

INDIAN ENERGY SCENARIO AND METHODS FOR REDUCING ELECTRICITY BILL IN RESIDENTIAL SECTOR

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ABSTRACT

This paper presents the Indian electricity scenario and growth of electricity usage in the residential sector. Till 31st March 2013 it was 21.79% of total electricity consumption, i.e. 852,902 GWh, which represents 2nd largest share of total electricity use as compared to industrial, commercial, traction, agricultural and miscellaneous load. The growth of electricity usage in any country shows the growth of country, but at the same time it increases the monetary expense on electricity. To reduce the monetary expense on electric bill a concept of smart home is introduced. Secondly, it discussed the case study of 2BHK house with a detail survey. Calculation of electrical loads (watts) in the house is tabulated to calculate the total electrical load. It shows the number of units consumed by survey and by load serving entity is approximately same. To reduce the electricity bill few suggestions are incorporated. It focused on each and every parameter in the electric bill calculation to reduce it. A novel idea of implementing a smart home through renewable source like solar system and calculation of solar panel as per requirement is also presented to emphasize its feasibility and reliability even at the micro level. Also, it gives brief idea of standby power (vampire power) and preventive majors to reduce it.

Keywords: Smart Home, Renewable Sources, Electric Bill and Standby Power.

I INTRODUCTION

According to the government of India, Ministry of Power, Central Electricity Authority published “Growth of Electricity in India”, from 31st Dec 1947 to 31st March 2013, the residential electricity usage in India is increasing day by day and in the year 2013 it is 21.79% of total electricity consumption i.e. 852,902 GWh [1], which includes second largest share of total electricity used. Fig. 1 is re-generated trend line to show the increasing development in the residential sector about electricity usage [1]. The electricity price in a competitive power market is closely related to the consumers’ demand, as demand increases the price also increases. However, the lack of real-time pricing, technologies presents challenges to electricity market operators to optimally signal and respond to scarcity, because electricity cannot be stored economically [2].

Over the last few decades, the average temperature of the earth has risen by 0.74 degree Celsius, which has caused a variety of environmental problems, such as changes in climate and rising sea levels, etc. Furthermore, fossil fuel is being run-down because of a sharp increase in the consumption of energy due to the industrial revolution. The environmental experts expect that fossil fuel will run out completely in the near future [3]. Coal and gas power plants cause environmental concern. Carbon emission, greenhouse gas (GHG) emissions have

forced us to aim at more aggressive goals of deep integration of large amounts of renewable generation, especially wind and solar, to meet our electric energy needs [4][5][6]. We are fortunate to have about 300 days in a year of good solar energy in India. The consumers can minimize their expense on energy by adjusting their intelligent home appliance operations to avoid the peak hours and utilize the renewable energy (Solar) instead [7].

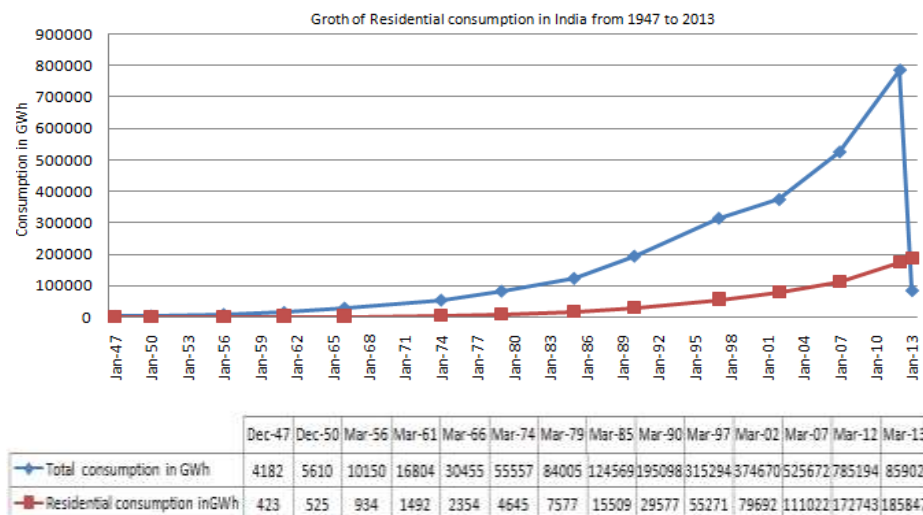


Fig.1. Growth of residential electricity consumption in India[1]

