ADDIS ABABA UNIVERSITY
ADDIS ABABA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING

ENERGY AUDITING AND CONSERVATION IN CEMENT PLANT
(Case Study: Diredawa National Cement PLC)

THESIS PROPOSAL SUBMITTED TO ADDIS ABABA INSTITUTE OF TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ELECTRICAL ENGINEERING (POWER ENGINEERING)

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Abstract

The cement production method has been extremely energy and price-intensive. To attain an actual and well-organized energy handling system, electrical and thermal energy review investigation was active on the cement plant. The cement plant requires 4,473.06 hours per year of the total operating hours to produce 587,375.67 tons of clinker.

The factories have the problem of proper utilization of energy, due to lack of proper replacement, regular maintenance, and control efficiency of most industrial equipment and processing is lower than the expected. This study focuses on energy audit and conservations in an exceedingly national cement plant that has been victimization knowledge collected from the cement plant, an in-depth assessment has been taken on energy using and loss. Due to these losses, Energy efficacy evaluations of the most energy-intensive equipment such as electrical motors and drives, lamps have been done. Additionally establish technological opportunities to decrease the energy consumption of the plant, increase productivity, and improve the assembly method. Specializing in energy consumption reduction efforts through method improvement, production management, and introducing new technologies achieved vital results.

By replacing the more efficient lamps (from T-12 to T-8 lamps) 92.52 MWh/year energy is conserved and saves 1713.33 Dollars/year. Motor Master international is used to choice good electric motor in form of efficacy, price-efficacy & energy conserving possible. Consequently, Motor Master + international software, 240.222 MWh/year energy is conserved and saves 13,223 Dollars/year. The Energy-efficient cement factory were nominated as a standard to compare their difference in electrical and fuel energy intensity (19.5 kWh/t and 779.4 KJ/Kg) and pays additional payments of 1, 1042,314.0974 Dollars per year.

Keywords: Cement Industry, Energy Audit, Energy Efficiency, Clinker, Energy Consumption, and Payback Period.

Acronyms

NCSC: National Cement Share Company

ECRA: European Cement Research Academy

T: Tone

Leo: Liters of Equivalent Oil

GJ/t: Gigajoule per tone

tCO2: Tons of Carbon di oxide

ES: Energy Saving

DS: Demand Saving

ASD: Adjustable Speed Drive

Lits: Liters

NEMA: National Electrical Manufacturers Association

TP: Total Power

ENL: Existing Number of Lamps

TLu: Total Lumen

E: Illumination produced by the installed lamps

R_A: *Room Area*

ALP: Actual Number of Lamps

HID: High-intensity discharge

RSE: Required Standard Illumination

RE: Required Energy

CFL: Compact Fluorescent Lamp

CT: Current Transformer

EU: Energy Utilized

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CHAPTER ONE

1. INTRODUCTION

1.1 Back Ground of the Study

National Cement Share Company was founded in November 2005 among a joint venture of East Africa Mining Corporation, the Federal Government of Ethiopia**'s** Privatization and Public Enterprises Supervising Agency and others. After few years, authorities stocks have been sold out through East African Mining Corporation. The corporation is placed 515 kilometers from Addis Ababa, in Dire Dawa Administrative Region. The manufacturing unit become the primary cement plant in Ethiopia, which become hooked up in 1936 through Italians. It turned into formerly known as Dire Dawa Cement Factory. After renovating the antique factory, the agency has boosted the manufacturing from 150 Tons per Day to 4,200 ton/day and is currently producing 3,000 TPD clinker. Cement factories are major energy intensive industries and it is also playing a great role in the economy of a country.

The general power intake of the commercial sectors of evolved nations contributes to around 30–40 % of general power demand. [9, 24] A notable amount of energy is used in the cement industry. [19] Therefore, considerable attention is needed for the reduction of energy and energy-related environmental emissions, locally or globally. Because of their widespread use, efficient plans achieving for controlling motors are of the most important. In National Cement plant more than 750 electric motors are found with various power ratings.

A range of capabilities are done with the aid of using electric powered vehicles and drives in a cement factory, which includes fan movement, grinding, kiln rotation and fabric transport. In the economic sector, power is fed on for a huge variety of activities, which include processing and assembly, area conditioning, and lighting. In general, the industrial sector uses more energy than any other sector, one-half of the world's total delivered energy was consuming. Energy is one of the largest costs that can be controlled in most organizations and the scope is considered for reducing energy consumption and its cost. Kinds of cement, depending on composition of national cement are as follows

- ✓ Ordinary Portland Cement (OPC)
- ✓ Portland Pozzolana Cement (PPC)

The core difference between the two kinds of cements in percentage ratio of clinker. Clinker is the mixture of three components i.e. limestone, basalt and clay when it goes through a sequence of stages. Pure cement without gypsum is called Clinker. Eventually, OPC is a kind of cement with ratio of gypsum (5%) and clinker (95%); while PPC is a kind of cement with clinker ratio (70%), gypsum (5%) and pozzolana (25%). The kiln expertise used by National cement plant is a dry manner five phase preheater kiln taking rotating cooler. The normal heat energy demand of dry process was among 3000 to 4000 MJ/t of clinker. [26]

National cement plant exploits electricity by way of main inputs energy to achieve their accomplishments. In addition that Coal and oil fuels are significant inputs in National cement making and is primarily used in kiln for making of thermal energy which habits for clinker making and in the absence of power for generating some part of the factory respectively. The industry uses coal before from Jimma and South Africa. But, now they are using from south Africa's only because of the high contents of ash. Introductions of coal with advanced heat and lower ash value were successfully forbidden with great charges from South Africa. On the other hand, introducing of coal is expensive and a drain on our national supply of money although it has aided cement plants receiving excellence coal. The worst and not consistent excellence of coal has turn out to be a restrictive influence in successful energy efficacy, output and clinker superiority. Due to use of coals amount of working difficulties for instance, unsuitable and incompetent burning and greater consumption of coal or lower working efficacies which have a tendency to additional growth to releasing of greenhouse gases.

1.2 Statement of the Problems

Most factories in Ethiopia have the problem of proper utilization of energy. They did not know their energy consumption patterns in well-defined manner by performing energy audit. Because of that they spent much money on energy bills, reasons for environment pollution, and industries are not competitive, etc. Using of inefficient energy faces in different problems. Some of them are:

- ✓ The efficiency of most industrial equipment and processing is lower than the expected.
- ✓ Poor design and improper installation and absence of measuring instruments for audit & Absence of energy audit team in the factories.
- ✓ The prevalence of bad management, as a result of the factories are in huge loss, the companies are not in a position to satisfy customer requirements. They are poor in handling and utilization of their resources such as machinery, and materials.

As a result of these facts, Diredawa National cement Factory were selected, which is so old and has so many energy related problems to conduct energy audit. The observed problems in the factory signify that it should conduct energy auditing. Hence this thesis is aimed at examining the energy consumption patterns of the factory and efficiencies of the major energy consuming systems thereby identifying energy conservation opportunities to save energy for the factory to make it more competitive in the market.

1.3 Objective of the Project

1.3.1 General objective:

- To conduct electrical and fuel energy audit, and energy conservation opportunity, as a result of energy auditing and conservation, which reduce energy consumption per unit of product output or in saving energy and to lower operating costs of Diredawa National Cement.

1.3.2 Specific objectives:

- To inspect energy wastage of the Diredawa National cement compared with nominated cement plants.
- To identify specific areas to reduce energy costs without disturbing production.
- To examine the reasons of energy wastages of energy intensive equipment's
- To advocate conceivable energy saving chances on:
    - Fuel consumptions reduction and Lighting systems
    - Electric motors, operating and maintenance competence and kiln process.
    - Opportunities to improve the power factor.
    - Minimizing the volume of imported fuels used for production.
    - Attaining Co_2 gas releasing decreases over energy efficiency upgrading in cement making.

1.4 Significance of the study

Through energy audit, the study:

- ✓ Identifying minimizing wastage, and cost of energy use.
- ✓ Promote awareness in energy efficiency and save non-renewable energy resources.
- ✓ Making changes to produce, equipment and system to save energy.
- ✓ Retrofit energy efficiency technologies in the machines.
- ✓ Protect the environment by reducing power generation.

1.5 Scope and Limitations of the Study

The scope was details the methodology for conducting and evaluating energy conservation and audit for national cement plant. The study encompasses reading relevant literature, collecting the data, simulating the electrical related problem, Study the work flow of the production processes, Study each equipment's that consume energy in the factory, and analyzing data from the company. The study was constrained by various limitations such as:

- ✓ The factory is very old, so some of the equipment's can be failed to work properly.
- ✓ Area of consideration was too big compared to the time spent to do the study.
- ✓ Limitations in getting information.

1.6 Methodology

Methods were used to contribution way of energy auditing and conservation of the energy intensive apparatus of the plants are as follows.

1.6.1 Identifications of Site

One of the existing Cement plants in Ethiopia, Diredawa National Cement plant were selected for the study.

1.6.2 Collection of Data's

For attaining the aim of the thesis various types of data's were gathered. Data's contains:

- ✓ Electrical energy and fuel consumptions required to yield product
- ✓ Different operating parameters of electrical motors
- ✓ Measurement on requirement operational parameters on various equipment's under unlike conditions to approximation their working efficiencies of the plant.
- ✓ Energy production price of the plant, energy invoice, plus lighting of the industry.

The data gathering involves done direct by observation and interviews with the professionals of the factory in order to have better understanding on the factories energy use, and operations.

1.6.3 Data Analysis

Data analyses were done through data collection to provide the background of the cement industry's such as motor efficiencies, loads and the energy saving potentials of the plant.

Moreover, it defines the broad energy use, making, energy efficiency and opportunities of cost reduction of the factory. Based on commercially available energy efficient motors Motor Master+ international software was used to decide the good efficient motors.

1.7 Related Works

The most energy efficient cement facility, so that it represents a facility similar to the user's cement facility, the user is first required to input production variables in the input sheet. [19] The input variables required include the following: The amount of raw materials used in tons per year, The amount of additives that are dried and ground (in tons per year), The production of clinker (in tons per year) from each kiln by kiln type, The amount of raw materials, coal and clinker that is ground by mill type, The amount of production of cement by type and grade (in tons per year), The electricity generated on site. The tool offers the user the opportunity to do a quick assessment or a more detailed assessment this choice will determine the level of detail of the energy input.

Ernst Worrell and Christina G., observed more than forty energy competent expertise and measures and predictable energy savings, asset costs, CO_2 reductions, process and preservation spending. The analysis of cement kiln energy-efficiency opportunities is classified into technologies and measures that are relevant to the different stages of production and kiln types used in China: raw materials preparation, clinker making, and finish grinding, or the plant events and product variations that will minimize energy ingesting for clinker production based on their reading they deliver the electricity and fuel conserves per ton, yearly functioning and investment costs per ton of cement or repayment age, and reductions of CO_2 releases the amount functional to the making of cement.[3]

In contrast, the Canadian and Mexican cement industries appear to be more efficient and in general energy efficiency has increased over the last decade. In Canada, a number of newer plants have come on-line since the early 1990s in part in response to the increased US demand. The Mexican plants tend to be newer, “dry” process facilities and most have preheaters and pre calcinatory as well.

In all the three countries, the use of fuels has changed significantly over the last five to ten years. In the U.S., there has been a general shift toward coal, petroleum coke and alternative wastes such as liquid and solid hazardous wastes, and a lessening dependence upon natural gas to fuel the cement making process. As in the U.S., kilns in Mexico have been shifting their use of fuels, in this case from an almost universal reliance on fuel oils to fuel oils, petroleum coke and alternative fuels. In Canada, there has been less of shift in terms of the type of fuel used, although there has been a decrease in the use of natural gas and an increase in the use of coal. This shift may reflect the changing price of natural gas rather than a major change in fuel use.

Anantharaman N. stated that the Energy Audit study carried out in Cement Industry (1500 tpd), they arrive at the motors running below 50% of rated load can be operated in star connection instead of delta connection, Oversized motors can be replaced by new energy efficient motors, by controlling the air infiltrate, the size of fans and drives can be reduced, which in turn reduces the power requirement to operate the fans, There will be a potential for saving and effective use thermal energy nearly 1000kJ/kg of clinker. The study thus concentrates on a very important area of energy conservation in one of the large energy intensive industry.[1] Conducting energy audits in such industries will help for better energy conservation and prove to a cost cutting measure conclusions.

1.8 Organization of the Thesis

Is prepared in to six sections. The 1st chapter describes the overview of the title i.e. the background of the plant, statement problem, aims, procedure and correlated works to the study. Next chapter describes energy auditing and conservation of cement plant discuses about cement making method, energy employment of cement plant and energy competence enhancement chances of cement plant. The 3rd chapter explains the files gathering and examination i.e. indications the whole energy of the plant, energy damage calculations and data examination. Chapter 4 arises for the replacement of loaded motors and most efficient lamp tubes using simulation of Diredawa NCSC factory (i.e. replacing the T12 lamps by T8 lamps) and how using Motor Master + software to nominate competent electric motor. Then chapter 5 discuses the replacing the diesel generator by the solar PV system. Finally chapter six presents the conclusions and recommendations of the study.

CHAPTER TWO

2. ENERGY AUDITING AND CONSERVATION IN CEMENT PLANT

2.1. Energy Auditing

An energy audit is a study of a plant or facility to see in what way and where energy is employed and to spot techniques for energy savings. Energy audits also are defined that a scientific study or survey to spot how energy is getting used in every plant. There is now a universal recognition of the actual fact that new technologies and far greater use of some that exist already provide the foremost hopeful prospects for the long run. The opportunities lie the utilization of existing renewable energy technologies, greater efforts at energy efficiency and also the dissemination of those technologies and options. This energy audit of the tutorial area has been dispensed and reported during this thesis. [14] Energy audit consists of several tasks which may be administered reckoning on the sort of audit and also the function of audited facility. It started with review the historical data of energy consumption which may be compiled from the electricity bills. The energy utilization like running hours of air-conditioning, lighting levels, locations of unnecessary air-conditioning and lighting because of unoccupied areas, temperature and humidity, pump scheduling and setting, efficiencies of equipment's and machine and therefore the areas of high energy consumption and therefore the possibility to cut back consumption should be record for further analysis.

2.1.1. Types of Energy Audits

Type of energy audit conducted based on the size, function, and the potential and magnitude of energy savings and price reduction desired. Industrial energy audit is classified into two types:

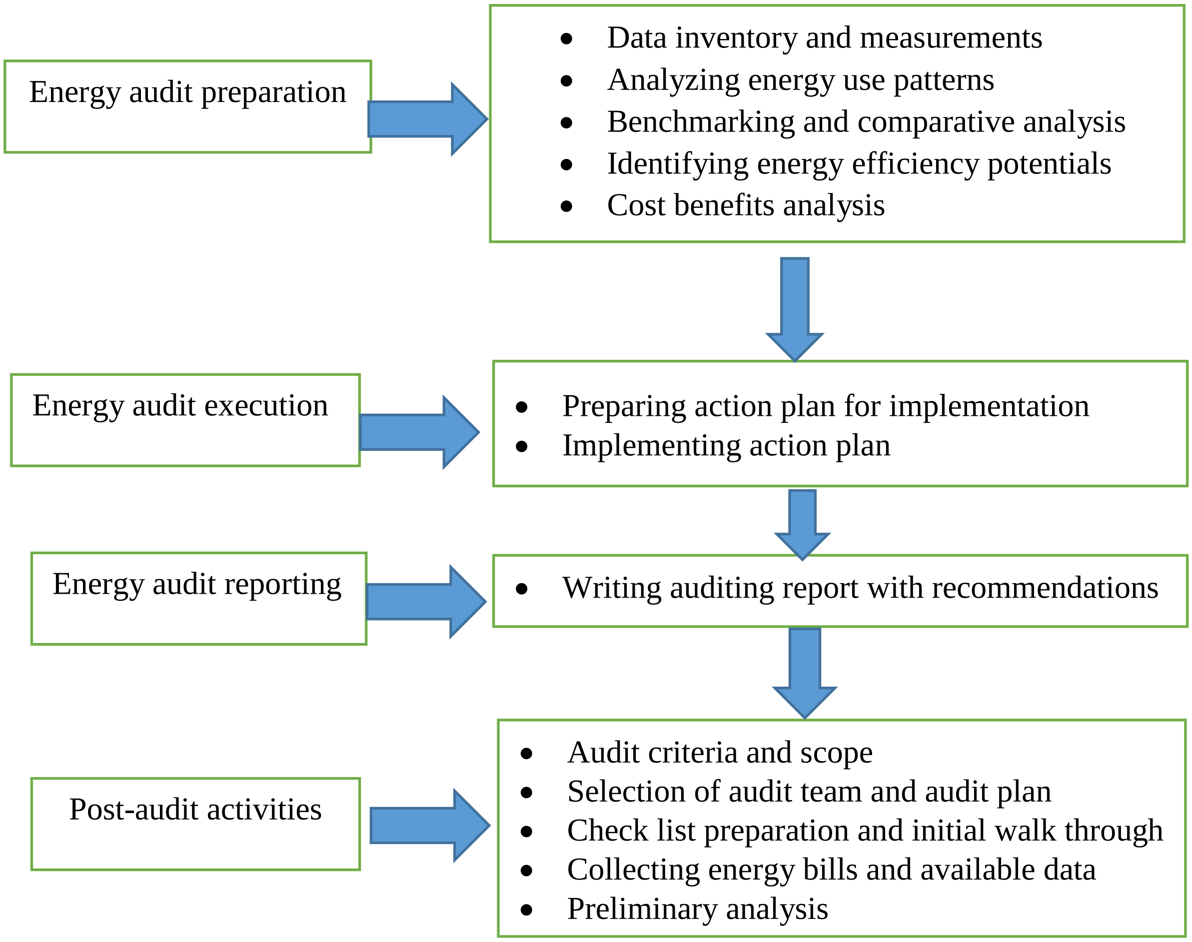
- Preliminary (Walk-through) audit: readily-available data are mostly used for a straightforward analysis of energy use and performance of the plant. This kind of audit doesn't require lots of measurement and data collection. These audits take a brief time and therefore the results are more general, providing common opportunities for energy efficiency. The economic analysis is usually limited to calculation of the straightforward payback period.
- Detailed (Diagnostic) audit: more detailed data and knowledge are required. Measurements and an information inventory are usually conducted and different energy systems (motors, fan, compressed gas, steam, process heating, etc.) are collected intimately.

Hence, the time required for this sort of audit is longer than that of preliminary audits. The economic analysis conducted for the efficiency measures recommended typically transcend the easy payback period and typically include the calculation of net present value (NPV), an internal rate of return (IRR), and infrequently also life cycle cost (LCC). [12]

2.1.2. Overview of Energy Audit Procedures

A preliminary audit contains a number of the identical steps of the procedure shown below, but the depth of the information collection and analysis could be different looking on the scope and objectives of the audit. Overall, there are four main steps each of which has several sub-steps. [8, 14]

Table 2.1 Overview of an industrial energy audit



2.2. Production Process of Cement

Raw material preparation:

The plant has one raw mill capacity of 120 TPH. Raw milling involves mixing the extracted raw materials to get the right chemical configuration, and grinding them to attain the correct particle size to confirm optimal fuel efficiency within the kiln and strength within the final concrete product. Blending & Storage silos are won't to store the mill output product as raw meal. To get rid of the moisture content from meal hot gas from preheater section is employed. Material moisture is 4% in inlet whereas after mill the moisture content in raw meal is 0%. [13]

- Mining and Quarrying: the foremost common raw materials used for cement production are limestone, Basalt and clay. The foremost component of the raw materials, the limestone, is typically extracted from a quarry adjacent to or very near the plant. Limestone provides the desired oxide and a few of the opposite oxides, while clay, shale and other materials provide most of the silicon, aluminum and iron oxides required for the manufacture of cement. The limestone is most frequently extracted from open-face quarries but underground mining may be employed. The raw materials are selected, crushed, pre-homogenized, ground, and proportioned in order that the resulting mixture has the required fineness and chemical composition for delivery to the pyro processing systems. In the cement industry, the first crushing of raw materials takes place in single- or twin-rotor hammer crushers. They're mainly employed in small cement plants together with roll or gyratory crushers for the crushing of hard and abrasive materials. The common power consumption for crushing is estimated to range between 0.5 and 0.9 kWh/ton of stuff. The gyratory crusher contains average power consumption of 0.42 kWh/ton of material, and is now available recognized as best technology.
- Removing and Conveyance of core material: the assembly progression of cement begins with stuff source, which includes like explosion of rocks, moving the substantial from quarries with dump cars, grinding rock and conveying to cement factory from that site. The foremost mutual ingredients intended for making of cements are limestone, basalt, and clay. Main elements of the core materials, limestone is sometimes derived from quarry near the factory. Limestone delivers the specified calcined lime and a few of the opposite oxides, however, clay and extra ingredients deliver peak of the aluminum (Al), silicon (Si) and iron (Fe) oxides used for manufacturing of Portland cement.

