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# Integration Planning and Operation Scheduling of Distribution Generation for Home Appliances

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## ABSTRACT

Use of distributed renewable energy sources for domestic energy consumption will increase in near future due to its advantages as being clean and infinite energy generation possibility. This trend allows more efficient energy consumption because of reducing distribution losses and dependence of domestic appliances to grid distribution. Electrical energy is an essential ingredient for the development of a nation. In this paper, it is proposed grid connected solar PV without and with battery at domestic level to minimize the load on live grid during peak time, excess power export to the grid when the PV generation is more compared to connected load and increase the participation of renewable energy sources in our daily energy consumption. The decision support program enables the consumer to implement the most efficient electricity management strategy while achieving the goal of minimizing the electricity bill and to supply the quality power. The cost of investment and payback periods are computed for PV system using cost benefit analysis

***Keywords* :** Distributed Generation, Load scheduling, Energy storage device, DSM, Net meter, Cost benefit analysis

## I. INTRODUCTION

The present century emerged with numerous challenges and opportunities that affect global energy, economics, environment, and security. These challenges have in part resulted from population growth, electric utility restructuring, and crises in fossil fuel production and delivery in various parts of the world, environmental pollution, and global warming. These driving forces underlie need and opportunity for enhancing the nation’s infrastructure for generating, transmitting, and delivering reliable and affordable energy [1]. It is envisioned that a portfolio of distributed generation (DG) technologies could provide a sizeable fraction of the nation’s electricity generation requirements and, in concert with other generation sources, supply reliable energy in a constrained energy infrastructure. DG systems generally consist of the following:

1) Small and modular generating systems (such as micro turbines, reciprocating engines, fuel cells, cogeneration of heating/power systems, and hybrid units) that use a diversity of fuels, such as natural gas and hydrogen;
2) Renewable energy resources (such as PV, solar, wind, geothermal, biomass, tidal, and hydropower).

In this paper to grid-connected PV systems without and with battery storage analyzed because of popularity of this type of system. With further developments in PV technology and lower manufacturing costs, it is envisioned that PV power will account for a higher percentage of electric power generation in near future. PV represents superior characteristics such as pollution free and abundant alternate source of energy with minute generation costs [2,3]. Domestic energy management will play an important role in the enrichment of security of next-generation electric grid. Electricity supply in India has been lagging in terms of service (measured by hours of supply) as well as penetration. Only 31% of rural households have access to electricity and supply suffers from frequent power cuts and high fluctuations in voltage and frequency, with so called black outs and brown outs [4].

In order to respond to this in an environment friendly manner, integration of distributed renewable energy farms and the utilization of distributed energy storages are becoming major concerns for stakeholders involved in the design of future energy delivery grids [5]. The integration of existing grids with renewable sources provides economical, sustainable and efficient power distribution, and this allows the control of greenhouse effect. Sharing renewable energy of distributed generators in large scale can considerably reduce energy demands from the grid, and thus, more environment-friendly energy harvesting and efficient energy distribution will be possible in near future [6]. There is extensive interest for integration of distributed renewable sources in future smart grid structures for sustainable and affordable energy generation.

**Benefits of DG integration**

DG integration fetches the following benefits [7]:

- Integration of DG at strategic locations leads to reduced line losses.
- Integration of DG provides enhanced voltage support thereby improving voltage profile.
- Improved power quality.
- Integration of RES based DGs provides substantial environmental benefits. This results in an indirect monetary benefit in terms of reduced health care costs.
- Reduced fuel costs due to increased overall efficiency.
- Reduced reserve requirements and associated costs. Lower operating costs due to peak shaving.
- Reduced emissions of pollutants.
- Encouragement to RES based generation.

## II. POWER SYSTEM MODEL

In the power system model of this paper we consider a single user. A consumer obtains electricity from different power supplies, mainly live grid, solar and local energy storage capacity (e.g. battery). In this power system model a consumer can turn on any appliance at any instant of time. Then an optimal scheduling of distributed energy storages and home appliances is done in order to minimize peak demand and total energy cost.

Relation of energy consumption of an appliance over a period is given as

$$E_a = \sum_{h=1}^{H} Z_a^h \qquad (1)$$

where, $E_a$ is energy consumption of appliance 'a', $Z_a^h$ is energy consumption of appliance 'a' over 1 hour.

We consider peak hours between 6 p.m to 11p.m. The electricity bill gives us a record to know how much electricity we consume at what cost. It depend on at which time how much power is consumed. Total energy consumption of appliance 'a' is the sum of energy consumption in on-peak hour and off-peak hour.

$$E_a = E_{a,p}^t + E_{a,op}^t \qquad (2)$$

Similarly, energy consumption of all the appliances over a period of 24 hour is given as

$$E_a = \sum_{a=1}^{A} E_a \qquad (3)$$

The optimization can be achieved by schedule operation of appliances from on-peak hour to off-peak hour. It results in minimize the peak load in on-peak hour [8].

