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Hybrid Renewable Energy Systems for Efficient Energy Generation, Storage and Monitoring of Electric Vehicles at Remote Charging Stations

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Abstract—This paper describes design of configuration for hybrid renewable energy system (HRES) to achieve efficient *energy generation, storage and monitoring using PLC-SCADA (Programmable Logic Controller, Supervisory Control and Data Acquisition) System suggested for electric vehicles at remote charging stations. The use of renewable energy sources is the major factor promoting for generation of clean energy around the globe. The conventional energy sources are depleting day by day due to its continuous consumption worldwide. The configuration study describes strategy to integrate multiple hybrid renewable energy sources, such as solar PV, wind power and biomass for continuous production of clean energy and monitoring purpose. The generated power from HRES can be measured using industrial controller PLC in which all source are integrated using power line transducer and monitored with the help of SCADA system. PLC-SCADA based system consists of rugged industrial programmable controller with high-level supervisory control and data acquisition facilities. The major advantage of HRES is to utilize generated power to charge electric vehicles at any remote locations. The proposed configuration can be easily implemented to monitor power from hybrid renewable energy sources and helps to deliver sustainable power as per load demand.*

***Index Terms*—hybrid energy, demand, power, depletion, remote location, supervisory control, PLC, SCADA, electric vehicle**

I. INTRODUCTION

The utilization of renewable energy sources has becomes important aspect in front of all human beings now days, because of finite source of fossil fuels are present on the earth. Furthermore, use of fossil fuels for power generation causes environmental pollution; consequently increasing the global temperature. The demand of electricity is increasing all over the world day by day as population increases. The major traditional power sources such as coal, fossil fuels, natural gas, petroleum etc. depleting due to faster consumption of these resources. Finite source of these non-renewable energy sources have been rapidly decreased in recent years. The major reasons for resource depletion are technological, industrial development and population growth. The non-conventional energy sources such as solar, wind, biomass, geothermal, hydropower's are on peak demand. They are clean source of energy. Solar and wind energy systems are being considered as promising power generating sources due to their availability. A review on the hybrid power generation using two or more energy sources such as solar, wind, and hydropower for period of five year from 2010-2015 is reported[1]. The integration of hybrid renewable energy sources with micro-grid and different topologies, energy management algorithms are discussed in detail for hybrid energy storage system [2].

The power generation in remote area is one of the important application of hybrid renewable energy systems, however one drawback which is common to solar and wind energy sources, is their unpredictable nature, dependency on weather conditions. The variations of solar and wind energy may not match with the time distribution of load demand. So power is stored when there is low demand and it can be used when load demand increases. Popular application of these systems is that generated power can be used to deliver to electric vehicles for charging purpose. The comparative study of developed products for a smart EMS (Energy Management Systems) is reported in order to optimize the use of PV production and consumption by consumers [3]. The wind energy is one of the main renewable energy sources. The stand-alone wind energy systems may not be

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practical for fulfilling the electric load demands at the places having unsteady wind speeds with high unpredictability. At those places wind-hybrid energy systems, comprising of the wind energy system combined with one or more other renewable energy systems, can be of great significance in overcoming the weaknesses of stand-alone wind energy systems [4]. The renewable technologies are environmentally sustainable and convenient alternative. These hybrid renewable energy systems have been studied for power generation using solar-wind-biomass sources [5-7]. Different configurations have been developed for generation and utilization of power renewable energy sources. The four types of Multi-Input Power Converter (MIPS) are reported for integration of the dc Bus and a hybrid renewable power supply system for general DC household appliances [8]. The optimized load model based on substitution effect of renewable energy generation has been discussed [9]. The new technologies such as Internet of Things (IoT) play an important role for monitoring real time data from physical objects over the internet network. Many physical objects with internet connectivity are embedded together to exchange data. A key features, architectural elements and applications are reported [10-11]. The various applications of IoT such as cloud service based monitoring of photovoltaic systems and Wind-PV-Battery based energy monitoring system are reported [12-15].

In this paper, design configuration for hybrid energy system has been proposed for efficient energy generation, storage and monitoring. The rugged industrial controller (PLC) with data acquisition system (SCADA) has been described with its configuration to monitor produced energy from hybrid system.

II. HYBRID RENEWABLE ENERGY SYSTEMS

Hybrid renewable energy systems are becoming popular as stand-alone power systems for providing electricity in remote areas due to advances in renewable energy technologies and subsequent rise in prices of petroleum products. A hybrid energy system, usually consists of two or more renewable energy sources used together to generate the power. In present work, we have considered three renewable energy sources. Solar PV (Photovoltaic), wind mill, and biogas plant. All these are clean source energy. These sources generates power in different form i.e. solar panel generates DC power; wind mill and biogas generate AC power. The general block diagram of hybrid energy system is shown below.

