MEDWELL PUBLICATIONS SINCE 2000
INTERNATIONAL JOURNAL OF
ELECTRICAL AND POWER ENGINEERING
Journal Home Page: https://medwelljournals.com/journalhome.php?jid=1990-7958

The Development of an Android Applications Model for the Smart Micro-Grid Power Pool System Monitoring and Control

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Key words: Android applications, Human Machine Interface (HMI), Arduino, power pool system, hybridized energy system and smart micro-grid

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Page No.: 12-18
Volume: 13, 02, 2019
ISSN: 1990-7958
International Journal of Electrical and Power Engineering

Abstract: This study presents the conceptual Android applications model for the smart micro-grid power pool monitoring and control scheme. The rational for energy sustainability is the focus of this research. Several hybrid formations are utilized on either standalone or off grid basis without formidable measures to monitor and control the system against energy wastage remotely. This research work proposed smart micro-grid integrated scheme with android enable operated soft-touch human machine interface for the remote monitoring and control of the hybrid power pool system with its load shedding capability for energy sustainability. The optimize hybridized renewable energy resources harvested from the abundant wind, sun, water and bio-resources with the grid and generator sources from afikpo local government area of Ebonyi state was considered as a research focal point. Proteus was used in designing system circuitries for the control and monitoring of the power pool system to ascertain its functionability. Arduino IDE was used in developing, monitoring and control algorithm for the system operation. The sublime text enables HTML, JAVA and CSS program for the android application implementation. The design provides a remote operated touch screen human machine interface for the pool resources to be centrally manage or control thus, eliminating energy wastage. Five communities where selected for this demonstration. The results reveal that the android enable remote soft touch human machine interface facilitates optimal energy operation. Further research work should be tailored towards developing a similar scheme using same approach for up to 10 communities in the similar local government areas to face out energy sabotage.

INTRODUCTION

The quest for the lasting solution to insufficient energy supply through research and technological advancement will not end until 1 MW of electricity is made available for one household. Several efforts have been made, though some of the already existing energy resources that are standalone need to be combined and recombined to optimal and efficient use. Few systems already hybridized required integration into micro-grid system. Siddiquee *et al*. (2015) developed an efficient industrial electrification system from an optimized hybrid renewable energy resource which can be adopted for the rural community application. These rural community electrification in its micro-grid form required adequate management criteria. In that, some communities have this renewable more than others without adequate harnessing it to its full potentials. Wastage of energy is also a factor this research intends to resolve. Remotely enable human machine interface has to be developed to manage or control this hybridized power pool system conceptual ideas via. Android apps.

In Nigeria for example, Ebonyi state has in abundance some commercial energy resources. These energy resources are not uniformly distributed in term of form and location but nearby location seems to has a close related resource that can be harnessed. These will foster zonal, district cooperation and integration by energy pooling. This will minimize the cost of supply, wastages of energy as well as a result of economies of scale (Xing and Isaacowitz, 2004). Recently, Java scripts, HTML and CSS has become the most general-purpose high programing language in that it is both event driven and object oriented. These developments have the potentials of providing the desktop graphical users interface like its PLC counterpart. To affirm its uncommon application in control and automation, it is encapsulated into its features the websites and web applications. The people and technology interaction have enhanced though industrial operation in many areas. The electromagnet water filter system was using Raspberry Pi and human machine interface was developed to ascertain its performance. It is on this note that the programme code interface was displayed on a soft-touch-screen. This allows user to input the system mode run times and as well determine the number of cycles each process should repeat (Hanies and Joyce, 2017).

