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To Control Grid Power Factor and Increase Energy Efficiency in Thermal Power Plant through Energy Audit: A Review

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Abstract— Energy is one of the major inputs for economic development in any country in the world. In developing countries, energy is a major contributor and huge investment is required to meet the energy needs in such countries. India has been a dynamic country since its inception. There are many industries here where electricity consumption is mostly 60% to 65%. The main objective of this paper is to maintain optimum energy throughout the organization by focusing on those energy points to reduce current and future energy costs and improve power quality. This paper presents "To Control Grid Power Factor and Increase Energy Efficiency in Thermal Power Plant through Energy Audit". In this energy audit analysis is done for a month to improve the power factor close to unity by the automatic reactive power control panel to maintain the grid p. f. to 0.99 by compensating for the required reactive power from the grid-connected alternator. . Energy audits will help you understand the energy and fuel systems used in any industry, and identify the various areas where energy loss can occur and where it has scope. The proposed approach is validated by considering the case study.

Keywords—Audit and control of energy, Energy Consumption, Energy Conservation, Energy Savings, PF Control, Auto Reactive Power Control.

I. INTRODUCTION

All over the world since the beginning of the Industrial Revolution, when natural resources were used, engineers have tried to increase the efficiency in the process of production, so that the factor of production is being used to the fullest. Labour, capital, and energy have been one of the earliest basic factors of production in history. However, energy was a minor factor at the time, contributing only 5%-10% of the cost of most products. But in today's time due to the increasing demand for production, energy has become an important part of our life. At present 60%-70% of the energy is being used in the field of production in industries. Due to the increasing demand for production, energy is being lost in the industries due to many reasons, and the industries are suffering financially. We are using Energy Audit to reduce energy loss and increase energy efficiency.

A. Energy Audit

Energy audits take energy management and energy conservation in a new direction and are a fundamental and most important step towards increasing energy demand. An energy audit helps to know how, where and how much energy can be used in industries. It provides an opportunity to look at energy use patterns and suggests ways and means to eliminate energy losses and improve systems. The immediate benefits of energy through energy audits include improved stability, energy reliability characteristics, and energy reduction disadvantages. Long-term energy savings can be achieved by using efficient equipment.
In today's generation, the world is at a stage where energy is becoming a major cost factor in new technologies used in industries like almost all processes of life. In addition, energy and profit are closely related in many organizations that financial and energy audits are closely linked. Many organizations are weak in keeping track of the energy expended and hence consume more energy than is required for optimum functioning. Energy audits clearly address the gains and losses in energy, whereby the use of energy leads directly to savings for the organization's profitability. Therefore many organizations need to pay maximum attention to the energy-saving opportunities available to them through a proper energy audit, the main objective of the energy audit is to promote the idea of saving energy.

B. Types of Energy Audits

The energy audit is basically divided into two categories:
- Preliminary Energy Audit
- Detailed Energy Audit

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1) Preliminary Energy Audit: The preliminary audit is done for a limited time. Mainly it is related to best and best operating practices, proper use of energy, and saving energy from loss and wastage is possible through a preliminary audit, preliminary audit mainly focuses on key energy supply, and demand and, accounting for at least 70% to 80% of the total energy required in this system. It mostly involves the following steps:

- Providing a strong team formation in the organization.
- Conducting walk-through survey.
- Providing a strong team formation in the organization.
- To collect system data related to energy consumed for the last one year.
- Develop a profile of energy consumption for the collection of data.
- Inspect and survey the energy used in non-working hours.
- Preparation of checklist of normal working hours keeping in view the routine work.

Energy accounting specialists are generally able to identify broad study areas that are extremely useful in preliminary audits and results.

2) Detailed Energy Audit: Detailed audits is done beyond the scope of cost and savings. This includes well-defined projects as well as prioritization and engineering recommendations. Detailed audits generally involve long-term measures such as major modifications to equipment, technology, control logic, systems, etc. Recommendations are typically long-term projects ranging from one to five years. It accounts for about 90% of the energy used in systems and industries. This energy test includes a detailed technical process and analysis of each individual device.

- Determine the measure of the amount of actual energy consumption over a period of time.
- Study in-depth for the variety of options that are available to modify.
- Continuously monitor consumption for counter reductions so as to implement changes for testing.
- Integrate the initial audit observations together.