- Grinder: encompasses a protection to appliance that defends the consumer (apron) feeder, hammer grinder, tie conveyors. Apron feeder is employed for straight, tending shipping of majority resources that derive from diggings in to grinder mill roller bay. Apron is determined by moving shaft by frequency organized motors which are fixed immediately on the shaft. The hammer grinder have one rotor, it haven't inlet grates, inlet rollers and is meant for giant decreasing in single stage.

Coal Mill: the plant there are two coal mills of capacity varying from 3.3 TPH to 10TPH. The coal that's to be burnt within the kiln and Precalciner section is dried and finely grounded. It's from the storage silos that the fined coal is fed to Kiln burner and Precalciner section. While entering the mill the moisture content within the coal is around 10% whereas it becomes 2% at the outlet.

Pyro process: Through four stages two strings are installed within the preheater section. In preheater the raw meal fed from top of the string will preheated by the recent exit gas coming from kiln, and within the precalciner combustion is happening for calcining (a heating process during which quicklime is formed) the raw meal. After this for burning within the kiln the calcined raw meal is fed into the kiln, and this is often the ultimate process in pyro processing. The raw meal fed into the kiln comes out as clinker at the top of this process. Clinker is made from the chemical reactions between the raw materials and it's hard, gray, spherical nodules. For combustion in kiln and precalciner fine grounded coal from coal mill is employed.

Grate Cooler: so as to preserve the perfect quality and for transporting carefully and elegantly by conveyors the clinker has cooled to 65-11000C after the clinker formation. . In cooler, clinker cooling is happening with the assistance of ambient air supplied by cooler fans to recover the warmth from clinker, after taking heat from clinker one a part of hot air is supplied into kiln as secondary air for complete combustion and one part is supplied to precalciner as tertiary air and remaining are going to be vent through fan.

Cement Mill: is that the end within the process of cement making and two mills installed with capacity of 55.8 TPH cement. Cement is grinded with slags, gypsum. To separate the materials that has not been completely grinded is shipped back to the mill and after it gets separated in separator. The output of the mill is then sent to cement storage silos where it's stored and sent to the packing units which are consisting of manual also as electronic packers.

Figure 2.1 Cement mill [from Diredawa National Cement]

Packing Section: The packing unit is that the section where the cement stored within the silo is packed. The sector is employed to storing the ultimate results of cement so as to be sold to the purchasers by conveying it to dissimilar marketplace. In storing part, the cement is packed by means of rotary paper sack storing machine over manual sack serving. The Plant was having two packing units, one is loaded within the wagon in bulk quantity and therefore the other one is packed into bags.

Figure 2.2 Packing and transportation section [from Diredawa National Cement]

A small amount of gypsum (3-5%) is added to the clinker to manage how the cement will set. The mixture is then very finely ground to get "pure cement". During this phase, different mineral materials, called "cement additives", could also be added alongside the gypsum. Finally, the cement is stored in silos before being shipped in bulk or in bags to the sites where it'll be used.

A cement production plant consists of the subsequent three processes.

- ✓ Raw material process
- ✓ Clinker burning process
- ✓ Finish grinding process

The general cement production process and process flow diagram of Cement plant are listed on figures 2.3 and figures 2.3 respectively.

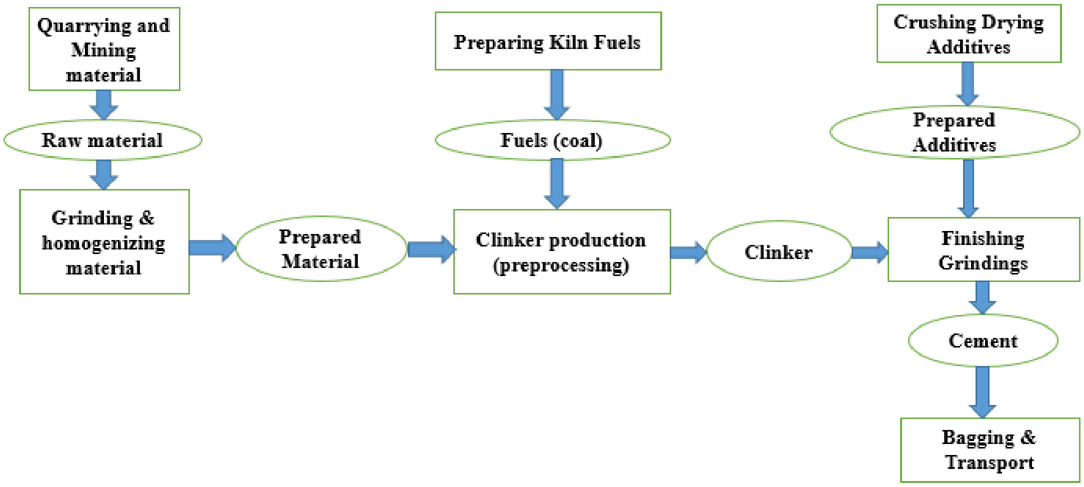


Figure 2.3 General Cement Production Process

From the limestone quarry to the delivery of the top product, follow every step within the cement manufacturing process.

Step 1: extraction of raw materials: removing of calcium carbonate, silica, etc. are generally extracted from limestone clay or rock. Suitable reserves are often found in most countries. They're then crushed and transported to the plant where they're stored and homogenized.

Step 2: raw grinding and burning: Very fine grinding produces a fine powder, referred to as raw meal, which is preheated then sent to the kiln. The fabric is heated to 1,500°C before being suddenly and dramatically cooled by burst so fair. This produces clinker, the essential material required for the assembly of all cements.

Step 3: cement grinding and shipping (Packing and transporting).

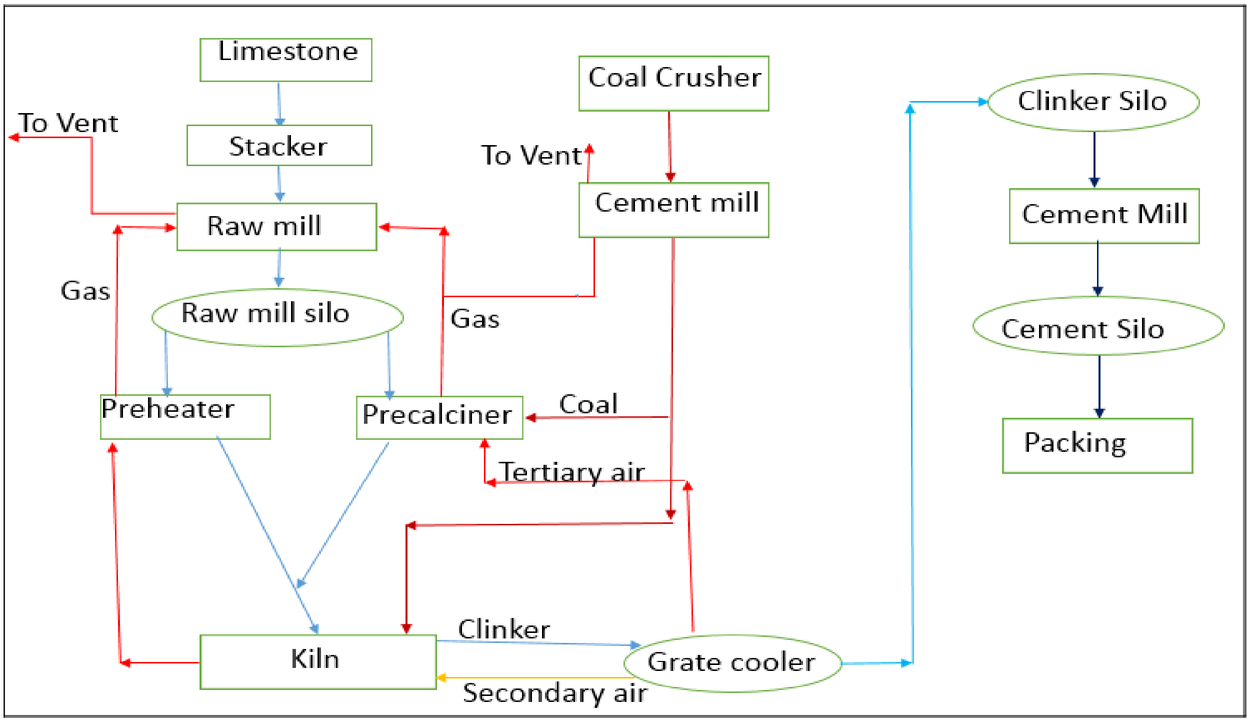


Figure 2.4 Process flow diagram of the cement plant

2.3 Coal Preparation

Coal is that the most used fuel within the cement industry, and therefore the main fuel for the overwhelming majority of clinker kilns within the N.C. most ordinarily a roller mill is employed for coal grinding. Coal is shipped "wet" to stop dust formation and fire during transport. Passing hot gasses through the mill combines the grinding and drying.

Waste heat of the kiln system (e.g. the clinker cooler) is employed to dry the coal if needed. Other advantages of a roller mill are that it's ready to handle larger sizes of coal and coal types with an improved humidity, and might manage larger variations in throughput. Coal roller mills are available for throughputs of in average of 102.5 tons/hour. Electricity consumption for a vertical roller mill is around 17 kWh/ton coal. The investment costs for a roller mill are typically above that of a tube mill or an effect mill, but the operation costs are lower; roughly 20% compared to a tube mill and over 50% compared to an impact mill and it saves around 8.5 Kwh/ton. Roller presses are often accustomed grind raw materials and coal interchangeably, although coal grinding equipment needs special protection against explosions. [24, 25]

2.4 Clinker production

This technique is comprised of the rotary kiln and its equipment. The kiln is in 4% slope. Fuel combustion within the foremost burner supplies the warmth to the fabric sintering. Clinker production are often split into the electricity required to run the machinery, including the fans, the kiln drive, the cooler and thus the transport of materials to the most effective of the preheater tower (“kiln preheaters” and “cooler system”), that the fuel needed to dry, to calcine and to clinkered the raw materials. At the assembly of clinker the raw mix is heated step by step within the kiln till reaches a maximum temperature of 1450 °C. [24]

The kiln feed have four basic steps:

- ✓ Step 1: the raw mixture is heated to 100-120 °C, to vaporize totally wetness. Subsequently, temperature rises to 450 °c to free additional inflexibly assured drying and preheating.
- ✓ Step 2: carbonate is heaty disintegrated in temperature-variety of 450-1100 °C to form CaO, getting by releasing of CO_2. During step two all organic substantial’s is fired and current alkalis somewhat evaporate (calcining).
- ✓ Step 3: Clinkerisation means the creation of clinker raw materials at temperatures until 1450^{o}C. A reactions between the quicklime then the selection staple constituents, the tactic is being formed di calcium silicate, tri calcium silicate, tri calcium aluminate and etc.
- ✓ Step 4: The kiln inner cooling, during which final product of $CaAl_2O_3$ and $CaFe_2O_3$ happens within temperature varieties of $1,400^{o}$C-1,250°C and cooled down to 100-200° C.

Figure 2.5 Production of Clinker [from Diredawa National Cement]

Incentives for using mineralizers can come from increased production, longer refractory lifetime, preparing raw mix, so the facility to use low cost fuels (high sulfur content). The only advantage though, is that the assembly of a product characterized by increased hydraulic activity that makes an oversized potential for clinker substitution. All moisture from coal drying is vented to the atmosphere and thus the pulverized coal is transported to storage via cyclone or bag filters. Pulverized coal is then densely conveyed to the burner with a little amount of primary transport air. Hoping on the secondary air temperature, a 5-10% primary air reduction translates into 43-69 kBtu/ton clinker energy savings in conventional cement kilns and about half this in modern kilns. The optimization of the combustion conditions will cause reduced NOx emissions, better operation with varying fuel mixtures, and reduced energy losses. The utilization of upper insulating refractories can reduce heat loss. Refractory choice is that the function of insulating qualities of the brick and thus the flexibleness to develop and maintain a coating. The coating helps to chop back heat losses and to safeguard the burning zone refractory bricks. The utilization of improved kiln-refractories can even cause better consistency of kiln and minimizing lost time, reducing production costs considerably, and reducing energy needs during start-ups. [11]

2.4 Energy Conservation

Energy conservation means decreasing the quantity of energy used without changing the amount of labor gained (production, temperature, brightness, distance). In other words, it means increasing the quantity of labor without changing the number of energy used. As a measurement energy conservation, “energy intensity,” which is that the quantity of energy consumption per unit of measurement, is sometimes used. [9]

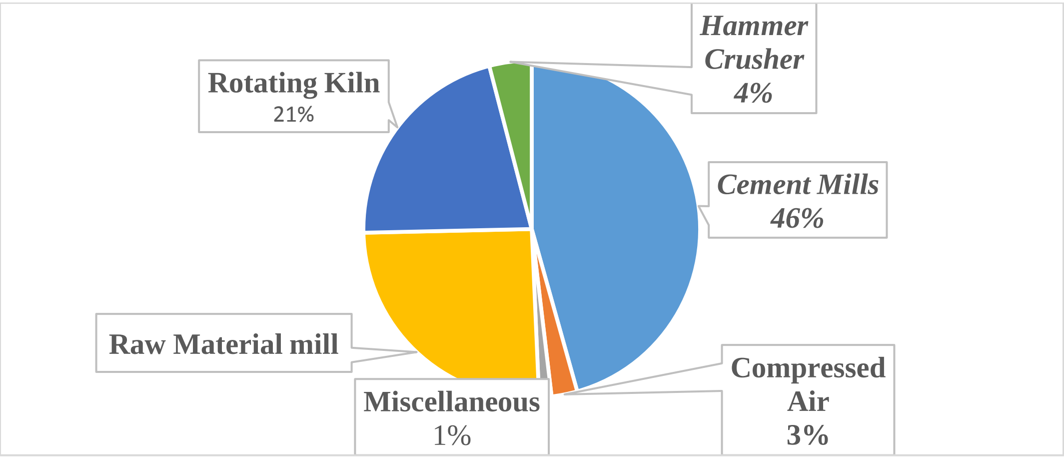


Figure 2.6 Average Electrical distribution of national cement

2.4.1 Energy Requirement of Cement Factory

Cement plant customs an honest group of energy sources as associated with the selection. The facility is various variety of producing and supply split out progressions. It uses coal, electricity, petroleum, and sources that can be replaced, additionally as several byproducts of these fuels for operating motors, drives, belt transport, fans, revolve kiln to crash, grinding natural constituents and lightings. Rotary kilns signify the foremost important energy end user and gas emission cause of the cement plant than their activities of production and cause fewer effectiveness with the rest of world. The kiln process takes around 93% of the energy uses within the cement industrial division. The heating and cooling temperatures of dry kiln and wet kilns are not the same. Thus, they want dissimilar amount of electrical and fuel energy. Electricity uses in cement production to power light, motors, funs, and in finishing of crushing mills, to figure fans and blowers in warming accommodations, to require a seat back the clinker and revolve kiln additionally, structure processes like lighting and freshening schemes. Moreover to electricity conversely, the essential purpose of rotating essential materials into clinker was gifted by the consumption of massive quantities of coal. Therefore, averagely a theoretical energy request of 1725 MJ/t of clinker was required for that progression. It considers the key energy assets of the plant coal energy and electricity use for staple preparation (fuel, essential material), grinding (end products).

Lighting System: is utilized to provide lighting to the plant. We've differing types of lighting lamps such us, High-intensity discharge bases ((metal halide, high pressure Na, and Hg vapor lamps) are took for storage and manufacturing spaces), Fluorescent, compact fluorescent (CFL), and incandescent lights.

Lighting limits had better used altogether zones of the industry. Lighting request is assessed through amount of lumen sunshine desired per a particular point of a long period of time. The efficiency is used to clarify the lamps energy efficiency. It's defined by the amount of sunshine it yields in lumens with relevance flexibility and it consumes in lumens/Watt. Flux (Ø) issued to measure the non-particulate radiation yield of lamps, actuality released after a light-weight altogether instructions of a plane. [1]

Illuminance describes the number of sunshine on an area in lumens/square meter or lux.

$$\text{Illuminance} = (\text{Luminous flux}) \,/\, (\text{area})$$

$$E = \text{Ø} / \text{A (lux) or (lumens)} / (\text{m}^2)$$

On behalf of fluorescent lamps and compact fluorescent lamps capability, the foremost significant features are:

- ✓ Luminous flux (Ø) and illuminance
- ✓ the energy effectiveness of lamp,
- ✓ standard lifespan operating hours,

Energy utilized in lighting is incredibly insignificant within the cement industry, energy efficiency upgrading chances can decrease the energy use. This is attained through by using more efficient lamps.

Electric Motor system: is additionally a tool for converting electrical power into mechanical power. An electrical motor will try to deliver the desired power even at the danger of self-destruction. Therefore, an electrical motor must be shielded from self-destruction. Motors is additionally ruined by physical damage to the windings but, usually, the enemy of a motor is excessive heat within the windings. When the insulation fails, the motor fails. Overheating is that the results of excessive current flow or inadequate ventilation. Accumulation of dust and dirt on and within the motor can reduce ventilation and heat removal. [1] The energy of electrical motor is employed for rotating a pump, fan or blower, driving a compressor etc. entirely motors have identical working mechanism such as:

- ➢ A current with an exceedingly very field will create force.
- ➢ If this carrying wire is bent into a loop, then the two sides of the loop, which are at right angle to the magnetic flux, will experience forces in opposite directions.
- ➢ Applied motors have numerous coils on an armature to deliver a more uniform torque and thus the magnetic flux is produced by electromagnet plan called the sphere coils.

Industrial motors may be largely categorized as DC motors, synchronous motors and induction motors. Reckoning on the commercial assembly, motor schemes version averagely for about 65% of electricity consumption in factories. After assuming energy efficiency enhancements to plants of motor structures, it's significant to boost the energy efficiency of the whole motor structures such us, motors, drives, apparatus like pumps, fans, and limiters. Steps involving to enhance the energy efficiency of motor system are:

- ➢ Specifications and conditions of every motor should be documented to produce an information.

- If upgrades are achieved, the performance of the upgraded motor systems should be monitored to see the particular cost saving.
- The necessities and also the real use of the motor schemes had better evaluated to see motors are correctly manufactured and in what way motor encounters well requirements of the working materials.
- All applications of motors (fans, machine tools, pumps, alternators, compressors, rolling mills, movers, etc.) during facility should be located and identified.

