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63 – 68

Comparative Analysis Of Combined Power Generation based on Renewable Sources by Using Fuzzy And PI Controller

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Abstract-This paper is mainly focused on the idea of smart grid to build in the future. To implement smart grid we have to manage the smart resources that are, solar, wind and fuel cell. So firstly we have to design the generation system which uses the solar, wind and fuel cell. To make the generation system in a effective way we have to utilize some controller which gives fruitful results as simulation model in MATLAB and take the outputs of solar and wind. After getting the outputs of solar and wind we manage the output as per our requirements.In this work our system is mainly based on wind, solar and also fuel cell. To make a combined system for desired outputs power, controlling parameter is planned for individual system that is for wind power generation,Fuzzy Logic controller (FLC) is used to minimize the variations in to change in wind speed any time. likewise in solar system an array of seventy two Photo-Voltaic cells is utilized and to enhance the power outputs Super conducting Magnetic Energy Storage (SMES) coil is used.. After the outputs obtained from the designed model of combined power generation system indicate that the output power is high and for solar power system due to SMES results in power enhances exponentially.

Keywords: *Renewable source Smartpower grid,Fuel cell,PI controller, FLC controller, wind turbine , solar energy* **.**

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I. INTRODUCTION

The electricity generation in India is largely depends upon conventional fuel, which are on the verse of scarcity. Conventional fuels like as coal, minerals, petroleum etc. Energy is a basic and main worldwide evaluate of all kinds of work by the human beings and nature. Environment and energy are two general problems expressed via peoples. The need of electricity has enlarged throughout the currently years with raising peoples and work development.

Harnessing renewable energy sources is very easy way to extract the energy from sun. Rajasthan alone has abundant source of solar energy.Continuous and uninterruptible power supply is a critical requirement in the operation of daily basis in modern life which employs continuous in touch with information technology systems, powerful servers, computers and its networks, high speed and long distance communication and data transmission system. Without having continuous power supply, the none of these systems will function satisfactorily and the loss in efficiency and total failure that could render the entire system useless and ineffective. Theoretically, India's solar power receptions about 5000 trillion kWh/year with 300 clear sunny days in a year [1]. The daily average solar energy incident over India varies from 4 to 7kWh/m² with about 2300 to 3200 sunshine hours per year, depending upon location. This is far more than current total energy consumption.

The daily average global radiation is around 5kWh/m² in north-eastern and hilly areas to about 7 kWh/m² in western regions and cold desert areas. The annual global radiation varies from range around 1500 to 2250 kWh/m², which is determination with radiation received in the tropical and sub-tropical regions/Although the highest annual global radiations is received in Rajasthan, northern Gujarat, Tamil Nadu and parts of Ladakh region, the parts of Andhra Pradesh Maharashtra, Madhya Pradesh, Karnataka also received fairly large amount of radiation as compared to other many parts of world especially Europe, Japan and the United States where development and deployment of solar projects are maximum. Thus it is clear that solar power projects are commercially viable in most parts of India. [32]

The Rajasthan has 5.5 to 6.5 kWh/m²/day solar radiations available as per NASA and NREL data base [2]. So that's why it is best way to harness solar energy in Rajasthan. Renewable energy sources of electricity have only catered to a smaller portion with compare to conventional sources of energy. It is such, because of having considered their single source of electricity usage. The energy consumption in India is the fourth biggest after China, USA & Russia. The total primary energy consumption from crude oil (29.45%), natural gas (7.7%), coal (54.5%), nuclear energy (1.26%), hydro electricity (5%), wind energy, biomass electricity & solar energy is 595 Mega tone of oil equivalent (Mtoe) in the year 2013.