Literature review: There is no doubt that python can also be used to develop a human machine interface for the control of power system and allie's applications. This is because similar software was experimented and proven by simulation of the operation interface of hybrid energy system using Laboratory Virtual Instrument Engineering Workbench (LabVIEW) and simulink. The LabVIEW is a system-design platform developed with visual programming language from national instrument (Lu and Yi, 2016). Renewable energy is inexhaustible energy with advantages of cleanliness, sufficiency and recyclable in nature. Harnessing energy and allowing it to waste does not encourage economic growth. The integration of the electricity generated by several renewable sources to a centralized point engenders economic growth and eliminate wastages. This has been a practice in Europe before now but on a large scale to the level of intercontinental exchange of power. Our nations are to implement even at community level (Biskas *et al*., 2013). Ghofrani and Hosseini (2016) and Bhandari *et al*. (2015) reviewed some optimized hybridized renewable energy resources and provide a progressive data on the status of renewable energy in the present markets. The emphasis was placed on the potentials of combining numerous sources of energy into a hybrid renewable energy system. The advantages of hybridizing different systems help in overcoming limitations mated on the individual generating system due to its economics nature, reliability, flexibility and abundantly availability. Ashok (2007) advocated for hybrid energy system as a solution for remote/rural electrification with the interconnection in a micro-grid scenario. The research was on the different components of hybrid energy system. A generalized model was developed which supported the optimal combination of energy components for a typical rural community usage. This helps minimize the life cycle cost. The developed model aids hybrid energy system sizing of the hardware with renewables energy option selection techniques capabilities. For some decade, power pool system has been in the market with one challenge or the other. The prime aim of the pool system was to provide a reliable and economic supply of energy to their clients. The intelligent systems reliability assessment show that the market is becoming more concentrated; the loss of load expectation will reduce, whereas the reliability will improve. Similarly, whenever the price elasticity of demandrises, the loss of load expectationwill reduce. This logically means that the more the load, the more strengthen the pool system is because of the large energy invested into the pool system (Haroonabadi and Barati, 2011). None of the remote communities around the Africa are physically or economically connected to an electric power grid through the conventional means of generating electricity. This is as a result of inability to coordinate resource together hence, the necessitated electricity power pool system (Sawle *et al*., 2016). Electricity pooling is a concept of integrating several generated energies into one central usage. This can be intercontinentally agreed and regionally agreed but this design considered a small-scale pooling system for a remote community-based system that are made of renewable resources. These are more or less a market arrangement from agents that have generated enough and believe to have wasted a lot of resources. There are recorded cases of compulsory and voluntary pooling. The voluntary or net pool agent volunteer to buy and sell energy on bilateral agreement whereas the compulsory or gross pool requires that all the generating agents all apart from the small or the smallest ones will sell their output to the pool mangers at the pools agreed price (Onaiwu, 2009).

The model design task: The prime objectives of this work are to develop an Android applications model for the smart micro-grid power pool system monitoring and control scheme with the rationally approach for energy sustainability encapsulation. This prime target was achieved with the aid of the following sub-objectives:

- By designing a remotely enable soft touch screen operated human machine interface to control the power pool system
- By designing a power pool scheme for the five communities in Afikpo local government area of the Ebonyi state
- By designing a hybrid, optimize renewable energy for the five communities understudy considering their energy demand
- By designing a system that is capable of handling the system resources with real-time data documentation, analysis and presentation

Statement of problem: Wastage of power supply has been a serious problem, especially in some areas in Afikpo North, Ebonyi state namely; Afikpo, Amaziri, Enohia, Ozzia and Unwana. Their potential energy resources are left unharvested, even the harvested ones are used on a standalone basis. Lack of resources integrated scheme for a named community led to the wastage of power supply. In order to consistently provide steady power supply, the energy generated from the above communities are integrated for common usage. The developed system maintains steady power supply and provides energy at the same time with ability to ration the generated supply, at a safer cost and eliminate wastage. The solution to this is development of the power pool monitoring and control system which ensures the control and also provide a monitoring medium for quality effectiveness and sufficiency of power supply.

MATERIALS AND METHODS

Materials and resources

Software:

- Proteus
- Android studio
- Arduino ID
- Sublime text

Hardware:

- Arduino Uno (At mega 328)
- GSM Module (SIM900A)
- Relay
- Voltage Regulator LM7805
- Lamps
- Battery
- Resistors
- Current sensor ASC 712

Figure 1 shows the formation of this smart microgrid power pool system with hybridized three sources: The grid; renewable system: wind energy, solar energy and biomass energy and alternative generating set. The power pool experimented design considers five different communities in Afikpo North local government area of Ebonyi state. The pool contributors are Afikpo, Amaziri, Enohia, Ozzia and Unwana.

