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Implementation of Microgrid for Optimal Power and Tariff Management in Institutions

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Abstract—*Recently intensive efforts have been made on the transformation of the world's largest physical system, the power grid, into a "smart grid" by incorporating extensive information and communication infrastructure. Key features in such a "smart grid" include high penetration of renewable and distributed energy sources, large-scale energy storage, market-based online electricity pricing and widespread demand response programs. The expected electricity cost with real-time electricity pricing, which is the focus of this paper. By jointly considering energy storage, local distributed generation such as Photo Voltaic (PV) modules or small wind turbines, and inelastic or elastic energy demands, we mathematically formulate this problem as a stochastic optimization problem and approximately solve it by using the Lyapunov optimization approach. From the theoretical analysis, we have also found a good tradeoff between cost saving. We have also evaluated our proposed solution with practical data sets and validated its effectiveness. Here the proposed system,monitoring the power usage at peak time and also off-peak time. It helps for reduce the total energy consumption cost and only pay for Time of Use(TOU). The tariff of the supply can checked at any instant time. The smart meter measurement is energy consumption monitoring unit (ECM). ECM unit is connected with Local Area Network (LAN) or Zig-bee to share the power consumption information. By connecting the ECM unit, all users automatically interact and overall performance is improved and peak demand is reduced by appliances. To minimize the expected electricity cost with real time electricity pricing.*

Keywords- Optimal Power Management, Smart Grid, Lyapunov Optimization, Renewable Energy Generation, Real-Time Pricing, Energy controlling Measurement Unit.

I. INTRODUCTION

The electricity sector in India had an installed capacity of 249.488 GW as of end June 2014. Captive power plants have an additional 39.375 GW capacity. India's network technical losses are 23.65% in 2013, compared to world average of less than 15%. The Government has pegged the national T&D losses at around 24% for the year 2011 & has set a target of reducing them to 17.1% by 2017 & to 14.1% by 2022. A high proportion of non-technical losses are caused by illegal tapping of lines, and faulty electric meters that underestimate actual consumption also contribute to reduce payment collection.

The term "micro grid" reflects a new way of thinking about designing and building smart grids. The micro grid approach focuses on creating a design and plan for local energy delivery that meets the exact needs of the constituents being served, whether a city, University, neighborhood, business park, or major mixed use development. At the local level, smart micro grid isthe economic and environmental benefits to consumers of the smart grid transformation are maximized, and are a significant multiple of the implementation costs.

The normal load requirement of our institution is shows in table.1, normally the a total electric load capacity in institution is 232 KW. Tamil Nadu solar purchase obligation install the solar power plant in the range of 20KW (off-grid system).Now it is generating 85 Units/day, monthly average is around2500 Units. In this system no battery storage unit it gets loss. To avoid this problem real time load monitoring system is to be used. It will monitor the present load demand of the individual block and distribute the solar power if load is within the generating capacity.

Table.1 LOAD REQUIREMENT OF INSTITUTION

S.NO	BLOCK	LOAD(KW)
01 02.	MAIN BLOCK ECE,EEE,LIBRARY,MECH, CIVIL,BOYS HOSTEL,ALL LAB	111.5 KW 111.5KW
03. 04.	WELDING WORK PRINCIPAL QUARTORS	9.5 KW 9.68 KW

Efficient utilization of the energy in the institution, the smart sensor network is implemented in the campus. It is used to monitor the type of energy consumption by the device and also tariff, and its switch-off the heavy loads like (AC/ Pumps and etc..,) based on the tariff rate. It is also used to reduce the power consumption and energy wastages.

II. METHADOLOGY

In proposed model, having wireless communication with GSM technology for controlling the electric power supply has effectively.

2.1 WIRELESS COMMUNICATION

Zig-Bee is a wireless communications technology that isrelatively low in power usage, data rate, complexity and cost of deployment. It is an ideal technology for smart lightning, energy monitoring, home automation, and automatic meter reading, etc. Zig-Bee and Zig-Bee Smart Energy Profile (SEP) have been realized as the most suitable communication standards for smart grid residential network domain by the U.S National Institute for Standards and Technology (NIST). The communication between smart meters, as well as among intelligent home appliances and in home displays, is very important.

