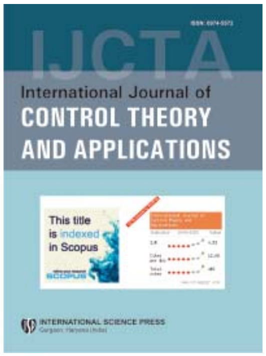

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Scheduling Unused Power in Grids by PSO to Reduce the Loss in Distribution System

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Abstract: To reduce the power loss of grids in the distribution systems by allocating the power uniformly to all the consumers who are connected to the grid.

Methods/Analysis: Particle Swarm Optimization (PSO) technique is used to reduce the wastage of energy from energy sources when it is not used in a correct manner. Demand Side Management (DSM) is used to allocate the power depends upon the requirements of consumers. These methods were applied in the solar and wind systems for each hour in a day to allocate the power in an optimized manner.

Findings: The loss of energy can be reduced by applying effective method of power allocation. The modified PSO technique is used for testing the consumer based DSM system. The unused power from the generating stations is stored in the external battery and it can be used for the peak load time. Hence, the unused power is not wasted and it can be used in an efficient manner. A real time analysis was done by considering solar and wind power system. The existing grid system is converted into the smart grid by including PSO optimization technique. The simulation result shows that 28% of cost saving is achieved for the end user. It leads the considerable annual savings of the consumers. The results show that the PSO technique is well suited for grid systems for efficient power allocation.

Novelty/Improvement: In the proposed PSO system the grid system is reshuffled in an optimized way and gives accurate results. This system can be compared with other optimization methods.

Keywords: *Demand side managements, Particle swarm optimization, Smart grid, Distribution systems, solar system, wind system.*

1. INTRODUCTION

The generation and distribution system is challenged due to the heavy increase of energy demand for consumers when they use different appliances in home and the rise of industrial machines. The population as well as the industries is increasing day by day in all over the world. Due to this a large amount of power is needed to satisfy their needs. The sources of energy are not enough to reach the demand side level. A small amount of energy that is generated from conventional and nonconventional energy sources are wasted when it is not used in a correct manner.

Several studies are conducted to modify the design of micro grid power system to increase the capacity and reduce the cost per year. The communication between the consumers and the grid system is extremely important in the smart grid system [1]. In the past decade the computer and internet played a main role to reduce the power losses in the structure of power systems. Also a lot of new software and algorithms are developed in the fast growth of the loss reduction task. Some of the methods and ways are Advanced Metering Infrastructure (AMI) and Meter Data Management Systems (MDMS). Home Area Network (HAN) and Demand Side Management (DSM) are new methods for a smart grid [2].

Now a days, advanced techniques are integrated to maintain the flexibility and the reliability of the smart grid systems. The technologies include smart metering, two way communication, generation of power and the storage in a distributed manner. The interconnection between the components is done by several communication devices so that a real time communication can be achieved between the consumers and the energy providers [2]. The desired smart functioning includes self healing, optimizing asset utilization and minimum [3].

In the proposed work the grids are rearranged in a proper way to decrease the power loss and to effectively use the grids. The operation of smart grid in the power system can be controlled by some controlling devices. Now a days most of the consumers are not having much awareness about the usage of power from the distribution line [2]. Hence the behavior of the consumers should be changed by conducting the awareness programs. The government of India is also interested to change the behavior of consumers by conducting many seminars and demonstrating the projects that aims the proper use of the power.

It is very important to reduce the loss of generated electrical energy in the transmitted and distributed system by effective power delivering methods. Lot of new methods and algorithms are used for the development and rearrangement of the grid to reduce the losses. The electric power consuming appliances and utilities around the world has a rapid change for the past ten years. The overall system stability is forced to deregulate because of new environment issues. For the individual utilities, reliability and stability must also be changed and new efficient methods must be implemented in them.

Maintenance of transmission and distribution system is one of the important factors for increasing the cost of production. The detail information about the appliances connected by the consumers is needed to determine the working conditions and the connected load of the consumers. The grid power distribution system has several difficulties which make it as a complex system [4].

Several new and advanced technologies are introduced in renewable energy systems like wind and solar power generating system. The grid will be complicated when these power systems are incorporated into it. So the complexity can be controlled by adding different controllers in grid systems [5]. The better utilization and economic energy usage can be achieved by introducing recent communication technologies [6].

Two goals are mainly considered by the system while a complex and adaptive distribution system is considered. This is the very most important thing that changes a lot of parameters which is considered throughout the system. The first one is to reduce the resource consumption by the consumers. The second goal is to deliver efficient electrical energy and changing the habits of the consumers [7].

