DC Microgrid With Smart Grid Paradigm

Major Project Report

Submitted in Partial Fulfillment of the requirements for Degree of

MASTER OF TECHNOLOGY
IN
ELECTRICAL ENGINEERING
(Electrical Power Systems)

By

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CERTIFICATE

This is to certify that the Major Project Report entitled "DC Microgrid With Smart Grid Paradigm" submitted by Mr. Rashmin Patel (15MEEE16) towards the partial fulfillment of the requirements for the award of degree in Master of Technology (Electrical Engineering) in the field of Electrical Power Systems of Nirma University is the record of work carried out by him under our supervision and guidance. The work submitted has in our opinion reached a level required for being accepted for examination. The results embodied in this major project work to the best of our knowledge have not been submitted to any other University or Institution for award of any degree or diploma.
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Abstract

By observing electric solutions from power plants to electric gadgets in demand sites. PV modules produce DC electric power. A small PV panel can not generate huge amount of DC power so assuming hug PV farm we can generate hug amount of DC power. But huge scale PV plants in remote sites have a significant problem on productive efficiency.
A PV module can generate DC power and efficiency was different from from different PV modules. we can design the system by HOMER software which is micro grid base power system software.

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Chapter 1

Introduction

1.1 Mainstream

The electricity supply industry faces many challenges like continuity of supply, keeping the costs down and sustainability are just a few. A DC micro grid structure has been proposed as a power network that allows the present a large quantity of solar power using spread photovoltaic production units. DC has advantage where interval are small, where DC loads more, where DC production is included and where storage is complicated. A micro grid is an isolated mass of electricity energy storage, production, and loads that normally operate connected to a traditional centralized grid.

1.2 Complication recognition

How can we increase the amount of DC electric power generation? From this point, Electric skill from power plants to electric devices in demand sites. Photovoltaic modules produce DC electric power. The power should be converted to AC that is synchronized with private network to be transferred and distributed to demand sites.
The main problem of system is low power generation and demand is high of consumers side. So how can we fulfill the demand and increase the power by renewable sources in DC micro grid.

1.3 Aim

The main aim of this project is to generate the DC electric power as much as possible and load of the main grid is minimize by using renewable sources. Therefore cost of the electric power will be minimized. Minimize energy excess and facility costs resulting from AC/DC conversion by combination the junction between a private grid and DC bus which connects PV units and accumulators. Supply power to loads via regular distribution lines even during the blackout of private grids.

1.4 Procedure

Various technology to install the micro gird:

- New distributed generation and storage systems can be added or removed from the micro grid
- Equivalent and stable current sharing between sources is enabled
- Output voltage oscillation can be corrected
- Necessary power flow from/to the micro grid jointly with technically and economically viable operation is enabled

Chapter 2

Documentation Study

[1] **Daud Mustafa Minhas, "Load Balancing in Smart DC Micro-grid Using Delay Tolerant User Demands," IEEE-2015.**

- In this paper author introduce the idea of differentiated load demands for scheduling consumer power devices in Smart DC Micro-grid (SDMG) to make power management efficient.

[2] **BaochaoWang, Manuela Sechilariu, Fabrice Locment, "Intelligent DC Microgrid With Smart Grid Communications: Control Strategy Consideration and Design," IEEE TRANSACTIONS ON SMART GRID, VOL.3, NO. 4, DECEMBER 2012.**

- This paper present a DC micro grid with smart grid communications. PV required generation, and takes into consider the grid availability and grid vulnerability by smart grid idea.
-This paper is connected to the presented better DC micro grid combination and provides chance to minimize the negative impact on the utility grid.

[3] **Ashok Jhunjhunwala, Aditya Lolla, Prabhjot Kaur, "Solar DC Microgrid for Indian Homes- A trasforming power scenario," IEEE Electrification Magazine 2325-5987, JUNE 2016.**

-This paper is present AC versus DC microgrid for homes. The benefit of dc microgrid for homes and supply them using solar rooftop.

[4] **A.Jain, S. Ray, K. Ganesan, M. Aklin, C.Y. cheng, J. Urpelainen,"Access to clean cooking energy and electricity:survey of states,"Couscil on Energy,Environment, and water, New Delhi, India,2005**

[5] **P. Kaur, S. Jain, and A. Jhunjhunwala, Solar-DC deployment experience in off-grid and near off-grid homes: Economics, technology and policy analysis, in Proc. IEEE First Int. Conf. DC Microgrids (ICDCM), Atlanta, GA, 2015, pp. 2631.**

[6] **Global Buildings Performance Network, Residential buildings in India: Energy use projections and savings potentials, Global Buildings Performance Network, Ahmedabad, India, 2014.**

Chapter 3

Advanced Grid

An advanced grid structure ultimate for consumers who will model grid connected systems with different grid prices. An advanced grid module grid extension is possible. A grid module adds connected with real time pricing, grid outage, scheduled rates. With advanced grid module a model can build own time-of-use rate schedule.

