CHAPTER-1

INTRODUCTION

An electricity meter, electric meter, electrical meter, or energy meter is a device that measures the amount of electric energy consumed by a residence, a business, or an electrically powered device.

Electric utilities use electric meters installed at customers' premises for billing purposes. They are typically calibrated in billing units, the most common one being the kilowatt hour (*kWh*). They are usually read once each billing period.

When energy savings during certain periods are desired, some meters may measure demand, the maximum use of power in some interval. "Time of day" metering allows electric rates to be changed during a day, to record usage during peak high-cost periods and off-peak, lower-cost, periods. Also, in some areas meters have relays for demand response load shedding during peak load periods.

The development of human society depends on the proper and wise utilization of all resources whether natural resource or a man-made resource. Electricity can be categorized as a manmade resource but its production depends on the availability of natural resources like coal, water, wind and gas etc. Per capita consumption of electricity is directly proportional to the economic growth of the country. Electricity is first Generated(G) then Transmitted (T) over long distances and finally Distributed(D) to consumers. In this process of GTD energy losses take place.

Energy loss is defined as the difference between energy generated and billed on consumers on consumption. There are three types of losses, namely Technical, Administrative and Theft incorporated with transmission and distribution of electricity.

Technical losses are those losses which occur due to properties of materials used in transmission and distribution system. For example, energy dissipated due to resistance of conductor used in supply lines. It also includes Dielectric losses, Induction and radiation losses. These losses can be reduced by substituting materials involved in supply with materials having desired properties.

Administrative losses are those losses which are given by unknown connections and missing meters in the system.

The third kind of loss is illegal use of electricity which is done in several ways like tampering with meters to make it record lower consumption reading, tapping (hooking) on LT lines and arranging false readings by bribing meter readers etc.

ELECTRICITY NETWORK

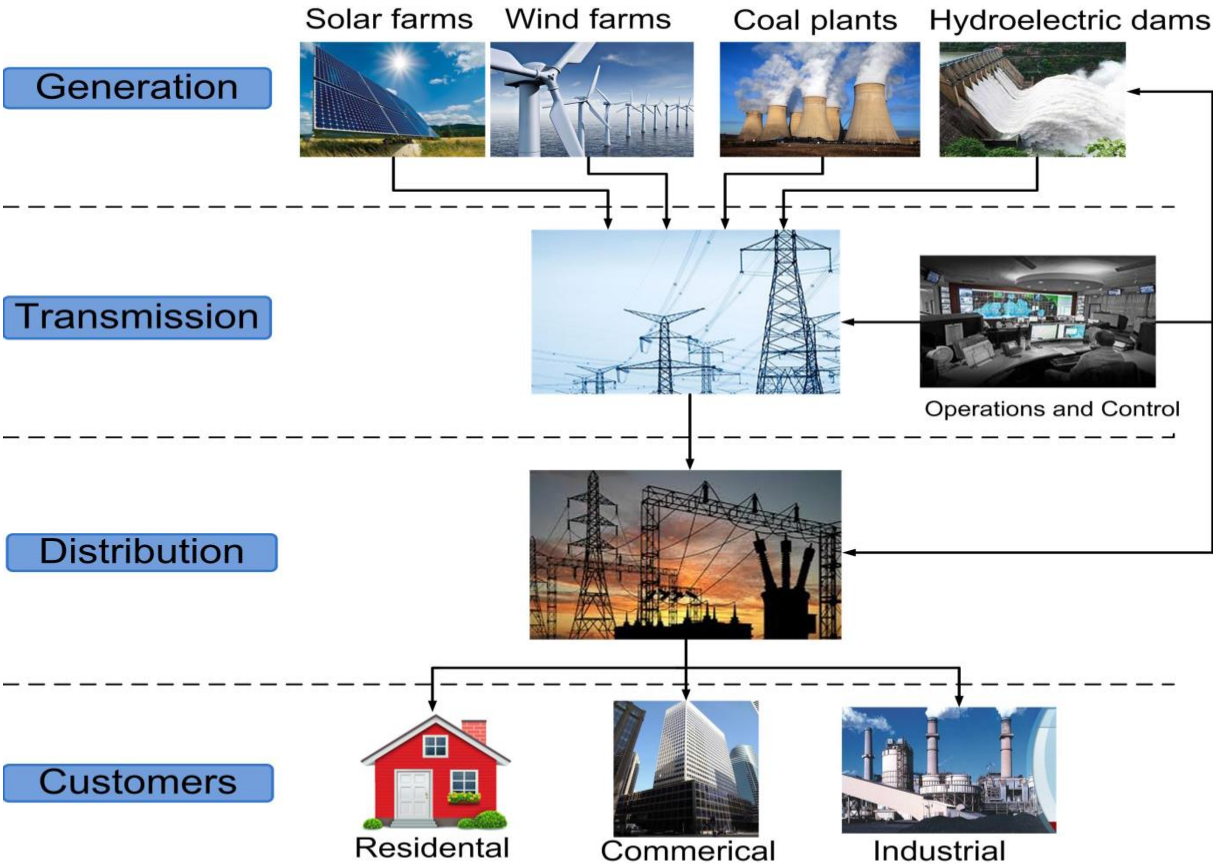

Fig.1.1. Electricity Network

According to a survey in most of the developing countries including India also, 32% of produced electricity is wasted as losses; approximately 47-48% of this loss is due to electricity theft. This problem of theft can be addressed to a certain extent by installing smart metering system.

The gap between peak demand and the available power is big, if time-wise consumption readings and thus variable tariff is imposed to encourage consumers to use their appliances during off peak hours then this gap may minimize without establishing any new power plants as depicted.

This needs improvement in the current metering system. Distributed Generation is becoming popular nowadays. DG is defined as an electric power generation source connected directly to the distribution network or on the customer side. As penetration of DG is increasing its grid interconnection is going to be a challenging task. Utilities may impose different tariff for this. Metering of this is further going to be tough with the current meters.

Smart and Prepaid meters are the latest metering technologies to overcome these drawbacks in present meters.

1.1. Conventional Electrical Metering System:

Conventional meter or credit meter means a meter where an account is issued subsequent to the consumption of electricity. These Meters work on electro-magnetic induction principle. These are also known as 1st generation meters. These meters can measure only energy. Electric utilities use electric meters installed at customers' premises for billing purposes. They are typically calibrated in billing units, the most common one being the kilowatt hour (*kWh*). They are usually read once each billing period.

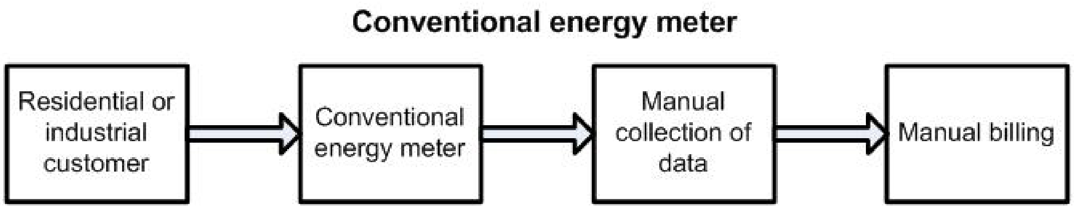

Fig.1.2 Process of Conventional energy meter system

The conventional meters are installed at consumer end that may be residential or industrial customer. The meter which reads the energy that utilized by the consumer is conventional meter. These data is collected manually by a person and does manual billing. This is the process of conventional energy meters.

These meters are reasonable cheap and reliable (if not tampered with). If necessary, the meter can be calibrated under laboratory conditions and then he reused again. Less exposed to lightning. If the administration regarding meter readings are performed correctly, then it will run well.

These meters have drawbacks. Meter reading errors may occur due to faulty readings forwarded by the meter reader. Estimated readings may appear on the account due to a process used by the Service Provider in the case of faulty readings or a faulty meter. Difficult to manage consumption because meter readings are not accessible. There is a long course of time between the meter reading, administration of and the delivery of accounts and the due date for payments. Processes of switching off the electricity due to non-payment can be problematic. (No warning is given beforehand; therefore, a home-owner might realize the situation after hours and the process of switching on the electricity can then only be done the next day during working hours).

1.2. Present Metering System:

To over come drawbacks of conventional meters present meters are developed. In present meters not only energy which is measured by conventional meters but also peak voltage, peak current, power factor, rms voltages, rms currents, active energy, reactive energy, apparent energy and frequency. These present meters are classified based on technology. Present metering systems are Smart Meter, Prepaid Meter and Net meters.

Advantages of present meters are, they can measure parameters for further usage like energy auditing, billing, tariff formulation, electricity regulation and load research. By using these meters energy management is possible. Intelligent tampering can be identified. Energy generated can be efficiently used. Data analysis is simple through this meters as they store data for long time. Manual operation can be reduced.

Disadvantages of present meters is mainly installation cost is high, to store data more storage is needed, dumping of huge conventional type equipment results in large quantity of electrical waste, this disposal is difficult to handle.

1.3. Objectives of Metering:

- Add and maintain records of power used by consumers.
- Provides a convenient solution of billing pattern.
- Add and maintain consumer details.
- Provide description of tariffs and rates of units.
- Add and maintain new entered category of consumer.
- Provides economic/financial reports to the manager monthly or weekly and Yearly.

1.4. Acceptance Tests On Energy Meters:

- Temperature Test.
- Starting current Test.
- No load Test.
- Meter Constant Test.
- Limits of Error test with voltage, current, Frequency variations at up to 0.5 lag and 0.8 lead.
- Repeatability of Error Test.
- Power consumption Test.
- High voltage Test.
- Megger Test.
- Vibration Test.
- Tri vector Meter with Lag only feature.

1.5. UTILIZATION OF METER DATA:

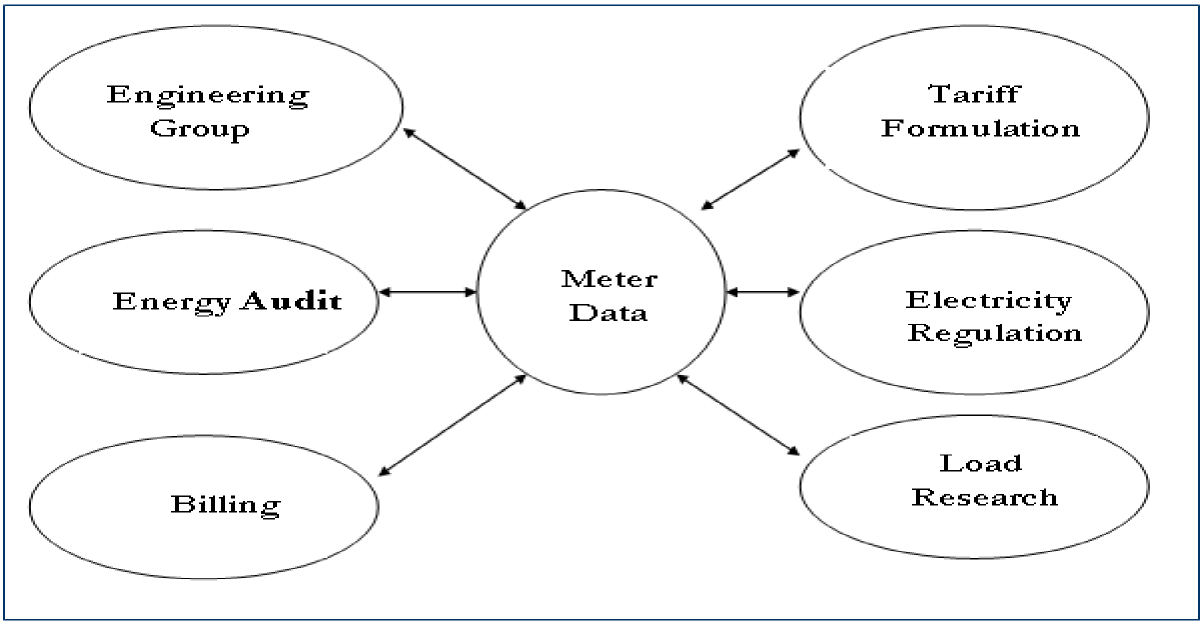

Fig.1.2. Utilization of meter data

Engineering Group: Meter data helps Engineering groups in estimation of production of electrical power to reach the demand of consumers.

Energy Audit: An energy audit is an inspection survey and an analysis of energy flows for energy conservation . It may include a process or system to reduce the amount of energy input into the system without negatively affecting the output. In electrical network, an energy audit is the first step in identifying opportunities to reduce energy expense and carbon footprint.

Billing: The process of calculating the electricity bill with all the charges and penalty for a consumer who has been given connection of electricity. It provides Consumer details, Meter reading, bill Payment date, next bill printing and Month end.

Tariff Formulation: The process of determining the cost of per unit (i.e., kwh) of electric power for different consumers different tariff rates.

Electricity Regulation: Power cannot be economically stored and area-wide blackouts occur if production either exceeds or falls short of demand for as little as a second. To avoid this conditions electricity regulation, manages the usage.

Load Research: An activity embracing the measurement and study of the characteristics of electric loads to provide a thorough & reliable knowledge of trends, and general behavior of the load characteristics of the customers serviced by the electrical industry.