New technologies will be added in the power systems to satisfy the future needs. When the renewable resources like solar and wind systems are included then the existing infrastructure will be changed. The new infrastructure should be flexible and satisfy the increasing needs of the consumers. The grids with this infrastructure are called a smart or an intelligent grid and this required for the management of the decentralized power plants. The current consumption of end points can be measured by different equipments like digital current meters and the smart meters.

One of the important applications of the smart grid is that it encourages home and business owners to invest in the micro-generation technologies in order to supply some of their own energy and to reduce the demand on the electric grid in the distribution system. The most popular renewable energy source among the renewable energy sources is the solar and the wind energy system.

2. MATERIALS AND METHODS

2.1. Congestion Management

In deregulated power systems, the most important requirement is congestion management. Normally, congestion occurs in the transmission line because of less coordination between the transmission utilities. Hence, the demand in load will be increased or the equipments may be damaged. The failure can be resolved by FACTS (Flexible AC transmission system) devices. To make the system more secure the congestion occurs in the grid should be eliminated. The security of the grid system can be achieved by the following steps.

2.1.1. Reducing the total congestion cost

The total congestion cost can be determined by the CMC (Congestion Management Cost) function. It is the minimum value of the difference between the generation cost function and the demand cost function.

$$CMC = \min\left(\sum_{i=1}^{N_G} C_{Gei}(P_{Gei}) - \sum_{i=1}^{N_D} B_{Dei}(P_{Dei})\right) \quad (1)$$

In the above equation $C_{Gei}(P_{Gei})$ denotes the real power P_{Gei} which is generated at bus i and $B_{Dei}(P_{Dei})$ denotes the demand function.

2.1.2. Analysis based on N-1 contingency

The congestion in grid system occurs by several factors like the high voltage output from the generators, heavy loads in transmission lines, variations in the energy demands and in the unsynchronized transmission lines. This analysis is helpful for selecting desired transmission line.

2.1.3. Increasing the voltage stability to maximum level

The voltage should be stabilized throughout the power systems to support secure operations. The voltage stability index is measured by the voltage stability level. The voltage stability level is the addition of operating point at a particular time and the small change in the increased load. It is given by the following equation.

$$\text{Voltage Stability Margin (VSM)} = VSM_i + VSM_{SC} \quad (2)$$

VSM_i denotes the VSM at operating value voltage at initial point

VSM_{SC} denotes the VSM change due to the demand in power and rescheduling of grid.

2.1.4. Increasing the corrected transient energy to maximum level

The stability of the grid system will be maintained when the congestion management techniques are applied. When the output of the generators assures the stability margin, the congestion management will be more secure. Due to this the synchronization of the grids are not affected when there is a possibility of high error. The power system will not be affected due to the possibilities of high errors [8]. The transient energy level is calculated by the following equation.

$$\text{Transient Energy Management (TEM)} = TEM_i + TEM_{SC} \quad (3)$$

where TEM_i represents the value of CTEM before the congestion management is applied.

TEM_{SC} represents the change in CTEM when the rescheduling of demand and power is applied.

2.2. Particle Swarm Optimization (PSO)

The problem solving in the grid system can be done by the of PSO algorithm. This algorithm is based on the activities of a group of animals which does not have any organizer in that group [9]. Generally, the group of animals that does not have any leader will randomly find out their food and they will follow a member of that group with the nearby location from the food. This is a type of potential solution for the problem. The members of the group attain the best condition concurrently by making the communication between the group members who already have a better condition. These members will intimate it to the group then they will also go to that place. This process will be repeated until the best solution or a food source is found.

This technique is used to find out the best possible value follows the behavior of the animal societies. It contains a group of elements and each element represents the potential solution [10]. Kennedy and Eerhart are the persons developed the concept of PSO in 1995. It was the novel heuristic technique and motivated by some public activities demonstrated by a group of birds or animals. This will be used to discover certain parameters that are necessary to achieve the desired objectives [11].