II. LITERATURE SURVEY

Jenna Joy et al [2016] This article proposed an energy audit & it is one of the most complete methods for determining how much energy is being used and wasted in a facility. Controlling maximum demand and minimizing energy losses by boosting the overall system's power factor are two ways to improve energy efficiency. This project seeks to do a detailed load analysis of our college. According to early research, the maximum monthly demand is 170 percent of committed agreement demand. Even more, new buildings and loads have been constructed in recent years, highlighting the significance of lease need assessment or the deployment of significant energy-saving measures. Because the former is more customizable, a full Energy Audit is required to determine the potential for savings. After reviewing the monthly account, it is discovered that the average power factor is.92, which can be reduced to near unity by reducing inductive loads. The rating of the capacitor panel that will be put on the L.T side has been determined. {1}

K. Lenin et al [2006] the paper the study provides an ant colony search algorithm (ACSA) for optimal power efficiency and power grid power control. ACSA is a unique concept for collaborative agencies based on real anthropological research into the topic of ant anthropology testing and browsing strategies. As a result, at ACSA, a group of cooperative agents known as "Ants" are working together to find a better solution to the problem of energy efficiency. The suggested algorithm's results on the bus power system demonstrate that it is capable of performing a full search with a quick convergence ratio and a vision of robust processing. According to the simulation results, ACSA converges to the optimization algorithm. [2]

Ibrahim Ahmad et al [2019] proposed a new approach to improving electrical quality and power factors in smart grids is provided in this study. Variations in power and acceptance values are used as inputs in the microprocessor that controls the production of active energy across all DG units in this process. Analysis shows that the microcontroller improves voltage and power factor quality efficiently. To test the new method, the actual data from the electrical systems were used in the simulation model in Matlab Simulink. A comparative analysis of energy use and the variability of energy over time between existing and proposed methods are described in detail in this publication. According to the findings, the level of energy efficiency in a building differs from the amount of energy lost; severe loss, and decreased efficiency. Reducing the maximum amount and minimizing power losses by improving the power feature on the circuit board are two ways to use more power. [3]

Abhishek Sinha et al [2016] in this paper a solar farm with a network can be used to improve the power factor of the system by introducing voltage, as described in this paper. The power of the injection varies depending on the system power factor. The installed voltage is in the quadrature grid and voltage. The solar farm can also be used to support the grid system during an error, as described in the next section. Various error cases were tested to evaluate performance under error conditions, as well as to use simulation / MATLAB. It has also been shown by analysis and waveform that the solar farm can be used to support the

system in the event of an error and therefore the performance of the system has been analyzed. From the results of the simulation, it can be concluded that the solar farm improves system performance and therefore has better performance than the Grid network system without the solar farm compensation unit. [4]

Andries T. Spies et al [2013] proposed the power control system for a permanent magnetic field slide is designed in this paper. The generator's terminal voltage can be varied by employing a solid-state-assisted on-load change transformer. The generator can thus work in a more or less enthusiastic mode, enabling adaptive regulation of the active generator power output. In transformer switchgear, solid-state switches are utilized to lengthen the life of the diverter circuit. Two tiny capacitor banks are utilized in conjunction with the transformer and provide additional active power as required. The efficiency of the model is modeled, and the findings are verified using a grid code. [5]

L Hassaine et al [2009] in this article a new single-phase digital inverter control approach is proposed in this paper. This controlling technique uses the phase shift is seen between inverter and grid voltages, as well as digital sinusoidal pulse wide modulation (DSPWM) patterns, to change the power factor in a broad range of current outlets, allowing for active energy coordination and monitoring. The suggested control approach has the advantage of being straightforward to execute in digital circuitry. In this work, a simulation study of this strategy was conducted using Mat lab / Simulink and PSM. To ensure its effectiveness, these controls have been applied to FPGA. An experimental test is performed that demonstrates the effectiveness of this control to control the power factor injected into the grid. [6]

Sertac Bayhan et al [2013] this paper was proposed the control algorithm for a grid-linked PMSG utilized in a wind conversion system is studied in this study. The GSC is operated using a vector control scheme in a designed system, and the PLL algorithm is used to accept phase differences between grid and GSC voltage. The simulation was used to test system performance 'The simulation findings show that under various operating situations, such as changing the speed of the drum and the various active and active reference values, the active and effective power can effectively track effective and efficient reference values. Due to its ability to adjust the production of autonomous and active power for the use of the reference active energy levels, the PMSG wind turbine can also support the grid. [7]

III.RESEARCH METHODOLOGY

In this paper we have taken step towards an energy audit of Vandana Global Limited, Industrial Area Phase-2 Siltara, Raipur Chhattisgarh to reduce Grid Demand electricity bill consumption. And energy audit to determine the loss in power plant energy use and power factor. We can study the grid and demand reactive power in depth through this. The methodology adopted for an energy audit is a three-stage process that includes.

A. Data Collection

In the initial phase of data collection, complete data collection was done using various tools like observation, measurement, and measurement of energy in months and years with the help of a power analyzer.

B. Data Analysis

The collected data was analyzed in detail. Databases maintained by Energy Audit were used to prepare the featured representations.

C. Recommendation

Based on the obtained data analysis results, certain steps were recommended to reduce the power consumption without affecting their satisfaction with the cost analysis.

