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A Resilient power opportunity in Hybrid Grid including DGs and Smart Appliance

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Abstract

The electrical industry is dominated by AC supply medium for more than a century now. In last few decades, the environmental pollution and limited resources for non-renewable energy led us to shift towards more sustainable renewable energy resources and smart efficient appliance for electricity saving. In modern electricity system Hybrid grid is much more energy efficient and reliable technology. In Hybrid system has both types of AC and DC supply and appliance are included with proper power modulator. In this paper optimized a hybrid grid with different types of DGs and AC-DC loads in linear platform using MILP algorithm with taken the example of a home as well as compared the electricity bill with previous condition. Here we done the work for automation of home as well as optimized hybrid grid and saw many benefits over the conventional grid.

I. INTRODUCTION

In some decade hybrid grid penetration of renewable energy resources in existing grid for reducing the carbon footprint in the environment. Everyone knows the non-renewable sources of energy is the major causes of environment pollution due to its more carbon footprint. In last few decades, the environmental pollution and limited resources for non-renewable energy led us to shift towards more sustainable renewable energy. In this paper we used the hybrid microgrid with renewables resources and various loads. Hybrid microgrid is the combination of AC and DC microgrid, as we know that there are both types of exiting loads are present in our system, so we can used the both (AC& DC) types of loads for domestic appliance. Using more DC loads will reduce the electricity bill because of dependency on main grid will be less due to minimize the AC loads. Many modern loads like computers, mobile phones, light emitting diodes (LEDs), brushless-direct current (BLDC) fans requires DC supply. Hence, DC to AC and AC to DC conversion is required to give supply to these loads [2]. Currently, these loads are designed with some kind of in-built AC to DC convertors. Recent development of power electronics

gave us efficient technologies for AC to DC, DC to AC and DC to DC conversions. When compared to each other, DC to DC conversion is proven to be more energy efficient than AC to DC conversion [3].

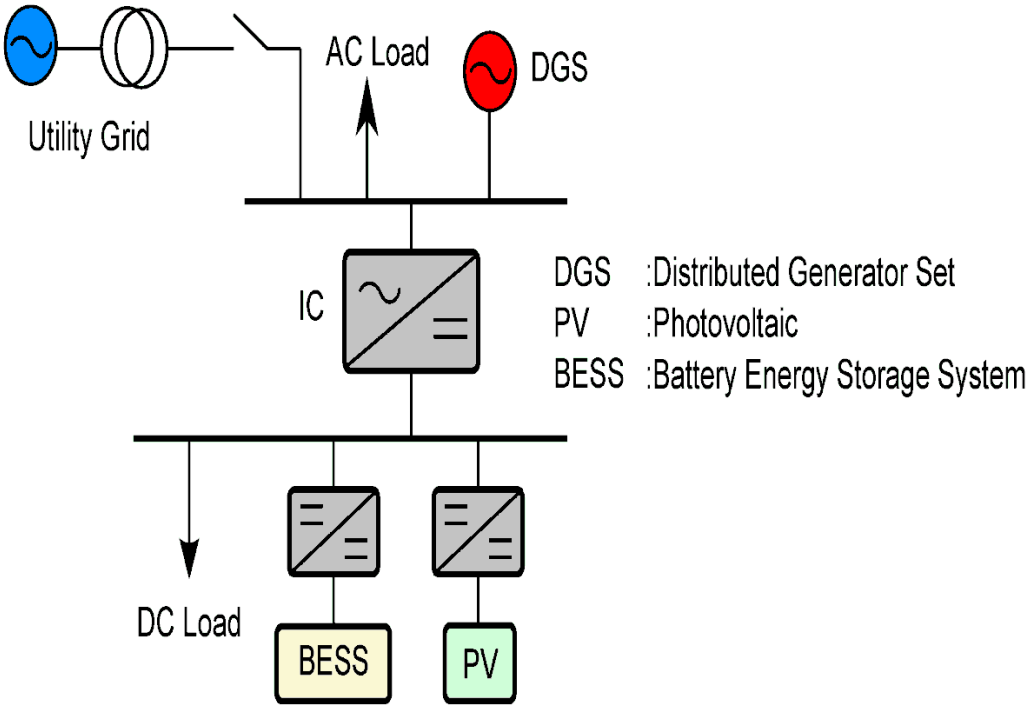

Fig no 1 Architecture of Hybrid Microgrid

Previous study indicates that low voltage DC distribution system for houses are more energy efficient than conventional AC distribution system, as the losses due to AC to DC and DC to AC conversion can be reduced [2]. Although in this DC distribution system, DC to AC conversion is required for AC loads. To overcome this issue, AC/DC hybrid microgrid has been proposed [4].