3. PROPOSED ARCHITECTURE

The distribution side block diagram is given in Figure 1 and the consumer side block diagram is given in Figure 2. The block diagram in distribution side consists of the following components:

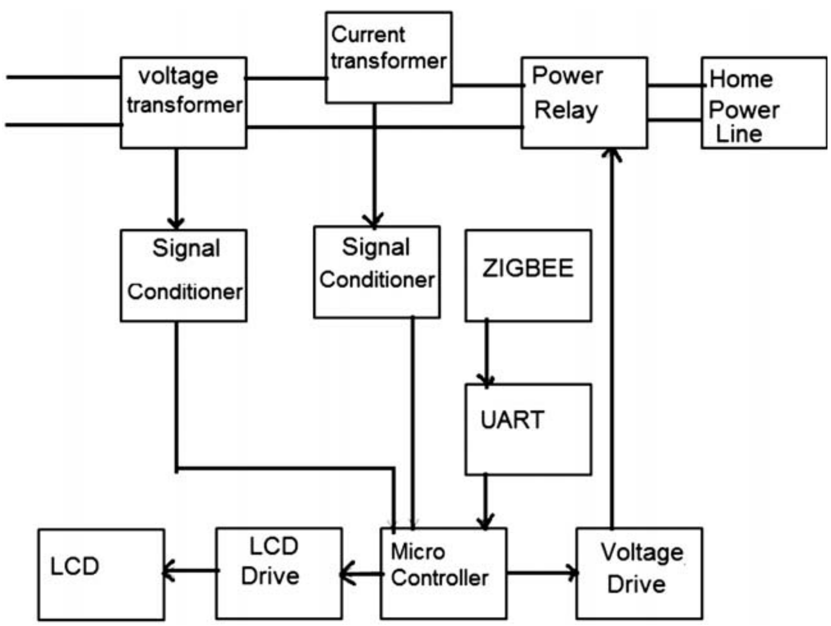

Figure 1: Block diagram (Distribution side)

1. **Signal conditioner :** Signal conditioning is the process of converting the analog signal to meet the requirements of the subsequent step. This is mainly used in analog to digital converters.
2. **ZigBee :** This is one of the communication protocol which is mainly used in private networks that use the low range digital radio signals.
3. **UART :** UART is the abbreviation of the Universal Asynchronous Receiver/Transmitter. It is a hardware used in computers to translate the data between serial and parallel format. It consists of shift registers to do this job. The transmission of digital data in terms of bits through any medium or a cable is little expensive than that are transmitted through a number of cables in parallel transmission.

4. **Relay :** This is an electrical switch. Most of the relays can be operated as a switch with the help of mechanically operated electromagnet. Other working principles like solid state relays can also be used. They can be used in low power signal applications that require for controlling the circuits. When multiple circuits have to be controlled by one signal or there is an electrical isolation between the control and the circuits then the relays are used.

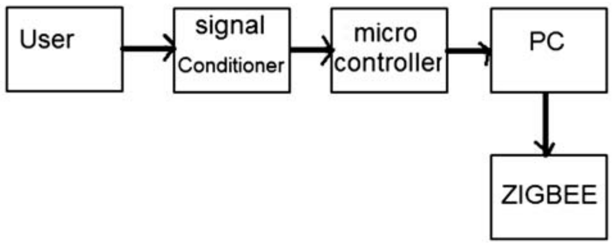

Figure 2: Block diagram (Consumer side)

Smart grid will encourage the home and business owners to invest in the micro generation technologies because some of their own energy can be supplied to the smart grid to meet the increase in the demand of electrical energy. It is one of the important application. In the Micro-generation models it has lot of sources of energy such as wind turbines, fuel cells and solar panels [12]. The combination of the above said energy sources in different forms results in multiple structure of the Hybrid Renewable Energy Systems (HRES) [13].

4. PROPOSED METHOD

The PSO technique is applied in the proposed grid system. The concept of load management is also included in the proposed system for efficient and reliable output and the DSM proposed real time simulation tool has designed [14-17]. Load management program will either decrease peak level energy demand or to transfer the demand from peak to off peak periods.

The solution is based on the HRES technology [18]. The battery storage is used to solve the demand when there is no renewable energy source at the peak demand time. The basic block diagram of the HRES is shown below in Figure 3.

