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Automatic Load Scheduling According to Demand & Price

Monika[1]
M tech student, Department of Electrical Engineering, DIET College, Karnal, Haryana, India

Mrs. Tanushree Kaul[2]
Assistant Prof., Department of Electrical Engineering, DIET College, Karnal, Haryana, India

Abstract: High peak demands are common occurrences in electricity market. Recently, reducing electricity demand has been one of the most common objectives for all electricity suppliers, environmental organizations and others at the national and international level. Peak demands make it difficult to meet the increased demand of electricity, to lower prices, to increase quality and to avoid negative impacts on the environment. A scheme that allows consumers to moderate own demand will reduce the electricity peak demands. This project describes and delineates the scheme of averting peak demands. The main premise up on which this study is designed is to enable electricity users to effectively manage and control own demand based on information. Adequately managing and controlling energy demands shall lead to enhanced system performance. The scheme is contributing towards achieving a Smart Grid environment.

Keywords: Smart grid, Advanced metering infrastructure, Demand side management, Demand response

I. Introduction

When millions of electricity consumers turn on/off various electric appliances it causes a change in the demand for energy. In an electric grid, the energy consumption and production must balance at all times; any significant imbalance could cause grid instability or severe voltage fluctuations, leading to blackouts in the system. Therefore, sufficient resources are needed to meet the load in the system at any point in time; balance between load and generation can be achieved either by increasing the generation or by decreasing demand. The energy production concept was primarily based on demand basis: if there is a demand for more power, utility company would simply increase its generating capacities to meet the essential demand. Power has been vital part of our life, so this has added pressure on the utility company to look out for every possible means of energy production. Given that the project design is one part of the entire smart grid, it would be beneficial for this project to provide some information about the smart grid. The Smart Grid is a bi-directional electric and communication network that improves the reliability, security, and efficiency of the electric system for small to large-scale generation, transmission, distribution, and also storage. The real-time two-way communications available in a Smart Grid will allow customers to be compensated for their efforts to save energy and to sell energy back into the grid through Advanced Metering technologies. After spreading distributed generation concepts such as residential solar panels and small wind turbines, the Smart Grid will improve the efficiency of energy industry by providing green energy recourses and reducing peak loads. It will allow small domestic customers and businesses to sell power to their neighbors or even back into the distribution grid. The same concept can be applied to larger commercial organizations that have renewable power systems that can give the excess power back into the grid during peak demand hours.

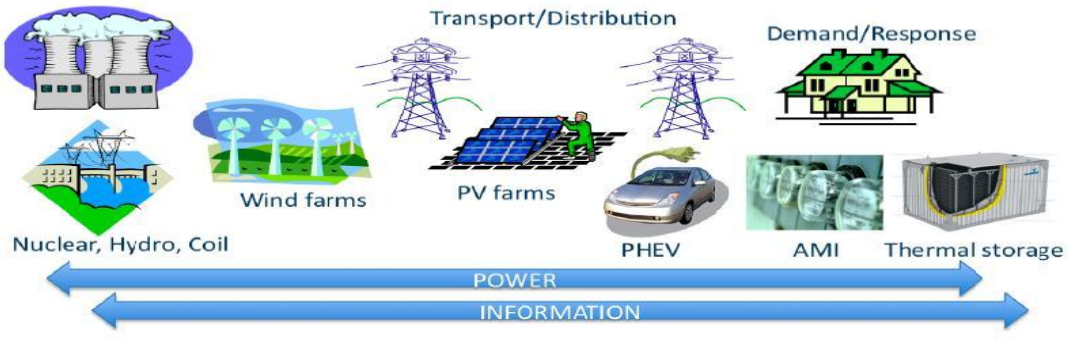


Figure1: Flow of power & information in smart grid

Over the past 50 years, social and economic developments have resulted in the increase in several requirements and challenges to the electricity network. These include the needs for more reliable electric power services, the integration of digitally controlled devices and renewable energy as well as the needs for mitigating the increased cyber security threats.