Hybrid microgrid consists of AC side as well as DC side with both sides interconnected with a bi-directional AC/DC converter. The AC side of hybrid microgrid is connected to the power grid as source for better reliability and DC side is connected to renewable energy source – PV. Various AC loads are connected directly to the AC side and DC loads are connected to the DC side, reducing the need of conversion. Advantages of both AC and DC can be achieved by using this type of microgrid. The block diagram of hybrid microgrid is given in fig.1 below.

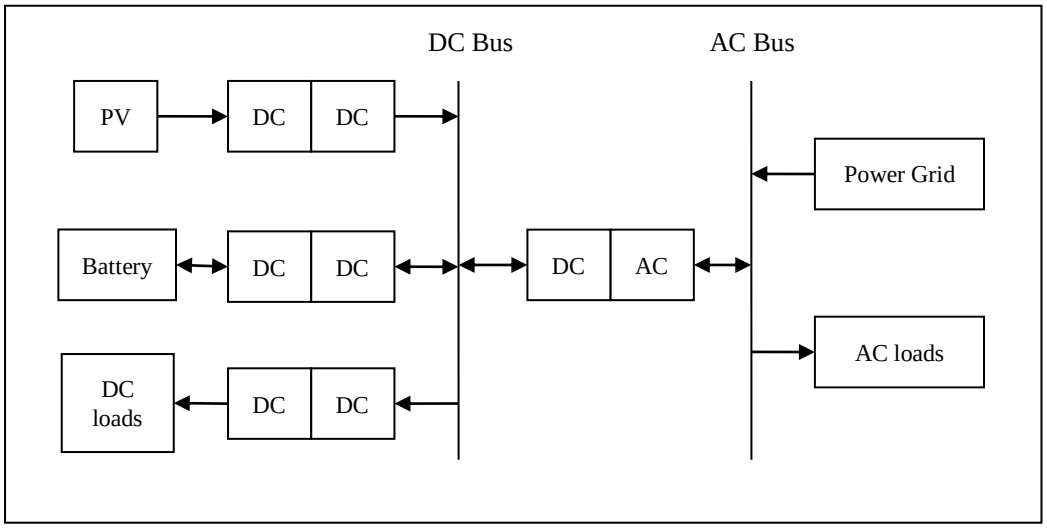

Fig.2 Block diagram of hybrid microgrid.

In this scenario, the more energy consumers take from the grid, more they have to pay for it. Generally, bill is calculated by adding two components, one is fixed charge and the other is product of per unit cost and units consumed. This can be represented mathematically as follow

$$Y = A + B*x$$

where, Y is the amount consumer has to pay

A is fixed charge applicable

B is per unit charge applicable

x is units consumed by the consumer which is equal to energy consumed in kWh

A and B are constants in the equation, but units consumed is variable and measured by energy meters. To reduce the bill, consumer has to reduced consumed units (x). In the present study, the microgrid is optimized to reduce the cost of electricity taken from the grid by utilizing maximum solar energy from PV panels and hence reducing units consumed by the AC source, power grid.

II. PROPOSED MODEL

In the present study, a house model is considered. Table No.1 contains the data for all AC equipments used in the house and Table No. 2 contains the data for all the DC loads/equipments.

Table No. 1: AC equipments used in the model house.

Equipment	Wattage (in W)	Number of equipments	Total Power (in W)	Source
Washing Machine	500	1	500	[2]
Refrigirator	125	1	125	[2]
AC (1.5 Ton)	2250	1	2250	[5]
RO Water Purifier	60	1	60	[14]
Toaster	850	1	850	[10]

Table No. 2: DC equipments used in the model house.

Equipment	Wattage (in W)	Number of equipments	Total Power (in W)	Source
BLDC Fan	40	5	200	[12]
DC LED Bulb	7	4	28	[2]
	11	8	88	
	23	4	92	
DC LED Tube light	20	5	100	
Personal Computer	270	1	270	[2]
Laptop	50	2	100	[2]
Mobile Charger	15	6	90	[7]
Mixer Grinder	180	1	180	[8]
Air-Cooler	110	2	240	[6]
Inverter with battery (2kVA)	1680	1	1680	[13]
Solar Geyser	1500	1	1500	

We have considered PM BLDC (Permanent Magnet Brush-less direct current) motor ceiling fans as it improves the overall efficiency when compared to the conventional ceiling fans [11][12]. BLDC motor ceiling fans are more energy efficient than the conventional ceiling fans and they can be connected directly to the 48V DC systems as well. A similar motor for air-cooler is used in present study which consumes approximately 90W [6]. The water pump used in air-cooler consumes 20W. The total

power consumed by the air-cooler is 110W. Bulbs and tube lights used in the present study are DC LED bulbs and DC LED tube lights respectively which can also be connected to 48V DC system [2].