CHAPTER-2

CLASSIFICATION OF METERS

2.1. TYPES OF ENERGY METERS:

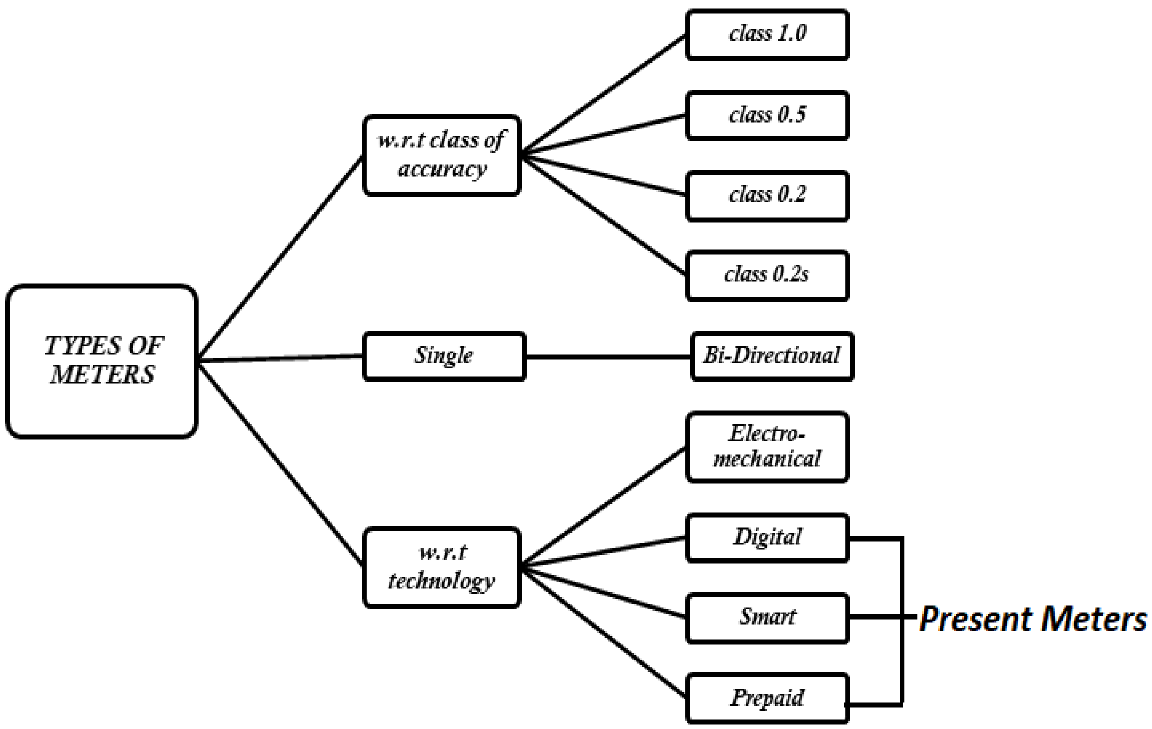

Fig.2.1. Types of Energy Meters

2.1.1. Types of Energy Meters with respect to Class of Accuracy:

- **Class 1.0 -** Whole Current meters
- **Class 0.5 -** CT's operated Meters
- **Class 0.2 -** HT Meters/PT's
- **Class 0.**2s – HT Meters/CT's

2.1.2. Types of Energy Meters with respect to Current Direction:

- Single Direction
- Bi-Directional

2.1.3. Types of Energy Meters with respect to Technology:

- Electro-Mechanical Energy Meters
- Digital Energy Meters
- Smart Energy Meters
- Prepaid Energy Meters

2.2. IS of Energy Meters:

- IS13779 – Whole current Meters of Non-DLMS
- IS14697 – CTs operated Meters of DLMS
- IS15884 – Prepaid Meters
- IS16444 – Smart Meters

2.3. Electro-Mechanical Energy Meters:

These energy meters are obsolete now but some countries are Still using it due to its cheapness and robustness. They are also called as Disk meter because a disk is present inside the Energy Meter which rotates when current flows through it. This rotation is captured by the dial and enhance its readings as per the amount of current flown. The dial of the Disk Meter shows only kWh usage since the time of Energy Meter installation. They came in both 3 phase and single-phase types. Current rating for 3 Phase Disk Type Energy Meter is normally up to 100 Amps.

Fig.2.2. Single phase energy meter

2.3.1. Working Principle of Electro-Mechanical Energy Meters:

As their name suggest, Electro-Mechanical Energy Meters are the combination of Mechanical and Electrical Technology. A mechanical disk present inside the meter rotates when the load applied. The speed of disk is directly proportional to the amount of load applied. With the rotation of disk, dial of the Energy Meter increases its value.

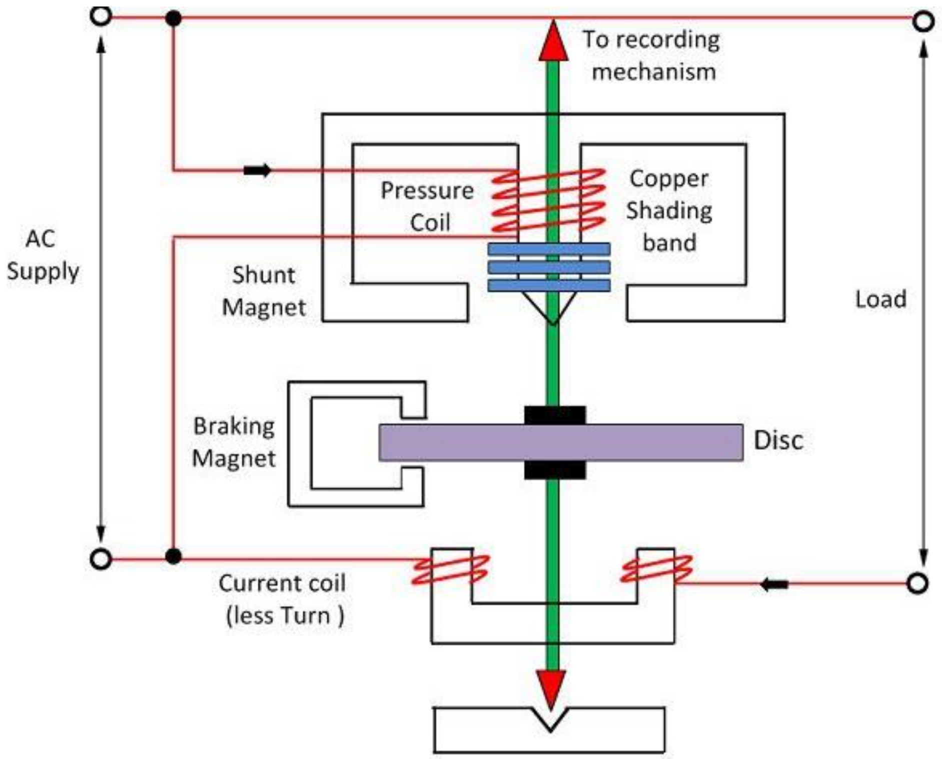

Fig.2.3. Working of Energy Meter

The above image is giving idea about the working principle of disk meters. There are two coils present in the diagram and in between these two coils a rotating disk is present. One coil is current coil which is connected in series with load, that's why it is also called as series coil as well. Other coil is voltage coil connected in parallel, that's why it is called as shunt coil as well. When both coils are energized, they will induce eddy current in the disk. There is a copper shading band present above the disk which gives 90 degrees' phase shift eddy currents, which results in the rotation of disk.

There will be no rotation of the disk, if the switch is open. As soon as the switch will close, current will start to flow which results in the voltage induction and hence the rotation of the disk. The speed of the disk depends on the load applied. As heavy load requires large current, thus when large current passes through the current coil, large amount of eddy current will produce which will rotate the disk fast.

2.3.2. Advantages of Electro-Mechanical Meters:

- **Robustness:** These meters are strong meters with respect to new energy meters. As Digital Energy Meters have small and sensitive components, they can burn easily with any stray jerk of voltage. On the other hand, Disk meters can endure those voltage fluctuations. Moreover, coils present in disk meters are tough and cannot easily be destroyed.
- **Mechanical Dial of Energy Meter:** Readings of the dial of Electro-mechanical Energy Meter is pretty hard to alter. So, its dial can be also taken as advantage of Electro-mechanical meters.
- **No use of battery:** Whenever battery of the digital meter dies or power turns off due to any reason, reading of meter will be vanished. But readings of disk meter will be always present due to Mechanical dial present on it.

2.3.3. Disadvantages of Electro-Mechanical Meters:

- **Future up-gradation:** There is no chance of future enhancement in these kinds of Energy Meters. They are what they are, you cannot improve it or include anymore innovation in it.
- **Accuracy limits:** Disk meters mostly gives class 2 accuracy. It is not possible to get more accuracy through disk method. It is mandatory to change the technology to get more accuracy.

- **Limited measurements:** As disk meters have only one dial so they only measure active or reactive power at a time. Moreover, they cannot measure MDIs, instantaneous power, voltage, current or other important factors.

- **Highly exposed to electricity stealers:** Yes, these meters are easy to manipulate because meter reversing or disk blocking techniques are really easy to implement on it.

2.4. Digital Energy Meters:

Digital Energy Meters are the 2nd generation of Energy Meters. These meters digitally measure the energy and other factors like voltage, current, instantaneous Power and show them on an LCD. They can store energy consumption data up to 2 years' in EEPROM.

Digital Energy Meters came in single phase and 3 phases both types. Single phase type digital energy meters normally just display and store MDI (Maximum Demand Indicator**)** and Energy units.

The digital 3 phase energy meters give tariff-based energy units storing as well. As the rate of the unit is more at Peak Load times than at off peak load times. So, Energy meters must store energy units in two slots i.e. peak slot and off-peak slot to differentiate the timing of electricity usage. This is the reason that they are also called as TOD (Time of Day) Energy meters.

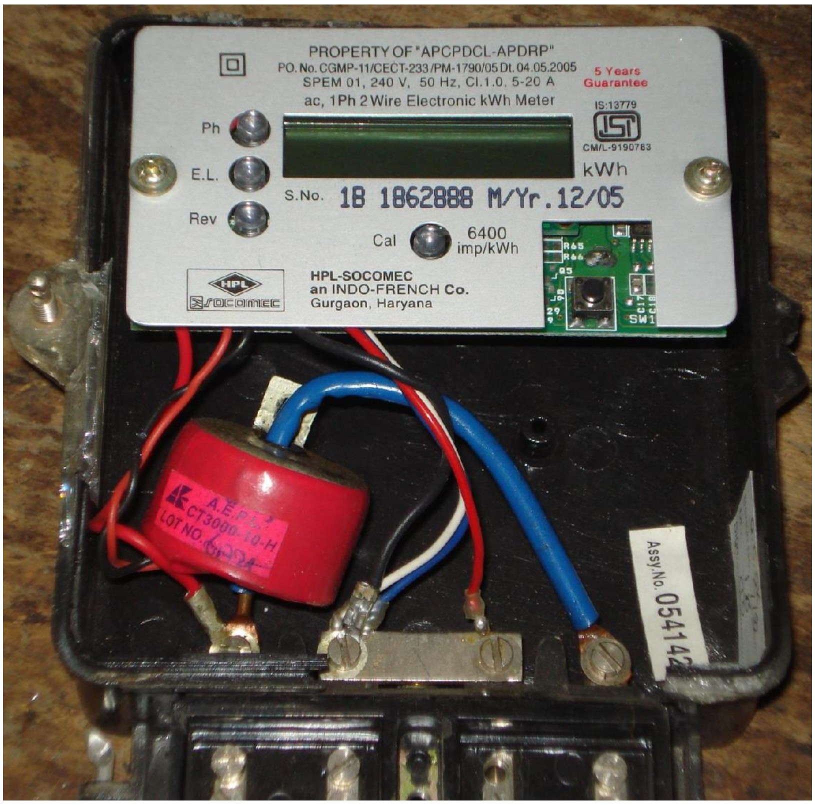

Fig.2.4.   1-Phase 2 Wire Digital Energy Meter

2.4.1. Working principle of Energy Meters:

There are many types of energy meters having different working principle. Basic working principle of all energy meters are same except disk type energy meter. To understand the basics, Simple Digital Energy Meters is the best option because all the other meters are merely an upgraded form of them.

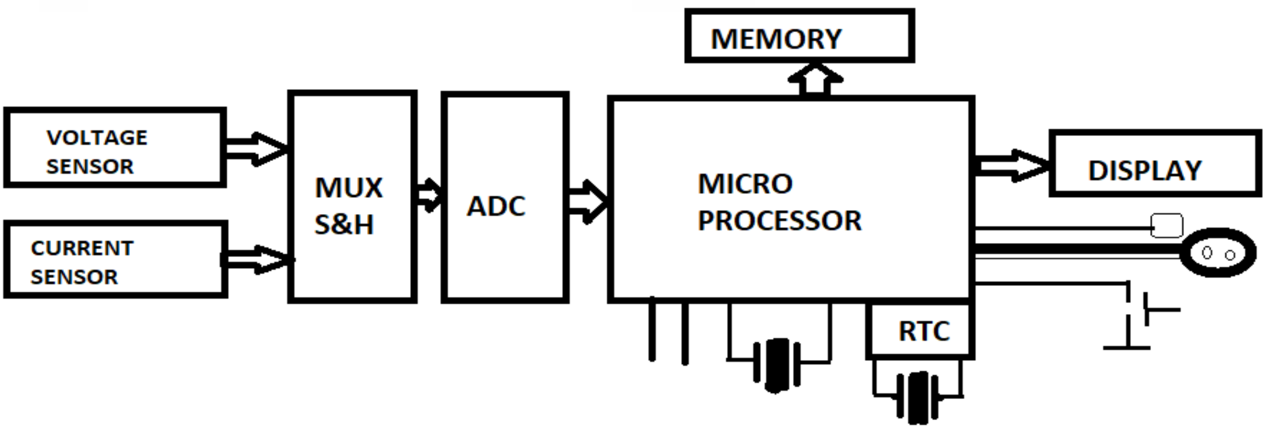

Fig.2.5. Block Diagram of Digital Energy Meter

Power supply circuit:

The goal of this circuit is to give 5 volts to the whole system. To Energize LCD and EEPROM without even power supply, a battery is an only option. For that purpose, a non-rechargeable Lithium battery should install inside to energize it for at least 4-5 years.

Current Measuring Circuit/Current Sensor:

There are many ways to measure current and for this purpose various kinds of sensors are available in the market. To measure current, sensor should be applied in series of the Live wire so that whole current can be passed through sensor. Current transformer is the best option in this case due to its economical price and efficiency.

Voltage Measuring Circuit/Voltage Sensor:

There are two main methods to measure voltage. One is through the voltage divider and the other through potential transformer. When voltage is too high like more than 500 volts then a potential transformer should be used to isolate the sensitive circuit from high voltage. But in case of 220 volts a voltage divider circuit is better option. Many Energy Meter manufacturers use this voltage divider method to make voltage measuring circuit.

Liquid Crystal Display:

An LCD is the face of Energy Meter. It gives reading to the meter readers. Any small and cheap LCD can serve the purpose here.

Normally following things are required to display on the LCD of single-phase energy meters:

- Previous Month KWh consumption.
- Present month KWh consumption.
- Total kWh consumption time of manufacturing.
- Previous month MDI (kW).
- Present Month MDI (kW).
- MDI Reset Number.
- Meter serial Number.

EEPROM (Electrically Erasable Programmable Read Only Memory):

EEPROM is another important part of Energy Meters. It stores MDI and total KWH consumption for every 30 minutes. So that retrieval of consumed units could be possible in case of any discrepancy.

Micro-Controller:

You can call micro-controller as Brain of the Energy Meter. Meter manufacturing company can use any micro-controller like PIC, Atmel AVR or ARM solely depends on their constraints. Moreover, specified micro-controllers "specifically designed for Energy Measurements" are also present in Market. The purpose of the micro-controller here is to collects analog values from current and voltage circuit and then convert it into digital values through ADC. After conversion, a multiplication of digital values of current and voltage done by micro-controller to get the value of power consumption. This value of power then add into the energy register with previous values. In the end, it displays all the values on the LCD and store it into the EEPROM as well.

