A PROJECT ON

" ENERGY ACCOUNTING, AUDITING AND REDUCTION OF LOSSES IN ELECTRICAL SYYTEM"

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APPENDIX – II

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"Save Energy for Benefit of Self and Nation"

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Declaration by the Guide

This is to certify that the Mr. MUKESHKUMAR U OJHA, a student of Executive MBA (POWER MANAGMENT), Roll No **500024816** of UPES has successfully completed this dissertation report on"**30.11.2015**" under my supervision.

Further, I certify that the work is based on the investigation made, data collected and analyzed by him and it has not been submitted in any other University or Institution forward of any degree. In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfillment for the award of degree of Executive MBA.

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APPENDIX – IV

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Definitions and Terms Related to Energy Accounting and Auditing

Alternative fuels: Fuels produced from waste products or biomass that are used instead of fossil fuels. Alternative fuels can be in gas, liquid, or solid form.

ASIDI: Average System Interruption Duration, reliability measure that includes the magnitude of the load unserved during an outage.

ASIFI: Average System Interruption Frequency, reliability measure that includes the magnitude of the load unserved during an outage.

Availability: Used to describe reliability. It refers to the number of hours the resource is available to provide service divided by the total hours in the year.

Backup power: Power provided to a customer when that customer's normal source of power is not available.

Base load: The minimum amount of electric power delivered or required over a given period of time at a steady rate, or the portion of the electricity demand that is continuous and does not vary over a 24-hour period.

Base load capacity: The generating equipment normally operated to serve loads on a 24-hour basis.

CAIDI: The customer average interruption duration frequency index. See power reliability for more information.
CAIDI=SAIDI/SAIFI=Sum of all customer interruption durations/Total number of customer interruptions

Capacitor: A device that maintains or increases voltage in power lines and improves efficiency of the system by compensating for inductive losses.

Capacity: The rated continuous load-carrying ability, expressed in megawatts or megavolt-amperes of generation, transmission, or other electrical equipment. Other types of capacity are defined below.

Base load capacity: Capacity used to serve an essentially constant level of customer demand. base load generating units typically operate whenever they are available, and they generally have a capacity factor that is above 60%.

Intermediate capacity: Capacity intended to operate fewer hours per year than baseload capacity but more than peaking capacity. Typically, such generating units have a capacity factor of 20% to 60%.

Firm capacity: Capacity that is as firm as the seller's native load unless modified by contract. Associated energy may or may not be taken at option of purchaser. Supporting reserve is carried by the seller.

Capacity factor: The amount of energy that an asset transmits (e.g., for a wire) or produces (e.g., for a power plant) as a fraction of the amount of energy that could have been processed if the asset were operated at its rated capacity for the entire year.

Demand: The rate at which energy is used by the customer, or the rate at which energy is flowing through a particular system element, usually expressed in kilowatts or megawatts. (Energy is the rate of power used. Energy is expressed in kilowatt hours or megawatt hours; power is expressed in kilowatts or megawatts.)

Instantaneous demand: The rate of energy delivered at a given instant.

Average demand: The electric energy delivered over any interval of time as determined by dividing the total energy by the units of time in the interval.

Integrated demand: The average of the instantaneous demands over the demand interval.

Demand interval: The time period during which electric energy is measured, usually in 15-, 30-, or 60-minute increments.

Peak demand: The highest electric requirement occurring in a given period (e.g., an hour, a day, month, season, or year). For an electric system, it is equal to the sum of the metered net outputs of all generators within a system and the metered line flows into the system, less the metered line flows out of the system.

Contract demand: The amount of capacity that a supplier agrees to make available for delivery to a particular entity and which the entity agrees to purchase.

Firm demand: That portion of the contract demand that a power supplier is obligated to provide except when system reliability is threatened or during emergency conditions.

Billing demand: The demand upon which customer billing is based as specified in a rate schedule or contract. It may be based on the contract year, a contract minimum, or a previous maximum and, therefore, does not necessarily coincide with the actual measured demand of the billing period.

Demand factor: For an electrical system or feeder circuit, this is a ratio of the amount of connected load (in kVA or amperes) that will be operating at the same time to the total amount of connected load on the circuit. This is sometimes called the load diversity.

Demand-side management: The term for all activities or programs undertaken by load-serving entity or its customers to influence the amount or timing of electricity they use.

Diversity factor: The ratio of the sum of the coincident maximum demands of two or more loads to their non-coincident maximum demand for the same period

Electric service provider: An entity that provides electric service to a retail or end-use customer.

Electric system losses: Total electric energy losses in the electric system. The losses consist of transmission, transformation, and distribution losses between supply sources and delivery points. Electric energy is lost primarily due to transmission and distribution elements being heated by the flow of current.

Grid: Layout of the electrical transmission system; a network of transmission lines and the associated substations and other equipment required to move power.

Interconnection: The system that connects a distributed generation resource to the grid. (Interconnection also refers to how central power plants connect to the grid.) The components of the interconnection vary according to the distributed generation system characteristics, whether the local grid is networked or radial, and the local utility requirements.

Line losses: Energy loss due to resistive heating in transmission lines, and to a lesser extent, in distribution feeder circuits. The energy loss is proportional to the square of the total current flow, which is in turn determined by both the real and reactive power flowing on the line. Line losses are also proportional to the resistance of the wire, which increases as the wire gets hotter.

Load: An end-use device or customer that receives power from the electric system. Load should not be confused with demand, which is the measure of power that a load receives or requires. See demand.

Load duration curve: A non-chronological, graphical summary of demand levels with corresponding time durations using a curve, which plots demand magnitude (power) on one axis and percent of time that the magnitude occurs on the other axis.

Load factor: A measure of the degree of uniformity of demand over a period of time, usually one year, equivalent to the ratio of average demand to peak demand expressed as a percentage. It is calculated by dividing the total energy provided by a system during the period by the product of the peak demand during the period and the number of hours in the period.

Network: A system of transmission or distribution lines cross-connected to permit multiple supplies to enter the system. Opposite of a radial system. Note that local interconnections are more complicated and costly for networked systems.

Off- and on-peak periods: Time periods defined in rate schedules that usually correspond to lower and higher, respectively, levels of demand on the system

Peak load, Peak demand: The maximum load, or usage, of electrical power occurring in a given period of time, typically a day.

Peak power: Power generated by a utility unit that operates at a very low capacity factor; generally used to meet short-lived and variable high-demand periods.

Rated voltage: The maximum or minimum voltage at which an electric component can operate for extended periods without undue degradation or safety hazard. Note that many components, including transformers and transmission lines can operate above or below their rated voltage for limited periods of time.

Real power, Reactive power: Both determined by voltage and current and are present in any electric line. The real power is available to do work (e.g., run motors and power lights) and the reactive power is needed to support the voltage on that line at the desired level. The power factor is the portion of the total power that is available to do useful work. The total power is also called the apparent power

SAIDI: The system average interruption duration frequency index. SAIDI measures the total duration of interruptions. SAIDI is cited in units of hours or minutes per year. Other common names for SAIDI are CMI and CMO abbreviations for customer minutes of interruption or outage. Also see power reliability.
SAIDI=Sum of all customer interruption durations/Total number of customer interruptions

SAIFI: The system average interruption frequency index. Typically, a utility's customers average between one and two sustained interruptions per year. See power reliability for more information.
SAIFI=Total number of customer interruptions/Total number of customers served

Watt (W): The unit of electric power, or amount of work (J), done in a unit of time. One ampere of current flowing at a potential of one volt produces one watt of power.

Voltage control: The control of transmission voltage through adjustments in generator reactive output and transformer taps, and by switching capacitors and inductors on the transmission and distribution systems.

3. EXECUTIVE SUMMARY / ABSTRACT

The energy crisis is the one of the crucial problems faced by all the countries in the world due to depletion in natural resources used for energy generation and the huge investment for generating energy from alternate resources. A viable and immediate solution in this juncture is the energy conservation as cited by the slogan "Energy conserved is Energy generated".

To conserve energy, an Energy balance sheet has to be prepared by doing the Energy auditing, which is accounting of electrical energy in every stage of energy transformation from generation to the utilization end. Any prospective electricity board, electricity-generating companies, captive power plant owners, transmission or/and distribution companies, industries, consumers can do this energy accounting studies and reduce the electrical energy losses in their system.