Desktop computers and Laptops are DC loads [2], but they use SMPS to obtain DC output generally from AC supply through wall socket. SMPS is the Switched Mode Power Supply circuit which is designed for obtaining the regulated DC output voltage from an unregulated DC or AC voltage. Most SMPS which are used in personal computers are designed to work on both AC as well as DC. We can use this type of SMPS or we can simply use a DC to DC converter which regulates the DC obtained from 48V DC Bus and gives the desired DC output suitable for personal computers. This way we can remove SMPS and operate our computers directly through 48V DC supply available.

Mobile chargers are designed to work on both AC and DC supply with a wide range of acceptable input voltage, so either we can use them directly or we have to step-up 48V DC to a voltage level which is acceptable for the proper operation of charger (generally about 110V DC is sufficient). In the present study, the chargers used have an input voltage rating of 100V-240V (both AC and DC) [7]. This means that we have to use DC to DC converter which can step up voltage from 48V DC to 110V DC (step-up chopper).

In previous study, a design of a BLDC motor solution for the mixer grinder application has been proposed. The mixer-grinder with a BLDC motor has better efficiency and helps to achieve a better performance than the conventional one [8]. So we have used a mixer-grinder with a 48V BLDC motor which is compatible with our 48V DC system for the present study.

III. PROBLEM FORMULATION

Objective function:-

The objective is to minimise the electricity cost of main grid and hybrid grid during its operation time, this can be expressed as

Main function = $C_g * \sum P_{grid}(t) + C_h * \sum P_{HG}(t)\ (1 \leq t \leq N)$(1)

here

$P_{grid}(t)$ = Supplied power from main grid in given no. of sampling time

$P_{HG}(t)$ = Optimizing power from hybrid grid in given no of sampling time

C_g = Cost of power of the main grid taken by the reference no [5]

C_f = Cost of power of hybrid grid

N = Time period in a day

Constraints:-

Many types of equality and inequality constraints will be used in optimal scheduling of hybrid microgrid. Here mainly two types of equality constraints are use they are given below

(a)Power balance equation:-

In this paper main equality constraint is power balance equation of hybrid grid. At any sampling time interval t , the sum of the supplied power from PV, ESS and main grid must be equal to connected load in Hybrid grid. This can be expressed as

$$P_{PV}(t) + P_{bat}(t) + P_{grid}(t) = P_{load\ AC}(t) + P_{load\ DC}(t) \quad (1 \le t \le N) \quad (2)$$

P_{bat} - Supplied power from ESS

P_{PV} – Supplied power from PV

P_{grid}– Supplied power from main grid

$P_{load\ AC}$ - AC type Connected load of Hybrid Grid

$P_{load\ DC}$ - Connected load of Hybrid Grid

b) Battery storage system:-

Battery storages system is installed to be manage the variability and vulnerability of the solar power generationsystem . Battery unit is modelled as per calculating loads and solar system.The dynamics of battery storage system is determined by the SOC (State of charge).The operating constraints are summarized below,

$$SOC_{b,t} = SOC_{b,t}^{ini}, t = 1 \quad (3)$$

$$SOC_{b,t} = SOC_{(t+1)} - SOC_{(t)} + \left(t_s * \left(\frac{\eta_{bat}}{E_{norm}}\right) * P_{bat,t}\right) \Delta t, \quad (4)$$

$$SOC_{b,t(min)} \le SOC_{b,t} \le SOC_{b,t(max)}, \forall t, b \quad (5)$$

$$P_{bat,t(min)} \le P_{bat,t} \le P_{bat,t(max)}, \forall t, b \quad (6)$$

$SOC_{(t)}$– State of charge

η_{bat} – Efficiency of battery

E_{norm} – Rated power of battery in kwh

P_{bat}– optimizing power of battery at a given sampling time

c) Inequality Constraints:

The PV solar system, Energy storage system, grid power are modelled as variable power sources controllable in the range of their minimum and maximum rated value. For the AC and DC load profile of 24 hours they supplied the different amount of power depends upon its rating. Therefore, the variable limits are the output limits of these different power sources as well as of the battery storage system at any time. The upper and lower bound defining the various element of hybrid grid.

