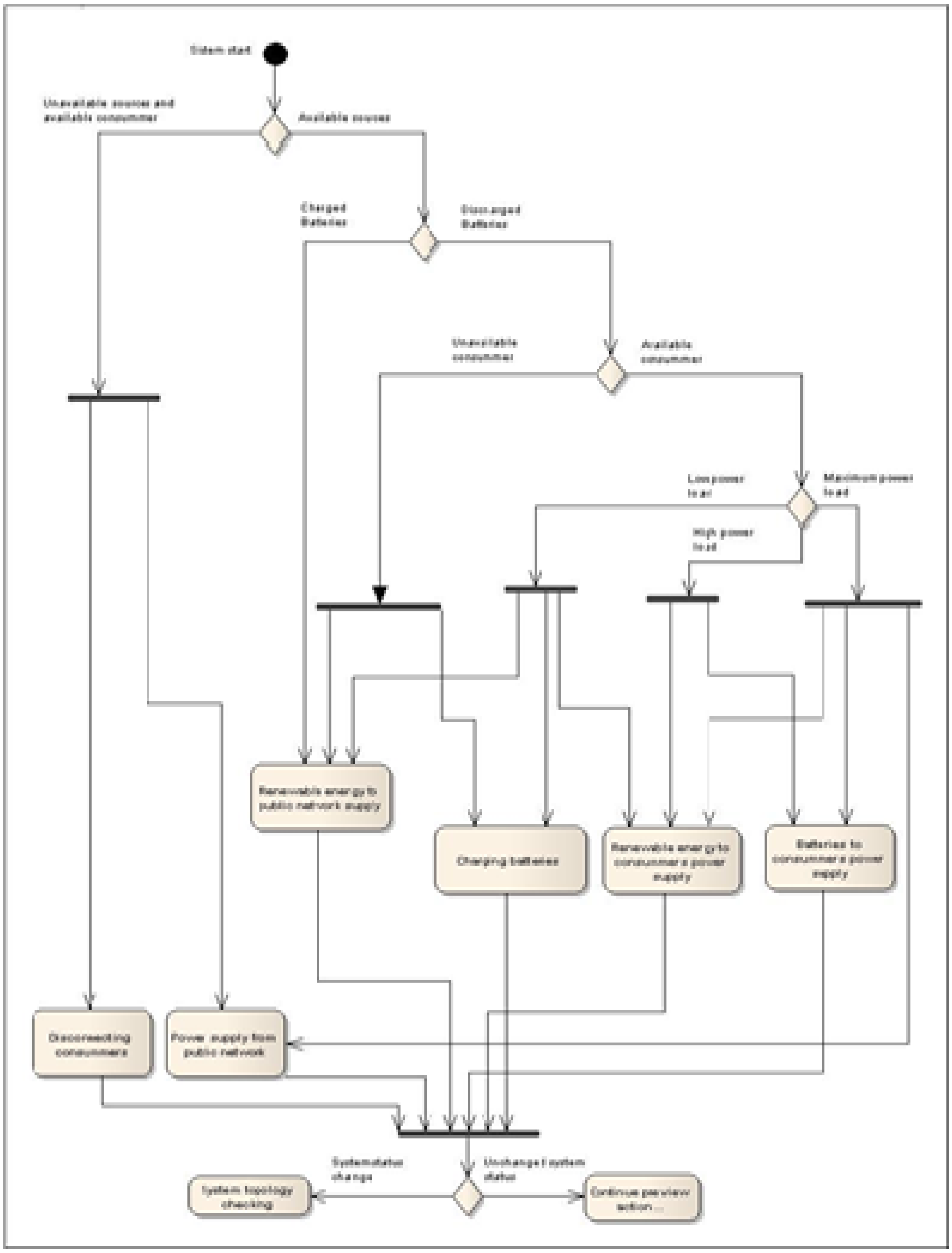

Fig. 2. Management principles for an application based on renewable energy system