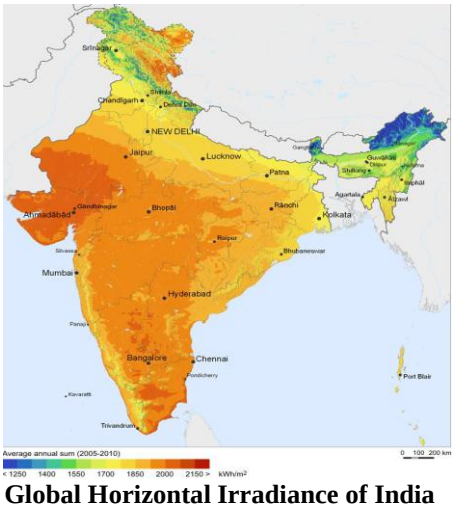

Figure-1 Global Horizontal Irradiance of India

In the year 2015, India's net imports are nearly 144.3 million tons of crude oil, 16 Mtoe of LNG & 95 Mtoe coal totaling to 255.3 Mtoe of primary energy which is equal to 42.9% of total primary energy consumption. About 72% of India's electricity power generation capacity is from fossil fuels [3]. India is mostly dependents on fossil fuel imports to meet its energy demands by 2030, India is largely

dependence on energy imports is expected to exceed 53% of the country's total energy consumption.

But In general, electricity generation schemes are still used in old standards by connected utility/grid supplied voltage and single source of renewable energy like solar energy electricity generation schemes. This doesn't guaranteed, high reliability and sustainability of the normal hybrid systems. So that solar wind and fuel cell hybrid is the recent need of mixing three renewable energy sources for generation and distribution of electricity. Natural sources are such as the sun and the wind. This in itself is a rare characteristic as it does not occur frequently in every other location. In this forefront, a hybrid solar wind and fuel cell system is considered an ecological measure. A hybrid renewable energy plant that is based on solar and wind energy conversion systems is designed and analyzed in this system. Each separate energy conversion system is controlled either using regular Proportional Integral (PI) controller or extended PI controller with an auxiliary controller with containing Perturb and Observe algorithm.

There is solar plant model constituted by connecting about 170W photovoltaic (PV) panels serially and energy conversion is performed with maximum power point tracking (MPPT) algorithm that controls the modulator of buck converter.

Hybrid Power Generation Systems

The demand of energy in last few years has hit their highest record. The conventional sources have affected the environment and global warming. Wind energy, solar energy and hydrogen as a power delivery service are the most suitable sources of renewable energy. Wind and solar generated power is pretentious by weather effects, using fuel cell as power storage. Solar wind and fuel cell are the eco-friendly sources. Fuel cell has several benefits, like high efficiency, small or nil carbon di-oxide production and small protection price.

II. LITERATURE REVIEW

A literature survey or literature review, is a study, that review and analysis of relevant literature materials in relation to a proposed topic of the thesis title. There are lots of literatures published and implemented on Solar wind and fuel cell. Some of the paper references have been taken consideration based on physical and online research from which idea of thesis title is taken.

[1] Ashari et al. proposed an optimum operation strategy and economic analysis of photovoltaic-diesel-battery-mains. The system comprised of a photovoltaic system, battery and bi-directional inverter that was connected in parallel to the grid. The optimum operation strategy of the system was proposed for the diesel-connected mode. The optimum value has been obtained by comparing the cost for the the diesel fuel consumption and the battery wear.

[2]Park et al. have investigated a PV-Diesel hybrid power generating system, used in a small ship having a load of 5 kW and proposed a simulation model considering the parameters like minimum and maximum battery terminal voltage, load pattern and operating modes (i.e. starting and stopping of DG set and charging and discharging of battery). The main objective was to maintain output of diesel generator constant so as to exploit the benefits of high efficiency and low fuel consumption for the diesel generator at constant load and to maximize the utilization rate of PV energy resource so as to minimize the capacity of the battery. It was found that the system with a large PV array and a small battery lead to least utilization rate of PV energy resource.