II MOTIVATION

In this section, we briefly highlight the key motivations for reduction in payment of electricity bill for consumer benefit, at the same time encourages people to use renewable sources like solar & wind energy. Fig.2 shows electricity usage in the residential sector is 2nd highest and increasing day by day as compared to other load which is a matter of concern. Hence need to concentrate on reduction in the payment of electricity bill for the residential customer benefit. As we have already discussed in section I, due to environmental changes fossil fuels will run out completely in the near future, so more emphasis will be on use of more and more renewable energy sources like wind energy & solar energy etc.

In [8], the author has focused on two exemplary battery storage systems, including the required power electronics. The grid integration, as well as the optimal usage of volatile energy reserves, is presented for a 5-kW PV system for home application, as well as for a 100-MW medium-voltage system, intended for wind farm usage. The efficiency and cost topologies are investigated as a key parameter for large-scale integration of renewable power at medium and low-voltage.

Organization of this paper is as follows. Section III presents the case study of 2BHK house which include the calculation of electrical load in watts, electric bill calculations which include different parameters in electric bill, etc., Section IV presents the basic requirements to save electricity bill; Section V presents the solar panel design calculation for smart home which will independently run on solar system (off-grid system) and standby power in electrical load; Section VI presents the benefits of using solar system and concludes the paper.

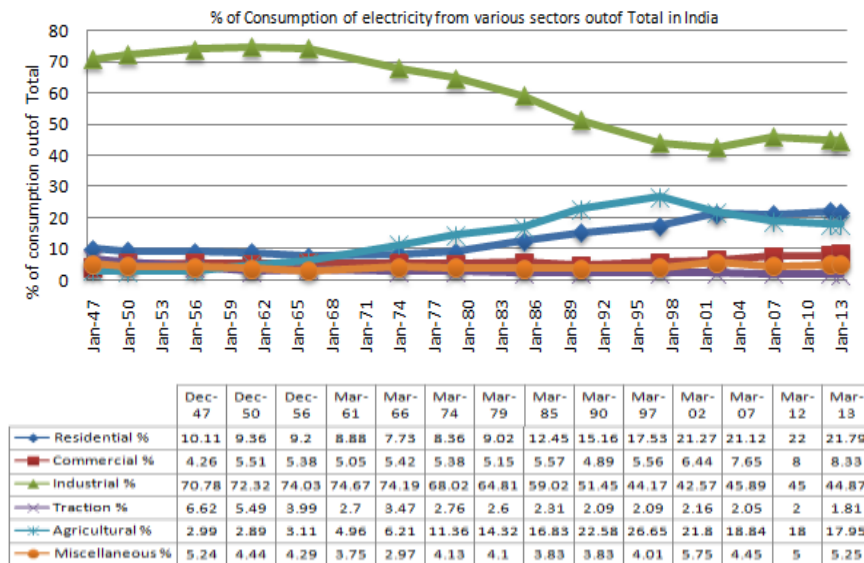


Fig.2. Growth of electricity consumption in India[1]

III CASE STUDY

3.1 Survey of 2BHK flat

To know the yearly units consumed, a survey of 2BHK flat was done. All the electronic and electrical equipments in the flat are listed as per session (summer, winter, rainy) along with their power rating, star rating and number of hours they are working in a day and from this data, for 365 days (1year) number of units consumed calculated. Also, electric bills for 12 months, provided by electricity serving entity studied and yearly unit consumed are calculated. This unit consumed by the customer compared with the unit consumed by the customer through survey it is almost same, shown in table 1.

