Development of Smart System for Renewable Energy Hybrid Power System Base on *SCADA*

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Abstract. This paper presents the development of smart energy monitoring and control system for Renewable Energy Hybrid Power Generation System (REHPGS) using SCADA. REHPGS model consists of photovoltaic, wind and gen-set system. SCADA is used to monitor and control the operation of Hybrid Power System (HPS) in real time. This paper planned a concept of smart grid by VisconDua Remote Terminal Unit (RTU)-IO Module. The RTU is responsible to collect information from power HPS plant. SCADA Expert controller is introduced to automatically control renewable energy sources. The monitoring and control system of REHPGS operated in real time and can perform under various operating conditions. The HPS plant will be fully automated, which mean the power plant would rely on the SCADA system on all its operations. Results show that the proposed system has the capability to monitor and optimize the output power generation of REHPGS.
Keywords: Smart energy, REHPGS, SCADA, RTU.

Introduction

In remote areas in developing countries, many people who have felt the presence of electricity, mainly for their social, educational purposes and economy development (Yamegueu *et al.*, 2011). To get a standalone generator using diesel generator systemis not economical because the price of diesel fuel is very expensive. Because of the increasing number of population, energy consumption in the future is also increasing (Lau K.Y at al. 2010).In fulfilling its energy needs in remote areas, renewable energy (RE) is a very appropriate choice. Many renewable energy sources available in nature like solar, hydro, wind, etc.(Wichert, 1997).In many applications several renewable energy sources are combined so as to provide a more reliable power supply and economical. The PV - wind - diesel generator hybrid system is the most suitable solution in terms of economic performance and pollution. Hybrid Power System for RE design should provide a reliable power supply and cost - effective for supply the load (Haidar *et al.*, 2011).

With the development of information technology and telecommunications, energy and distribution so that arrangements can be made with a system that call is SCADA system. Power measurements made in real time and then transferred over by network for processing on a remote monitoring centre (Arghira at al., 2011).SCADA for power system was developed in the 1960's and has been improved since then. The architecture of SCADA changed in the philosophy of computing in organization, fromthe mainframe-dominated, centralized computing systems to network-based distributed computing in the early of 1990's. The modern SCADA that is called open distributed systems has designed based on this new architecture.

This Paper proposes a novel monitoring and control system for achieving real-time monitoring and control of a PV-Wind-Diesel Hybrid Power System. The proposed system constitutes a Supervisory Control and Data Acquisition (SCADA) integrated with Microcontroller-based Remote Terminal Unit and variety of transducers and control devices.

Materials and Methods

SCADA hardware: remote terminal unit

Remote Terminal Unit (RTU) is the ability to perform data acquisition and control of a substation is required of a terminal that can meet these requirements, RTU installed at each substation or plant centre are going to be monitored. RTU is tasked to find out any conditions of high voltage equipment through the collection of electrical quantities, equipment status and alarm signals are then transmitted to the control centre via the telecommunications network data. RTU can also receive and execute commands to change the status of high voltage equipment via the command signals sent from control centre.

I / O module are an interface with the equipment that was in substation. So the main function of the module I / O is to serve the input and expenditure for the analogue and digital signals from the contacts, transducers and other signal sources of electrical power equipment.Telemetering (TM) coming from the transducer is connected directly to the Analogue Input module. Telemetering kinds of arrangements are monitored by a central load are:

1. Voltage measurement (Volt)
2. Power Active measurement (kW)
3. Power Reactive measurement (kVar)
4. Current measurement (A)
5. Frequency measurement (Hz)

Tele Metering is a remote data collection or data retrieval measurement is performed by the RTU metering then the data is transmitted and stored in memory where data collection is still updated for 24 hours. The kind of data is displayed like bellow:

- Data reporting.
- Graphic/power curve.
- The power calculated.

Tele signalling (TS) which comes from the substation equipment connected to the digital input module. Tele signalling function for sending signals over symptoms or changes in circumstances on the substation for setting distribution Centre, as well as reading status data in the substation equipment , such as the status of the contactor close or open. With disorders of the substation is expected to be detected more quickly because the monitoring control centre of the main switch status can be known in real time.Telecontrol (TC) issued from the analogue output modules are connected to substation equipment that can be regulated loading system. Telecontrol (TC) issued from the digital output modules connected to the Start / stop relay unit that can be controlled.

