



MULTI-AGENT MODEL OF HYBRID ENERGY SYSTEM IMPLEMENTATION

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Abstract: Development and adoption of reliable sources of renewable energy nowadays has become a major challenge to the most part of the India. Sustainable development of energy sector is a potential factor to maintain economic competitiveness and progress. The feasibility of a stand-alone hybrid wind-photovoltaic (PV) system incorporating diesel generator was studied for Barmer (Rajasthan-India). Barmer has an average annual solar and wind energy availability of 1784 and 932 kWh per m², respectively. The combination of solar panels, wind turbines and DG will ensure continuous electricity no matter what the weather conditions are. In this paper, we introduce advanced agent technology into the wind-solar-DG hybrid power generation system. Then, based on Multi-agent model, establish the decision-making model of wind-PV-DG hybrid power generation system. According to its functions, system is divided into various agent modules and each agent module is again divided into some detailed agents. Paper shows decision-making process by the flexible collaboration and communication of these agents. The scheme can be applied into Barmer region, and it can enhance power system intelligence.

Index term: wind-solar energy hybrid power generation, optimization control, decision-making model. Plant load factors (PLF)

I. INTRODUCTION

Wind solar hybrid power generation is a novel and promising power system. But because of random nature and complexity of the environment, it makes wind-solar hybrid power generation system to be a complicated system. In Order to reduce these complications we add on diesel generator in system. Multi-agent system (MAS) is an important branch of distributed artificial intelligence. MAS can decompose a complicated system into several agents and the collaboration. Wind-solar energy hybrid power generation multi-agent system (WSHGMA) is very useful for Barmer region because of rich source of solar, wind, and oil. This system is based on decision making where system choice one or more than one source to supply the load demand. This paper presents an economic analysis, design process and climate considerations of a mini-grid hybrid power system with reverse osmosis desalination plant for providing electricity and clean water supplies for remote areas. The design steps are presented for supplying electricity and clean water in remote areas by utilizing renewable energy sources (wind and photovoltaic) and a diesel generator as alternate solution for continuity. The economic analysis considers the annual cost needed, the fuel consumption and initial capital cost, the total net cost and the cost of electricity generated per kWh.

II. ABOUT BARMER

Barmer is the second largest district of Rajasthan. Recently, a large oil field has been discovered and made functional in Barmer district. The total area of the district is 28,387 square kilometres (10,960 sq mi). The district is located between 70, 05' to 72, 52' E Longitudes and 24, 58' to 26, 32' N Latitudes. In 2009, the Barmer district came in news due to its large Oil basin. The British company Cairn Energy is already started the production from year 2010 on the large scale. Mangala, Aishwariya and Bhagyam are the major oil fields in the district. This is India's biggest oil discovery in 23 years. Cairn works in partnership with Oil and Natural Gas Corporation (ONGC). In March 2010, Cairn increased oil potential from this field to 6.5 billion barrels of oil – from an earlier estimate of 4 billion barrels. In summers the temperature soars to 46 °C to 51 °C. In winters it drops to 0°C (41 °F).

III. MULTI-AGENT CONTROL MODEL

Multi-agent technology is a new technology of artificial intelligence farther development. A MAS is composed of many interaction agents that together accomplish a complicated task on the basis of communication and

cooperation one another so as to optimize a system. Agent is a software entity with self-adaptation and intelligence on behalf of customers or other programs to accomplish a task by the way of initiative service. That is to say, Agent is an encapsulated module with independent functions includes its own data and algorithms of operating these data can accept and process the messages from other Agents and also send messages to other Agents, so it is an entity which has its independent problem-solving ability and can change along with the changing environment. Multi-agent system is a loose coupling agent network and these agents who have autonomous behavior are dispersive in physical unit and in logistic unit. The agents which associate one another by some protocol can solve a problem beyond single agent's solving ability. It is MAS' goal that disassembles a big complicated system (software or hardware system) into some mutual, easy managed, small systems. The MAS which is characteristic of "divide and rule"; "inter cooperation" is likely to solving some complicated questions.