Zig-Bee has 16 channels in the 2.4 GHz band, each with 5 MHz of bandwidth. 0 dBm (1 mW) is the maximum output power of the radios with a transmissionrange between 1 and 100 m with a 250 Kb/s data rate and OQPSK modulation. From the table-2, Zig-Bee is considered as a good option for metering and energy management and ideal for smart grid implementations along with its simplicity, mobility, robustness, low bandwidth requirements, low cost of deployment, its operation within an unlicensed spectrum, easy network implementation, being a standardized protocol based on the IEEE 802.15.4 standard.

Table.2 WIRELESS COMMUNICATION TECHNOLOGIES

Technology	Spectrum	Data Rate	Coverage Range
GSM	900 - 1800 MHz	Up to 14.4 Kpbs	1-10 km
GPRS	900 - 1800 MHz	Up to 170 kbps	1-10 km
3G	1.92-1.98 GHz 2.11-2.17 GHz (licensed)	384 Kbps-2 Mbps	1-10 km
WiMAX	2.5 GHz, 3.5 GHz, 5.8 GHz	Up to 75 Mbps	10-50 km (LOS) 1-5 km (NLOS)
PLC	1-30 MHz	2-3 Mbps	1-3 km
ZigBee	2.4 GHz- 868 - 915 MHz	250 Kbps	30-50 m

Zig-Bee SEP also has some advantages for gas, water and electricity utilities, such as load control and reduction, demand response, real-time pricing programs, real-time system monitoring and advanced metering support. The zig-bee communication with the proposed system architecture has shown in figure.1.

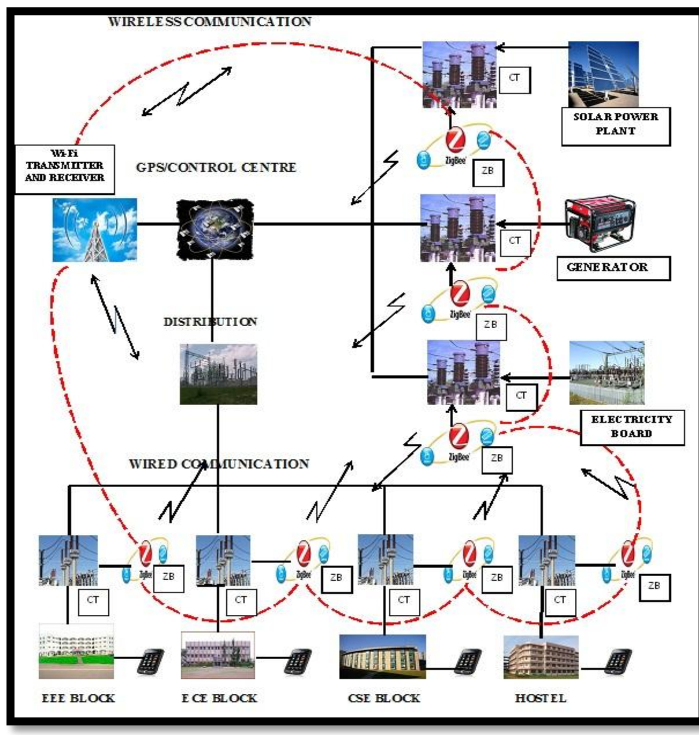

Fig 1. Wireless Communication

ARCHITECTURE FOR PROPOSED SYSTEM

Smart Metersystem, every smart device is equipped with a radio module and each of them routes the metering data through nearby meters. Each meter acts as a signal repeater until the collected data reaches the electric network access

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point. Then, collected data is transferred to the utility via a communication network.