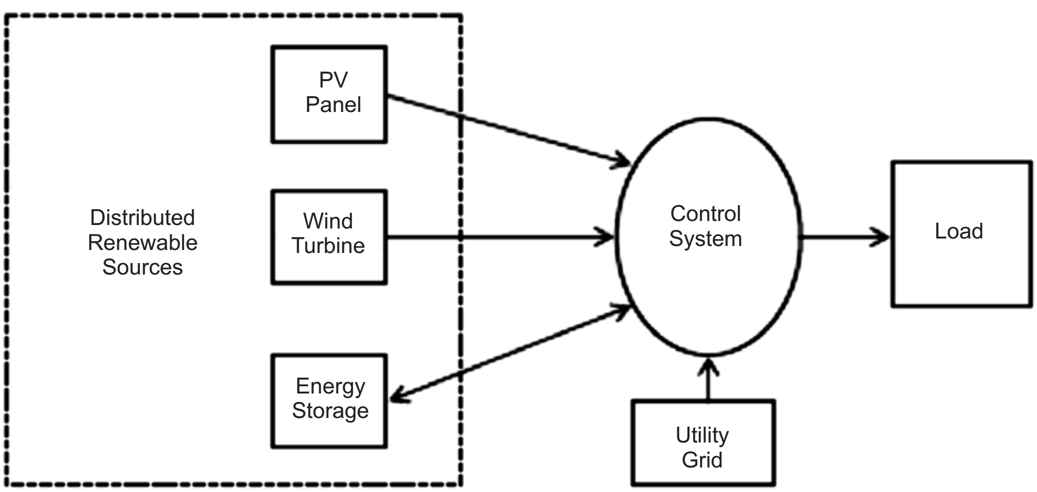

Figure 3: Architecture of HRES

The proposed simulation tool is developed on the axis of load management DSM [19]. The Load management programs will reduce the demand of electricity at peak time or to change the demand from peak time to off peak time [20]. The architecture for the simulation tool is shown in Figure 4.

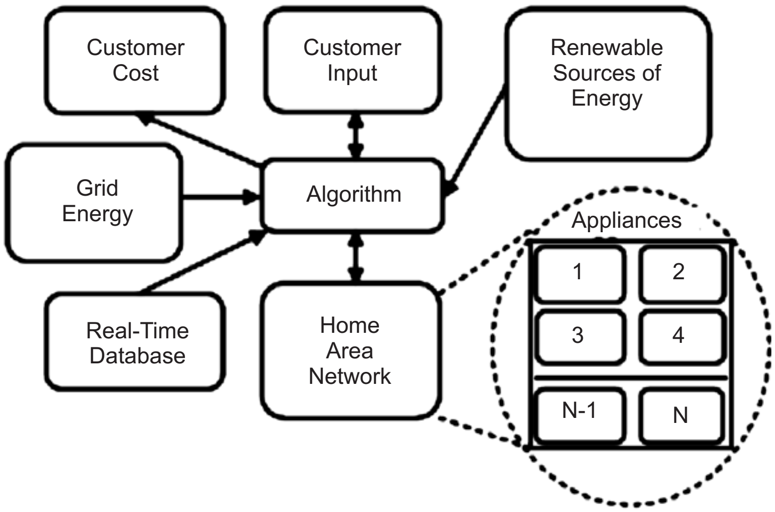

Figure 4: Proposed simulation tool architecture

4.1. Design

$$F(x) = (E - ((1 - i) * (P_e + W_e)))*CR \quad (4)$$

i is the optimization parameter

E = Appliances total energy consumption

CR = Cost rate

P_e = Solar energy

W_e = Wind energy

Battery charging energy at any instant is given as

$$i* (P_e + W_e) \quad (5)$$

The difference between maximum capacity of the battery and the amount available for the given instant during the recharge

$$G(x) = E_b - (E_{ba} + i * (P_e + W_e)) \quad (6)$$

E_b = The maximum battery capacity

E_{ba} = The maximum energy available at the time of calculation

At any instance, the value of x is a percentage value

and it is in $0 \leq i \leq 1$

During the recharging $G(x) \geq 0$

i.e $$E_b - (E_{ba} + i * (P_e + W_e)) \geq 0 \quad (7)$$

4.2. Simulation results

For obtaining better simulation results we have to consider how much of energy is produced in each hour of a day for wind as well as for solar power. They are shown in the below tables. Table 1 for wind energy and table 2 for solar energy.

Table 1
Values of Wind Power

Hour (in a day)	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Power (W/m2)	0 .0	0.0	0.0	0.0	0.0	0.0	58	225
Hour (in a day)	9	10	11	12	13	14	15	16
Power (W/m2)	356	704	955	1035	999	949	890	789
Hour (in a day)	17	18	19	20	21	22	23	24
Power (W/m2)	582	351	76	0.0	0.0	0.0	0.0	0.0

Table 2
Values of Solar Power

Hour (in a day)	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Power (W/m2)	45.2	16.5	5.9	34.7	20.4	27.0	36.7	12.4
Hour (in a day)	9	10	11	12	13	14	15	16
Power (W/m2)	6.7	36.6	2.9	32.6	19.8	43.2	10.9	11.2
Hour (in a day)	17	18	19	20	21	22	23	24
Power (W/m2)	14.7	27.7	34.7	20.8	31.3	3.27	35.6	2.10

After number of iterations the PSO will give the better output and it is there in the Figure 5. It shows the efficiency of the system by the solar and wind energy sources to the connected loads. The output values from the PSO are given in Table 3.