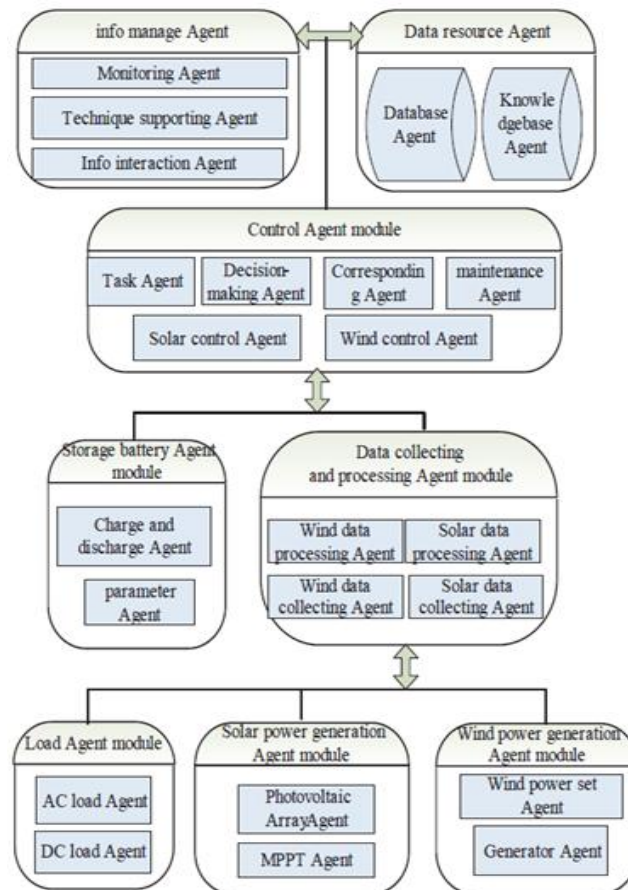


Figure 1: Multi-Agent system model in MACMWSHPS

IV. RUNNING MODE OF WSHGMAS

The four running modes of the WSHGMAS are as follows:

- According to climate condition, when wind energy resource is abundant and solar energy resource is lacking, the system starts up wind energy power generator agent, then calculates the capacity of load, directly supplies power into load. If energy is superfluous, system starts up charging and discharging manage agent, superfluous energy is charged into storage battery. Then if necessary, storage battery supplies energy into load.
- When solar energy resource is abundant and wind energy resource is lacking, the system starts up solar energy power generator agent under the control of control agent module, then calculates the capacity of load, directly supplies power into load. Superfluous energy is charged into storage battery under the control of charging and discharging manage agent and if necessary, storage battery supplies energy into load.
- When both wind energy and solar energy are abundant, they are both started up, the system come into hybrid power generating state. At the same time, supply energy into load or storage battery.
- When the weather is cloudy and windless, under the control of discharging agent, storage battery alone provides power to load.

V. COMPONENTS OF HYBRID MODEL

The model includes 7.5kW wind turbine, 5.6kW PV, 20KW diesel generator, and 48V battery. All of these components are connected to the load, and also connected to the dump load to control the system.

Battery

Two strings of EXIDE XL3000 batteries are used at Barmer each battery is 2V and has a capacity 3000Ah with 48V total bus voltage. These batteries are replaced every 10 years.

Diesel Generator

The main purpose of the diesel generator is to use as a backup energy sources when the renewable resources under performs. The sizing results show the energy production from the generator is around 2% of the total power demand. This generator is running at 1800rpm and used to deliver AC power to the system through the inverter. This generator has capacity of 20kW.

Photovoltaic Array

Each PV panel provides 280W with 24V. So, two PV modules are connected in series to meet the bus voltage which is 48V. 6.5kW PV rated capacity used in this system connected in 10 strings each one has two modules with twenty modules total.

Wind Turbine

Each turbine has rated capacity of 7.5kW and provides 48V DC. The hub height of 30 meters was selected. The HOMER software generated relationship (power curve) between the wind speed and the generated power, which is shown in figure 4. Wind data of 10m heights is used.

