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Smart Energy Management in Green Buildings

Akhil Nigam[1], Kamal Kant Sharma[2]

[1]Akhil Nigam, Phd Research Scholar, Electrical Engineering Department, Chandigarh University, Mohali, Punjab (8958647623; e-mail: akhilnigam03@gmail.com).
[2]Dr. Kamal Kant Sharma is with Electrical Engineering Department, Chandigarh University, Mohali, Punjab (e-mail: sharmakamal2002@gmail.com).

Abstract
With the increasing size of supply and demand growth in the next decades there will be need of smarter distribution system. The installation of large number of electric power generation units may have adverse impact on environment. So smart energy management system is one of the best and novel approaches which enables smart grid operations. During the installation and incorporation of smart grids there are some factors like consumption of electric energy, energy storage, and generation resources should be optimized in such a manner that saves energy, improves efficiency, maintains security and enhances reliability during increasing demand at minimum operating cost. Some of the renewable energy sources may be taken as the pillars for making smart energy buildings which reduces the cost of building systems. From the point of distributed generation it may be considered as future power generation by the installation of renewable energy systems and storage systems. It will lead into smart energy buildings which will be in the form of Off-grid/Hybrid/Grid tied based solar system. Due to the development of smart techniques like fuzzy systems and artificial neural network system it is helpful to reduce billing cost of energy building systems. Green house gas emission is also a serious concern during the installation of energy buildings so hydro or wind energy systems are fully weather dependent and they can reach up to only 14% generation of electricity due to intermittent sources in nature. To overcome the problem of more energy demand and gas emission a new method proposed such as smart system services for the improvement of building performance. This paper deals with advanced techniques for smart home energy management system in order to control its operations in reliable, secure and economical manner.
Keywords:Artificial neural network, Energy management system, Energy consumption, Fuzzy system, Renewable energy system, Solar heating system

1. INTRODUCTION

Increasing in rapid growth in population and energy demands is introduced energy management system under in this environment. Due to over demand there is problem of keep balancing between energy demand and energy suly. There is a need of such a system which compensates these problems without any energy loss and provides sustainable energy. Hence there are various sources available bring out in such an environment at optimum capacity and making system less cost effective. There is a major aspect of cost because with introducing smart system it requires more cost to keep system under reliable operation.

The aim of demand side management is to provide balancing between customer demand and energy supply under all circumstances [1]. Also conventional energy sources have introduced smart energy management system because these sources use huge amount of fossil fuels and comprise of complexity. In order to compensate energy loss and distortions in energy system there is need of employing smart technologies to enhance continuous supply. In this era utilization of renewable energy sources keep balancing between continuity of supply and customer demand. Having advantages over conventional energy sources they use fewer amounts of fuels as requires and less cost [5].

These sources perform under all weather circumstances keeping all considerations. Few problems arise when we connect many distributed energy sources at any time it is having difficulty to synchronize all the sources at same time due to different properties. Hence a decentralized management system is to be introduced which may be refer as integral fraction of smart grid system [11]. So aim of smart energy management is to attain maximum efficiency with the exploitation of smart technologies.

Smart energy management system has been defined as series of different policies, procedures and methods to monitor operational utilization of energy. Some techniques like PLC have also been introduced for making smart building infrastructure [17].

Energy is simply the direct consumption of fossil fuel like coal, water or natural energy source requires operating function of plants. So there is an strategy of utilizing energy sources and produce electricity with high efficiency by employing smart methodologies keeping under consideration of low cost. Due to this it focuses on maximizing profits with reducing operational cost [21].

Figure no.1 shows the block diagram of smart energy management system in which it performs various functions like monitoring and control, measurement and analysis, load balancing, load forecasting, energy planning and enhance factors of energy generation and transmission. All these functions are maintained during normal and dynamic condition. Thus the smart energy management system has capability for monitoring, controlling and the optimization of entire system operation for achieving better response. Fig.1 shows the basic block structure of smart energy management system.

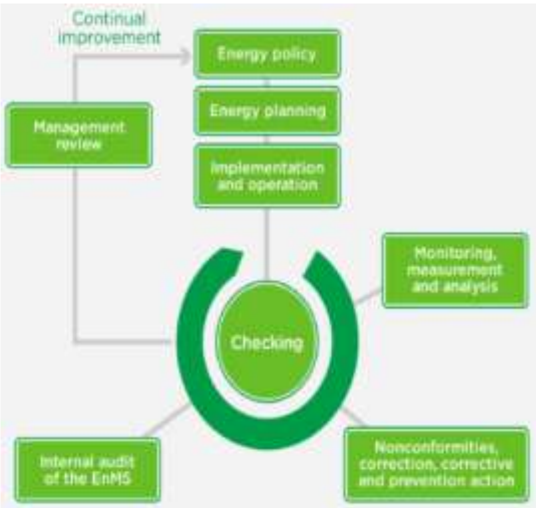

Figure 1. Block diagram of smart energy management system

2. SMART TECHNIQUES FOR IMPROVING EFFICIENCY AND APPLICATIONS OF SUSTAINABLE RESOURCES

Role of smart techniques is very important and essential to solve population issues around their environment so that they can achieve better results with new foundation of sustainable energy source. It is an opportunity for customer to develop a new model for enhancing continuity of energy demands in their life. So some major aspects like global warming, minimization of energy cost, balancing between demand and supply etc are required to overcome to get sustainable energy life.