The power installed capacity of 3 kW and demand of the order around 2.5 kW, there are 1 kW of Wind power, 1 kW solar system and 1kW generator set.

ViscondDua remote terminal unit

ViscondduaRemote Terminal Unit (RTU) is a hardware device that can control the activities of electric power system intelligently. The device was designed and developed by Prestigious Discovery Sdn.Bhd, which strongly supports its function SCADA system. Basically ViscondDua remote terminal unit consists of input and output modules (RTU port). This module provides a single card for CPU and three cards for I / O. All cards are placed on the motherboard and intertwined. The three types of I / O card can be used for digital input (DI cards), digital output (DO card) and analogue input (AI card). The three types of I / O card can also be used simultaneously or separately (Prestigious Discovery Sdn. Bhd. 2011).An example of a Viscon Duo RTU subsystem with all these components installed is as shown in the Figure1.

Figure 1.Viscon Dual Remote Terminal Unit

SCADA software: SMART controller

The Expert Controller is developed using modular concept and written using Microsoft Visual Basic 6 programming. The modularity of the controller integrates various types of generators with different priority options, loads, knowledge base and database. One of the key points of modular concept is to use high-level abstractions models of HPS. The high-level models shall contain information about their behaviour and interaction that is essential to the expert controller functions such as scheduling of generators, switch in to utility grid- connected power supply, ensuring power balance, grid stability, etc.

Figure 2 shows the flow diagram of the integrated power. The controller input are solar power (PV), Wind power and generator set power and average hourly load demand. The controller sense the load if solar power (PV) power is available (i.e. between 8AM to 6PM), the PV will supply power to the load. If solar power (PV) is less than the load, then Wind Power and generator set will run depending on the range setting. When solar power (PV) is unavailable (6PM to 8AM), this is the time where power from Wind and Generator set used to supply the load.