An advanced grid the sample grid power price is Rs. 7.22/kWh and sell back price is Rs. 8.00/kWh as per government rates. Net metering is also connected with the advanced grid so as per designing of model calculate the per monthly and annual net purchases.

3.1 Electric load

Electric loads are two types. Ac load and DC load. The month vise load is decided by consumers consumption. In this model the scaled annual average load is 4443.1 kWh/day DC type load is calculated as per model. Peak load is 2005.11 kW. If the load is DC then generation cost, operating and maintenance cost is lower than AC loads. So grid will connected with DC load as compare to AC load. Reliability of DC loads are more than AC loads.

3.2 Converter and Battery

Generation of power is AC but loads are AC and DC. If the loads are DC then converters are used to convert the power. In the HOMER (Hybrid Optimization of Multiple Energy Resources) software there are a few converters likes Leonics GTP, Leonics MTP, Leonics S219CHP, Leonics STP, ZBB EnterSection. Here as per design Leonics S219CHP is used for low voltage of loads. This converter is bidirectional. Capital cost of converter is low and efficiency is more and life of converter is 10 years so it is reliable.

Figure 3.1: Leonics S219CHP

Figure 3.2: IND13-6V TROJAN Deep-Cycle Flooded/Advanced Lead Acid Battery

Chapter 4

Photovoltaic Solar Panels

Photovoltaic (PV) convert the light energy into electricity operate semiconducting materials that called the photovoltaic effects. The solar cells generate the electric power. Photoelectric effect come after electrochemical operations where crystallized atoms, ionized in a series, produced an electric current. PV installations may be ground,rooftop, wall mounted. PV generate no pollution. PV systems have the great drawback that the power production is based on direct sunlight. so about 10-25 percent is lost if a tracking system is not used. Net metering is better feed-in tariffs for solar generated electricity. Many countries have supported solar PV installations. In India, Installed and total solar power capacity in 2015 is 5,050 MW.

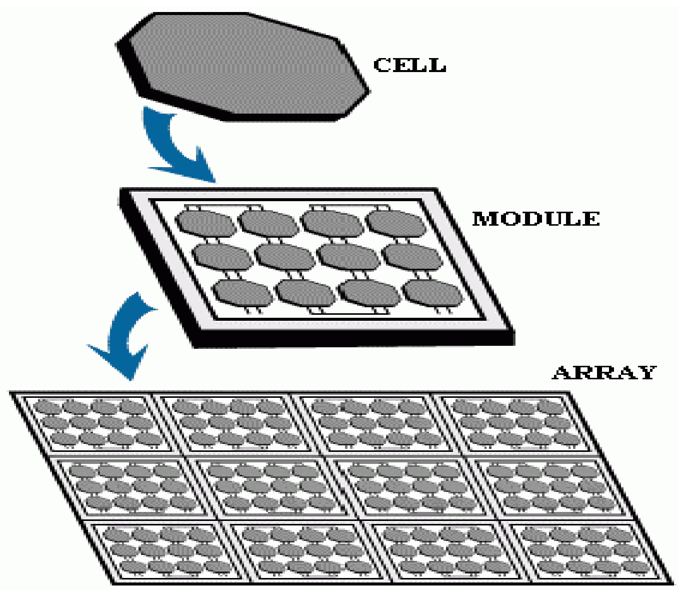


Figure 4.1: Cell, Module and Array

A number of solar cells electrically attached to each other and mounted in a support shape or frame is called a photovoltaic module. The current produce the directly depends on light. light is how much strikes on module. Multiple module generates the array.

4.1 Generic flat plate PV

In this design, there is generic flat plate PV array used. These panels can either be fixed in place or allowed to tracking the sun. In sunny day 50% radiation is spread and in cloudy whether 100% radiation is spread. Life of flat plate pv is more than polymethyl methacrylate (PMMA) and wave lenght is also more than PMMA.