Since green house gas emissions are continuously increasing day by day on large scale due to change in climate issues so it impacts on the global environment. It increases on scale like in 2017 it is around 1.7% but in 2018 it is increased by 9%. The current level of carbon dioxide is 415m but some years ago it was low around 400m.

Apart from rise in carbon dioxide gas emission there is also problem of nitrogen monoxide and methane gas emission. In 2030 it is some expectation that China could ban the plastic wastage as China is importing about 40% of the overall world's plastic waste since 1993. Now when we come into energy sector the production of electricity is globally based on fossil fuel on large scale particularly on coal and natural fuel. So rate of energy conversion is also very low because of low efficiency and large gas emissions [27].

For coal based energy plants it is expected level of energy production to around 30%-40% in terms of efficiency while for natural gas efficiency may be extended upto 65%. The function of current fossil fuels based techniques may be followed with a huge rate of waste heat.

So apart from the development of transportation system like electric vehicle or any other alternative transportation system it is possible to improve low combustion of fossil fuels. The utilization of renewable energy sources demands large amount of installation among various countries with huge investment and limited efficiency but they have improved infrastructure of solar PV installation and enhance more efficiency. Fig.2 shows about global distribution of plastic waste in world's ocean measured in tons.

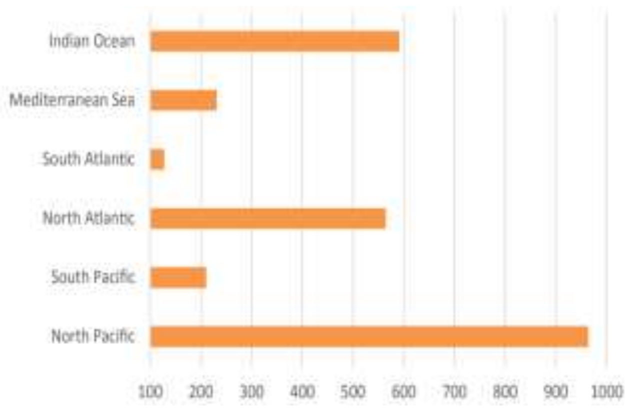

Figure 2. Global distribution of plastic waste in world's oceans in thousands on tons, (Weforum, 2018) [27]

In these days energy conversion efficiency of solar PV has been increased beyond previous years from 13 to 17%. Similarly employing wind energy conversion technologies have also impact with an average efficiency of 35% to 40% depends upon the type of wind farm it may onshore or offshore. Basically the present scenario of wind energy is installation cost it is a major issue and larger than any other energy source. The best way of utilization of renewable energy sources besides of advanced technologies is to connect with transmission grid properly means to ensure perfect connectivity for enhancing continuous suly of energy. Hence globally energy interconnection with grids is highly on demand for sustainable energy production and keeps balancing between customer and energy supply. Fig.3 shows the comparison among renewable energy capacities from year 2007-2017.

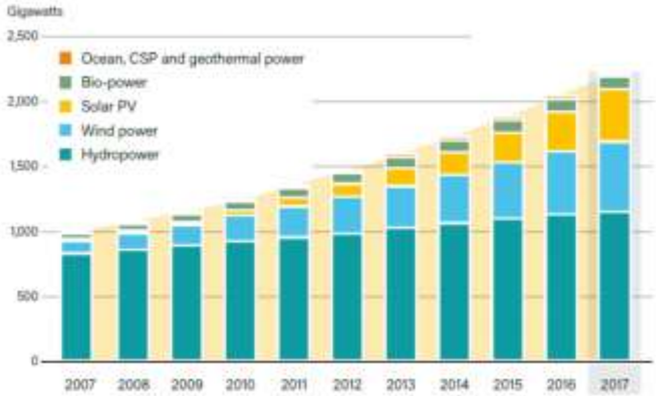

Figure 3. Comparison of global renewable energy capacities [27]

Further advance in energy storage technologies like thermal storage, flywheel and batteries are essential. In this era these energy storage systems are highly on demand because of low connectivity or problem from hazard conditions.
From recent report energy storage has reached a record level in year 2018 it is doubled from year 2017. Behind meter storage expansion was particularly resourceful almost four times that of 2017. In these situations the main leading country was Korea, followed by China, the United States and Germany. New markets have been emerged quickly wherever governments and utilities have generated suortive mechanisms which include Southeast Asia and South Africa, indicating that storage continues to need policy suort. The main aim of existing advanced energy storage devices is to remain at least for 20 years with synchronously reducing degradation with acceptable cost and security. Similarly rising in batteries causes more intense environmental issues which are associated with technologies of batteries.