As most of the implementations in the power industry today are still based on the traditional technology available 120 years ago, the power grid is inevitably facing the modern challenges with a traditional system. In response to the worldwide challenges in the power industry, smart grid is increasingly recognized as a perfect way to improve the energy efficiency of producing and using electricity in homes, businesses, and public institutions. Many believe that a smart grid is a critical foundation for reducing greenhouse gas emissions and transitioning to a low-carbon economy. Smart grid is also considered as a platform that allows an easier integration and higher penetration of renewable energy. The smart grid is a broad collection of technologies that delivers an electricity network that is flexible, accessible, reliable and economic. Smart grid facilitates the desired actions of its users and these may include distributed generation, the deployment of demand management and energy storage systems or the optimal expansion and management of grid assets. . From the Information Technology point of view, the Smart Grid technology will significantly increase the amount, quality, and use of data received from various sensors and meters.

This will solve two of today's main problems in the grids: environmental concerns and power disturbances. Introduction of Smart Grid will increase both security and efficiency of the supply. New software, implemented in various microcontrollers will help to avoid grid congestions and enable distributed generation, making accent on the use of renewable energy resources. Imagine a network, in which a customer can manage his consumption and take advantage of pricing schemes, while being able to choose the type of electricity supply (i.e. 100% renewable energy, conventional energy, mixed mode).

II. Problem Statement

Reaching high electricity demands for a few hours a day is one of the most significant problems at the national and international level. The current increase in demand peaks in INDIA is unprecedented particularly at the level of the residential sector. The reason for electricity demand peaks includes the simultaneous high consumption of electricity. Not only does the wasted energy resulting from the unconscious consumption like over cooling or over heating or in lighting contribute to the electricity demand peaks, but the rapidly increase in miscellaneous Information Technology (IT) and entertainment equipments has also contributed to the increase in the simultaneous electricity consumption Other reasons contributing to increase in demand peaks include the lack of residential consumers' awareness of the dramatic increases occurring due to simultaneous high consumption. This estimated ratio is expected to considerably increase in the coming years due to the growing of the population and other factors such as increase in Heating, Ventilation and Air Conditioning (HVAC) system usage due to increase in population and residential households. The number of the occupied residential households is expected to increasing every year. Technical and economic difficulties are presented mainly in congestions at peak demands associated with compromises in quality and high-priced energy. The relationship between electricity users and suppliers in the electricity market has been usually based on that whenever and whatever loads are required by users, they are expected to be met by suppliers at the expected time with the maximal quality. The above electricity consumption increase in the residential sector and other sectors is leading to the overcrowding electricity demands. However, to meet the current continuous growing electricity demands, there should be a constantly growing electricity supply; this would lead to assist the existing network with more electricity generators and improve transmission and distribution infrastructure. More noticeable negative impacts could occur including increase in energy generating cost, increased electricity prices, compromised quality e.g. voltage fluctuations, technical and economic deficiencies and even undesirable environmental impacts e.g. greenhouse gas emissions. Technical and economic difficulties are presented mainly in congestions at peak demands associated with compromises in quality and high-priced energy.

III. Proposed Work

With the problematic issue of the increased electricity demand and excessive peak demands, there is a need to design a system that enables electricity consumers to decrease and defer their usage as required according to time. The users are receiving information in advanced metering infrastructure which would help effectively manage own electricity demand. The system enables users to rationally decide the quantity of energy usage based on information publicly received on the AMI. With such effective engagement, the users could contribute and control electricity demand paving the way towards achieving improved electrical supply services. The main premise of this research is based on information made public through HPGCL OR SLDC Haryana to the electricity users through the AMI about the state of electricity market (electricity demand or load profile). The load curve will show a peak point where electricity consumption reaches critical points causing undesired consequences. Providing consumers with such a load curve will enable users to switch off certain load when the state of electricity demands reaches certain limit according to time.

A. Objective:

On a long term, applying the system could lead to the followings benefits:

- Decreasing Peak Demand.
- Raising users' awareness.
- Reducing Environmental impacts.
- Improved system reliability.
- Reducing electricity Price.
- Reducing price volatility.
- Improved efficiency.

- Improved economics.

B. Goals:

The project goals which are to be accomplished during the offered period are as follow:

- Problem identification.
- Identification of solutions.
- Define project components.
- Components selection.
- Coordination with concerned utilities and suppliers.
- Choosing and writing software.
- Familiar with the components and software.
- Work evaluation.
- Writing the dissertation

IV. Load Scheduling/Demand Response

A. Advanced metering infrastructure (AMI):

Conventional electromechanical meters served as the utility cash register for most of its history. At the residential level, these meters simply recorded the total energy consumed over a period of time typically a month. Smart meters are solid state programmable devices that perform many more functions, including most or all of the following:

- Time-based pricing
- Consumption data for consumer and utility
- Net metering
- Loss of power (and restoration) notification
- Remote turn on / turn off operations
- Load limiting for "bad pay" or demand response purposes
- Energy prepayment
- Power quality monitoring
- Tamper and energy theft detection
- Communications with other intelligent devices in the home

Advanced metering infrastructure (AMI) includes the both the physical smart meter (a digital electricity meter located at the end consumer that enables two-way communication) as well as the communications infrastructure to transport the data that is generated.