$$P_{bat,t(min)} \leq P_{bat,t} \leq P_{bat,t(max)} (1 \leq t \leq N) (7)$$

$$0 \leq P_{PV(t)} \leq P_{PV(max)} (1 \leq t \leq N) \quad (8)$$

$$SOC_{(min)} \leq SOC_{(t)} \leq SOC_{(max)} \quad (1 \leq t \leq N) (9)$$

$$P_{grid(min)} \leq P_{grid(t)} \leq P_{grid(max)} (1 \leq t \leq N) \ (10)$$

All this equality and inequality constraints are play the main role for optimization of hybrid grid, here MILP (mixed integer linear programming) is used for the optimal calculation of hybrid grid in a small home.

IV. RESULT AND DISCUSSION

In this paper done the optimization of a small house with AC and DC both types of connected load, this house optimization perform just like the hybrid grid with power resources of PV solar system, Energy storage system, main grid power supply and AC & DC types of connected loads. For the optimization used the MILP algorithm in MATLAB platform, following figures represented the optimal solution of various resources and loads.

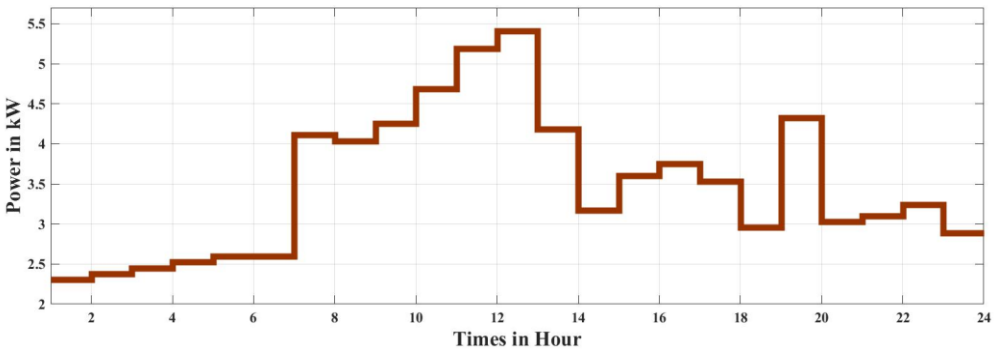

Fig no 3 AC Type connected loads of Model house in kW

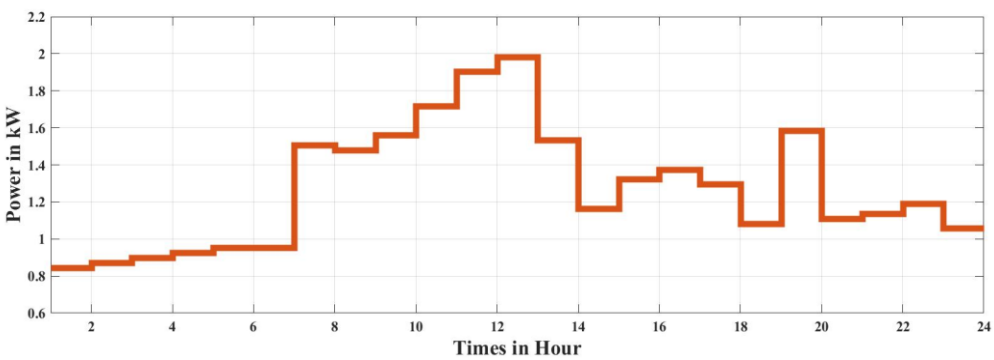

Fig no 4 DC Type connected loads of model house in kW

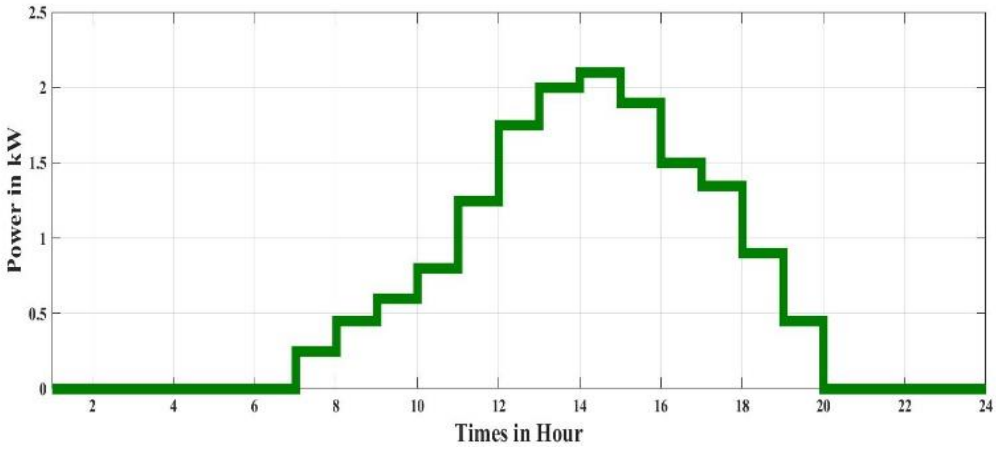

Fig no 5 Power output from PV Solar System in kW

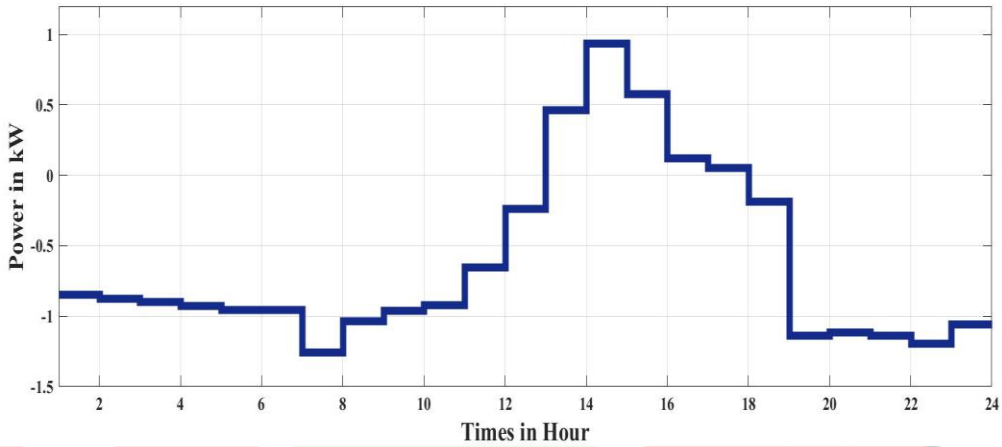

Fig no 6 Power drawn from battery in kw

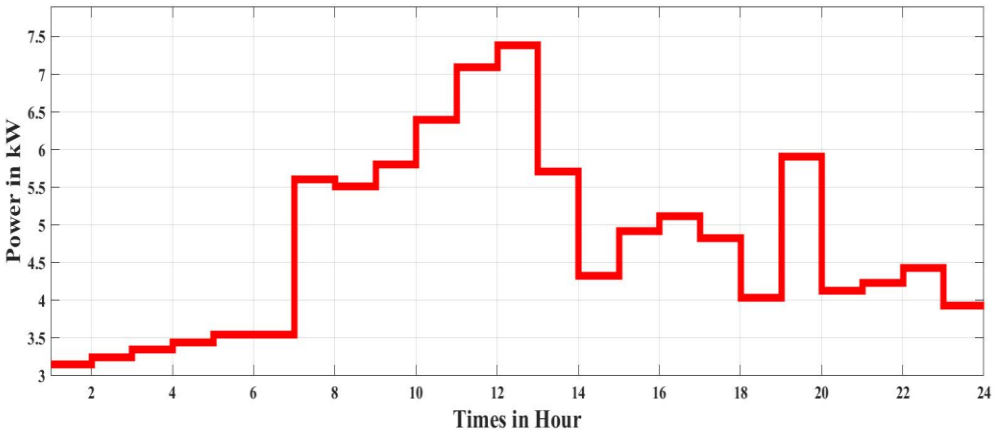

Fig no 7 Power drawn from main grid without hybrid grid

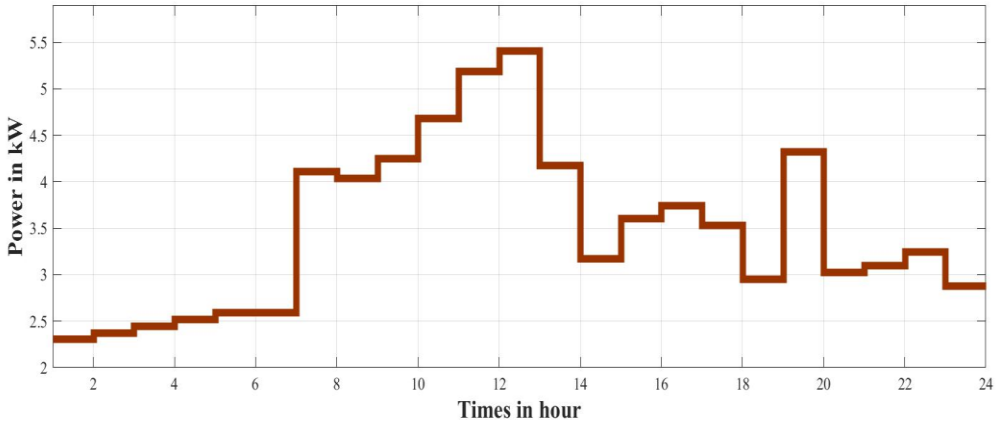

Fig no 8 Power drawn from Main grid with hybrid grid