The architecture of a monitoring and control system based on computer systems that would cover most of the existing requirements is the architecture structured on three hierarchical levels shown in Fig. 3(a). In this figure we can see that the evolution of physical quantities of interest is monitored by sensors and transducers, and signals are conditioned and processed by a specialized signal processing hardware, such as microcontrollers, programmable logic or processor-based computing structures signal - DSP (the field equipment level). Furthermore, signals are transmitted through operating system calls to the monitors modules, which can graphically display the values of interest, may generate commands transmitted also through system calls towards the command hardware or can store the values of command or purchased databases for further analysis (intermediate hierarchical level).[13]

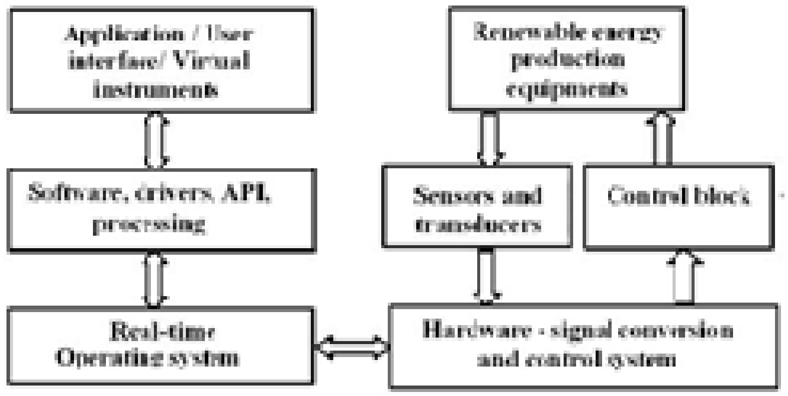

Fig. 3(a) System architecture

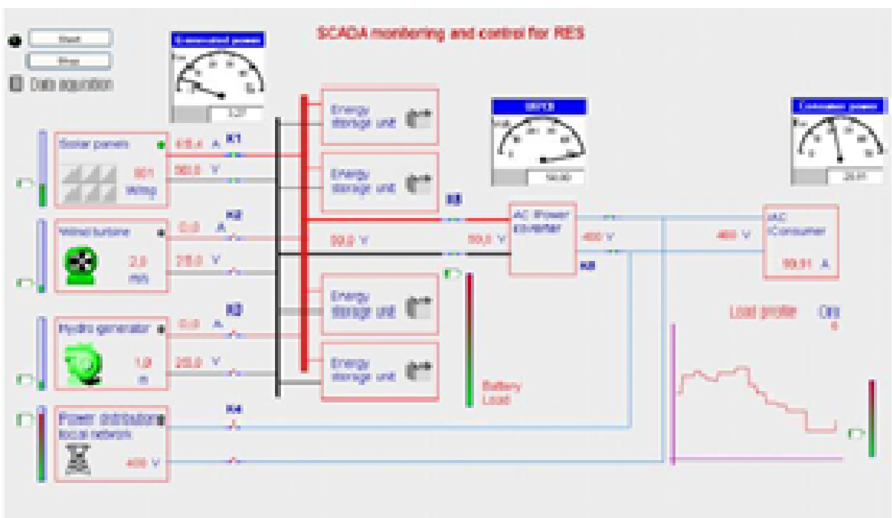

Fig. 3b) Main GUI of main SCADA monitoring and control module

The application of this architecture is represented by complex software with assisting decision function. It is structured in advanced human-machine interfaces built in modules that implement advanced algorithms for monitoring, command and control, often based on soft-computing algorithms, including techniques of artificial intelligence, fuzzy logic, evolutionary algorithms and expert systems. This level allows the use of virtual instrumentation user interface, which is a modern way of tracking the evolution of various physical parameters of the systems monitored with the maintaining of the conformity in the interpretation of data, thus providing to the operating personnel the possibility to adapt easily to new technologies.

The field equipment shall monitor the parameters of interest in the monitoring and control system via sensors, transducers and command and control the function performed by the field controllers. The conversion of the physical parameters into numerical parameters is done using analog-digital converters. Based on these numerical values, the digital-analog conversion and command block works automatically or manually from the GUI on the command parameters of the monitored system. The implementation of the SCADA system is based on the management principles shown in Fig. 2 and on the architecture shown in Fig. 3(a), and is organized around functional modules such as: generators (wind, hydro and photovoltaic), batteries, power conversion, consumer and local network.