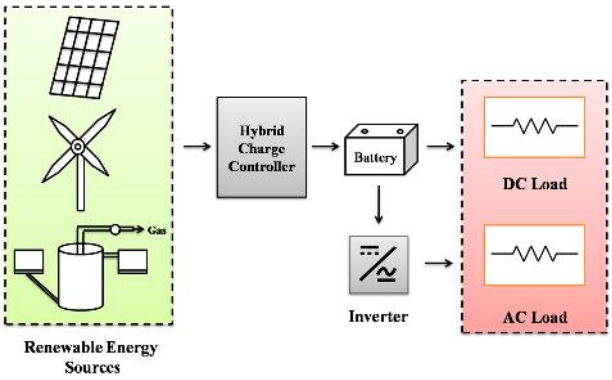

Figure 1. Basic block diagram of hybrid renewable energy system

Biogas is generated using anaerobic digestion process of organic waste material. Biogas is mainly composed of methane (CH_4), and carbon dioxide (CO_2) gas. Methane is flammable gas. Conversion of biogas to electric power by a generator set is much more practical. In most cases, biogas is used as fuel for combustion engines, which convert it to mechanical energy, powering an electric generator to produce electricity. The combustion engines are available in market such as gas turbine, gas motor and diesel engines etc.The generated power from all sources is stored using hybrid charge controller. A charge controller limits the rate at which electric current is added to or drawn from electric batteries. The wind-solar charge controllers can simultaneously charge the storage batteries. The maximum powers available from individual sources are stored. If one of the sources is not generating power then storage batteries will charged through available energy source. The complete safety function of hybrid charge controllers prevents overcharging and may protect against overvoltage. It provides anti-reverse connections protection of solar batteries, lightning protection, current limiting protection, temperature monitoring and short circuit protection. The use of high-quality charge controller ensures good battery management which extends battery life and reduces associated costs. The charge controllers available with functions such indication for the status of battery voltage, temperature, voltage or current from sources etc.

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There are different types of hybrid charge controllers available with multifunctional capabilities. These are ON-OFF charge controller, MPPT (Maximum Power Point Tracking) controller and PWM (Pulse Width Modulation) controller. The ON-OFF charge controllers are earliest kinds of PV charge controllers. It monitors the battery voltage and when the voltage comes up to a pre-set point, it disconnects the PV modules.When the battery voltage settles down it reconnects the modules. The MPPT charge controllers truly identify the best working voltage and current of the energy source exhibit and match that with the battery bank. The third charge controller is the PWM which are most effective charge controllers. When a battery voltage reaches the regulation set-point, the PWM algorithm slowly reduces the charging current to avoid heating and gassing of the battery, yet the charging continues to return the maximum amount of energy to the battery in the shortest time. The result is a higher charging efficiency, rapid recharging, and a healthy battery at full capacity. PWM controllers are less expensive than MPPT systems due to less complexity.

III. DATA ACQUISITION USING PLC-SCADA

The measurement of power from hybrid energy sources is important and crucial task. The process of measurement starts with data acquisition. Data acquisition is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer.

A. Power Line Transducers

Transducers play an important role for measurement of physical quantity and converts into measurable electrical quantity. As active transducers generate electrical output without any external power for its operation while passive transducers require an external power source to operate. To measure the power, we use power line transducers which are specially designed to measure power from various sources. Power line transducers are suitable for measuring electrical parameters like AC voltage, current, frequency, KW (kilo watt), PF (Power Factor) and for DC signal isolation. They are best suited for PLC- SCADA based data acquisition and metering systems. The PLC requires industrial standard 0-10 V DC or 4-20mA current as input signal. The power line transducers designed to convert high AC voltages into low DC signals. These signals are compatible to PLC input for measurement purpose.This transducer works in harsh environment and gives reliable, linear output signals.

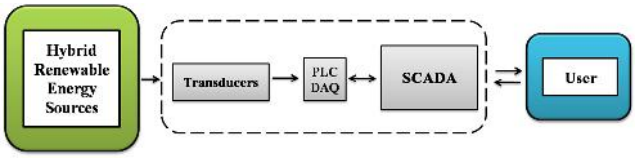

Figure 2. Block diagram of user interface with hybrid energy sysem using PLC-SCADA

B. PLC and SCADA Systems

A programmable logic controller (PLC) is an industrial digital computer which has been ruggedized and adapted for the control of manufacturing processes. These processes are assembly lines, or robotic devices, or any activity that requires high reliability control and ease of programming and process fault diagnosis. Ladder logic is programming language used to develop software for PLC used in industrial control applications. The programmable logic controllers are replacement of hard-wired relays and timers which were previously used in control industries. Due to complex design and wiring constraints of relay logic, PLC in developed to increase reliability, flexibility and accuracy in process control industries. The SCADA is Supervisory Control and Data Acquisition. It is real time monitoring and controlling software platform for local or remote industrial equipment. i.e. motor, pump, valve, and relays etc. SCADA has several advantages such as increasing production efficiency, man power reduction, reliability of systems, supervisory control and monitoring from remote site which save time etc. Dynamic process graphic, security, device connectivity, database connectivity, alarm and real-time historical trending are features of SCADA system.