[3] Abdullah Al-Sharafi et al.

presented a paper about Techno-economic analysis and optimization of solar and wind energy systems for power generation and hydrogen production in Saudi Arabia. The objective of this study is to investigate the potentials of power generation and hydrogen production via solar and wind energy resources at different locations in the Kingdom of Saudi Arabia, namely; Dhahran, Riyadh, Jeddah, Abha and Yanbu. These locations represent the climatic conditions variety in the Kingdom with different solar radiation and wind speed potentials. At each location, different renewable off-grid power generation systems are considered to cover a load demand of a typical house incorporating; photovoltaic (PV) array, wind turbines, converter, batteries, electrolyzer, fuel cell (FC) and hydrogen tank. Six systems are considered in hourly base simulations; PV/battery bank, wind/battery bank, PV/wind/battery bank, PV/FC, wind/FC and PV/wind/FC.

III. MODLING OF HYBRID GENERATION SYSTEM USING PV, WIND AND FUEL CELL

This article is mainly focused on proposed work that is, to design the simulation model of solar generation, wind generation and fuel cell generation.The block diagram of the propsed system is as given below:-

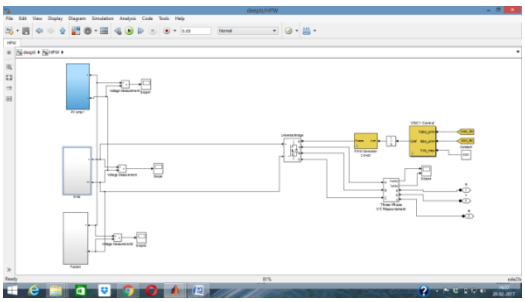

Fig 2 Combined power generation model.

The speed of the wind and solar irradiation data for the proposed system are evaluated. Firstly we have to make a separate model for solar, wind and fuel cell, after that results obtained through the simulation of separate models we have to make sure that the availability of PV potential and wind energy potential must be high sufficient for generation of electrical energy by solar and wind.

In this work we are using two type of controllers first one is proportional-integral controller and other one is fuzzy logic controller. Fuzzy logic controller is one of the artificial intelligence techniques used for accuracy of work in particular areas. For simulation of hybrid system we are

 ISSN: 2454-4248
63 – 68

using fuzzy logic controller as an effective tool. Controller are necessary for generation of electrical energy because with the varying in wind speed and PV potential oscillation occurs and it can be controlled by controllers only. So in this work controllers are very much required for this work.

The simulation & designing of hybrid electrical generation system is made in MATLAB SOFTWARE using different block used in this software. All the components related to this work are used by MATLAB library. By simulation of hybrid model the results which are lists of power supply systems have been generated

Outputs of Wind Generation of power

Here we represent the outputs of wind turbine using PI and fuzzy logic controller. On seeing the outputs when fuzzy logic is used at that situation our power generation set up gets it stability as comparing to when no controller is used. Following output is depicted in figure . on compare the results of power generation with and without controller is shown in table

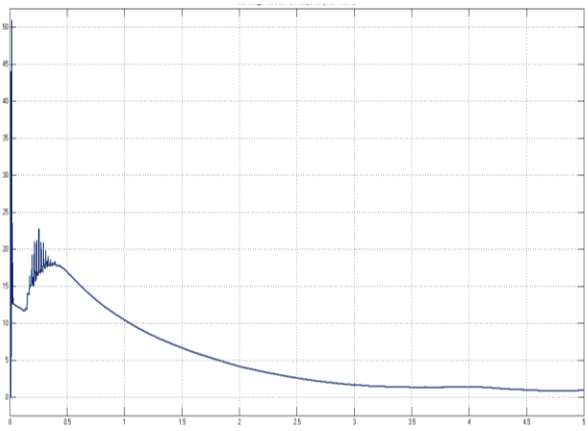

Fig 3 Wind system output using Fuzzy Logic Controller

Table 1 gives the comparasion value of FLC and PI controller which indicates that FLC enhances the system stability and efficiency to PI controller and acquire stable in less settling time.