As with AMI, grid optimization includes both hardware (such as synchrophasor and other sensors), software (to quickly analyze incoming data and alter power flow accordingly), and communication networks (to gather information from the sensor network). Another major driver of smart meter functionality is improving local anti-tempering capabilities. This is especially important in developing markets where electricity theft accounts for a large percentage of overall power usage.

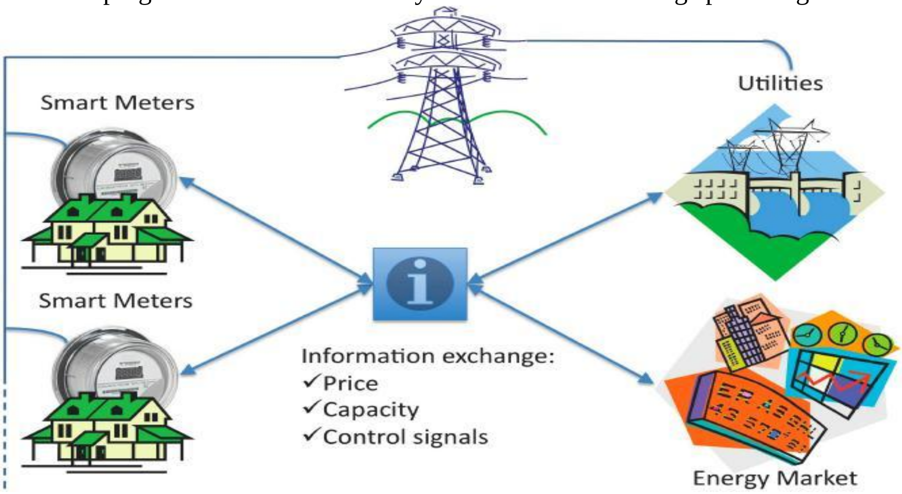


Figure2. Two Way Communication Infrastructures

The ability of solid-state electricity meters to detect and prevent tampering can significantly improve control and cost recovery for utility companies. Here again, high-level anti-tempering objectives are both driving the adoption of solid-state metering and dictating required feature sets at the chip level. Finally, the promise of improving service to customers represents an important goal of smart metering, especially over the long term. By enabling customers to better manage their own energy usage through incentive-based programs such as direct load control, interruptible rate agreements, and demand bidding/buyback smart metering can help utilities manage overall energy consumption patterns and cope with peak-demand challenges. With the right capabilities built into chip-level solutions, smart meter deployments can effectively lay the groundwork for expanded customer-service functions, such as wireless integration with thermostats to automatically adjust usage during peak-demand periods.

B. Demand side management:

Demand Side Management (DSM) commonly refers to programs implemented by the utility companies to control the energy consumption at the customer side of the meter. DSM is employed to use the available energy more efficiently without installing new generation and transmission infrastructure. Figure shows the concept of DSM integration of energy Efficiency, Energy Conservation and Demand Response.

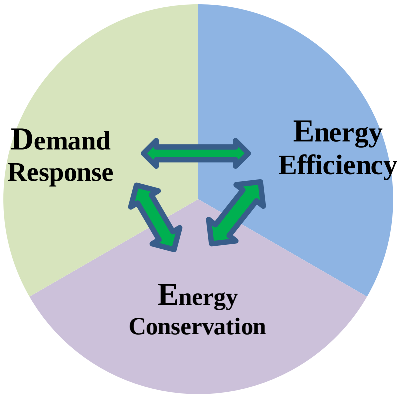


Figure3. Demand side management

Energy Efficiency: It refers to the permanent installation of energy efficient technologies for the reduction of energy losses in existing systems. The main aim of energy efficiency is to maintain a comparable level of service with the reduction in energy usage.