Compressed Air System: are used for mixing of slurry and within the bag house or dust collector to filters out and related applications. Thanks to poor efficiency of compressed gas is that the costliest sort of energy available during a plant. Poor maintenance can lower the efficiency and increase air vapor or pressure variability. Therefore to scale back these problems and to avoid wasting energy we must be improve our maintenance. Compressed gas systems comprises variety of major subsystems and components. Compressed gas systems are often subsided into the availability and Demand side. The availability side includes compressors, air treatment and first storage. The Demand lateral comprises spreading piping, auxiliary storage and end use apparatus. Accurately succeeded demand side reduces pressure variances, reduces wasted air from leakage and drainage and employs compressed gas for suitable uses.

2.5 Energy Efficiency of Cement Plants

Energy efficiency refers to what quantity economic benefits may be brought by one unit of energy, namely the problem of energy utilization efficiency. The advance of energy efficiency could reduce the energy consumption producing the identical output, and the other way around. By maximizing efficacy, energy request is reduced without reducing any changes or unfavorably affecting economic process. Some reasons of using energy efficiency are: [25]

- Better energy saving will extend the supply of energy sources.
- Price effective energy saving techniques can save with range of 10%-30% of industrial energy consumption.
- Better energy saving will increase the output efficiency of the plant.
- Energy saving will minimize the environmental pollution.

Generally it delivers energy efficiency enhancement chances of skills and events of cement plant.

2.6 Energy efficient occasions in cement plants

Energy efficiency occasions can be a minimum of three primary categories: [2, 9]

- O&M activities to make sure that the installed equipment is running efficiently
- Installation of high efficiency equipment/processes
- Control of the assembly process to confirm efficient use of inputs

a) ***Operations and maintenance***: Operations and maintenance practices include elements like motor and bearing lubrication, motor belt replacement, vane cleaning, fan wheel balancing, and compressed gas system maintenance including leak minimization and filter replacement.

b) ***More Efficient Equipment's***: Significant energy savings projects typically involve major process and/or equipment modifications that are industry-specific and highly specialized. Often highly specialized expertise is important to spot and be ready to quantify energy savings of technology improvements. Number of energy efficiency equipment opportunities identified by customers, with a primary target electricity savings, includes:

- ❖ Conversion to more efficient kilns
- ❖ Variable speed drives and High efficiency classifiers
- ❖ Compressed air system improvement and Efficient materials transport system
- ❖ Conversion of ball mill to roller mill for both raw materials and finishing grinding

c) ***Process Controls***: Key opportunities for improved process controls involve clinker production and finish grinding, moreover as operation of compressed gas systems. In clinker production, computerized controls is employed in variety of applications, such as

- ✓ Optimizing the combo of raw materials entering the kilns to confirm proper chemical composition and supply for steadier kiln operation;
- ✓ Optimizing the combustion process and conditions within the kiln to enhance product quality and grind ability; and
- ✓ Improving heat recovery, material throughput, and emissions from the clinker cooler.

Table 2.2 Energy efficient opportunities in cement plants

Raw material preparation	✓ Replace traditional mills (Roller and high pressure pressing) ✓ Improve ball mills and Utilizing pre-crusher ✓ Applying efficient separators ✓ Insulating hot piping entering mills in order to dry materials ✓ Continuous control of raw material level in mills ✓ Adjusting raw material size
Clinker production	✓ Combustion system improvement ✓ Heat loss reduction by insulation ✓ Improve cooler operation and substituting satellite coolers by grate ones ✓ Using mechanical transportation system ✓ Adding (multi stage) pre-heater and pre-calcinatory ✓ Support developing the dry type and semi dry type ✓ Low pressure cyclones and Complete tighten of system ✓ Efficient fans and Recycle waste heat ✓ Use secondary fuels as waste tires ✓ Utilizing variable speed drivers in order to control air inlet
Finish grinding	✓ Improve ball mills and Introducing pre-crusher ✓ Replace traditional mills with Roller mills and high ✓ Continuous control of cement level in mills ✓ Apply grinding-aid materials in order to increase the ✓ capacity and reduce the energy intensity ✓ Using the high-efficiency separators
Preventive maintenance	✓ Correct maintenance in order to operate in optimal point

Grinding mill controls optimized the flow within the mill and classifiers to boost product quality and increase production.

2.6.1. Energy Efficiency Improvement Opportunities in Lighting System

Different types of lamps are classically used for lighting activities. The most purposes to be considered by the lighting designers are to deliver the proper amount and deliver the proper quality of sunshine. By applying of lighting energy-efficacy upgrading occasions such as clarification optimization, changing of T-12 lamps by T-8 lamps, lighting switches, daytime illumination, and replace magnetic ballasts with electronic ballasts etc... , We will improve our lighting efficiency.

High-Intensity Fluorescent Lights: it is a new system incorporated more efficient fluorescent lamps, electronic balances and more efficient fittings that exploit the output to workplace. The importance of using High-Intensity Fluorescent Lights are: they need lower energy consumption, lower lumen reduction over the lifetime of the lamp, faster start-up, less glare and improve productivity and have reduced maintenance costs.

Lighting management: Lights is blackout manages during light is not required, by using like instruments that close up lights after an area isn't working. Devices can save averagely at least 15% of ability lighting energy consume.

Substitute Magnetic by Electronic ballasts: Ballast controls the number of electricity requisite to give a fitting and preserve a gradual productivity of sunshine. Magnetic stabilizers needs averagely 21% more power than that of electronic.

2.7.2. Energy Efficiency Improvement Opportunities in Electric Motors

Electric motors usually account for nearly half total industry energy consumption, and represent a big opportunity for financial savings from energy consumption. Motor load mentions to the torque yield and parallel rapidity requisite. Features of loads can be characterized as follows:

- ✓ *Constant torque loads*: the output power prerequisite may differ with the speed of operation without any variation of torque.
- ✓ *Variable torque loads*: the required torque varies with the square of the speed operation.
- ✓ *Constant power loads*: the torque requirements typically change in reverse with speed.

Performance of Motor be determined by on how the operating features match with the load. Potential savings with regard to the selection and operation of electric motors energy efficiency of industries can be increase:

- ✓ Correctly sizing electric motors to the load and energy efficient motors.
- ✓ Arranged and correct lubricating of electric motor bearings, and variable speed drives.
- ✓ Reducing electric motor system friction losses and regular maintenances.
- ✓ Substituting unsuccessful electric motors through energy/ best competent motors.

Correctly Sized Motors: In many applications, the speed of a tool powered by an electrical motor is comparatively constant. However, careful attention should be paid to making sure that the motor isn't significantly oversized given the standard load. Industrial motors frequently operate under varying load conditions thanks to process requirements. An alternative is to pick the motor rating supported the load duration curve of a specific application. The biggest risk is overheating of the motor, which adversely affects the motor life, efficiency and increases operating costs.

Overheating can occur through:

- Recurrent and long times of overloading
- Restricted skill for the motor to cool down, in warm surroundings or once motors are bounded or having dusts.
- Dangerous load variations, such as recurrent starts and stops, or high primary loads

Adjustable Speed Drives (ASDs): Electric motors, which are able to operate at different speeds according to the amount of power supplied to the drive unit, are known by a variety of terms including, Variable or Adjustable Speed Drives and Adjustable or Variable Frequency Drives, also as inverters. Variable speed drives allow the speed of the drive, and hence the flow rate of the fluid, to be reduced by decreasing the amount of power supplied through the use of power control units. The main advantage of these drives is when the speed of the fluid fluctuates between low and high flow rates. Several motors have great working periods per flexible loads and uses more energy. Wherever loads differ considerably with time, speed regulator ways are often applied additionally to correct motor sizing. Utmost variable speed devices can mostly practical to cement industries, and aids the motor to give only the actual requisite power as the capacity prerequisite. There was completed by correcting the motor speed and torque to direct situation differences that occur. [10]

The inclusive outcome is meaningfully minor power ingesting than static efforts of related capacities using motorized governor values in incomplete load set-up. After loads vary, adjustable speed devices motors frequently decrease electrical power ingesting in centrifugal driving and fan uses further than 50%.

Maintenance of Electric Motors: electric motors and the devices they drive should be regularly serviced and maintained to:

- Ensure components are clean and free from dust and oil.
- operating at peak performance as compared to the manufacturers specifications
- identify areas of wear or damage before the performance of the motor is degraded
- Increase the operating life of the motor.

Frequently, when electric motors fail, it's thanks to a fault within the stator wire. Whilst motors can be rewound to have about the same level of efficiency, some reduction in efficiency will usually occur. It is usually not practical, or cost effective, to possess an electrical motor of a lower efficiency rewound to a better efficiency because the material utilized in the stator core and rotor also will influence the general efficiency of the motor. However, a motor failure does represent a chance to upgrade to a better efficiency motor.

Improving Maintenance: Good repairs of motors essentially used to extend motor lifespan and to show motor letdown. Motor preservation actions could be classified into defensive or forecasting. Defensive actions, include voltage disproportion decreasing, load thinking carefully, motor arrangement, grease and motor freshening and measures avoids increased motor temperature which results in increased winding resistance, shortened motor life, and increased energy consumption. Forecasting motor maintenance is used to observe ongoing motor temperature, vibration, and other operating data to identify when it becomes necessary to replace a motor before failure occurs. The savings related to an ongoing motor maintenance program could range from 2% to 30% of total motor system energy use.

Rewinding: occasionally, uphold motor efficiency, but in most belongings it results less competence. When rewinding motors it's essential to think about the following: Motors 40 horse power in extent and quite life time 15 years often have efficiencies significantly less than currently available energy-efficient models. It’s usually best to exchange them. If the rewind cost exceeds 50% to 65% of a replacement energy-efficient motor price, buy the new motor. Improved consistency and efficiency should quickly improve the worth quality.

Power Quality Improving: electrical disorders universally disturb manufacturing progressions For instance of: voltage falls, surges, harmonics, and capacitor controller. Subsequently the holders of commercial procedures even take skilled practice disturbances and unexpected apparatus blackouts, thanks to those consequences decline of power excellence. Voltage destabilize reduces the capability, cuts the lifetime of a 3-Ø motor and rises spreading scheme injuries, on motor stator depots source current destabilize distant from ratio there. The Common causes of voltage unbalance include:

- Unstable utility supply.
- Faulty operation of power factor correction equipment.
- An open circuit on the distribution system.
- Unequally spread 1-Ø loads on matching power value.
- Unknown 1-Ø to earth errors.

$$Unbalanced\ voltage\ in\ percentage(\%) = \frac{maximum\ deviation\ from\ mean\ voltage}{mean\ voltage} * 100\%$$

It had been suggested that voltage imbalances on motor ends not go beyond one percent. Voltage destabilize of just two percent be able to rise motor injuries by around 11%. Disproportions above 5% specify a significant difficult. Destabilizes above 1% need lower rated capability of the motor, and can cancelled utmost producers' guarantees.

Voltage unbalance are often minimized by:

- ✓ Separating any one phase load which disturbs the load stability and feed them from a distinct line.
- ✓ Regularly monitor voltages on all phases to see that an equivalent power grid have a lowest difference occurs.
- ✓ Install essential fault pointers on the bottom.

Power factor adjustment: A motor needs real and reactive power toward work in proper condition. The active power consumes and produces heat (work). The reactive power is stored and discharged within the inductive or capacitive elements of the circuit, and establishes the magnetic flux within the motor that causes it to rotate. Low power factor is produced by the utilization of inductive loads and may specify a likely small efficiency of electrical functioning. Inductive loads such as transformers, motors, and lighting produce a small power factor. When motors operate near their rated load, the facility factor is almost one, small loaded motors the facility factor descents meaningfully. [9, 16]

Small power factors are improved by

- ✓ Implementing exterior capacitors at the core transformer of the department or each sections of apparatus
- ✓ By removing the function of kit over regarded voltage. and
- ✓ Maximize and therefore the cost of exterior improvement reduced by decreasing operation of these not working or not much loaded motors, etc.

2.7.3. Chances to Advance Use of fuel Consumption of Cement Plants

There are four main process routes for manufacturing cement: the dry process, the semi-dry process, the semi-wet process and therefore the wet process. The selection of process is essentially determined by the state of the raw materials (dry or wet). An outsized a part of world clinker production remains supported wet processes. However, in Europe, around 90% of production is predicated on dry processes because of the supply of dry raw materials. Wet processes are more energy-consuming and, thus, costlier.

Future new investments in wet technology are often expected to prove an interesting exception to the overall trend of phasing out this technology.

All these process routes include an equivalent three main activities which will be summarized as:

- Preparing/grinding the raw materials,
- producing the intermediate clinker and
- Grinding and blending the clinker with other products to form cement.

The activity during which the most important difference within the manufacturing process appears is in preparing and grinding the raw materials. All processes use rotary kilns for the second stage that there are big differences in those kilns: the length of the wet-process kilns ranges from 120 to 180 m, with an indoor diameter from around 4.5 to 7 m, whereas within the modern dry technology the length ranges are typically 45 to 75 m, with internal diameters of three.5 to 4.5 m. In opposite side, the dry process uses a smaller amount energy and its operating price is minor. In future, the wet process won't be used positively.

Wet Process Conversion to Semi-Dry Process (Slurry Drier): In modernized wet kilns, a slurry drier are often added to dry the slurry before entering the kiln using waste heat from the kiln. This is often different from a semi-wet process as a gas drier is employed rather than a slurry press filter. The drier are often combined with a hammer mill for a reliable and drying system.

Average specific fuel consumption in wet kilns is estimated at 5.8 MBtu/ton clinker. Due to improvements in grinding, electricity use will decrease by 15 kWh/ton clinker.

Heat Recovery for Power Generation: Waste gas discharged from the kiln exit gases, the clinker cooler system, and the kiln pre-heater system all contain useful energy that can be used for raw material and fuel drying or for power generation.

Generally the two basic methods to produce cement are the wet and dry manufacturing processes. The total heat requirement with new dry precalciner kiln systems ranges from 850 to 900 kcal/kg which is approximately 56 to 66% of the energy requirement of old wet process kilns (1300-1600 kcal/kg).

CHAPTER THREE

3. Data Collection and Analysis

3.1 Collection of Data’s

Important information are gathered to get extra interpretation on energy auditing and conservation of the energy exhaustive apparatus of National cement plant. Documents are gathered from different bases due to open remark of the plant and over conducting individual discussions and dialogs and also gathered from other related study in the matching area, or from other correlated problem zones. It contains documents and archives gained from the industry, websites and other historically records significant for the study. The research was prepared from service bills, fuel purchase incomes and processes of energy meter and different departments. The following were included on the collected data:

- Average energy consumption (electrical, coal and fuel oil) and specific energy consumption for the last three years (2014-2016) from the plant billing,
- Average energy costs and average production capacity from recorded
- Electric motors energy consumption, (motor name plate, measurement and calculations).
- Lighting system energy use.

National cement plant consumes coal and electrical energy inputs. Coal uses for manufacture of thermal energy or heat for clinker production in kiln and electric is used to run electrical equipment’s in factory and offices.

3.1.1 Coal and electrical consumptions of national cement

Quality of Coal for Cement Industry

Coal is the main fuel for manufacture of cement in Ethiopia, due to high cost and inadequate availability of oil and gas. Coal is usually analyzed for moisture, volatile matter, fixed carbon and ash. Typically, characterized quality aspects of coal are lower to medium grade, high ash, low moisture, and low Sulphur. The major issues faced by the industry since previous few decades, leading to further quality deterioration, are as follows:

- Increased production from lower seams
- reduced coal to relatively small size
- Low wash ability index (coal is difficult to wash when the index is low)
- Depletion of fine quality coal seams (coking also as thermal coal)

Owing to an extremely wide spectrum of coal usage, ranging from power generation to production to infrastructure and commercial usage, the technology of coal by washing must be improved, to chop back the environmental impact, enhance coal quality and increase process efficiency.

The Central Institute of Mining and Fuel Research has developed the next processes for coal beneficiation:

- ✓ Improved froth floatation process
- ✓ Oleo flotation process
- ✓ Oil agglomeration process

Table 3.1 Cement Production and Energy Consumption Data for 3 years of Cement production of national cement factory

No	Item		Production years		
			2014	2015	2016
1	Cement production (ton)		719,778	625,158	689,701
2	Clinker production (ton)		623,895	509,535	628,697
3	Electric consumption (KWh)		85,250,880	84,827,868	94,723,200
4	Coal consumption (ton)		102,411.18	81,635.2	82,377
5	Specific Ele. Consumption (cement) (KWh/ton)		118.4	135.6	137.3
6	Specific coal Consumption(clinker) (Ton coal/ton clinker)		0.164	0.160	0.131
7	Fuel consumption(oil)	Liters(average)	33,137.985		
		Ton	*41.3*		

The standard specific electrical consumption and coal consumption of National cement consumes 130.5 kWh/ ton of cement and 0.152 ton of coal/ ton of clinker annually. To convert the consumption of fuel oil to coal, one ton of coal is equivalent with 803 liters of fuel oil. The standard average coal consumption is 88,807.79 ton/year of coal on the cement factory and the fuel oil consumption in terms of coal consumption is 41.3 tons of coal. [27] The total consumption of coal and fuel consumed averagely ***88,849.05*** ton/year. The total cost of the factory's energy consumption is summarized at table 3.2.

Table 3.2 Electrical Energy and Coal Consumption (2014-2016)

Item	***Birrs in a Year***		
	2014	***2015***	***2016***
Electrical consumption	***42,776,257.33***	***42,585,901.73***	***47,038,801.33***
Coal consumption	***135,182,757.6***	***107,758,464***	***108,737,640***
Total cost	***177,959,014.93***	***150,344,365.73***	***155,776,441.33***

Total consumption cost per year.	***161,359,940.46***
Fuel consumption	***563,345.745***
Yearly Total paid in birr	***161,923,286.205***

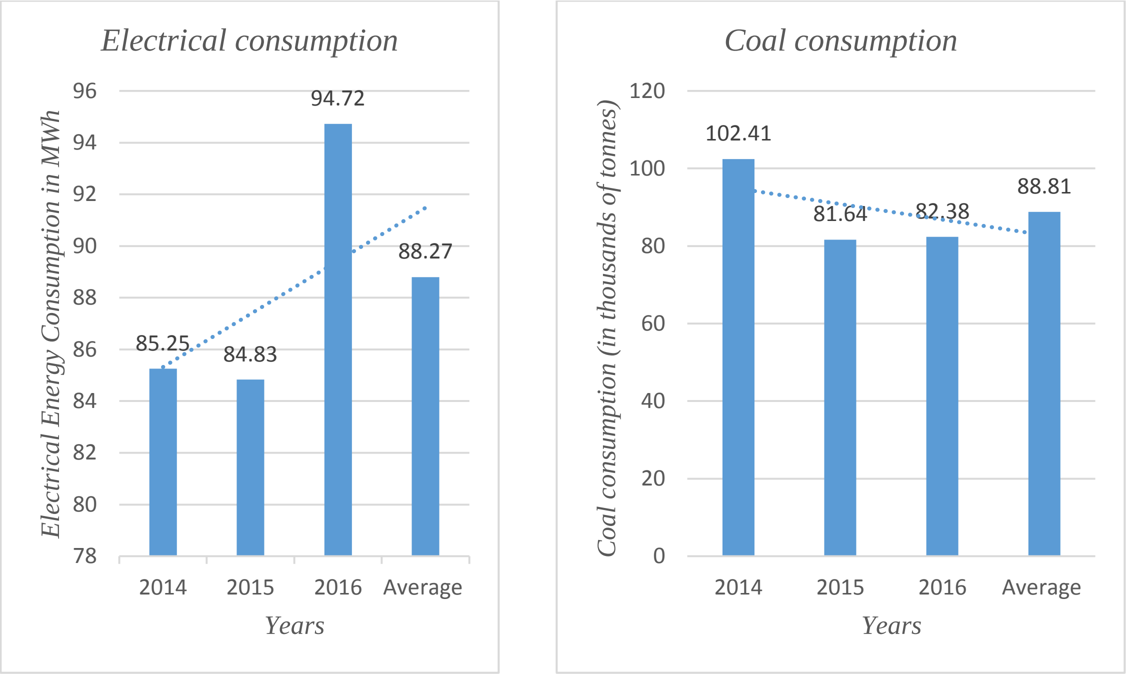


Figure 3.1 electricity and coal consumption of three consecutive years

The national cement share company's monthly electricity consumption from grid for a year is given in table 3.3.