2.4.2. Analog to Digital Conversion and Sampling (ADC):

- The input voltage and currents are isolated from the line and sensed through internal potential and current transformers.
- The power supply voltages required to operate the electronics is derived from the input line voltage
- The voltage and current are sampled at suitable sample frequency and converted to digital form by analog to digital converters.

- Then these values are fed to the microprocessor.
- The multiplication of both voltage and current values is done by the microprocessor and displays the energy

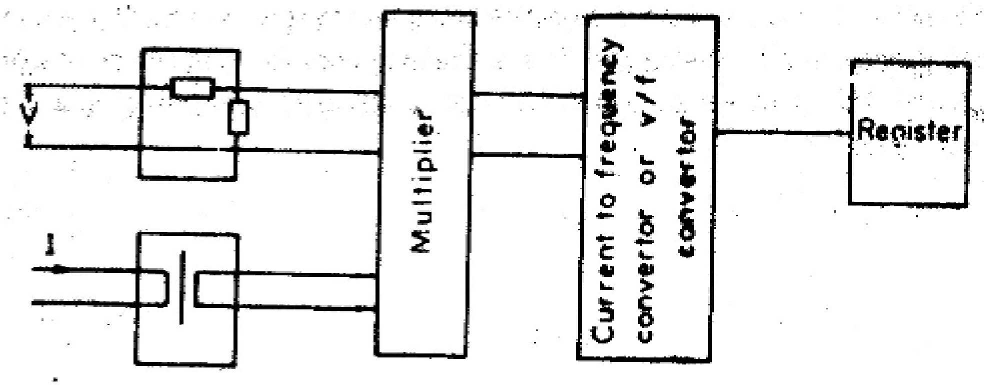

Fig.2.6. Analog to Digital Conversion and Sampling

2.4.3. Advantages of Digital energy meters:

Digital meters functionally outperform the traditional meters in variety of ways:

- **Accuracy:** One of the most significant benefits of using Digital meter is its accuracy. In nonlinear loads, it's metering is highly accurate and free from observational errors.
- **Auto Polarity:** By using digital meters we can read the negative values as well. An excellent example of this is voltage. Placing the probes into the opposite polarity result in negative output. This is considered to be a huge advantage of using digital energy meter over analogue which can cause the equipment to be broken.
- **Output Display:** The readings of a digital meter are extremely easy to gauge as the outputs are automatically displayed in numbers through a seven-segment display. Unlike the analogue type which takes time, resulting in huge chances of occurring mistakes especially for those with poor eyesight.
- **Inexpensive:** It measures the electricity in both phase and neutral lines and calculate power consumption based on the larger of the two currents, thereby helps in improving the cost (comparatively cheaper than analogue meters) and quality of electricity distribution. With the advent of integrated circuits, sizes and cost, the power requirements of digital meter have been drastically reduced.

2.4.4. Disadvantages of Digital energy meters:

- Manual reading is needed.
- Data analysis is difficult.
- Can't identify illegal consumption of energy.
- Can't estimate further usage of consumer.
- Excess usage cannot only identify when monthly billing is performed.

Chapter-3

EMERGING TRENDS IN METERING, BILLING & COLLECTION

3.1. Introduction:

Meter reading billing and collection known as MBC activity deals with millions of utility consumers and therefore MBC function has to be oriented to provide best customer service. Quality service not only improves the image and good will of utility in the society, but also helps in many ways in improvement of revenues of the utility. Obviously, all customer related functions have to be integrated and provided as single point service, for minimization of cost and value addition. Such an integrated service is called "customer relationship management" popularly known as CRM.

3.2. Types of Machines used in Metering, Billing & Collection:

1. Spot Billing Machines
2. Automated Meter Reading System
3. IR/IRDA Port Meters
4. RF Meters
5. Thread through CT Meters
6. ABT Meters
7. Smart Meters
8. Prepaid Metering System
9. Net Meters

3.3. Spot Billing Machines:

The Spot Billing Machine (SBM) is a Hand Held Computer, in which the program is stored along with all the relevant data, for issue of electricity bills, right at the customer premises, immediately after the meter reading is read and input to SBM.

The storage of program and data is done through a Personal Computer (Host PC), and is called pre-journey configuration for the specific meter-reader route, user-connection record including type of connection, applicable tariff, previous reading, past payments etc.

The master data pertaining to the tariff tables, type of connection, consumer profiles are stored on the Host PC, and made available for uploading on to the SBM at the time of configuration

Once the pre-configuration is over the SBM is ready for field operations. The meter-reader reports at the consumer site, accesses the customer's account on SBM and record the current reading. On the basis of the last reading and tariff structure, a bill would be generated instantly. Payment in non-cash mode can also be collected then and there. In such case, the receipt would also be generated.

The payment could be collected through noncash modes. A collection report can be prepared at the end of trip. After a journey is over the transaction data files are transferred from SBM to the Host PC, over a communication cable connected to serial communication port. The SBM requires about three hours for full charging after which it can be used continuously for 7-8 hours.

Fig.3.1 Spot Billing Machine.

3.3.1. Features:

- ❖ The bill is immediately generated.
- ❖ The collection of dues, through non-cash instruments, is performed in the field.
- ❖ Variety of reports can be prepared.
  - Utility Bill with all relevant details
  - Receipt against the Bill
  - Day end Collection report
  - Duplicate receipt

3.3.2. Specifications:

- High Speed CPU.
- 256 KB program memory.
- 4 MB data memory.
- Real Time Clock.
- LCD display unit (4 rows x 20 character) with backlight.
- 30 Keys soft silicon rubber Keypad.
- High speed serial port / program port (115 Kbps).
- Built-in 24 column Impact printer.
- Built in 2.2 AH Lithium-Ion or 1.7 AH Ni MH battery.
- ABS plastic case housing.
- Programmable as per user requirement.
- Light weight, versatile and affordable.

3.3.3. Application software:

- Spot Billing Machine software.
- PC-end data transfer (to and from SBM) software.

3.4. Automated Meter Reading System:

Automatic meter reading(**AMR**) is the technology of automatically collecting consumption, diagnostic, and status data from water meter or energy metering devices (gas, electric) and transferring that data to a central database for billing, troubleshooting, and analyzing. This technology mainly saves utility providers the expense of periodic trips to each physical location to read a meter. Another advantage is that billing can be based on near real-time consumption rather than on estimates based on past or predicted consumption. This timely information coupled with analysis can help both utility providers and customers better control the use and production of electric energy, gas usage, or water consumption.

AMR technologies include handheld, mobile and network technologies based on telephony platforms (wired and wireless), radio frequency (RF), or powerline transmission.

3.5. IR/IRDA Port Meters:

Infrared Data Association, or IrDA in short, is a group of device manufacturers that developed a standard for transmitting data via infrared (IR) light waves. It provides specifications for the complete set of protocols for wireless IR communication. The main reason for using IrDA had been wireless data transfer over the “last one meter” using point-and-shoot principles. It is famous for secure data transfer, line-of-sight and very low bit error rate that makes it very efficient. IR communication is an inexpensive and widely adopted short-range (1-3m) wireless technology. It is widely used in consumer electronics, automobiles, computers, medical devices, household appliances, commercial services, etc. IRDA-enabled devices can communicate and are bi-directional. IRDA is inexpensive, secure and fast (supporting speeds of up to 100Mbps and even more). The Meter is provided with IR/IRDA Port. The Meter data (KWH, Max Demand) can be collected to SBM through IR Communication to avoid manual error reading and willful suppression of Meter readings.

Fig.3.2 Single Phase IR Meter

Some of the specifications based on the OSI (Open Systems Interconnection) model are given below:

- ❖ **Infrared physical layer (IrPHY):** This specification is intended to facilitate point-to-point communication between electronic devices. It specifies the optical media interfaces for Serial Infrared (SIR) data transmission and is part of the first layer of the OSI model.

- ❖ **Infrared link access protocol (IrLAP):** This specification is part of the second layer of IrDA specifications. It lies on top of the IrPHY layer and below the IrLMP layer. It represents the data link layer.

- **Infrared link management protocol (IrLMP)**: It is the third layer of IrDA specifications. It defines link management multiplexer and link management information access service.

- **Transport protocol (TinyTP)**: This optional protocol specified in the fourth layer lies on top of the IrLMP layer.

- **Infrared communication protocol (IrCOMM)**: The IrCOMM protocol specified in the fifth layer lets the infrared device act like either a serial or parallel port.

- **Infrared Financial Messaging (IrFM)**: This protocol specified in the sixth layer is a wireless payment standard developed by the Infrared Data Association.

3.5.1. Single Phase IR Meter Specifications:

- Available in Single Phase : 5-20A, 5-30A, 10-60A
- Accuracy Class 1.0 as per IS 13779
- Display / Data down loading in absence Power
- Large Size LCD Display for Simultaneous display of Billing Parameters

  (a). kWh

  (b). Maximum Demand

  (C). Average pf
- Optional RS 232 Port of Data download and GSM / GPRS Modem communication.
- Logging and display of tamper data.
- TOD, load survey, tamper information downloadable to CMRI.
- Low voltage operation up 96 Volt (Ph-N).
- Compatible for spot billing machine to print bill on site.
- Large Range of Meter Boxes to house these Meters.
- Supplied over 30 million meters to various utilities in India.

3.6. RF Meters:

RF power meters measure the strength of radio frequency signals in dBm or watts. They are also referred to as RF wattmeters. Their ultimate objective is to calculate transmitter output. RF power meters operate at specific frequency ranges and energy levels to quantify the power from transmitting devices. Measurement methods vary depending on the meter employed.

Evaluation of the energy output attributable to a source is a crucial factor when designing RF and microwave amplifiers. Wattmeter's are engaged in computing intensity levels when evaluating the performance of unique components under testing. Typical units are exploited by RF design engineers, with different configurations available for numerous modes of operation. The vast majority of products in use today are digital. They convert analogy signals to digital indicators with four digits representing energy in watts, milliwatts, microwatts, or decibel milliwatts (dBm). Readouts in decibels (dBm) are the most common form of display for the calculations implemented by microwave engineers.

3.6.1. Applications of RF Meters:

RF power meters serve a broad scope of applications, including:

- Directional power calculation.
- Determining total power.
- Indicating peak envelope power.
- Pulse power measurement.
- Laboratory usage.
- Field usage.

3.6.2. Selecting RF Power Meters:

Several considerations require attention when selecting RF power meters. Devices employing radio frequency power sensors based on heat are ideal for integrated measurement activities. On the other hand, diode-powered detectors are chosen when readings of a base level or instantaneous nature are necessary.

A system's suitability for recording unique indicators such as average power, pulse power, or peak envelope power must be considered as well. Absorptive type RF power meters are recommended for obtaining laboratory data of exceptional accuracy while through-line type instruments are appropriate for field tasks.

3.7. Thread Through Ct Meters:

CT (Current Transformer) Meters are installed on any connections with a load greater than 100 Amps. Conventional meters cannot be used to measure current for these larger connections as they would simply have to be too large to be practicable. A CT meter only measures a fraction of the current passing through the connection and a multiplier is applied to this reading to reflect the actual current.

Fig.3.3. CT Metering

3.7.1. Three Phase LTCT Meter:

The 3 Phase CT Operated Tri-vector Meter is designed for metering of LT consumers and for feeders. The meter has advanced data and tamper recording capabilities and is provided with communication ports. The software is available for data collection, load survey analysis and energy management applications. The meter can be interfaced to a variety of communication devices.

3.7.2. Salient Features:

- Class 0.5s as per relevant IS and IEC Standards
- 5A current rating
- 3 Phase 4 Wire
- 4 Quadrant Measurement
- Anti-tamper features
- Self-diagnostic capability
- Multiple tariff / Time of day feature
- Bidirectional Energy recording
- Up to 4 Maximum Demand registers
- Load Survey (Interval Data) features
- Up to 12 reset backups
- Optical port/RS 232 / RS 485 / IR / IrDA / RF (2.4 GHz/865-867 MHz) (optional)
- Suitable for Indoor/Outdoor Metering
- Suitable for Consumer/DT Metering
- 3 X 40-200 A Current Coils are used in place of CTs.
- Potential Contacts by piercing screws.
- CT reversal, loose potential contacts, Wrong phase association can be eliminated.
- Class of accuracy 1.0
- In-built modem.

3.7.3. Applications:

Submeters for high performance monitoring and analysis, system integration & specialty applications.

- Metering of Distribution Feeders, Transformers, Generators, Capacitor Banks and Motors
- Medium and Low Voltage Systems
- Commercial, Industrial, Utility
- Power Quality Analysis
- Data Logging.

3.8. ABT Meters:

Availability Based Tariff (ABT) is a frequency based pricing mechanism applicable in India for unscheduled electric power transactions. The ABT falls under electricity market mechanisms to charge and regulate power to achieve short term and long term network stability as well as incentives and dis-incentives to grid participants against deviations in committed supplies.

ABT Mechanism in Electricity sector in India is adopted since the year 2000 and in a few other countries for pricing bulk power across various stakeholders. ABT concerns itself with the tariff structure for bulk power and is aimed at bringing about more responsibility and accountability in power generation and consumption through a scheme of incentives and disincentives. As per the notification, ABT was initially made applicable to only central generating stations having more than one SEB/State/Union Territory as its beneficiary. Through this scheme, the Central Electricity Regulatory Commission (CERC) looks forward to improve the quality of power and curtail the following disruptive trends in power sector:

- Unacceptably rapid and high frequency deviations (from 50 Hz) causing damage and disruption to large scale industrial consumers
- Frequent grid disturbances resulting in generators tripping, power outages and power grid disintegration.
- Consumers connected to the distribution utilities, though consuming active energy may or may not consume reactive energy.
- There may be consumers whose loads are predominantly inductive and other consumers whose loads are predominantly capacitive.
- There may be bulk consumers who have their own generators who operate their generators in synchronism with the grid, drawing active energy from the system or even exporting active energy into the system.
- The exchange of electricity is complex in such situations, and four quadrant energy measurements are needed to accurately measure the active and reactive energy under different export/import conditions for both active & reactive energy.
- These Meters are used for frequency-based tariff billing (15 min time block)
- These Meters are preferred for Grid Metering, Bulk Consumers, Generators and OA Consumers.

3.8.1. ABT Features:

- ABT brings about enhanced grid discipline
- Economically viable power with right pricing
- Promote competition and efficiency
- Encourage use of Merit Order Dispatch / Economic Dispatch in India.
- Addressing grid disturbance issues
- Gaming and avoiding the same
- Requires special meters, remote metering with open protocols and communication mechanisms to read meters timely
- Software that is comprehensive to do calculations, address regulatory issues and modifications as per different Regulatory Commission requirements.
- Interface options to various stakeholders in the ABT mechanism on line to enable effective implementation and **benefits to all*** Capability of power producers to be able to control their cost of production as well as flexibility in operations.