Table 1: Electrical Load Survey of 2BHK Flat

Rooms	Maximum loading (watts)	Yearly Consumption By Survey (Units)	Yearly Unit Consumption By Reliance Energy (Units)
Hall	428	431.845	-
Kitchen	1054	550.7265	-
Bedroom1	1315	1200.635	-
Bedroom2	180	80.32	-
Bathroom1	3415	308.425	-
Bathroom2	15	5.475	-
Passage	15	21.9	-
Total unit consumed	6422 watts	2599.327 Units (May be equipment changes in between, not frequently used)	2172 Units (addition of 12months no. of unit consumed. Exact reading traced by load serving entity)

From table 1 it is clear that the number of units consumed by the survey is 2599.327 Units and by electric meter it is 2172 Units for a complete year. The difference of 427 units may be due to a) Human error b) instrumental

error c) or equipment is replaced by similar equipment before survey d) faulty equipment e) equipment not frequently used etc.

List of equipment used in sample flat

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List of equipment used in sample flat:

1. Hall

2 Tube light - 40W & 36W, 1 Fan – 60W, 1 Cooler – 175W, 1 LED TV 39” – 81W, 1 DVD player – 11W, 1Set-Top box – 15W, 2Mobile charger – 10W each.

2. Kitchen

1 Tube light - 40W, 1 Fan – 24W, 1 Food Processor – 600W, 1 Refrigerator – 180W, 1 Aqua-guard – 30W, 1 Blender – 180W.

3. Bedroom 1

1 Tube light - 40W, 1 CFL – 15W, 1 Fan – 60W, 1 AC 1Ton – 1200W.

4. Bedroom 2

1 Tube light - 40W, 1 CFL – 15W, 1 Fan – 60W, 1 laptop – 65W.

5. Bathroom 1

1 CFL – 15W, 1 washing machine – 400W, 1 Water heater – 3000W.

6. Bathroom 1

1 CFL – 15W.

7. Passage

1 CFL – 15W.

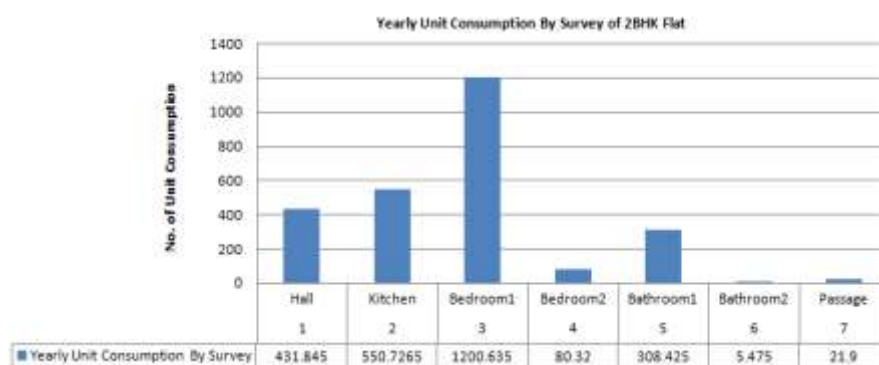


Fig. 3. Yearly unit consumed in the sample flat by survey

3.2 Electric Bill Information

1. The electricity meter readings are very important to keep the meter readings up to date in order to avoid the under billing or over billing for electricity supply.

2. The electricity meter works on the regular basis and this will not happen always. So need to take the gas meter readings for every three months. Then it should inform the supplier either through phone calls or sending the entire meter reading through online managed account.
3. The amount a consumer needs to pay depends on the difference between the current and previous meter readings. It is obtained by multiplying the unit rate excluding VAT.
4. For example, consider the current reading as 8761 kW and the previous reading as 8425KWh. After calculating the difference it shows as 3825 kilowatt hours or also termed as units. Now, multiply this 3825 with unit rate and this result should be paid for electricity usage.
5. If there is a charge for the gas bill, then it will show separately on the electricity bill. Some of the electricity supplier will have the standing charges and some won't charge for this.
6. VAT is added to the electricity bill at 5% for the domestic customers.
7. The final part of the bill shows the total amount need to pay [9].