The reduction in T&D losses would improve the efficiency, performance, reliability and stability of the electrical system at minimum cost. This results in energy savings directly and improvement in voltage profile indirectly and in addition, benefiting the State Electricity Boards Twice by increase in revenue by means of additional energy sales with the saved energy without investing in infrastructure for new power generating stations.

In addition to the above, this will result in better consumer satisfaction by ensuring quality power supply. For any prospective electricity user, reduction in loss leads to reduction in consumption and electricity charges bill.

The reason behind the depletion of natural resources is due to continues use of that resources for the generation of energy so the best way to avail the energy for consumer it is very necessary to done accounting energy at each level of its consumption and use energy efficient equipments and must do auditing by consumer indexing and providing necessary infrastructure for energy auditing so the main purpose of losses in electrical system is solved by segregating the technical and non-technical losses into separate category.

There is huge amount of energy losses while transmission and distribution of power takes places due to high amount of power losses occurs during corona effect and skin effect on conductor. So to minimize such losses there is high amount of voltage and low amount of current is passed through the conductor and to maintain such voltage level booster transformer is installed at some interval to maintain the voltage level. The said voltage is step down at the distribution level to avail the power supply to the consumer.

4. INTRODUCTION & OVERVIEW

Power is a critical infrastructure input for the growth of Indian economy. Acceleration in the economic growth will depend upon a financially and commercially viable power sector that is able to attract the fresh investments. Recognising this reforms were initiated in the distribution sector in the year 2001-2002 with emphasis on various efficiency improvements initiatives being given to bring the distribution sector on track.

The main issue in Distribution system or rather more important the issue confronting the power sector as whole, is the reduction of Aggregate Technical and Commercial Losses (AT&C Losses) to acceptable minimum level. The AT&C Losses at the beginning of the reforms process stood at 38.18 % in year 2001-02. With the initiatives taken the AT&C Losses have reduced to 33.82 % in the year 2004-05.

With the large amount of electricity is being handled by the power utilities, 1% reduction in AT&C Losses would provide substantial financial benefits to the utilities. To realize the benefits, a systematic approach to reduce the technical and commercial losses would be necessary. The loss estimation drives the reduction initiatives and therefore the correct loss estimation through energy accounting and auditing is the starting point for the loss reduction process.

Once the losses are estimated and segregated into technical and non technical losses and there location identified, suitable measures can be devised for reduction of these losses. The reduction of technical losses can be achieved through the system improvements and up gradation schemes to reduce the overloading of lines, transformer and improvement of voltage profile, etc but requires large capital investments.

However the reduction of commercial losses can be achieved at much lesser cost and in shorter time frame through administrative and legislative action. Development of comprehensive energy accounting system would enable quantification of losses in different segments of the system and energy auditing would the means to identify the area leakage, wastage and inefficient use. This would help in identifying measures suitable for reduction of AT&C Losses.

4.2. BACKGROUND

CORPORATE OVERVIEW OF UTTAR GUJARAT VIJ COMPANY LIMITED

UTTAR GUJARAT VIJ COMPANY LIMITED is one of the pioneer Power Distribution Utilities in India in the Electricity Industry. Incorporated under the Companies Act, 1956 in Sept-2003 as a result of unbundling of erstwhile Gujarat Electricity Board pursuant to Power Sector Reforms initiated by the Central and State Governments, the Company became commercially operational since April-2005. The Company is a wholly-owned subsidiary of Gujarat Urja Vikas Nigam Limited (A Govt. of Gujarat Undertaking).

The Main Object to be pursued in terms of the Memorandum of Association of the Company is: To undertake the electricity sub-transmission distribution and retail supply in the State of Gujarat or outside the State and for this purpose to plan, acquire, establish, construct, erect, lay, operate, run, manage, maintain, enlarge, alter, renovate, modernize, work and use a power system network in all its aspects and also to carry on the business of purchasing, selling, importing, exporting, wheeling, trading of electrical energy, including formulation of tariff, billing and collection thereof and then to study, investigate, collect information and data, review operations, plan, research, design and prepare project reports, diagnose operational difficulties and weaknesses and advise on the remedial measures to improve and modernize existing sub transmission and supply lines and sub-stations.

With a Vision to be World Class Electricity Utility striving for social and economic development of the assigned region with a mission of 'Consumer Satisfaction through Service Excellence', the Company operates through the network spread over 50,000 Sq. Kms. covering six full districts in northern region of Gujarat and three part districts in western and central areas.

The Company serves more than 28 Lac consumers of various categories, such as residential, commercial, industrial, Agricultural and others, through 129 Sub Division Offices and 21 Division Offices throughout its operational area divided into four Circles. The business affairs are managed/taken care of by Corporate Office, presently headquartered at Mehsana. The operations are managed by more than 7,300 employees who contributed to business turnover of approximately Rs. 5,500 Crores in 2011-12.

Engaged in the business of distribution of electricity in the northern parts of the State of Gujarat, it has been the winner of National Awards, a Gold Shield and a Bronze Shield; India Power Awards for four consecutive years, IEEMA Power Award-2008 in the Category: Excellence in Rural Electrification, ICWAI Awards and various other awards of national repute.

UGVCL is a pioneer company for Special Design Transformers, accredited with ISO 9001:2008 Standard for 'Management and Enhancement of Electricity Distribution Operations', and the Company's Hi-Tech Meter Testing Laboratory is accredited with National Accreditation Board for Testing and Calibration Laboratories, the first among State DISCOMs.

VISION

- To be World-class electricity utility, striving for social and economic development of our region.

MISSION

We meet the expectations our customers and stakeholders by:

- Providing a sustainable, affordable, safe and reliable electricity supply
- Providing prompt and efficient customer services
- Developing and incentivising our employees
- Being the preferred equal opportunity employer
- Undertaking our business in an environmentally acceptable manner

VALUES

- Respect
- Honesty
- Loyalty
- Ethical business conduct
- Pride and ownership
- Service excellence
- Superior performance
- Team culture

4.3. PURPOSE OF THE STUDY

The essential need for any Power Distribution company is to maintain reliable power supply and reduced its AT&C Losses and to improve its billing efficiency to avail the power supply to its consumer through service excellence.

The Distribution company of any state or power sector as a whole suffers due to high Aggregate Technical & Commercial Losses (AT&C Losses). The loss estimation would be necessary for reduction of losses in the electrical system. The proper technique for measuring the AT&C loss estimation and segregation through the Energy Accounting and Auditing is the starting point for the loss reduction process.

Once the losses is estimated and segregated into technical and non technical losses then after through the Energy Accounting and Energy Auditing process the location for losses can be identified and suitable measures provided to reduce the losses.

The reduction of technical losses can be achieved by reducing overloading of lines and proper maintenance activity done and renovating and modernizing the old conductor and by maintaining the voltage profile and by avoiding the theft and pilferage activities. The study is very important as the aspect because the reduction of AT&C Losses must be very necessary and is only possible through the Energy Accounting and Energy Auditing at every stage of consumption of energy. Large capital investments also requires so the Central as well as State Government has taken the initiatives to provide proper infrastructure for Energy Accounting and Energy Auditing for reduction of losses in the electrical system for Distribution utilities. Through this process the energy is being recorded at every stage such as substation panel meter wise, different feeder wise, category wise and distribution transformer wise to calculate the actual transmission and distribution losses in the power system.

The reduction of non-technical losses means of commercial losses can be achieved much easier way at lesser cost and through the administrative and legislative action. The proper billing of each consumer can be done by cross-checking the billing program.

The Energy Accounting means the quantification of losses in different segments of the system and the Energy Auditing means identifying the area of leakage, wastage and inefficient use of energy.

4.4. RESEARCH HYPOTHESIS

Research hypothesis means the statement created by the researcher when they speculate upon outcomes of a research or experiment. The outcomes of a research are as follow

- This study provides the detailed analysis of technical and non technical losses and segregation of technical and non technical losses.
- Every consumer who feed power from the 11 kv feeder and transformer thereof need to be indexed through the GIS based data base for correlating the energy used by each consumer.
- This study provides proper interphase of recording of energy which is sent and the total energy billed realized is sold so the exact calculation of transmission and distribution losses would be calculated.
- The Adoption of IT based energy accounting and audit would provide the platform for creation of the information base for timely, effective decision making at the operational and strategic levels.
- Energy Accounting and Energy Auditing form the basis for detail and complete evaluation of losses occurring in the distribution systems.
- Adoption of IT for energy accounting and audit provide details of every consumer at each sub divisional level as well as divisional level for calculating transmission and distribution losses through the data acquisition systems.
- This would be facilitate the increased revenue realization for energy supplied to the consumers, identification of areas and causes of high energy losses.
- The same energy is being utilizing in a proper load pattern so the benefit to the utility In terms of reduction in capacity additions will however largely be through reduction of technical losses.
- The study would enable improving the financial health of the utility and would contribute substantially towards overall development of the power sector.