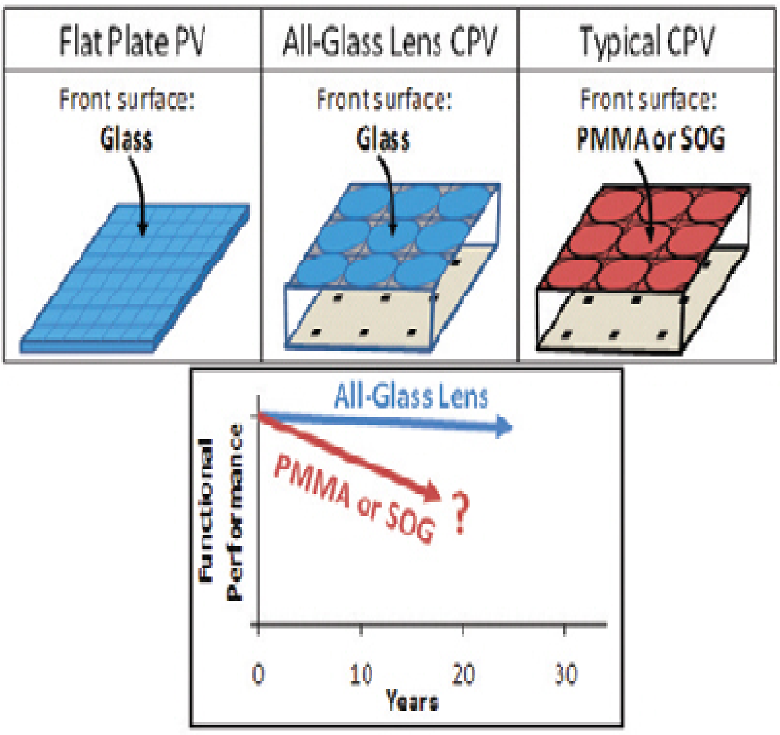


Figure 4.2: Flat Plate PV

A fixed type flat plate pv panels is used on the rooftop of consumers house. It is fixed so continuous sun light put on the panels is necessary. So the angle of fixed type flat plate pv panel is 15 degree to the sunset side. Therefore more sun light and more efficiency the system can get.

Chapter 5

Case Study

In this project, Grid is isolated from the renewable resources and connected with the renewable resources. With grid connection AC loads are more economical or DC loads are more economical. How much loads are AC and how much loads are DC. Generation of power is AC so convert the power from AC to DC for the use of DC type equipments. If the loads are DC so PV generate the electric power directly used to the equipments. There are no converter used so economically it is useful for consumers.

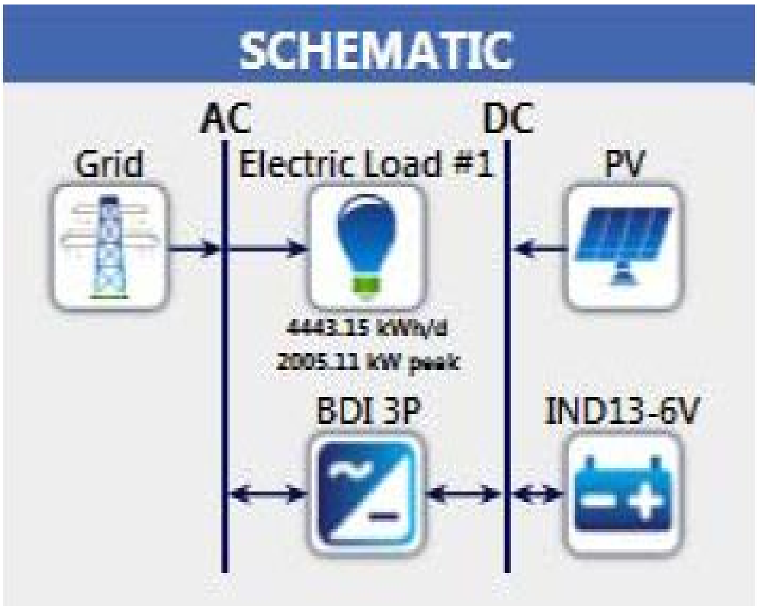


Figure 5.1: Schematic of proposed model

In this circuit diagram generator and grid are connected to AC electrical bus. Electrical load is connected to DC electrical bus and PV also connected DC electrical bus. Converter is bidirectional so it convert and store the power by multiple uses. If the load is DC so cost of energy and net present cost is low as compare to AC load.

Table 5.1: Optimization results 1

PV (kW)	400
BDI 3P (kW)	400
Cost of energy (Rs.)	5.42
Net present cost (Rs.)	12,60,00,000
Operating cost (Rs.)	77,20,000
Initial capital cost (Rs.)	2,63,00,000
PV capital cost (Rs.)	1,78,20,000
PV production (kWh)	6,78,221