3.8.2. ABT drawbacks:

- Whenever distribution feeders from a substation are switched on after a break down or scheduled power cut, it should be done only when grid frequency is above 50 Hz such that it does not lead to steep drop in the frequency. The total numbers of feeders switching on, in a day are substantial at national level to cause load (≥ 500 MW) increase on the grid to cause wide fluctuations.
- The incentives and disincentives are prefixed (annually/periodically) by the electricity regulator (CERC) for the variation in the grid frequency which may not reflect the actual situation temporally and spatially on day-to-day basis. There is a need to decide the electricity tariff by the grid participants (generators, discos, Transco's & final consumers) on day-to-day basis for achieving further fine tuning. To correct these anomalies, CERC has proposed 100% sale and purchase of power produced in day ahead market.
- The ABT mechanism aims to maintain grid frequency at 50 Hz but does not permit the grid participants to decide the optimum frequency within the permitted frequency band (say 49.20 to 50.80 Hz) on day-to-day basis. This is required not to impose additional load shedding/power cuts when frequency is within the safe variation limits.

CHAPTER-4

SMART METER

Being a limited and very important resource, the metering of electricity consumption is essential. Generally, people don't care for the consumption of electricity in their day to day processes and are concerned about it when they get their electricity bills or in case of power shortage. Measuring of electricity consumption was started with Electromechanical Induction meter which operates by counting the revolutions of a metal disc rotating at a speed proportional to the power.

Later in 1990s Electronic meter was introduced which use LED or LCD displays and can also transmit readings to remote places but they could use only one-sided communication. This process is also referred as Automated Meter Reading. Further to improve the communication between utility and costumers and for time wise billing first generation of Smart meter was introduced in 2005. Smart meters are the new generation devices which are used by utilities for electronic measurement and to remotely communicate information for billing customers and operating their electric systems. These meters can take the reading and send the information to the control office repeatedly in small time intervals. Control office can monitor the meters because a two-way communication is used in smart metering system which is commonly known as AMI. AMI is capable of detecting power outages and monitoring voltage profiles. Being two-way communications, the consumers will have the information about their daily electricity consumption along with its cost and thus they will try to minimize it by its sensible utilization. This will also help in protecting our valuable Mother Nature and environment.

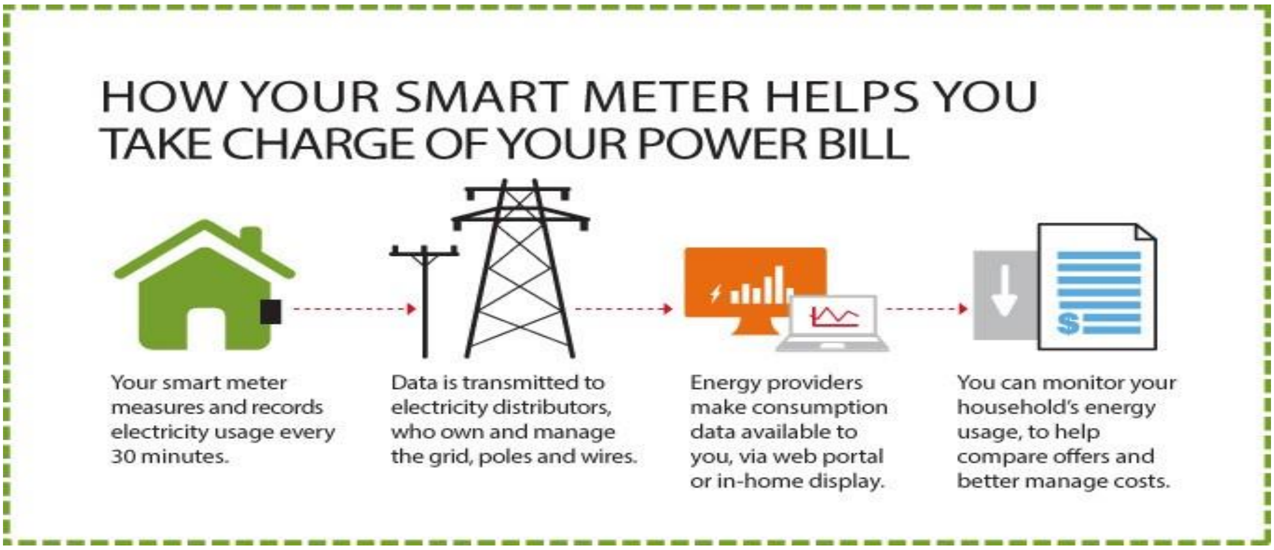

Fig.4.1. Smart Meter

Fig.4.2 Smart Meter

Smart meters work through two-way communication via a wireless or Powerline communications network. Not only is the data transmitted to your own personal energy monitor, but it's also distributed to your energy provider.

They enable you to monitor the amount of energy you're using in real time, keeping your energy company updated and ending the need for inconvenient knocks on the door.

They usually come with a monitor, which give you detailed information as to the amount of energy you're using. This means you'll be able to adjust your consumption accordingly, potentially saving you quite a bit of cash.

Plus, better still, they can bring an end to estimated billing – meaning you're only charged for the energy you actually use. Essentially, it means power to the consumer.

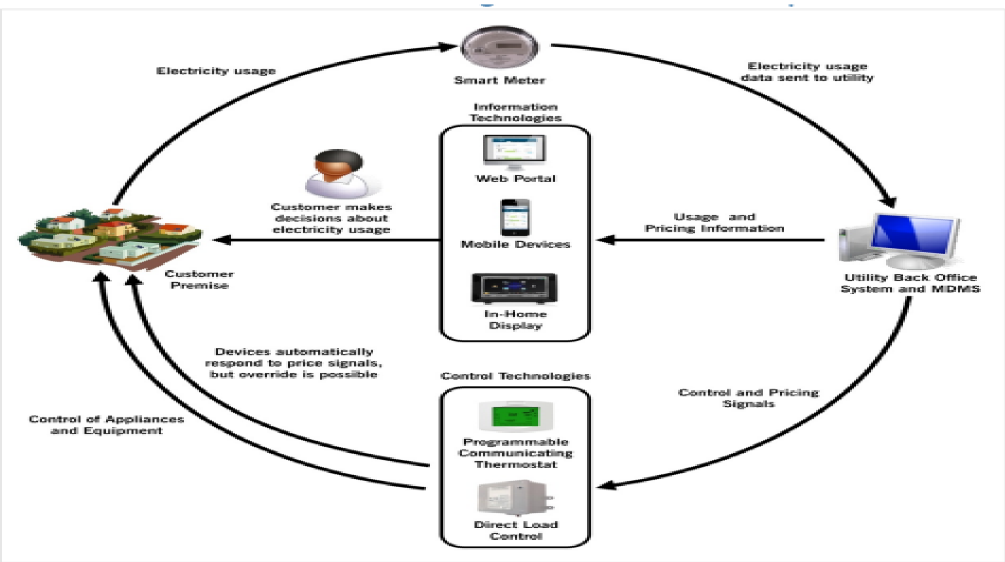

Fig.4.3 AMI and Customer Systems Work Together to Automate Functions and Manage Demand-Side Consumption

4.1. Advanced Metering Infrastructure (AMI):

4.1.1. What is Advanced Metering?

Advanced Metering is a broad term that can be used to describe Automatic Meter Reading (AMR) or Advanced Metering Infrastructure (AMI) programs. In general, the technology enables automatic communication between meters or sensors and a utility.

AMR systems enable one-way communication from a meter to a meter-reading device. Data is collected at regular, pre-determined intervals (daily, weekly, monthly, etc.) by walk-by, drive-by, or fixed network methods, and is provided to the utility for billing.

AMI is an integrated system of smart meters, communication networks, and data management systems that enables two-way, real-time communication between utilities and customers.

Fig.4.4 Advanced Metering System

4.1.2. Benefits AMI:

Benefits AMI enables a wide range of capabilities that can provide significant operational and efficiency improvements to reduce costs, including:

- Remote meter reading and remote connects/disconnects that limit truck rolls.
- Tamper detection to reduce electricity theft.
- Improved outage management from meters that alert utilities when customers lose power.
- Improved voltage management from meters that convey voltage levels along a distribution circuit.
- Measurement of two-way power flows for customers who have installed on-site generation such as rooftop photovoltaic (PV).

4.1.3. AMI deployment typically consists of three key components:

- Smart meters installed at the customer's premise that typically collect electricity consumption data in 5-, 15-, 30-, or 60-minute intervals.
- New or upgraded communications networks to transmit the large volume of interval load data from the meter to the utility back offices.
- A meter data management system (MDMS) to store and process the interval load data, and to integrate meter data with one or more key information and control systems, including head-end systems, billing systems, customer information systems (CIS), geographic information systems (GIS), outage management systems (OMS), and distribution management systems (DMS). (Not all utilities used an MDMS.)
- Integration with Information and Management Systems Participating utilities aimed to extract as much value as possible from their smart meter deployments by integrating smart meter data with one or more information and data management systems, including:
  - **MDMS:** process and store interval load data for billing systems, web portals, and other information systems.
  - **Billing systems**: process interval load data to automate bill generation.
  - **CIS**: process data from MDMS and connect with billing systems for storing data on customer locations, demographics, contact information, and billing histories.
  - **OMS**: process data about meter on/off status to isolate outage locations and often connect with GIS for dispatching repair crews and managing the restoration of services. Outage data from smart meters is made more valuable to grid operators when it is integrated with GIS and data from customer call centers.
  - **DMS**: process data on outages and customer voltage levels for implementing electric reliability and voltage and volt-ampere reactive (VAR) optimization procedures.

4.1.4. Smart Meter Infrastructure:

Major components of smart metering infrastructure are smart meter, communication network, meter data collection system and meter data management system. Smart meter measures energy usage at different time intervals and transmit measured data to utility through communications technology networks. This infrastructure shall provide a reliable, efficient and secure power supply to the consumers and reduce the cost of electricity. In this paper, we review smart metering infrastructure model, smart metering infrastructure communication network options and outline smart metering infrastructure challenges.

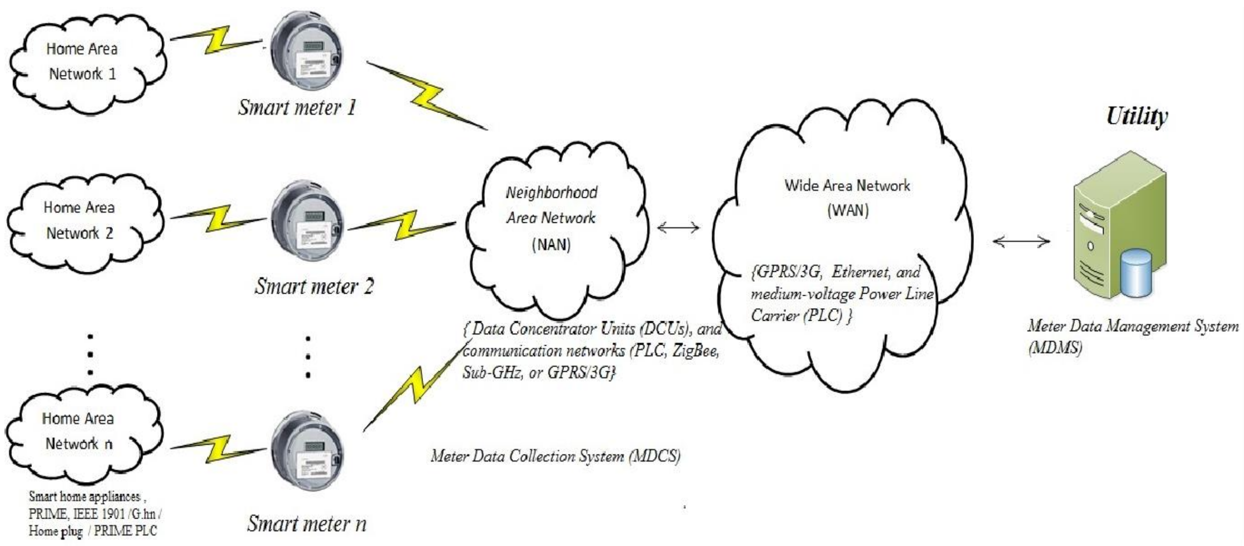

Fig.4.5 Smart Metering Infrastructure Network

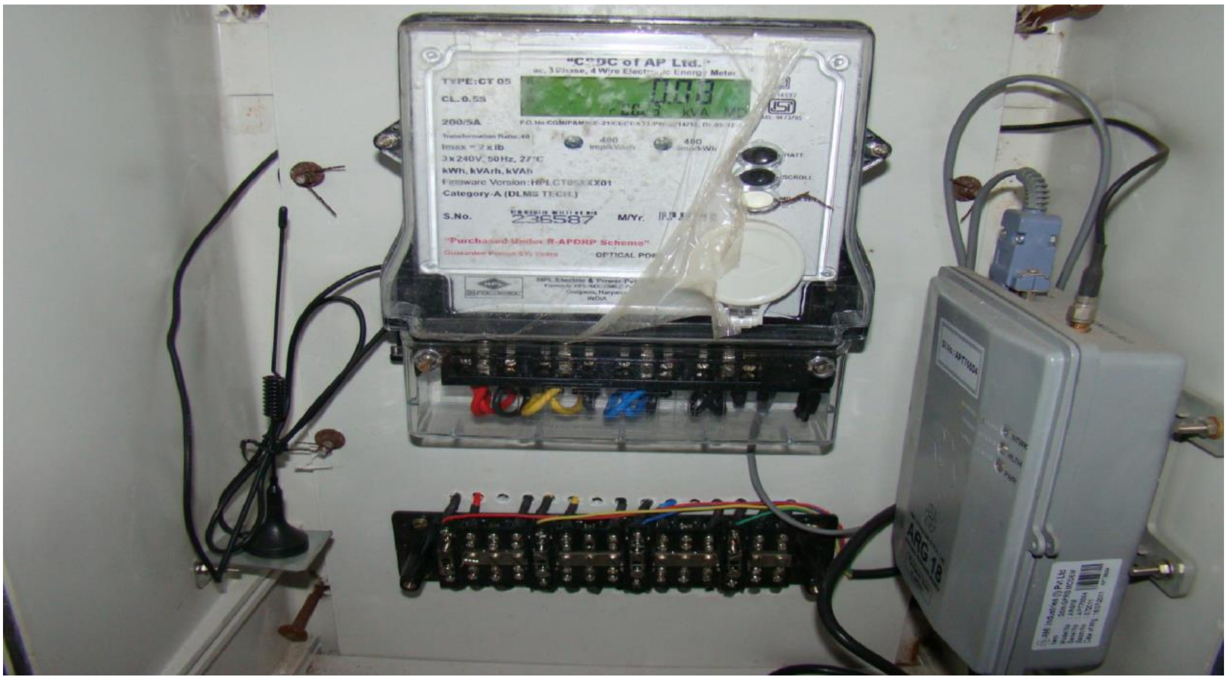

Fig.4.6. DLMS Meter with MODEM

4.2. Components Of Smart Metering System:

The main components inside smart meter are:

- Advanced Measuring Device.
- Communication Network Management.
- Meter Data Management.