**(A) The load scheduling problem**

In load scheduling problem, grid customer can operate certain appliances in off peak period instead of peak period. The tariff considered as grid tariff and main objective is to avoid the overloading of distribution system during peak time.

**(B) The energy storage device**

In our study, we have assumed that each individual customer $m \in M$, is equipped with a dedicated electricity storage device with a storage capacity $B_m^{cap}$ a charging efficiency $\eta_c$ and a discharging efficiency $\eta_d$ grid with battery connected system. We further denote charging behavior of house hold *m* at period *h* as $B_{h,m}^c$ and its corresponding discharging power profile for the same period as $B_{h,m}^d$. If $B_c^{\max}$ and $B_c^{\min}$ represent the maximum charging rate and the minimum rate of discharge respectively,

$$B_{h,m}^c \geq 0, \quad \forall h \in [1,24], \quad \forall m \in M \qquad (4)$$

$$B_{h,m}^d \geq 0, \quad \forall h \in [1,24], \quad \forall m \in M \qquad (5)$$

$$B_{h,m}^c \leq B_c^{\max}, \quad \forall h \in [1,24], \quad \forall m \in M \qquad (6)$$

$$B_{h,m}^d \leq B_d^{mim}, \quad \forall h \in [1,24], \quad \forall m \in M \qquad (7)$$

If $B_m^h$ is customer *m* battery state of charge at period *h*, then:

$$B_m^h = B_m^{h-1} + \eta_c B_{h,m}^c - B_{h,m}^d, \quad \eta_c [0,1] \qquad (8)$$

Where $B_m^h \leq B_m^{cap}$ (9)

Because of inefficiency associated with battery charging and discharging, concurrent charging and discharging operations in any given time period h, would result in power losses through the battery. Thus for optimal power management the constraint [9] is imposed:

$$B_{h,m}^c + B_{h,m}^d \leq 1 \qquad (10)$$

Since the power discharged from the storage device during total period H must be less than initial state of charge, $B_m^0$ and power delivered into battery during same period, we have:

$$B_m^0 + \sum_{h=1}^{24} \eta_c B_{h,m}^c \geq \sum_{h=1}^{24} \eta_d B_{h,m}^d \qquad (11)$$

In our model, customers have to charge their batteries from SPV during day time to meet their certain electrical appliances load demand. Considering $E_{h,m}^g$ being the power purchased from the utility grid by customer *m* at time *h*,

$$E_{h,m}^{PV} = E_{h,m} + B_{h,m}^c + E_{h,m}^g \qquad (12)$$

During high peak hours, consumers purchase as little electricity as possible from the utility grid. They primarily rely on their battery backup power to run their certain appliances. The households' electricity load is therefore either supported by the utility grid or the battery banks [10].

$$E_{h,m} = E_{h,m}^{g} + \eta_{d} B_{h,m}^{d} \tag{13}$$

In first case i.e grid without battery connected system, we have considered the exchange of power from the inverter devices to the grid. Thus,

$$E_{h,m}^{PV} - E_{h,m} \geq 0, \forall \mathrm{h} \in [6,18], \quad \forall \mathrm{m} \in \mathrm{M} \tag{14}$$

In second case i.e grid with battery connected system, we have considered the exchange of power from PV/the storage devices to the grid. Thus,

$$E_{h,m}^{PV} - (B_{h,m}^{\mathrm{c}} + E_{h,m}) \geq 0, \forall \mathrm{h} \in [6,18], \quad \forall \mathrm{m} \in \mathrm{M} \tag{15}$$

### (C) Net-meter

If during a sunny day more electricity is produced by solar PV system then use or consumes, this excess solar power is delivered back to the utility grid with effect of rotating electric meter backwards. When this happens we will normally be given credits by local power company for amounts of electricity produced by grid connected PV system. If during billing period we use or consume more electrical energy than we generate, we are billed for the "net amount" of electricity consumed as we would be normally. If, however, we generate more solar energy than we consume, we are credited for the "net amount" of electricity generated which may be either a reduction in our monthly electricity bill or a positive payment.

### (D) Demand side management

The main idea of the DSM is that customers are educated and encouraged to use the power during the off-peak hours, so that peak demand comes down, thus $I^2R$ losses are reduced. Demand side management (DSM) can be achieved by cooperative activities between the utility and its customers (sometimes with the assistance of third parties such as energy services companies, Non Government Organizations and other trade allies) to implement options for increasing efficiency of energy utilization, with resulting benefits to the customer, utility and society as a whole. Its main aim is reduction of peak demand or reduction of energy consumed during periods when energy-supply systems are constrained.

