Household energy usage pattern in 2200 VA

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Abstract. Household energy usage is important for us to know because we can use the data for energy saving and prototyping solar system installation. We could see what the maximum usage is and reduce it. In this research, power data logger is made to see the total energy usage and will get result discrete graph. The result for household energy usage for 2200 VA will get 9.82kWh/day.

1. Introduction
Household energy usage is important for us to know because we can use the data for energy saving and prototyping solar system installation. Householders can find it difficult to reduce their domestic electricity consumption because electricity use is not only effectively invisible [1], but is also billed in aggregate, at long intervals and retrospectively [2]. Behavior change is becoming an important research in order to reduce energy consumption [3]. We will provide load graph, so householder can see in what hour electricity usage in its peak and can try to save the electricity energy. Household energy consumption is broken down into major demands: cooling, heating, hot-water, supply lighting and electric appliances. Of these, the energy consumption of lighting and electric appliances has shown the biggest increase in recent years [4]. To ensure the efficient and effective use of energy in residences, it is necessary to clarify the factors behind the increase in the energy consumption of lighting and electric appliances and to predict the level of energy consumption in the future [4].

Sugiura use a few years before of electrical appliance usage to know the pattern, what electrical appliance has the most usage of all time and to forecast how much usage in year later [4]. While on Sugiura et al research method used household activity to know the pattern [5]. Another method in Simanaviciene is using the research for changing people perspective and behavior use of electrical usage [3].

This research is challenging because in residential area has so much uncertainty factor [5-12] because of their lifestyle [13]. In this paper we will provide consumer behavior in what hour householder use electric appliances. With this we suggest consumer to reduce electricity consumption in hour which usage in its peak. Also, we will know what electric appliance we used that has the most power consumption. It will be a challenge for electrical industries to reduce power rating in that electric appliance which has the most electricity consumption. This will bring us to the era which energy usage is reducing constantly. Load rating will be provided which is already been served by factory on labels. Rating from electrical appliance specification will be served in section 3. With power data logger we could know every power that has been used for every electric appliance.
2. Method

In this section information provided on how the data retrieved and analyses load graph, which electric appliance show the biggest usage.

To analyze the data, we serve consumer behavior in table 1. As shown in table 1, it has much activity in dawn and afternoon. But we will see in this section the real-time graph and specification graph.

| Table 1. Consumer behavior in hour, ‘1’ is indicating that the electric appliance is being used. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hour | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Washing Machine | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| Samsung LED TV | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| Bulb 37W | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| Mosquito Lamp | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| Bulb 7w 6 pcs | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| Fridge LG Brand (GN-C422SLCN) | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| Miyako Fan (KAD-1227B) 4 pcs | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| Miyako Dispenser | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| Iphone Charger 4 pcs | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| Laptop Charger 2 pcs | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| Rice cooker (Philips HD3132) | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| AC LG | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| Phillips Classic Iron (HD 1172 dry) | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |
| LG TV LCD (22LD340- TA) | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I | I |

2.1. Power data logger

Power data logger or can be further used like advanced metering infrastructure (AMI), will measure power usage and the result will be saved. There are many components in prototyping power data logger such as SDM120-Modbus, Arduino Uno, Real Time Clock (RTC), Arduino RS485 and Ethernet Shield. The use of SDM120-Modbus is for power sensing awhile Ethernet Shield will connect to Internet and saved in google drive.

![Figure 1. Block diagram of power data logger.]
As the goal to compare result of retrieved data from data logger, specification electric appliances that writer use is shown in table 2.

| Number | Electric Appliances                  | Total Current (A/min) | Total Voltage (V/min) | Output | Total Power Wh/day |
|--------|-------------------------------------|-----------------------|-----------------------|--------|--------------------|
| 1      | Washing Machine                     | 220                   | 220                   |        | 1380               |
| 2      | Samsung LED TV"                     | 240                   | 5V~1A                 | 1700   |
| 3      | Bulb 37W                            |                       |                       | 185    |
| 4      | Mosquito Lamp                        |                       |                       | 45     |
| 5      | Bulb 7w 6 pcs                       |                       |                       | 574    |
| 6      | Fridge LG Brand (GN-C422SLCN)       | 1.3                   | 220                   | 19.5V~3.33A | 4440   |
| 7      | Miyako Fan (KAD-1227B) 4 pcs        | 220                   |                       | 3840   |
| 8      | Miyako Dispenser                     |                       |                       | 7560   |
| 9      | I-phone Charger 4 pcs               | 0.15                  | 240                   | 5V~1A  | 40     |
| 10     | Laptop Charger 2 pcs                | 1.7                   | 240                   | 195    |
| 11     | Rice cooker ( Philips HD3132)        | 350                   | 240                   | 4400   |
| 12     | AC LG                               |                       |                       | 11520  |
| 13     | Philips Classic Iron (HD 1172 dry)   |                       |                       | 1050   |
| 14     | LG TV LCD (22LD340-TA)              | 0.8                   | 240                   | 1400   |

Sum of Power per Day 38329

2.2. Newton polynomial interpolation

This method is known in numerical method to get equation from obtained data to forecast future data, in this paper the real time power will be compared with what will be obtained from equation (1).

\[ f(x) = b_0 + b_1(x - x_0) + \cdots + b_m(x - x_0)(x - x_1) \cdots (x - x_m) \]  

(1)