Here the figure no 3 & figure no 4 shown the connected AC loads and DC loads in hybrid grid for 24 hours of times, figure no 5 shows the power drawn from the PV solar system, figures no 6 represented the optimal power from ESS resources. We can see in figure no 7 optimal powers drawn from main grid when all the loads are AC types and there are no any hybrid grid, in this time cost of energy is very high because of all the energy supplied is fulfill by the main grid. In the figure no 8 , seen that the amount of power drawn from main grid is less and cost of energy bill is also low because of hybrid grid , here mainly AC equipment's are replaced by DC type equipment and PV solar system and ESS also supplied the power for load requirement. DC equipment are smart and efficient, so used of this dependency on main grid is less and we can save the electricity bill for using renewable sources of energy system.

V. CONCLUSION

The optimal scheduling had been done of hybrid grid by using of MILP algorithm, and obtained this results, main cost function is this scenario is cost of electricity including main grid power cost and the cost of generation power of hybrid grid.So, the optimal bidding cost of both the cases are shown, we should be comparing in both the cases and observed in hybrid grid is better than the conventional grid due to its flexibility, more economic, reliability and minimum line losses property. In hybrid grid reliability and availability of power supply is very high.So all the work in this paper obtained the hybridgrid is more reliable and economy as previous power system scenario as well as consumers can be found out the more economy power supply with minimum cost.

REFERENCES

[1] P. Wang, L. Goel, X. Liu and F. H. Choo, "Harmonizing AC and DC: A Hybrid AC/DC Future Grid Solution," in IEEE Power and Energy Magazine, vol. 11, no. 3, pp. 76-83, May-June 2013, doi: 10.1109/MPE.2013.2245587.