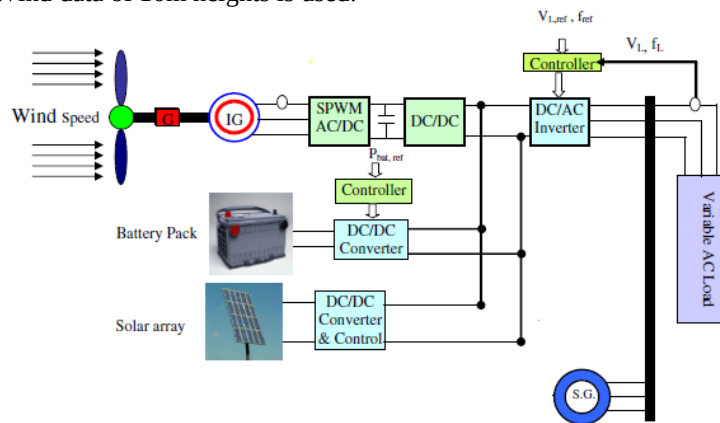


Figure 2: Hybrid Model

VI. GRAPHICAL RESULTS

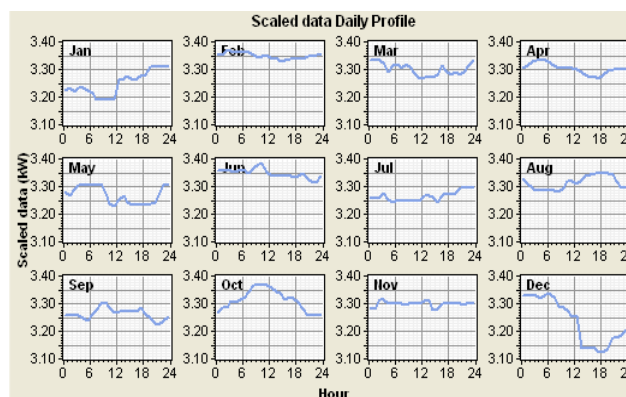


Figure 3: Load pattern of a microwave repeater

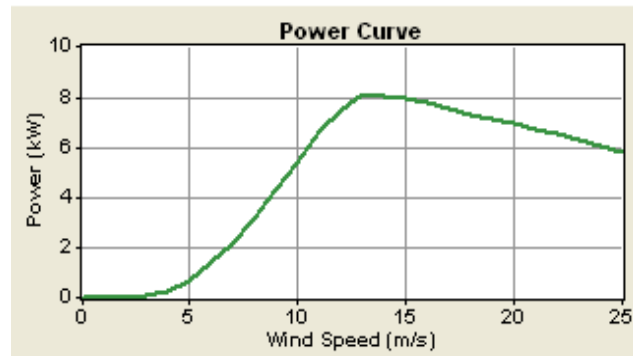


Figure 4: Wind turbine power curve

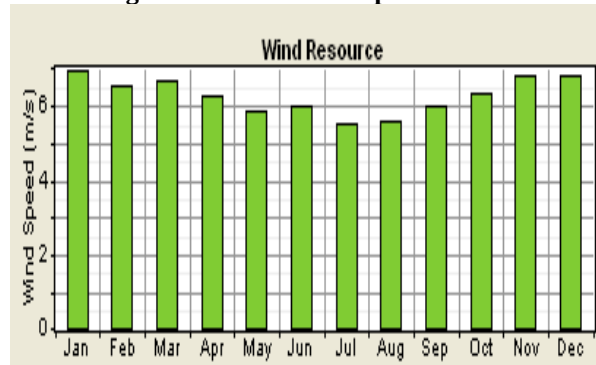


Figure 5: Average wind speed over a year

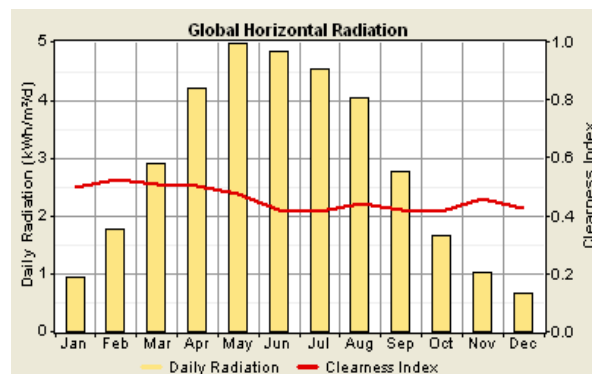


Figure 6: Monthly solar radiation

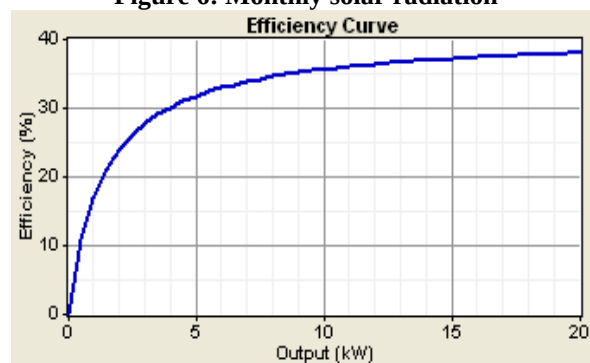


Figure 7: Average wind speed over a year

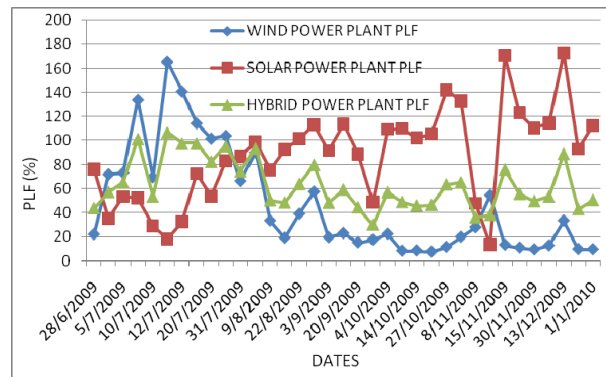


Figure 8: Plant load factor data of 6 month

VII. CONCLUSION

This paper presented a proposed hybrid power system for a remote site in Barmer. Graphical results are presented. It is shown that hybrid energy system for that site can have a renewable energy fraction of 98%. Dynamic modeling of the proposed hybrid system in MATLAB/SIMULINK is also presented. Transient response indicates a stable result. Hybrid power plants are green and clean unlike thermal or nuclear power plants. Earlier studies have shown that a hybrid power plant of 10 kW capacity, over its lifetime can prevent the release of considerable quantum of environmental pollutants, such as CO₂- 107.2 tones, H₂O- 17.66 tones, SO₂- 0.58 tones, O₂- 17.385 tones and N₂- 348.35 tones [13]. This certainly is an achievement towards the environment conservation and hence research in this field and installation of many such hybrid projects needs to be promoted on a much larger scale.

VIII. REFERENCES

- [1] Chunyi Shi, Wei Zhang, The Introduction of Multi-Agent system[M], Publishing House of Electronics Industry, Beijing, 2003.