Energy Conservation: It deals with making a behavioral choice or change in consumer. The change may last for a short time instant or may be incorporated into a habit of lifestyle .Examples of energy conservation are:

- Lowering thermostat temperature by certain degree to reduce energy consumption during winter.
- Opening window in summer instead of using air conditioner.
- Shutting off electrical appliances such as television, computer when they are not in use.

Demand Response/Load Management:

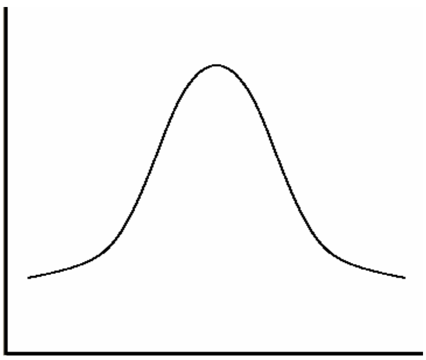
Demand Response is related to electricity market and price signals. Customer connects or disconnect load in response to a signal from a service provider. . DR initiatives often include information and communication technologies such as Advance Metering Infrastructure (AMI), to maximize the user's awareness of his energy consumption and the related cost in a time basis. . The traditional DSM activities taken by the utility company to alter the load shape can be characterized into six categories based on the state of the existing utility system:

Peak Clipping: peak clipping is one of the classic forms of load management which aims at reduction of system peak generally by means of direct load control. Peak clipping reduces the need to operate peaking units.

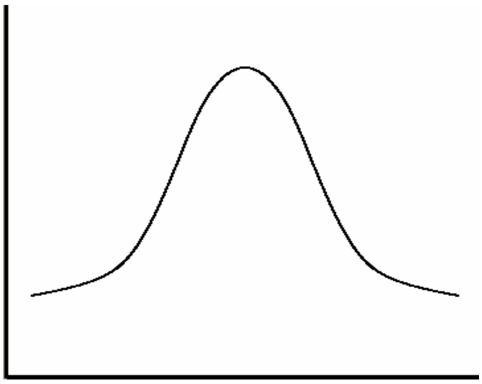
Valley Filling: Valley filling is a form of load management that increases or builds the off-peak loads, for instance, uses of thermal storage units. This strategy may be desirable when the long-term average price is lower than the cost of load building in the off-peak Hours.

Load shifting: Load shifting is also one of the classic forms of load management taken by the utilities which involves shifting loads from peak to off-peak periods .Conventional devices for load shifting include space heating storage, cooling storage, domestic hot water storage, and customer load shifting, etc.

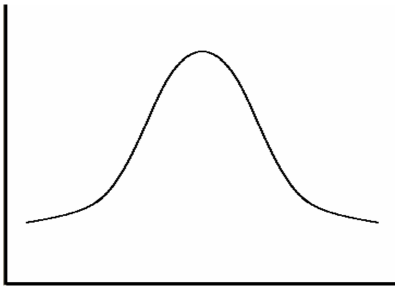
Strategic conservation: strategic conservation is the load shape change that occurs from targeted conservation activities. This strategy is not traditionally considered by the utilities as a load management option since it involves a reduction in sales not necessarily accompanied with peak reduction.



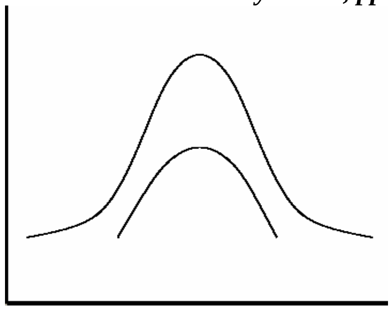
Peak clipping



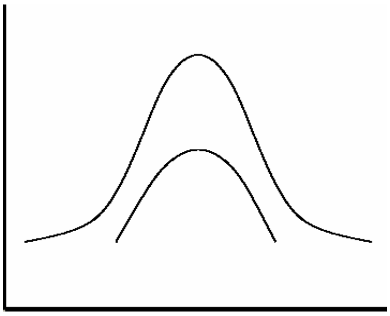
valley fillings



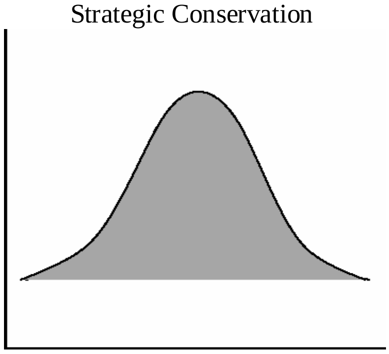
Load Shifting



Strategic Conservation



Strategic load growth



Flexible load shape

Strategic load growth: strategic load growth refers to a general increase in electricity sales beyond valley filling and the spontaneous effects of economic growth.

