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Cost Optimization For Energy Consumption in Microgrid using ZIGBEE

1.Anush P, IEEE Member
Assistant Professor,
Department of Mechatronics Engineering,
Kumaraguru College of Technology
Coimbatore - 641049, India
anushcbe@gmail.com

2. Mr. S. Premanand
Assistant Professor,
Department of Mechatronics
Sri Krishnacollege of Engineering and Technology,
Coimbatore, India
Prem_selvam1983@yahoo.com

3. S.Kannaki
Assistant Professor,
Department of Mechatronics
Sri Krishnacollege of Engineering and Technology,
Coimbatore, India
mounakannaki@gmail.com

***Abstract*—Microgrid is a load and source management system in the distribution side which can sustain by itself or in interconnection with the main power grid. The energy consumption cost would rise drastically due to less investment on energy production in the absence of such grids. So, inorder to reduce the carbon foot print, the utility company has to invest in renewable energy source such as solar wind, fuel cells, etc. If this condition persists, the energy consumption charge followed in future years will be higher during the peak demand hours.**

This paper deals with cost optimization by strategically shedding down the load at distribution side depending upon the energy cost of the hour. By shedding down the less priority load during peak hour, the running cost can be optimized. Exporting the power to grid from the distributed storage and distributed generation system during these peak hours, maximum cost will be charged from the power grid. Thus, the operation optimization technique proposed above can be incorporated in the house hold micro grid to run with minimum energy consumption cost.

The consumer load classification and load schedule is forecast by the daily behavioral model.

***Keywords*—*MicroGrid*, Zigbee, Cost function, energy consuption Cost Optimization, distributed generation, distributed storage, operation cost.**

I. Introduction

Micro grid operation is vastly spreading its presence in the disturbed generation and load side management. The interaction with the power grid [1] i.e. synchronization and islanding operation which is the main distribution grid is the function of the micro grid, it has to be operated at a cost effective manner to reduce the running cost of the consumers operating the electric load [2]–[5].

Autonomous generation and utilization of power supply the fuel cost and scheduling of the load are given significant importance this is due to many utilizes company are trying to met up with the ever inexorably rising electrical load. By improving the distributed generation and distributes storage, the load capacity is drastically increased with bi directional power flow from consumer side [6]. The losses that occur in the transmission of power, the objective of increasing the load capacity might be limited. The power consumption cost will also peak if these steps are not undertaken [2].

The micro grid is centrally controlled and management of micro grid is done by micro grid central controller [7]. The comparison of bi directional energy and information flow envisioned in smart grid is be found in [8] here they have talked about the advantage and disadvantage of the existing grid and future grid. To meet with the demand of the gird the smart metering and infrastructure to support the two-way communication has to be implemented, for this IoT which referring to unique identification of object (smart meter) is the key technology for the future smart grid. This integration of Ethernet i.e. internet and the power grid has lead to the so called Energy Internet: the Enernet [9].

This paper deals with the intelligences that required by the apparatus to turn on and off depends upon the floating tariff of the present power grid rate. Technology employed for the communication is ZIGBEE [10] for Enernet capability. Employing with this backbone the Microgrid system would have the two way communication with the central controller,

the cost estimation and floating tariff from the central controller. From this information the optimization of the local load and running/power consumption cost reduction is the main objective of this paper. Various parameter to be considered for the optimization checked and simulation of the proposed microgrid is been done.

This paper is organized as follows: Section II deal with the modelling the problem statement and identification of the parameter to find the optimal scheduling of the load. In section III the algorithm for the proposed microgrid operation is explained and optimization with power consumption cost. In section IV simulation and result are discussed, and in section V deals with conclusion of the proposed system and future work.

II. System Model

Microgrid modelling has to taken in sense of power and communication line. The typical model of a Microgrid is show in **Error! Reference source not found.**. The proposed Microgrid system has the four hierarchical controls structure that shown in **Error! Reference source not found.**.