- [2] Hongchun Shu, Lan Tang, Jun Dong,, A Survey on Application of Multi-agent System in Power System, Power System Technology, Vol.29, No.6, pp. 27-31.
- [3] Chuang Fu, Luqing Ye, Yongqian Liu, Yuanchu Cheng, Intelligent Control-Maintenance-Management System (ICMMS) based on Multi-agent System, Control and Decision, Vol.18, No.3, pp.371-374, may 2003.
- [4] Rachid Belfkira, Lu Zhang, Georges Barakat, "Optimal sizing study of hybrid wind/PV/diesel power generation unit" *Elsevier trans on solar energy* 2011, P.p 100-110
- [5] D.B. Nelson, M.H. Nehrir, and C. Wang "Unit Sizing of Stand-Alone Hybrid Wind/PV/Fuel Cell Power Generation Systems" *Elsevier trans on solar energy* 2005, pp.89
- [6] Picklesimer, D. ; Rowley, P. ; Parish, D. ; Carroll, S. ; Bojja, H. ; Whitley, J.N. ; , "Techno-economic optimization of sustainable power for telecommunications facilities using a systems approach", International Symposium on Sustainable Systems and Technology (ISSST), 2010 IEEE, pp1-6, May 17-19, 2010.
- [7] J.K. Kaldellis, "Optimum hybrid photovoltaic-based solution for remote telecommunication stations", *Renewable Energy*, Vol, 35, Pages 2307-2315, October 2010.
- [8] Smith, S.S.; Iqbal, M.T. ; , "Design and Control of a Hybrid Energy System for a Remote Telecommunication Facility ", presented at IEEE 17, NECEC conference, St.John's NF, 2007.
- [9] X. S. Han, H. B. Gooi, and D. S. Kirschen, "Dynamic economic dispatch: feasible and optimal solutions," *IEEE Trans. Power Systems*, vol. 16, pp. 22-28, Feb. 2001.
- [10] S. S. Rao, *Engineering Optimization, Theory and Practice*, 3rd Edition. John Wiley & sons, 1996.
- [11] Rai GD. Non Conventional Energy Sources. 4th Edition. India: Khanna Publishers. 2008: 37- 42