2.2 GLOBAL SYSTEM MONITORING TECHNOLOGY

Global System for Mobile communication is the most popular standard for mobile phones in the world. Its promoter, the GSM Association, estimates that 82% of the global mobile market uses the standard GSM is used by over 2 billion people across more than 212 countries and territories, the architecture is in figure.2. Its ubiquity makes international roaming very common between mobile phone operators, enabling subscribers to use their phones in many parts of the world. GSM differs from its predecessors in that both signaling and speech channels are digital call quality, and thus is considered a second generation (2G) mobile phone system. This has also meant that data communication was built into the system using the 3rd Generation Partnership Project (3GPP).

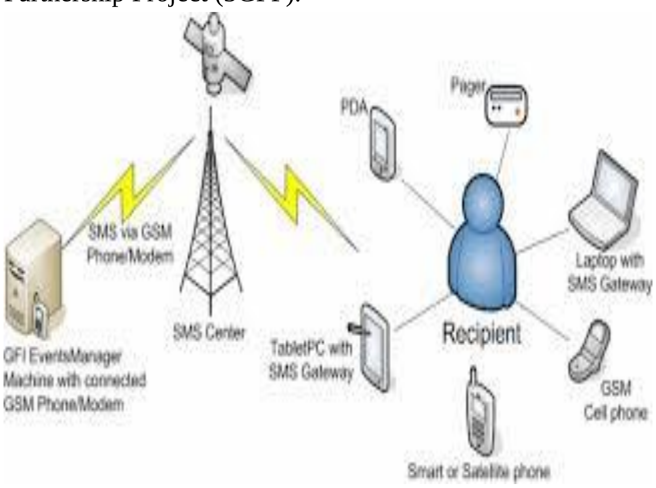

Fig.2 Global System Monitoring technology

The ubiquity of the GSM standard has been advantageous to both consumers (who benefit from the ability to roam and switch carriers without switching phones) and also to network operators (who can choose equipment from any of the many vendors implementing GSM. GSM also pioneered a low-cost alternative to voice calls, the Short message service (SMS, also called "text messaging"), which is now supported on other mobile standards as well.

Newer versions of the standard were backward-compatible with the original GSM phones. For example, Release '97 of the standard added packet data capabilities, by means of General Packet Radio Service (GPRS). Release '99 introduced higher speed data transmission using Enhanced Data Rates for GSM Evolution (EDGE).GSM (Global System for Mobile communication) is a digital mobile telephone system that is widely used in Europe and other parts of the world. GSM uses a variation of Time Division Multiple Access (TDMA) and is the most widely used of the three digital wireless telephone technologies (TDMA, GSM, and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1,800 MHz frequency band.

GSM is the de facto wireless telephone standard in Europe. GSM has over one billion users worldwide and is available in 190 countries. Since many GSM network operators have roaming agreements with foreign operators, users can often continue to use their mobile phones when they travel to other countries.GSM technology can be integrated with a wide range of applications; it describes the hardware interface of the SIMCOM SIM300 module that connects to the specific application and the air interface.The SIM interface supports the functionality of the GSM Phase 1 specification and also supports the functionality of the new GSM Phase 2+ specification for FAST 64 kbps SIM (intended for use with a SIM application Tool-kit).Both 1.8V and 3.0V SIM Cards are supported. The SIM interface is powered from an internal regulator in the module having nominal voltage 2.8V. All pins reset as outputs driving low.

2.2.1 GSM AT COMMANDS

1. A command string should start with "AT" or "at", except for the commands "A/" and "+++". At or aT are invalid.
2. Several commands can be given in one command string.
3. The commands can be given in upper or lower case.
4. A command string should contain less than 40 characters.
5. When an error is made during the typing of the command, it can be corrected using the backspace key.
6. Commands and command strings must be terminated with an <ENTER>, except +++ and A/
7. A telephone number can exist of following characters: 1 2 3 4 5 6 7 8 9 * =, ; # + > . All other characters are ignored (space, underscore). They help formatting the dial string.
8. Commands that use a numerical parameter can be used without a numerical value. In this case the command will be issued with the value zero.

9. If the command string contains two consecutive commands without parameter, as discussed above, the modem will respond with an error.
10. After the command ATZ has been issued, a pause of two seconds should be respected before entering the next commands.