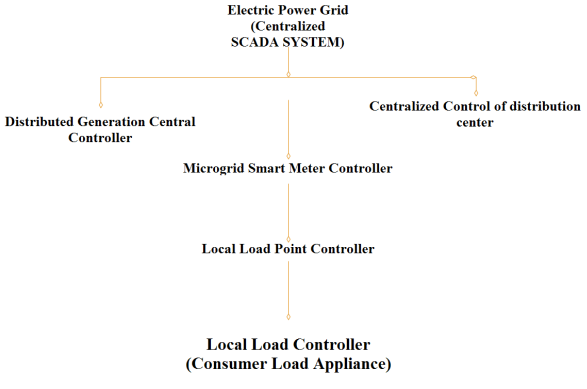
- Local Load controller (LLC)
- Local Load Point Controller (LLPC)
- Microgrid Smart Meter Controller (MSMC)
- Distributed Generation Central Controller (DGCC)

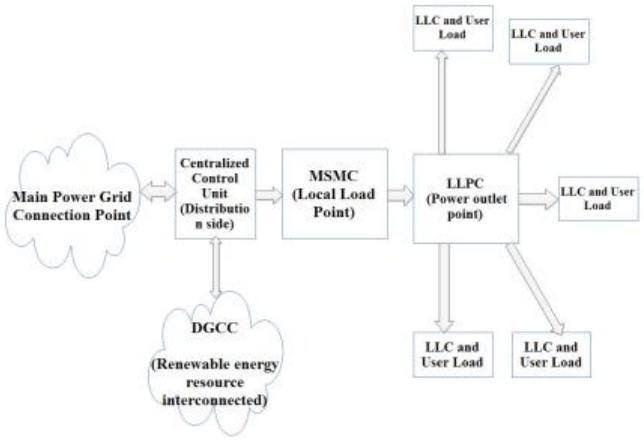
Figure 1 Typical Consumer centric Microgrid Layout

The **Local Load Controller** (LLC) takes advantage of the two way wireless or wired communication with an inbuilt controller which supports the local processing of load shedding or resuming the operation of the load. LCC device will act as a slave to other higher order system. LLC will have the information about the duration and pattern of the load usage throughout its working life time. The priority of the LLC depends on the life style of the user. Based on the priority level and the load consumption factor data is transmitted to its master suggesting the working status approval from the local load point controller.

Figure 2 Control structure hierarchic of consumer centric Microgrid

The **Local Load Point Controller** (LLPC) has a wired communication with the MSMC; controller has a two way communication with both LLC and MSMC. Control signal





form the MSMC mention of the maximum demand (MD) that can be turned ON for that particular period of time. The time slot maximum demand (MD) value will be selected by the MSMC unit and passed to the LLPC. This LLPC controller will monitor the MD point and maintain within its envelope by using the load shedding method algorithm.

The **Microgrid Smart Meter Controller** (MSMC) is the main controller for the consumer centric Microgrid, which maximization of the target set by the user i.e. minimization of the energy consuming cost and the peak load reduction set by the utility companies. Market prices of the power consumption will various with peak hour utilization; this value of the date is send to the MSMC. The MSMC is responsible for the maximum demand of the load for given time slot, then it have to perform the optimization of the energy cost and load priority set by the energy consumer.

MSMC will communicate with its LLPC points for scheduling the load and its power consumption pattern of the individual load. Under MSMC there are n numbers of LLPC points; communication to and fro with the LLPC will be done in a sequence manner. MSMC will communicate with the DGCC and load dispatch centre with a hourly time interval and the MSMC duty to update the utility sever with thye monthly energy consumption data for billing purpose. This communication might contain even the other parameter like max demand, power factor and power utilization quality for the further billing and planning process. [3] proposed a principle in which another NN yield input control law was created for an under incited quad rotor UAV which uses the regular limitations of the under incited framework to create virtual control contributions to ensure the UAV tracks a craved direction. Utilizing the versatile back venturing method, every one of the six DOF are effectively followed utilizing just four control inputs while within the sight of un demonstrated flow and limited unsettling influences.