[2] Arafat, Yasir, and Mohammad Amin, "Feasibility study of low voltage DC house and compatible home appliance design," 2011.

[3] P. Paajanen, T. Kaipia and J. Partanen, "DC supply of low-voltage electricity appliances in residential buildings," CIRED 2009 - 20th International Conference and Exhibition on Electricity Distribution - Part 1, Prague, Czech Republic, 2009, pp. 1-4, doi: 10.1049/cp.2009.0925.

[4] J. Hofer, B. Svetozarevic and A. Schlueter, "Hybrid AC/DC building microgrid for solar PV and battery storage integration," 2017 IEEE Second International Conference on DC Microgrids (ICDCM), Nuremburg, Germany, 2017, pp. 188-191, doi: 10.1109/ICDCM.2017.8001042.

[5] http://www.mpez.co.in/portal/Jabalpur_home.portal

[6] D. Kamalakannan, V. Mariappan, V. Narayanan and N. S. Ramanathan, "Energy efficient appliances in a residential building," 2016.

[7] https://www.samsung.com/in/mobile-accessories/travel-adapter-white-ep-ta200nwegin

[8] D. Kamalakannan, N. J. Singh, M. Karthi, V. Narayanan and N. S. Ramanathan, "Design and development of DC powered BLDC motor for Mixer-Grinder application," *2016*

[9] https://www.lg.com/in/microwave-ovens/lg-MC2146BP

[10] https://www.myborosil.com/catalog/product/view/id/5513/s/ss-krispy-pop-up-toaster/category/108/

[11] A. Saxena, "Performance and cost comparison of PM BLDC motors for ceiling fan," 2014.

[12] M. Fazil and K. R. Rajagopal, "Development of external rotor single-phase PM BLDC motor based drive for ceiling fan," 2010.

[13] https://www.luminousindia.com/rc-18000-2kva-cruze.html

[14] https://www.kent.co.in/water-purifiers/ro/kent-grand-plus