International Journal of Engineering Research
Volume No.6, Issue No.3, pp :154-157
ISSN:2319-6890 (online),2347-5013(print)
1 March. 2017

Analysis of Isolated Hybrid Renewable Energy System: A Study Report

Kshitij Arajpure[1], Adarsh Tripathy[2], Dr S.S Dash [3], Dr D.P. Kothari [4]

[1, 2] Student, Department of Electrical and Electronics Engineering, SRM University, Chennai (TN) India

[3] Professor, Department of Electrical and Electronics Engineering, SRM University, Chennai (TN) India

[4]Director-Research, S.B Jain College of Engineering and Management Research, Nagpur (M.H.) India

Email:arajpure55@gmail.com[1,] adarshtripathy96@gmail.com[2], sekhardash.s@ktr.srmuniv.ac.in[3], dpkvits@gmail.com4

Abstract-- Power generation in this era is considered to be one of the most challenging aspects due to severe energy crisis, which has forced to develop new and alternative methods of power generation. Hybrid energy systems are the one amongst many solutions that are being considered implicitly for the production of cleaner, cheaper and reliable source for energy. Since these energy systems particularly involves the combination of two or more renewable energy sources; naturally the efficiency of energy conversion, cost of production and reliability over the conventional resources comes into the picture.

The paper investigates and focuses on different hybrid systems, their working, performance parameters and cost involved in power generation. It also underlines the benefits and philosophy of renewable energy coupled with hydrogen energy resources, to provide a viable solution for uninterrupted power supply as well as reduce the greenhouse effect. This initiative becomes the yardstick in energy production sector, which helps to meet the deficiency of electric power in peak load conditions and finally meet the objectives of sustainable development.

Keywords: Power generation, Energy conversion, Renewable energy, Hydrogen energy, Sustainable development

I. Introduction

India is a country where about 96% of the villages are electrified out of which about 69% of the homes actually receive power. In other words about 72% of the existing rural households are still unpowered [1].This scenario could be due to the features of rural populations, which are disperse and remote, have small incomes and whose electric consumption is low. In this situation extension of power grids is either complex or too expensive [2].Production of clean, cheaper and continuous power to meet the demand of domestic and industrial houses is significantly important for developing countries like India to maintain GDP growth as well as to become a superpower [3].

In addition to this the conventional energy resources are considered as the major component responsible for atmospheric heating. Secondly, it also has issues related with fossil combustion technologies include acid rain, unequal distribution of resources and resource depletion [4].

In this situation, hybrid energy systems provide a satisfactory solution to the above-mentioned problems as hybrid power is pollution free, reduces the use of fossil fuel and also avoids the long range transmission losses. It also discourages the lack of electrification in some regions and non-sustainability of fuel based generation [6].

II. Hybrid Energy Systems

Hybrid energy system is generally considered as the technology that collaborates two or more renewable energy sources to provide a more efficient and cleaner way of providing an uninterrupted power supply [5].Another definition would enlighten hybrid system as the renewable power generation technology consisting of solar, wind, biomass, and biodiesel which satisfies today's energy demand and avoid the need of long distribution infrastructure [6]. In this paper, photovoltaic, wind and hydrogen based hybrid energy system is taken for the purpose of study.

When the non-conventional energy resources are considered for the purpose of electrification solar and wind energy resources do have advantages over other non-conventional energy resources also the availability of these in Indian subcontinent is vast and could be used without much energy tapping [7].

A. Solar/PV Energy

Solar energy is considered as the cleanest form of energy as it doesn't have any by-products i.e. it is pollution free it has low maintenance and high reliability.

The Indian subcontinent is tapped with a capacity of solar power generation of about 749 GW while the solar output that we get at present is less than one percent of the total [7]. This provides a clear knowledge that only solar power is not enough to produce the required amount of energy for medium load standalone systems as a result there is a requirement of additional system modification.

B. Wind Energy

The wind is a dynamic form of energy that is extracted from wind caused due to uneven heating of the atmosphere. This form of energy is less polluting, more efficient and reliable [8]. But the main disadvantage of this form is that winds can never be predicted. In areas where wind doesn't blow reliably or winds strength is too low to support wind turbine. Thus there is a need of additional system modifications that needs to be think of to make this more effective and reliable.

C. Hydrogen Energy

Hydrogen is considered as both energy storage medium and a fuel in this scenario. Hydrogen has a lot of advantages over battery storage systems [9] the batteries have their own limitations such as discharge rate, charging time, idle discharge, etc. [9]. Considering this as a flaw in hybrid system

ISSN:2319-6890 (online),2347-5013(print)
1 March. 2017

We use hydrogen as an energy storage rather than using batteries and use this for power generation.