### (E) Cost benefit analysis

The costs can come down by as much as 18% to 22% for solar PV and 10% for wind. The result is striking: renewable energy technology equipment costs are falling and the technologies themselves are becoming more efficient. The combination of these two factors is leading to declines, rapid ones, in cost of energy from renewable technologies. To date, this transformation is most visible in the power generation sector, where dramatic cost reductions for solar photovoltaic (PV), but also, to a lesser extent, for wind power are driving high levels of investment in renewables. At the same time, where untapped economic hydropower, geothermal and biomass resources exist, these technologies can still provide the lowest-cost electricity of any source [11].

$$\text{Pay back period} = \frac{\text{Cost of Renewable Energy}}{\text{Money Saved per Year}} \tag{16}$$

## III. CASE STUDIES

In our work, two case studies are considered with same load profiles; calculate capital cost of system, monthly bill and payback period of each case study.

1) Grid connected PV system without battery
2) Grid connected PV system with battery

### 3.1 Grid connected PV system without battery

The grid-connected PV system is an electrical power generating system that uses a PV array as primary source of electricity generation and is intended to operate synchronously and in parallel with ac utility grid. Grid connected PV without battery systems, solar PV supplies entire load, excess energy is given to grid during sunny day generate power more than their individual requirement and rest of the time the entire load is shifted to grid as shown in fig 1.

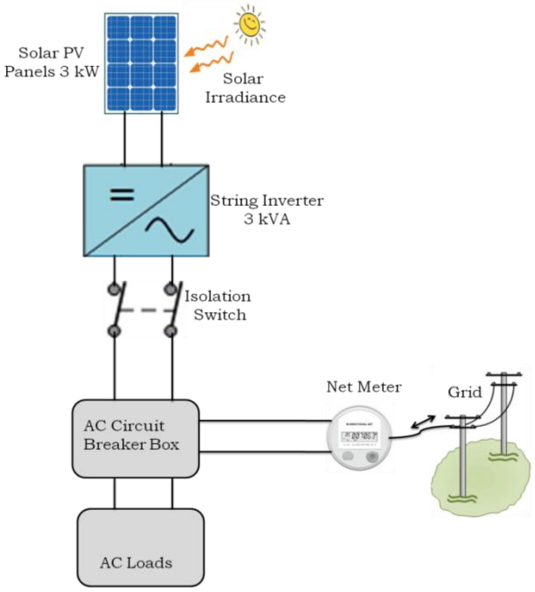


Fig.1 Grid connected PV without battery

Grid connected PV with battery systems, solar PV supplies entire load, excess energy is given to grid during sunny day generate power more than their individual requirement and rest of the time some of the loads are connected to battery and remaining loads are shifted to grid. Net meter is bidirectional meter, it can read energy drawn from grid and export to grid as shown in fig.2. In grid connected system lights and fans are connected to battery and battery is supplying entire day for lights and fans. Remaining loads are connected to grid supply.

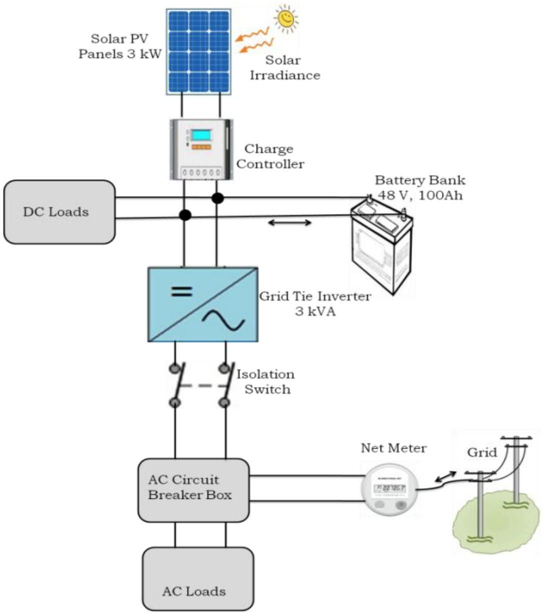
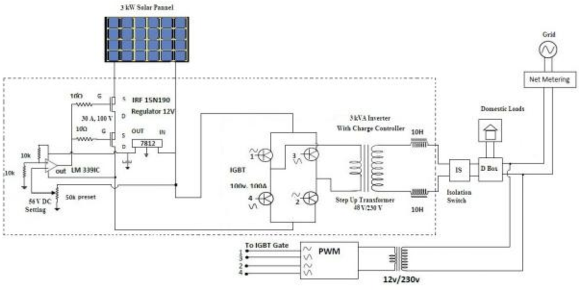
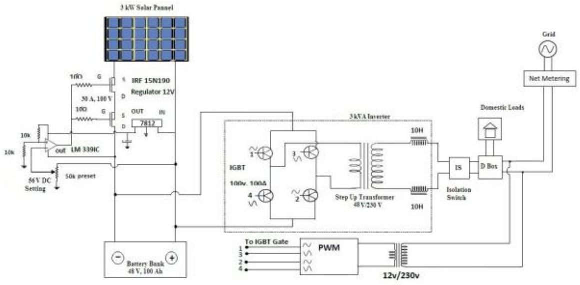


