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# Preliminary electrical energy audit analysis of mineral based industry

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***Abstract*** **–** India has long been recognized as a nation well endowed in natural mineral resources. India is ranked 4th amongst the mineral producer countries, behind China, United States and Russia, on the basis of volume of production. It is an extremely important sector and contributes significantly to our Gross Domestic Product. As our country India rather whole world is moving towards track of energy efficiency, one should have idea of how energy efficiency in every electrical system starting from power generation, power transmission, power distribution to the energy consumer load centre's can be achieved. It is very essential and pertinent not only for country's economic development but also for achieving Sustainable environment. In this paper concept of preliminary electrical energy audit, methodology of audit, results and findings of preliminary audit of mineral based industry has been discussed.

***Index Terms*** **-** Electrical energy audit, preliminary audit, energy bills and major power consuming areas.

## I. INTRODUCTION

Energy is the capacity of a physical system to perform work. Energy exists in several forms such as heat, kinetic or mechanical energy, light, potential energy, electrical or other forms. Energy is the ability to do work and work is the transfer of energy from one form to another. We have almost exploited Coal and other fossil fuels which have taken three million years to form, are likely to extinct for future generation. For sustainable development, we need to adopt energy efficiency measures. The term energy audit is commonly used to describe a broad spectrum of energy studies ranging from a quick walk-through of a facility to identify major problem areas to a comprehensive analysis of the implications of alternative energy efficiency measures sufficient to satisfy the financial criteria of sophisticated investors. The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect. The term energy management means many things to many people.

There was drastically increase in energy consumption in India and around world also and it has to be checked by any means **[1]**. Increasingly in the last several decades, industrial energy audits have exploded as the demand to lower increasingly expensive energy costs and move towards a sustainable future have made energy audits greatly important. Their importance is magnified since energy spending is a major expense to industrial companies (energy spending accounts for ~ 10% of the average manufacturer's expenses). This growing trend should only continue as energy costs continue to rise.

While the overall concept is similar to a home or residential energy audit, industrial energy audits require a different skill set. Weatherproofing and insulating a house are the main focus of residential energy audits. For industrial applications, weatherproofing and insulating often are minor concerns. In industrial energy audits, it is the HVAC, lighting, and production equipment that use the most energy **[2]**.

Today, 85% of primary energy comes from non-renewable and fossil sources (coal, oil, etc.). These reserves are continually diminishing with increasing consumption and will not exist for future generations. In this paper we study Methodology of energy audit, procedure to carry out preliminary electrical audit and results and major findings of preliminary electrical audit of mineral based industry i.e. mining industry. My research areas are energy audit, electrical safety audit and energy management in industries with special focuses on mining industries. Currently I am doing energy audit and energy management in metal mining industries.

## II. ELECTRICAL ENERGY AUDIT

As per the Energy Conservation Act, 2001, Energy Audit is defined as "the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption" **[3]**.

An energy audit, therefore, is a detailed examination of a facility's energy uses and costs that generates recommendations to reduce those uses and costs by implementing equipment and operational changes **[4]**. The essential step to the energy efficiency improvements is the performance of an energy audit **[5]**. Extensive attention is given to understanding not only the operating characteristics of all energy-consuming systems, but also situations that cause load profile variations on short and longer term bases (e.g. daily, weekly, monthly, annual) **[6]**.

### 2.1. Type of Energy Audit

The type of Energy Audit to be performed depends on **[3]**:

- Function and type of industry
- Depth to which final audit is needed, and

- Potential and magnitude of cost reduction desired

Thus Energy Audit can be classified into the following two types.

i) Preliminary Audit
ii) Detailed Audit

**2.2. Benefits of Audit in Industrial Facilities:**

1. Financial benefits which contribute to reduction in operating costs or an increase in the profits of organization. These must be assessed against cost of implementation of energy efficiency measures.
2. Operational benefits that assist the management of industrial site improve the comfort, safety and productivity.
3. Environmental benefits like reduction in CO2 concentrations or other green house gases and emissions **[7]**.
4. It was also found that correct decision-making depended on accurate energy audit data. In order to improve the quality and efficiency of the energy audit, the government should establish an energy-information-sharing platform among the enterprises **[8]**.