The system conceptual design model

Circuit diagram for the software implementation: Figure 2 shows how the microcontroller is configured to toggle between the three energy sources with priority to Grid resource followed by the renewable and to initiate the generator startup operation whenever the first two sources are OFF. This was achieved through simulation.

Hardware implementation: The design hardware implementation was achieved using components assembly on bread board and later transfer to the Vero board and soldering process followed on making up the circuit to make sure that all components are permanently mounted.

Figure 3 shows how the microcontroller is configured to toggle between the three energy sources with priority to grid resource followed by the renewable and to initiate the generator startup operation whenever the first two sources are OFF. This was achieved through relay operation.

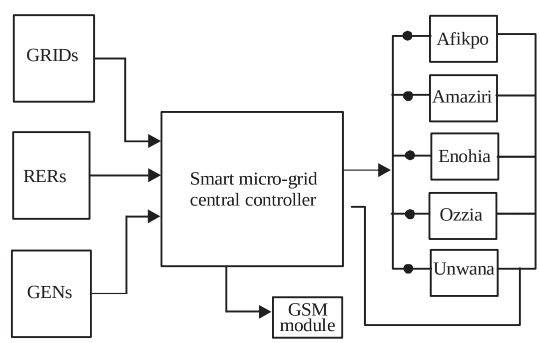

Fig. 1: The block representation of the smart microgrid power pool system

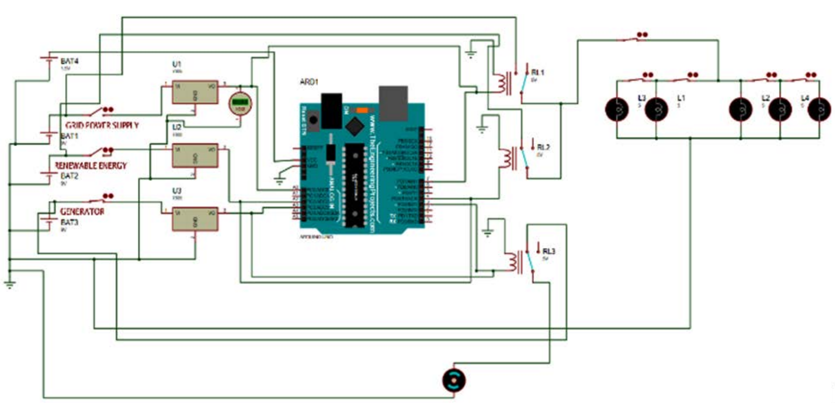

Fig. 2: The circuit diagram of the smart microgrid power pool system

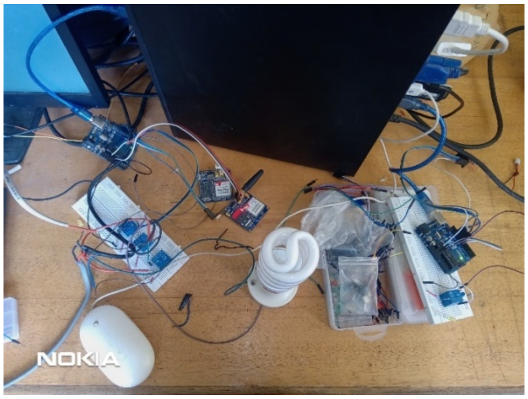

Fig. 3: The implementation model for the smart microgrid power pool system

Fig. 4: The implemented hardware human machine interface model for the smart microgrid power pool system

Figure 4 shows how the microcontroller is configured to toggle between the three energy sources with priority to grid resource followed by the renewable and to initiate the generator startup operation whenever the first two sources are OFF. This was achieved through relay operation. The indicator shows how the five communitie's benefit from the integrated energy resources.