Table 2: Electric Bill of 2 BHK Flat for 12 Months

Sr.No.	Month	Unit consumed	Electric Bill (Rupees)
1	May-14	220	1480.00
2	April-14	334	2110.00
3	Mar-14	163	1010.00
4	Feb-14	141	880.00
5	Jan-14	149	930.00
6	Dec-13	175	1150.00
7	Nov-13	175	1140.00
8	Oct-13	172	1120.00
9	Sept-13	155	990.00
10	Aug-13	149	850.00
11	July-13	155	830.00
12	Jun-13	184	2650.00
Total	365 days	2172 units	15140.00 Rs

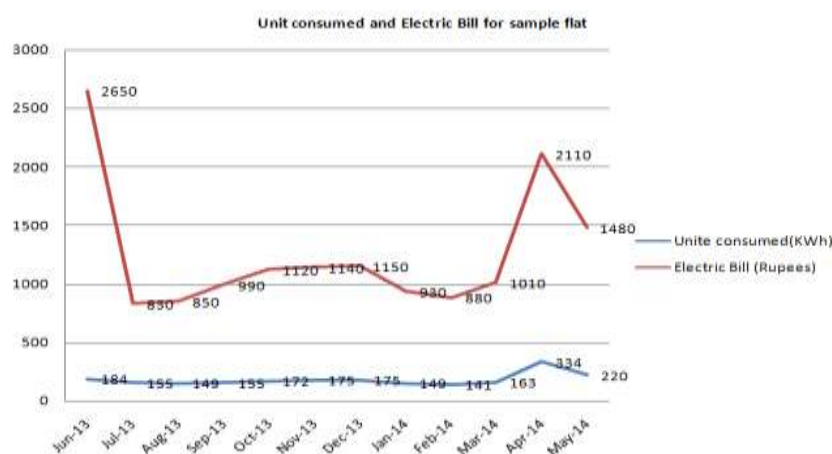


Fig.4. Actual unit consumed & electric bill of a sample flat (from table 2)

3.3 Actual electric bill calculations (for May-2014)

Number of units consumed in sample is 220 unit from electric bill statement. Calculation for the same discussed below:

3.3.1 Fixed charge

This is like a rental for the meter. This depends upon three factors – customer classification, consumption slab and the nature of electricity meter. If the customer is classified as below the poverty line (Less than 30 units' consumption in a month), the fixed rate is Rs 3. Therefore, the fixed charge varies as per consumption from month to month. There is one further complication – if customers have a three phase meter, then fixed charge is fixed at Rs 100 per month irrespective of consumption.

Consumption (Unit kWh) for may-14 is 220 Units; from tariff structure since 220 units' falls under slab 2 (101-300), so fixed charges correspond to slab 2 is 75 Rs/month. Hence, Fixed charge = 75Rs.

Table 3 Tariff slab (Effective from 1/4/2014)

Tariff Slabs /months	Units	Fixed Charges Rs/Month	Energy Charges Rs/Unit	Wheeling Charges Rs/Unit	RA Charge Rs/Unit	FAC rate Paise/Unit May-14
0-100		40	2.11	1.24	0.57	43.90
101-300		75	3.58	1.24	0.74	69.20
301-500		75	4.36	1.24	0.86	75.58
>500 (Balance units)		100	6.36	1.24	1.17	96.39

3.3.2 Energy Charges

From tariff bill mentioned, since 220 units fall under slab 2 (101-300), so energy charges corresponding to 220units calculated from table 3 as: Energy charge = $(100 \times 2.11) + (120 \times 3.58) = 640.60$ Rs.