Flexible load shape: Change of reliability in electricity services could be used as a demand-side option to change load shapes. Flexible reliability offers consumers with options to variations in quality of services in exchange for other benefits (for example, lower rates).

DSM Program implement in India:

- **Maharashtra:** First Pilot Ag DSM project was launched in 2009 at MANGALWEDHA sub-division of SOLAPUR Circle. In this first pilot project agricultural pumps are replaced with new energy efficient agricultural pumps. First pilot Ag DSM project covers 2221 agricultural pumps connected on four feeders (BRAMHAPURI, NANDESHWAR, BORALE and BHOSE) in MANGALWEDHA subdivision of SOLAPUR Circle, Maharashtra. Total cost of first pilot Ag project in Maharashtra shown in Table1.
- **Gujarat:** After the initial success of the Pilot Ag DSM in Maharashtra and as a part of National Ag DSM scheme, the second batch of Ag DSM pilot projects were launched in Gujarat, Punjab and Rajasthan & Haryana states. Total cost of this project is shown in Table2.

Particulars	**Values in Rs. (Lacks)**
Cost of Energy Efficient Pump Sets	401.8
Cost of dismantling existing pump set and installing EEPS	9.8
Cost of replacing foot valves for mono-block and flexible coupling pump sets	7.2
Replacement of GI pipes and fittings	11.75
Cost for Efficiency testing and demonstration - pre and Post installation	2.22
Total Project Cost	432.8
Total Project Cost Including R&M and Administration cost for 4 years	583.2

Table1. Total cost of first pilot Ag project in Maharashtra

Particulars	**Values in Rs. (Lacks)**
Cost of Energy Efficient Pump Sets	191.68
Cost of dismantling existing pump set and installing EEPS	3.567

Cost of replacing foot valves for mono-block and flexible coupling pump sets	0.205
Repair & maintenance cost	60.98
Total Project Cost	256.44

Table2. Total cost of second pilot Ag DSM project in Gujarat

L.E.D. LIGHTS		CONVENTIONAL LIGHTS	
▪ 7 /10 Watt LED Lamps		▪ 40/60 /100 Watt Incandescent Lamps	
▪ 16 Watt LED Tube lights		▪ 40Watt Florescent Tube Lights	

Table3. Conventional light replaced by LED lights

V. Result & Analysis

A. System operation:

Web Relay fed with power supply is first connected to the computer. Then, the computer is configured according to the Web Relay manual- in order to recognize the web relay. The interface unit (Web relay) used for the experimental part of this project contains ten output signals. The ten signals are designed for seven different loads or devices which can be simultaneously controlled. Therefore, the written software is designed to send ten commands based on threshold limits. The all device will be turned on/off according to time.

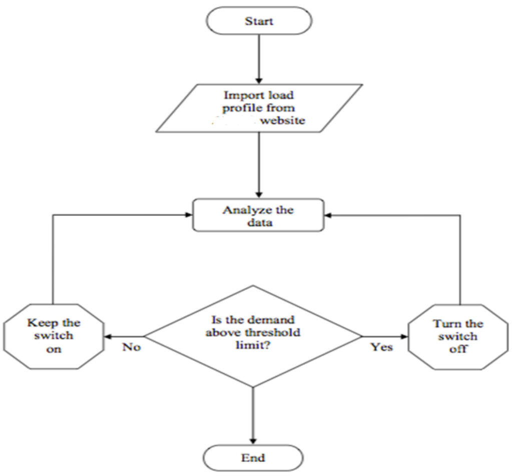


Figure4. Flow Chart

Selection of the appliances to be controlled should be made according to consumers' preferences; however, priority is to be maintained while ranking the switches. Therefore, the first switch to be turned off should be the one connected to the least important device and so on. In addition, in some cases, instead of connecting a single device, the customer may prefer to connect a circuit which feeds a room with least usage.

B. Methodology

Proposed Design: The scheme is based on the electricity market and deploying operational information; demand and other information on the AMI. Electricity users (user's computer), on their end, are receiving this information and controlling accordingly own electricity demand on the premises. Figure illustrates the circuit diagram of the proposed design which reflects the idea of the project.