Flow chart; pseudo-code:

```
Check power supply
If grid is available
    Switch to grid
If RE is available
    Switch to renewable energy
If grid and renewable energy are not available
    Switch to generator
Else
Check power supply
```

Mobile application interface development: The remote-control interface is developed using Hypertext Mark-up Language (HTML), JavaScript and Cascading Style Sheets (CSS): HTML provide the overall outlook of the pool interface without any functionality given to the components of the pool interface, it allows for the arrangement of words and paragraphs on the interface; Cascading Style Sheets (CSS) provides several styles and colors used in designing the pool interface. It beautifies the interface making it eye-catching to the pool operator and the JavaScript gives functionality to the components of the interface. The components on the interface are buttons and switches. These buttons and switches are used to actuate the transfer of energy within the system. On the account of each energy transfer, JavaScript enables visible display of the device on the interface. The sign in and up interface for the operator are also designed.

RESULTS AND DISCUSSION

Mobile application interface layout

Sign up Interface results: Soft-touch remote human machine interface results with the layout of the mobile application, a user can control all the three sources of the energy, from grid, renewable energy and generator. The interface which has a label and a switch on a card separated for each energy source. The user has control over all the sources and can choose to turn all sources off with a single click of the switch (Fig. 5 and 6).

From Fig. 7 when the switches are on, the power supply 9V is stepdown to 5V using a 7805 voltage regulator which is now used to power the microcontroller (ATMega 328). Then program uploaded to the microcontroller from Arduino IDE will now control the relay, thereby closing and opening. Then supply is given to the load to the lamps arranged to represent the communities.

There are three relays, each relay is given to the grid, renewable energy and generator, respectively. When the grid relay is on, then the other two relays are tripped off.

In the case of breakdown supply from the grid, renewable energy or generator acts as the backup supply to the load. Backup supply that is battery will charge using grid during normal operation. Thus, DC supply is given to the load without interruption in power supply by switching the relay signal from slave relay to the master relay.

Thus, provide a continuous power supply to the load by means of any of the sources from those that are operating the load, (i.e., grid, renewable energy and generator automatically in the absence of any of the source).

