

Development of electrical energy saving assistant

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Abstract— *The main objective of the device introduced in this paper is to help reducing the peaks of daily demand curve of national power grid, with the introduction of an automatic power disconnection function. The device simultaneously provides electrical consumers with a graphical indication of electrical energy usage of single phase electronic installation and several other useful parameters.*

The device mainly consists of an energy metering unit, a processing unit, a real time clock calendar and a user interface. There is an auxiliary line to supply power to the non – critical electrical appliances such as Refrigerators, AC machines, etc... and a 433MHz Radio Frequency range Amplitude Modulation Receiver unit to receive information on peak hours of the Daily Demand Curve which will be sent to the processing unit of the system for the function of turning off the auxiliary power line. The device can be fixed to any single phase electrical installation of 230V and 40A (max).

In the consumers view point, this device not only shows information about daily consumption as a graph but also helps the consumer to plan his next month energy consumption.

In order to illustrate the effectiveness of this device, a detailed analysis was conducted to show how the device reacts to the behaviour of the demand curve. Secondary data about various sources of power generation and consumption were used to analyse the total impact on demand curve and finally the energy saving and financial benefits were estimated.

Keywords— **Electrical energy saving, Power demand curve, Energy consumption plan**

I. INTRODUCTION

Today, the entire planet is reaching towards a serious energy crisis due the inadequacy of energy sources, especially the electric energy. It is nowadays a big problem in Sri Lanka too with the increase of industrial and domestic power demand.

We can contribute to reduce the energy consumption by changing our energy usage patterns. In order to do so, as a first step, it is essential to have a good sense of daily energy usage. But there is no such method to know

the daily energy usage in individual appliances and the monthly electric bill is the only reference.

From the side of electricity suppliers and distributors, they are hardly trying to manage the total power demand in the national grid. If they have the control of each individual electric consumer, it will be highly useful in managing rapid variations of power demand. Currently, Sri Lanka uses time of use based tariff based metering and billing schemes for the industrial and commercial sector enabling their consumers to adjust their electric usage during peak and off-peak times.

II. BACKGROUND

For Sri Lanka, with regard to the domestic electric consumption, the price paid to an energy unit is fixed. In other words, it does not vary with the time of the day. But due to dynamic power demand, the production cost of an electric energy unit varies with the time of the day. In peak hours, the production cost of energy can be much higher than that of off-peak hours. Further, for peak hours, only hydro power is insufficient to meet the demand. Then the expensive fuel has to be used to generate extra energy. In this situation, a self motivated demand side management scheme will be highly beneficial for both consumers and electricity suppliers.

III. OBJECTIVES

DSM involves actions that influence the quantity or patterns of use of energy consumed by consumers, such as actions targeting reduction of peak demand during periods when energy-supply systems are constrained.

This paper mainly focuss on developing a unit which helps the user to achieve DSM in following ways,

- A. A demand-side response system can reduce the peaks of daily demand curve automatically without consumer intervention to an acceptable level.
- B. Energy savings from direct feedback - displaying information of daily energy consumption as shown in Figure 1. Though vital to modern life, electricity is invisible and intangible. Most people aren't even sure how they use it, aside from turning on a light switch. Say "kilowatt" and eyes glaze over instantly.



Fig 1. Energy saving from direct feedback

If home energy management is to be successful, electricity needs to be made obvious, tangible, and meaningful. A widely-cited study by Oxford University Environmental Change Institute's Sarah Darby shows that simply displaying information (providing direct feedback to the consumer) only reduces power consumption by five to 15 percent. (Darby S. 2006) Hence to obtain the results from Energy savings from direct feedback I developed user friendly interface to fix on wall of living room. Then the family members can effortlessly see the Daily Electrical Energy Consumption graph and other meaningful data which motivates them to manage their energy consumption.

IV. METHODOLOGY

This section conveys design and development process of a configurable, energy usage display unit with intelligent switching system.

A. Proposed On-premises energy management system will wirelessly connect with central control station of the national grid to control local loads during peak events and manage the loads at other times as necessary. As shown in figure 2, total power demand is measured and if it is above the average the control station sends instructions to each household energy management system. It can be done individually

or group wise since all units has unique network address.