3.3.3 Fuel Adjustment Charge (FAC)

This varies from month to month and is the reason why the bill may go up even if consumption has less or not. This item is also stated in Pisa per unit. This charge reflects the reality of the wholesale electricity market. The cost of electricity generation varies every month with variation in the cost of fuel – coal and oil. Furthermore, a retail distributor like Reliance buys electricity from several sources which vary in cost from time to time. This mix of sources also affects the cost in the hands of Reliance. Reliance passes this extra cost to the customers after approval from MERC (Electricity Regulator for Maharashtra). This is usually an estimate and therefore an adjustment is made next month in case of overcharge.

From tariff bill mentioned, Since 220 units fall under slab 2 (101-300), so Fuel adjustment charges corresponding to 220units calculated from table 3 as:FA charge = $(100 \times 43.90 \text{ paisa}) + (120 \times 69.20 \text{ paisa}) = 4390\text{p} + 8304\text{p} = 12694 \text{ paisa} = 126.94$ Rs.

3.3.4 Government of Maharashtra charges as taxes

The first one is a duty of 15% on the total of fixed charge, energy charge and fuel adjustment charge. The second one is a tax of 15 paise per unit consumed. All these added together make the current month's bill. From this, Reliance deducts interest on security deposit, prompt payment discount and discount for e-payment. It also adds delayed payment charge for the last month and interest on arrears (if any). Sometimes, it may have discount for e-payment and also a delayed payment charge.

Lastly, there is adjustment of last month's outstanding amount which is essentially due to the rounding up that Reliance does. It's usually under Rs 5 unless the last bill hasn't been paid. All these put together make up the electricity bill at Reliance Energy.

Government electricity Duty = (fixed charge + wheeling charge + RA charge + Energy charge + Fuel adjustment charge) * 0.15

Government electricity Duty = (75+ 272.80+ 145.80+ 126.94) * 0.15 = 189.17 Rs.

Maharashtra Govt. tax on sale of electricity 15.00 paise/unit

Maharashtra Govt. Tax on sale of electricity = 220*0.15 = 33.00 Rs.

3.3.5 Calculation of connected Load

Well, it is done by engineers from the utility from which customer takes a connection. When a customer fills up a form to take a connection, customers have to mention the list of appliances at home. Utilities also do something called a "Load Survey" to profile specific areas in the cities to figure out the lifestyle of people living in the area. Based on inputs provided by the customer in the form and the profiling, they decide on the connected load for a house [10]. The connected load is also periodically adjusted based on the usage (it does not decrease but only increase if usage pattern is on the high side).

3.3.6 Selection of supply

In India a single-phase supply is a 230V supply through two wires and 3-phase supply is 415 V supply through 4 wires and in the house the line can be divided to give 230V at individual point. The basic difference between the two is that a three-phase connection can handle heavy load while a single-phase cannot. In India, observed with most distribution companies that if the residential connected load is more than 5-7 kW, they assign a three-phase connection to that house. And typically connected load is evaluated by assuming that a certain percentage of all the appliances in a customer's house will run together. So if a customer has 3 ACs and few water heaters and even if do not run them together, a three-phase connection will be assigned to the customer. The reason for that is, in case run them together, it will have the potential to bring down the electricity distribution system [11].

IV REQUIREMENTS FOR ELECTRICITY BILL SAVING

Basic requirements to save electricity bill are- a) Use Star rated electronic equipments b) Replace tube light (Incandescent lamp) by LED, CFL, Halogen lamp c) Turn things off when not in the room such as lights, TVs, entertainment systems, and computer & monitor d) Plug home electronics, such as TVs and DVD players, into power strips; turn the power strips off when the equipment is not in use—TVs and DVDs in standby mode still use several watts of power e) Look for the ENERGY STAR® label on light bulbs, home appliances, electronics,

and other products. ENERGY STAR products meet strict efficiency guidelines set by the U.S. Environmental Protection Agency and the U.S. Department of Energy [11].