LOGIC CONTROLLERS

The ATMEGA-8 logic controller is High-performance, Low-power AVR 8-bit Microcontroller. The AVR core combines a rich instruction set with 32 general purpose working registers. All the32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

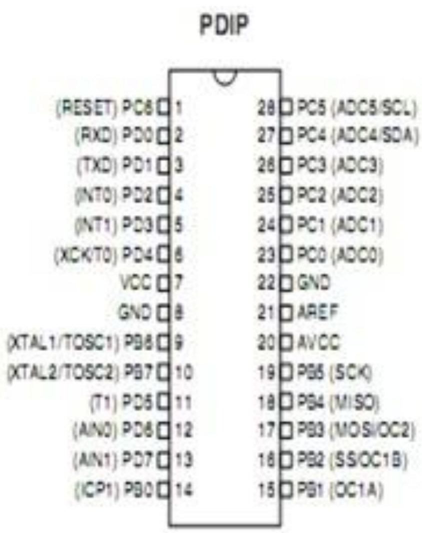

Fig.3 Micro Controller Chip for ATMEGA-8

The figure.3 ATmega8 provides the following features: 8K bytes of In-System Programmable Flash with Read-While-Write capabilities, 512 bytes of EEPROM, 1K byte of SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte oriented Two-wire Serial Interface, a 6-channel ADC (eight channels in TQFP and QFN/MLF packages) with10-bit accuracy, a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next Interrupt or Hardware Reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping.

The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption. The device is manufactured using Atmel’s high density non-volatile memory technology. The Flash Program memory can be reprogrammed In-System through an SPI serial interface, by a conventional non-volatile memory programmer, or by an On-chip boot program running on the AVR core for proposed system. The proposed system is shown in figure 4.

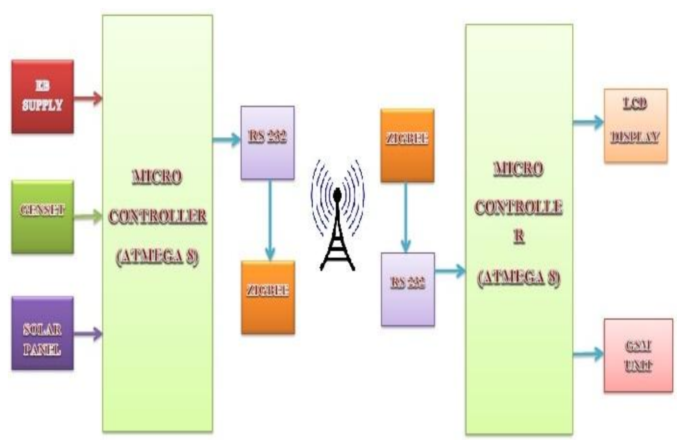

Fig.4 Proposed Block Biagram

The boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash Section will continue to run while the Application Flash Section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the AtmelATmega8 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications. The ATmega8 AVR is supported with a full suite of program and system development tools, including C compilers, macro assemblers, program debugger/simulators, In-Circuit Emulators, and evaluation kits.

III. CONTROL OBJECTIVE

As electricity markets are liberalized, consumers become exposed to higher electricity prices and may decide to modify their demand to reduce their electricity cost. Real Time Pricing (RTP) and Time of Use pricing (TOU) function as load management tools. The magnitude of variation of price (for e.g. weekly or seasonal) would require setting up a model to consumer behaviour. The model relies on the concept of demand elasticity across time, degree of consumer economic rationality and on the supply side, on the price formulation model.

Under this tariff structure, two components are considered:

1. Base rate based on Cost of Service (COS).
2. Time-of-use charges based on Cost of Unserved Energy (CUE).

The price will be the actual marginal cost of production,appropriate corrected for transmission and distribution losses. When the production cost is high and less efficient plan has to be run, the selling price will be high.

At times of low load, when high efficiency base load generators carry the bulk of load, the selling price will be low. Sufficient price incentives will be given to move away load from high load to less expensive low-load period. Investments in installed capacity will be curtailed. The average fuel cost will be reduced. Both these savings will be reflected in a further reduction in consumer electricity bills.