Fig.2 Grid connected PV with battery



(a)



(b)

Fig.3 Schematic diagram of grid connected PV (a) without battery and (b) with battery

The solar PV is connected to charge controller. The charge controller gives maximum voltage of 48 V and it is fed to a battery bank of rating 48 V, 150 Ah (in case of grid connected with battery otherwise PV output is directly connected to string inverter). The battery is connected to inverter designed with MPPT having less than 4% THD circuit consists of four IGBT' rated 100 V, 100 A each is used, firing circuit is designed and gate pulses are generated using pulse circuit PWM technique. The output voltage of 48 V, 50 Hz is stepped upto single phase, 230 V, 50 Hz connected to load. Two 10 Hy filter circuits have been connected to the inverter output in order to smooth the output AC voltage

Table 1. Home appliances used in case study in Regular Home Consumption

| Home appliances | Grid connected PV with and without battery | | | |
|---|---|---|---|---|
| | Rating (W) | Qty | working schedule (h) Session-I | working schedule (h) Session-II |
| CFL lamps | 18 | 18 | 5-6/17-22 | 5-6/17-22 |
| Fans | 80 | 9 | 1-24 | 1-24 |
| Washing machine | 600 | 01 | 7-8 | 7-8 |
| Refrigerator | 300 | 01 | 1-24 | 1-24 |
| Air conditioner | 2000 | 01 | 1-6/14-16/21-24 | -- |
| Geezer | 800 | 01 | 7-8 | 7-8/18-20 |
| Wet grinder | 800 | 01 | 19-20 | 19-20 |
| Motor (1.5 hp) | 1117 | 01 | 19-20 | 19-20 |
| Rice cooker | 800 | 01 | 12-13 /20-21 | 12-13 /20-21 |
| Mixer | 800 | 01 | 19-20 | 19-20 |
| Television | 100 | 01 | 7-8/12-14/19-22 | 7-8/12-14/19-22 |
| Iron box | 1000 | 01 | 20-21 | 20-21 |
| Others | 500 | 01 | 9-11/15-16 | 9-11/15-16 |

| S. No. | Item Description | Qty | Capital cost in Rs. |
|---|---|---|---|
| 1 | Solar panel 24V-250Wp | 12 | 235550 |
| 2 | Module Mounting Structure | 01 | |
| 3 | PCU (Inverter with inbuilt charge controller)48V/3KVA Grid Tie Inverter | 01 | |
| 4 | Array Junction Box 5 in 1 out | 01 | |
| 5 | Cables | 01 | |
| 6 | Accessories-Danger, Display boards etc... | 01 | |
| 7 | Battery Bank (LMLA type) 12 V-150 Ah (48V-150Ah) | 04 | 50000 |
| 8 | Battery Stand (Equivalent to place specified battery bank) | 01 | |
| 9 | Earthing | 01 | |
| 10 | Total capital cost without battery | | 235550 |
| 11 | Total capital cost (with battery) | | 285550 |

Table 2. Technical Specifications for Array 3 kWp Capacity without/with battery and capital cost

Assumptions:

1) Solar energy produces under normal working conditions
2) The batteries will operate at a maximum depth of discharge of 85%.

Tables 1and 2 shows home appliances used in the case study in regular home consumption and technical specifications for Array 3 kWp capacity without and with battery and capital cost.