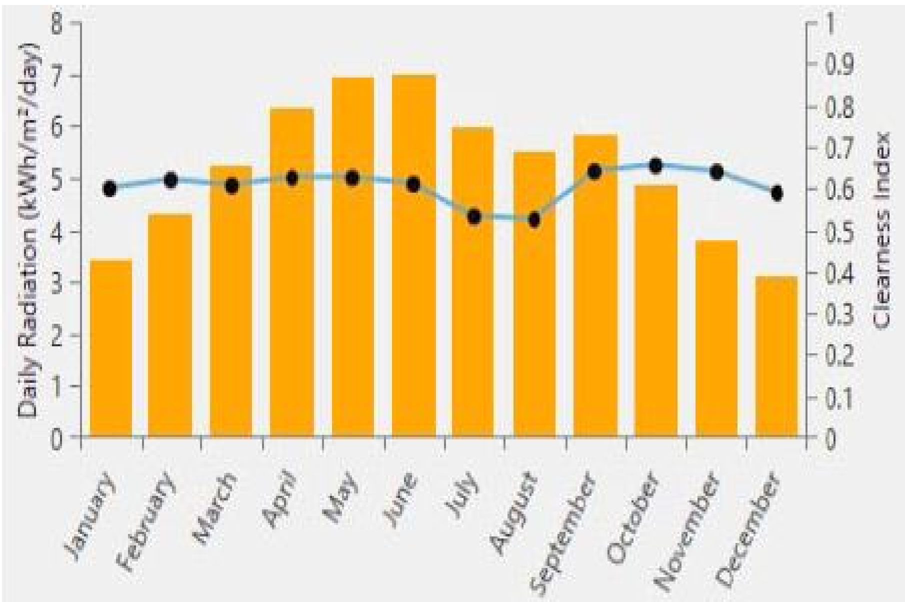


Figure 5.2: Monthly average solar radiation clearness index

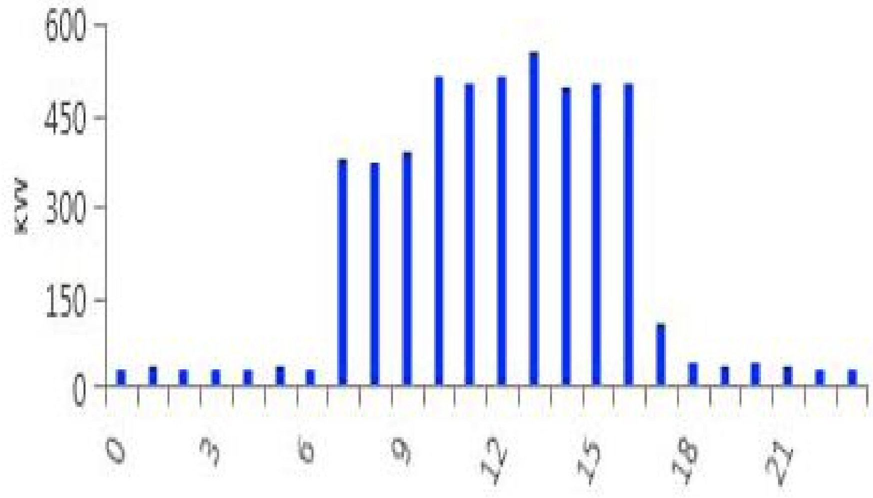


Figure 5.3: Daily Load Profile

The energy cost and net present cost are more as compare to DC load. PV generate the energy and it stores in battery. At any time the power can be used by transforming the power in to AC loads. Net metering is there so usage of power can be calculated easily and demand of consumers can be obtained by net metering. All over DC load and grid are reliable and efficient.