5. LITERATURE REVIEW

Literature Review is an account of what has been published on a topic by the researcher and accredited scholars. While writing the Literature Review my purpose is to convey to all my reader what knowledge and ideas has been established on a topic and what their strengths and weaknesses are.

Energy Accounting Method and Procedures

Energy accounting in electricity sector involves evolving procedures and checks for account Energy form generating stations down to consumer level. The objective is "to prepare the energy account so as to establish the energy input and quantum consumed by/billed to various category of consumers". The energy losses are to be computed for each element of the network on the basis of actual energy sent out and actual consumption recorded by the meters as installed on both sides of the element. The underlying ideas is to treat One Energy Unit (Kwh) as a unit of electrical money and follow and develop a system for accounting each unit similar to that is followed in financial accounting and auditing which has established practices to enable proper accounting of money to detect the leakages, misappropriation, fraudulent transactions etc.

The fundamental approach to energy accounting should be bottoms-up and related to organizational and responsibility structure of the utility. Each Junior level Engineer should be entrusted with responsibility of covering a 11 kV feeder(s), which could be feeding a number of consumers. The exercise would involve establishment of energy measurement system and preparation of energy balance for the feeder/ Distribution transformer. The energy made available at sub-station/11kV feeder/Distribution transformer and units utilized by consumers are to be compared to see whether the difference between the two are reasonable and within permissible limits.

In addition it should be seen that all energy consumption by the consumers is billed and revenue realized in an effective manner. Similarly responsibility area of the SDO could be the Sub-Division in his area, that of the Executive engineer the Division in his area and for the Superintending Engineer the Divisions in his area.

The exercise is highly data intensive as it involves large number of feeders at 11 kV and 0.4 kV level connected from the different S/Ss and each serving to the large number of consumers of various categories. Preparation of electrical network database and documentation and consolidation of consumer details would be the first step in energy accounting. This would involve

• Indexing and allotment of unique identification number to consumers, Poles, DTR, etc.

Each consumer should be identified with the pole he is connected, LT feeder and Distribution transformer through which he is fed, and then each Distribution transformer would be identified with the feeder on which the transformer is installed. In turn each feeder would be identified with substation from which electric supply is received. Giving one 'Code No.' to each consumer, which would be his 'technical address' on this bill, could do this.

• Establishing data gathering procedure for Energy input at feeder and Distribution Transformer levels i.e., by incorporating Sub Station and DTR Remote Terminal Unit

• Establishing System to relate commercial billing data with energy input at feeder level.

• Establishing energy billed for each feeder.

• Estimation of loss levels using the efficacy of the data for energy accounting would largely depend on the quality of meters employed in the system. Network metering and consumer metering system should be reviewed and non-working, defective, unmetered supply etc. should be identified and corrective action taken.

• Electronic trivector meters with data logging facilities are provided on the 11 KV feeders/ secondary side of distribution transformers to record load curve.

What is an energy audit?

An energy audit is key to developing an energy management program. Although energy audits have various degrees of complexity and can vary widely from one organization to another, every audit typically involves

- Data collection and review
- Plant surveys and system measurements
- Observation and review of operating practices
- Data analysis

In short, the audit is designed to determine where, when, why and how energy is being used. This information can then be used to identify opportunities to improve efficiency, decrease energy costs and reduce greenhouse gas emissions that contribute to climate change. Energy audits can also verify the effectiveness of energy management opportunities (EMOs) after they have been implemented. Although energy audits are often carried out by external consultants, there is a great deal that can be done using internal resource. This guide, which has been developed by Natural Resources Canada, presents a practical, user-friendly method of undertaking energy audits in industrial facilities so that even small enterprises can incorporate auditing into their overall energy management strategies.

Defining the Energy Audit

There is no single agreed-upon set of definitions for the various levels of energy audits. We have chosen the terms "macro-audit" and "micro-audit" to refer to the level of detail of an audit. Level of detail is the first significant characteristic of an audit. The second significant characteristic is the audit's physical extent or scope. By this we mean the size of the system being audited in terms of the number of its subsystems and components

TYPES OF ENERGY AUDIT

The types of Energy Audit to be performed on depends on

- Function and types of Industry
- Depth to which final Audit is needed and
- Potential and magnitude of cost reduction desired

Macro audit	Micro audit
The **macro-audit** starts at a relatively high level in the structure of energy-consuming systems – perhaps the entire site or facility – and addresses a particular level of information, or "macro-detail," that allows EMOs to be identified. A macro-audit involves a broad physical scope and less detail.	The **micro-audit**, which has a narrower scope, often begins where the macro-audit ends and works through analysis to measure levels of greater detail. A micro-audit might be a production unit, energy-consuming system or individual piece of equipment. Generally, as an audit's level of detail increases, its physical scope decreases.

NEED FOR ENERGY AUDITING

"AUDIT" a is generally defined as a formal examination and verification of accounts. Auditing in electricity means something more. Energy Audit is the technique to establish the current status of energy efficiency of the various elements in the system. It involves identifying high loss areas, segregating the losses into technical and commercial losses, estimating energy conservation potential and proposing visible and economically attractive solutions. The segregation is a very complicated exercise and that is why to date very few utilities have carried out this segregation.

The Energy Audit gives the positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities.

Such an Audit programmes will help to keep focus on variations which occurs in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipments.

In general, Energy Audit is the translation of ideas into realities, by lending technical feasible solutions with economic and other organizational considerations within a specified time frame.The primary objective of Energy Audit is to determine the ways to reduce energy consumption per unit of product output or to lowering operating costs.

Energy Audit provides a benchmark (Reference point) for managing in the organization and also provides basis for planning a more effective use of energy throughout the organization.

The Energy Audit can be classified into the followings types

1. Benchmarking

The impossibility of describing all possible situations that might be encountered during an audit means that it is necessary to find a way of describing what constitutes good, average and bad energy performance across a range of situations. The aim of benchmarking is to answer this question. Benchmarking mainly consists in comparing the measured consumption with reference consumption of other similar buildings or generated by simulation tools to identify excessive or unacceptable running costs. As mentioned before, benchmarking is also necessary to identify buildings presenting interesting energy saving potential. An important issue in benchmarking is the use of performance indexes to characterize the building.

These indexes can be:

- Comfort indexes, comparing the actual comfort conditions to the comfort requirements;
- Energy indexes, consisting in energy demands divided by heated/conditioned area, allowing comparison with reference values of the indexes coming from regulation or similar buildings;
- Energy demands, directly compared to "reference" energy demands generated by means of simulation tools.
-

2. Walk-through (or) preliminary audit

The preliminary audit (alternatively called a simple audit, screening audit or walk-through audit) is the simplest and quickest type of audit. It involves minimal interviews with site-operating personnel, a brief review of facility utility bills and other operating data, and a walk-through of the facility to become familiar with the building operation and to identify any glaring areas of energy waste or inefficiency.

Typically, only major problem areas will be covered during this type of audit. Corrective measures are briefly described, and quick estimates of implementation cost, potential operating cost savings, and simple payback periods are provided. A list of energy conservation measures(ECMs, or energy conservation opportunities, ECOs) requiring further consideration is also provided. This level of detail, while not sufficient for reaching a final decision on implementing proposed measure, is adequate to prioritize energy-efficiency projects and to determine the need for a more detailed audit

Preliminary Audit is a relatively quick exercise to

- Establish energy consumption in the organization
- Estimate the scope for saving
- Identify the most likely and easiest area for attention
- Set a "reference point"
- Identify more areas for detailed study/measurement
- Preliminary energy audit uses existing or easily obtained data.

3. Detailed Energy Audit Methodology

A comprehensive energy audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems. This types of audit offers a most accurate estimate of energy savings and cost. It considers the interactive effect of all projects, accounts for the energy use all major equipment, and includes detailed energy cost saving calculations and project cost.

In comprehensive energy audit, the one of the key element is the "energy balance". This is based on an inventory of energy using systems, assumptions of current operating conditions and calculations of energy use. The estimated use is then compared to utility billing charges.