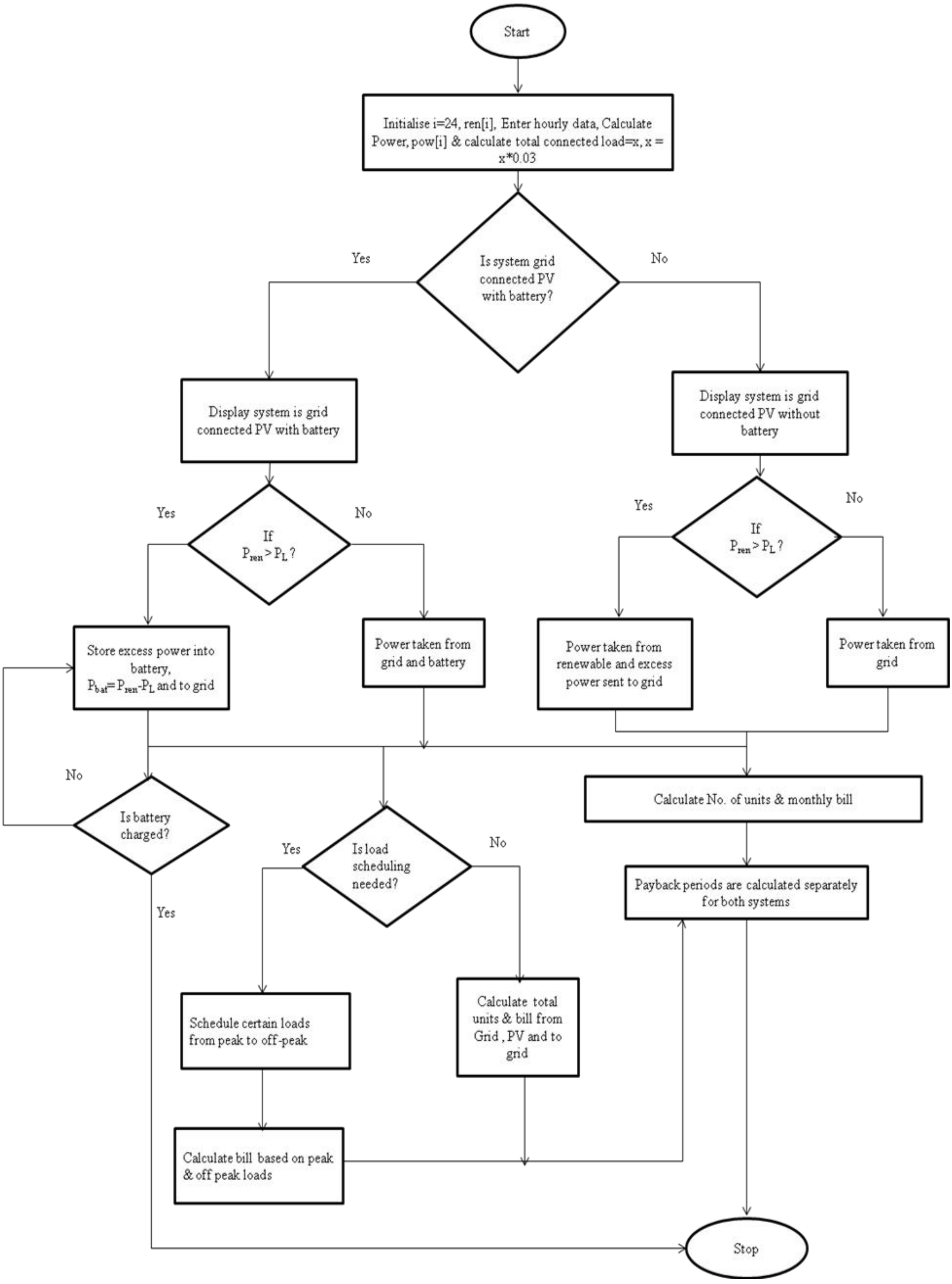
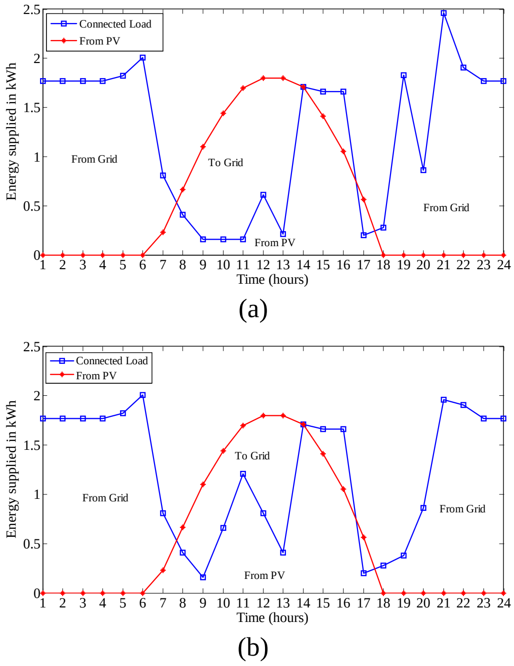


Fig.4 Flow chart for the proposed method

Fig.4 shows flow chart of proposed method for grid connected PV without battery, with battery backup and load scheduling. Initialize the hourly load, calculate the total connected load. If $P_{ren}>P_{load}$, all loads are connected to renewables except fans and lights (battery supplies fans and lights whole day), charge the battery and excess power exported to the grid. If $P_{ren}<P_{load}$, fan, light load are connected to battery, remaining loads are connected to grid. Consider the load scheduling, calculate electricity bill for without and with scheduling.

## IV. RESULTS AND DISCUSSIONS

For simulation purpose, we have used a scenario of thirteen loads: lights, fans, TV, fridge, geezer, AC, washing machine, motor, rice cooker, mixer, iron box, wet grinder and other loads with energy consumption ratings of 0.018kWh, 0.08kWh, 0.1kWh, 0.16kWh, 0.8kWh, 2kWh, 0.8kWh, 1.05kWh, 0.8kWh,0.8kWh, 1kWh, 0.6kWh and 0.05kWh respectively. In our scheme we schedule certain appliances operate from peak to off peak period. We consider peak hours between 6 P.M to 11 P.M. Here we consider two sessions: session-I (March to August) session-II (September to February).