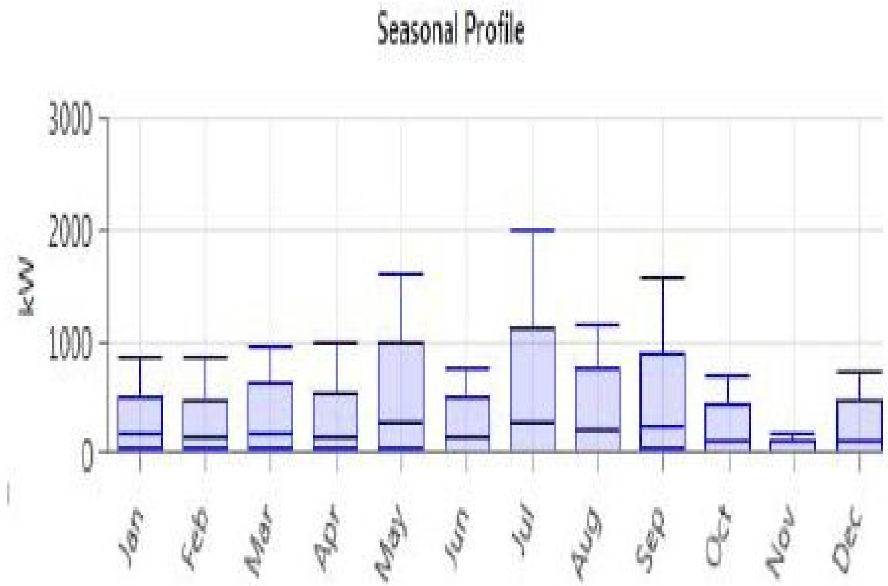
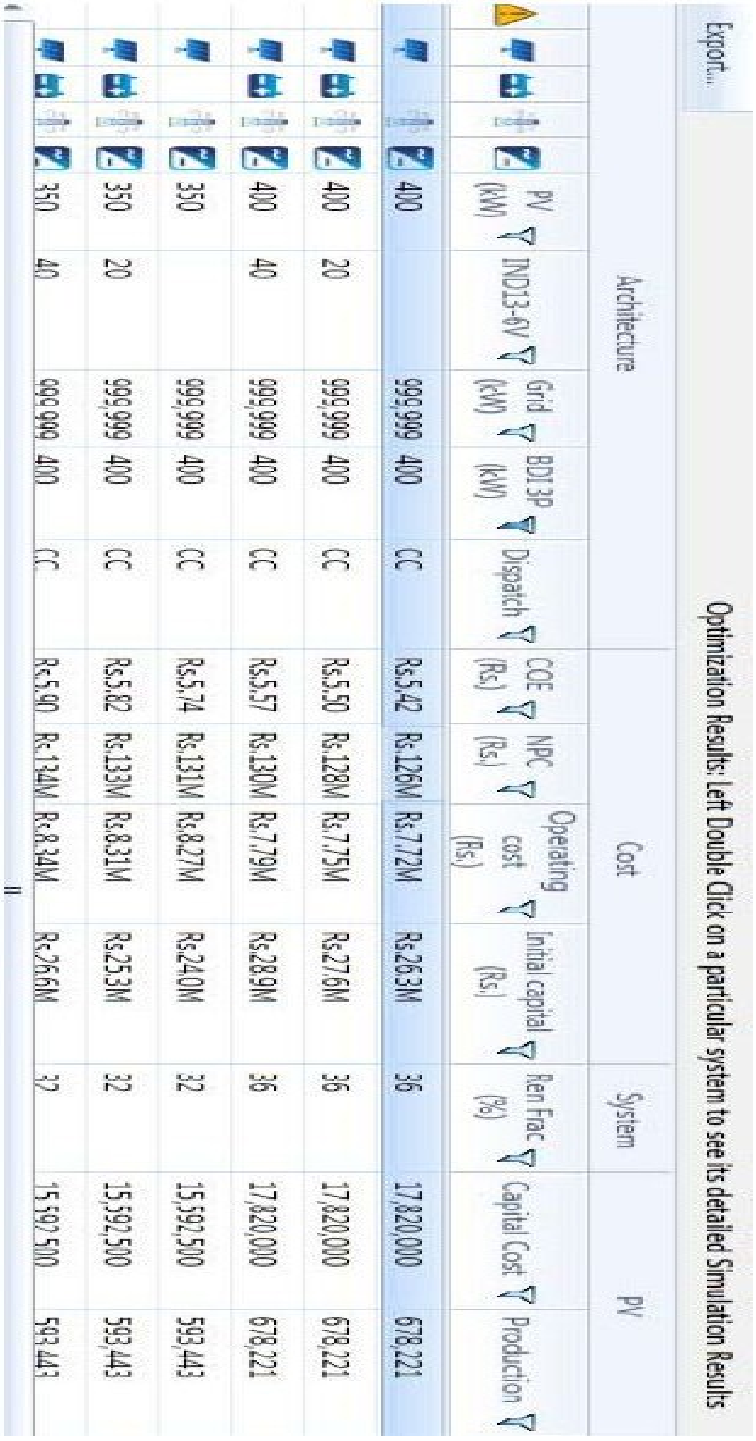


Figure 5.4: Seasonal Load Profile



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Optimization Results: Left Double Click on a particular system to see its detailed Simulation Results

Architecture						Cost				System	PV	
PV (kW)	IND13-6V	Grid (kW)	BDI 3P (kW)	Dispatch		COE (Rs.)	NPC (Rs.)	Operating cost (Rs.)	Initial capital (Rs.)	Ren Frac (%)	Capital Cost	Production
400		99,999	400	CC		Rs.5.42	Rs.126M	Rs.7.72M	Rs.26.3M	36	17,820,000	678,221
400	20	99,999	400	CC		Rs.5.50	Rs.128M	Rs.7.75M	Rs.27.6M	36	17,820,000	678,221
400	40	99,999	400	CC		Rs.5.57	Rs.130M	Rs.7.79M	Rs.28.9M	36	17,820,000	678,221
350		99,999	400	CC		Rs.5.74	Rs.131M	Rs.8.27M	Rs.24.0M	32	15,592,500	593,443
350	20	99,999	400	CC		Rs.5.82	Rs.133M	Rs.8.31M	Rs.25.3M	32	15,592,500	593,443
350	40	99,999	400	CC		Rs.5.90	Rs.134M	Rs.8.34M	Rs.26.6M	32	15,592,500	593,443

Figure 5.5: Simulation Result

Table 5.2: Optimization results 2

PV (kW)	350
Cost of energy (Rs.)	5.74
Net present cost (Rs.)	13,10,00,000
Operating cost (Rs.)	82,70,000
Initial capital cost (Rs.)	2,40,00,000
PV capital cost (Rs.)	1,55,92,500
PV production (kWh)	5,93,443