4.2.1. Advanced Measuring Device:

It consists of the following

- A small transformer that steps down the voltage to 10V ac
- A microprocessor core, a real-time clock, flash memory, and an LCD driver
- A low power dual operational amplifier and a medium power amplifier IC
- Around 1 GHz SOC with a microcontroller and some bytes of flash memory
- Time differentiated registers, Connect/disconnect switch and LCD/LED display
- In home display: It is a device which details the usage of data in a graphical and user-friendly manner.

4.2.2. Communication Network Management:

Electricity meter communicates with LDCs using the low voltage power supply cables between the meters and the transformers which come under Local Area Networks (LANs) and it is used for short distance communication. Communications between LDCs and the Central System Controller may be provided virtually by any standard Wide Area Network (WAN) medium, including PSTN telephone lines, GSM, X-25 packet switched radio and microwave Links.

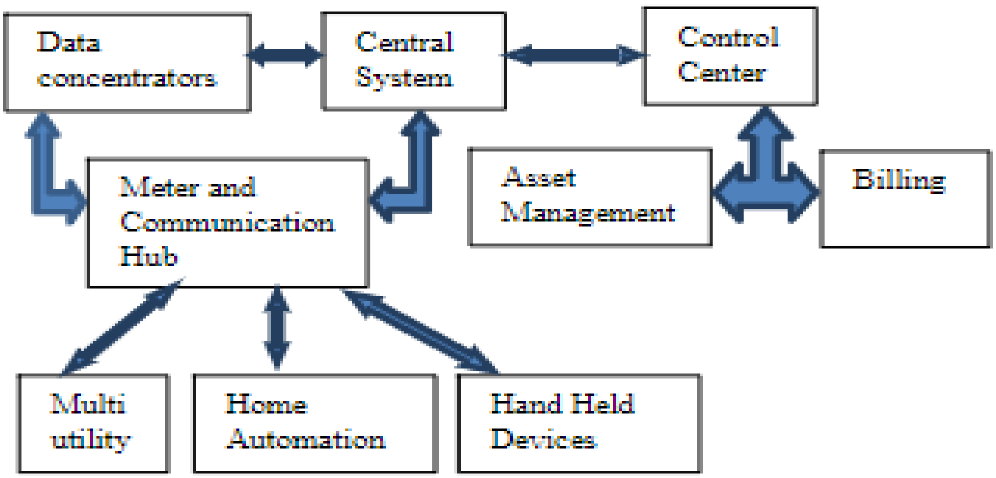

Fig.4.7. Communication Network Management

4.2.3. Meter Data Management (MDM):

It should be able to collect at least following information.

- **Meter registrations**: serial numbers, meter types, location and programmed data.
- **Local Data Concentrators (LDCs):** location, serial numbers and programmed functions.
- **Meter data extraction:** Customer details, Customer transaction records, Peak demand and load curve.
- Tariff structures and prices, Invoice generation, maintenance and Payment transaction records
- Error logs and message texts, System activity and maintenance logs.
- System administration records

4.3. DCU (Data Concentrator Unit):

Data Concentrator Unit (DCU) is the backbone of Advanced Metering Infrastructure (AMI) that helps in data acquisition, transfer of energy data to the central database, and automated meter reading in electronic energy meters. DCUs are primarily used in low voltage electric power systems.

Fig.4.8.DCU

4.3.1. Technical Specifications:

- 32-bit ARM9 hardware platform
- Linux Operating System Platform
- GPRS Communication Technology
- Electric Power Carrier Communication Technology

4.3.2. Distinguishing Features:

1. Data collection
2. Data Storage
3. Data Recovery, Alarming
4. Time Hack Function
5. On site Copying function

1. Data collection:

- Demand data reading
- Day data reading
- Billing data reading
- Key users profile data reading
- Power quality profile reading
- Event reading

2. Data storage:

- Capacity of one concentrator: 1024 pcs PLC meters
- Data storage period
  - ➢ Curve of daily data: 60 days
  - ➢ Monthly billing data: 12 months
  - ➢ 96 hourly curve data of 20 key users in 10 days
  - ➢ Record of last 1024 events
  - ➢ Data Storage Capacity: 32MB

3.Data Recopy, Alarming:

- In case of automatic meter reading failures, the concentrator initiates a retransmission mechanism. The number of retransmissions can be configured and the default transmission value is 3.
- When the concentrator fails to read the meter in desired time interval, the concentrator re-reads the meter 'n' times to achieve the desired time interval ('n' can be configured). If untimely reading errors exceed 'n', the concentrator sends a warning to the main station

4. **Time Hack Function:**

- Concentrator's time can be adjusted by the main station.
- The master station can ascertain the start-time and end-time for day light saving in concentrators.
- Supports Persian and Gregorian calendars

5. On site Copying function:

- Support optical port (IEC61056-21)
- Support RS485 (IEC62056-46)
- Self-diagnose & Abnormal information record
- Remote control function
- Upgrade function
- Key users Monitor
- Data Security
- Inbuilt Web server

4.4. Working of Smart Metering System:

The three main internal areas of a smart meter design include the power system, microcontroller, and communications interface. The power system has a switched mode power supply and battery backup to ensure that the metering electronics remain powered even when the main line is disabled. A Micro Controller Unit (MCU) typically includes an Analog-to-Digital Converter (ADC) and Digital-to-Analog Converter (DAC) to provide intelligence. Finally, a wired or wireless communication interface allows the meter to interact with the rest of the grid, and in some cases the end user's network. The main and auxiliary sections of a smart meter design are shown below.

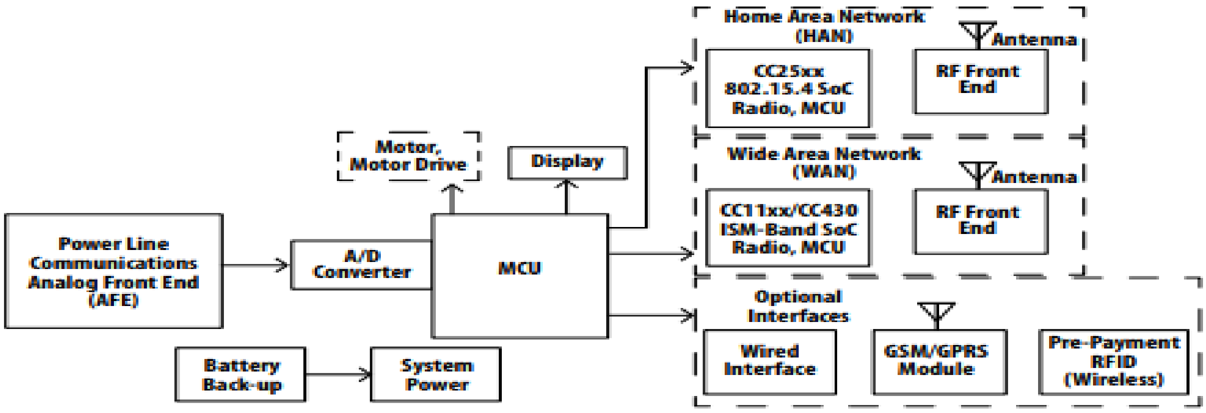

Fig.4.9. Smart Meter Block Diagram

Power System:

A switched-mode power supply provides power to the electronics in the meter, converting from the main line Alternating Current (AC) voltage to the Direct Current (DC) voltages required. A switch will turn on the battery backup AC/DC only when there is no power from the main line. The battery remains isolated from the power system during normal operation.

Microcontroller:

While a microcontroller is of central importance to the design, there are several possible levels of integration with the other functional blocks in the system. The figures below illustrate three possible architectures for a smart meter that all include Analog Front-End (AFE) metrology, ADC, Digital Signal Processor (DSP) or MCU, and communications. The first example is a two-chip solution that provides flexibility for system upgrades. Second is a single-chip solution with tight hardware and software integration, making it less flexible for upgrades or modification. The data transmission over the network, shown third, may be the best communication solution depending on the location.

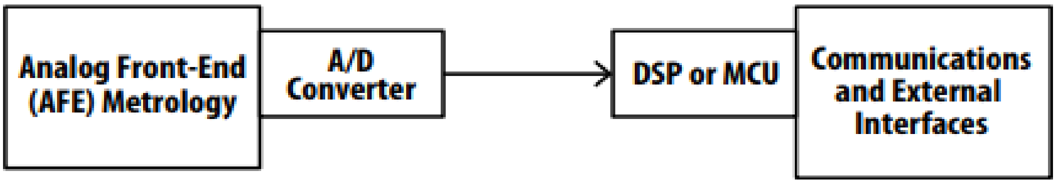

Fig.4.10. Two-Chip Architecture

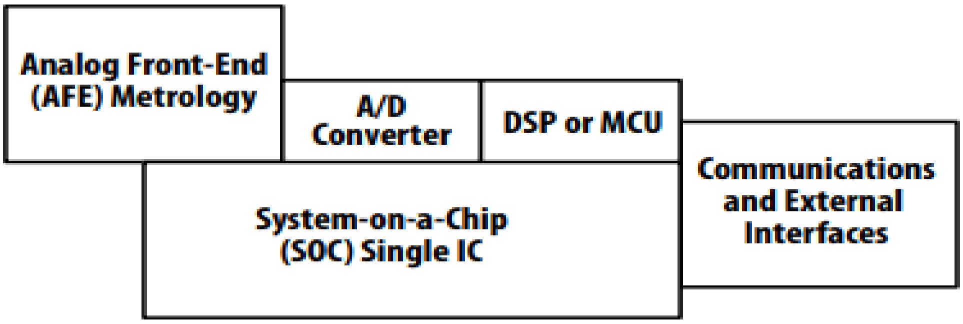

Fig.4.11. Single-Chip Architecture

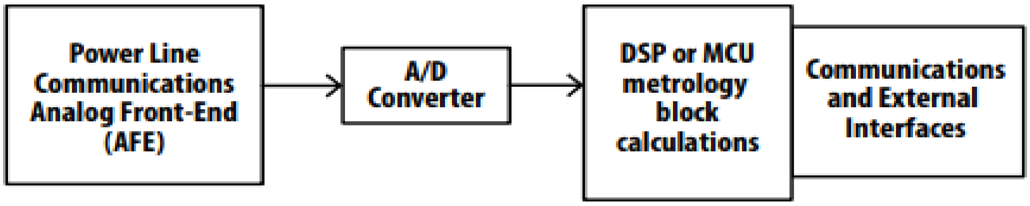

Fig.4.12. Network Architecture

As with the microcontroller architecture, no single solution has been adopted for communication between the smart meter and the utility or end user. Communication protocols vary widely based on factors such as geographical regions, location of an individual meter, what is supported by the utility servicing the area, and the maturity and longevity of those supported technologies. Wireless protocols are quickly emerging as the preferred method of connecting the networks within the grid. Radio Frequency (RF) based technology is changing the way that customers and the utility company interact with the use and sale of resources.

In some cases, smart meters act as the gateways for home automation, using RF signaling such as Zigbee® to communicate the resource pricing and consumption to the end user. Devices operating with 6LoWPAN, Zigbee®, and RFID are examples of RF based technology connected with RF mesh networks. Cellular solutions make use of the existing cellular network to transmit metering information. Broadband over Power Line (BPL) has been viewed as a potential replacement of POTS and cable networks for providing broadband, though it is not in service in all areas. It is desirable for a network to be capable of connecting a variety of device types, like WiMAX, since it increases the interoperability of equipment from different manufacturers following numerous protocols. With this variety of protocols, the equipment that supports communication in the grid will be quite diverse. The following table outlines a selection of the types of equipment that are found in these networks.

Network Type	Equipment
RF Mesh Networks	Bridges, relays, routers, access points, wireless gateways
Cellular	Cell relays, access points
Broadband over Power Line (BPL)	Gateways, bypass equipment
WiMax	Routers, access points

Table-1 Networks used for different equipment

4.5. Report Analysis of Recorded Electrical Parameters:

Instantaneous Electrical Parameters like Voltage, Current, Power factor, Active Power and Reactive Power Can be viewed at any given point of the time.