If the real-time data plotted in discrete it can be seen that the graph is having 12 stationary point. So \( f(x) \) will be approached with 12-order polynomial function to get precise equation. To obtain \( f(x) \) \( b_m \) can be got from:

\[ b_m = f[x_m, x_{m-1}, \ldots, x_1, x_0] \]  

(2)

With \( f[x_m, x_{m-1}, \ldots, x_1, x_0] \) that is known as Finite divide-difference:

\[ f[x_m, x_{m-1}, \ldots, x_1, x_0] = \frac{f[x_m, x_{m-1}, \ldots, x_1] - f[x_{m-1}, x_{m-2}, \ldots, x_0]}{x_m - x_0} \]  

(3)

From equation (2) and (3) can be known 12-order polynomial equation:

\[ f(x) = -0.03722 x^{12} + 2.74764 x^{11} - 89.5196 x^{10} + 1693.648 x^9 - 20594.1 x^8 + 168205.6 x^7 - 936337 x^6 + 3527963 x^5 - 32025873.08 x^4 + 3429640 x^3 - 5163694 x^2 + 3303292 x + 14488.7 \]  

(4)
So, it will get result a continue graph as shown in figure 2.

![Figure 2. Continue load graph of real-time graph.](image)

As specification load will be compared with real-time graph, so specification graph will be plotted as well as shown in figure 3.

![Figure 3. Continue graph of specification graph.](image)

3. Result and discussion

Found that real-time graph of load is having difference with graph of specification. In table 3 real-time power is having difference with specification which has been shown in table 2 because of electric appliance such as fridge, fan, AC, Iron, and etc is not stable in power rating. Also, it has more than one mode so the upper the mode will give much power and the lower mode will also get result low power. Electric appliance which has the most total power difference is Air Conditioner and dispenser which has tenfold and fourteen power difference. Air Conditioner has range 600W to 697W when sensed by power data logger, which is different from specification that is 960W, while dispenser has range 308W to 320 W and it is also different from specification, that is, 420W all over the hour. In specification electric appliance it shows the maximum power rating which why retrieved real-time data as shown in table 3 is so different with specification. We see in table 3, total power in every electric appliance relatively different with specification which is shown table 2. The real time data we took by power data logger is in minutes, as shown in table 3.
Table 3. Electric appliances power based on real-time data.

| Number | Electric Appliances                  | Total Voltage (V/min) | Total Current (A/min) | Total Power Wh / day |
|--------|--------------------------------------|-----------------------|-----------------------|----------------------|
| 1      | Washing Machine                      | 297.583,40            | 37.69                 | 184.728              |
| 2      | Samsung LED TV"                      | 299.356,32            | 239.13                | 768.979              |
| 3      | Bulb 37W                             | 65.190,44             | 150.65                | 456.171              |
| 4      | Mosquito Lamp                         | 302.569,40            | 17.54                 | 67.8883              |
| 5      | Bulb 7w 6 pcs                        | 235.297,40            | 123.48                | 403.207              |
| 6      | Fridge LG Brand (GN-C422SLCN)        | 262.974,25            | 745.03                | 1622.63              |
| 7      | Miyako Fan (KAD-1227B) 4 pcs         | 318.063,48            | 581.48                | 2145.57              |
| 8      | Dispenser                             | 292.392,50            | 129.96                | 592.55               |
| 9      | I-phone Charger 2 pcs                | 49.336,60             | 7.62                  | 20.891               |
| 10     | Laptop Charger 2 pcs                 | 30.274,24             | 31.72                 | 101.868              |
| 11     | Rice cooker (Philips HD3132)         | 298.489,74            | 311.93                | 675.933              |
| 12     | AC LG                                 | 300.528,01            | 584.71                | 1929.39              |
| 13     | Philips Classic Iron (HD 1172 dry)    | 43.680,75             | 54.35                 | 195.633              |
| 14     | LG TV LCD (22LD340-TA)               | 289.912,96            | 190.91                | 650.733              |

Sum of Power per Day 9816.17

From table 3 can be known that power usage daily for 2200 VA household is 9816.17 Wh or 9.82 kWh. Power usage peak is also different. In figure 2, usage peak is around 11.00 a.m. which is not relevant, because people tend to do chores, and do indoor activity around 06.00 p.m. While figure 3 shows that power usage peak is around 06.00 p.m. and it is relevant with common usage behavior. Maximum usage is in minute 1081 (at 18.01 hour) almost 1.6 kW while in hour (at 19 o’clock) almost 60kW.

So, with data from table 3 we can design photovoltaic system that suffice the power requirement as already calculated, that is 9.82 kWh / day. If we want to reduce the energy usage (to do energy saving) we have options to use, that is, change the consumer behavior of using electrical appliance regarding the primary need to do chores or living especially around 06.00-07.00 p.m. Another option is we can indulge and ask for government to support electrical industries to reduce wattage electrical appliance and upgrade the efficiency.

4. Conclusion

From this research can be concluded that real-time graph of power is different from specification because power usage is not at maximum every time. Daily load of 2200 VA is 9.82 kWh per day. Usage peak is around 06.00 p.m. The most power-consumed is Air Conditioner with 1929.39 Watts/hour. To do energy saving householder whose having 2200 VA type of house can start to evaluate at what hour electric appliance shouldn’t be use like AC can be turned off when the time is already over 05.00 p.m. Also, government which work on industries sector can influence industry to upgrade the efficiency of electric appliance.

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