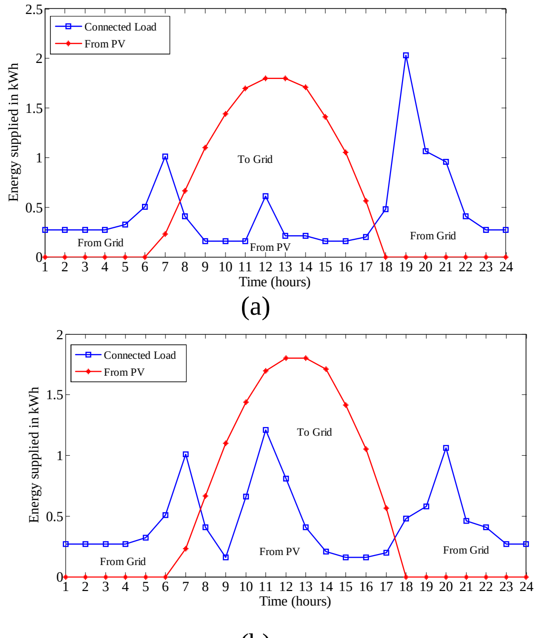


(a)

(b)

Fig.5 Average daily profile of the house for grid connected PV without battery (a) session-I before scheduling (b) session-I after scheduling.

Grid connected PV without battery as shown in fig.5 before and after scheduling in session-I (March to August). We observed that during day all connected loads are connected to solar PV when PV is more than the connected load and excess power is exported to the grid. During night time all loads are shifted to grid and there is no backup power supply.

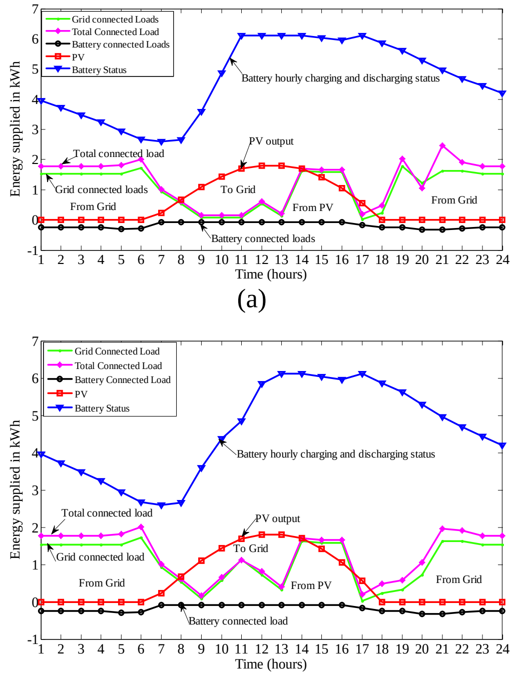


(a)

(b)

Fig. 6 average daily profile of the house's for grid connected PV without battery (a) session-II before scheduling (b) session-II after scheduling

Grid connected PV without battery as shown in fig.6 before and after scheduling in session-II (September to February).



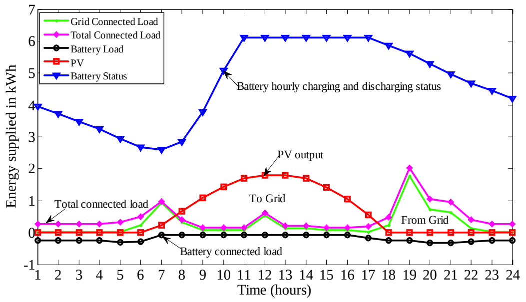
(a)

(b)

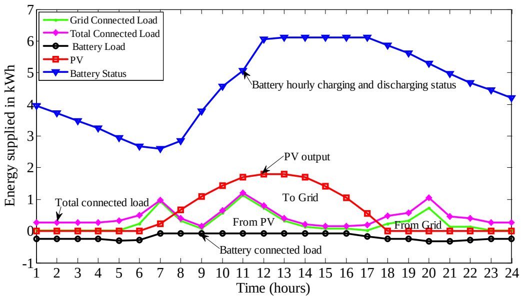
Fig.7 average daily profile of the house's for grid connected PV with battery (a) session-I before scheduling (b) session-I after scheduling

We observed that during day time all connected loads are connected to solar PV when PV is more than the connected load and excess power is exported to the grid. During night time all loads are shifted to grid and there is no backup power supply.