Detailed energy study is carried out in three phases

a. Phase 1 : Pre Audit Phase
b. Phase 2 : Audit Phase
c. Phase 3 : Post Audit Phase

Ten Steps Methodology for Detailed Energy Audit table.2

Step :- 1 Pre Audit Phase Plan of Action	Purpose/Results
▪ Plan and Organise Walk through Audit Informal interview with EnergyManager, Production / PlantManager	Resources planning, establish/organize a energy audit team Organize instrument and time frame, Micro data collection Familiarization of process and plant activity
Step :- 2 Conduct of brief meeting / awareness programme with all divisional heads and persons concerned.	Building of cooperation, issue questionennaire for each department, orientation and awareness creation.
Step :- 3 Audit phase Primary data gathering, Process flow diagram & Energy Utility diagram	Historic data collection, Baseline data collection & Prepare process flow chart All service Utility system diagram i.e. single line power distribution diagram
Step :- 4 Conduct survey and Monitoring	Measurement: Motor survey, Insulation and Lighting survey with portable instrument for collection of more and accurate data. Confirm and compare operating data with designed data.
Step :- 5 Conduct a detailed trials/experiment for selected energy guzzlers	Trials / Experiments : 24 hours of power monitoring (MD, PF, Kwh etc), load variations trend in pumps and fans, Boiler and efficiency trails for 4 to 8 hrs, furnace efficiency trails equipment performance experiments.
Step :- 6 Analysis of Energy Use	Energy and Material balance & energy loss/waste analysis
Step :- 7 Identification and Development of Energy conservation opportunities	Identification and consolidation of energy conservation measures, conceive, develop and refine ideas, review the previous ideas

	suggested by unit personal Review the previous ideas suggested by the energy audit if any, Use brainstorming and value analysis techniques, contact vendors for new/efficient technology.
Step :- 8 Cost benefit analysis	Assess technical feasibility, economic viability and prioritization of energy conservation options for implementation, Select most promising project, prioritizes by low, medium, and long term measures.
Step :- 9 Reporting and Presentation to the Top management	Documentation and Report presentation to the top management
Step :- 10 Post Audit Phase implementation and follow up	Assist and implement Energy Conservation recommendation measures and monitor the performance Action plan, schedule for implementation, follow up and periodic review.

KEY INSTRUMENT FOR ENERGY AUDIT

The requirement for an energy audit such as identification and quantification of energy necessitates measurements; these measurements require the use of instruments. These instruments must be portable, durable, easy to operate and relatively inexpensive. The parameters generally monitored during energy audit may include the following:

Electrical Measuring Instruments:

These are instruments for measuring major electrical parameters such as kVA, kW, PF, Hertz, kVAr, Amps and Volts. In addition some of these instruments also measure harmonics.

These instruments are applied on-line i.e on running motors without any need to stop the motor. Instant measurements can be taken with hand-held meters, while more advanced ones facilitates cumulative readings.

Combustion analyzer:

This instrument has in-built chemical cells which measure various gases such as O2, CO, NOX and SOX.

Fuel Efficiency Monitor:

This measures oxygen and temperature of the flue gas. Calorific values of common fuels are fed into the microprocessor which calculates the combustion efficiency.

Fyrite:

A hand bellow pump draws the flue gas sample into the solution inside the fyrite. A chemical reaction changes the liquid volume revealing the amount of gas. A separate fyrite can be used for O2 and CO2 measurement.

Contact thermometer:

These are thermocouples which measures for example flue gas, hot air, hot water temperatures by insertion of probe into the stream.

For surface temperature, a leaf type probe is used with the same instrument.

Infrared Thermometer:

This is a non-contact type measurement which when directed at a heat source directly gives the temperature read out. This instrument is useful for measuring hot spots in furnaces, surface temperatures etc.

Pitot Tube and manometer:

Air velocity in ducts can be measured using a pitot tube and inclined manometer for further calculation of flows.

Water flow meter:

This non-contact flow measuring device using Doppler effect / Ultra sonic principle. There is a transmitter and receiver which are positioned on opposite sides of the pipe. The meter directly gives the flow. Water and other fluid flows can be easily measured with this meter.

Speed Measurements:

In any audit exercise speed measurements are critical as they may change with frequency, belt slip and loading.
A simple tachometer is a contact type instrument which can be used where direct access is possible.
More sophisticated and safer ones are non contact instruments such as stroboscopes.

Leak Detectors:

Ultrasonic instruments are available which can be used to detect leaks of compressed air and other gases which are normally not possible to detect with human abilities.

Lux meters:

Illumination levels are measured with a lux meter. It consists of a photo cell which senses the light output, converts to electrical impulses which are calibrated as lux.

Benefits of Energy accounting and auditing

Proper energy accounting and auditing would facilitate in creation of a data base to act as input for following improvements to the distribution system:

- Load Management.
- Assessment of diversity in the system
- Optimum utilisation of equipment and services.
- Improved voltage profile in the system.
- Details of category-wise consumption of loads and proper forecast of demand.
- Better system augmentation and expansion planning.
- Formulating strategies for reduction of technical and non technical losses.
- Load survey analysis

Segregation of losses into technical and non technical losses

The energy account gives the total losses (technical + commercial) over any element. To segregate the losses into losses due to commercial and technical losses, the first step is to compute the technical losses.

Computation of technical losses

The technical losses in distribution network may be estimated by computer aided system studies through simulation of the network equipment. The essential input for estimation of technical losses is;

• Network map with length and conductor sizes

• Equipment data

• Load data

• Peak and average loadings

• Power flow at critical buses of the network

• Load flow analysis for complete 66/33 kV network emanating from 220/132 kV grid substation, 11 kV lines and distribution transformers to determine peak power loss

• Load flow analysis for low voltage network emanating from distribution transformer under typical 11 kV feeder covering high, medium and low load density area of the circle to determine peak power loss. The results of this low voltage typical network may be extrapolated for the complete low voltage network on the circle.

• Validate the load flow results by measurement of voltages at selected buses or/and measurement of currents at selected distribution transformers.

• Computation of technical energy loss using appropriate load factors and loss load factors. System studies are carried out through well established distribution system analysis software's available in the market. Load flow studies for the distribution system can be carried out utilizing the data from 11 kV feeder's meter and field data of distribution transformer loading (through tong testers) and energy losses may be worked by applying load and loss load factors suitably. With availability of software, load flow studies can be carried out for different loading conditions during the energy accounting period for more reliable results. Estimation of losses in LT network may be done initially for sample network emanating from representative distribution transformers covering different category of consumers and load density. With full computerization of database

It would be feasible to cover the whole LT system as per needs.

We consider the steady state model to find technical losses and take the loads to be of constant impedance.

1. Assessing Load Factor (LF) and Loss Load Factor (LLF)

a) Copper losses of all transformers = Copper loss of each transformer capacity wise in kWh x Numbers of transformers capacity wise in the feeder

b) LF = Energy input to the transformer= Energy input to the transformer/(Peak load of the transformer during the month × number of hours the transformer is in service during the month)

c) LLF = 0.3 (LF) + 0.7 (LF) 2

d) Energy input to the transformer =((Energy sent out on the 11kV feeder from SS –Energy losses in the 11 kV feeder) × Capacity of the transformer)/Total transformer capacities in the feeder

2. Distribution Transformer Losses

a) No-load losses, i.e., iron losses :

No-load losses in kWh of one distribution transformer = No load loss of transformer in kW x number of hours the transformer was
in service during the month

b) Load losses, i.e., copper losses: Copper losses in kWh = Copper loss of each transformer capacity wise in kW x (Actual load / Full load) 2 x number of hours the transformer capacity wise was in service during the month x LLF.

3. Calculation of LT Line and Network Losses

a) The losses of LT network of each capacity transformer are computed by averaging the losses of the LT network of all similar capacity transformers.
b) The computed average losses of LT network radiating from each capacity transformer are extrapolated for assessing the total energy losses of LT network on the feeder.

4. 11 kV Feeder Loss

The monthly energy losses in the feeder should be computed by extrapolating the daily energy loss proportional to the energy sent out in the feeder, for all feeders for all the months in the audit period.

5. Energy losses in loose jump connections, short circuit and earth faults on the lines, service mains and energy meters are assumed to be:

a) 1% of the total energy sent out through the 11 kV line from the substation, for the 11 kV lines of 20 km and more, and

b) 0.5% of the total energy sent out through the 11 kV line from the substation, for the 11 kV lines of less than 20 km.