Table 3.3 Monthly consumption of electricity

Months	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Electrical consumption (KWh)	5,584,200	5,154,782	4,135,670	5,264,082	5,874,080	5,294,983	4,602,382	3,215,564	5,813,482	4,588,990	6,891,981	5,856,384

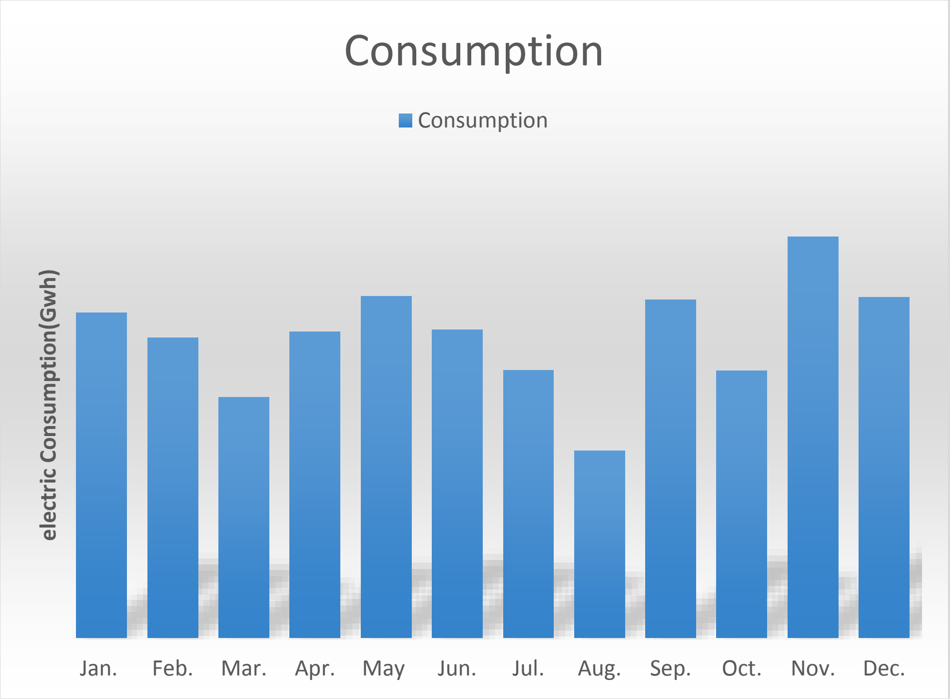


Figure 3.2 Monthly consumption of electricity

Table 3.4 the monthly production of clinker

Months	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Production rate (Tons)	44,373	68,044	51,899	52,326	48,393	38,370	57,752	61,602	79,310	72,791	55,656	59,185

From table 3.4, it's shown that there is an unlimited gap among monthly production. This means that a production shortfall can be occurred due to operation stop results from deterioration of facilities.

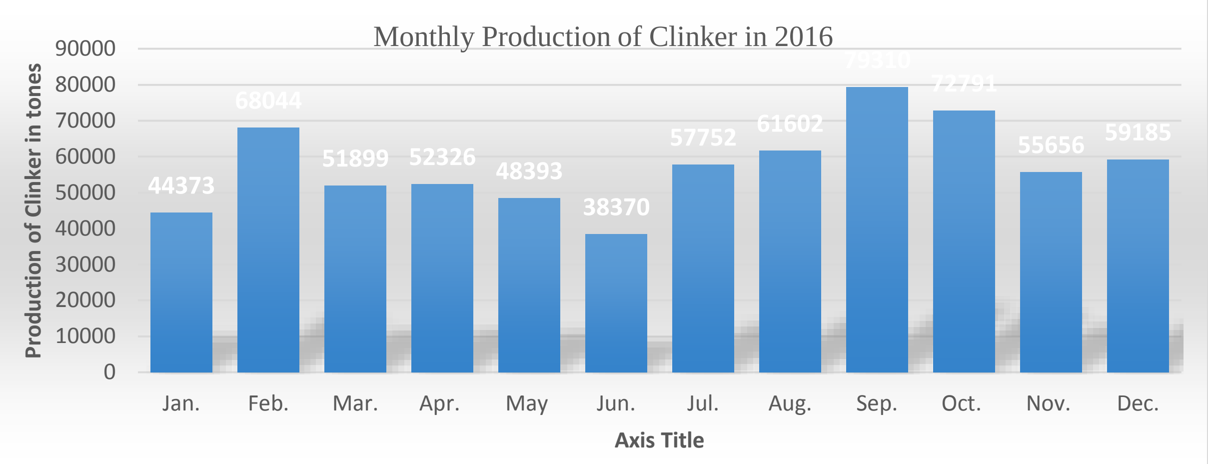


Figure 3.3 monthly production of clinker

Monthly clinker productions were fluctuating plenty and it's visiting because by the following reasons: Shutdown because of deterioration in performance of facilities and a variety of products.

Table 3.5 Average coal consumption

Month	Jan	Feb	Mar	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Coal cons. (Tons)	*8466.2*	*8103.4*	*8425.1*	*5979*	*5464.8*	*5075.7*	*8559*	*8285*	*7233*	*8528*	*8223*	*6466*

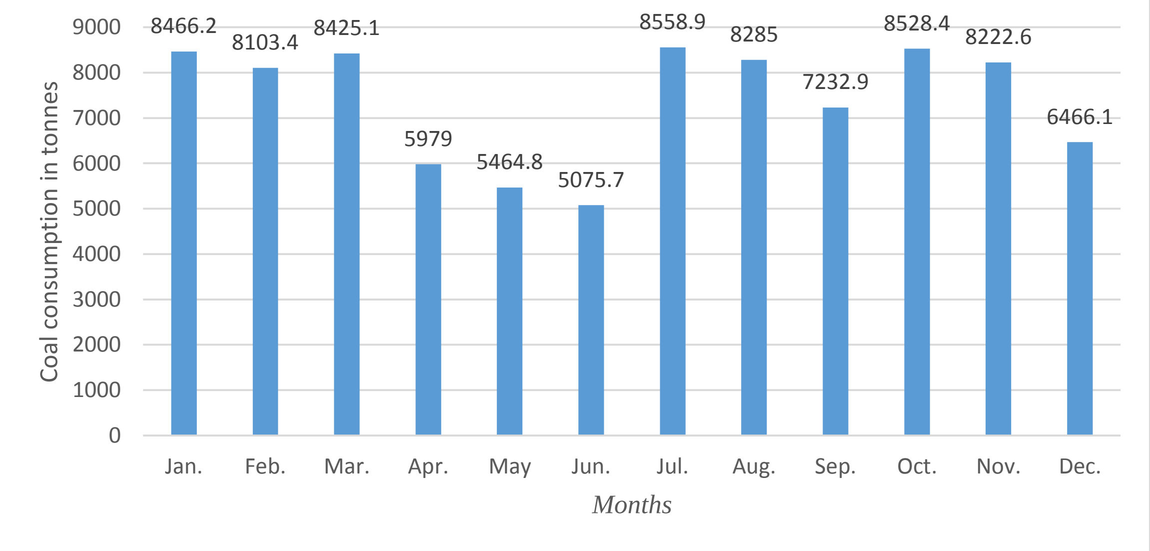


Figure 3.4 monthly coal consumption

Measures to reinforce energy efficiency in cement production can include [25]:

a) Lower kiln exit gas losses: install devices to provide better conductive heat transfer from the gasses to materials.
b) Reduce moisture absorption opportunities for raw meal and fuels.
c) Decreases dust in flue gases by minimizing gas.
d) Lower the clinker cooler stack temperature: recycle excess cooler air and reclaim cooler air by using it for drying raw materials and fuels.
e) By using the correct mix and more energy efficient to control kiln temperature zones to lower kiln radiation losses.
f) Maximizing kiln operations to regulate process disruption and downtime.
g) Upgrade existing technology: the addition of pre heater sections, precalcination sections or more efficient clinker coolers serves to maximize heat recovery.

3.1.2 Transformer capacities of the main transformer

Power System details of Mains 132 kV Substation are as under:-

- Mains Transformer :-1 No. x 31.5 MVA; 132 kV / 6.3kV substation transformer,
- Vector Group:- YNd11,(Star primary grounded) and Percentage Impedance :- 10.8%

Earthling Transformer: Vector Group- Star / Delta ;(Primary Star point grounded)

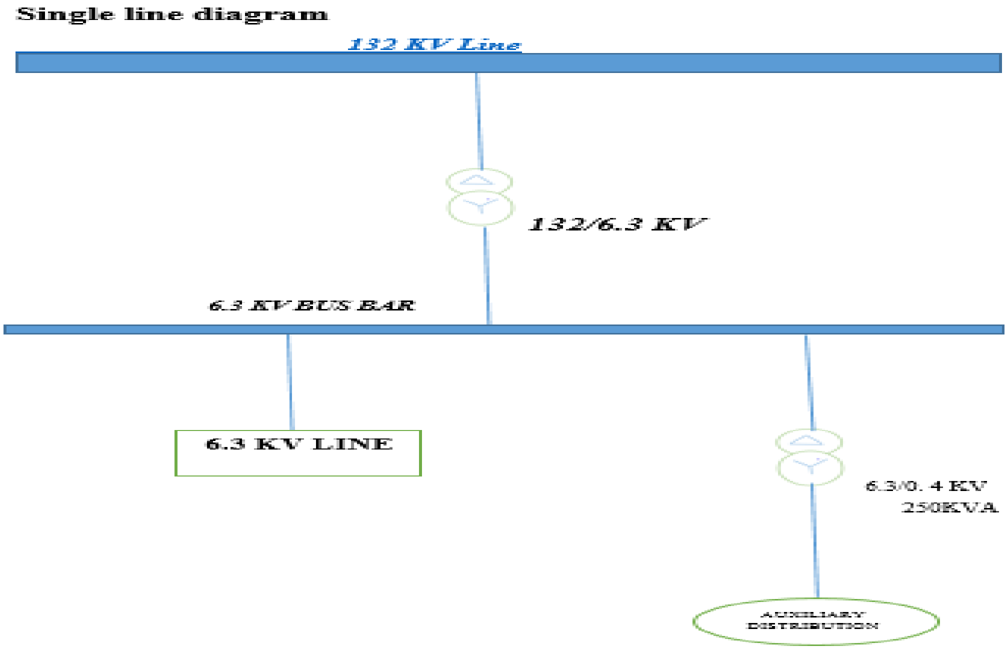


Figure 3.5 Single line diagram of the Dire Dawa National Cement

Main transformer is with tank top mounted secondary bushings. On down side, there's an out of doors isolator serial with secondary side (31.5 MVA). Connection of secondary side of power transformer bushings (6.3kV) with incoming terminals of isolator, should be done by open copper bar instead of enclosed type bus duct which is preferable for ease operation and maintenance works.

CT Accuracy Class for Differential Protection Circuit: -Accuracy Class of 10P30, for canopy cores is chosen. It recommend that the 6kV isolator is removed here, thanks to the following reasons:

- ✓ 3 sets of 132kV isolator is arranged before 132kV transformer incoming side and main transformer, during maintenance, the foremost circuit is disconnected, during this manner, the safety is guaranteed. Therefore, we do not arrange 6kV isolator here.
- ✓ The bus duct is used for 6kV side of the main transformer (the isolator cannot be added).
- ✓ This arrangement at 6kV side has no practical significance, but only adds point of potential failure.
- ✓ The 132/6KV substation is a terminal substation, when the main switch is off, the station will not be charged. The outgoing line of the diesel generator is interlocked with the incoming line of 6kV main substation. If the diesel generator is in operation, the 6kV incoming line has to be disconnected. So the transformer will never be charged during maintenance.

Transformer Ratings: Engineers rate power transformers according to the maximum output voltage and current they deliver. For a given unit, we'll often read or hear about the volt-ampere (VA) capacity, which equals product of the nominal output voltage and maximum deliverable current. Transformer ratings power points are measured in volt-amperes (VA) or kilovolt-amperes (WA). This means that the primary winding and the secondary winding are designed to withstand the VA or kVA ratings stamped on the transformer nameplate.

Table 3.6 Three phase core type Main Transformer in Diredawa National Cement

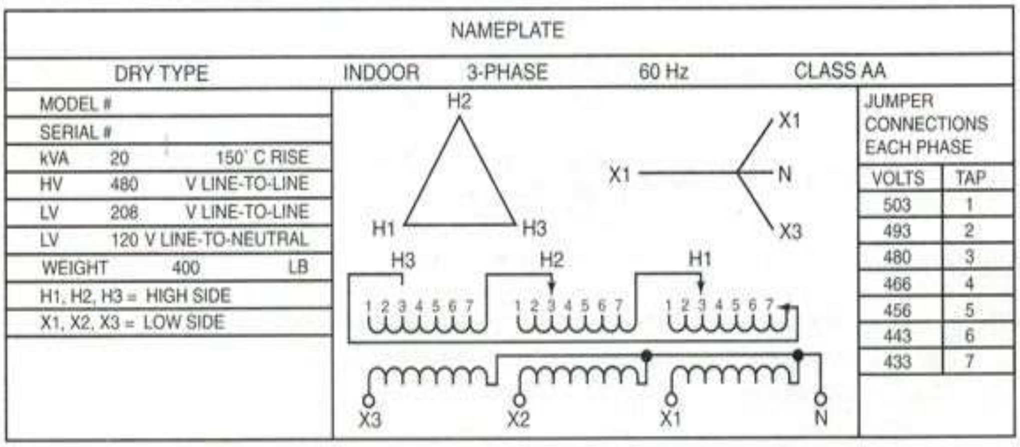
HV				*HV*				*LV*	
Tap position	*Voltage [V]*	*Current [A]*		*Tap position*	*Voltage [V]*	*Current [A]*		*Voltage [V]*	*Current [A]*
		ONAN 25.2MVA	*ONAF 31.5 MVA*			*ONAN 25.2MVA*	*ONAF 31.5 MVA*		*ONAN 25.2 MVA/ 2309.4*
1	*145200*	*100.2*	*125.3*	*10*	*130350*	*111.6*	*139.5*		
2	*143550*	*101.1*	*126.7*	*11*	*128700*	*113.0*	*141.3*		

3	141900	102.5	128.2	12	127050	114.5	143.1	6300	ONAF 31.5 MVA/ 2886.8
4	140250	103.7	129.7	13	125400	116.0	145.0		
5	138600	105.0	131.2	14	123550	117.6	147.0		
6	136950	106.2	132.8	15	122100	119.2	148.9		
7	135300	107.5	134.4	16	120450	120.8	151.0		
8	133650	108.9	136.1	17	118800	122.5	153.1		
9a9b9c	132000	110.2	137.8						

The ideal and secondary complete-load score transformer currents typically aren't given however is also calculated from the rated VA or kVA as follows: we've varieties of calculations of transformer load currents. Single Ø and three Ø complete load currents.

$$Single\ phase: \quad full\ load\ Current = \frac{VA}{Voltage} = \frac{KVA * 1000}{Voltage} \qquad (3.1)$$

$$Three\ phase: \quad full\ load\ Current = \frac{\sqrt{3} * KVA * 1000}{Voltage} \qquad (3.2)$$



NAMEPLATE

DRY TYPE INDOOR 3-PHASE 60 Hz CLASS AA

MODEL #
SERIAL #
kVA 20 150° C RISE
HV 480 V LINE-TO-LINE
LV 208 V LINE-TO-LINE
LV 120 V LINE-TO-NEUTRAL
WEIGHT 400 LB
H1, H2, H3 = HIGH SIDE
X1, X2, X3 = LOW SIDE

JUMPER CONNECTIONS EACH PHASE

VOLTS	TAP
503	1
493	2
480	3
466	4
456	5
443	6
433	7

Figure 3.6 Typical Transformer Ratings Nameplate [from Diredawa National Cement documents]

Information that require to be blanketed at the nameplate of each transformer are as follows:

- Rated kVA, Frequency and Clearances for transformers with ventilating openings
- Primary and secondary voltages,
- Amount and kind of insulating liquid where used.
- Temperature class for the insulation system if transformer is the dry type.

Principle of Power Factor Correction

The whole wattage (kVA) utilized by the economic or industrial facility has components:

- Active Power (kW) which produces work
- Reactive Power (kVAr) which generates the magnetic fields required in inductive electric devices (AC automobiles, transformers, inductive furnaces, ovens, etc.), which produces no effective work.

The ratio of Productive Power (kW) to Total Power (kVA) is Power Factor and is represented as a percentage or a decimal.

Apparent energy = 31.5MVA, Active energy = 24.5 MW, Reactive energy = 19.8 MVAr

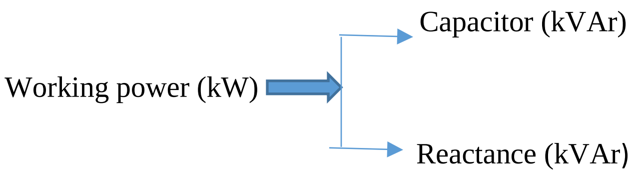
$$Power\ Factor = \frac{kW(Active\ Power)}{kVA(Total\ Power)} \qquad (3.3)$$

Sources of Reactive Power

- ✓ Transformers
- ✓ Induction motors
- ✓ Induction generators(wind mill)
- ✓ High intensity discharge lighting

Thus, it comes as no marvel that one manner to growth energy element is to feature capacitors to the machine. The methods of growing energy element are indexed below:

1. Installing capacitors (kVAr Generators): decreases the importance of reactive energy (kVAr or foam), as a result growing your energy element.



2. Reducing action of idling or not weighed loaded motors: previously communicated about the detail that low power factor is produced by existence of induction motors. Nevertheless, more precisely, small power factor resulted by functioning induction motors less weighed loaded.
3. Removing working of apparatus beyond its ranked voltage.
4. Substituting ordinary motors, if failure exists and causes less energy effective motors.

Even with energy effective motors, power factor is meaningfully attacked by dissimilarities in load. Motor functioned close to graded load is acceptable to understand the welfares of high power factor plan.

Significance of Improving Power Factor

- *Reduce Utility Power Bill*: Removing machine kVAr improves the ability Factor and reduces the Utility Power Bill. Most software payments are prompted with the help of using kVAr usage.
- *Increase System Capacity*: Improving the ability Factor releases machine potential and allows extra loads (electric motor, lighting, etc.) to be brought without overloading the machine. In a standard machine with 80% P.F., best 800 kW of effective energy is to be had out of 1000 kVA mounted. By correcting the machine to unity, the kW = kVA. Now the corrected system will support 1000 kW, versus the 800 kW at the .80 P.F. uncorrected condition; an increase of 200 kW of productive power.
- *Improved machine working characteristics*: good power factor (0.95) presents a “stiffer” voltage, commonly a 1-2% voltage rise can be expected when power factor is brought to (+\-) 0.95. Improving power factor will lower losses in the distribution system of the facility since losses are proportional to the square of the current.

The capacitor bank size is designed based on the load reactive power requirement for power factor correction. Currently there is no any capacitor bank installed on the transformer. The transformer have the following specifications according to name plate: line frequency 50 Hz, three phase voltage 6300 V, current rated 2886.8A, apparent power(S) 31.5 MVA and power rated (P) 24.5 MW. The power factor improved to 0.9 without any change of its rated power.