Grid connected PV with battery as shown in fig.7 before and after scheduling in session-I (March to August). We observed that during day all loads are connected to solar PV when PV is more than the connected load and excess power is exported to the grid. During night time, fans and lights are connected to battery, remaining loads are shifted to grid and here we use battery backup of 48 V, 150 Ah.



(a)



(b)

Fig.8 average daily profile of the house for grid connected PV with battery (a) session-II before scheduling (b) session-II after scheduling

Grid connected PV with battery as shown in fig.8 before and after scheduling in session-II (September to February). We observed that during day all connected loads are connected to solar PV when PV is more than the connected load and excess power is exported to the grid. During night time, fans and lights are connected to battery, remaining loads are shifted to grid and here we use battery backup of 48 V, 150 Ah.

Table.3 Grid connected PV without battery before scheduling

| Type | Grid connected PV without battery before scheduling **Session-I** (March to August) | | | | Grid connected PV without battery before scheduling **Session-II** (September to February) | | | |
|---|---|---|---|---|---|---|---|---|
| | From Grid | Grid with PV | | To Grid | From Grid | Grid with PV | | To Grid |
| | | Grid | PV | | | Grid | PV | |
| Energy consumed in kWh | 886 | 696 | 189 | 214 | 325 | 245 | 80 | 324 |
| Tariff/month in Rs. | 6512 | 4840 | | 751 | 1707 | 1112 | | 1134 |
| Monthly saving in Rs | 1672 | | | 751 | 595 | | | 1134 |
| Session wise Saving in Rs. | 10032 | | | 4506 | 2380 | | | 4536 |
| | Six months | | | | Four months | | | |
| Total saving in Rs. | 21454 | | | | | | | |
| Payback period in years | 11 | | | | | | | |

Table.4 Grid connected PV without battery after scheduling

| Type | Grid connected PV without battery after scheduling **Session-I** (March to August) | | | | Grid connected PV without battery after scheduling **Session-II** (September to February) | | | |
|---|---|---|---|---|---|---|---|---|
| | From Grid | Grid with PV | | To Grid | From Grid | Grid with PV | | To Grid |
| | | Grid | PV | | | Grid | PV | |
| Energy consumed in kWh | 886 | 638 | 248 | 156 | 325 | 186 | 139 | 265 |
| Tariff/month in Rs. | 6512 | 4330 | | 547 | 1707 | 739 | | 930 |
| Monthly saving in Rs | 2182 | | | 547 | 968 | | | 930 |
| Session wise Saving in Rs. | 13092 | | | 3282 | 3872 | | | 3720 |
| | Six months | | | | Four months | | | |
| Total saving in Rs. | 23966 | | | | | | | |
| Payback period in years | 10 | | | | | | | |

From Table 3 and Table 4 observed that energy consumed in kWh, tariff/month, monthly saving, session wise saving, total saving (session-I and session-II) and payback periods of before and after scheduling for grid connected PV without battery. We consider total saving 10 months over a year (300 sunny days) for session-I from March to August (consider 6 months) and session-II from September to February(consider 4 months). The payback period for grid connected PV without battery before scheduling is 11 years and after scheduling is 10 years.

Table: 5 Grid connected PV with battery before scheduling

| Type | Grid connected PV with battery before scheduling **Session-I** (March to August) | | | | | Grid connected PV with battery before scheduling **Session-II** (September to February) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | From Grid | Grid with PV | | | To Grid | From Grid | Grid with PV | | | To Grid |
| | | Grid | PV | Battery | | | Grid | PV | Battery | |
| Energy consumed in kWh | 886 | 586 | 168 | 132 | 104 | 325 | 139 | 54 | 132 | 218 |
| Tariff/month in Rs. | 6512 | 3864 | | | 364 | 1707 | 482 | | | 764 |
| Monthly saving in Rs | 2648 | | | | 364 | 1225 | | | | 764 |
| Session wise Saving in Rs. | 15888 | | | | 2184 | 4900 | | | | 3056 |
| | Six months | | | | | Four months | | | | |
| Total saving in | 26028 | | | | | | | | | |
| Payback period in years | 11 | | | | | | | | | |

Table: 6 Grid connected PV with battery after scheduling

| Type | Grid connected PV with battery after scheduling **Session-I** (March to August) | | | | | Grid connected PV with battery after scheduling **Session-II** (September to February) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | From Grid | Grid with PV | | | To Grid | From Grid | Grid with PV | | | To Grid |
| | | Grid | PV | Battery | | | Grid | PV | Battery | |
| Energy consumed in kWh | 886 | 528 | 226 | 132 | 46 | 325 | 81 | 112 | 132 | 160 |
| Tariff/month in Rs. | 6512 | 3353 | | | 161 | 1707 | 227 | | | 560 |
| Monthly saving in Rs | 3159 | | | | 161 | 1480 | | | | 560 |
| Session wise Saving in Rs. | 18954 | | | | 966 | 5920 | | | | 2240 |
| | Six months | | | | | Four months | | | | |
| Total saving in | 28080 | | | | | | | | | |
| Payback period in years | 10 | | | | | | | | | |