The total technical loss in the 11 kV feeder is the sum of the various losses described above.
Total Technical Loss on the 11KV Feeder

This is equal to the sum of

1. 11 kV line losses,

2. Distribution transformer (no load and load) losses,

3. LT network losses, and

4. Energy losses in loose jump connections, service mains and energy meters.

Energy losses in the feeder = Energy input to the 11 kV feeder – Energy sales

Computation of commercial loss

The difference of energy input measured at feeder end and the recorded Consumption, is the total loss. The difference of total loss and the loss obtained from Simulation studies **(technical loss)** is an indication of the **non- technical loss** in each Distribution feeder.

- Energy loss as calculated from meter readings = A
- Technical loss as computed from system studies = B
- Commercial loss = A-B

SUMMARRY OF LITERATURE REVIEW

The complete study of Energy accounting, auditing and Reduction of losses in the Electrical system are to be analyzed through the literature review and it is found that the various energy accounting methods and procedure are useful to make a perfect record of energy at each and every stage of the leakage and consumption of energy through the complete analysis of energy accounting procedures. Each consumer of any lines are to be indexed properly to made the perfect accounting of each unit of energy at each stage of energy consumption, leakages and losses.

In an energy audit of a power distribution system, the energy losses are to be computed for each element of the network on the basis of actual energy sent out and actual consumption as recorded by the meters installed on both sides of the element .It may not be possible to conduct energy audit for the entire power system of a utility in one go. This could be due to financial, organizational and logistical constraints. Hence it may have to be conducted in stages. So the study of types of energy audits and the key instrument requires for energy audit are to be analyzed.

There are many kind of losses in the electrical systems which can be summarized through proper energy accounting and energy auditing techniques. There are technical and non-technical losses found through the proper energy auditing process. The total energy sent out at feeder level is to be recorded at substation meter and the total sold out at the consumer level is to be recorded at each energy meter installed at consumer level. So the exact calculation of transmission and distribution losses can be found.

6. RESEARCH DESIGN, METHODODLOGY AND PLAN

- **A Practical Auditing Methodology** The energy audit is a systematic assessment of current energy-usė practices, from point of purchase to point of end-use. Just as a financial audit examines expenditures of money, the energy audit identifies how energy is handled and consumed, i.e.
  - how and where energy enters the facility, department, system or piece of equipment
  - where it goes and how it is used n any variances between inputs and uses n
  - how it can be used more effectively or efficiently

The key steps in an energy audit are as follows:

1. **Conduct a condition survey** – Assess the general level of repair, housekeeping and operational practices that have a bearing on energy efficiency and flag situations that warrant further assessment as the audit progresses.

2. **Establish the audit mandate** – Obtain commitment from management and define the expectations and outcomes of the audit.

3. **Establish the audit scope** – Define the energy-consuming system to be audited.

4. **Analyse energy consumption and costs** – Collect, organize, summarize and analyse historical energy billings and the tariffs that apply to them.

5. **Compare energy performance** – Determine energy use indices and compare them internally from one period to another, from one facility to a similar one within your organization, from one system to a similar one, or externally to best practices available within your industry.

6. **Profile energy use patterns** – Determine the time relationships of energy use, such as the electricity demand profile.

7. **Inventory energy use** – Prepare a list of all energy-consuming loads in the audit area and measure their consumption and demand characteristics.

8. **Identify Energy Management Opportunities (EMOs)** – Include operational and technological measures to reduce energy waste.

9. **Assess the benefits** – Measure potential energy and cost savings, along with any co-benefits.

10. **Report for action** – Report the audit findings and communicate them as needed for successful implementation.

Each step involves a number of tasks that are described in the following sections. Several of the steps may result in identifying potential EMOs. Some EMOs will be beyond the scope of a macro-audit, requiring a more detailed study by a consultant (i.e. an external micro-audit). Other EMOs will not need further study because the expected savings will be significant and rapid; such EMOs should be acted on right away.

Establish Audit Mandate Assess the Benefits Identify EMOs Inventory Energy Use Profile Energy Use Patterns Comparative Analysis Analyze Energy Consumption and Costs Establish Audit Scope EMO Assessment Required Implement External Micro-Audit In-House Detailed Analysis None, Immediate Implementation Micro-Audit Report Macro-Audit Report for Action Condition Survey EMOs

The Detailed Energy Audit Methodology are discussed below

1. Preparing for The audit

An audit plan is a "living" document that outlines the audit's strategy and process. Although it should be well defined, an audit plan must be flexible enough to accommodate adjustments to allow for unexpected information and/or changed conditions. An audit plan is also a vital communications tool for ensuring that the audit will be consistent, complete and effective in its use of resources. Your audit plan should provide the following:

- The audit mandate and scope
- When and where the audit will be conducted
- details of the organizational and functional units to be audited (including contact information)
- Elements of the audit that have a high priority
- The timetable for major audit activities
- Names of audit team members
- The format of the audit report, what it will contain, and deadlines for completion and distribution

2. Establish the Audit Mandate

Condition survey: In a more detailed audit or an equipment micro-audit, checklists with more detail than those provided in this guide will be required. It may be more effective to enlist the support of people with expertise in external systems or equipment to assess the general condition of the systems and equipment involved.

Audit mandate: A micro-audit involves a greater level of detail, and its mandate must define the extent of the investigation. This will be driven in part by the desired level of certainty or, conversely, the uncertainty that can be accepted in the result. The detail required in order to secure financing for proposed measures will need to be provided as well. A micro-audit will often be carried out by an external consultant. In this case, the audit mandate and the subsequent step – developing the audit scope – form an integral part of the consultant's terms of reference.

3. Audit scope:

The micro-audit will often have a scope within the boundaries of a site or within the walls of a building. The scope may be a specific process or piece of equipment. In this situation, defining the audit boundary and the associated energy inputs will be a more difficult undertaking.

4. Energy consumption and cost analysis:

The boundary for a micro-audit may not include utility-metered energy inputs. In some cases, direct measurement of energy inputs may be available from sub-meters for electricity, gas, fuel or steam. In each of these cases, it will be necessary to assess an input cost for each energy form. The incremental or marginal cost may be applied to these inputs.

5. Comparative analysis:

The comparative analysis performed in a macro-audit typically deals with monthly utility metered data and impact data. A micro-audit provides an opportunity to perform similar types of analysis on metered data for individual processes and equipment on a much shorter time scale, possibly weekly or daily.

6. Energy use profile:

The electrical demand profile measured at the service entrance is a common profile used in a macro-audit. Such profiles can be measured for virtually any single electrical load or group of loads. The micro-audit can use detailed profiles to fully describe the operation of many processes, systems or pieces of equipment.

More detailed profiles include

- subsystem power (process system, air compressors, refrigeration, etc.)
- compressed airflow and pressure
- steam flow and pressure
- illumination level and occupancy

7. Energy use inventory:

The level of detail to which the inventories are conducted will increase from the macro-audit to the micro-audit. A more detailed breakdown will require more measurements, metering equipment and expertise.

8. EMO identification:

The micro-audit mandate and scope may be developed from the list of EMOs and will require further analysis. The micro-audit will further define EMO actions, costs and resulting savings.

9. Costs and benefits:

A detailed assessment of savings for specific EMOs is usually the primary purpose of the micro-audit. In this case, the macro-audit may involve a cursory assessment of savings and begin to assemble the data required for more detailed analysis.

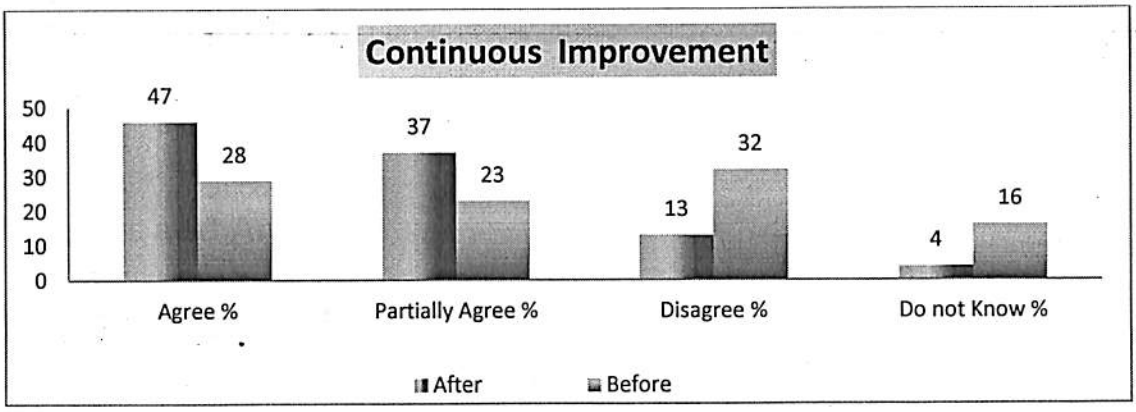
10. Report for action:

Presenting audit findings in a conventional written report is more appropriate to the tightly focused micro-audit. The contents, including specific data and information arising from the audit, required in a micro-audit report may be specified by the providers of project financing. Such requirements should be clearly specified in the micro-audit mandate.