To communicate the SCADA with PLC, device drivers are must. The communications protocols such as Ethernet, RS232/485 are industrial standard protocols which used to communicate with other hardware or software. PLC has Ethernet connector, and RS232/485 serial connectors to communicate with the other PLC or SCADA system. The importantfeature of a SCADAsystem is its ability to

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communicate with control equipment inthe field, through the PLC network.

IV. CONFIGURATION DESIGN

The configuration of hybrid renewable energy is nothing but the systematic arrangement of different electrical components in logical manner. The power generation from different sources with their storage and control strategy is considered in present design work. The total power generated hybrid energy system equal to the addition of the power generated by the solar PV panel, wind turbine and biogas plant. It is mathematically represented as,

$P_T = ((Ns \times Ps) + (Nw \times Pw) + (N_B \times P_B))$,

Where,

P_T is the total power generated,

P_S is the power generated by solar panels,

P_W is the power generated by wind turbines,

P_B is the power generated by biogas plant,

Ns is the number of solar panels used,

N_W is the number of wind turbine,

N_B is the number of biogas plants used.

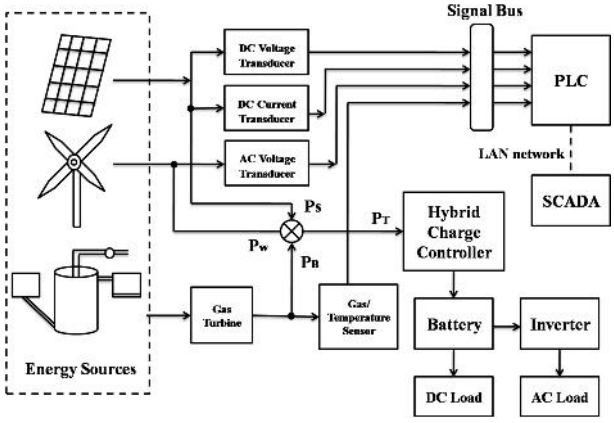

Figure 3. Configuration of hybrid renewable energy system for electric vehicles at remote charging stations

In present work, configuration design is considered with a single unit of three differentpower sources.The power from individual source is represented mathematically which isdescribed in detail [16]. The power from each source is in different forms. Such as solar panel generates power in DC voltage at its output, wind mill generate power in AC voltage and biogas which is converted into electrical AC power using gas combustion turbine. To combine power generated together, we use hybrid charge controller. It takes power from these sources and store in the storage batteries. Then stored DC power drives the DC load as well as AC load with the help of inverter. To get maximum power at the output of inverter, the higher power factor is always recommended. The master-slave network of PLC connected to different local power plant for supervisory monitoring and control purpose.Each power source is connected to the central managementplatform. Themaster PLC communicates with a SCADA system thatenlarges the system communication capabilities, allowing on-line monitoring and control, events recording, alarm management, etc using SCADA is reported [17]. The self-sufficient hybrid systems based on renewable energy and hydrogen is designed and its power is monitored using LABVIEW-based SCADA system is reported [18].The power generated from all sources should be greater than demand so that load can be easily driven in continuous manner. The day by day increasing demand of power so it is quite difficult to monitor generated and consumedpower efficiently. For that, the smart devices play an important role to solve the complexity of the system. These smart devices are connected to the site location using internet network. They communicate to central network station and send real time data of generated and consumed power.

V. CONCLUSION

In this paper, design configuration for hybrid energy system has been proposed for efficient energy production at EV charging stations. The rugged industrial controller (PLC) with data acquisition system (SCADA) has been described with its configuration to monitor produced energy from hybrid system. The Hybrid Renewable Energy Systems play an important role in clean energy development. The major advantage of these systems is to utilize generated power anytime, anywhere. Many charging stations are available in the metropolitan city areas but not in rural locations so use of HRES for Electric Vehicles at remote locations will be beneficial for charging purpose.

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REFERENCES

[1] Bhushan D. Agarkar, Shivprakash B. Barve, "A Review on Hybrid solar/wind/ hydro power generation system", International Journal of Current Engineering and Technology E-ISSN 2277-4106, P-ISSN 2347 – 5161 ©2016.