The **Distributed Generation Central Controller** (DGCC) is responsible for the availability of the source and the pricing of the fuel/running unit cost is determined and the peak hour charge is also been dispatched to the MSMC's units. DGCC will estimate the supply and demand cost and predicate the allowable load in the system for a safe operation, this process gives the DGCC load capacity for that given time slot. Information is transmitted to local MSMC unit for further processing and realization of the target set by the DGCC.

Thus DGCC will operate the system in optimal manner without any black out or entire load shedding could be avoid.

A. *Communication structure*

Microgrid required two way communication network to operate seamlessly without interruption. The proposed system have a wireless communication structure shown in **Error! Reference source not found.**. LLC has a wireless network with the LLPC and the LLPC communicate with the MSMC with Zigbee network. MSMC communication with the DGCC use the fiber optics for interconnections with the main grid and the other DGCC. The proposed system used two type of communication network, the bridge for communication is taken care by the microgrid smart meter architecture. The MSMC forms the bridge between the external power system to the consumer load circuit. By this system the power loading and shedding is maintained or created by the MSMC unit for optimized operation of cost factor. This microgrid is constructed in means of not having its own power generation capacity inside the MSMC unit.

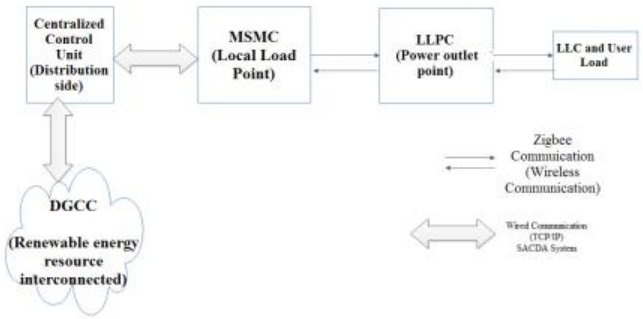


Figure 3 Proposed communication structure of power grid layout of a Microgrid.

B. *Power grid structure*

Power structure of proposed system is simple structure which could be seen in any typical house hold appliances. The load site will filled with n numbers of load that been utilized by the user. The typical loads of the house hold are as follows:- Light, fan, Television, cooling system, fridge, mono block pump are some of the generally utilized system. Critical loads are present in a house hold are computer system, any other Critical system are lighting and ventilation fans.

Loads are utilized by the users choice, the choice of running each load differ based on consumer's age, life style, priorities, etc. To predict these priorities automatically is not within our scope of the project. These priorities and cost benchmarks are assumed in this paper to move forward.

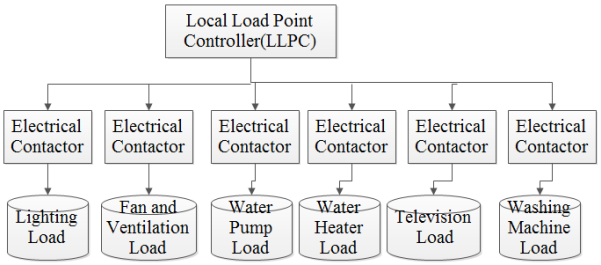


Figure 4 Proposed Power System of a typical house hold appliances

Proposed consumer centric power system is shown in **Error! Reference source not found.**. Here the load are mainly load capacity is of 100Watts in average the load factor in a given day. The highest demand load will be water heater and air conditioning unit, nowadays the induction stove is also getting into the household loads. Rest of the major house hold load are light, fan, television, water pump, mixer, refrigerator, etc.

Priorities of these loads are assumed are given in **Error! Reference source not found.**, from this assumption the load are tripped and connected according to the cost factor set by the consumer.