Our objective is to minimize the long-term time-average expected electricity cost. Electricity price in the real-time electricity market has both, time-diversityand location-diversity.Smart tariff with the existing tariff structures:

$$P = a - b*Qd \qquad (1)$$

Where, a & b are the parameters which depends on thevarying quantity. Here, P is the price in Rs. /unit,Qd is the demand in MW. Alternatively, it can be expressed as,

$$\ln P = c - d*\ln Qd \qquad (2)$$

Now let us consider a general case. A linear demand function is represented as,

$$Qd = a-b*P$$

And linear supply as,

$$Qs = -c + d*P$$

At equilibrium, Qd=Qs

Practically, there can be a lag in supply because a firm cannot respond immediately to changes in demand.Current Transformer place an important role in this project, to measure the load current of the various generation Units(solar, Diesel Generator and TNEB).This analog signal is modulated and it is transmitted through Zigbee transmitter to the control centre. A receiver receives and demodulates the signal. ARM – 7 processor receives that signal and functions based on the programming. Output of the processor signal is given to the GPS system and the information is sent to the operators. The proposed system circuit diagram is shows in figure.5.

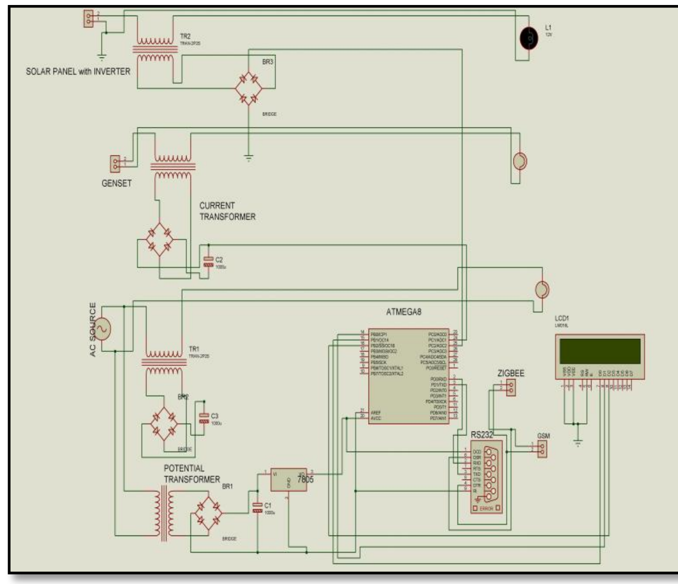

Fig.5 Proposed Circuit Diagram

Display devices are used to indicate the present power level and tariff. Also indicate the total energy demand and available solar energy power. By means of this, demand is within the level renewable energy power is used to avoid greenhouse gases.Real time and economic way of wireless communication, are used Zig-bee devices are used to transfer and receive the data. It is preferable for short range of transmitting the data within 100 feet's.GPS devices used to send the information to the operator to schedule the proper power supply to the loads.Display devices are used to indicate the present power level and tariff. Also indicate the total energy demand and available solar energy power.This will give better tariff control and avoid power outage in the Institution. In future this project is implemented in commercial, industrial and domestic areas to reduce the power outage and to reduce tariff.Several simulation characteristics can be observed and compared with exciting results.

To avoid the energy outage and reduce the tariff of the consumer, this project is developed with low cost and user friendly. This project is implemented any were without disturbing the present system, so the implementation is user friendly. GPS devices are used to give the present load and

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the tariff. This helps the user to choose the energy based on the tariff so the energy uses is reduced.

IV. SIMULATION RESULTS

The proposed system was simulated using Simulink of proteus embedded software. Different tests were carried out, considering the power generating periods.

4.1 GSM MESSAGE DISPLAY

The GSM system simulation of figure.6 shows can helps for monitoring and display theelectrical energy requirement of peak-time and off-peak time through the mobile phones. This is an effective technology to reducing the power demand during peak time.