4.1 Tips to Save Electricity Bill

Use of right illumination Use the right illumination by replacing incandescent bulbs with tube lights, CFLs, LEDs. Now a day LED lights, CFL lights are available in the market which are more efficient than tube light. e.g. 40W incandescent gives 450 Lumens output, same output will be given by 4-5W LEDs or by 8-12W CFLs.

Save 2/3rd energy Replace traditional chokes of tube lights with Electronic chokes which only consume one-third Energy compared to the traditional chokes.

Saving in Drawing room Drawing room does not need too many lights when guests are not visiting. Use dimmer switches to adjust the amount of lighting you may need at any time. This will help in saving valuable power.

Saving due to paintings In rooms uses light colors for walls, which helps in reducing lighting requirements up to 20%.

Use of light as per task/requirement Rearrange the furniture to make lighting task-based. Reading, Studying, Cooking and Sewing require more light. Use CFLs in Puja room, Kitchen, passage, Bathrooms.

Saving by cleaning light Keep lights and fixtures clean and dirt-free. Dust and dirt reduce lighting levels as much as 20%

Make light of heavy duty home appliances Buy only those appliances really need and of the right size. Try to get the maximum benefit from them with minimum power consumed. Avoid using kitchen machines every day, i.e. grinds spices (masalas) once or twice a week, unless the household is big enough to require its use in every day. Use washing machine every alternate day, or as and when a full load of clothes is collected.

Use AC Optimally & Effectively Consider Using the AC optimally – for an hour or two less every day. An AC switched off for an hour can keep a 40 watt tube light on for 50 hours! Maintain AC temperature around 24 – 25°C (Human Comfort Level) Keep windows shut after switching off the AC to keep the room cool for some more time. You would be saving significantly on power consumption. Clean the AC filter at least once a fortnight. A choked filter means poorer quality of cooling and more power consumed

Savings on refrigerators Use minimum size refrigerators, according to the need of the family. Oversized refrigerators mean more power consumed. Cool the food sufficiently before storing in refrigerators. Avoid opening the fridge door frequently. **Savings on Ironing** Start with ironing clothes that require low temperature keeping clothes that require higher temperature towards the end. Avoid creasing of clothes when hanging them on a clothesline for faster and smoother Ironing.

Use TV, radio, stereo system only when required Radio, TV and stereo systems are low consumers of power, nevertheless, switch them off when no one is listening or watching. Switch off Electronic Gadgets from the mains instead of switching them off from the remote control or placing them on stand-by.

During evening peak load (6.00 pm to 9.00 pm) Minimize the use of Gadgets like Grinders, Washing machines etc.

V THE SOLAR PANEL IS DESIGNED FOR SMART HOMES

Fig. 5 shows a block diagram of a smart home system where solar energy is stored in batteries and then used to run the electrical load like home appliances and also for charging electric vehicle. The system can be operated either in stand-alone mode or grid-connected mode, to conditioning the electricity, safely transmit the electricity to the load that will use it, or store the electricity for future use [12]. With stand-alone systems (those not connected to the electric grid) the required equipments depends on what we want our system to do. However, if we want to store power for use when the system isn't producing electricity, we need to purchase batteries and a charge controller. Fig. 5 shows that PV modules serve DC supply to charge controller, through which battery will charge to its maximum. Then through the inverter, AC supply will give to the electrical load. This is the case for night time, but during daytime PV modules can be directly connected to an inverter which is directly connected to a load. So in this way this system can be used in daytime as well as night time, which is independent of the grid connected system.