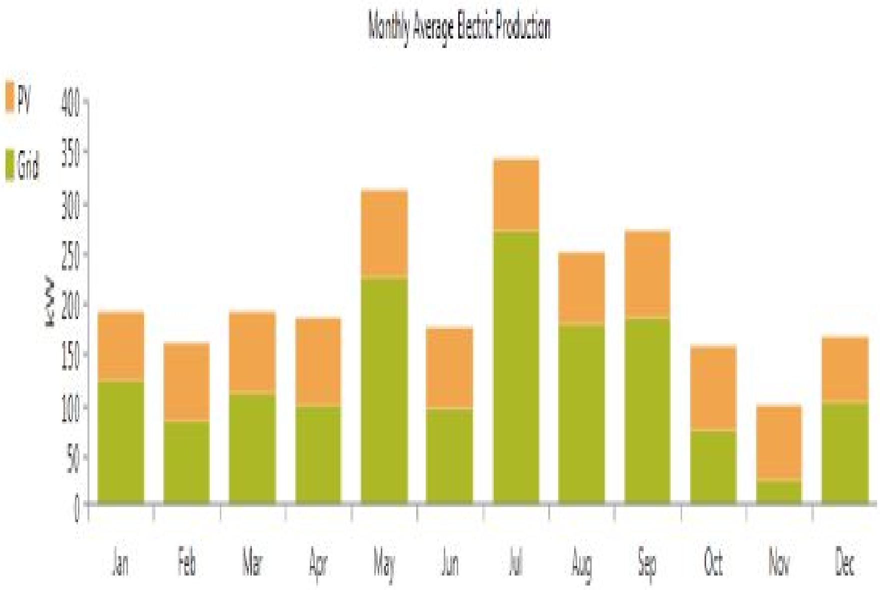

Figure 5.6: Monthly energy production from PV grid

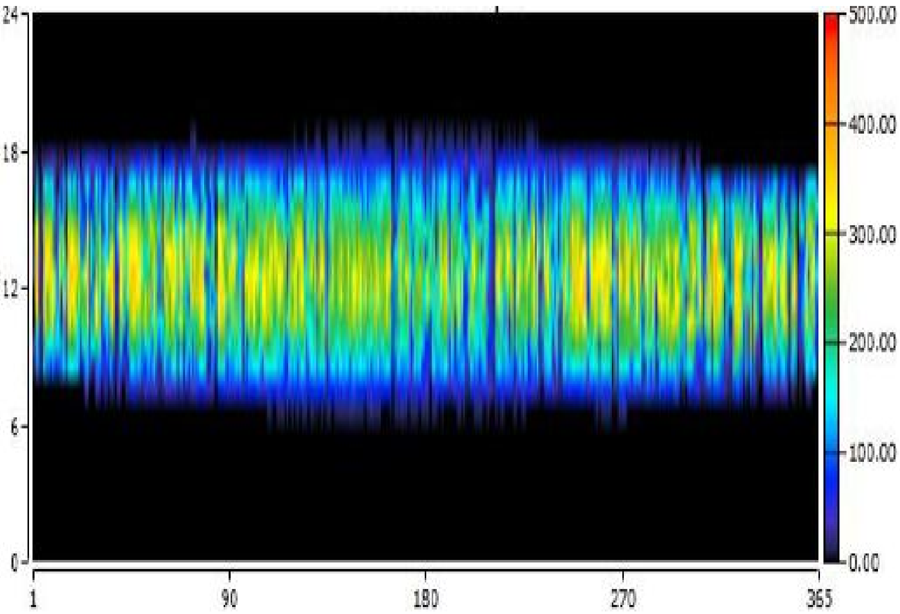

Figure 5.7: PV Power Output

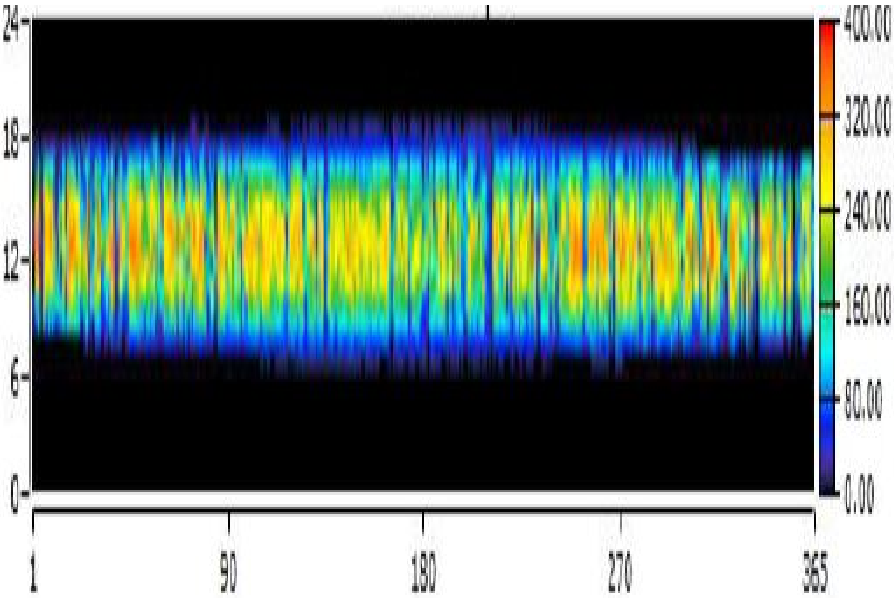

Figure 5.8: Inverter Power Output

Chapter 6

Case study 2

6.1 Analysis of Power Connection

The rooftop pv panels attempt to sell alternate origin on power generation. No TD losses would be there in system. A calculation of solar panels installed will be Rs.50/watt, and PV would be amount to Rs.3/unit. Interest rate is 75 and reduction over 20 years assuming. During daytime, the solar power is available and variation of the continue collection of solar power. If the the peak demand demand is there so load shedding would be there during peak hours. Collection of solar power would required battery, which increase the cost of overall system.
The PV generation power is DC needs to be converted to AC. If the power is 10 kW of DC and converted it in to AC so the losses will be only 3%. The main problem of system battery is converted the ac power into dc power to charge the battery. And when the usage of load and drive the load then the dc power converted into ac. So these type of conversion make the 15% losses of the system.
In India, 62% load of the total load consume only the ceiling fans and tube lights (CFLs,LEDs etc.). DC equipment like induction motor fans and brush less motors is only consume %40 of conventional ac power system. In recent time, LED lights replace the CFLs and fluorescent lamps.