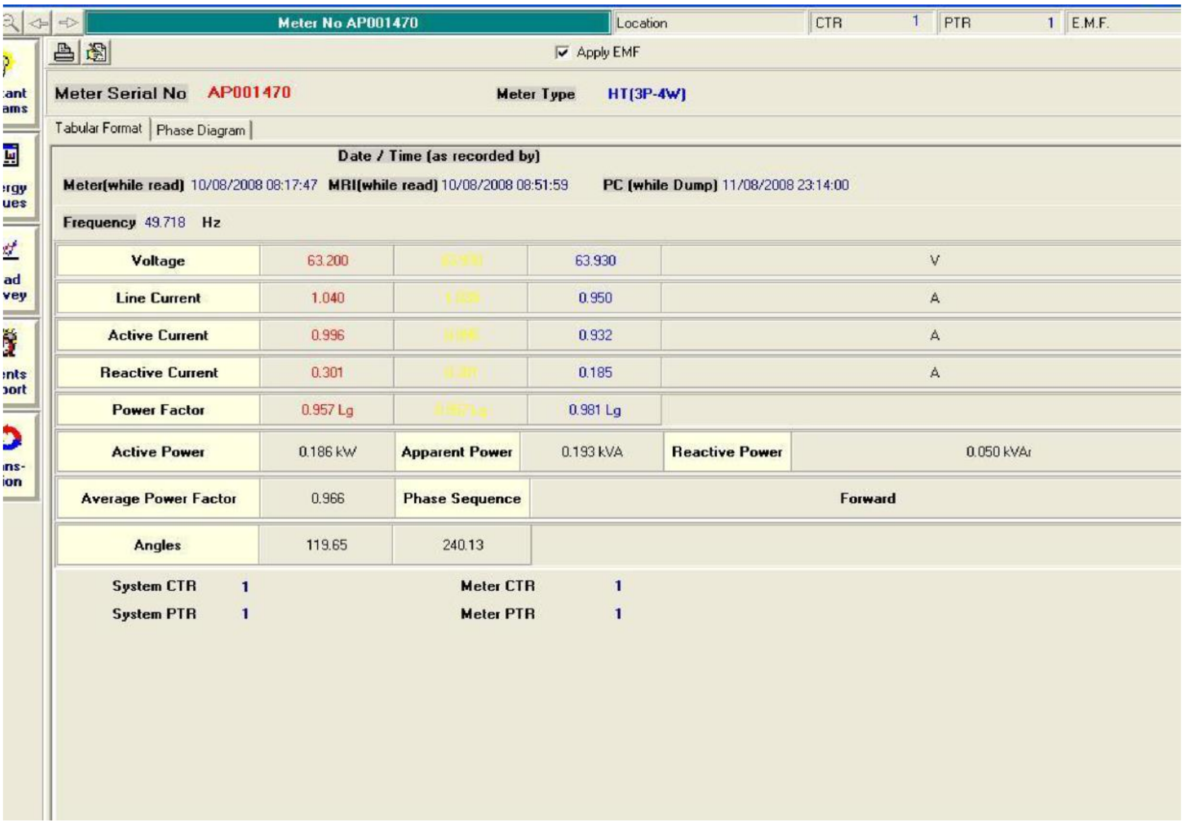

Fig.4.13. Measured Electrical Parameters representation of a meter

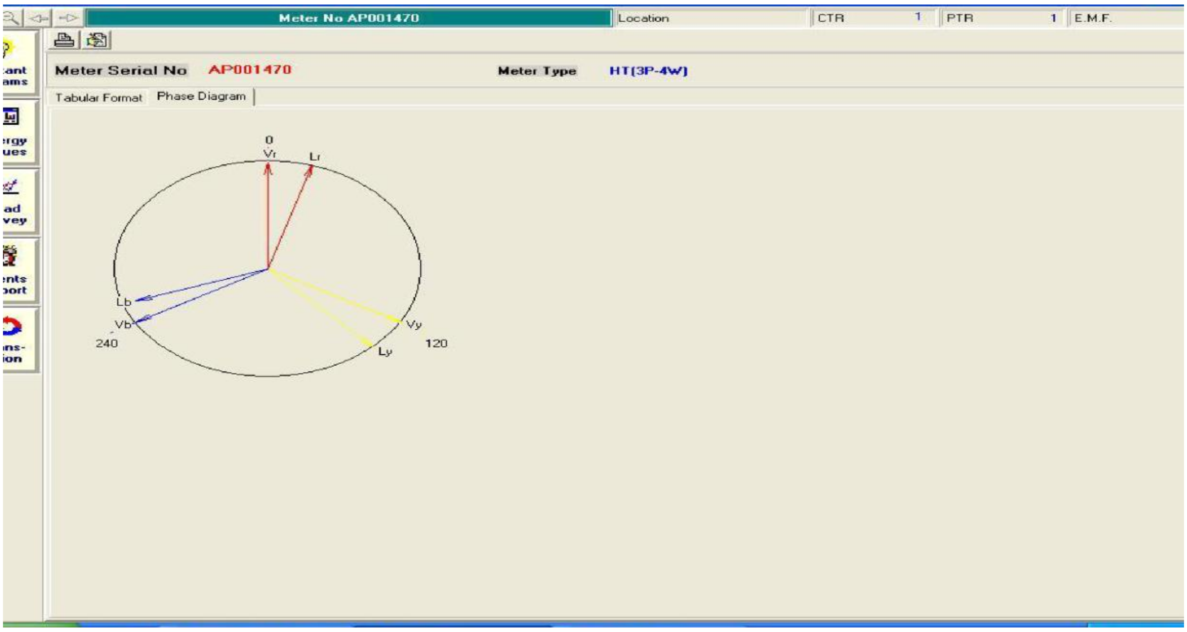

Fig.4.14. Phasor Diagram of a Meter

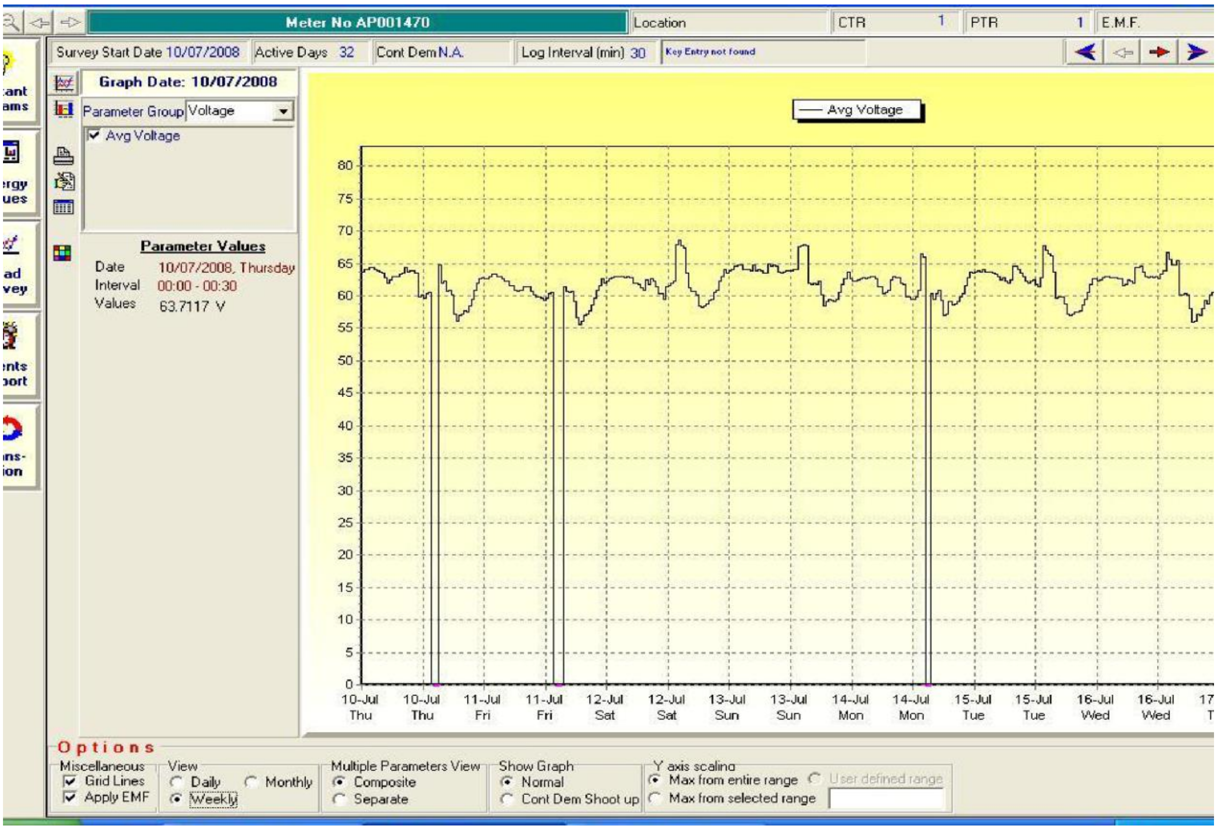

Fig.4.15. Average Voltage representation of a particular Meter

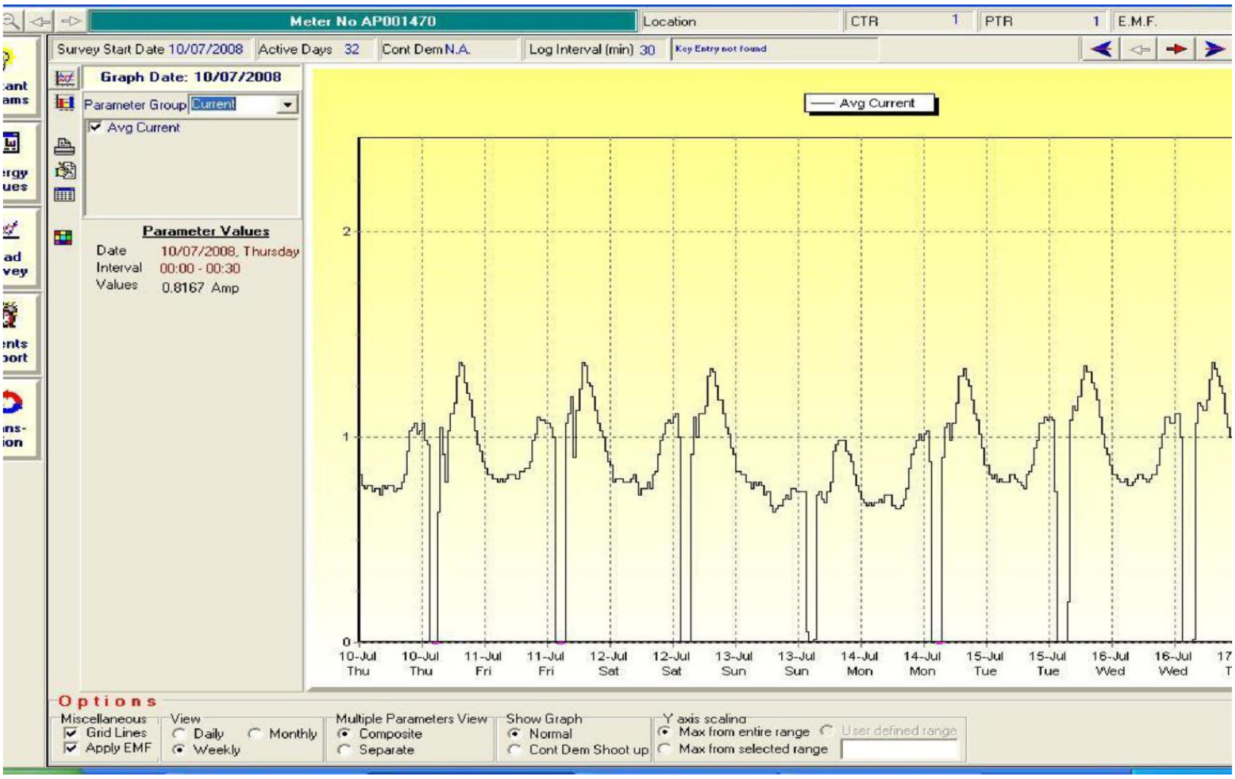

Fig.4.16. Average Current representation of a particular Meter

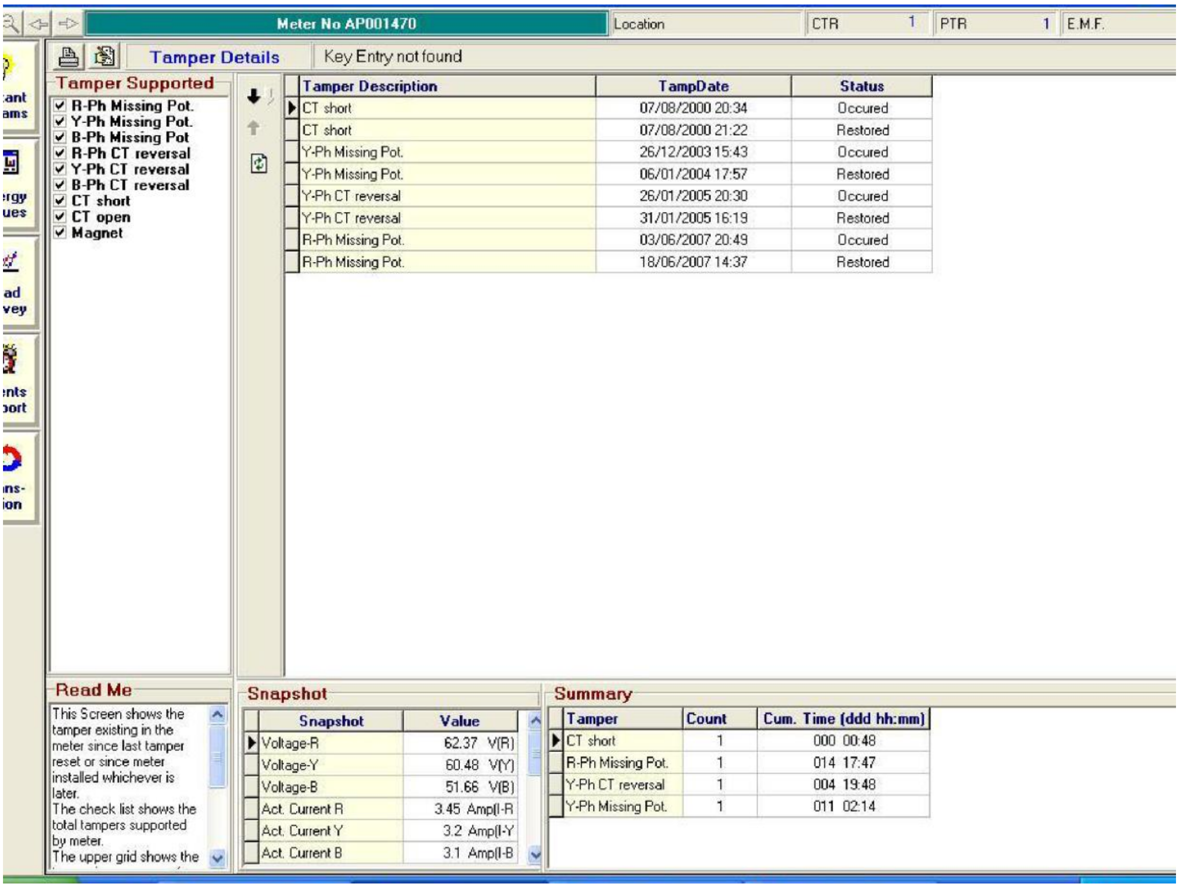

Fig.4.17. Tamper Details of a meter

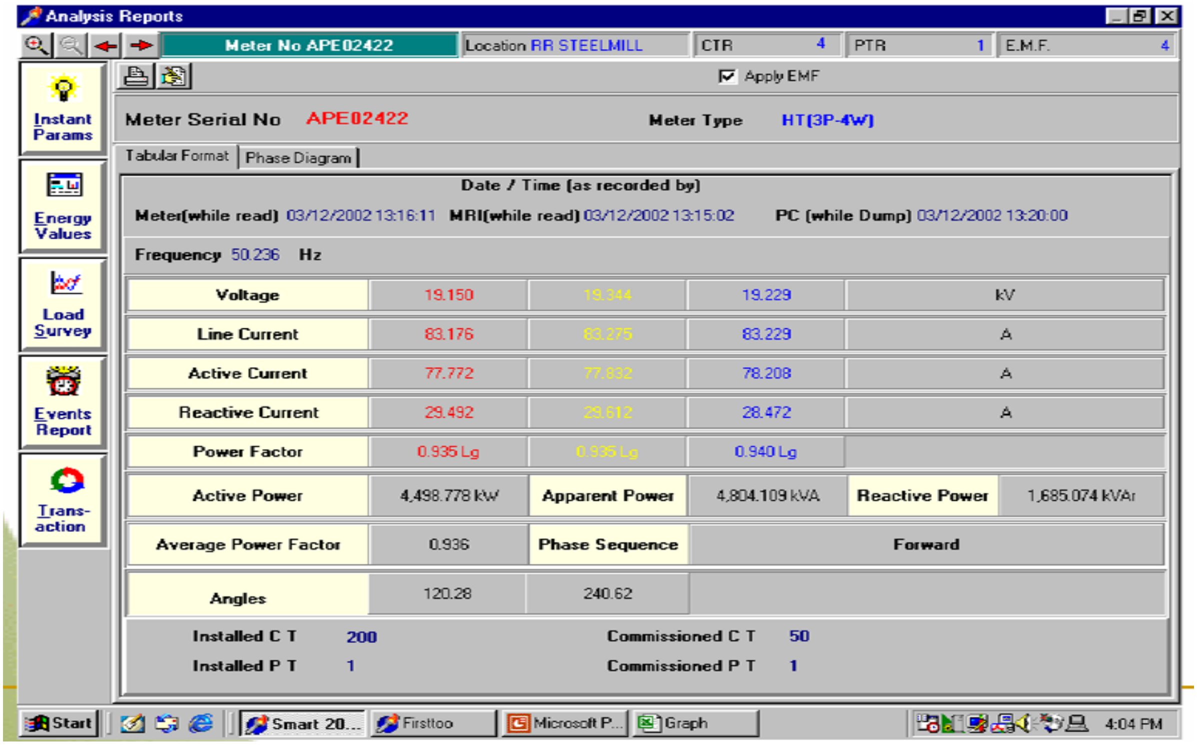

Fig.4.18. Measured Parameters of a Meter

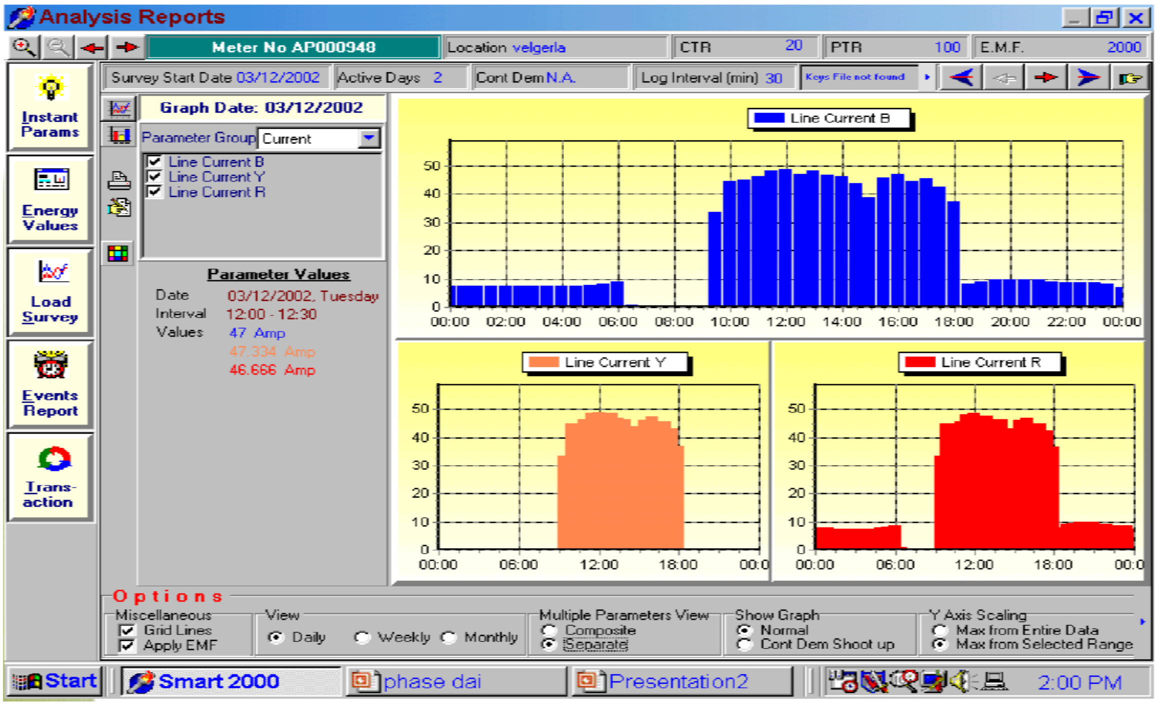

Fig.4.19. Phase wise current status representation of a meter

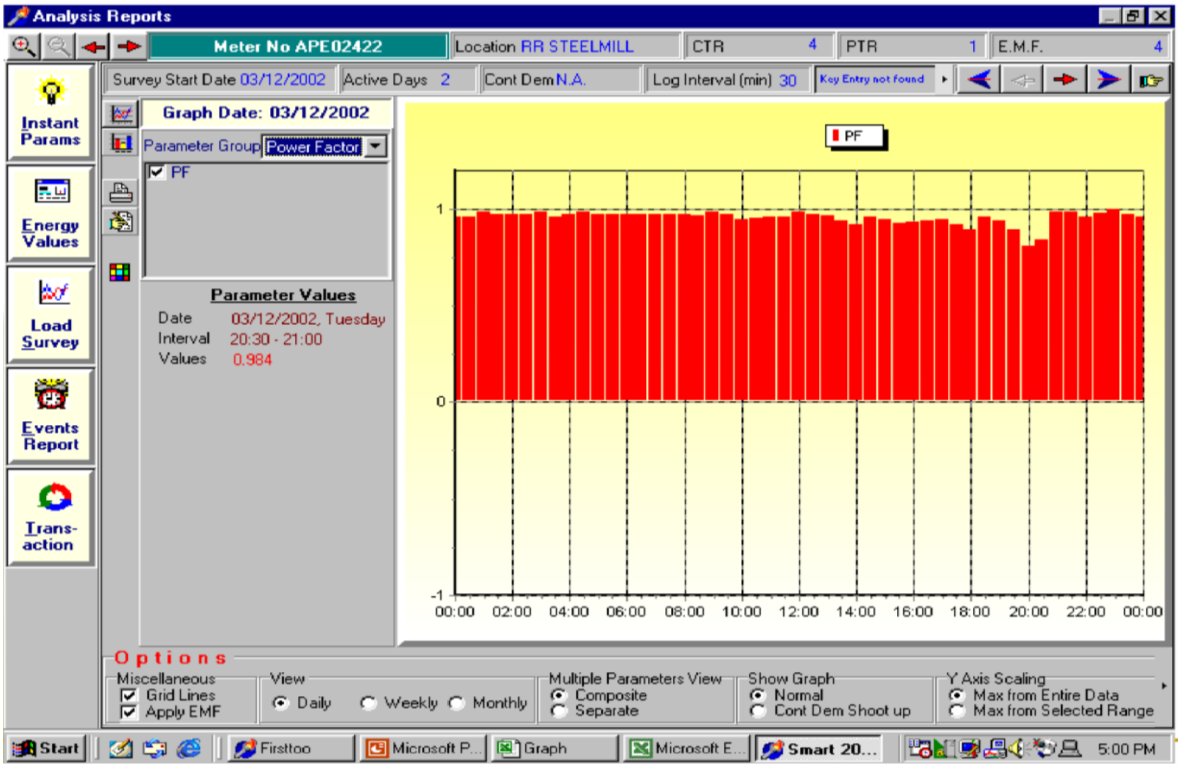

Fig.4.20. Power factor during the day of a particular meter

4.6. Benefits of Smart Meter:

- **Automatic outage detection and restoration**: Smart meters quickly notify your electricity distributor if your power is out. The problem can be located faster, repair crews can be allocated in a priority manner and repairs can begin sooner.
- **Smoother switching between retailers -** As your meter is read daily, you no longer need to wait for weeks or months to switch retailers. Connecting, disconnecting or switching to a new electricity retailer is cheaper and easier because you can get onto a better plan and start saving more quickly.
- **Flexible pricing -** On a flexible pricing plan the cost of electricity changes according to what time of the day you use it. The technology of smart meters has made it likely that other innovative pricing options will also become available in the future.
- **Smart appliances / smart thermostats -** You can time when your appliances will start, or turn them on remotely. A smart thermostat takes all the guesswork out of keeping your house at the right temperature.
- **Solar -** You can easily monitor what percentages of solar and mains electricity you are using and change your usage patterns to take advantage of your solar generation.
- **Remote meter readings**: Your meter is remotely read, eliminating the need for manual meter reading. This means you will no longer receive estimated bills.
- **SMS Notifications from Distributors of Power Outages**: Victorian electricity customers can register for a free SMS service to notify of major electricity outages. You will receive information about outages in your area and the estimated restoration time.
- **Monitor your energy -** You can monitor your own usage in almost real time using web portals and in-home displays. This means you can have more control over your daily energy use.
- **Energy alerts -** You can set up your system to receive messages warning you of excessive energy consumption, giving you the opportunity to take action.
- **Cheaper costs when moving house -** Power companies can now remotely turn power on or off, which means that disconnection and reconnection fees have dropped.

4.7. Smart Meter Challenges:

Smart meters present these challenges and costs to the electric company:

- Transitioning to new technology and processes.
- Managing public reaction and customer acceptance of the new meters.
- Making a long-term financial commitment to the new metering technology and related software.
- Managing and storing vast quantities of metering data.
- Ensuring the security of metering data.

Smart meters pose these challenges to consumers:

- Verifying that the new meter is accurate.
- Protecting the privacy of their personal data.
- Paying additional fees for the new meter.

CHAPTER-5

PREPAID METER

Electric energy meters, the direct billing interface between utilities and consumers for long, have undergone several advancements in the last decade. The conventional electromechanical meters are being replaced by new electronic meters to improve accuracy in meter reading. Still, the Indian power sector faces a serious problem of lean revenue collection for the actual electric energy supplied owing to energy thefts and network losses. One of the prime reasons is the traditional billing system which is inaccurate many times, slow, costly, and lack in flexibility as well as reliability. Therefore, attempts are being made to automate the billing systems. Even though more accurate and faster meter readings have seen the light of day, bill payment is still based on an old procedure. They require an individual/agent to personally come down to customer place and note the meter readings and report the amount one has to pay to the household/office.