7. Findings and Analysis

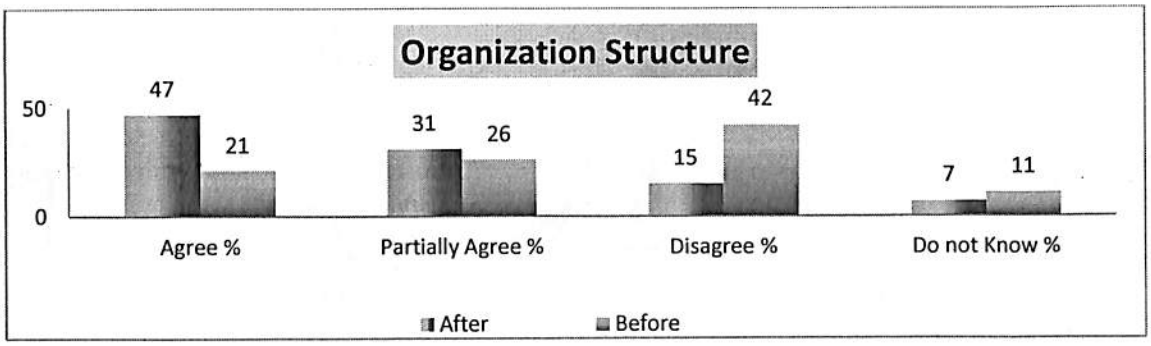
1. Continues Improvement

Electricity Utility Industries were suffering from huge amount of transmission and distribution losses due to unrecorded energy and not proper accounting of energy so after implementing proper energy accounting and auditing there is huge amount of T & D being saved. So continue improvement through method.



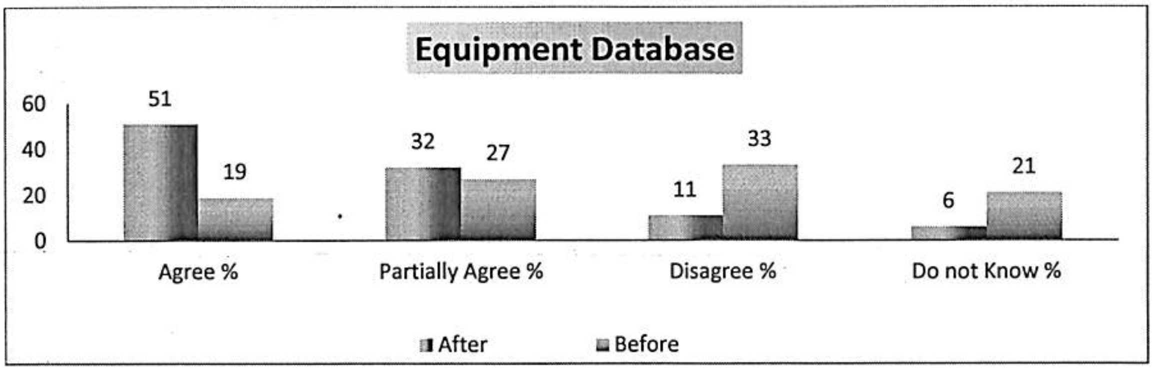
2. Organization structure

Most of the person working under electricity utility industries is satisfied with proper energy accounting and auditing which improves the whole organization structure.



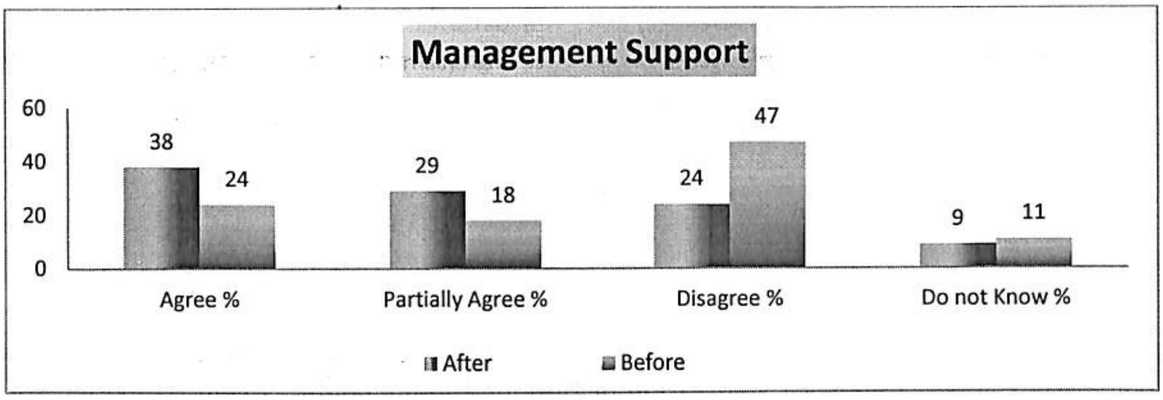
3. **Equipment Database:**

People understand importance of equipment data base, and try to generate and well maintained equipment data base for reference during energy accounting and auditing method.



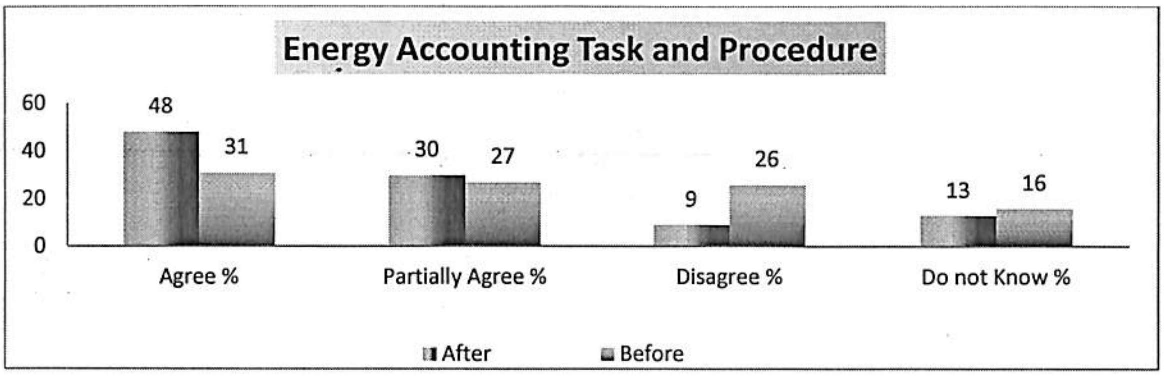
4. **Management Support:**

38% workmen believe management support in performing their duties where as 29% partially agree with this. 24% disagree that management does not give proper required support for energy accounting and auditing work.



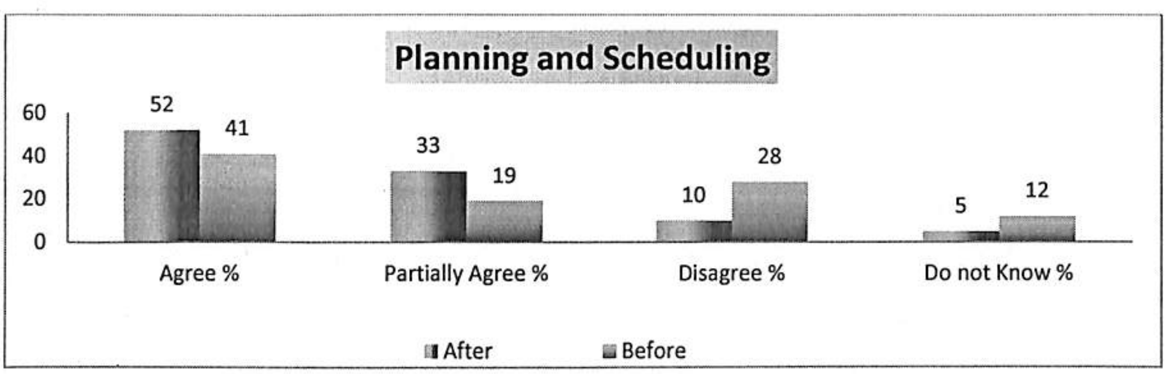
5. **Energy Accounting Task and Procedure:**

48% Workmen feel that maintenance task and procedure is accurate while 30% workmen partially agree with energy accounting task and procedure.