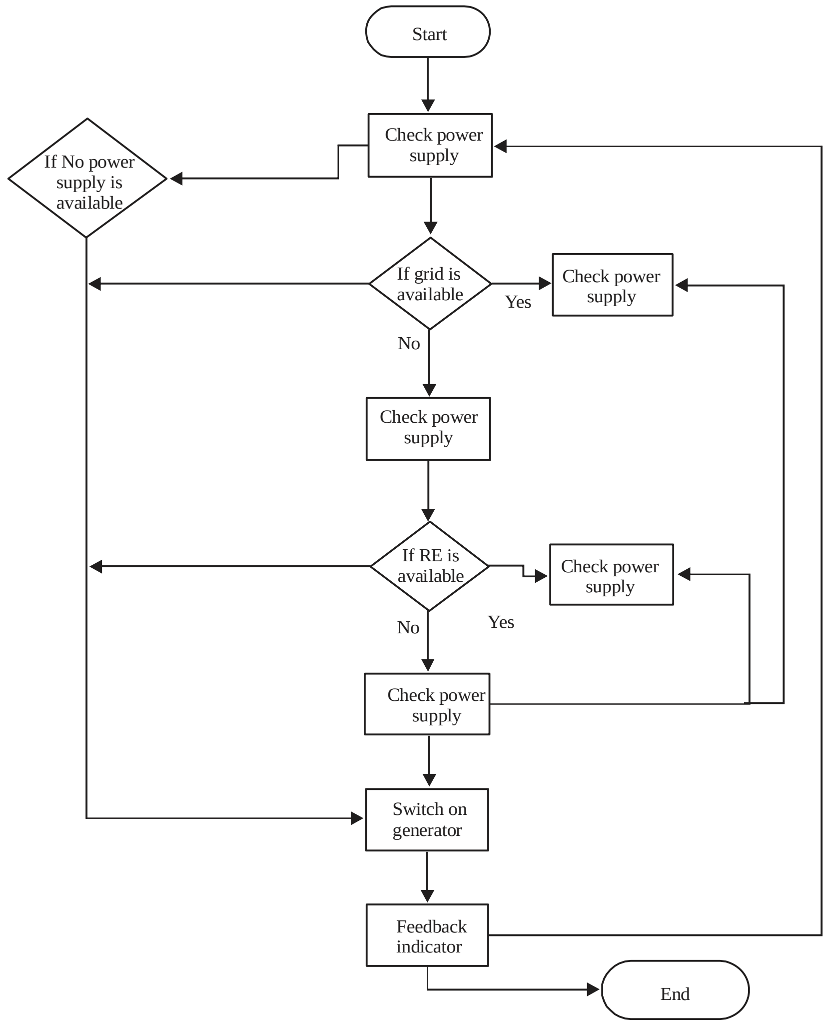

Fig. 5: Flowchart of the smart microgrid power pool system

Table 1: Power supply results to the microcon

Output (Current sensor)	Input (Voltage regulator)	Output (Voltage regulator)	Input (Microcontroller Vcc)
12 VDC	12 VDC	5 VDC	5 VDC

Table 2: Power supply results to load in different communities

Power source	Input (power source) (VAC)	Switch status	App display	Load status
Grid	220 V	ON	Grid	Bulb light
Grid	220 V	OFF	No power	No light
Renewable energy	220 V	ON	Renewable energy	Bulb light
Renewable energy	220 V	OFF	No power	No light
Generator	220 V	ON	Generator	Bulb light
Generator	220 V	OFF	No power	No light

Table 1 shows the input status of the current sensor, voltage regulator input and output as well as input to the controller. In this research, a Table 2 is created with three objects. These objects contain the grid, generator and renewable energy having a Boolean value of either true or false. The Boolean value is determined based on the active source which bears the true value, leaving the rest as false.

Database result: Figure 8 is the cloud storage where both the generated and the consumption energy are documented for future use. The communication between the microcontroller and the mobile application interface are documented on cloud. Cloud storage is built for app to store and serve user-generated content. It is the most suitable storage platform for mobile development data.

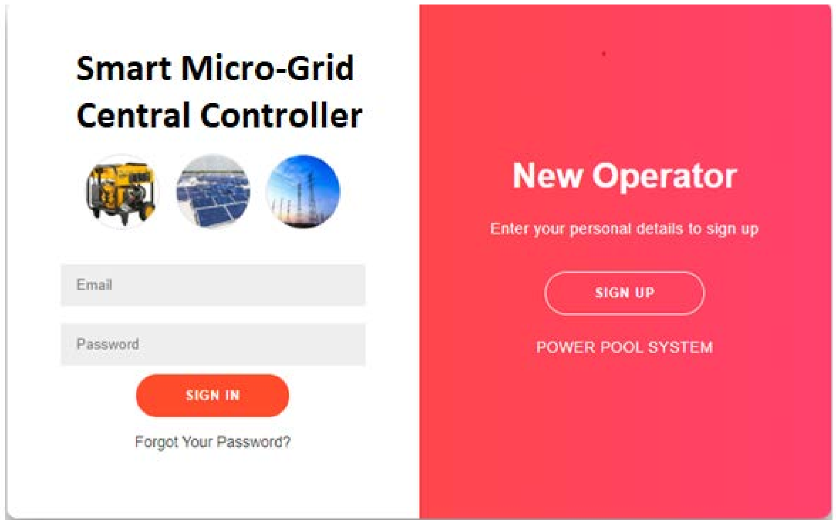

Fig. 6: The Android sign up page for the smart microgrid power pool system

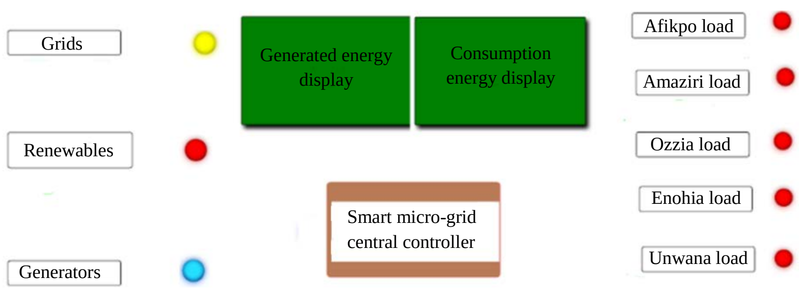

Fig. 7: The remote soft-touch interface for the smart microgrid power pool system