Fig.5.1. 1-Phase Prepaid Energy Meter

But the demand for computing power at all levels of electronic systems is driving advancements in semiconductor chip technology. The AMR and power quality monitoring systems manufacturers are taking advantage of these advances and integrating them into new meters and instruments. The networking technologies are driven by the demand for interconnection of computer users worldwide. The AMR and power monitoring systems are using these advances to expand the monitoring systems.

A Prepaid Energy Meter enables power utilities to collect electricity bills from the consumers prior to its consumption. The prepaid meter is not only limited to Automated Meter Reading [AMR] but is also attributed with prepaid recharging ability and information exchange with the utilities pertaining to customer's consumption details. The idea of prepaid metering will be very important for the new research fields of Micro-grid and Smart Grid and is an inevitable step in making any grid smarter than it is now.

Literature has witnessed quite an amount of work in this area. The use of electronic token prepayment metering has been widely used in UK for customers with poor record of payment. A paper suggests a design of a system which can be used for data transmission between the personal computer and smart card. The device will transmit the data in half duplex mode.

The system designed in this project can be used to develop more complex system where a smart card can be used to several applications including prepayment. Another paper features a 3-tier smart card secure solution for a novel prepaid electricity system. It uses an IP-based controller in addition to a power meter, providing efficient online control of the amount of electricity consumed by the user.

Prepaid meters can also make use of state of art technologies like WiMAX owing to the idea of centralized accounting, monitoring and charging. It brings telecommunication to the core of its activities to support more Smart Grid applications such as Demand Response and Plug-in electric vehicles.

Prepayment polyphase electricity metering systems have also been developed consisting of local prepayment and a card reader-based energy meter. In this paper, we have attempted to initiate a different idea of using mobile communication to remotely recharge as well as bill the consumer's energy consumption. A prepaid card capable of communicating with power utility using mobile communication is attached to the energy meter. The idea has been successfully implemented in MATLAB and results obtained have been presented.

5.1. Design of Prepaid Energy Meter:

The proposed idea is not to replace the existing energy meter and chalk out a completely new prepaid meter but up-grade the available energy meters to prepaid meters. Thus, our design primarily has an energy meter, a prepaid card and the communication module encapsulated and provided as an upgrading attachment along with a contactor and a liquid crystal display (LCD).

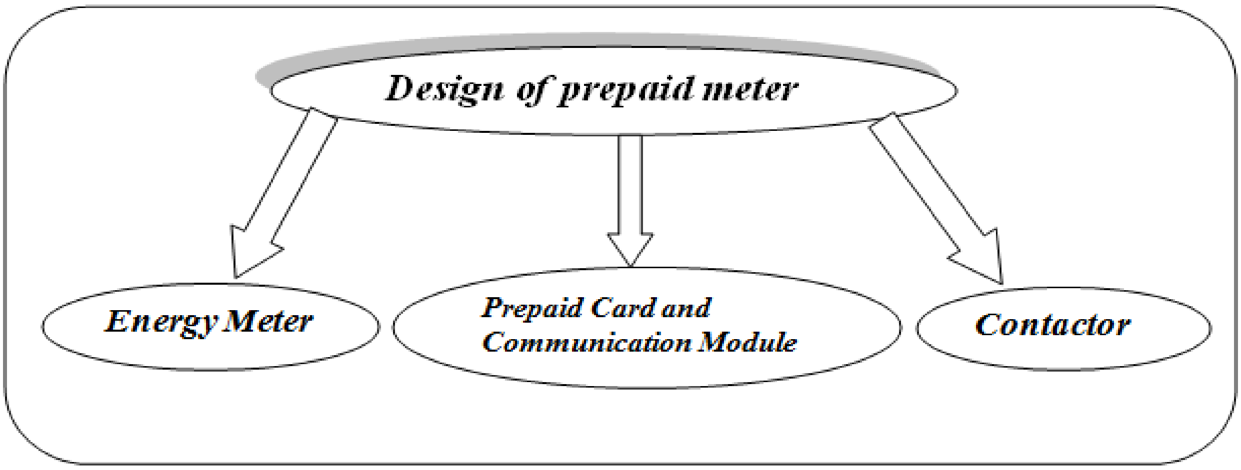

Fig5.2. Design of Prepaid Energy Meter

Energy Meter: The electromechanical energy meter calculates the electrical energy or units consumed by the load based on the mechanical energy of the disk or rotor. The electronic meter has this existing structure attached with a microcontroller programmed to perform specific calculations and present it in terms of electrical energy units consumed to a prepaid card. The meter is also connected to a contactor apart from the consumer load.