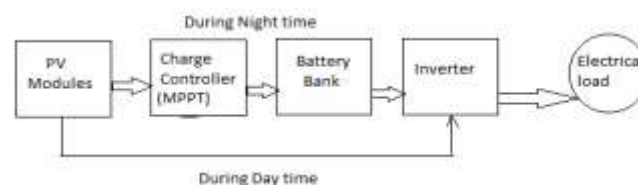


Fig. 5. Block diagram of solar system serving electrical load

5.1 Design of solar panel serving electrical load

One single solar panel from type standard 250 Watt / 24 volts can deliver a power of 250 Watt Per hour, considering full sunshine [13]. Knowing that the sunshine vary during the day, the effective sun power of one day is equal from 4 to 6 hours with a maximum measured at midday. Since this maximum at midday is not the same every day, it should be taken in consideration, that more or less heavy cloud reduces the possible power [14]. The electrical power is stored in batteries, similar to the one used in cars. The design of solar panel as per requirement is explained below:

For example,

Step 1: Electrical Load requirement (connected load): 3KW

Step 2: Battery bank: (Twice the requirement) + (50% of Requirement) = $(3 \times 2) + 50\% (3 \times 2) = 9\text{KW}$

Step 3: Solar panel: panel size = $9\text{KW} / 6\text{Hrs} = 1.5\text{KW}$

Step 4: Type of battery bank: $I = ?$ & $V = ?$; $P = V \times I$;

$9\text{KW} = 24 \times I$; Hence $V = 24$ volts & $I = 375\text{Amp}$. Hence, (1 Battery of 200A + 1 Battery of 250A) I. e.

Total two batteries are required.

Step 5: No. of solar panel required (for generating 1.5KW):

$250\text{W} \times 6 = 1500\text{W}$ i.e. 1.5KW so 6 panels of 250W, $V = 24\text{v}$; $P = 250\text{W} \times 6 = 1.5\text{KW}$; $I = P / V = 10.41\text{A} \approx 10\text{A}$.

Step 6: MPPT rating:

Battery required 375A current's i.e. $375\text{A} / 6\text{hrs} = 63\text{AH}$ (Battery current per hour). For 2 batteries 2MPPT required.

$(40A, 24V + 20A, 24V) = 60A, 24V$ Panel output.

Step 7: Inverter rating:

The solar panel is about 1.5KW so Inverter is double of solar panel i.e.2 KW.

The main thing is to get an idea of the electrical power needed for the devices that are supposed to be powered by solar energy, and also an idea of the duration of use of each device. With these two information's, it is possible to calculate the size of the solar panel Required to obtain good results. On most electrical devices, the power consumption is written on it, and these specifications are based on one hour of usage [15] [16].

Standby power in e-appliances:

Standby power is a power consumed by an appliance when switched off or not performing its primary function. Many domestic appliances have no standby feature, but equipped with wall-packets. Though they are switched off, a small amount of energy is wasted in the low voltage power supply, mainly due to cheap transformers with high core losses [21][22]. Household appliances like refrigerator, television, air-conditioner, etc. and office equipment such as telephone answering, computers, and printers etc. contribute to standby loss. To mitigate these losses there are two methods like behavioral and technical. First method involves better consumer awareness, use of energy efficiency standards, energy efficiency labels and second method involves the technical innovations [21].

VI CONCLUSION

In this paper, the extensive use of electricity in the residential sector is discussed. Comparison of the residential sector with other sector like industrial, commercial, traction, agricultural and miscellaneous sectors are presented in the form of trend lines from 1947 to 2013 in fig. 1 and fig. 2. It also presents the background and motivation for doing the detail survey of electricity usage in the residential sector to find the cause for extensive use of electricity and remedy over it. So the detailed survey of 2BHK house is discussed. This paper has also given an opportunity for using renewable source because fossil fuels are running down in the near future; especially solar energy for serving residential load to reduce the electricity bill and also it shows how electricity bill is calculated. Solar panel design is discussed in detail, which can be easily implemented for residential purpose. Also, this paper focuses briefly on standby power in e-appliances and methods to reduce it.

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