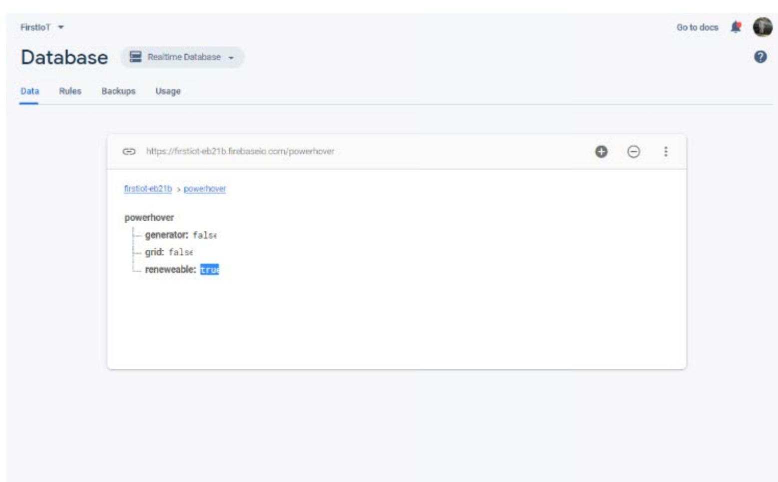

Fig. 8: The cloud storage database for the smart microgrid power pool system

CONCLUSION

The conceptual Android applications model for the smart micro-grid power pool monitoring and control scheme was developed. The rational approach for energy sustainability was achieved and serve as a formidable measure to monitor and control the system against energy wastage remotely. The proposed smart micro-grid integrated scheme with android enable operated soft-touch human machine interface for the remote monitoring and control of the hybrid power pool system with its load shedding capability for energy sustainability was achieved. The optimize hybridized renewable energy resources harvested from the abundant wind, sun, water and bio-resources with the grid and generator sources from Afikpo North local government area of Ebonyi state was put to use. Proteus was used in designing system circuitries for the control and monitoring of the power pool system to ascertain its behavior through simulation and Arduino IDE was used in developing monitoring and control algorithm for the system operation. The sublime text enables HTML, JAVA and CSS program was developed for the android applications. The design provides a remote operated touch screen human machine interface for the pool resources to be centrally managed, thus, eliminating energy wastage. Five communities were selected for this demonstration. The results reveal that the android enable remote soft touch human machine interface facilitates optimal energy operation. Further research work should be tailored towards developing a similar scheme using same approach for up to 10 communities in the similar local government areas to face out energy sabotage.

Contribution to knowledge: The contribution made in this research work: The Android applications model for the smart micro-grid power pool monitoring and control scheme is the major contribution to the work.

The rational approach for energy sustainability was achieved and serve as a formidable measure to monitor and control the system against energy wastage remotely. The experimented smart micro-grid integrated scheme with android enable operated soft-touch human machine interface for the remote monitoring and control of the hybrid power pool system.

The cloud storage where both the generated and the consumption energy are documented for future use was achieved. Remote energy monitoring and control is another achievement.

RECOMMENDATIONS

The development of an Android applications model for the smart micro-grid power pool system monitoring and control scheme: the rationally approach for energy sustainability witnesses the following hindrance which further research work should be tailored towards:

- Developing a similar scheme using with the same approach for up to 10 communities in the similar local government areas to face out energy sabotage
- Zigbee network should added for wider coverage
- Community load assessment scheme should be incorporated

ACKNOWLEDGEMENTS

My profound gratitude goes to the Almighty God for giving me the strength and wisdom to execute this research work despite all challenges and to my Mentors, Engr. Prof D.O. Dike; Engr. Dr. Matthew Olubiwe and Engr. Dr. Jude-kennedy Obichere, I say thank you for your professional guidance that provided a foundation for research action tothrive successful.

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