**2.3. Preliminary Energy Audit Methodology**

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.

The preliminary analysis helps the energy auditor to better understand the plant by providing a general picture of the plant energy use, operation, and energy losses. This effort provides enough information to undertake any necessary changes in the audit plan **[9]**.

**Preliminary energy audit is a relatively quick exercise to:**

- Establish energy consumption in the organization
- Estimate the scope for saving
- Identify the most likely (and the easiest areas for attention
- Identify immediate (especially no-/low-cost) improvements/ savings
- Set a 'reference point'
- Identify areas for more detailed study/measurement
- Preliminary energy audit uses existing, or easily obtained data

**2.3.1. Benchmarking:**

Benchmarking can be a useful tool for understanding energy consumption patterns in the industrial sector and also to take requisite measures for improving energy efficiency **[2]**.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. 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 **[2]**. 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.

**2.3.2. Initial Site Visit and Preparation Required for Auditing**

An initial site visit may take one day and gives the Energy Auditor/Engineer an opportunity to meet the personnel concerned, to familiarize him with the site and to assess the procedures necessary to carry out the energy audit. During the initial site visit the Energy Auditor/Engineer should carry out the following actions: -

- ❖ Discuss with the site's senior management the aims of the energy audit.
- ❖ Discuss economic guidelines associated with the recommendations of the audit.
- ❖ Analyze the major energy consumption data with the relevant personnel.
- ❖ Obtain site drawings where available - building layout, steam distribution, compressed air distribution, electricity distribution etc.
- ❖ Tour the site accompanied by engineering/production **[3].**

**2.3.3. The main aims of visit**

- To finalize Energy Audit team
- To identify the main energy consuming areas/plant items to be surveyed during the audit.
- To identify any existing instrumentation/ additional metering required.
- To decide whether any meters will have to be installed prior to the audit e.g. KWh, steam, oil or gas meters.

- To identify the instrumentation required for carrying out the audit.
- To plan with time frame.
- To collect macro data on plant energy resources, major energy consuming centers.
- To create awareness through meetings/ programme **[3].**

## III. CASE STUDY OF MINERAL BASED INDUSTRY

on strictly following the guidelines given by Bureau of energy efficiency and literature available regarding process, methodology and procedure of preliminary electrical energy audit, Preliminary electrical energy audit was carried out at mineral based industry i.e. (let us say) Mining Industry A.

### 3.1. Data analysis

On rigorous study of historical data and easily available data available with industry regarding energy bills, power factor, and maximum demand following results were presented.

**Table 1: Comparison of Annual Summary of Energy Bills from 2007- 2009**

| Details | 2009 | 2008 | 2007 |
|---|---|---|---|
| Compressor | 23,41,680 | 23,61,141 | 24,23,839 |
| Vertical shaft | 8,94,552 | 9,27,192 | 8,56,056 |
| Ventilation fan | 31,08,982 | 26,75,809 | 29,68,056 |
| STP | 4,92,364 | 5,59,201 | 4,99,767 |
| Underground mines | 49,01,221 | 52,32,010 | 54,44,945 |
| Workshop mechanical | 10,82,999 | 13,02,377 | 12,16,897 |
| Workshop electrical | 57,003 | 67,275 | 64,051 |
| Colony | 31,78,536 | 31,26,360 | 30,54,910 |
| others | 6,46,435 | 6,34,615 | 6,13,761 |
| Total | 1,67,03,772 | 1,68,85,980 | 1,71,42,282 |
| Maximum demand | 3760 KVA | 3880 KVA | 3906 KVA |
| Power factor (Cos ϕ) | 0.935 lag | 0.932 lag | 0.936 lag |

Note: all values in above table are in Electrical Units (Energy units)