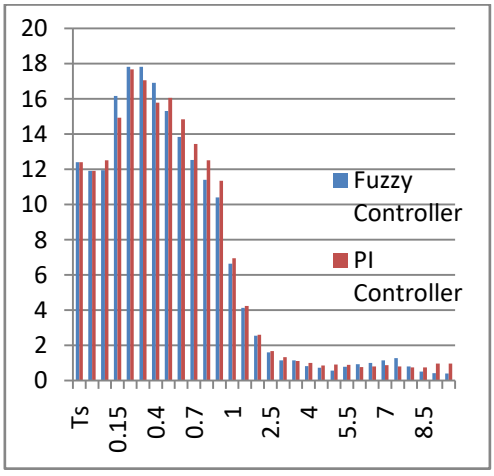

Fig. 4 outputs of wind power generation with fuzzy & PI controller.

Outputs of photovoltaic Power Generation

Outputs of photovoltaic power generation utilizing Superconducting Magnetic Energy Storage scheme. Comparison of solar outputs with and without SMES.

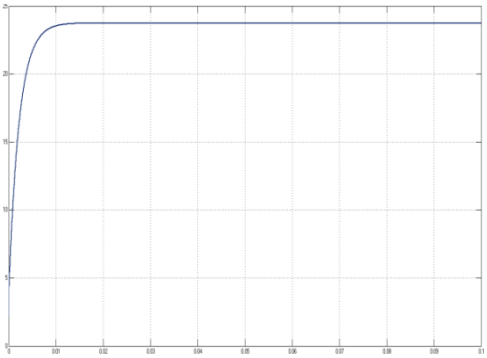

Fig. 5 outputs of solar power generation

Here we get the outputs of PV power generation using PI and fuzzy logic controller. On seeing the outputs when SMES is used at that situation our power generation set up gets it stability as comparing to when no SMES is used. Following output is depicted in figure

Outputs of Wind power generation
TABLE. 1
Comparing value of FLC and PI controller outputs

Ts	Fuzzy Controller	PI Controller
0.05	12.40012	12.40012
0.1	11.9027	11.90271
0.15	11.95432	12.51604
0.2	16.15638	14.9258
0.3	17.82581	17.67047
0.4	17.82026	17.05863
0.5	16.91449	15.7753
0.6	15.3035	16.04632
0.7	13.83514	14.83885
0.8	12.52674	13.43048
0.9	11.40317	12.50631
1	10.40032	11.3404
1.5	6.62951	6.94489
2	4.129891	4.237102
2.5	2.553445	2.608354
3	1.606517	1.66446
3.5	1.14737	1.32297
4	1.141449	1.102438
4.5	0.825628	0.993446
5	0.723729	0.852298
5.5	0.561627	0.908579
6	0.775405	0.89858
6.5	0.93088	0.77154
7	1.005333	0.79971
7.5	1.141249	0.875666

ISSN: 2454-4248
63 – 68

8	1.266664	0.793015
8.5	0.806137	0.747985
9	0.511013	0.744946
9.5	0.419338	0.970457
10	0.401263	0.971235

Table 1 depicts the outputs of Wind power energy.

generation. Outputs indicate that when wind energy is attached to combined power generation system it enhances the power and stability constraints by rasinating batary..

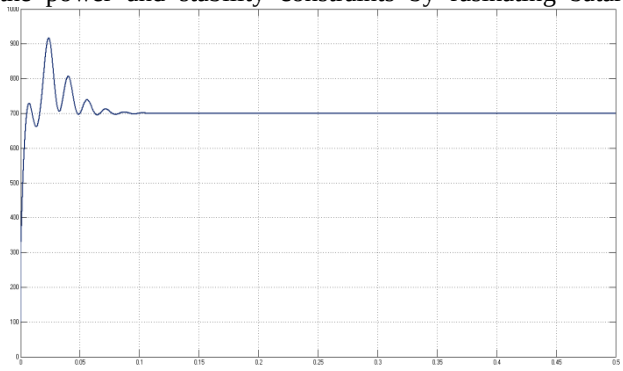

Fig6 Outputs of fuel cell power generation system

Outputs of combined Power Generation system

Outputs of combined power generation utilizing FLC and PI controller indicated in above graphs. Outputs indicate that combined system attached with FLC attains stability before normal system and the output gain is a lesser amount of distorted and filtered. Fig.5.7 and Fig.5.8 indicates the combined system output with PI and FLC controller respectively. Fig 5.9 and Fig 5.10 indicates the output power of combined system before grid and at AC load respectively.