MVAr before correction

$$Q_1 = (S^2 - P^2)^{1/2} \qquad (3.4)$$

$$= \{(31.5)^2 - (24.5)^2)\}^{1/2} = 19.8 \text{ Mvar.}$$

Thus, the reactive power demand for a 0.9 power factor would be:

Active power (kW) =24,500 kW and Apparent power (kVA) = 27,200 kVA.

For power factor 0.78, $\phi 1 = 38.7^0$ and for the improved power factor (0.9), $\phi 2 = 25.84^{0.}$ Therefore,

$$P_1 = Q_1 \tan(\phi_1) \qquad (3.5)$$

$$P_2 = Q_2 \tan(\phi_2) \qquad (3.6)$$

Since the active power remain same for the cases before and after the power factor correction:

$$P_1 = P_2 \tag{3.7}$$

$$Q_2 = \frac{Q1 * \tan(\phi\ 2)}{\tan(\phi\ 1)} \tag{3.8}$$

Thus, the reactive power demand for a 0.9 power factor would be

$$Q_2 = \frac{\mathbf{19.8}\ Mvar * \tan(25.84)}{\tan(38.7)} = 11.97 \text{ Mvar} \tag{3.9}$$

In three phase system, capacitor bank consists three capacitors with the same value connected in star to get the capacitance of each phase as shown in figure 3.7.

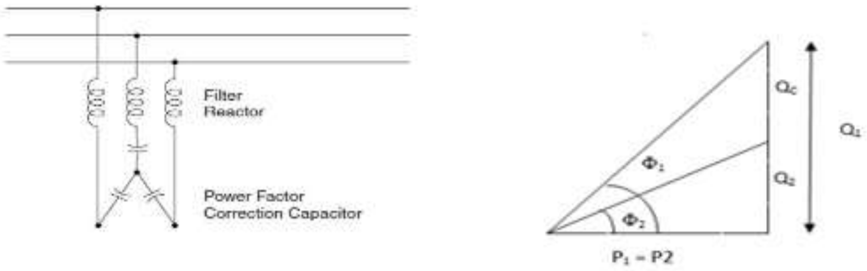


Figure 3.7 Three phase circuit star connection.

$$Q_C = Q_1 - Q_2 \tag{3.10}$$

$$Q_{Compensation} = 7.83 \ Mvar$$

The capacitance value corresponding for the above capacitive reactance is calculated in eq. 8:

$$C = \frac{Qc}{(V/\sqrt{3})^2} \tag{3.11}$$

$$C = \frac{7.83\ Mvar}{(6300V/\sqrt{3})^2} = 591.8\ \mu\text{F}$$

3.1.3 Lighting System

Lighting is not considered in a proper way in the plant. The illumination level at different departments is not fit with the required illumination level (lux). Around 793 florescent lamps presently connected in National cement plant per rating power 40 Watt of separately lamps. [4] The lighting system of selected departments of National cement's number of lamps, total power consumption, room area, and operating hours of the lamps are listed in table 3.7.

Table 3.7 gathered lighting scheme information of National cement plant

No.	Department	NL	TP(w)	$A_R(m^2)$	OH (hrs.)	UE(wh/d)
1	Raw Material store.	30	1,200	168	24	28,800
2	Production Control Room	25	1,000	92	24	24,000
3	Administration Building.	96	3,840	624	8	32,720
4	Raw Mill Control Room	35	1,400	172	24	33,600
5	Workshops	34	1,360	200	8	10,880
6	Clinic	20	800	112	20	16,000
7	Cooler control Room	30	1,200	164	24	28,800
8	Engineering Department	220	8,800	680	24	211,200
9	Cement Mill control Room	35	1,400	144	24	33,600
10	Crushing	10	400	86	23	9,200
11	Packing & transporting	50	2,000	370	16	32,000
12	Water treatment room	10	400	52	24	9,600
13	Coal Pre. Control Room	32	1,280	212	24	30,720
14	Garage	28	1,120	205	8	8,960
15	Cafeterias	24	960	212	8	7,680
16	Maintenance	25	1,000	170	8	8,000
17	Pump Room	6	240	38	16	3,840
18	Crushing control Room	30	1,200	218	24	28,800
19	Cement Stores	25	1,000	150	24	24,000
20	Substation control room	20	800	210	24	19,200
21	Shift Keeper	3	120	36	24	2,880
22	Guard room	5	200	30	10	2,000
		793	31,720			606,480

3.1.4 Electric Motor Systems

Electric Motors are used to crush the core material, to move fans, to revolve the kiln, to conveyance ingredients and crushing cements throughout the cement plant. Around 750 electrical motors putted at National cement plant. Motors which have dissimilar rating power now are in action on the plant. Most of the motors are used for the long time, rewound, and not continuously preserved and have low efficiency motors because of rewinding. Energy efficient motors reduce energy losses through design improvement, better materials, and improved manufacturing techniques. With proper installation, energy-efficient motors can also run cooler and have higher service factors, longer insulation life, and less vibration. [19] Table 3.8 below shows that the elementary electric motors records were gathered from cement plant by various designation considerations and actual measured assessment of the current electric motors of the plant. Those motors are selected from the motors existing in the cement plant.

Table 3.8 the gathered electric motors information of National cement plant

No.	Explanation of motors	Types of motors	Designation Number plate of motor			Real measurement of motors				Department
			R. power (kw)	R. effic (%)	Speed in (rpm)	O/p power in (kw)	PF %	Voltage(v)	Current (A)	
1	Coal mill	L92BL1	400	81	990	209.8	93	5.27k	21.12	Coal mill
2.	Crusher main drive	M212H 1M1	800	86	1500	676	91	6.27k	44.6	Crusher
3	Raw mill	412BL2 M1	2500	89	1400	2112	92	5.18k	258.3	Raw Mill
4	Fan of Raw mill	YKK710 -6	2500	85	1450	2120	93	5.33k	260.4	Raw Mill
5	Bucker Elevator	M212F N3M1	160	76	1500	79.2	87	387	116.3	Cement m.
6	Id fan	442FN1 M1	2000	80	994	1548	91	6.23k	174.7	Raw Mill
7	Waste air fan	M472H M1	1400	86	740	938.8	90	6.11k	91.2	Rotary k.
8	Injection Water Pumper	Y132S2 2	7.5	75	2900	4.6	87	396	6.3	C. Mill
9	Fan of filters	L42BE M1	37	75	1000	25.3	86	360	29.8	C. Mill
10	Fan of coal mill	YRKK45 0-4	400	81	1500	202	91	5.17k	22.3	Coal mill
11	Crusher for Clinker	Y280M4	90	85	1450	53.8	94	388	53.4	In all dept.
12	Fan of filter kiln outlet	L92BL1	500	81	990	262.2	93	6.12k	26.4	Rotary k.

13	Separator fan 1	L92BL11	500	81	994	262.2	93	6.13k	26.4	Cements. m.
14	Separator fan 2	L92BL2	500	81	994	262.2	93	6.13k	26.4	Cement m.
15	Belt conveyer	592FN4M	5.5	83	1450	3.5	91	390	5.8	In all dept.
16	Chain Conveyor	392CV5M1	90	78	1460	43.3	87	378	31.6	Raw Mill
17	Belt conveyer	592FN4M	5.5	83	1450	3.5	91	390	5.8	Cement m.
18	Fan of filtration	L42BEM21	37	75	1000	25.3	86	360	29.8	Mill coal
19	Reversible belt conveyer	Y2132M4	5.5	80	1440	3.6	95	378	5.3	Cements m.
20	Cement mill 1	56BE3MD1	4000	87	1500	3377.7	92	6.08k	296	Cement m.
21	Cement mill 2	56BE3MD2	4000	87	1500	3400	92	6.09	294	Cement m.

3.2 Data Analysis

3.2.1 Analysis of Lighting Systems

The lighting system of the factory was replaced with suitable enlightenment level for numerous sections of the National Cement, it can be minimize the energy usage of the whole plant. Necessary, thing to consider and determine for examining the enlightenment of the lighting systems of the plant are as follows:

- ✓ Counting the currently total lamps and total rating powers installed in each subdivision
- ✓ Calculating total flux intensity and clarification created via presented lamps fixed in the section
- ✓ Measuring the area of the room in m^2 and working hours of individually lamps per day
- ✓ Calculating the Required standard illumination (RSE) of particular functioning locations.

Table 3.9 summary of the Flux intensity of several lamps

No.	*Types of Lamps*	*Flux Intensity(lumen/watt)*
1	*Fluorescent lamp (T-12)*	*60*
2	***Fluorescent lamp (T-8)***	***80 - 100***
3	*High sodium-70W*	*5,740*
4	*CFL up to & including 7W*	*45*
5	*High mercury vapor -400W*	*14,400*
6	*Fluorescent tube (T-5)*	*80 -105*
7	*High sodium-400W*	*46,800*
8	*CFL (11W - 15W)*	*55*
90	*Low sodium–18W*	*3,150*
101	*High mercury vapor -(80W)*	*2880*
11	*CFL (8W to 10W)*	*50*
12	*Low sodium-10W*	*1,000*
13	*CFL (16W - 24W)*	*60*
14	*Tungsten Incandescent*	*15*

The association between the lumen and power is significant to estimate the luminous flux (Ø) a specific lamp will yield by bearing in mind the released power on respectively wavelength and the matching perceptiveness compassion at that wavelength. (Take the intensity of lamp 80 lumen/watt).

$$TLu(lumens) = ENL(watt) * Intensity\left(\frac{lumens}{watt}\right) \qquad (3.12)$$

TLu ----- total lumen amount produced from the lamp implemented in the section

The illuminance E on a working area is calculated as flux (Ø) event until a minor component of working area to m^2 of the room. (i.e. 1 lux is correspondent to 1lum/m^2.)

$$E = \frac{TLu}{A} \qquad (3.13)$$

Where, E – illumination created by the existing lamps

A-area of the room in m^2

Lighting desires to fix due to the required standards illumination of particular functioning locations, plant had better be fixed lighting scheme based on normal level. The appropriate current installation of lamp system is evaluated through the luminous flux of numerous lamps and necessary normal illuminations. (The standard illumination required for offices and workshops are 500 and 750 lux respectively.) To determine actual number of lamp required, the current number of lamp, necessary normal illumination of particular work places and the illumination created by the implemented lamps of individual sections be used.

$$ALR = \left[\frac{RSE(lux)}{E(lux)}\right] * ENL \qquad (3.14)$$

Where, ALR –-- The actual number of lamps desired to fix in each section.

RSE ------Required standard illumination for specific units

$$EU = ENL * \text{power rating of lamp} \qquad (3.15)$$

$$RE = ALR * \text{power rating of lamp} \qquad (3.16)$$

$$ES = EU - RE \qquad (3.17)$$

Where, *EU*---the existing energy lost by the lighting scheme of the industry

RE----the essential energy after maximizing the employment of clarification level of the plant

The lighting data of the National cement are T-12 lamps with power rating of 40 watt and the table 3.10 shows the existing number of lamps comparing with the actual required lamp and comparing the illumination of before and after installation and calculating energy saving from the lamps etc.

Table 3.10 Number of Lamps in National cement factory after analyzing

No.	*Department*	*E.N.L.*	*TP(w)*	*TLU(lumens)*	*A_R (m2)*	*E (lux)*	*A.L.R.*	*O.H. (hr.)*	*U.E. (wh/d)*	*R.E. (wh/d)*	*E.S. (wh/d)*
1	R. material Store	30	1200	96000	168	571.5	20	24	28800	19200	9600
2	Prod. control R.	25	1000	80000	92	869.6	16	24	24000	15360	8640
3	Admi. BLG.	96	3840	307200	624	492.3	88	8	32720	28160	4560
4	Raw Mill control R.	35	1400	112000	172	651.2	26	24	33600	24960	8640
5	Clinic	20	800	64000	112	571.4	15	20	16000	12000	4000
6	Cooler control R.	30	1200	96000	164	585.4	25	24	28800	24000	4800
7	Eng. Dep.	220	8800	704000	680	1035.3	165	24	211200	158400	52800

8	Cement Mill control R.	35	1400	112000	144	777.7	25	24	33600	24000	9600
9	Packing & transport	50	2000	160000	370	432.4	46	16	32000	29440	2560
10	Water treatment R.	10	400	32000	52	615.4	8	24	9600	7680	1920
11	Workshops	34	1360	108800	200	544	30	8	10880	9600	1280
12	Coal Pre. Control R.	32	1280	102400	212	483.0	31	24	30720	29760	960
13	Garage	28	1120	89600	205	437.1	26	8	8960	8320	640
14	Kibebs	24	960	76800	212	362.3	23	8	7680	7360	320
15	Maintenance	25	1000	80000	170	470.5	23	8	8000	7360	640
16	Crushing control R.	30	1200	96000	218	440.4	30	24	28800	28800	0
17	Cement Stores	*25*	1000	80000	150	533.3	24	24	*24000*	23040	960
18	Oil Pump R.	*6*	240	19200	38	505.2	5	16	*3840*	3200	640
19	Substation control R.	*20*	800	64000	210	304.7	25	24	*19200*	24000	-4800
20	Time Keeper	3	120	9600	36	266.6	5	24	*2880*	4800	-1920
21	Guard	*5*	200	16000	30	533.3	5	10	*2000*	2000	0
22	Crushing	*10*	400	32000	86	372.09	14	23	*9200*	12880	-3680
		793	*31720*				675	413	606,480	504,320	102,160

After calculating the required number of lamps of the factory, the Energy saved which is the difference between the utilized energy and the actual required energy has been found. In above table 3.10 the average operating hour of each department has been taken 18.77 hrs.

$$Annual\ energy\ consumption = total\ power\ of\ lamps * \ average\ operating\ hours * 365 days/year \tag{3.18}$$

$$= 31.72\ kW * 18.77\ hrs. * 365\ d/yrs.$$

$$= 217{,}315.306\ kWh/yrs.$$

$$= 217.3\ MWh/yrs. \qquad \approx 0.22\ GWh/yrs.$$

The Factory have been installed with 793 T-12 florescent lamps with total power request of 31.72 kW and energy consumption of 0.22GWh/yrs. [21] Nonetheless when improved the actual number of T-8 lamps needed in the plant minimizes to 675 lamps. From this 118 needless lamps are reduced, and the reason to spend extra payment. The investigation of lighting has been done by consisting of the present illumination standard on detailed section of the plant with the more acceptable illumination level conserving potential of lighting schemes from illumination enhancement and around 4720 watt power is saved.

3.2.2 Analysis of Electric Motors

To study the Analysis of electric motor we have been considered the motor load and efficiency of motor.

3.2.2.1 Load of Electric Motor: motor efficiency and power factor approximately one is necessary for a competent process and for protection minimum costs of the complete factory. Due to the above case, the importance to control load and efficiency after evaluating motor's capacity. The prerequisite for producers to show the full load competence on motor notice plate.

Motor Load Estimation Techniques: Power and energy capacities are accustomed to limit loads on apparatus, consumption of energy, to prove appropriate method sizing, running costs and working principle. To associate the effective costs of a present motor and an extra efficient spare element desires to control

- ♣ functioning constraints of the motor,
- ♣ Efficiency enhancement standards, and load.

Motor load investigation accomplishes to measure the functioning load of dissimilar motors thru the factory. To compute the motor load, it is advisable to comparing the obtained power by voltage or watts meter, p.f. and ampere amounts with the nameplate assessment of the motor.

$$P_i = \frac{[\sqrt{3}*V*I*PF]}{1000} \qquad (3.19)$$

Where: P_i= measured three-phase power in kW
I = RMS current, mean of 3 phases
PF = Power factor as a decimal
V = RMS voltage, mean line-to-line of 3 phases

Rated power is calculated by using the nameplate rating due to the following equation:

$$P_r = \frac{[hp * 0.746]}{\eta_r} \qquad (3.20)$$

Where,
P_r = power input at full load (kW)
h_p = value power listed on motors (hp)
η_r = full load Efficiency listed at motors

Motor load can be determined

1. ***Voltage Compensated Slip Method***

This technique is used while nameplate value, voltage and speed (rpm) are known.

$$Motor\ load = \frac{[RPMsynch - RPM\ measured]}{\left[RPMsynch - RPMfullname\ plate\right]*[\frac{Rated\ voltage}{Measured\ voltage}]^{2}} *100\% \qquad (3.21)$$

$$= \frac{\text{Slip}}{(S_s - S_r)(\text{Vr}/\text{V})^2} *100\%$$

Where: Load = Output power as a % of rated power
Slip= Synchronous speed - Measured speed in rpm
S_s= Synchronous speed in rpm
S_r= Nameplate full-load speed
V= RMS voltage, mean line to line of 3 phases
V_r= Nameplate rated voltage

2. ***Power(kW) Proportion Motor Load Approximation Method***

Motor load is calculating by means of power proportion method if motor complete load efficacy standards are accessible and while power factor, ampere and power or voltage interpretations are accessible.

$$Motor\ load = [P_i/P_r]*100\% \qquad (3.22)$$

Where: P_i= accessed three-phase power in kW

P_r= Input power rated on complete load (kW)

3. ***Amperage Ratio Method (Line Current Measurements)***

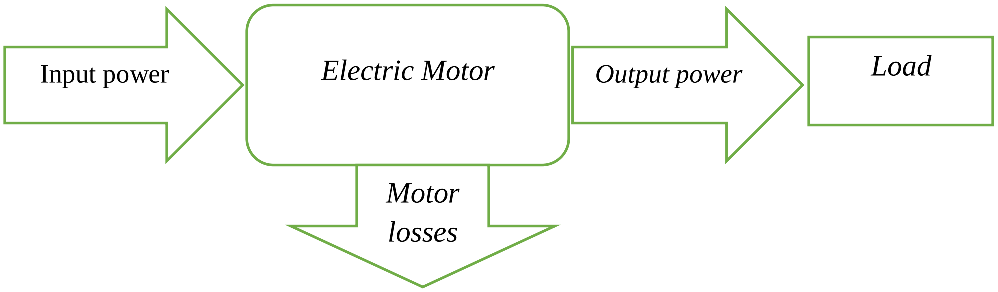
If supply voltage and current quantities are accessible.

$$Motor\ load = \left(\frac{\text{Amps measured}}{\text{Amps nameplate}}\right) * \left(\frac{\text{volts measured}}{\text{volts name plate}}\right) * 100\% \qquad (3.23)$$

3.2.2.2 Efficiency of Electric Motor: explained as

$$\eta = [\frac{[output\ power\ at\ the\ existing\ load]}{[0.746 * Name\ plate\ rated\ power]}]*100\% \qquad (3.24)$$

Method of translate electrical to mechanical energy to assist a definite load of motor losses. Losses can vary approximately 7%-15%. Flow diagram of electric motor energy losses are as follows:



Intrinsic losses affects motor efficiency. There are of two types intrinsic loses:

- ✓ fixed losses - independent of motor load, and
- ✓ Variable losses dependent on load.

Fixed losses contain of magnetic essential injuries, friction and winding losses. Magnetic core losses in the stator contains of hysteresis losses and eddy current.

Core Losses: losses creates through hysteresis and eddy current outcome in 50 Hz magnetization of the essential material. The hysteresis losses which are a function of flux density, are be reduced by utilizing low-loss grade of silicon steel laminations.

Stator and Rotor I^2R Losses: I^2R losses are heating losses resulting from current passing through stator and rotor conductors. I^2R are chief losses and classically account for 58 % of the entire losses. As the length and area of any conductor increases, the increase in the conductor resistance. Minimizing motor current is best to gradually achieve when reducing the magnetizing element of current.