**Table 2: Comparison of Annual Summary of Energy Bills from 2010 - 2012**

| Details | 2012 | 2011 | 2010 |
|---|---|---|---|
| Compressor | 23,91,090 | 25,82,092 | 25,89,520 |
| Vertical shaft | 8,99,244 | 8,91,684 | 9,34,416 |
| Ventilation fan | 30,14,220 | 30,95,379 | 34,36,182 |
| STP | 5,28,702 | 5,43,077 | 5,45,525 |
| Underground mines | 49,59,299 | 49,60,144 | 48,49,475 |
| Workshop mechanical | 12,76,985 | 11,62,133 | 9,88,088 |
| Workshop electrical | 67,222 | 61,166 | 52,008 |
| Colony | 36,81,810 | 32,89,500 | 31,25,820 |
| Others | 6,44,346 | 6,07,917 | 6,53,769 |
| Total | 1,74,62,918 | 1,71,93,092 | 1,71,74,803 |
| Maximum demand | 3890 KVA(industry meter) 3780 (state board meter) | 4050KVA (industry Meter) | 3456 KVA (industry meter) |
| Power factor (Cos ϕ) | 0.920 lag(industry meter) 0.916 lag (state board meter) | 0.934 lag | 0.955 lag |

Note: all values in above table are in Electrical Units (Energy units)

Note: In above Table others consists following sections

- Mines office
- GM office
- Central stores
- Ventilation shaft office
- CISF office
- Lightning plant area
- Pumping surface
- Canteen
- Auto section
- Fire station

**Table 3: Power consumption details month wise for the year 2009-12:**

| Month | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|
| January | 13,81,182 | 13,88,712 | 14,14,824 | 14,91,756 |
| February | 12,62,970 | 12,73,830 | 13,45,482 | 13,89,366 |
| March | 13,41,012 | 13,74,756 | 14,52,054 | 14,34,300 |
| April | 13,21,542 | 14,10,948 | 13,71,348 | 13,91,100 |

| | | | | |
|---|---|---|---|---|
| May | 14,23,182 | 14,14,914 | 14,23,674 | 15,14,286 |
| June | 14,70,630 | 14,21,184 | 14,57,724 | 14,76,312 |
| July | 15,74,490 | 14,94,450 | 15,30,330 | 15,27,5540 |
| August | 14,94,402 | 14,99,222 | 15,11,094 | 15,25,908 |
| September | 14,77,662 | 14,88,929 | 15,12,932 | 14,67,096 |
| October | 9,99,672 | 14,79,372 | 11,68,308 | 14,68,836 |
| November | 14,82,312 | 14,20,788 | 14,56,596 | 14,68,886 |
| December | 14,74,716 | 15,07,698 | 15,48,726 | 13,07,532 |

Note: all values in above table are in Electrical Units (Energy units)

**Table 4: Comparative power consumption statement feeder wise:**

| Feeder | 2012 | 2011 | 2010 | 2009 |
|---|---|---|---|---|
| Others | 6,44,346 | 6,07,917 | 6,53,769 | 6,46,435 |
| Colony | 36,81,810 | 32,89,500 | 31,25,820 | 31,78,536 |
| Workshops | 13,4,4207 | 12,23,299 | 10,40,096 | 11,40,002 |
| U/G mines | 49,59,299 | 49,60,144 | 48,49,475 | 49,01,221 |
| STP | 5,28,702 | 5,43,077 | 5,45,525 | 4,92,364 |
| Ventilation fan | 30,1,4220 | 30,95,379 | 34,36,182 | 31,08,982 |
| Vertical shaft | 8,99,244 | 8,91,684 | 9,34,416 | 8,94,552 |
| Compressor | 23,91,090 | 25,82,092 | 25,89,520 | 23,41,680 |

Note: all values in above table are in Electrical Units (Energy units)