A comprehensive ten-step methodology for conducting an INDUSTRY-LEVEL energy audit at Vandana Global Limited is presented below. Through these steps, Energy Managers and Energy Auditors can follow these TEN STEPS to start and add/change as per their requirement and variety of industries.

TABLE I
TEN STEPS METHODOLOGY FOR DERAILED ENERGY AUDIT

Phases of Audit	Steps No	Plan of Action Taken	Purpose
Phase I:- Pre-Audit	Step-1	• Editing and Planning. • Walkthrough Audit assessment. • Informal dialogue with energy department in-charge, producer/	• Editing resources. Establish/organize an energy research team. • Plan and set tools, Instruments, and time management.

		plant head.	• Big data collection (appropriate for industry type). • Familiar with process/plant functions. • Preview and evaluate current performance and processes.
	Step-2	• To organize awareness programs and brief meetings (1-2 hrs.) with all the divisional heads of the industry and their concerned persons.	• Building collaboration and sharing. • To select questions separately for each department. • Orientation and awareness building.
Phase II:- Audit	Step-3	• Power diagram, process flow diagram, and basic data collection.	• Historical data analysis, and basic data collection. • Prepare a power flow chart for the process. • Diagram of all active resource systems (example: one-line distribution diagram of electricity, steam, air, and water). • Operational application of data and design. • Discuss semi-annual or annual electricity bills and energy consumption patterns (see manuals, log sheets, nameplates, etc.).
	Step-4	• Analysis and survey of monitoring data.	• Measurements: Motor winding insulation, vibration, sound survey, and temperature survey with portable instruments for more accurate data collection. • Verify current operating data and compare it with design data.
	Step-5	• Conducting intensive testing for energy messengers.	• Testing: ➔ 24 hours power monitoring (MD, PF, KWH, etc.). ➔ The practice of load variation in pumps, compressor fans, etc. ➔ Performance testing of the use of equipment etc.
	Step-6	• Measurement of electricity or energy consumption in different areas.	• Analysis of electricity or energy consumption, and power loss in all those areas.
	Step-7	• Identification of Energy saving/Transformation/conversion Opportunities (ECOs) across industries.	• Identify the measurement of the ECOs and the integration of the ECOs. • Visualize the evolution of new ideas to edit. • Review energy audit ideas in the past industry. • Use analysis and discussion strategies. • Contact vendors or vendors for new and modern technologies.
	Step-8	• Study of energy consumption and its costs and benefits.	• Use various ECOs methods to initiate work on technical, priorities and economic performance. • Select valuable and outstanding projects. • Prioritize short, medium, and long-term measures.
	Step-9	• Reporting to Senior Management	• Submission of the report in writing to Senior

		and the human resource department for submission of a final report	Management and Human Resource Department.
Phase III:- Post-Audit	Step-10	• Actions and following.	• Support and implement ECOs recommendations and monitor performance: ➔ Plan applications and programs to be used. ➔ Tracking and updating time.

IV. POWER FACTOR IMPROVEMENT

Higher currents flowing to the lower power factor loads in the distribution system increase the energy loss, due to which those loads require large and thick wires and many types of equipment. Due to this the cost of large equipment with a low power factor is increased and energy is wasted, due to these devices, electric utilities will generally charge more cost to the industry. In an AC circuit, if a load has a low power factor for the same supply load and voltage, then the current drawn to that load will be high due to the low power factor, resulting in a large amount of copper loss in the cable due to the high current and will increase transmission wire and transmission loss. This is a two-part tariff. The actual energy consumed by a load with a low power factor represents the economic loss resulting from the sum of the fixed contracted demand kWh and the variable charge, which is up to the power user. With the exception of heating elements on alternating current, this load not only absorbs active energy from the network but also converts it into mechanical work, light, heat, etc. Alternating current has inductive reaction energy, which produces magnetic fields in loads. By which electricity is able to conduct the load. A load with a low power factor is costly and inefficient and some utility companies that sell electricity such as CSEB charge extra for having a power factor less than 0.95. The capacitor is installed to increase the efficiency of the induction motor. And others use different methods such as capacitors, Auto Reactive Power Controllers, etc. to increase the efficiency of the demand energy and power factor of the load. Linear loads with low power factors (such as induction motors) can be corrected with the help of capacitors. And non-linear loads with low power factors, such as rectifiers, distort the current drawn from the system. In such cases, active or passive power factor correction can be used to counteract the distortion and increase the power factor.