Losses of winding and Friction: consequence from the manner of friction, winding and mixing air on the motor. The decrease in hotness produced thru stator and rotor injuries licenses the custom of minor fan. Winding losse decrease with diameter of fan principal to decreasing loss windings. The primary factors affecting motor efficiency are:

- ✓ Speed (high-speed motors have more efficient) and Age (New motors are more efficient).
- ✓ Size motor (Size increases with efficient).
- ✓ Suggestion cataloguing (lower slip motors have extra efficient).
- ✓ Rewinding (but decrease's efficiency)
- ✓ Temperature absolutely-encircled fan-ventilated motors are effective than screen sealed drop-resistant motors.

Table 3.11 analyzing of electric motor

No.	***Description of motor***	***Type of motor***	***Name Plate***			***Calculated***		***Actual measurement***				***Department***
			Rated power(kw)	*R. effic (%)*	*Speed (rpm)*	*Loading (%)*	*Input power (kw)*	*Output power (kw)*	*PF %*	*Voltage(v)*	*Current drawn(A)*	
1	*Coal mill*	*L92BL1*	*400*	*81*	*990*	*42.5*	*259.1*	*209.8*	*93*	*5.27k*	*21.12*	*Coal mill*
2.	*Crusher main drive*	*M212 H1M1*	*800*	*86*	*1500*	*72.6*	*786.04*	*676*	*91*	*6.27k*	*44.6*	*Crusher*
3	*Raw mill*	*412BL2M1*	*2500*	*89*	*1400*	*75.2*	*2373.1*	*2112*	*92*	*5.18k*	*258.3*	*Raw Mill*
4	*Fan of Raw mill*	*YKK710-6*	*2500*	*85*	*1450*	*72*	*2494.1*	*2120*	*93*	*5.33k*	*260.4*	*Raw Mill*
5	*Bucker Elevator*	*M212 FN3M1*	*160*	*76*	*1500*	*37.6*	*104.21*	*79.2*	*87*	*387*	*116.3*	*Cement m.*
6	*Id fan*	*442FN1M1*	*2000*	*80*	*994*	*61.9*	*1936*	*1548.8*	*91*	*6.23k*	*174.7*	*Raw Mill*

7	*Waste air fan*	*M472HM1*	*1400*	*86*	*740*	*57.7*	*1091.6*	*938.8*	*90*	*6.11k*	*91.2*	*Rotary k.*
8	*Water injection Pump*	*Y132S2-2*	*7.5*	*75*	*2900*	*46*	*6.13*	*4.6*	*87*	*396*	*6.3*	*Coal Mill*
9	*Fan for filter*	*L42BEM1*	*37*	*75*	*1000*	*51.3*	*33.73*	*25.3*	*86*	*360*	*29.8*	*Coal Mill*
10	*Fan of coal mill*	*YRKK450-4*	*400*	*81*	*1500*	*40.9*	*249.38*	*202*	*91*	*5.17k*	*22.3*	*Coal mill*
11	*Clinker crusher*	*Y280M-4*	*90*	*85*	*1450*	*50.8*	*63.29*	*53.8*	*94*	*388*	*53.4*	*In all dept.*
12	*Fan of filter kiln outlet*	*L92BL1*	*500*	*81*	*990*	*42.5*	*323.7*	*262.2*	*93*	*6.12k*	*26.4*	*Rotary k.*
13	*Separator fan 1*	*L92BL1*	*500*	*81*	*994*	*42.5*	*323.7*	*262.2*	*93*	*6.13k*	*26.4*	*Cement m.*
14	*Separator fan 2*	*L92BL2*	*500*	*81*	*994*	*42.5*	*323.7*	*262.2*	*93*	*6.13k*	*26.4*	*Cement m.*
15	*Belt conveyer*	*592FN4M*	*5.5*	*83*	*1450*	*52.8*	*4.21*	*3.5*	*91*	*390*	*5.8*	*In all dept.*
16	*Chain Conveyor*	*392CV5M1*	*90*	*78*	*1460*	*37.5*	*55.5*	*43.3*	*87*	*378*	*31.6*	*Raw Mill*
17	*Belt conveyer*	*592FN4M*	*5.5*	*83*	*1450*	*52.8*	*4.21*	*3.5*	*91*	*390*	*5.8*	*Cement m.*
18	*Fan for filter*	*L42BE/M1*	*37*	*75*	*1000*	*51.3*	*33.73*	*25.3*	*86*	*360*	*29.8*	*Coal Mill*
19	*Reversible belt conveyer*	*Y2-132M-4*	*5.5*	*80*	*1440*	*52.3*	*4.5*	*3.6*	*95*	*378*	*5.3*	*Cement m.*

20	*Cement mill 1*	*56BE3 MD1*	*4000*	*87*	*1500*	*73.5*	*3882.4*	*3377.7*	*92*	*6.08 k*	*296*	*Cement m.*
21	*Cement mill 2*	*56BE3 MD2*	*4000*	*87*	*1500*	*73.9*	*3908.1*	*3400*	*92*	*6.09*	*294*	*Cement m.*

3.3 Improvement of Clinker Production (Kiln)

The actual use of coal is difficult to measure accurately because consumption is not usually metered. [22] Monthly consumption is typically estimated based on fuel delivery dates and may not correspond to actual consumption. Coal consumption can be estimated from the combustion efficiency and energy output of coal-fired equipment at the kilns of the clinker production. [26]

Process Control & Management Systems: Heat from the kiln may be lost through non optimal process conditions or process management. Automated computer control systems may help to optimize the combustion process, conditions under a variety of fuels, and also to advance the manufactured excellence and grind capability. The installation costs equal $0.32/ ton of clinker, with an estimated payback period of one year.

Kiln Combustion System Enhancements: can be providers to kiln less efficiency with unwell accustomed firing, imperfect fuel burning by extraordinary CO creation, and burning thru extra air difficulties. The average payback period is estimated to less than a year.

Mineralized Clinker: Mineralizers and fluxes are substances used to improve raw mill burn ability. Fluxes (Al_2O_3 and Fe_2O_3) can lower the viscosity of the melt, and the temperature at which clinker starts to form. Mineralizers (i.e. fluorine) promote the formation of clinker. With the use of mineralizers, the temperature in the sintering zone can be reduced, resulting in less fuel consumption. A 360^{o}F temperature decrease can result in 5% fuel savings.

Indirect Firing: Historically the most common firing system is the direct-fired. This can lead to high levels of primary air (up to 40%). These high levels of primary air limit the amount of secondary air introduced to the kiln from the clinker cooler. The investment costs of the indirect firing system were $5 million for an annual production capacity of 680,000 tons.

Oxygen Enrichment: Several plants use it to increase production if the local market demand for cement can justify the additional costs for oxygen purchase or production.

Mixing Air Technology: The injection of a high-pressure air stream into the kiln results in improved mixing of the stratified gas layers created within the kiln. The result is improved burn ability, reduced fuel use, lower emissions and improved kiln stability.

Seals: used at the kiln inlet and outlet to minimize incorrect air diffusion, in addition to heat loss. The repayment age for enhanced preservation of kiln covers is assessed at six months or fewer.

Kiln Shell Heat Loss Reduction: The use of better insulating refractories can reduce heat losses. Refractory choice is the function of insulating qualities of the brick and the ability to develop and maintain a coating. Coating helps to reduce heat losses and protect the burning zone refractory bricks.

Preheater Shell Heat Loss Reduction: The outer part of the upper preheater vessels and the cooler housing can also be insulated. The energy savings are estimated at about 17 kBtu/ton clinker, at an investment cost of $0.30/ton.

Variable Speed Drive for Kiln Fan: variable speed drives for the kiln fan result in reduced power use and reduced maintenance costs.

Conversion to Efficient Clinker Cooler Technology: Four main types of coolers are used in the cooling of clinker: shaft, rotary, planetary, travelling and modern reciprocating grate coolers.

Optimization of Heat Recovery/Upgrade Clinker Cooler: The clinker cooler drops the clinker temperature from 1200°C down to 100°C.

At the kiln the thermal energy was produced due to the burning of fuels (coal). The reference range of the average thermal energy consumption corresponds to the lower limit of energy consumption 2900 MJ/t clinker, plus between 160 to 320 MJ/t clinkers to allow for the annual variability in kiln operation. This reference range (from 3060 to 3220 MJ/t) applies only to a low humidity content (Approximately 3 %). For other humidity contents it should be increased accordingly. Therefore, we have taken the average thermal energy consumption of 3140MJ/t of clinker. Thermal energy can be conserved through: [21]

- Avoid leakage in clinker production & Raw material treating, close unnecessary openings, and provide more energy efficient seals,
- Increase efficiency
- Grinding: adjustment of ball charges, modifying particle size distribution, controlling gypsum dehydration.

- Cooler: adjust the zero point of cooler, remove operational damages of cooler, reduce vent air of fan and, adjust pressure, recycle excess cooler air and fuels or preheating fuels or air.
- Pre-heater: improve or adding of additional capacity
- Combustion process: monitoring the combustion process, modify burners, heat recovery techniques by reduction of stream temperature or using the heat capacity of the stream in preheating sections, fuel reduction, control combustion air input,
- Dust collector: by minimizing gas turbulence to tower dust in exhaust gases.

Thermal Energy: Thermal energy relates to the Pyro processing system. For a 1 million mt/year clinker production, savings of 10 kcal/kg-cl would result in annual savings of approximately $185,000. (1,000,000 tpy*1,000 *10 kcal/kg. * $120/t-coal/ (6,500kcal/kg-coal*1,000 t coal). So, in national cement we have collected around 587,375.67ton/year of clinker production.

= (587,375.67tpy*10 kcal/k.g. * $ 49/t-coal)/ (6,500kcal/kg-coal*1000 t coal)

Therefore the result in annual saving is of approximately $ 44.28 it is somewhat low.

In addition of the above possibilities of conservation of thermal energy, the Potential savings can also be derived from:

- Cooler optimization
- Arresting in-leakages
- Optimization of operational strategy

3.4 Overall Cost of Electrical and Coal Consumptions of *NCSC*

The overall workout is shown below visibly how much the plant is really expending on energy annually. The normal yearly cement and clinker production of National Cement Plant from 2014-2016 collections given as follow: [12]

Production of Cement = 678,212.4 tons of cement/yrs.

Production of Clinker = 587,375.7 tons of clinker/yrs.

$$\text{Average electric energy consumption} = 88{,}267{,}316\,\frac{\text{kWh}}{\text{yrs}}.$$

$$\text{Average coal consumption} = 88{,}807.79\,\frac{\text{ton}}{\text{yrs}}.$$

Average fuel oil cost = 17 Birr/Lit.

Average electricity cost = 0.5 Birr/kWh.

Average coal cost =1320.2Birr/ton.

$$Annual\ average\ electricity\ cost = electric\ energy\ consumption(kWh/yrs) * cost\ of\ electricity\ (Birr/kWh) \quad (3.25)$$

$$= 88{,}267{,}316\,\frac{\text{kWh}}{\text{yrs}}.* 0.5\ \frac{\text{Birr}}{\text{kWh}}.$$

$$= \mathbf{44,133,658}\ \frac{\textbf{Birr}}{\textbf{yrs}}.$$

$$Annual\ average\ coal\ cost$$

$$= average\ coal\ consumption(ton/yrs) * cost\ of\ coal\ \left(\frac{Birr}{ton}\right) \quad (3.26)$$

$$= 88{,}807.79\,\frac{\text{ton}}{\text{yrs}}.* 1320.2\ \frac{\text{Birr}}{\text{ton}}. \quad = \mathbf{117,226,282.8}\,\frac{\textbf{Birr}}{\textbf{yrs}}.$$

1 kW = 859.85 Kcal/hr., 800kW = 687,876.18 Kcal/hr., 1 Kcal = 0.00044 liters, 687,876.18 Kcal/hr. =302.63 liters. Averagely the diesel generator operates for 0.3 hours.

$$\text{Total diesel consumption } = 0.3\,\frac{\text{hrs}}{\text{day}} * 302.63\,\frac{\text{lit}}{\text{hr}} = 90.789\,\frac{\text{litrs}}{\text{day}}.$$

$$\text{Total diesel consumption per year } = 90.789\,\frac{\text{lits}}{\text{days}} * 365\,\frac{\text{days}}{\text{yr}}. = 33{,}137.985\,\frac{\text{lits}}{\text{yrs}}. \quad (3.27)$$

$$\text{Total cost of diesel } = 17\,\frac{\text{ETB}}{\text{lit}} * 33{,}137.985\,\frac{\text{lit}}{\text{yrs}}. = \mathbf{563,345.745}\,\frac{\boldsymbol{ETB}}{\boldsymbol{yr}}.$$

$$Over\ all\ total\ cost\ paid\ per\ year = (\text{Annual average electricity cost} + \text{Annual average coal cost} + \text{ Total cost of diesel}) \quad (3.28)$$

$$= (\mathbf{44,133,658} + \mathbf{117,226,282.8} + \ \mathbf{563,345.745})Birr/yrs$$

$$= \mathbf{161,923,286.545}\,\frac{\boldsymbol{Birr}}{\boldsymbol{yrs}}. \ \approx \mathbf{5,997,158.761}\,\frac{\boldsymbol{Dollars}}{\boldsymbol{yrs}}.$$

National cement have annually an average electrical and thermal energy intensity of *130.5* kWh/ ton and 3140 KJ/Kg, and the Iranian cement have also an average electrical and thermal energy intensity of 111 kWh/ton and 2360.6 KJ/Kg) respectively. So, the electrical and thermal energy intensity difference between national and the selected benchmark Iran) cement is 19.5 kWh/t and 779.4 KJ/Kg annually. National cement factory pays additional payment due to the use of inefficient energy utilization.

Cement production = 678,212.4 ton/year

Average cost electricity = 0.5 Birr/kWh.

Coal in J/ton =28 GJ/ton (4000 kcal/kg)

Clinker production = 587,375.7 ton/year.

Average cost coal =1320.2 Birr/ton

Exchange rate (One Dollar =27 Birr)

Annual value because of unwise use of coal energy

$$=\left[\frac{\left[\text{coal energy intensity}(\frac{\text{kJ}}{\text{kg}}) * \text{clinker production}(\frac{\text{ton}}{\text{year}})\right]}{\left[specific\ heat\ fuel(\frac{\text{kJ}}{\text{tons}})\right]}\right] * \text{cost of fuel}\ \left(\frac{\text{Birr}}{\text{ton}}\right).$$

$$=\left[\frac{\left[779.4\left(\frac{kJ}{kg}\right)*587{,}375.7\left(\frac{ton}{year}\right)\right]}{\left[28\left(\frac{GJ}{tons}\right)\right]}\right] * 1320.2\ \left(\frac{Birr}{ton}\right). \qquad (3.29)$$

$$= 21{,}529{,}909.73\ Birr/year$$

Yearly price caused by unwise use of electrical energy

$$= (\text{electrical energy intensity} * \text{prod. of cement} * \text{electrical cost})$$

$$= 19.5\left(\frac{kWh}{ton}\right) * 678{,}212.4\left(\frac{ton}{year}\right) * 0.5\ \left(\frac{Birr}{kWh}\right). \qquad (3.30)$$

$$= 6{,}612{,}570.9\ Birr/year$$

Consequently, the over-all yearly price of energy because of ineffective use of energy is calculated as follows:

$$Total\ wastage\ = \text{value of electricity} + \text{value of fuel} \qquad (3.31)$$

$$= (6{,}612{,}570.9 + 21{,}529{,}909.73)\frac{\text{Birr}}{\text{year}} \quad = 28{,}142{,}480.63\frac{\text{Birr}}{\text{year}}. \ = 1{,}042{,}314.0974\frac{Dollars}{year}$$

3.5 Carbon Dioxide Emissions

Carbon dioxide emissions within the cement business are created each through the combustion of coal and waste fuels, and therefore the oxidization of sedimentary rock cathartic to the encircling.[5] Since National cement business uses coal and electricity for producing cement, people’s lives round the cement works affects their health. In the totally different completely different departments of the cement plant there's different rating of carbonic acid gas created. Within the oxidization method 0.51 a lot of greenhouse gas are emitted for each a lot of clinker created, and 0.43 t greenhouse gas/ton of cement to unevenly approximation of the greenhouse gas emanations from production of cement. Additionally an emission issue of 93.5 t greenhouse gas/TJ of coal and 0.82 Kg CO^2/kWh toward unevenly approximate greenhouse gas releases after electricity and fuel ingesting. [7] Cement business results in greenhouse gas emissions. Greenhouse gas is released when the method of shifting sedimentary rock to clinker, burning of fuel coals and unwise consumption of electrical energies. Generally, Cement industries are answerable total international releases of greenhouse gas is 5 %. Energy consumption knowledge is predicated on the physical consumption knowledge as provided by the international earth science Survey. The consumption knowledge are increased with typical international energy contents for the various fuels, as given by the producing Energy Consumption Survey (MECS) and therefore the Energy data Administration's Annual Energy Outlook. [20, 26] due to the approximation influences of the most energy input of works, greenhouse gas releasing of National cement works are the average production & energy consumption knowledge of three consecutive years are estimated table 3.12.

Table 3.12 Average greenhouse gas Emissions ensuing from method making and energy consumption of National cement plants

			Emission factor	***Emission (ton of CO_2)***	***Total Emission (ton CO_2)***
Production	Cement Production	678,212.33 ton	0.43 t CO_2/t	291,631.30	**768,303.24**
	Clinker Production	587,375.67 ton	0.51 tCO_2/t	299,561.59	
Energy Consumption	Electricity	88,267,316 kWh	0.8Kg CO_2/kWh	70,613.85	
	Fuel	1139TJ	93.5 t CO_2/ TJ	106,496.5	

As shown within the on top of table 3.12, the plant releases about 0.768 million CO_2 per year. This consequence would be minimized by rising the economical of energy concentrated equipment's exist in the plant. Because the outcome, the plant uses great extent of energy and that fee plenty of value because of unwise taking of energy when compared with the chosen standard cement plant. As an example, precise energy consumption unit is calculated to be a 130.4 kWh/ton cement. The quantity of carbon dioxide gas emission per kWh of energy consumption will be taken as 820 g. the quantity of emission is found to be 106.92kg CO2/ton cement.

Opportunities thought of throughout analysis, and audit stages uses to increasing potential reduction of greenhouse gas emissions are as follows:

- Fuel combine for clinker production: the chance to use low carbon fuel (e.g., natural gas) and different fuels (e.g., waste biomass)

- Different raw materials: like ash throughout clinkering method (i.e., sedimentary rock substitute);
- Clinker to cement ratio: mixing clinker with clinker substitutes for cement production ought to be thought of, among the bounds of regulative and quality necessities necessary for a secure use of cement;
- Energy economical electricity-consuming equipment: High potency fans and motors ought to be used, likewise as energy economical mill technologies like vertical roller mills or roller presses rather than ball mills, as appropriate;
- Automated kilns: Kiln operation should be computer assisted whenever possible, as it ensures process, quality, and energy consumption optimization:

Generally increasing the efficiency of pyro process (Clinker), minimizes energy consumption and releasing of CO_2.

CHAPTER FOUR

4. REPLACEMENT OF OVER AND UNDER LOADED MOTORS AND EFFICIENT LAMPS

4.1 Introduction of Motor Master international software

Motor Master+ International are getting to be an area of the upcoming Energy Management Toolkit, which may act because the first delivery mechanism for extra tool access from the Energy Management Portal. Motor Master+ International has multi-language capability and allows users to conduct economic analyses using various currencies. The software also allows users to insert applicable country or regional motor full-load minimum efficiency standards and country-specific motor repair and installation cost defaults. Motor Master+ international uses for selection motor and supports the motor system improvement, identifying the worth effectiveness, replacing of the prevailing motor. Purposes of Motor Master

- ✓ Assist motor users so on pick the proper motor.
- ✓ To match the capacity of the prevailing motor with the energy efficient motors.
- ✓ It Increase the notice of motor system efficiency.
- ✓ It gives decision in order to exchange the overloaded and under loaded motors.