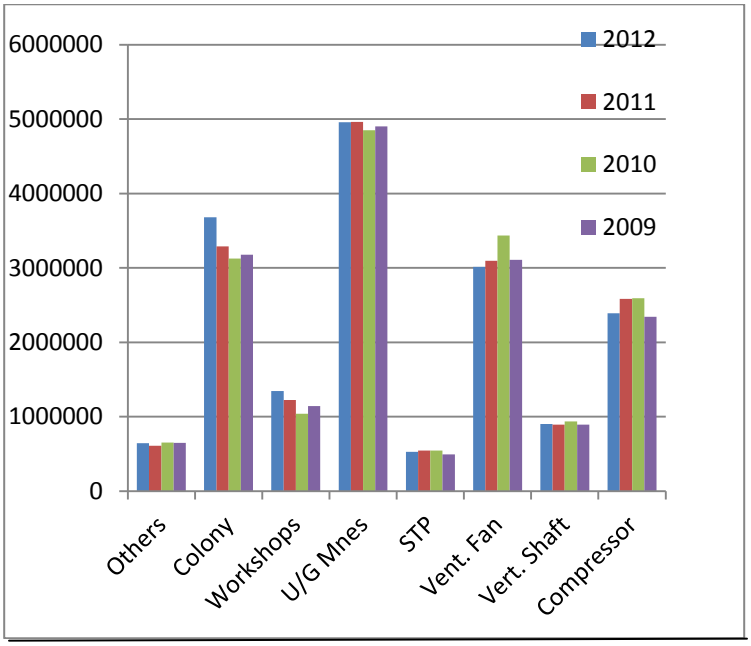
Feeders come under Productive section:

- Compressor
- Vertical shaft
- Ventilation fan
- U/G Mines
- Workshop (Mech.)
- Workshop (Elect.)
- Others

Feeders come under Non-Productive section:

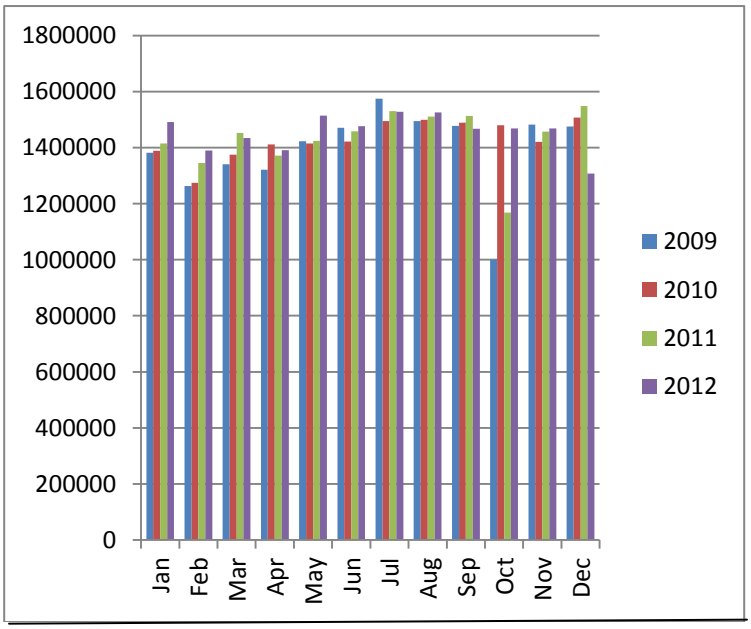
- STP
- Colony

**Graph 1: Comparative Power Consumption Statement Feeder wise for the year 2009 – 2012:**




Note: all values in above table are in Electrical Units (Energy units)