Types of method to improve Power Factor
Automatic capacitor banks.
Compensation technology for low voltage fixed capacitors.
Auto Reactive Power Control Panel

V. CONCLUSIONS

After analyzing all the literature, we have seen that different consumers of energy in industries use energy according to their needs and but some consumers waste some part of their consumed energy, the energy wasted. The loss of energy increases. To prevent these losses and to use energy properly, a strategy is prepared through energy audit, in which the energy created and the energy used and different methods are used to reduce the loss from it. A systematic energy audit has been used to reduce energy billing and increase consumer efficiency. As a result, energy audit should be done once in a year for a good industry to run smoothly. For the research, it was found that through a better energy audit, we can control the reactive power in demand energy in an industry through several means, maintain the power factor and prevent wastage of electricity, and reduce the demand electricity bill. Taxes can make you financially strong. Prioritizing the consumer's digestion of energy in different ways in the industry, and exploring opportunities to save energy and improve the quality of the consumed energy. By reducing the wastage of energy, electricity bill can be reduced economically. By maintaining the power factor of demand energy and reactive power in different ways, the quality and efficiency of on-demand power can be increased. Execution of an energy audit to increase the efficiency and quality of electricity, and to reduce the electricity bill economically by maintaining the demand power factor. As a result, it has been decided to adopt a systematic energy audit to control and control the reactive power.

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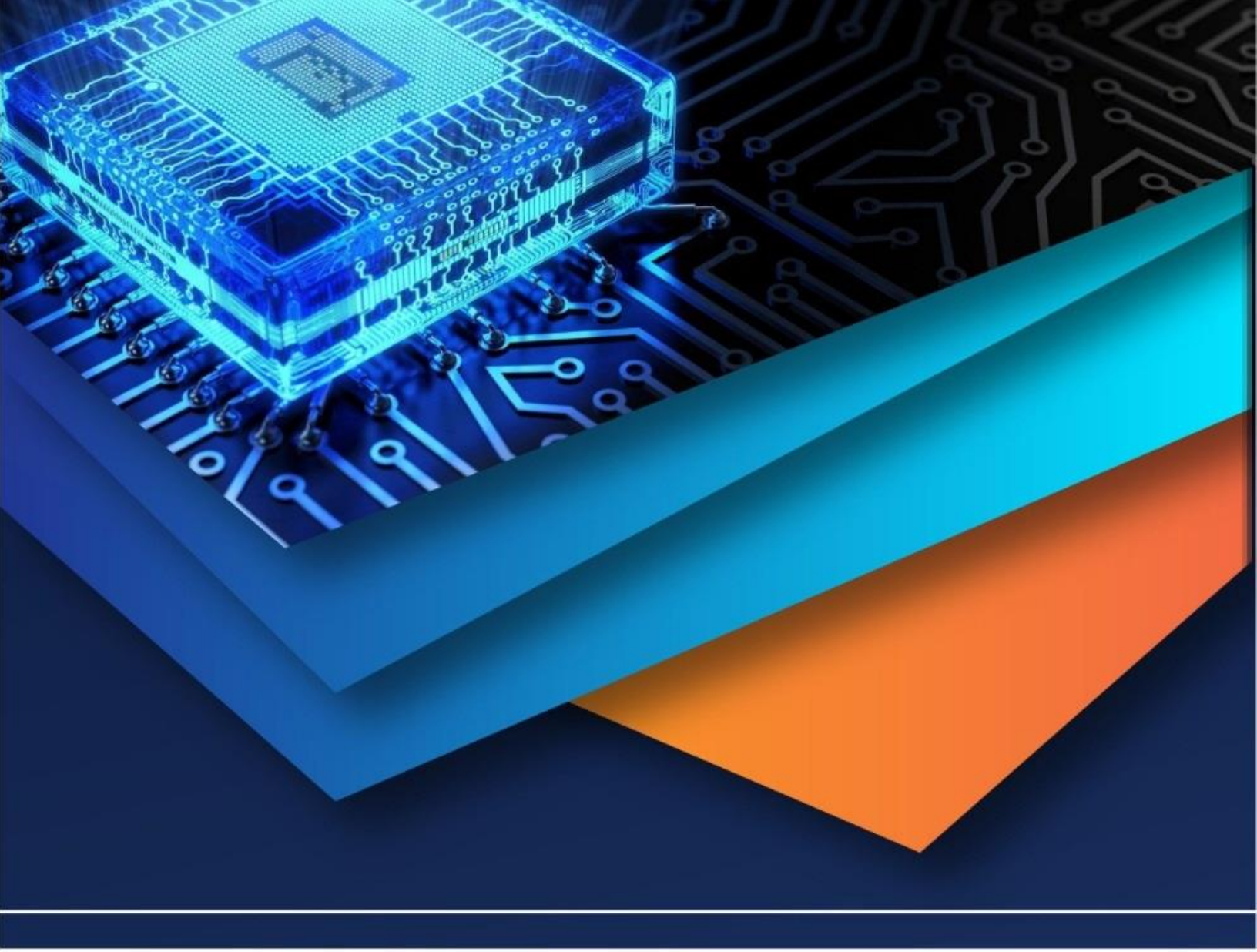

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