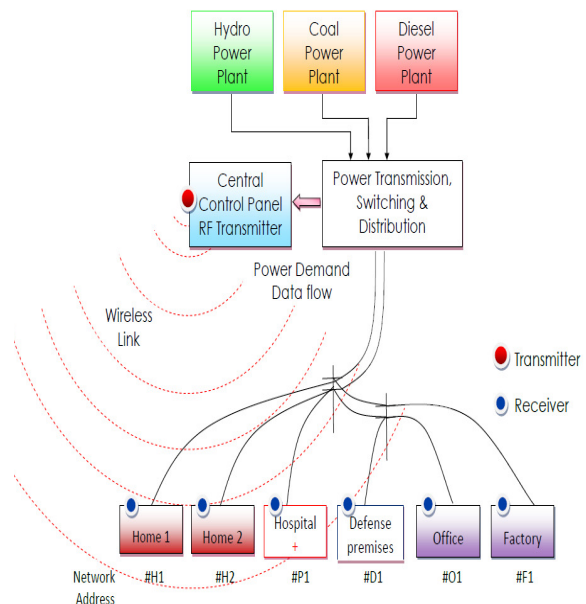


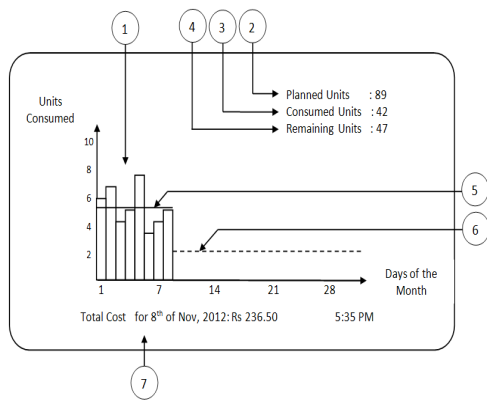
Fig 2. Wireless Network of energy management units

The aim is to shift end user loads towards periods where energy demand is low. As a result, this will flatten the load profile and avoid load peaks which are expensive in terms of generation.

B. To obtain these results this device has wireless receiver with automatic power disconnection function to auxiliary line, power supplying to the non – critical electrical appliances such as Refrigerators, AC machines or any equipment which can be switched off at peak demand period as the wish of user. In the peak time the electrical Service Provider (SP) sends an RF signal to this device from the central control station. Then it disconnects the auxiliary power line. As the power demand falls, the service provider sends another RF Signal to connect the auxiliary line with the power.

This system consists of Modulation Receiver unit of the range of 433MHz Radio Frequency to receive information from SP. Also it has indicator lamp and audible buzzer to generate periodical beep to aware the consumer about the indication of peak hours.

To obtain the results of energy savings from direct feedback a comprehensive user interface was developed in this unit. With the help of it consumer not only can see meaningful data but also he can plan the next month energy consumption. As shown in the figure 3, 128x64 resolution Graphical Liquid Crystal Display (LCD) module was used as display.



Main page of the screen according to the Figure 3,

- Daily Electrical Energy Consumption as bar-graph is shown by arrow head (1).
- Planned units for monthly consumption are shown by arrow head (2). The consumer can plan his energy usage of the month. This parameter can be changed in the page, Planned Consumer limit of the month
- Total energy consumption for previous dates of month is shown by arrow head (3). According to this graph energy consumption is shown for 8 days.
- Remaining units = Planned units - Consumed Units, is shown by arrow head (4).
- Actual Average Energy Consumption level is shown as a horizontal line on the graph. This is shown by arrow head (5). According to the graph, average energy consumption is shown for 8 days
- Remainning Average Energy Consumption level is to indicate the usage limit for remaining dates of the month. This is shown by arrow head (6).
- Up to date value of total cost in rupees is shown by arrow head (7).

To plan the next month energy consumer has to enter the value in energy units (kWh) that he wishes to consume. Then in the main screen it will show the remaining units and the difference of planed value and actual energy consumption. Except these information on main screen, user can navigate through the pages with the help of keypad and see

- Instantaneous power in W
- Date and time
- Load switching setting at peak time
- Manual override setting of peak time indication.

V. DESIGN

The design was carried out for the actual model which can be connected into any single phase electrical installation that is compatible with following Design Parameters

Line voltage: 230V

I MAX: 40A

The main circuit can be represented as a collection of several functional units as shown in the figure 4.