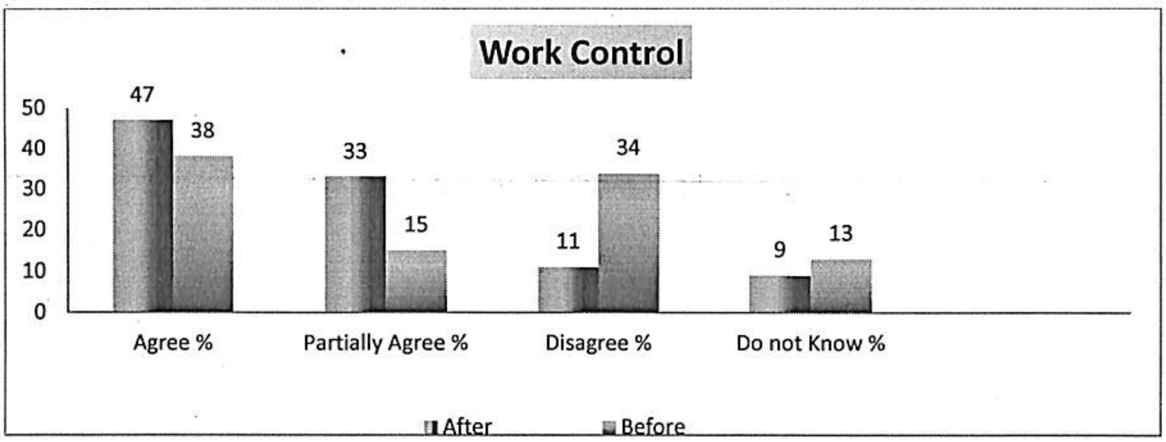
6. **Planning and Scheduling:**

Regarding planning and scheduling, 10% workmen feel that there is no proper and effective planning and scheduling for doing energy accounting and auditing task while 52% agree and 33% partially agree with that.



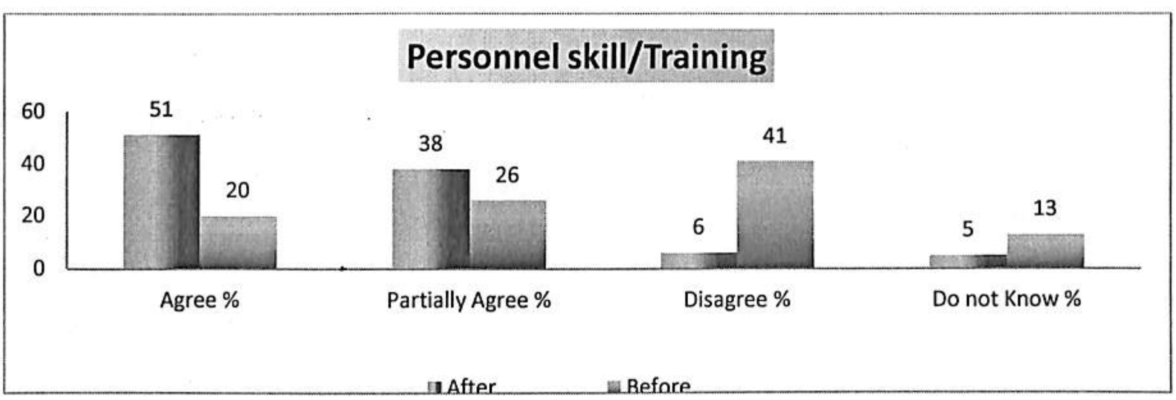
7. Work Control:

47% workmen fully agree and 33% partially agree that there is proper work control system.



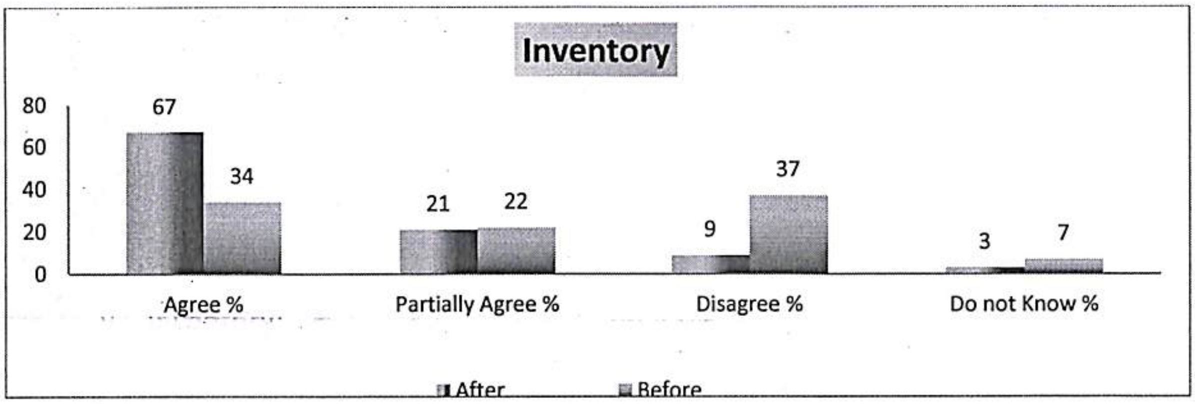
8. Skill/Training:

51% workmen believe that management provides training/seminar which required for performing their duties, improving their skill and knowledge to do best possible job in first time.



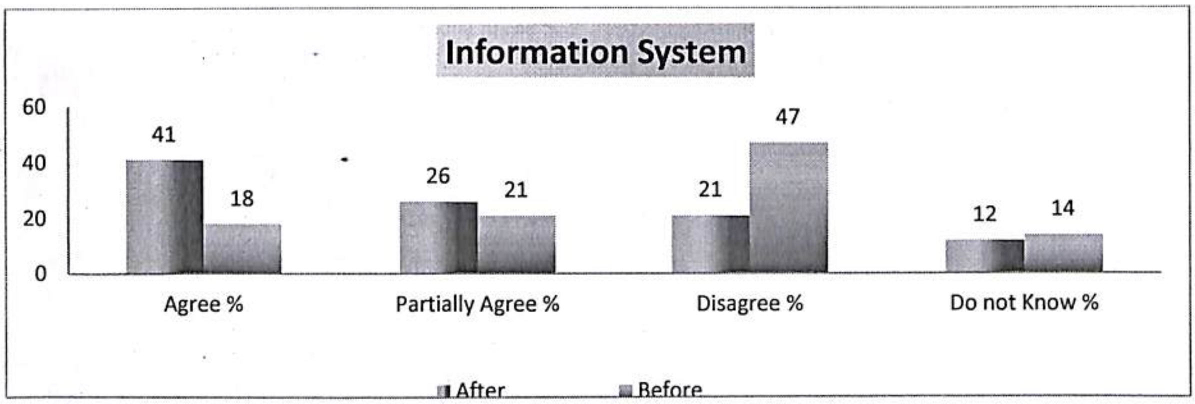
9. Inventory:

67% workmen feel that they got material whenever required for performing their energy accounting and auditing activities while 9% disagree with this



10. Information System:

41% workmen are satisfied with information system prevailing in energy accounting and auditing section.



8. Interpretation of Results

Results before NOT proper energy accounting and auditing on T & D Losses in U.G.V.C.L

Month	Total sent unit	Total sold unit	Difference losses	%T & D loss
Feb-14	29818580	25787234	4031346	13.52
Mar-14	31909970	28716727	3193243	10.52
Apr-14	29218580	25787234	3431346	11.78
May-14	31809970	27716727	4093243	12.86
June-14	29816580	26572290	3244290	10.58
July-14	31136700	27416520	3720180	11.92
Aug-14	29359780	25025052	4334728	14.72
Sept-14	31374912	27461930	3912982	12.47
Oct-14	29518580	25787234	3731346	12.64
Nov-14	31509970	27716727	3793243	12.38
Dec-14	29918580	25887234	4031346	13.47

Results after proper energy accounting and auditing on T & D Losses in U.G.V.C.L

Month	Total sent unit	Total sold unit	Difference losses	% T & D loss
Feb-15	29218580	27787234	1431346	5.80
Mar-15	31809970	29716727	2093243	6.58
Apr-15	28218580	26787234	1431346	5.07
May-15	29809970	28716727	1093243	3.66
June-15	28916580	27572290	1344290	4.50
July-15	30136700	29416520	720180	2.39
Aug-15	29374912	28461930	912982	3.10
Sept-15	28359780	27725052	634728	2.23
Oct-15	Not calculated			
Nov-15	Not calculated			
Dec-15	Not calculated			

The results show that the proper energy accounting and auditing procedures in the distribution utilities helps to reduced and control the transmission and distribution losses in a huge amount.