The DC microgrid homes supplied by the PV panels and connecting the batteries and connected the converter through ac incoming line as shown in figure.

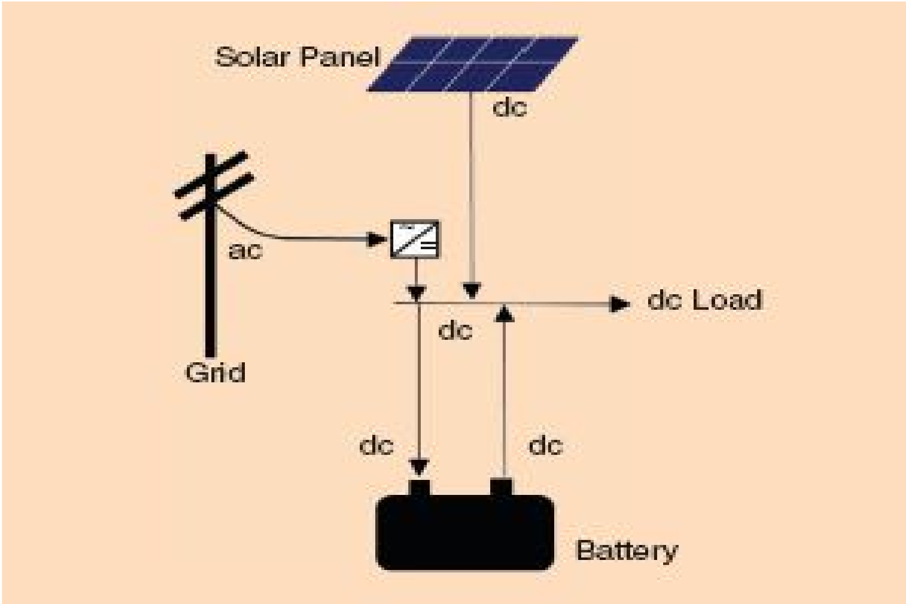

Figure 6.1: A dc microgrid for homes [1]

The Solar panel, the grid and the battery are set in order that the losses are kept to minimum, then the overall cost of home is considerably down,although battery is used. Now, rooftop panels used widely in recent time and the grid can supply the less power to the homes. The government helps in subsidy in domestic sector so more easy in cost for homes. So the grid can extend to more homes then only no homes remains without electricity.

6.2 Cost of ac-dc solar home and usage of power

(1) If the home is disconnected to grid so the cost of electricity is lower for solar dc home as compare to grid connected ac home. In off grid, per day cost is lower for solar dc home.

(2) On grid connection suppose the power cut cuts, but in off grid dc home there will be a 24/7 electricity would be available with the lower cost.

(3) If the grid is connected with home without power cuts, Power saving is possible in dc solar power for home.

6.3 Assumptions

In India solar panels generate 4-5 kWh/kWp power per day, so 100-Wp solar panel was generate the 432 Wh of solar power per day.