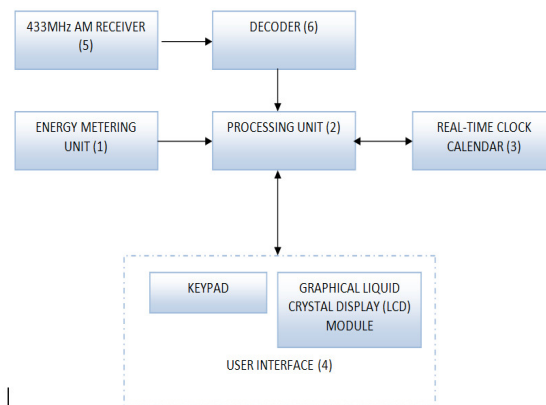


Fig 4. Block Diagram of the System

A. Energy Metering Unit (1)

This is the most crucial section of the system, because all the system processes and calculations depend on the accuracy of measurements acquired by this section. AD7755 energy measurement IC manufactured by Analog Devices Inc was selected for this purpose. It surpasses the accuracy requirements as quoted in the IEC 1036 standard.

B. Processing Unit (2)

This unit serves as the 'Brain' of the system, performing all required tasks and interacting with other units. It gets energy information from ENERGY METERING UNIT (1) and processes data according to the time period information supplied by REAL-TIME CLOCK CALENDAR (3). After that it saves processed data in its internal E2PROM and displays on LCD panel, meanwhile it responds to the keypad.

Actually this unit is a Microcontroller which has sufficient resources to perform all the tasks described above. PIC 18F452 Microcontroller was selected for this function.

It has following features:

- Maximum operating frequency: 40MHz
- Program Memory: 32Kb
- Data Memory: 1.5Kb
- Data E2PROM: 256 b
- Interrupt Sources: 18
- Internal Timers: 4
- CCPWM Modules: 2
- Serial communication: MSSP, USART
- 10 Bit A2D: 8 Channels

C. Real-Time Clock Calendar (2)

This is a semiconductor chip and keeps the time and sends time information into the Microcontroller when required to do so. It provides seconds, minutes, hours, dates, and months and year information in BCD format. It also has a built in power sense circuit that detects power failures and automatically switches to the battery backup supply.

D. User Interface (4)

This unit consists of two sections.

1. A Graphical Liquid Crystal Display (LCD) module which shows all the system parameters.
2. A keypad which helps to navigate between the pages of the LCD screen and change the system settings. It has 7 push buttons, UP, DOWN, PREVIOUS, NEXT, OK, MENU and ESCAPE.

V. CONCLUSION

Hydropower is not sufficient to match the power demand in the peak hours. The diesel and coal power generation is a must. Using this system not only we can reduce usage of expensive fuels like diesel and coal but also we can decrease environmental pollution reducing carbon emission.

The main factor which is governing the project is Economic feasibility. This system can be affordable to consumers at economical rates. Cost of the project to about 5000 LKR, which is fairly economical, compared to the long-term savings achieved by this system.

It will be much beneficial for the country if this system is used as nationally, but initially as a regional experimental project rather than directly installed by individual consumers.

VI. DISCUSSION

In this project I attempted to reduce the energy wastage through DSM through two ways. Initially power management is done by automatic peak demand reducing system. Although I used radio communication for data transmission of peak time it can be done through many ways. GSM, Internet Protocols and power line communication are feasible technologies. Each one of them has merits and drawbacks, the most suitable one can be adopted

as required for our country after close comparison. By using Bi directional communication as GSM technology or internet and modern communication systems instead of uni directional communication topology we can enhance the system capabilities such as,

- a. Semi automated Billing process can be adopted. This will allow the Electrical Utility Company to eliminate the need to employ meter readers to visit every electricity consumer in order to record the meter reading.
- b. Prepaid paying system can be adopted.
- c. This will also facilitate the introduction of the time of the day tariff scheme.
- d. Remote line disconnection and reconnection facility
- e. Energy related data acquisition

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BIOGRAPHY OF THE AUTHOR



Author is a student of the University of the Vocational Technology, Ratmalana, Sri Lanka. His research interests include embedded control systems and Electrical Power saving.