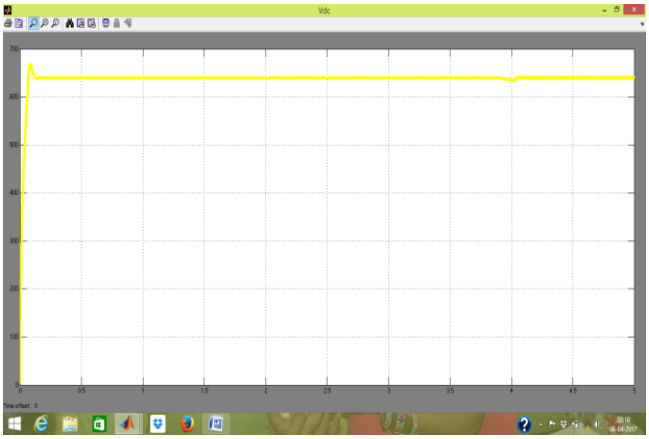

Fig 7Combined system output using PI controllers

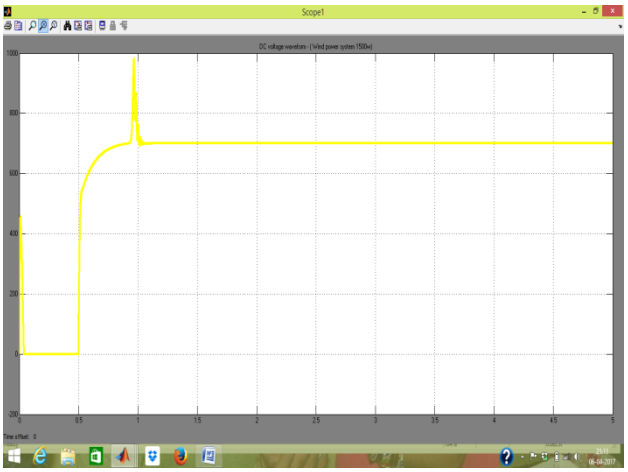

Fig.8 combined system output using FLC controllers

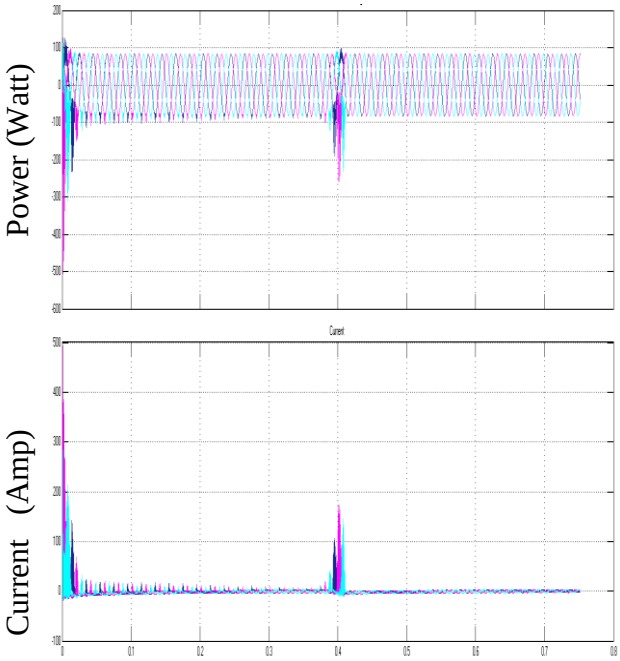

Fig. 9 Outputs of combined system before grid

ISSN: 2454-4248
63 – 68

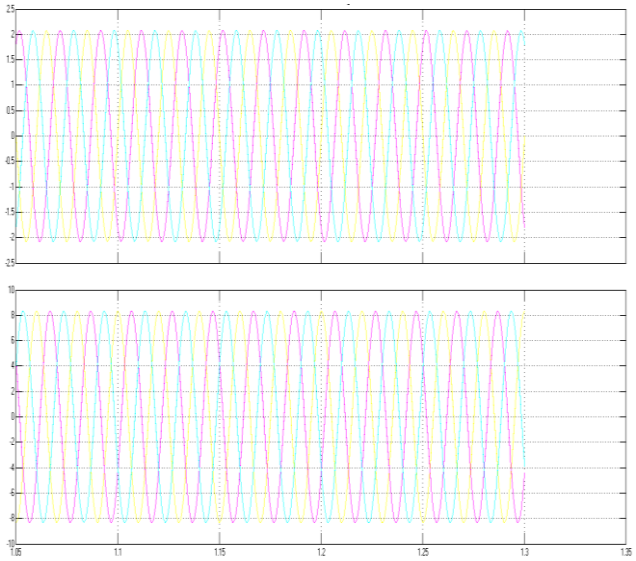

Fig. 10 Output power at AC load

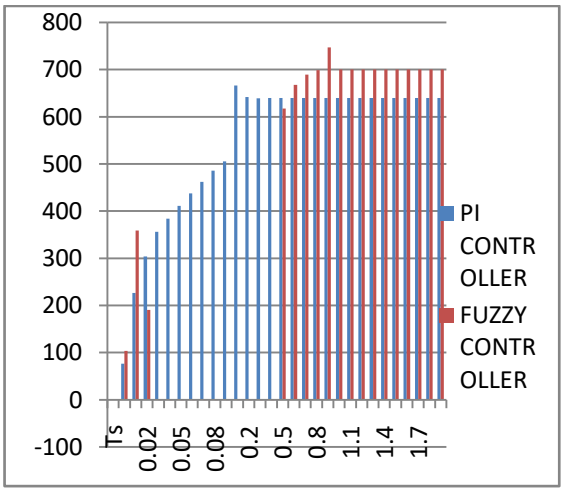

Fig 11 Output of combined system with PI and fuzzy controller

TABLE 5.3

Comparision chart for combined system indicating stabality

Settling Time (Ts)	PI CONTROLLER	FUZZY CONTROLLER
0.001	76.30564739	103.8860015
0.02	226.2505644	358.9982521
0.03	303.5422359	190.642833
0.04	356.2134014	-0.018689738
0.05	383.9955306	-0.101150881
0.06	411.405961	-0.10065226
0.07	437.5644903	-0.101135156
0.08	461.6768482	-0.101002078
0.09	485.6792745	-0.100772632
0.1	505.4713069	-0.100731464
0.2	666.4073811	-0.089905584
0.3	641.9510011	-0.07264547
0.4	639.0881931	-0.061619164
0.5	640.0875912	-0.057035988
0.6	639.8565387	617.6398404
0.7	639.9351638	667.8199042
0.8	639.9626921	689.6730671
0.9	639.9627995	699.0964546
1	639.8972616	747.2008709
1.1	639.9402143	700.0672445
1.2	639.9330975	700.0044142
1.3	639.9116199	699.999589
1.4	639.9737872	700.0010007
1.5	639.9342732	700.0013516
1.6	639.9101644	700.0022262
1.7	639.8951116	700.00497
1.8	639.9014513	700.0067405
1.9	639.9096003	700.0099695
2	639.9176395	700.0110139

IV. CONCLUSION AND UPCOMING WORK

Conclusion

This research shows a model of renewable energy by combination of photovoltaic, wind with fuel cell power managing system. The given model and work of combination power system is completed by taking suitable power generation controllers.

The combination power generation system is more impressive and potential generation system. Solar and wind sources such as radiation and wind speed are dependent on weather conditions so connect the battery and fuel cell in the power generation system The fluctuation of voltage and frequency in solar wind combination system during combination model is being simulated using some controllers.

The simulation outputs obtain out from wind solar combination model to produce power generation along with settling time explain that when fuzzy logic controller and SMES are applied with photovoltaic and wind model correspondingly. Now the results recognized is more stable and profitable as evaluated to the model with regular situations. When the implementation of controllers in the system then system move towards its performance much previous then regular model.

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