Table 6.1: Power usage of device, No. of appliances usage in a home

Appliances	AC power appliances in ac Homes	DC power appliances in dc Homes	Numbers	Number of operational hours/day
Fan	67	24	2	6
Bulb	40	5	2	12
Tubelight	36	18	2	10
TV	40	30	1	4
Phone	6.5	5	1	10

Table 6.2: Power losses in the system

System	Solar to battery loss (%)	Grid to battery loss (%)	Battery to load loss (%)	Solar to load loss (%)	Grid to load loss (%)
ac	30	15	25	15	0
dc	5	15	10	3	6

Table 6.3: Efficiency in delivering power from the source to the load at homes

	AC home efficiency (%)	DC home efficiency (%)
Grid to load	100	94
Grid to load via battery	63.7	76.5
Solar to load	85	97
Solar to load via battery	52.5	85.5

If the grid is shedding the load, so the efficiency of ac home will be poor and dc home efficiency will be good as compare to ac home. In off grid home battery is consumed only when the solar power is not enough to drive the load.

Table 6.4: cost of power per unit

Source of power	Per unit cost (Rs.)
Grid	5
Solar dc system	4
Battery	12
Solar ac system	5

Table 6.5: Off grid per day cost of power

Home	Load per Day (Wh)	Cost per Day (Rs.)	Efficiency (%)
ac	3,266	50.6	65.1
dc	1,212	12.6	91.4

6.4 Results

100 Wp solar panel powered each home connected 1 kWh battery to drive the dc loads.

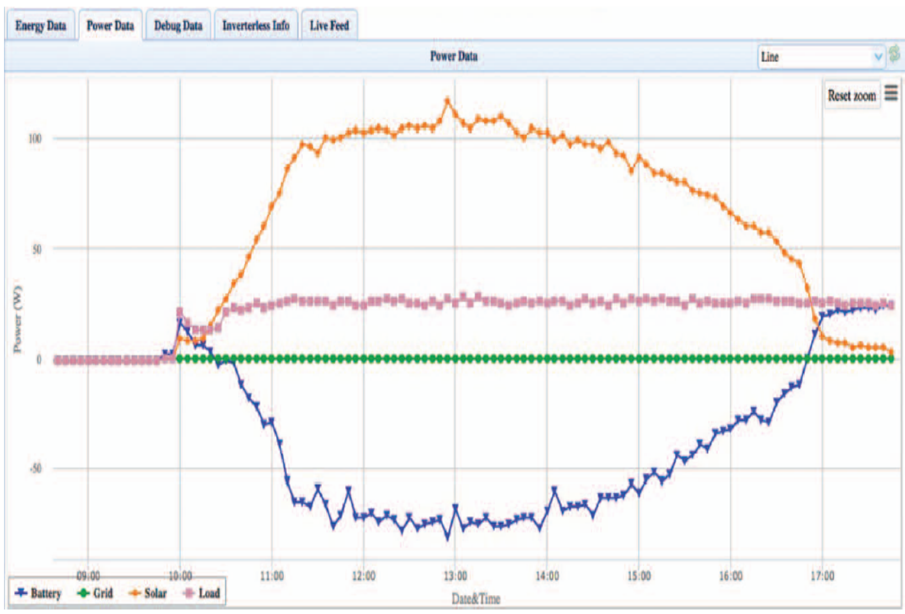

Figure 6.2: Data measured per day with inverterless dc system

Table 6.6: Load shedding of a few hours in per day cost of power

Home	Load per Day (Wh)	Cost per Day (Rs.)	Efficiency (%)
ac	3,266	28.9	88
dc	1,212	7.3	93.3

In ac and dc system the cost is affected. The load shedding is affect on overall cost of the system. In dc powered home almost 4 times cheaper cost as compare to ac powered home. There will be huge power saving in monthly cost data sheet.

For the calculation of data there will be about 15% of power saving is possible in dc powered appliances as compare to ac powered appliances.

Chapter 7

Conclusion & Future Work

7.1 Conclusion

From the survey and case study, AC loads and DC loads are used with and without connected with electrical bus. Homer software supported the design of PV and the grid generation as per the load demand. Minimum purchase the load from the grid and more the sell back to the grid is possible if the PV generation is higher and cost is lower to generate the higher power from PV. More accurate design is needed and payback period is small as possible. From the result PV combination is optimum for cost minimization. The rate per unit of power has minimized from and 24/7 electricity would be connected to the solar dc homes.

7.2 Future Work

The generation of power will more to connected grid and load side demand will fulfill with connected the higher rating of PV panels. So consumers will consume low power of grid side and more usage of power to the renewable sources like PV panels and also stored the power to the battery. In recent days dc power is not using in home wiring. Industries and telecom use 48 V dc. DC appliances have the benefit to avoiding ac-dc conversion and increase the reliability and reduction of cost. In dc power factor correction is not required.

Refernces

[1] D. M. Minhas, "Load balancing in smart dc micro-grid using delay tolerant user demands," in *Smart Grid Communications (SmartGridComm), 2015 IEEE International Conference on*, pp. 157–162, IEEE, 2015.

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