Prepaid Card and Communication Module: The prepaid card is the most important addition to the design. The power utility sets the amount in the prepaid card to a measure that the consumer recharges the card to, called Fixed Amount. The tariff rates are already programmed and fed into the card. As the load is consumed, the meter sends the units consumed to the prepaid card which continuously converts these units into expenditure at each instant and then subtracts it from the fixed amount. The communication module uses mobile communication to share prepaid card balance with power utility at certain instants as required by utility for tracking the balance and also for any other application e.g. Demand Side Management (DMS) etc. The fixed amount in the prepaid card will go to zero eventually with the consumption. The consumer can recharge the prepaid card by prepayment through internet. The utility on receipt of recharge request and desired prepaid amount, recharges the customer's energy meter i.e. prepaid card. The prepaid card sends a signal to the contactor for monitoring the supply to the consumer. The communication module has prepaid card encapsulated inside the encryption authentication module which is Embedded Security Access Module (ESAM). It thus enables the card to use the mobile communication to communicate with power utility and share information regarding the card's balance details.

Contractor: A local contactor is the connecting link between the consumer load and utility supply. The opening and closing of this contactor depend on the balance present in the prepaid card at a moment. While the prepaid card has some fixed amount more than zero, it stays closed and keeps the utility supply uninterrupted to the consumer load. When the card runs out of balance, it opens and disconnects the load from the supply. Hence, even when the energy meter receives voltage supply, it does not reach the load while the contactor is open because the balance in the prepaid card is not available. Since the contactor too will consume some amount of electrical energy, it will be inclusive in the calculations made by meter and prepaid card.

5.2. Working:

A simplest type of prepaid energy meter consists of 2 EEPROMs interfaced to a microcontroller. One EEPROM contains the recharged balance amount. The microcontroller reads this balance and stores it in the other EEPROM along with the tariff.

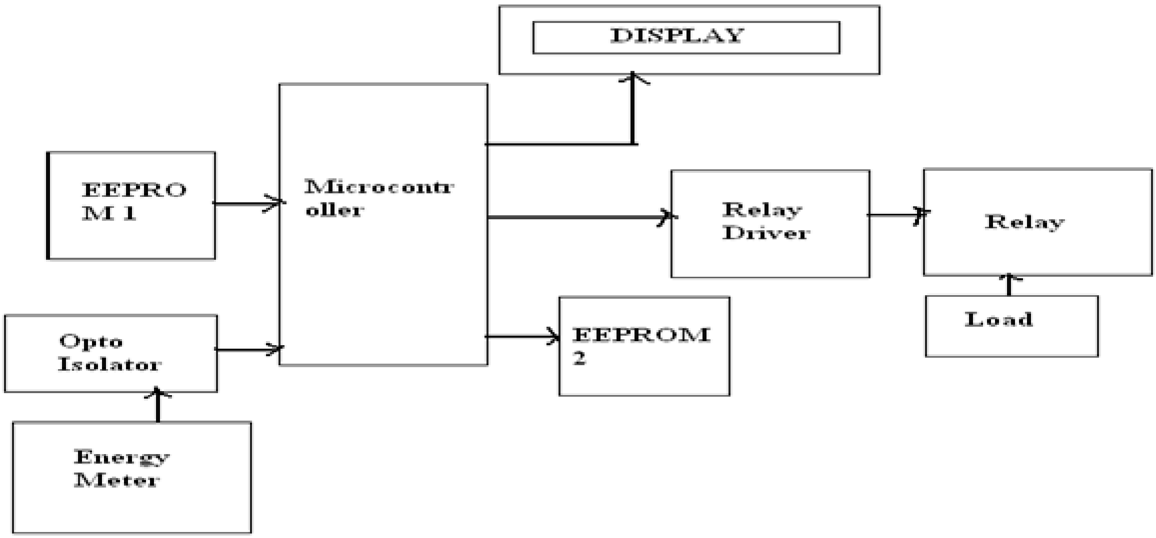

Fig.5.3. Block Diagram of Prepaid Energy Meter

The energy meter supplies pulses to the microcontroller for every unit of energy consumed. The microcontroller increases the spent energy unit by one and decreases the balance amount in the EEPROM by the fixed tariff. As soon as the balance amount in the EEPROM comes down to zero, the microcontroller sends a signal to the relay driver which in turn switches off the relay, such that the main supply to the load is switched off. An LCD is also interfaced to the microcontroller which displays the amount of energy consumed.

The recharge card is actually an EEPROM in which the balance amount along with the allocated energy units is stored. The Microcontroller reads the balance amount and stores it along with the tariff and the energy units allocated in its RAM and are programmed to delete off the information present in the EEPROM (making the card invalid for further use). The energy meter gives electric signal to the opto isolator which consists of an LED and an opto-transistor combination such that the LED glows and emits light for every electric signal received by the energy meter (which sends an electric signal for every unit consumed). The opto-transistor starts conducting and sends high and low pulses to the microcontroller. The microcontroller is programmed such that a counter is kept incrementing for every pulse rate, which gives the value of the energy consumed.

Another EEPROM is interfaced to the microcontroller where the balanced amount and the energy units consumed are stored. For every increment in count, the balanced amount in this EEPROM is deducted. Finally, when the balance amount is zero, the microcontroller sends a low signal to the Relay driver to give a high signal at its output, which switches off the relay. Normally the microcontroller gives a high signal to the input pin of the relay driver, which develops a logic low signal at its corresponding output pin and the relay coil is energized, thus connecting the load to the main supply.

5.3. Advantages:

- High accuracy over a wide current dynamic range.
- Reliability and robustness.
- Flexibility of design.
- Automatic Meter Reading (AMR).
- More easily enable new functionalities.
- Multi tariff billing.
- Tamper proofing.
- Prepayment meters.
- Power out range detection.
- Power factor detection.
- Easily reconfiguration, upgrade.
- Do not use gears that wear out or magnets that saturate with DC current.
- Do not require precision mechanics or have large tolerance variations over temperature.

5.4.DISADVANTAGES:

- The main disadvantage of the system is, because of huge electronic hardware involved in the system, the overall system consumes more electric energy.
- **Remedy*:*** When the system is converted into engineering module, the bulky hardware can be converted into a small-integrated chip. When the hardware is minimized naturally the system consumes less power.
- Since it is a prototype module, because of huge hardware the system occupies more space.
- The consumer or the electrical department has to spend more amounts for installing this kind of smart energy meters. Economically it is not advised.

CHAPTER-6

Net Metering

Net metering is a billing mechanism that credits solar energy system owners for the electricity they add to the grid. For example, if a residential customer has a PV system on their roof, it may generate more electricity than the home uses during daylight hours.

With the right size solar energy system, you can produce enough electricity to match your home's electricity use for the entire year. However, the amount of electricity your solar panels produce will vary throughout the year. Net metering helps your account for these differences by crediting you for the excess electricity your panels produce so you can use it later.

Fig.6.1. Net Meter

6.1. Construction & Principle:

The basic principle is simple – the producer (supply owner) has on the roof of his house for example a photovoltaic power unit and simultaneously is connected to the grid. They use both sources, so if the sun shines, they take electricity from photovoltaic s and if they need more power or during the night, they take it from the network. If they produce an excess the electricity is feed into the grid, "spinning the meter on the other way" this "performs a virtual storage using the grid". The electricity bill, which the individual manufacturer pays is then calculated by the difference in their production and consumption for any given period. A more precise term, sometimes used, is "net billing".

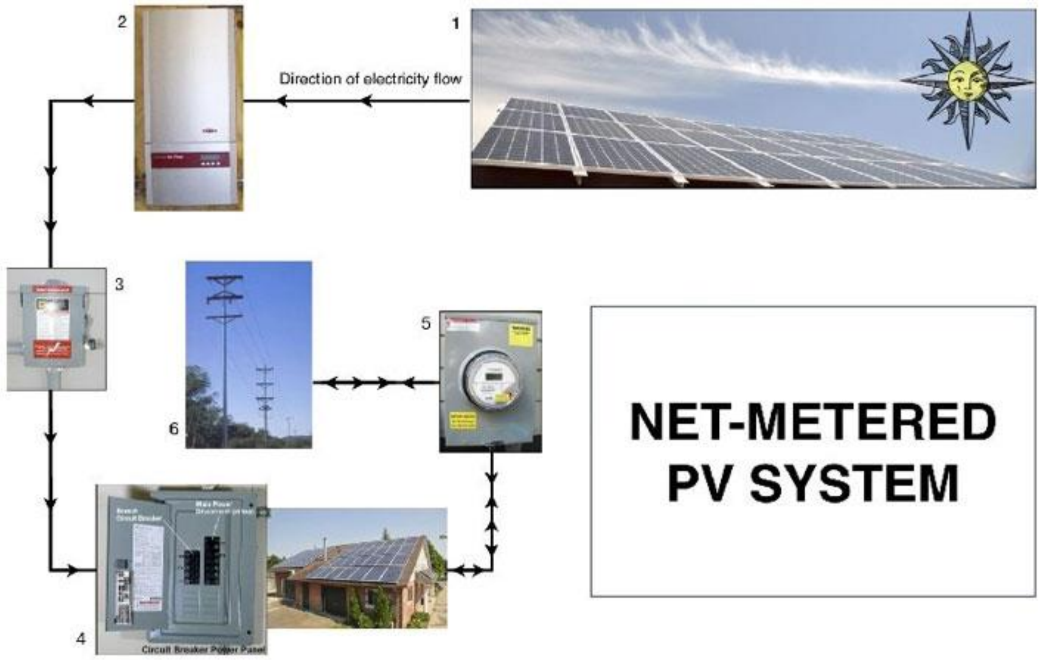

Fig.6.2. Schematic Diagram of Net Metering

Solar energy systems typically hit peak electricity production in the afternoon, when many people aren't home using electricity. By contrast, home electricity use is typically higher in the mornings and evenings. Net metering helps you to account for these ups and downs in your day-to-day electricity production and usage.

With net metering, excess electricity is fed into your electric utility's grid when your system is producing more than you need. When this happens, your meter actually runs in reverse. When your system isn't producing enough electricity, you can draw it from your utility just as you did before you went solar. This "back-and-forth" between your system and the grid ensures that your excess production will still be used and your shortages will be met. With net metering, the excess electricity your home produces cover the times when you don't produce enough.

When your solar power system generates more electricity than you use over the course of a month, your utility bill will receive a credit based on the net number of kilowatt-hours you gave back to the grid. If you produce less electricity than you use in a given month, you must buy electricity from your utility to make up the difference. In these instances, you would pay for the electricity you use, minus any excess electricity your solar panels generated.

6.2. Advantages of Net Metering:

The most obvious benefit of net metering is to consumers. If you install net metering in your home, you can reduce the amount of money you spend each year on energy. You can even make money if you produce more than you consume and your utility company pays you for that excess energy at the retail rate.

Here are a few other benefits of net metering:

- The system is easy and inexpensive. It enables people to get real value for the energy they produce, without having to install a second meter or an expensive battery storage system.
- It allows homeowners and businesses to produce energy, which takes some of the pressure off the grid, especially during periods of peak consumption.
- Each home can potentially power two or three other homes. If enough homes in a neighborhood use renewable energy and net metering, the neighborhood could potentially become self-reliant.
- It encourages consumers to play an active role in alternative energy production, which both protects the environment and helps preserve natural energy resources.
- Homes that use net metering tend to be more aware of, and therefore more conscientious about their energy consumption.
- It saves utility companies money on meter installation, reading and billing costs.

6.3. Disadvantages:

In the US, most often heard against energy companies (abroad generally called "utility"), which lose profits from the sale of electricity. First, selling less electricity and, secondly, there must from customers to purchase their excess electricity. With falling revenues while reducing the ability of energy companies to provide their services and maintain the infrastructure at the appropriate level. To maintain profits must increase distribution fee and other charges, which carry costs Net Metering for customers who still do not use the Net Metering. This, however, further motivate the customer to have purchased alternative sources of electricity, whose price continues to decline. So, there is a further reduction in the profits of energy companies and fee increases. Net Metering is in this case support regressive, since actual sources of electricity usually takes people who are doing better financially. Fees course, applies to customers who cannot afford their own power and Net Metering utilized.

States address this question usually different kinds of regulation Net Metering. These include capping power sources annually connected via Net Metering, determine the maximum amount redeemed or electricity purchase prices adjustable according to the size of the source.

However, as pointed out by "pro-renewable" organization, the problem is not so much Net Metering itself, as a general increase in the use of renewable energy sources in private ownership. Energy companies, namely does not operate any form of renewable energy sources, if they themselves do not own.

However, as shown by studies in California organization Vote Solar (prepared in accordance with the methodology of the California regulator CPUC), if next immediate costs off against other factors, not only energy companies, but also the taxpayers Net Metering eventually earn. I for energy companies is Net Metering (and the associated development of decentralized renewable energy sources) is advantageous at least in terms of reducing losses in the grid, the supply of cheap electricity at peak times or savings in the production of electricity from conventional sources. In terms of state (and hence taxpayers), then decrease the cost of reducing CO_2 emissions and develop renewable energy.

CHAPTER-7

CONCLUSION

Smart meters can record energy consumption in each half-hour period and communicate with energy suppliers and network companies. Because traditional meters are incapable of doing this, replacing traditional meters with smart meters is a necessary step towards enabling a future ‘smart energy system’ a system that uses information and communications technology to control electricity generation and use in near real-time to provide a more reliable and cost-effective electricity system. The government expects this to have significant economic benefits in the long term as renewable energy and electric vehicles become more widespread. In addition to enabling a smart energy system, the government sees smart meters as a way of reducing energy suppliers’ costs and encouraging consumers to pay more attention to the energy they use, reduce energy consumption and increase competition in the market.

The successful Pre-Payment system implementation by the utility, as well as the social acceptance among customers coupled with the Regulators support will prove to be a win-win situation for all the stakeholders. The payment system brings potential advantages with it, but there are certain issues which have to be addressed when moving from a conventional postpaid system to a prepayment system so that its introduction on a large scale proves to be beneficial to all the concerned.

Net metering offers multiple benefits helping us make a difference to the environment. The regulatory support from state bodies and improved grid reliability are therefore supreme for widespread adoption of solar systems under net metering in India. Net metering is a win-win situation where all are benefited. Solar energy and net metering are both in their initial stage and the blend of the two is a great incentive for more people to go solar, save money and the planet at the same time.

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