From the above three sections it becomes clear that all the three types of systems face some or the other kind of limitations that effect the overall system. May it be the efficiency of energy conversion in case of photovoltaic systems or the availability of the wind in case of wind energy systems? In this paper we propose the Hybrid system that can use both these energy systems simultaneously or using any one system and keeping the other idle. This gives a more stable reliable and efficient system and limits the disadvantages of any single individual system.

III. Design of PV-Wind based Hybrid Energy System.

To design any kind of system various data's need to analysed and summarised in order to provide an optimum solution to the given problem.

The PV-Wind-Hydrogen based Hybrid energy system constitutes a PV array and a wind Turbine along the power generation side. These system produce an uninterrupted power at optimum conditions irrespective of the human intervention [9]. These type of power generation units give an uncontrolled output i.e. the output of a PV array could not be controlled and relies directly on the intensity of the light radiation. The below given curve clearly illuminates on how the power generation depends on the intensity of light in case of a solar cell.

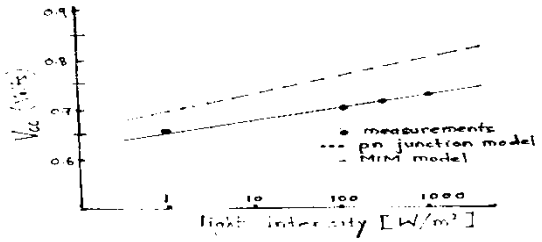

Fig.1. Typical Light intensity vs V_{oc} Curve

Similarly, the wind flow could not be controlled and the amount of power generated depends directly on the wind flow rate [10].The below givencurve clearly illuminates on how the power generation depends on the wind speed in case of a wind turbine.

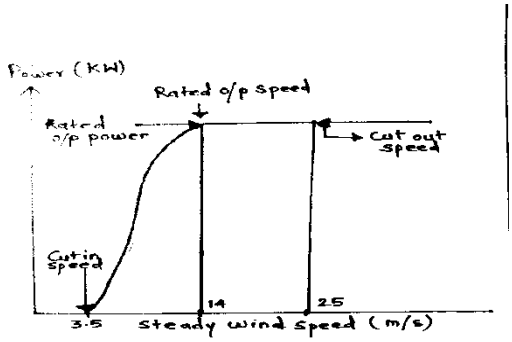

Fig.2. Typical wind turbine power O/P with wind speed.

Conventional energy resource unbalance is the most important reason why a hybrid energy supply system is being installed. The PV-wind-hydrogen hybrid system suits to conditions where sunlight and wind has seasonal shifts [12]. As the wind does not blow throughout the day and the sun does not shine for the entire day, using a single source will not be a suitable choice. A hybrid arrangement of combining the power harnessed from both the wind and the sun and stored in form of hydrogen can be a much more reliable and realistic power source. The load can still be powered using the stored energy in the hydrogen even when there is no sun or wind. Hybrid systems are usually built for design of systems with lowest possible cost and also with maximum reliability. The high cost of solar PV cells makes it less competent for larger capacity designs. The below given figure shows a block diagram of a PV-Wind-Hydrogen hybrid system with its system component being discussed in later sections of this paper.