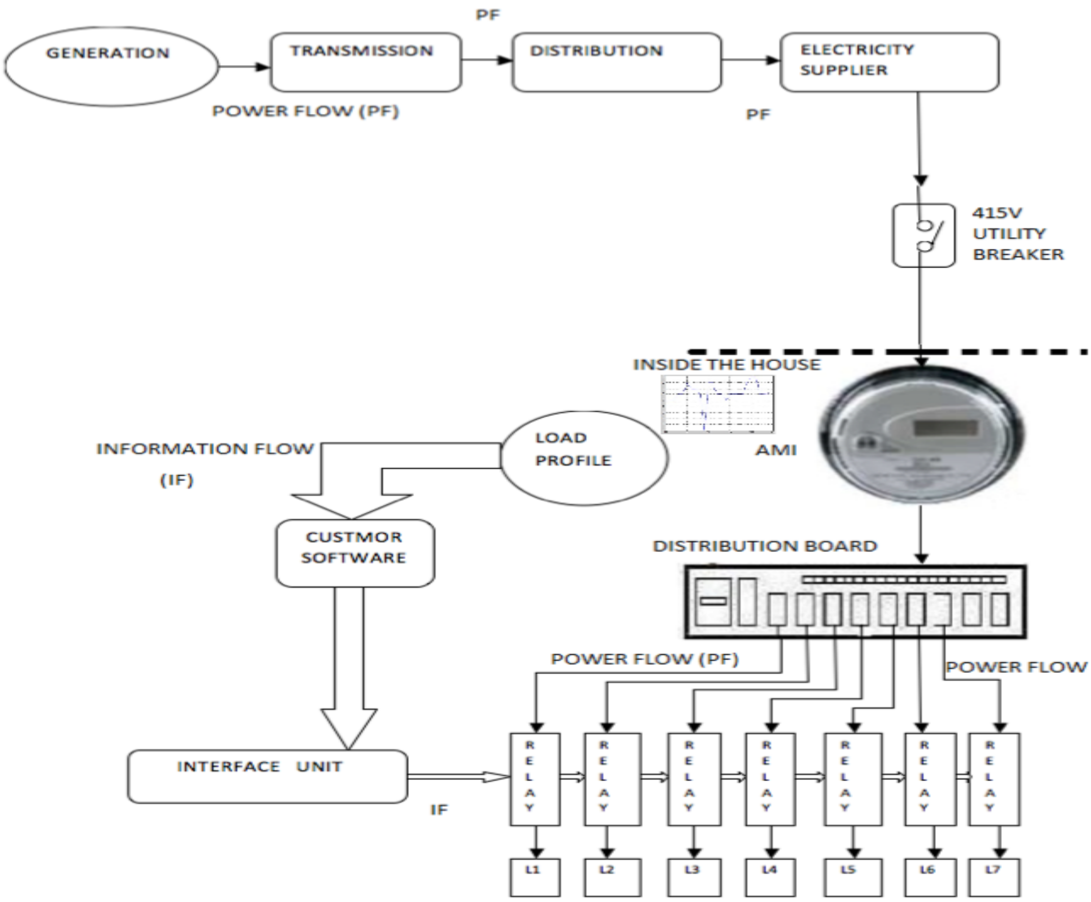


Figure6. Circuit diagram of proposed design

The main components of the design include a specially written software, internet modem, computer, interface device and controllable smart switch. Internet functions as the medium or channel through which information are transferred from HPGCL or SLDC websites to electricity users computers. The especially written software imports the electricity load profile through the AMI & then analyzes its data. Based on threshold load limits set by customers, the software sends commands to the customer load switches to turn OFF or ON.