**Graph 2: Power Consumption Month wise for year 2009 - 2012:**

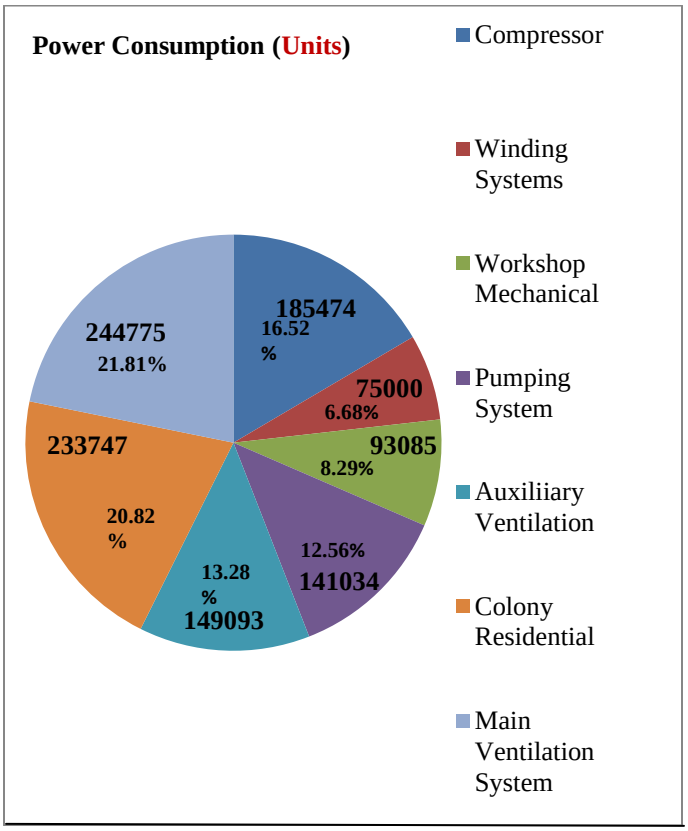



Note: all values in above table are in Electrical Units (Energy units)

## IV. CRITICAL ANALYSIS AND MAJOR FINDINGS

On the basis of data analysis some of critical results were drawn out and major findings during preliminary electrical energy audit were discussed with industry. Those are -

**Graph 3: Major power consuming sections**




### 4.1. Major findings regarding electrical operations during audit

#### 4.1.1. General:

1. Starting matter of motor- slip ring induction motor with resistance cut method.
2. Reactive power compensation- capacitors are using at industry.
3. Motors are of older one, need to be changed with high (energy) efficient motors.
4. Calibration of gas analyzers is not accurate.
5. Standards of Exhaust (emissions) levels regarding different vehicles used in underground uranium mines are not clear to (industry) them.
6. Processing cycle and man power management is not clear.
7. Idle running hours of diesel operated vehicles is going on increasing.
8. Down time of vehicles is increasing, need to be decreased.
9. How to give maximum output with less no of stopes.
10. Allocation of work is to be optimized.
11. Overhead fault, earth fault protection measures has been taken.
12. Continuous monitoring not done during operation of mine.
13. Cable losses not carried out at all.

#### 4.1.2. Compressor:

1. Leakage has been occurring.
2. Measures regarding quick repair during running of compressor is not clear.
3. Motors are of old type (1995.)
4. Latest one.
5. Oil free compressor/screw compressor.
6. Schedule of operation: (9.00 am-1.30 pm), (5 pm -9.30 pm), (1 am- 5.30 am).
7. Peak time: 10.30 am – 1.00 pm.
8. Leakage in cooling towers (there are 2 towers and leakage between them).
9. Installation of venture at drilling site.

#### 4.1.3. Pumping systems

1. To pump more quantity with same capacity and with minimum utilization of energy.
2. Motors (1988) need to be check for efficiency (requires detailed audit).
3. No inlet and outlet gauges provided.

#### 4.1.4. Winders

1. DC Motors unbalance with heavy sound.
2. Vibrations due to unbalances.
3. Overloading problem.

#### 4.1.5. Main ventilation system

1. Transformer is exceeding their maximum temperature ($45^0$).
2. One motor is under heavy duty.
3. 50HP ×2 : Auxiliary fan house in case of breakdown and belt loose.
4. Records are maintained regularly for input supply, output supply and transformer.

### 4.2. Energy conservation steps taken by industry:

1. Solar power plant for lightning.
2. CFL replacement with ordinary lightning bulbs.
3. Load management for compressor operation.

## V. CONCLUSIONS

Preliminary electrical energy audit was carried out at mineral based industry as per standards provided by bureau of energy efficiency and data was critically analyzed to benchmark major power consuming sections within industry. Now detailed audit is

necessary to examine what is happening in existing electrical system of industry and what is to be done in order to improve system so that efficiency in each section of electrical operations can be achieved.

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