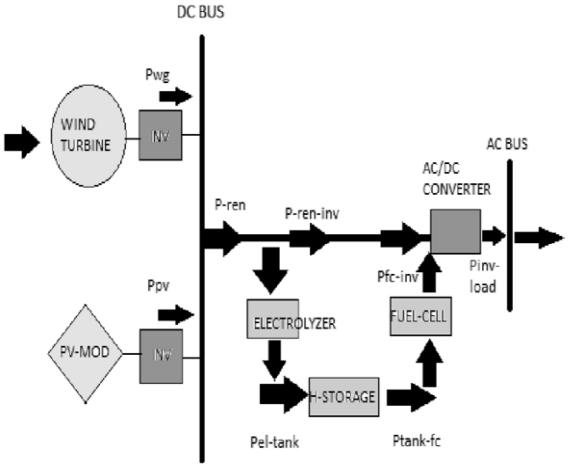

Fig.3. Block Diagram

IV. Implementation of Hybrid Energy System.

A. Photovoltaic solar power

Solar arrays a device consisting of solar cells that convert solar energy into the electrical energy. Solar cell can convert the energy directly. PV (Photo-voltaic) cells are made up of semiconductor materials as used in the computer technologies. Solar radiations are absorbed with this material and electrons are emitted from the atoms .This release activates a current. PV is known to be a process between radiation absorbed and the electricity induced. Solar power is converted into the electricity by a common phenomenon so called photo electric effect. The solar cell array or panel consists of an appropriate number of solar cell modules connected in series or parallel based on the required power output [12]. It is observed that a typical PV cell can produce a potential difference of around 0.5 to 0.8 volts depending on the type of semiconductor and the built-up technology [13]. Under peak sunlight conditions a typical commercial PV cell with a surface area of about 25 square inches will produce about 2 watts peak power [14].

ISSN:2319-6890 (online),2347-5013(print)
1 March. 2017

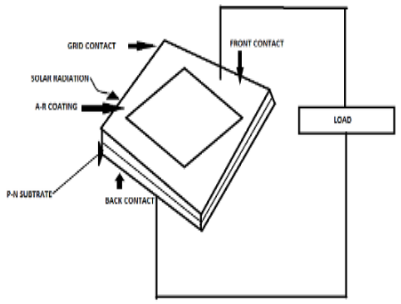

Fig.4. Structure of a PV cell

B. Wind Power

The wind energy is a non-conventional source of energy. Wind turbines are used to convert the wind power into electricity. Electric generator inside the turbine converts the mechanical power into the electric power. Wind turbine systems are available ranging from 50W to 3-4 MW [15]. The energy production by wind turbines depends on the wind speed acting on the turbine. Wind power is able to feed both energy production and demand in the rural areas. It is used to run a windmill which in turn drives a wind generator or wind turbine to produce electricity [15].

C. Electrolyser

An electrolyser is a thermodynamics based equipment used to produce and utilize hydrogen through the electrolysis of water. With the help of an electrolyser, one can create hydrogen and oxygen from a pure water supply and electrical supply. The electrolyser's membrane and catalysts work to take advantage of an electrochemical reaction in order to separate the oxygen and hydrogen molecules of water. Hydrogen can then be utilized to power a fuel cell stack [16].

D. Hydrogen Storage

This is an important part of the hybrid energy system as this part is responsible for pressurised storage of hydrogen produced using an electrolyser. There must be an optimum storage cylinders used for H_2 storage so that it could carry the fuel effectively without any damage to both the surroundings and human life. Underground hydrogen storage is a useful method both safe and reliable to provide energy storage for hybrid energy technologies that couple wind and solar power compressed hydrogen is a storage form where hydrogen gas is kept under pressures to increase the storage density. Compressed hydrogen in hydrogen tanks at 350 bar (5,000 psi) and 700 bar (10,000 psi) is used for hydrogen tank systems.

E. Fuel Cell

A fuel cell is a device that works on the principles of chemical thermodynamics and is used for electricity production using hydrogen. Every fuel cell has an anode, cathode and a proton exchange membrane sandwiched in between. Hydrogen, from the storage cylinders, enters into the anode part of the fuel cell. Oxygen, from the air, enters the cathode part. As the hydrogen molecule encounters the membrane, a catalyst forces it to split into electron and proton. The proton moves through the fuel cell stack and the electron follows an external circuit, delivering current to the electric motor and other vehicle components. At the cathode side, the proton and electron join again, and then combine with oxygen to form water [16]. This gives an electrical output which is then provided to a step-up Transformer having a secondary voltage output of 240 V.

F. DC/AC Converter

The DC/AC converter is nothing but an inverter. The inverter chosen for this purpose is generally greater than the desired rating. An inverter is required to convert DC power into AC supply. As our load working on the AC supply so we need to convert DC power. The input voltage Output voltage and frequency, and overall power handling depends on the design of the specific device [13].

Thus, the solar-wind-hydrogen hybrid energy systems require an initial high investment and is expected to compete well in coming generation. The cost of the system depends solely on the type of system chosen, wind resource on the site, electric costs in the area, and the hydrogen fuel required. The cost of the Solar-Wind-hydrogen hybrid system is to be minimized for which we need to increase the use of non-conventional energy sources. So that production of solar and wind power generator will be increase. That will reduce cost of the whole system.