Database: IEC2005_50Hz.mdb
Language: English

Database date: December 29, 2005
Working Currency: Euros (€)
Operating frequency: 50 Hz
Efficiency test standard: IEC 34-2

Version: 1.1.5 - August 2, 2011

Motor type: IEC Design N
Size: 110 kW
Speed/Poles: 1500 (4) RPM
Degree of protection: IP55
Voltage: 400
Definite purpose: <All - purpose motor>
Rebate program: <None>
Frame size: <All>
Vertical shaft ☐
Manufacturers (28) All ☑
ARCELIK AS
Baldor UK
BESEL S.A
BROOK & CROMPTON
CEG Srl
CELMA S.A
☑ Premium Efficiency

Manufacturer	Model	Catalog	kW	Encl	Eff FL IEEE %	EFF FL IEC %	Vol
Baldor UK	GENERAL PURPO	EMM4410-57	90	IP55		95.3	415
CELMA S.A.	SEE 280 M4		90	IP55		95.2	400
LAFERT AEG	AMHE 280M V4	2.2.1	90	IP55		95.2	400
ROTOR bv	4RN280M04A3	4RN	90	IP55		95.2	400
Teco	Advantage+ V seie	TBC	90	IP55		95.2	400
LEROY SOMER	LSMV 280MK		90	IP55		95.1	380
Dutchi Motors B.V	DM1-HE 280M4	11134A90HE	90	IP55		95.1	400

22 motors found

Figure 4.1 Motor master+ international software

Motor Savings Analysis - Replace Existing

INPUTS

Motor Characteristics

	Existing Motor	**Energy Efficient Motor**
Description:	Old Standard Efficiency	EFF2 - Improved Efficiency
Size (kW) / Speed (RPM) (Poles):	90.0 kW: 1500 RPM	75.0 kW: 1500 RPM
Degree of protection /Voltage (Volts):	IP54 400 Volts	IP54 400 Volts
Load (%):	50.8	61.0
Efficiency (%):	85.0	93.3
Full load RPM:	0 RPM	0 RPM
Centrifugal load:	False	
Old Motor Efficiency Loss (%):	0	

Costs/Use

	Existing Motor	Energy Efficient Motor	Utility Data
Dealer discount (%):	N/A	35	Energy price (€/kWh): 0.04
Purchase price (€):	N/A	3,072	Demand charge (€/kW/mo.): 5
Installation cost (€):	N/A	283	Power factor (%): N/A
Motor rebate (€):	N/A	0	Rebate program: <None>
Peak months:		1212	Simple payback criteria, yrs.: 10
Hour's use/yr.:	4000		

RESULTS - SAVINGS

	Existing Motor	Energy Efficient Motor	Energy Savings
Differential cost (€):		3,355	Energy (kWh/yr.): 19,140
Energy use (kWh/yr.):	215153	196013	Demand (kW): 4.8
Energy cost (€/yr.):	8,606	7,841	Energy savings (€/yr.): 766
Demand charge (€/yr.):	3,227	2,940	Demand savings (€/yr.): 287
Greenhouse Gas Emissions Reduction			Total savings (€/yr.): 1,053
State:	New York	Tone's CO2/yr.: 7.47	Simple payback (yrs.): 3.2

4.2 Replacing Under Loaded by Proper Sized Motors

Under-loading is that the most typical explanation for motor inefficiencies and it reduces motor efficiency, motor power factor and increases motor losses. Lower efficiency, low power factor and other control equipment of motor results because of under loading. Reasons for the motor inefficiencies because of Under-loading:

- ✓ Equipment is typically under-used. E.g. the manufacturer provides full capacity load for a motor rated.
- ✓ Apparatus manufacturers tends to custom a high factor of protection in choosing motor.
- ✓ Huge motors nominated to facilitate the output to be preserved at the required standard even though primary voltages are small in value.

Motor size is chosen by its load rating. Replacement of a loaded motor with an accurate motor is vital to have possible competence. Large motors consume advanced graded competences than small motors. If motor works below 50% of its full rated load, we've to exchange by incompletely and full loaded motors. From the loaded motors that are existing within the cement plant was the motors driving of the Clinker crusher, Bucker Elevator, Reversible belt Conveyer, Fan for bag filter from Cement Mill, and Fan for filter, Coal mill, Roots Fan, from Coal Mill.

Table 4.1: Under loaded working motor of national cement plant

No.	Types of Existing motors	Existing Motors			Types of replaced motors	replaced motors			Investment cost $\$/years$	Energy saving KWh/year	Total saving $\$/year$	CO^2 reduction (ton/yr.)	Pay back period
		KW	η %	Load %		KW	η %	Load %					
1	Old Standard	90	85	50.8	Improved	75	93.3	61	3,350.4	19,031	1,047	7.4	3.2
2	Standard	160	76	37.6	Standard	132	91.6	45.6	6,228.6	53,924	2,966	21	2.1
3	Standard	5.5	80	52.5	Standard	3.7	89	75	218	1,983	109	0.77	2.6
4	Old Standard	7.5	73	46	Improved	5.5	94	72	350.3	2,053	113	0.8	3.1
5	Standard	37	75	51.3	High	30	93.4	63.3	2,415.6	19,968	1,098	7.79	2.2
6	Standard	132	81	51	Improved	110	90.8	61.2	4,752.5	34,568	1,901	13.5	2.5
7	Standard	55	80	39	Improved	45	91.3	47.7	2,035.6	13,219	727	5.2	2.8
8	Standard	400	82	39	Standard	450	91.1	43.3	23,152.8	95,676	5,262	37.3	4.4
Total									42,503.8	240,422	13,223	93.76	

From table 4.1 the replaced under load operation *of* motors by energy efficient motors or proper sized motors saves *240.422 MWh* of energy, and *13,223* Dollar/year.

4.3 Energy Efficacy Enhancement for Light Schemes

While lighting is typically a little element of plants energy customs, efficacy enhancements to lighting schemes primes an enormous energy conserving. There are different types of lamps which have their own efficiency and life span in the working time. So, the select type of lamp that fits our system is T-8 tube fluorescent lamp with efficiency rate of 80-100%.

Table 4.2 Performance comparison of lighting sources

Lamp	Efficiency(lumen/Watt)	Life time(hours)
halogen	<24	1,000
CFL	20-70	8,000-15,000
Incandescent	5-20	1,000
Fluorescent T-12	60	20,000
Fluorescent T-8	80-100	20,000
Fluorescent T-5	80-105	20,000
Mercury vapor	30-50	60,000
LED	10-120	5,000
High pressure sodium	85-150	10,000-50,000
Metal halide	70-115	20,000
Induction	80	100,000

In most industries, typical T-12 lamps are functional. T-12 lamp mentions to the diameter in 1/8 inch addition. Primary production and energy ingestion for T-12 lights are great. T-12 characteristics are poor efficacy, lumen reduction, and color performance. Due to the maintenances and energy prices of the lamps are high. When we substituting T-12 lamps by T-8 lamps efficacy is twice and saves approximately 30% of energy.

4.3.1 Installing the required number of lamps of the Factory

In the plant 793 lighting lamps fixed with the rating of 40 W fluorescent lamps. There are unbalanced illumination in the factory because of the excess number of lamps. Next the enlightenment has been analyzed, 675 lamps with similar value power was demanding.

4.3.2 Changing of T-12 lamps by T-8 lamps

After replacement of actual number of lamps, the required energy 504.32 Kwh/d (average operating hours is taken around 18.7 hours) have been saved. Hence, the energy reserves, after the changing of real quantity of lamp (ANL) of T-12 lamps by T-8 lamps, through equal power (40Watt) fluorescent lamps, and be able to calculate:

$$Power\ Demand\ Saving\ (PDS) = 0.3 * ANL * rating\ power\ of\ lamp/1000 \qquad (4.1)$$

$$= 0.3 * 675 * 40/1000 \ = 8.1\mathrm{kW}$$

Energy Saving (ES): $$ES = 0.3 * R.E.* operating\ day/years \qquad (4.2)$$

$$\mathrm{ES} = 0.3 * \mathrm{R.E.}* \frac{365\mathrm{days}}{\mathrm{yrs}} = 0.3 * \frac{504.32\mathrm{kWh}}{\mathrm{d}} * \frac{365\mathrm{days}}{\mathrm{yrs}} = \frac{55.22\mathrm{MWh}}{\mathrm{yrs}}.$$

Unit cost of electric energy per Birr/kWh = 0.5 Birr/kWh

$$Total\ Unit\ cost\ of\ electric\ energy = ES * 0.5\ Birr/kWh \qquad (4.3)$$

$$= 55.22 \frac{\mathrm{MWh}}{\mathrm{year}} * 0.5\ \mathrm{Birr/kWh} = 27{,}610 \frac{\mathrm{Birr}}{\mathrm{year}}. \approx 1022.59\ \mathrm{US}\frac{\mathrm{Dollars}}{\mathrm{yrs}}.$$

From the above outcomes the overall energy feeding can conserves *55.22* MWh/yrs. Which is equivalent to *1,022.59* US Dollars annually. The reduced number of lamps are 118 fluorescent lamps. The total energy saved from the removed lamps is *102.160* kWh/day.

$$E.S.\ (reduced) = \frac{102.160kWh/d*365d/yr}{1000} = 37.3\ MWh/yr. \qquad (4.4)$$

$$\mathrm{Cost\ saving} = 37{,}300\mathrm{kWh/yr} * 0.5\mathrm{Birr/kWh} = 18{,}650\mathrm{Birr/yrs} \quad \approx 690.74\mathrm{USD/kWh}$$

Payback Period: A term often used in regard to energy conservation is payback period. Payback period can be estimated to determine the feasibility of making a capital investment that will provide energy savings. Simple payback period is an indication of the amount of time it will take for an organization to recover the cost of an energy-saving investment which is purchased. The formula for estimating simple payback period is:

$$Payback\ period = \frac{cost\ of\ investment\ (\$)}{average\ yearly\ savings\ (\$)} \qquad (4.5)$$

For the calculation of the simple payback period we considered for the under loaded motors (8 motors) that are measured above. $Average\ cost\ of\ investment = 42{,}503.8\ (\$)$

$$Average\ yearly\ savings = 13{,}223\ (\$)$$

$$Payback\ period = \frac{42{,}503.8\ (\$)}{13{,}223\ (\$)} \approx 3.21$$

Generally the payback period of replacing loaded motors was averagely ***3.21*** years.

CHAPTER FIVE

5. REPLACING THE DIESEL GENERATOR BY SOLAR PV SYSTEM

The factory needs diesel energy on the presence of Power interruption to derive some portions of the department. One diesel generator having a rate of 800 KW is used in the factory. [17] Therefore, the diesel energy is more expensive when compared with solar photovoltaic system. The conversion of kW to liters is as follows: (1 kW = 859.85 Kcal/hr., 800Kw = 687,876.18 Kcal/hr., 1 Kcal = 0.00044 liters, and 687,876.18 Kcal/hr. =302.63 liters/hr.

Averagely the diesel generator operates for one hours.

$$Total\ diesel\ consumption = 1\frac{hrs}{day} * 302.63\frac{lit}{hr} = 302.63\frac{litrs}{day}.$$

$$\text{Total diesel consumption per year} = 302.63\frac{\text{lits}}{\text{days}} * 365\frac{\text{days}}{\text{yr}} = 110{,}459.95\frac{\text{lits}}{\text{yrs}}.$$

$$\text{Total cost} = 17\frac{\text{ETB}}{\text{lit}} * 110{,}459.95\frac{\text{lit}}{\text{yrs}} = 1{,}877{,}819.15\frac{\text{ETB}}{\text{yr}}. \approx \mathbf{69,548.86}\frac{\textbf{dollars}}{\textbf{yrs}}$$

The energy consumption cost is averagely ***69,548.86 US*** dollars/years for buying fuel oil. The power is interrupted averagely for eighteen mins/day. Therefore, to avoid the unnecessary payments of diesel in the factory it is better to design solar energy (PV) as a Backup Power and more source of solar is available at the factory.

5.1 Design of PV System*:* Photo voltaic (PV) devices offer replaced naturally or controlled carefully and therefore can be used without any risk of finishing its energy from an unlimited power source (sun). The solar modules (group of PV cells) convert power from sunlight into DC electricity that can be used to recharge the battery bank. The significant of installing the PV modules with in the factory, which the grid donating to provide the electricity request for the various loads accessible in small area of the factory.

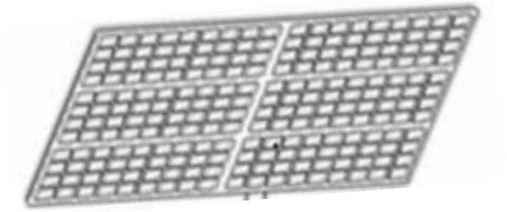


Figure 5.1 Module of solar cell

5.2 Selection of the System Components

5.2.1 Module type: because of its cost and efficient power production a thin film amorphous module is selected. They can provide averagely 110 watts/m^2 in full sun day.

5.2.2 Inverters: it converts the DC power from the battery bank to AC powers and inverter provides a 240V AC for stand-alone power systems high quality AC.

5.2.3 AC - DC Systems*:* the voltage requirement of AC and DC scheme loads are different in rating. Electricity results from direct current (DC) of modules and storage batteries, nevertheless most applications works on by converting the DC to AC current and with 50 Hz frequency. DC schemes have small voltage (12, 24, or 48 V) and high amperage value power source. So, DC schemes needs much denser wiring than normal AC wiring to function carefully and professionally. Converter changes DC power from storage battery to AC. They consume averagely 10% of the PV system power to operate well.

5.2.4 Batteries: are main body of all solar power schemes. It uses as the energy storing to safeguard the obtainability of power to loads. Battery nominated is lead-acid, which is either flooded liquid electrolyte or valve-regulated type. Battery life is maximized by keeping the daily discharge of the battery capacity below 20%.

5.2.5 System Sizing*:* The number of modules, size of the battery, wires, controller, inverter, etc. mainly depend on the amount of power consumption, and the amount of solar radiation available on the area. Batteries consumes about 10% of its energy stored.

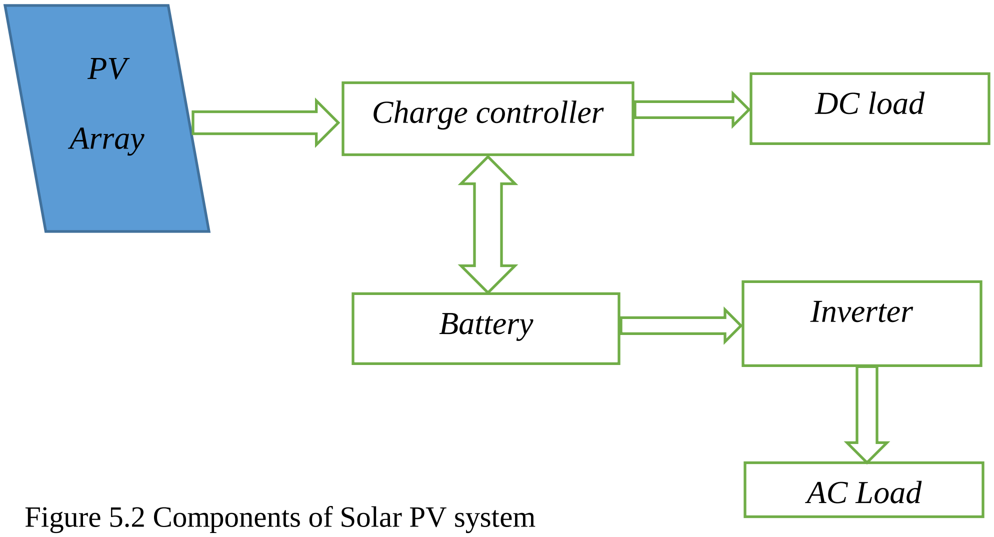


Figure 5.2 Components of Solar PV system

5.3 PV System sizing

5.3.1 Panel Inclination: Solar panels need the maximum amount of sunlight to produce the maximum amount of solar power.

The best angle that will have our solar panels is influenced primarily by two factors.

1. The geographical locations latitude
2. The time of year we need to have more energy.

If you find that the energy generated by your solar panels is sufficient for your summer energy needs assuming that your highest energy usage is in the summer just leave with same direction. In different seasons Solar angle inclination can be calculated through:

- ✓ ***Summer (there is less sun) = (degree latitude *0.9) +29^0***
- ✓ ***Winter = (degree latitude *0.9)-23.5^0***
- ✓ ***Spring and Fall = degree latitude – 2.5^0***

Diredawa is situated 41.52^0 (41° 51' 59.99") east longitude and 9.36^0 (9° 35' 59.99") north latitude. There are different methods to tilt the solar panel for different situations. Consequently, the plate inclination would have been **37^0** through south.

5.3.2 Solar data analysis and estimation*:* Solar radiation data are available in several forms. More or less tool used to change the values of the measured documents to the obligatory solar rays. The solar radiation of the nominated location is determine through the following calculation:

$$G_{on} = [G_{sc}\,[1+0.033\cos\left(\frac{360\,m}{365}\right)]] \qquad (5.1)$$

Where:

G_{on} - the extraterrestrial radiation on the plane normal to the radiation on the nth day of the year (W/m^2) and G_{sc} is solar constant (i.e. 1353W/m^2) measured.

The total incident radiation on a horizontal surface is calculated by:

$$H_o=24\,\frac{3600\,GSC}{\pi}[1+0.033\cos\left(\frac{360\,Nd}{365}\right)]*[\cos\varphi\cos(\delta)\sin\omega_s+\frac{\pi\,\omega s}{180}\sin(\varphi)\sin(\delta)] \qquad (5.2)$$

Where:

Where

δ is declination angle, ω_s -sunset time in degree, and Φ -latitude of selected area.

The δ angle which displays the angular location of the sun at noon with deference to level of the equator is calculated below.

$$\delta = 23.45 \sin\left(360\,\frac{284+m}{365}\right) \quad (5.3)$$

Where: *m* - the day in the year.

The sunset hour in degrees: $\omega_s = \cos^1(\tan(\varphi)\tan(\delta))$ (5.4)

The maximum average daily hours

$$N_s = \omega s\,\frac{2}{15} \quad (5.5)$$

Table 5.1 Monthly Average day of declination angle

Month	m for i^{th} day of the Month	Date	m, days of year	declination angle δ
Jan.	i	15	15	-21.3
Feb.	31+i	17	48	-12.2
Mar.	59+i	15	74	-2.8
Apr.	90+i	14	103	8.8
May	120+i	16	136	19.03
Jun.	151+i	10	161	23.01
Jul.	181+i	12	193	21.96
Aug.	212+i	13	225	14.42
Sep.	243+i	12	255	3.41
Oct.	273+i	13	286	-8.85
Nov.	304+i	12	316	-18.42
Dec.	334+i	15	349	-23.33

5.3.3 Sunshine duration of solar radiation: the empirical formulas can be used to estimate the average solar radiation from the hours of sunshine duration. Monthly regular solar emission is estimated through the following:

$$\frac{H}{Ho} = a + b\frac{m}{Nd} \quad (5.6)$$

Where a and b are the regression coefficients which are reliant on the place, H - monthly average of the daily global radiation on a horizontal surface.

5.3.4 Availability of solar radiation: Availability of solar radiation: solar radiation is evaluates by taking data from NASA and from different literatures. In the first approach, the data taken from National metrology service agency is analyzed using the above formulas based on the sunshine duration data collected through past three years. Sunshine duration data taken from the NASA is given in table below. Hence, only the three year data is taken to convert in to MJ/m^2 using Equation (5.6).