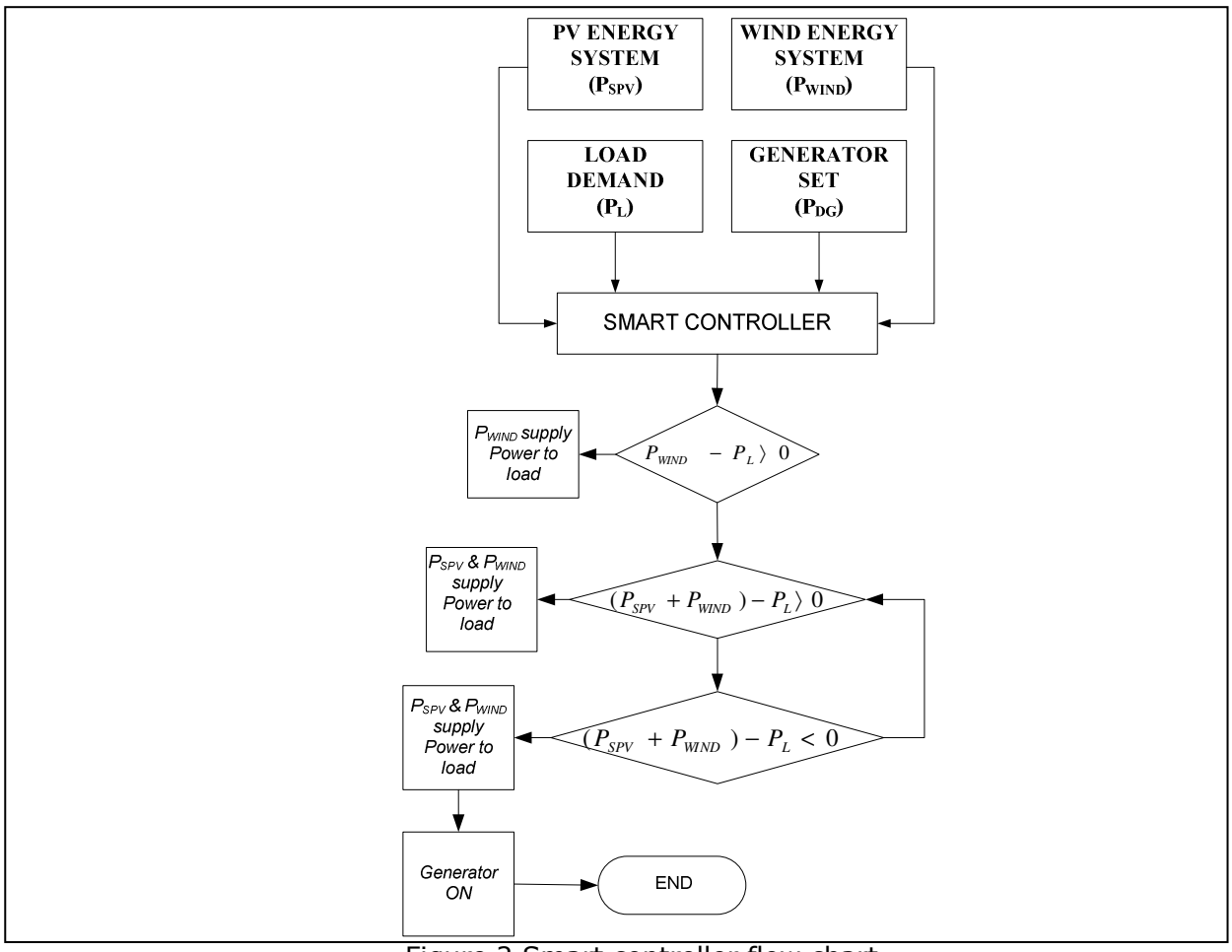

Figure 2.Smart controller flow chart.

Configuration system

The hybrid controller used to arrange the power generated by renewable energy. An industrial SCADA system by Prestigious Discovery Sdn. Bhd. provide internet function combines

with multifunctional digital power meters is also shown in Figure 3. In the figure 3 also shows the relationship the control centre with RTU, where the main function control centre to set up communication between itself and with RTU. The control centre is used to send and receive data from the RTU and then translate that information into a form understandable user, distributes the information to the Man Machine Interface (MMI).RTU acts as a switching service, change of state of the load and perform real time measurements. The Control centre to monitor the load flow and control the RTU found in plants. RTU is a terminal that determines the distribution of signal generator which will in turn and the control centre sent the data signal to the RTU.