[2] I. Vechiu, J.M. Vinassa, H. Camblong, "Hybrid Energy Storage Systems for Renewable Energy Sources Integration in Microgrids: A Review", International Power Electronics Conference, 978-1-4244-7398-4/10 ©2010 IEEE.

[3] Khawla Ettalbi, Hanan Elabd, Mohammed Ouassaid and Mohamed Maaroufi, "A Comparative Study of Energy Management Systems for PV Self-Consumption", International Renewable and Sustainable Energy Conference (IRSEC), 978-1-5090-5713-9/16/$31.00 ©2016 IEEE.

[4] Muhammad Shahazad Aziz, Sohaib Ahmed, Umair Saleem, Gussan Maaz Mufti, "Wind-hybrid Power Generation Systems Using Renewable Energy Sources-A Review", International Journal Of Renewable Energy Research M. S. Aziz et al., Vol.7, No.1, 2017.

[5] Rahul Sharma, Varinder Goyal, "A Hybrid Model of Solar-Wind-Biomass Power Generation System: A Review", International Conference on Computing for Sustainable Global Development, 978-9-3805-4416-8/15 2015 IEEE.

[6] A.D. Dhass, S. Harikrishnan, "Cost Effective Hybrid Energy System Employing Solar-Wind-Biomass Resources for Rural Electrification", International journal of renewable energy research S. Harikrishnan et al., Vol.3, No.1, 2013.

[7] Gang Liu, M. G. Rasul, M. T. O. Amanullah, M. M. K. Khan, "Feasibility study of stand-alone PV-wind-biomass hybrid energy system in Australia",Power and Energy Engineering Conference (APPEEC), 2011 Asia-Pacific, 978-1-4244-6255-1/11/ ©2011 IEEE.

[8] Ting-Chia Ou,Whei-Min Lin, and Cong-Hui Huang, "A Multi-Input Power Converter for Hybrid Renewable Energy Generation System",IEEE PES/IAS Conference on Sustainable Alternative Energy (SAE) 2009.

[9] Yi-ming Tang, Wei-quig Sun, Ping liangZeng, Heng Li, "Research on an Optimized load model based on Substitution Effect of Renewable Energy Generations",978-1-5386-0394-9/17/ ©2017 IEEE.

[10] Jayavardhana Gubbia, Rajkumar Buyyab, Slaven Marusic, Marimuthu Palaniswami, "Internet of Things (IoT): A vision, architectural elements, and future directions"Future Generation Computer Systems 29 (2013) 1645–1660.

[11] Eleonora Borgia, "The Internet of Things vision: Key features, applications and open issues", Computer Communications 54 (2014) 1–31.

[12] Yeonghyeon Ryu, Jeakyu Yoo, Youngroc Kim, "Cloud service based mobile monitoring for Photovoltaic Systems", 2012 IEEE 4th International Conference on Cloud Computing Technology and Science.

[13] Soham Adhya, Dipak Saha, Abhijit Das, Joydip Jana, Hiranmay Saha, "An IoT Based Smart Solar Photovoltaic Remote Monitoring and Control unit", 2016 2nd International Conference on Control, Instrumentation, Energy & Communication (CIEC), IEEE.

[14] Li W*ang*, Kuo-Hua Liu, "Implementation of Web based Realtime Monitoring and Control system for Hybrid-Wind-PV Battery Renewable Energy System", 2007 International Conference on Intelligent Systems Applications to Power Systems, CD-ROM ISBN: 978-986-01-2607-5.

[15] Mr. Nerella Ome, Mr. G. Someswara Rao, "Internet of Things (IoT) based Sensors to Cloud system using ESP8266 and Arduino Due", International Journal of Advanced Research in Computer and Communication Engineering, ISSN (Online) 2278-1021.

[16] Ashish S. Ingole, Prof. Bhushan S. Rakhonde, "Hybrid Power Generation System Using Wind Energy and Solar Energy", International Journal of Scientific and Research Publications, Volume 5, Issue 3, March 2015 1 ISSN 2250-3153.

[17] Joao M. Figueiredo, Jose M. G. Sada Costa, "An Efficient System to Monitor and Control the Energy Production and Consumption", 5th International Conference on the European Electricity Market, 978-1-4244-1744-5/08/ ©2008 IEEE.

[18] Isaias Gonzalez Perez, Antonio Jose Calderon Godoy, Manuel Calderón Godoy, Jose Luis Herrero Agustin, "Monitoring of Electric Power Systems: Application to self-sufficient Hybrid Renewable Energy Systems", 9th International Conference on Compatibility and Power Electronics (CPE), 978-1-4799-6301-0/15/©2015 IEEE.