Comparison of Results with actual assumption (Hypothesis)

	Achieved position			Assumption position		
Month	Total sent unit	Total sold unit	%T&D loss	Total sent unit	Total sold unit	%T&D loss
Feb-15	29218580	27787234	5.80	29218580	28634208	2.00
Mar-15	31809970	29716727	6.58	31809970	31173770	2.00
Apr-15	28218580	26787234	5.07	28218580	27654208	2.00
May-15	29809970	28716727	3.66	29809970	29213770	2.00
June-15	28916580	27572290	4.50	28916580	28338248	2.00
July-15	30136700	29416520	2.39	30136700	29533966	2.00
Aug-15	29374912	28461930	3.10	29374912	28787413	2.00
Sept-15	28359780	27725052	2.23	28359780	27792584	2.00

The above result shows for the industrial category of feeders for one of the subdivision office of the U.G.V.C.L.

The comparison of actual T&D Loss results with the assumption results match for the nearby month as due to proper techniques for proper energy accounting and auditing adopted for one the subdivision offices in the U.G.V.C.L.

The energy must be accounted in each level from the substation panel meter of each industrial category of feeder, 11 kv panel meter installed for recording of each and every unit of energy and moreover the for the auxiliary consumption station transformer wise meter is installed and thereof station wise loss being calculated. Same as the meter is being installed at each distribution transformer wise to calculate the losses of transformer and at the end each category of consumer is having meter installed at the premises and the same meter is being read by monthly or bi monthly basis and sold out unit reflected in the LT Billing PRT and the same sold unit being subtracted from the sent out unit of that month and actual T&d loss for the same Feeder is being calculated. After doing proper billing and accounting of energy procedure the transmission and distribution losses is reduced as shown above table.

By doing the proper energy accounting and auditing procedure the energy which is being recorded at each and every interval so the actual transmission and distribution losses can be calculated very easily. By proper monitoring of the same the further reduction of transmission and distribution loss may achieved.

Functions of Various Organizations Involved in Energy Auditing

Energy Conservation Center (ECC): an entity affiliated with the local government. Despite some variation,

key functions of ECCs include policy research related to energy efficiency, development of energy efficiency standards, conducting energy-saving pilots in key areas, evaluation and promotion of energy saving products and technologies, provision of technical assistance, trainings, and education related to energy efficiency.

Energy Conservation Supervision Center (ECSC): part of local government responsible for monitoring and inspecting the energy-related activities of institutions and individuals to ensure compliance with energy saving related laws, rules, regulations and standards. ECSCs also investigate violations. ECSC's energy-saving inspection covers energy-consuming entities, energy-related investment projects, the production and delivery of energy-consuming products and equipment's, entities pursuing energy production and energy business, and institutions providing energy services.

Demand-Side Management Guidance Center (DSM Center): an entity affiliated with the local government (e.g, Hebei DSM Center) ora state-owned enterprise (e.g., the State Grid DSM Instruction Center). Main functions include promotion and training of DSM techniques and methodologies and dissemination of related information and best practices.

Cleaner Production Center: an entity affiliated with the local environmental protection bureau. Main functions include supervision and evaluation of enterprises' cleaner production activities, certification of cleaner production auditing entities and professionals, development of demonstration pilots, provision of trainings, and dissemination of cleaner production information and technologies.

Energy management centre (EMC Centre) : an entity affiliated with the local government for management of energy related things remotely. Such centre monitor the data of local subdivision to analyse actual energy use pattern of any area to decide the further needful action.

9. CONCLUSION AND SCOPE FOR FUTURE WORK

By implementing and suggesting the Energy Accounting, Auditing for reduction of losses in the electrical system each distribution utility may achieve the desired results.

The AT&C losses for the country as a whole are still about 33% as per data received from the utilities and there is a considerable potential for reduction of losses. Accounting and Audit form the basis for detail and complete evaluation of the losses occurring in the Distribution system. Segregation of losses into technical and commercial losses will help in devising targeted strategies for reduction of these losses leading to substantial benefits for the utilities.

The adoption of IT based energy accounting and audit would provide the platform for creation of the information base for timely, effective decision making at the operational and strategic levels. This would facilitate increased revenue realization for the energy supplied to the consumers, identification of areas and causes of high energy losses and cutting down on its own expenses on account of the operational inefficiencies. It also helps the utility in bringing accountability and efficiency in its working.

The benefit to the utility in terms of reduction in capacity additions will, however, largely be through reduction of technical losses and to some extent through commercial losses as commercial losses contain some element of wastage of electricity. Commercial losses are generally considered as a financial loss but not an economic loss. However whenever there is an element of free electricity, wasteful use creeps in. The reduction of these wastages would also lead to reduction in capacity additions required. This would enable improving the financial health of the utility and would contribute substantially towards overall development of the power sector.

However the reduction of commercial losses can be achieved at much lesser cost and in shorter time frame through administrative and legislative action. Development of comprehensive energy accounting system would enable quantification of losses in different segments of the system and energy auditing would the means to identify the area leakage, wastage and inefficient use. This would help in identifying measures suitable for reduction of AT&C Losses.

This project was live one and I worked on every stage from the idea conception phase to the implementation phase. So it was totally different experience to work on this project. I also get lots of freedom for my approach towards the project and at the same time full support. It was really challenging to meet the all requirement of the organization with the limited time I have for the project

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12. APPENDIX: INTERVIEWER SCRIPT

Questionnaire related to energy accounting and auditing

1. A viable and immediate solution in this juncture is the energy conservation as cited by the slogan "Energy conserved is Energy ______________".

A) Transmitted B) Distributed C) Generated D) None of the above

2. Average System Interruption Duration, reliability measure that includes the magnitude of the ________ un served during an outage.

A) Demand B) Load C) Energy D) Voltage

3: Power provided to a customer when that customer's normal source of power is not available is called as

A) Power B) Back power C) Reliable Power D) Zero power

4. The customer average interruption duration frequency index measures

A) SAIDI/SAIFI B) SAIFI/SAIDI C) SAIFI/SAIFI D) None of the above

5. A device that maintains or increases voltage in power lines and improves efficiency of the system by compensating for ________ losses.

A) Capacitive B) Resistive C) Inductive D) none of the above

6. The amount of capacity that a supplier agrees to make available for delivery to a particular entity and which the entity agrees to purchase is called as

A) Demand B) Peak demand C) Load demand D) Contract Demand

7. The ratio of the sum of the coincident maximum demands of two or more loads to their non-coincident maximum demand for the same period is called as

A) Demand factor B) Diversity factor C) Load factor D) None of the above

8. Layout of the electrical transmission system; a network of transmission lines and the associated substations and other equipment required to move power is called as

A) Grid B) Line C) Substation D) Generating station

9. The reduction in T&D losses would improve the efficiency, performance, reliability and stability of the electrical system at __________ cost.

A) Maximum B) minimum C) equal D) partial

10. The Energy Accounting means the ________ of losses in different segments of the system

A) Classification B) quantification C) Diversification D) None of the above

11. The Energy Auditing means _____the area of leakage, wastage and inefficient use of energy.

A) Classifying B) identifying C) quantifying D) none of the above

12. The Energy Audit gives the __________ orientation to the energy cost reduction, preventive maintenance and quality control programs which are vital for production and utility activities.

A) Negative B) Positive C) Zero D) none of the above

13. ________ instrument has in-built chemical cells which measure various gases such as O2, CO, NOX and SOX.

A) Fyrite B) combustion analyzer C) contact thermometer D) none of the above

14.________instrument is useful for measuring hot spots in furnaces, surface temperatures etc.

A) Infrared thermometer B) contact thermometer C) Fyrite D) none of the above

15. To ________ the losses into losses due to commercial and technical losses, the first step is to compute the technical losses.

A) Bifurcate B) segregate C) analyzed D) none of the above