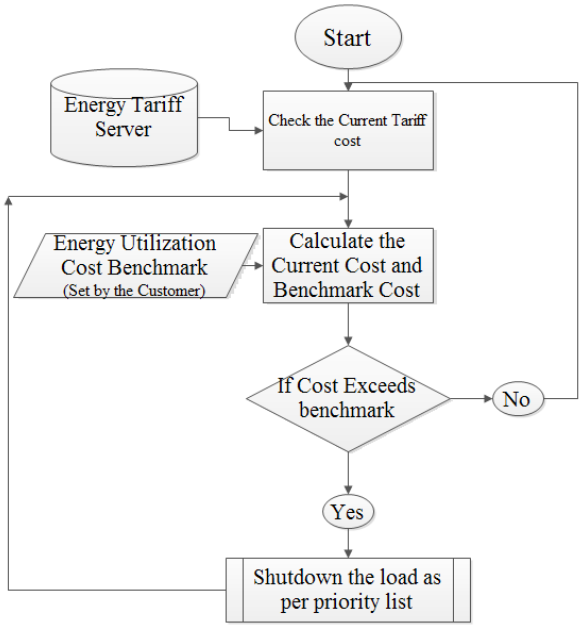
Table 1 Priorities of typical house hold items

Priority Level	Typical Consumer House hold loads		
	*Particulars**	*Power usage*	*Total time of usage*
1	Lighting loads Tublight and CFL Lamps	40 to 10 Watts	18Hrs
2	Fans and Ventilation system	60 to 200 Watts	24 Hrs
3	Water Pump	700 Watts	30 Min
4	Water Heater	1200 Watts	2Hrs
5	Television	180 watts	20 Hrs
6	Waching Machines	1000 Watts	2 Hrs

* Data taken from typical house hold consumption pattern

III. Problem formation and Algorithm

Problem definition of the system is done with cost optimization factor of the consumer load. This model is consumer centric based which gives an optimal energy utilization cost for the consumer. The cost minimization function algorithm is given in **Error! Reference source not found.**.



Algorithm is simple yes or no process where the current tariff cost and user defined cost is compared then the decision is made to shed the load based on priority of each load.

Figure 5 Flowchart of Proposed system

Problem formation is estimating the cost for monthly bill if this load runs in current tariff with future tariff with current value. Thus it calculate the monthly tariff based on current and past utilization of the power and depending on these factor the load shedding is initiated.

IV. Results and Discussion

Simulation is based on the proposed model is done the following are the result of predicting algorithm.

The **Error! Reference source not found.** shows the cost change in given day, based on this real time cost of energy, this system going to shed the load to meet the benchmark set by the consumer.

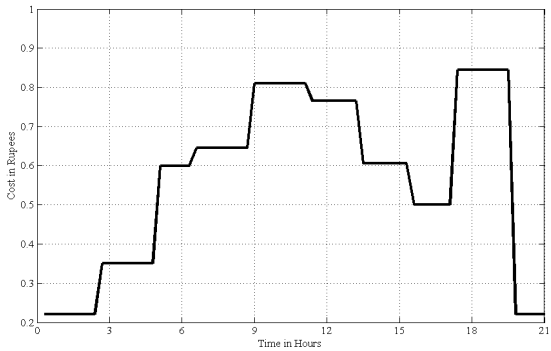


Figure 6 Consumer centric Microgrid Cost from the Grid.

A typical house hold appliances are tabulated in **Error! Reference source not found.**, when the real time cost is fed into the algorithm the LLPC will shed the load depend upon the command given by MSMC. This shedding is done based on the user priority level. **Error! Reference source not found.** shows the water pumps are allowed to operate only during mid night and at afternoon. This load can be controlled in this manner due to stage tank will provide the required water during the later hours.