From Table 5 and Table 6 observed that energy consumed in kWh, tariff/month, monthly saving, session wise saving, total saving (session-I and session-II) and payback periods of before and after scheduling for grid connected PV with battery. We consider total saving 10 months over a year (300 sunny days) for session-I from March to August (consider 6 months) and session-II from September to February(consider 4 months). The payback period for grid connected PV with battery before scheduling is 11 years and after scheduling is 10 years. The capital cost of grid connected with battery is more than without battery system by Rs.50000, but payback periods of both the systems are same. In grid connected PV with battery system fans and lights are connected to battery for whole day. In grid connected PV without battery, grid and PV supply the load where as with battery, grid, PV and battery supply the load. The main difference between the grid connected PV without battery and with battery backup is that the grid connected PV without battery is always grid alive otherwise the power generated by solar PV is unutilized but in case of grid connected with battery backup, grid is not alive due to power failure or local maintenance power generated by solar PV is utilized through battery backup.

Table: 7 Comparison of Capital Cost, Saving and Payback Period with/without subsidy

| On Grid | | Total capital cost in Rs. | Total annual saving in Rs. | | Payback period | |
|---|---|---|---|---|---|---|
| | | | Before scheduling | After scheduling | Before scheduling | After scheduling |
| Grid connected PV without battery system | Without subsidy | 235550 | 21454 | 23966 | 11 | 10 |
| | With 30% subsidy | 164885 | | | 7.5 | 7 |
| | With 50% subsidy | 117775 | | | 5.5 | 5 |
| Grid connected PV with battery system | Without subsidy | 285550 | 26226 | 28266 | 11 | 10 |
| | With 30% subsidy | 199885 | | | 7.5 | 7 |
| | With 50% subsidy | 142775 | | | 5.5 | 5 |

From Table 7 observed that the subsidy 30% and 50% will be given by the government, payback periods will be same for grid connected PV without and with battery backup for different capital cost of the systems.

## V. CONCLUSION

With the observed fast reduction of PV and battery system prices in recent years, interest in the use of grid connected PV without and with battery backup systems has ably increased. The goal of this research was to develop a decision support tool to help end-users identify the best investment decision and optimum system size for their specific applications. We have developed a grid connected PV system without and with battery backup program with the objective to maximize saving by minimizing the electricity bill and scheduled certain loads to avoid the overloading of distribution system during peak hours verified by MATLAB simulation results. The model was capable of identifying the feasibility of an investment in PV without and with battery backup systems, and the specifications of the optimal system. The cost of investment and pay back periods has been calculated for solar PV by using cost benefit analysis.

## REFERENCES

[1]. M. Shahidehpour, Investing in expansion: The many issues that cloud transmission planning, IEEE Power Energy, 2 (1), 2004, pp. 14–18.

[2]. M. Shahidehpour and F. Schwatrz, Don’t let the sun go down on PV,”IEEE Power Energy, 2 (3), 2004, 40-48.

[3]. I. Gyuk, The global markets for uninterruptible power supplies, volume 1: North America 5.0 KVA and under; Volume 2: North America over 5.0 KVA, in Proc. Conf. Elect. Energy Storage Syst., Appl., Technol., Orlando, 2000, 18-20.

[4]. Blue print for power sector development, Ministry of Power, Government of India, New Delhi, 2001.

[5]. B.B. Alagoz, A. Kaygusuz, A. Karabiber, A user-mode distributed energy management architecture for smart grid applications, Energy, 44, 2012, 167–177.

[6]. J. Paska, P. Biczel, M. K1os, Hybrid power systems-an effective way of utilizing primary energy sources, Renewable Energy, 34, 2009 2414–2421.

[7]. Priyanka Paliwal, N.P.Patidar, R.K.Nema, Planning of grid integrated distributed generators: A review of technology, objectives and techniques, Renewable and Sustainable Energy Reviews, 40, 2014, 557–570.

[8]. Kunal Patel, Arun Khosla, Jessy Badarimaya Deimon Khonglah, Autonomous Integration of Distributed Energy Sources and Home Appliances Coordination Scheme in Future Smart Grid Networks, 4th International Conference on Eco-friendly Computing and Communication Systems, 2015.

[9]. Centolella P, The integration of price responsive demand into regional transmission organization (RTO) wholesale power markets and system, Energy, 35(4), 2010, 1568-74.

[10]. Christopher O. Adika, Lingfeng Wang, Smart charging and appliance scheduling approaches to demand side Management, Electrical Power and Energy Systems, 2014, 232–240.

[11]. http://www.irena.org/documentdownloads/publi cations/i rena_re_power_costs_2014_report.pdf