C. Result:

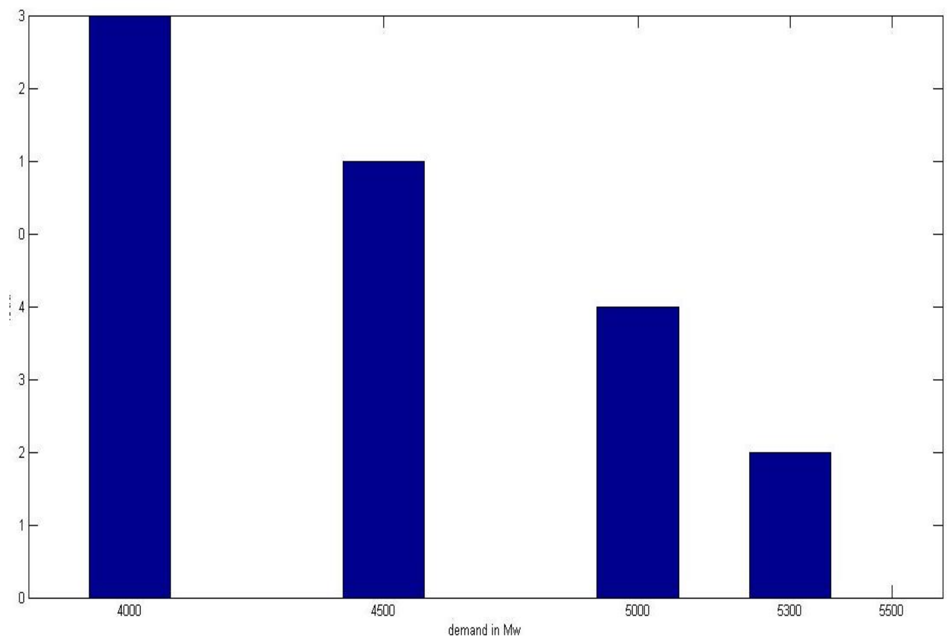


Figure7. Result according to demand

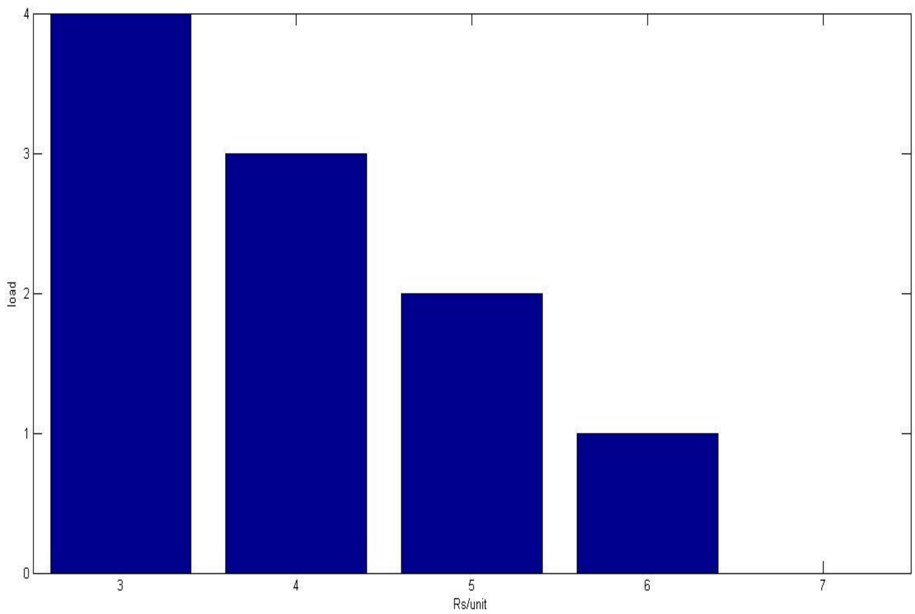


Figure8. Result according to price

VI. Conclusion

Smart grid technology provide opportunity for enhance the exiting grid and preventing reoccurrences of major incidents. Smart grid technology can improve the reliability, security and efficiency of current electrical grid. Intelligent devices can automatically adjust to changing condition to prevent blackouts and increase capacity .Before implementation location has to study and do proper planning to ensure smart grid is execute smoothly and comprehensively. Demand side management (DSM) is one of the important functions in a smart grid that allows customers to make informed decisions regarding their energy consumption, and helps the energy providers reduce the peak load demand and reshape the load profile. This results in increased sustainability of the smart grid, as well as reduced overall operational cost and carbon emission levels. Most of the existing demand side management strategies used in traditional energy management systems employ system specific techniques and algorithms. In addition, the existing strategies handle only a limited number of controllable loads of limited types. Demand response has become a key feature of the future smart grid. In additizn to having advanced communication and computing infrastructures, a successful demand response program must respond to the needs of a power system. In other words, the efficiency and security of a power system dictate the locations, amounts and speeds of the load reductions of a demand response program.

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