3. FUZZY BASED SMART ENERGY MANAGEMENT SYSTEM

Using fuzzy based system in smart energy system has been carried out to solve issues in entire system. There are several approaches to achieve optimal control for smart energy system with monitoring and controlling all the parameters keeping all the considerations. Zhang and Hanby [36] utilizes supervisory control occupying renewable energy source and employs evolutionary algorithm in order to achieve optimal solution. There are also optimization techniques developed to overcome the problem of energy demand during peak load condition where power consumption and high usage of power have to be controlled.

Fuzzy based system in smart building needs automatic monitoring for energy management system under environmental conditions through the use of sensors [37]. So there are some processes to proceed energy management system through fuzzy based system are like fuzzification, fuzzy inference, and de-fuzzyfication. In fuzzification it is required to convert non fuzzy variable into fuzzy variable. In fuzzy inference it uses IF THEN to establish fuzzy relations. In last step defuzzification converts fuzzy variable into numerical value which further conveys to the equipment.

So this process is carried out based on environmental aspects which are detected by the sensors. Hence fuzzy system technique analyzes the level of illumination which is caused by lighting [38]. Fig.4 shows fuzzy logic based energy management system.

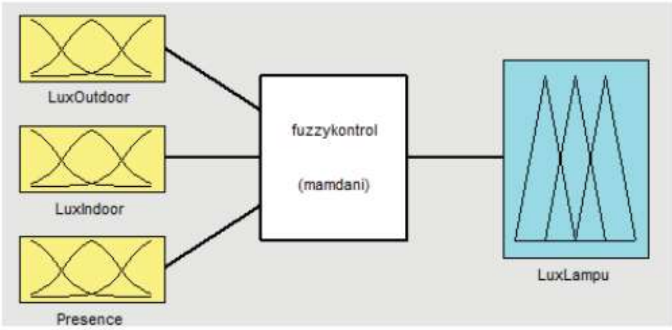

Figure 4. Fuzzy based energy management system [38]

Fuzzy logic controller has been designed in order to optimize energy consumption to ensure proper functioning. Many researchers have been developed intelligent energy management system with maintaining all the suitable conditions prefer to smart buildings. Fuzzy based systems are used to monitor and regulate characteristics and climate conditions. So fuzzy logic based system has been introduced by Lotfi Zadeh keeping in order to implement knowledge about controlling of system [39]. In this whole mechanism utilization of inference can be proceed from enhancing inputs, decides rules on which it has to perform and output has to be taken as final conclusion.

4. APPLICATIONS OF FUZZY LOGIC SYSTEM

Fuzzy logic system has been used for renewable energy sources like solar, wind, bio-energy and hybrid energy. Like Mamlook et.al have proposed fuzzy logic set methodology to compare the benefits cost for various solar systems [40]. Look like Gunderson et.al have presented graphical method based on fuzzy logic to measure potential sites for solar system power plants. So fuzzy densities are achieved for criteria and sub-criteria purposes. The criteria purposes are land factor, energy factor, environmental and social factor. Each of these criteria has its own sub-criteria. There are some dynamic fuzzy set models which are used to solve problems in solar based array systems. Hence fuzzy logic tool is to introduced to handle spatial data to know potential sites for solar array system installations.

Also for maximum power point tracking system in solar system fuzzy logic controllers have been compared with traditional PI controllers. So a fuzzy based logic controller has been selected for stand-alone application of solar power system. Hence the designing of fuzzy logic based system has been proposed for various factor measurements like voltage control, stability of power system and speed control purposes. So for smart buildings we can develop fuzzy logic controller using renewable energy sources. Table 1 shows the techniques employed for different renewable energy systems using fuzzy logic:

Table 1: Renewable Energy System With Techniques

Techniques	Renewable Energy System	Proposed Year

Fuzzy expert	Building design	1995
Neuro-Fuzzy ANFIS	Wind	2000
Neuro-Fuzzy ANFIS	Bio-mass	2002
Fuzzy clustering	Solar	2003
Fuzzy optimization	Solar	2004
Fuzzy expert	Renewable	2006
Fuzzy MCDM	Solar	2008
Fuzzy regression	Solar	2010
Neuro-fuzzy, ANFIS	Hybrid	2011
Fuzzy MCDM	Wind	2012
Fuzzy TOPSIS, VIKOR	Solar	2013
Fuzzy AHP, ANP	Renewable	2014
Neuro-Fuzzy GA	Solar	2014
Fuzzy PSO, QPSO, Cuckoo optimiza	Hybrid	2015

tion

5. Artificial Neural Network Based Smart Energy Management System

An artificial neural network is basically an algorithm in which it develops non linear models and simulates human brain. It has unique method to deal with non linear relationships between input and output signals. So it collects input and output signals from dataset, pre-processes of inputs and outputs then it designs neural network designing and evaluates the performance of neural network [41]. Fig.5 shows artificial neural network system which is based on smart energy management system.

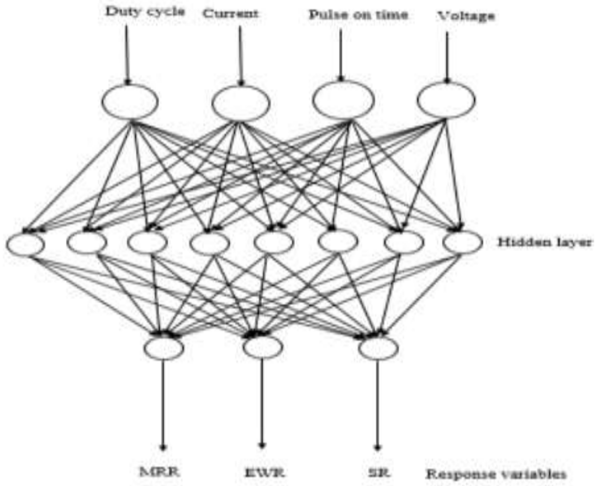

Figure 5. Artificial neural network system [41]

6. Applications of Artificial Neural Network System

Many researchers have published their wok based on artificial neural network through modeling and prediction in energy systems for buildings applications. They require proper models for the prediction of solar energy and wind power systems. These systems are designed based on their environmental perceptions on which they operate. So ANN based system can be operated in various ways like solar water heating systems.

In solar water heating systems, a multilayer feed forward artificial neural system can be preferred. This system is installed under all solar power prediction aspects under which it operates reliably. The useful extracted energy from the output network is stored and utilized for rising the temperature of collected water. Solar heating system is operated with keeping parameters which is obtained from performance equations. All the predicted values using for operation of entire system are easily comparable. So the results obtained show the proper estimation of parameters and represent the overall optimal performance of solar heating system [42]. Fig.6 shows artificial neural network system for solar system.

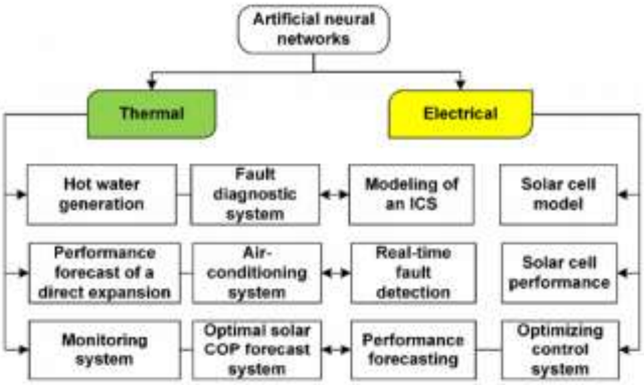

Figure 6. Artificial neural network system for solar system [44]

Table 2 shows the different methodologies for the prediction of solar radiation with input parameters and type of neural network.

Table 2: Artificial Neural Network With Different Parameter

Input Parameters	Type Of Artificial Neural Network	No. of Neurons
Solar radiation, temperature, humidity	Feed-forward back propagation	7
Lat, Lon, Alt, time	Multilayer feed forward	13
Lon, Lat, Alt, Sunshine percentage	Feed-forward back-propagation	7
Average wind velocity average humidity	Back propagation	8
Lat, lon, alt	Multi-layer feed-forward	22
Mean land surface temperature	Feed-forward back-propagation	20
Daily solar irradiance, mean daily air TEMP	Feed-forward	17
Day, Hour, TEMP	Back propagation	3
Hour, declination, zenith angle	Feed forward back-propagation	40
Global horizontal solar radiation time series	Feed forward	13
TEMP Solar radiation	Feed-forward Neural Network with fuzzy logic	---

7. Conclusion

In this paper smart energy management has been discussed with its techniques and applications. There are various techniques preferred for modeling of smart energy management systems like fuzzy based and artificial neural network based systems. All the performance has been carried out under all the predictions of various parameters. So further for making smart energy management system we may also preferred artificial based techniques to implement all home or industrial appliances for achieving better response.

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