All these components are available for configuration, monitoring and control from the central control and monitoring module, which can be accessed through the graphical user interface shown in Fig. 3(b). The figure also shows power generated and consumed blocks, but also shows the measuring of the voltage at the consumer and the converter blocks.

The software module can operate in control or simulation mode. If in the control mode the software module monitors and implements the management and control principles for a real system, the simulation mode can be used for off-line testing. In the latter case the consumer is modeled after a daily load curve representing the power absorbed by it. The implemented scheme allows us to study a system of energy production based on renewable energy sources depending on the availability of primary energy resources, the availability of local network, the charge level of batteries and not least depending on the hourly load curve after which the consumer is modeled.

4. RECOMMENDATION AND CONCLUSION

Energy demands by industries in Nigeria will continue to grow when optimization scada implemented. Presently most of industries are financially and environmentally unstable. With increasing pressure on available resources due to large population, very low GDP, loss of competitive edge in the global market of goods produced in Nigeria, and a drive to catch up with the rest of the world in improving the standard of living of her citizens by at least 2020, Nigeria cannot afford to waste her energy resources through inefficient industrial production processes. There is therefore an urgent need to promote energy efficiency and management measures for sustainable industrial development in Nigeria. Energy flow management requires a close attention from the designers and from those who operate on a long term the renewable energy sources-based systems because long-term operation of these systems depends heavily on weather conditions.

The integration of sources such as photovoltaic panels, wind groups, hydropower groups etc., in a system based on renewable energy sources, must be judiciously analyzed, because these sources provide intermittent electricity. It is no less true that many systems based on renewable energy sources benefit from the existence of electrical networks, which allows the supply from an alternative source when considering local unavailability of primary renewable resources. But this aspect of the centralization - decentralization of power supply plays an important role in terms of network management and distribution system, involving a series of technological and economic calculations about resource consumption and production. To solve all these problems mentioned in the present paper, the main principles of management were identified and they were used for the design, implementation and testing of a SCADA system which can be applied to manage a small power generation system based on renewable energy sources specific to the central area of the Nigeria which operates in isolation or interconnected with the public network. [13]

REFERENCES

1. Design and analysis optimize http://www.ijetch.org/papers/266-T778.pdf
2. Application optimization,http://www.uni-obuda.hu/journal/Kadar_43.pdf
3. Evaluating Microgrid Management and Control with an Implementable Energy Management System, http://smartgrid.ucla.edu/pubs/EMS_system.pdf
4. Securicon, Introduction to Microgrid, ErnieHayden Cis spceh 2013
5. SCADA system security http://webpages.uncc.edu/yonwang/papers/ywangsmartgrid.pdf
6. Design and analysis optimize…http://www.ijetch.org/papers/266-T778.pdf
7. Raph Masiello and S.S. (Mani) Venkata Microgrids 2013- http://www.ateneo.edu/sites/default/files/zprymepowersystems.pdf
8. International journals of Environment and sustainability' Vol.1 No.3, pp.53-65 (2012)
9. Microgrid Protection – 'International Conference on Renewable Energies and Power Quality' (ICREPQ'13)
10. B.E. (ELECTRONICS), programmable logic controller, https://www.eeiitb.ac.in
11. Next generation scada Daisuke Katoa ,http://www.hitachi.com/rev/pdf/2014/r2014_04_101.pdf
12. Control for Renewable Energy http://ieeecss.org/sites/ieeecss.org/files/documents/IoCT-Part1- 06RESG.pdf
13. Sciverse Science Direct Procedia Economics and Finance 3 (2012) 262-267
14. Energy in perspective of sustainable in Nigeria, http://pubs.sciepub.com/rse/1/2/2 © Science
15. Addressing Human-Centered Challenges through Multidisciplinary Innovations and Inter-tertiary Collaborations' Book of Proceedings Series 9 Vol. 1, pp. 471-478 (2016)