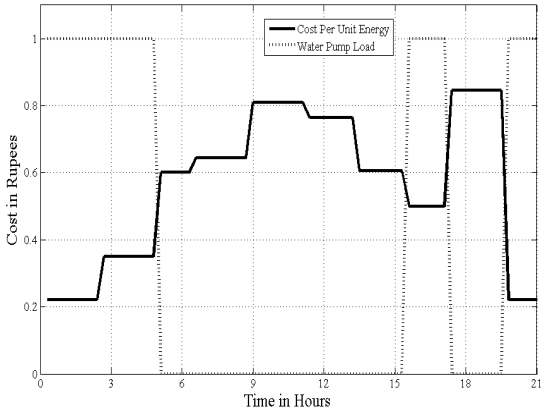


Figure 7 Consumer centric Microgrid Load Shedding of water Pump operation

Error! Reference source not found. shows the water heater working time considering the load of the machine and priority the load shedding is done. Only at early morning the water heater can be used with this algorithm to meet the target.

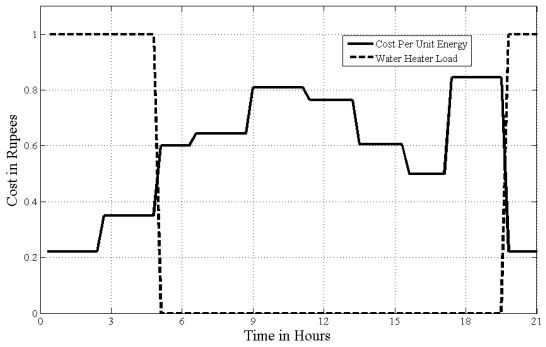


Figure 8 Water Heater working time

Error! Reference source not found. is the mostly required load as per consumer requirement this load is shed on very peak hours where the total power cost will reach maximum.

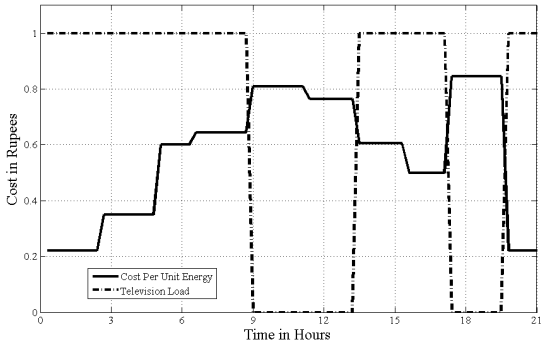


Figure 9 Television Load

Error! Reference source not found. is basic requirement of any house hold this load cannot be shed at any cost presently the load is been shut for 6 hours. To run the load use has to set the cost benchmark bit higher.

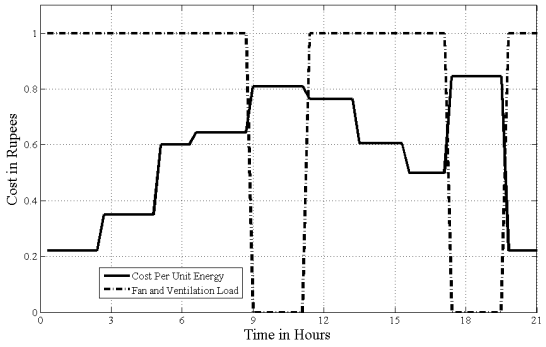


Figure 10 Fan and Ventilation Load

Lighting are not been shed in this proposed model due to its highest priority set by the user.

v. Conclusion

This paper deals with the utilization cost optimization for electric power consumption. Managing the power flow by controlling the local load, the overall micro grid is operated in cost optimized value which is the major objective of the power grid. The results shows that, this technique will not only reduce the electric power consumption cost but also improves the overall reliability of the electric power grid. But the consumer critical load might also shed if the cost benchmark is not set right. And if the cost benchmark is high, non-priority loads will also run during the peak hours. Balance between these two parameter is out of the scope of current paper.

Further improvement of the model can be done with the introduction of local generation within the scope of MSMC unit, but it would make the system more complex. Thus the load shedding of consumer load could be reduced and if possible power injection or power exporting will also happen. Therefore reducing the total power consumption without load shedding might also be possible.

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