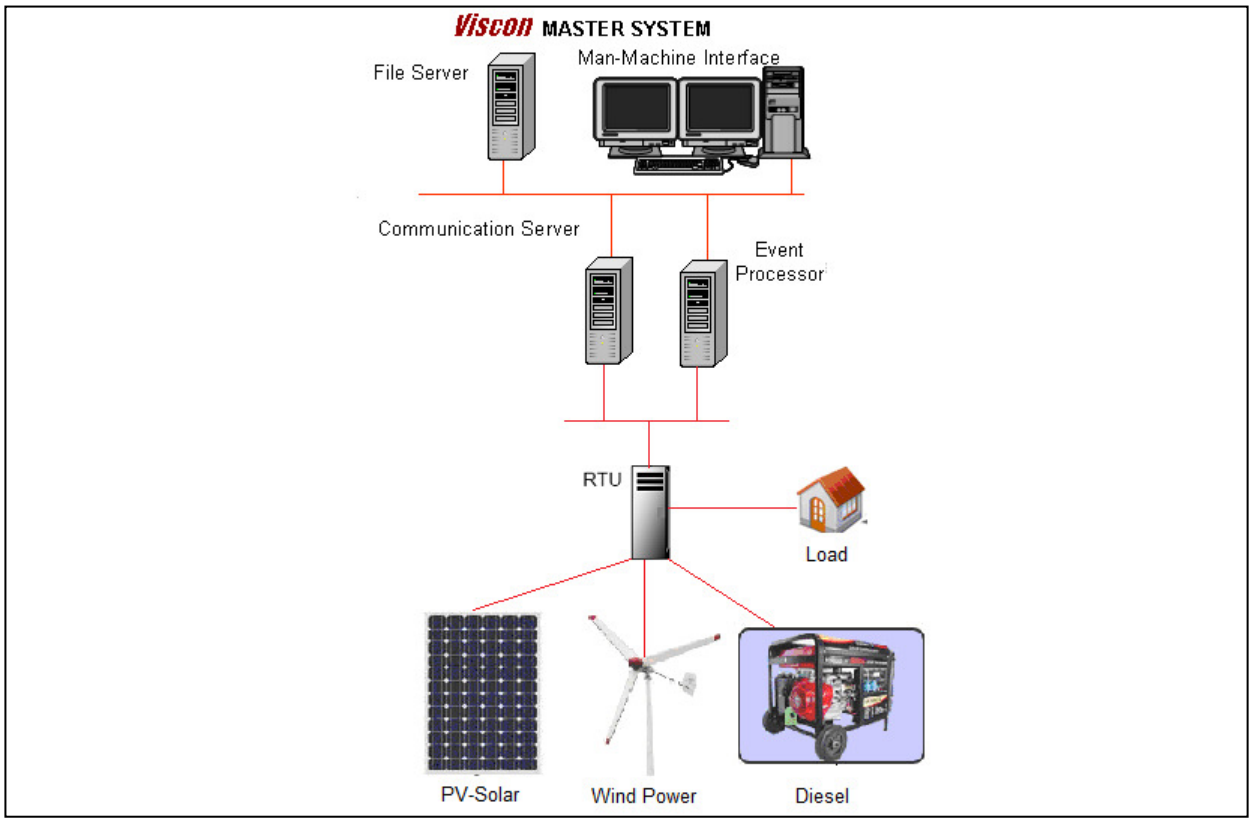

Figure 3. Configuration of development smart system for wind-PV-diesel hybrid power system

Results and Discussion

The electricity consumption data used in this investigation was measured and recorded for a typical off-grid remote house for a 24 hours period. The data was recorded every 2 hour. Table 1 shows the daily load profile for the remote off-grid house for 24 hours. For a typical day, higher energy consumption is observed during the daytime with peaks occurring between 08:00h–12.00h and 20:00h–22.00h, and lower energy consumption is observed at the morning hours.

To determine the power of load used sensors that serve to detect fluctuations in load. So in this case the sensor will read some logic load conditions to provide information to the RTU, which is the mode I needs loads 0-500W, mode II load power between 500W and 1500W and mode III above 1500W. Then the characteristic of RE power also used for control logic in the distribution of power, such as PV and wind power is equal to zero so that the power supply is taken over by generator set. If one of RE generation is zero, so that the RE is supplying to the load up to the maximum, but when exceeding, the generator set will be turned on. RTU work based on this logic and it can be ordered MMI to running the generator is required.

Table 1.The daily load profile.

Time (h)	PV Power (W)	Wind Power (W)	Gen Power (W)	Total Power (W)	Load (W)
24.00	0	625	0	625	150
02. 00	0	500	0	500	120
04. 00	0	375	0	375	120
06. 00	0	0	1000	1000	900
08. 00	232	500	1000	1732	1550
10.00	1230	375	1000	2605	2100
12.00	1330	375	0	1705	1400
14.00	710	250	0	960	780
16.00	270	750	0	1020	680
18.00	90	1000	0	1090	920
20.00	0	750	1000	1750	1700
22.00	0	500	1000	1500	1500
23.00	0	625	0	625	300

In Table 1, where the condition of the load will be read by a sensor at 24.00am-4.00am and give a signal to RTU where the power required by an average of 130W as the logic is mode I. So the RTU will instruct MMI to run the sources generating sufficient capacity. In this condition, the smart system will only turn ON the wind energy generation as shown in Figure 4. While at 6.00 am the average power is about 900W, in this condition, none of REs are in the OFF condition, so the power supply is taken over by generator set. Between 8:00am-11:00am, the condition is using logic III as the required average load power is about 1825W,therefore all the plants will operate as shown in Figure 6. While the model II where the load logic between 500W to 1500W are shown at 12:00 to 18:00 pm, which in this model that works all the REs, while the generator set in the OFF position as shown in Figure 5.