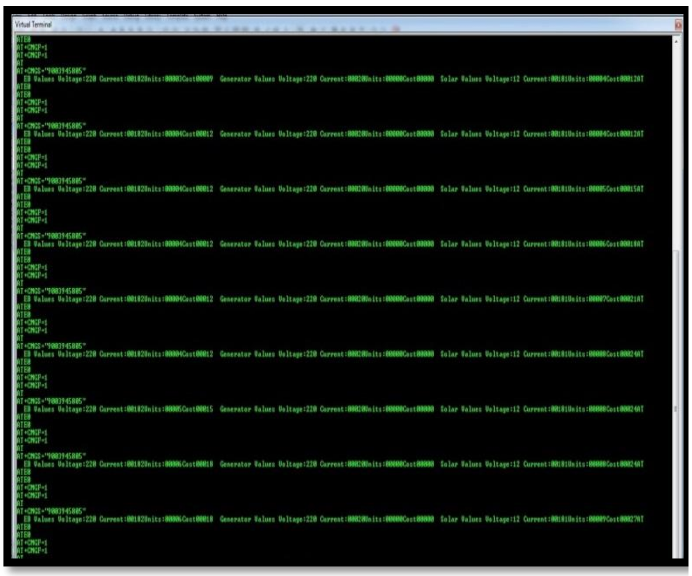

Fig.6 Proposed Display of Gsm Message

4.2 POWER GENERATING RESULTS

The generating of electrical energy output parameters is showed by the below simulation results.

4.2.1EB SUPPLY;

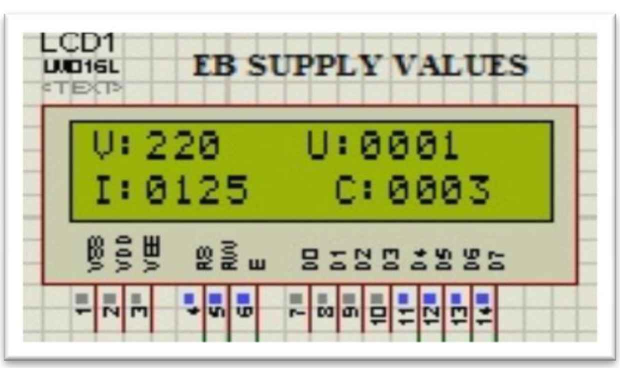

Fig.7 Generating Output Of EB Supply

VOLTAGE = 220V,UNIT = 01
CURRENT = 125mA, COST = Rs.3.00

4.2.2GENERATOR SUPPLY;

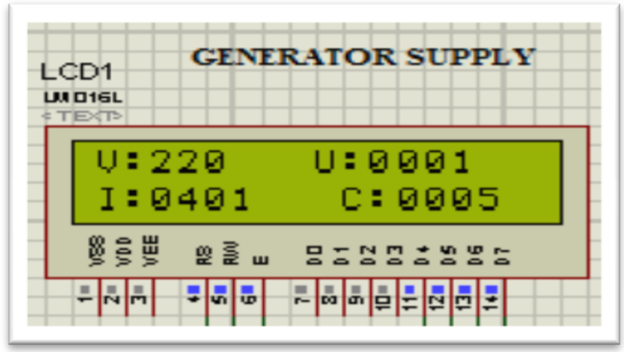

Fig.8 Generator Supply Output

VOLTAGE = 220V, UNIT=01
CURRENT = 401mA, COST=Rs.5.00

4.3.3 SOLAR POWER PLANT;

Fig.9 Output of Solar Supply

VOLTAGE = 12V, UNIT =01
CURRENT = 182 mA, COST =Rs.9.00

V. CONCLUSION

The output results are comparing with the exciting result. Fine tuning is made to get the exact result. To avoid the energy outage and reduce the tariff of the consumer, this project is developed with low cost and user friendly. This project is implemented any were without disturbing the present system, so the implementation is user friendly. GPS devices are used to give the present load and the tariff. This helps the user to choose the energy based on the tariff so the energy uses is reduced.

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