Table 3
Output values from PSO

Hour in a day	*PSO out for Wind*	*PSO out for solar*
1.	19.9571	0
2.	0.8703	0
3.	0.0434	0
4.	8.6407	0
5.	1.8670	0
6.	1.3426	0
7.	10.8961	0.0524
8.	0.3929	0.1982
9.	0.0534	0.2881
10.	1.4552	0.0824
11.	0.0057	0.8601
12.	6.6971	0.9486
13.	1.7056	0.9445

Hour in a day	*PSO out for Wind*	*PSO out for solar*
14.	13.2330	0.6226
15.	0.1595	0.4255
16.	0.2950	0.6726
17.	0.5520	0.5340
18.	4.5134	0.3235
19.	1.0150	0.0075
20.	1.9208	0
21	6.5047	0
22.	0.0071	0
23.	8.4190	0
24	0.0017	0

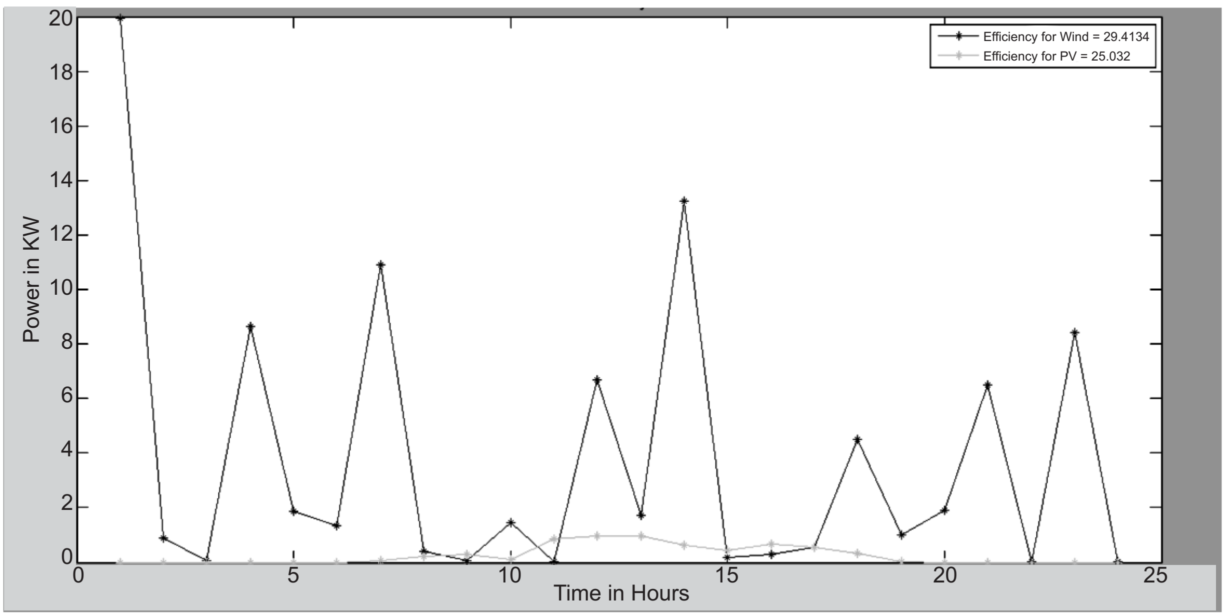

Figure 5: Output from PSO (Efficiency)

5. CONCLUSION

The new PSO used for the development and testing of consumer based DSM is presented in this paper. The simulation results are also shown. By using this PSO the proposed grid system works well for different power systems. It provides better performance and possible benefits for DSM. The tool simulates a house hold environment. Also it provides the consumer a real time analysis of optimized appliance selection and resource management. This result from the PSO simulation achieves an average of 28% of cost saving for the end-user. These results lead to significant annual savings for the customer. This PSO totally reshuffle the grid system by choosing the most efficient way and gives accurate result. This PSO tool is also used for extending the research and for more improvement of the power system as well as the grids. The concept of selling back excess energy to the grid is the concept of using plug in Hybrid electric vehicles for storing energy. Thus for the better development of the smart grids this PSO can also considered along with other existing methods.

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