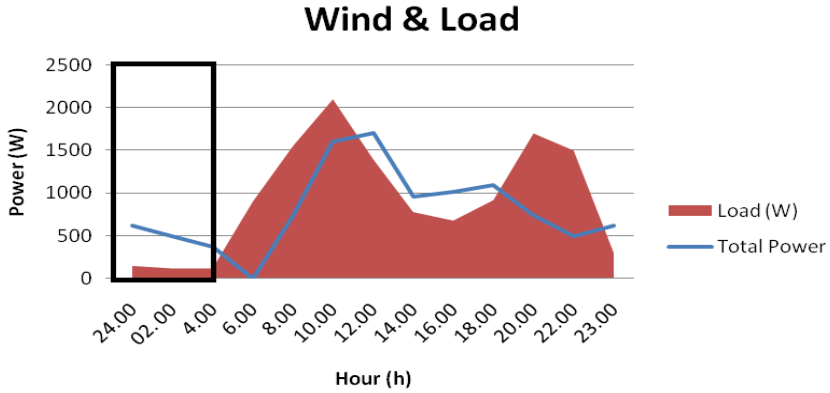

Figure 4.The wind power to suplly load demand.

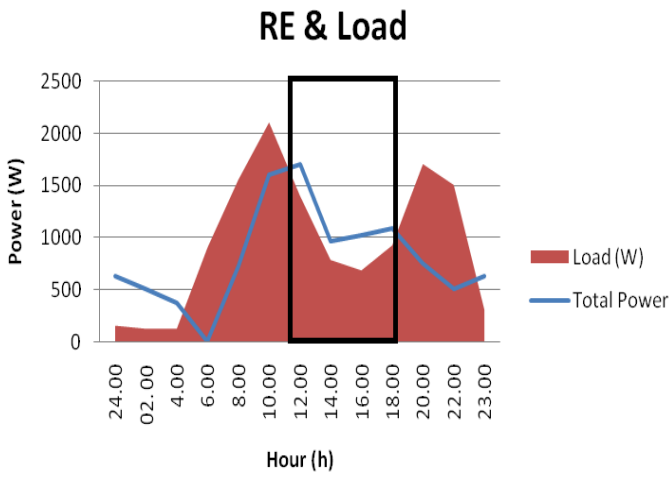

Figure 5.The RE power to suplly the load demand

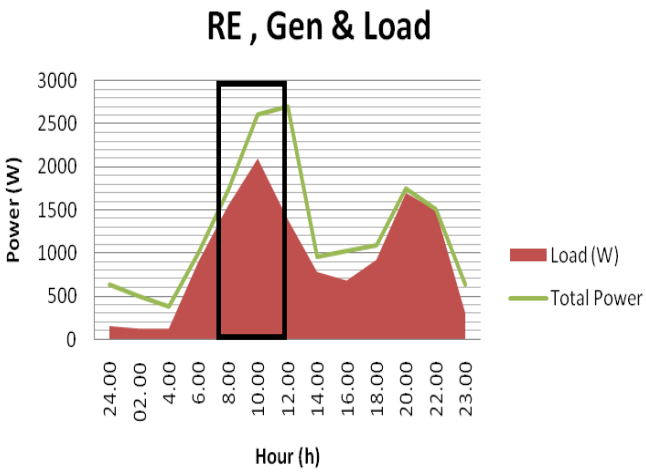

Figure 6.The RE and generator set to supplythe load demand

Conclusions

Nowadays electrical energy derived from renewable energy has been used throughout the world on a relatively larger scale. Therefore, renewable energy sources cannot provide continuous energy and it needs to be integrated with other alternatives such as diesel generators. Thus, the electrical energy can be accepted throughout the day and the system reliability can be improved and the unit cost of power can be minimized.The use of smart systems based on SCADA can optimize the power distribution of hybrid power system for renewable energy generation. For remote areas, the setting hybrid wind power, solar and diesel is more economical impacts and can meet the electrical energy needs for 24 hours. The control of SCADA systems can be performed by computing at remote monitoring centre.SCADA-based intelligent system can maintain the power generation equipment from premature wear due to the using it is not continuous for all day. From the analysis of the data obtained for use in remote areas of household expenses power averaged only 2200 VA and peak load occurs only for 2 hours , so the use of diesel should not be too long, just 2 hours.

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