V. Conclusion

Hybrid renewable energy source is increasingly becoming popular because it is consists of two or more renewable energy sources with a good output efficiency. It has a huge scope for the non-electrified rural population in a country like India where the extension of the grid is not possible since the connections involved are neither economically feasible, nor encouraged by the main actors. The combination of two or more renewable energy sources for uninterrupted power is an efficient way of generating energy. Hybrid energy systems must be used in remote rural areas for power generation. The use of hybrid energy systems can optimize the power supply especially in rural areas. However it is still considered expensive and difficult to couple more than two types of energy resources together. This onetime expense can be of many uses to people living in remote areas. It also has a long life span, it is good, reliable and affordable solution for electricity generation.

VI. Acknowledgement

Authors wish to thank University, Chennai, India and would also like to pay gratitude towards Department, Electrical and Electronics Engineering, SRM University, Chennai India for their valuable support and encouragement.

VII. References

i. *Access to Clean Cooking Energy and Electricity Survey of State, a CEEW Report September 2015.*

ii. *H. Zerriffi, Rural Electrification: Strategies for Distributed Generation, Springer Science Business Media B.V. (2011) pp.1-3.*

iii. *The Role of Energy in Economic Growth; David Stern, CCEP Working Papers from Centre for Climate Economics & Policy, Crawford School of Public Policy, The Australian National University.*

iv. *Potential of Non-conventional Source of Energy and Associated Environmental Issue: An Indian Scenario Arabinda Sharma Civil Engineering Department BRCM College of Engg and Technology Bahal-127 028, Bhiwani, Haryana Chadetrik Rout Civil Engineering Department M.M. University, Mullana-, Ambala, HaryanaResearch and Development in Hybrid Renewable Energy Systems. (IJETAE: ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 2, February 2014).*

ISSN:2319-6890 (online),2347-5013(print)
1 March. 2017

v. Alliance for Rural Electrification-WG Technological Solutions-Brochure Hybrid Systems.

vi. Infrastructure for Sustainable Renewable Energy in India: A Case Study of Solar PV Installation S. A. Khaparde, Senior Member, IEEE, and ArunavoMukerjee, Member, IEEEOverview of Renewable Energy Potential of India, October 2006, Global Energy Network Institute (GENI).

vii. Xing Luo, Jihong Wang, Mark Dooner, Jonathan Clarke ,Overview of current development in electrical energy storage technologies and the application potential in power system operation, Elsevier, Applied Energy Vol-137.

viii. Characteristics of Wind Turbines Under Normal and Fault Conditions E. Muljadi, C.P. Butterfield, and B. Parsons, National Renewable Energy Laboratory, A. Ellis Public Service Company of New Mexico ,IEEE Power Engineering Society 2007 General Meeting Tampa, Florida June 24-28, 2007.

ix. J.B.V.SUBRAHMANYAM, P.K.Sahoo and Madhukarreddy," Local PV-Wind hybrid systems development for supplying electricity to industry" ActaElectrotechnica, Vol.53, No.1, 2012, pp10-15.

x. T. Salmi, M. Bouzguenda, et.al. ―MATLAB/Simulink Based Modelling of Solar Photovoltaic Cell.‖ International Journal of Renewable Energy Research, Vol.2, No.1, May 2012.

xi. D.P.Kothari and S. Uma Shankar, "Wind Energy Systems and Applications", Narosa Publishing House Pvt Ltd, New Delhi, 2013.

xii. Hydrogen for IC Engines: A Review Vinayaka S, Syed fareeskhaleelrahman H.K, Nawaz Shariff& P Vamsidhar Reddy Department of Mechanical Engineering, Atria Institute of Technology, BangaloreHydrogen Fuel Cell Study June 12, 2003 A Report Prepared for the Panel on Public Affairs (POPA), American Physical Society Craig Davis Ford Motor Co. (retired) and Michigan State University, Bill Edelstein General Electric Co. (retired) and Rensselaer Polytechnic Institute, Bill Evenson Brigham Young University ,Aviva Brecher The John A. Volpe National Transportation Systems Centre , Dan Cox University of California.

xiii. Bhimbra .P.S Power Electronics, Khanna Publishers New Delhi, Fifth edition.

xiv. D.P.Kothari, K.C.Singal and Rakesh Ranjan, "Renewable Energy Sources and Emerging Technologies", Prentice-Hall of India, New Delhi, 2007; 2nd edition 2011.

xv. D. P. Kothari, K. C. Singhal and Rakesh Ranjan, "Environmental Science And Engineering", Narosa, 2015

xvi. An Overview of Hydrogen Production and Storage Systems with. Renewable Hydrogen Case Studies. May 2011. Prepared by: Timothy Lipman, PhD.