Table 5.2 Average Sunshine duration of Diredawa

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Radiation	9.6	9.2	9.5	8.3	8.5	6.4	4.5	4.9	7	9.4	9.6	9.8

The average solar radiation of the selected area based on the year measured data is summarized and obtained in table 5.4. Where- m and ϕ represents measured sunshine duration and the latitude angle of the area respectively. The value of a and b varies with location, and hence the approximate values taken to be 0.3& 0.5 for a and b respectively.

Table 5.3 Monthly average solar radiation in MJ/m2 for year 2016

Month	Radiation	declination angle δ	φ	sunset angle (ω_s)	day length (N_d)	H_o(MJ/ m^2)	H(MJ /m^2)
Jan.	9.6	-21.3	14.23	84.33	11.24	29.76	29.73
Feb.	9.2	-12.2	14.23	86.85	11.58	33.6	27.39
Mar.	9.5	-2.8	14.23	89.28	11.90	36.82	31.06
Apr.	8.3	8.8	14.23	92.24	12.29	39.46	32.18
May	8.5	19.03	14.23	95.02	12.67	41.67	33.69
Jun.	6.4	23.01	14.23	96.18	12.82	40.64	26.85
Jul.	4.5	21.96	14.23	95.86	12.78	40.62	25.63
Aug.	4.9	14.42	14.23	93.73	12.49	40.06	24.62
Sep.	7.0	3.41	14.23	90.86	12.11	38.41	25.59
Oct.	9.4	-8.85	14.23	87.74	11.69	34.87	27.35
Nov.	9.6	-18.42	14.23	85.15	11.35	31.06	29.01
Dec.	9.8	-23.33	14.23	83.72	11.16	28.79	31.17

After all the Monthly average solar radiation in MJ/m^2 is converted in to kWh/m^2 using the conversion relation 1x106 J is equal to 277.78Wh.

Table 5.4 Monthly solar radiation (H) of Diredawa in KWh/m2 on 2016

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Radiation	8.26	7.61	8.63	8.94	9.36	7.46	7.12	6.84	7.11	7.60	8.06	8.66

The annual average solar radiation of the area is found to be 7.83 kWh/m^2, and then when we compare this value with the NASA surface metrology and solar energy indicates that the site has good potential to install the photovoltaic system.

5.3.5 Load Specification: As a backup power 800KW total diesel consumption in one year is required to install the PV solar module are calculated below:

Total power = 800 kW

Total energy consumption = total power * operating hour/day * operating days/year (5.7)

=800 kW * 0.3 hr. /day * 365 days/year

= 87,600kWh/yrs. Or 240 kWh/day.

5.4 PV module Sizing*:* solar module is a collection of many solar cells. Average peak sun hours for Diredawa is considered to be 8 hours, and the Approximate Total System Losses (12% for Battery, 15% for Inverter) = 27% of 240 KWh/day = 64.8 kWh/Day

Therefore, total power consumption of the plant and the losses of the system

$$= 240\ kWh/day + 64.8\ kWh/day = 304.8 kWh/Day \qquad (5.8)$$

To select the module we have to calculate the ampere hour rating by considering system voltage of 24V. Total power required by the solar panel is 304.8 kWh.

5.4.1 Peak Output wattage required from the Solar Panel is calculated through

$$= \frac{(daily\ watt\ hours + total\ losses\ watt\ hours)}{(peak\ sun\ hours)}. = \frac{304.8\ kWh}{8h} = 38.1\ kW \qquad (5.9)$$

Because of panels not be on a tracking frame, an additional of a nominal 15% to the total peak output wattage is required, so,

$$Total\ Peak\ Wattage\ Required\ from\ module = (38.1\ kW + 5.72\ kW) = 43.82\ Kw \qquad (5.10)$$

5.4.2 Number of Solar Panels Required***:*** Siemens solar M-55 module with its specification.

Table 5.5 Siemens Solar M-55 Module Specification

Electrical specification of M55	Max. power(W)	V_{oc}	I_{sc}	V at load	I at load
	53	21.7	3.35	17.4	3.05
Physical specification	Depth	Length	Weight	Width	Mounting holes
	36mm	1293 mm	5.7 K.g	330	1265 mm

The power output from a single solar panel is calculated through the number of photovoltaic panels required by using the M-55 module specification, the product V at load and I at load which is 53W.

The number of solar panel (N) required is

$$N = \frac{43.82 kW}{53\ W} = 827 \qquad (5.11)$$

The amount of solar segments linked in sequence is assumed by

Ns = System battery Voltage /Operating Voltage of a particular segment.

Ns = 24/17.4 = 1.38 ≈ 2 modules

The amount of solar modules linked in corresponding are named as strings (Np) is estimated by dividing the amount of modules obligatory to the energy requirement to the quantity of modules obligatory per each string.

$$Np=\frac{N}{NS} = \frac{827}{2} = 413.5 \qquad (5.12)$$

5.4.3 Total daily Power Output of Panels

= *827* panels * 53 W = 43.83kW

Daily energy output = *43.83kW * 8 hours* (5.13)

= 360.84 kWh/day

The load current of the lighting is determined by

$$I_L = \frac{EL}{24*VDC} \qquad (5.14)$$

Where E_L is the daily energy demand of the house hold which is equal to 360.84 kWh/day and system voltage V_{DC}=24 V.

$$I_L = \frac{EL}{24*VDC} = \frac{360.84\ KWh}{24\ *24\ V} = 626.5\ A \qquad (5.15)$$

A Nominal current is the product of load current and number of hours in a day divided by the number of peak solar hours

$$I_{PV} = \frac{24\ *IL}{PSh}, \qquad I_{PV} = \frac{24h*\mathbf{626.5A}}{8\ h} = 1879.5\ A \qquad (5.16)$$

5.5 Sizing a Battery: Lead-acid batteries area unit commonest in PV systems. Sealed batteries don't need periodic maintenance. Day of autonomy is the energy keep once the sun isn't shining adequately. Diredawa has adequate irradiance thus, 2 days area unit enough.

$$\text{Battery Capacity} = \frac{\text{Total Watt−hours per day used } *\text{Days of autonomy}}{(0.85 \text{ x } 0.6 \text{ x nominal battery voltage})} \qquad (5.17)$$

= 58,961*Ah*

A lead-acid battery storage can last longest if it's discharged solely 80%. The maximum battery capability is set by dividing the entire amp-hours by 0.8,

=58,961 *Ah /0.8 = 73,701Ah*

From the Exide battery manufacturer's specification a 3E120-27 with a 6V per unit and 1750 amp-hours is capability is chosen.

Number of parallel batteries = Total amp-hours/amp-hours of a single battery (5.18)

= 31750 Ah /1750 Ah = 18 batteries.

Number of series batteries = System bus voltage/Single battery voltage = 24/6 = four batteries that area unit accustomed offer the specified DC bus voltage.

Based on the chosen batteries the entire battery capability in power unit hours is set by

$$= \text{Total amp-hours capacity} * \text{system bus voltage} \quad (5.19)$$

$$= 31{,}750 \text{ Ah} * 24\text{V} = 762{,}000\text{W h} \approx 762 \text{ kWh}$$

5.6 Sizing of Charge Controller: work to control electrical charge and that they limit the speed at that current is else to or withdrawn from the Batteries. They work to regulate voltage and watts from the Panels; so, passing through additional stable energy, preventing overcharging and protective against overvoltage-which will hinder and scale back Battery performance or lifetime.

5.6.1 Steps for Sizing a Charge Controller:

$$I_{PV} = \text{total wattage solar panel} / \text{system voltage} \quad (5.20)$$

$$= 43.82 \text{ kW} / 24 \text{ V} = 1.8 \text{ kA}$$

Add 20% as a safety margin, Charge Controller = 0.2 * 1.8 kA + 1.8 kA = *2.16 kA*

5.7 Inverter Size: an electrical converter (inverter) uses to converts DC to AC provide supply. Changing DC to AC leads to a loss of potency that is energy losses area unit assumed to be 15% for the electrical converter. Since the entire electric power (total wattage) needed from the PV module is forty 43.82 kW.

$$\text{Electrical convertor (Inverter) size} = 43.82 \text{ kW} - 43.82 * 0.15\text{kW} = 37.3 \text{ kW} \quad (5.21)$$

5.8 Space needed by the PV system: the total annual energy consumption by the lighting: to install 827 solar panels, solar irradiance 7.83kWh/m^2/day having a conversion efficiency of 16% and rated at 53 Watts each. The total power output of the solar system can be calculated as:

$$\text{Total power per year} = \text{total power consumption of the system} * 365 \text{ days/year} \quad (5.22)$$

$$= 360.84 \text{ kWh/day} * 365\text{day/year} = 131{,}706.6 \text{ kWh/yr.} = 131.7 \text{ MWh/yr.}$$

The average annually solar power radiation is

$$= 7.83 \text{ kWh/m}^2\text{/day} * 365 \text{ days/year} = 2857.95 \text{ kWh/m}^2\text{/year.}$$

The area required to get the facility is:

$$\text{Area} = (\text{kWh}) / (\eta_{pv}(\text{kWh/m}^2)) \quad (5.23)$$

$$A = \frac{131{,}706.6 \ \text{KWh/year}}{0.16 * 2857.95 \ \text{kWh/m2/year}} = 288 \ m^2$$

Solar power Price in USD: assuming the price of module as 1.75 $/W that is 76,685 US Dollars.

Table 5.6 worth for solar power per USD

Materials	Panels	Inverter	Batteries	Charge contr.	Cable	Installation
Cost in $	76,685	599	7200	9000	700	1000

$$Total\ price\ of\ PV\ system = cost\ of\ (Battery\ + Charge\ contr. + cables\ +\ installation + PV\ module)\ = 95{,}184\ USD \tag{5.24}$$

Finally I have been calculated the simple payback period of the installed solar photo voltaic system in Diredawa national cement to replace the diesel generator. The factory spends 20,865 $/year for diesel oil. The overall PV cost is 95,184 $. So to calculate the simple payback period:

$$Simple\ payback\ period = \frac{Investment\ (PV) cost}{Saved (desiel)\ cost} \tag{5.25}$$

$$\text{S.P.P.} = \frac{91{,}957}{20{,}865}\text{yrs.} = 4.4\text{ yrs.}$$

By comparing the saved price (diesel) and investment price of scheme at the corporate is recommended the payback amount is around four years and half. Therefore, the investment price is not the maximum amount as immense.

CHAPTER SIX

6. DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

6.1 RESULTS and DISCUSSIONS

Generally, the national cement making and energy feeding of three successive making years yields regular cement of 678,212.33 ton/yrs. and production of clinker of 587,375.67 ton/yrs. It consumes 33,137.985 liters of fuel (oil), 88,807.79 tons of coal, and 88,267,316 KWh of electrical energy annually. National cement factory's average specific electrical energy consumption of 130.5 kWh/ ton of cement and thermal energy intensity of 3140 KJ/Kg annually and the Iranian cement have also an average electrical and thermal energy intensity of 111 Kwh/ton and 2360.6 KJ/Kg respectively. The difference between the Iranian cement average electrical and thermal energy intensity consumption 19.5 KWh/t and 779.4 KJ/Kg cement energy consumed due to inefficient utilization. We have taken that the average thermal energy and average electrical energy consumptions were 3140 MJ/t of clinker (1,844,359.6 GJ) and 130.5 kWh/ ton of cement (88.5 GJ) annually. The factory spends 5,997,158.761 dollars annually for these energies.

The improving of the replaced lamps from T12 to T8 fluorescent lamps are 675 out of the total installed 793 lamps have been saved 55.22MWh energy and it saves around 1,022.59US Dollars/yrs. The total Energy saving of lamps is the sum of the improved (from T12 to T8) and the reduced lamps have been saved 37.3 MWh/yrs. (it saves around 690.74USD) one which is 52MWh/year and the total cost saved from lamps is 1713.33USD/year.

Replacement of the under load operation of motors by energy-efficient motors or properly sized motors saves 240.422 MWh of energy, which is 13,223 Dollars per year.

The actual use of coal is difficult to measure accurately because consumption is not usually metered. Coal consumption can be estimated from the combustion efficiency and energy output of coal-fired equipment at the kilns of the clinker production.

The kiln can be improved through Process Control & Management Systems, Kiln Combustion System Improvements, Mineralized Clinker, Indirect Firing Oxygen Enrichment, Mixing Air Technology, Kiln Shell Heat Loss Reduction, Preheater Shell Heat Loss Reduction, Conversion to Efficient Clinker Cooler Technology, and Optimization of Heat Recovery/Upgrade Clinker Cooler

At the kiln, the thermal energy was produced due to the burning of fuels (coal). The average thermal energy consumption of the plant is 3140MJ/t of clinker.

Thermal energy can be conserved through: Avoid leakage in clinker production & Raw material treating, close unnecessary openings, and provide more energy-efficient seals, Increase efficiency, Grinding, Cooler, Pre-heater, Combustion process, and Dust collector. So, the total conserved or saving of the factory from lamps, some selected motors, and due to inefficient use of the electricity and thermal energy is 1,042,314.10 dollars annually.

6.2 Conclusion

The intention of this examine turned into to decide electricity scenario in cement enterprise in countrywide cement and the feasible electricity and monetary saving potentials. Energy auditing is a powerful tool, which has been successfully and effectively used in the design and performance evaluation of energy-related systems. In order to reach this purpose, there would be done energy audit site visit on all factories and the production process is analyzed by considering energy consumption. The result of the study revealed that ***NCSC*** has an enormous opportunity to save both fuel and electrical energy. Proper and strong kiln operation can lessen electricity intake and upkeep costs, grow kiln output, and enhance ordinary product quality. Besides, it can be concluded that the root causes of high energy losses have resulted from the improper design of equipment and operational incompetence. The kiln is the heart of the cement plant, as the critical step of linearization takes place here. The kiln is the major consumer of thermal energy and also one of the major electrical energy consumers in the cement plant. So any inefficiency in the kiln section will reflect directly on the whole plant irrespective of the inefficiencies of the other parts of the plant. Hence, the kiln section needs to be systematically and seriously concentrated upon to achieve maximum energy efficiency. In many industrial facilities, it is common to find T-12 lighting tubes in use. T-12 tubes have high energy consumption, very small efficiency, lamp age, lumen reduction, and color version catalogue.

Generally, the Benefits of replacing T-12 to T8 have approximately doubled the efficacy of the former, and T-8 tubes can last up to 60% longer than T-12 tubes. For saving energy and reducing costs, the dry raw materials are available as a basic input, dry process plants more comfortable than that of the wet process (30% less than wet So packages for helping the improvement of recent dry procedure kilns have to be continued. Promoting recycle economy, facilitating technological development lessen intake and shield the environment. In the future, Applying standards will help the industry to reduce energy costs.

The main sources of reductions in CO2 emissions are the decrease in the proportion of clinker-to-cement ratio, the Fuel mix for clinker production, Alternative raw materials, Energy Efficient Electricity consuming equipment, and automated kilns. Failing and unpredictable exceptional of coal has emerged as a proscribing component in enhancing electricity efficiency, productiveness, and clinker exceptional.

6.3 RECOMMENDATIONS AND FUTURE WORK

It is recommended that the Diredawa National Cement to have energy audit team. Some of the machines nameplate are invisible to read easily. Producing responsiveness on overall administration of the plant on custom of their energy efficiency, to solve the main constraint of the plants (getting of full information). In addition that, The study concluded that energy is not sufficiently utilized in these companies and recommendations for efficient energy usage in the industries was proposed by auditing the total cost of the company, by replacing the loaded motors with more efficient motors and by adjusting the kiln system improvement opportunities for saving the consumption of coal. Finally, it recommends that the factory have not any meters readings for getting accurate readings from the measuring devices simply taking assumptions.

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Appendix A: *Performance during 2014-2016(taking from Diredawa National Cement Documentation)*

Performance during 2014

Types of Departments	R.H.	Production in tons	Fuel Consumption in tons	
Raw mill	4,351.75	981,551.92		
Kiln	5,427.93	623,895	79,169.27 South Africa	23,241.91 Jimma
Cement mill 1	5,086.77	303,586.47		
Cement mill 2	5,999.69	416,191		

Performance during 2015

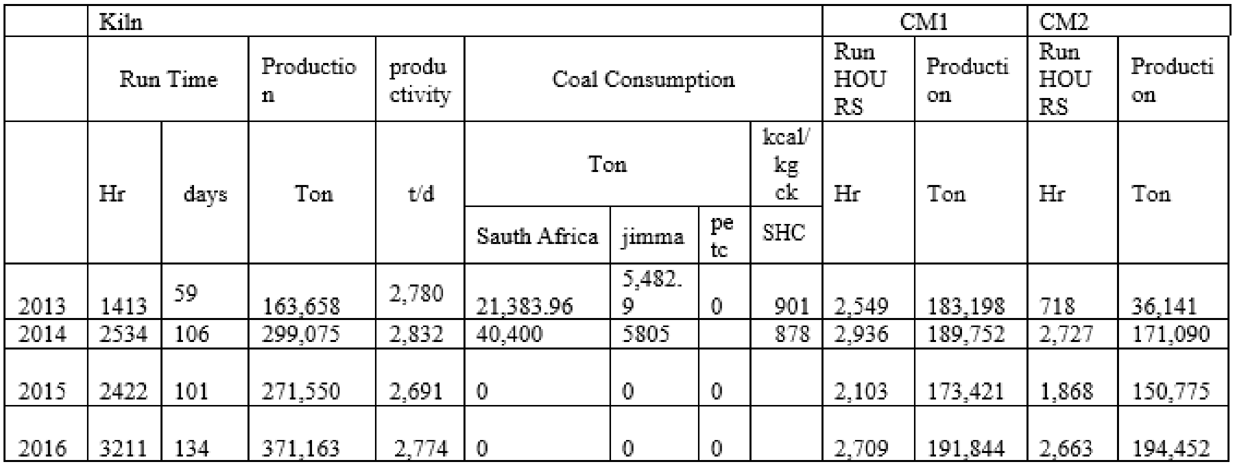
Types of Departments	R.H.	Production in tons	Fuel Consumption in tons	
Coal mill	3,717.8	76,817.9		
Raw mill	3,485.8	77,772.6		
Kiln	4,923.5	50,953.5	63,869.72 S.A.	17,765.48 Jimma
Cement mill 1	4,299.19	33,679.7		
Cement mill 2	3,790.72	28,836.1		
packers	2,250.89	92,397.17		

Performance during 2016

Types of Departments	R.H.	Production in tons	Fuel Consumption in tons
Coal mill	4,394	75,225	
Raw mill	4524	976,890	
Kiln	5410	628,697	82,377 South Africa
Cement mill 1	5033.58	356,784	
Cement mill 2	4448.17	332,917	
packers	13656	689,819	

252.75	3106	32715	4654	0		593.69	30958	496.38	30099
441.62	2727	50172	6278	1860		464.7	30238	486.55	31767

659.68	3203	88042	10900	2059		619.36	42719	515.74	32524
267.6	2570	28660	3837	721		365.8	24186	342.8	18161
357.5	2441	36364	6058	1165		386	28016	304.8	19716
2534.37	2832	299075	40400	5805	0	2935.63	189752	2727.15	171090
563	2653	62237				527.25	44167	397.25	31193
547	2679	61062				327.17	29605	479.26	41908
628	2603	68101				392	31394	276.17	21684
592	2820	69554				307.75	25831	210.68	17240
92	2764	10596				336	25808	387.92	29955
-		0				212.92	16616	116.75	8795
2422	2691	271550	0	0	0	2103.09	173421	1868.03	150775
609	2807	71235				504	28907	461	28845
596	2774	68877				376	26158	452	35444
440	2606	47778				556	41736	532	37574
619	2878	74235				386	27054	581	45737
502	2980	62324				560	42711	171	12945
445	2519	46714				326.5	25278	466	33907
3211	2774	371163	0	0	0	2708.5	191844	2663	194452



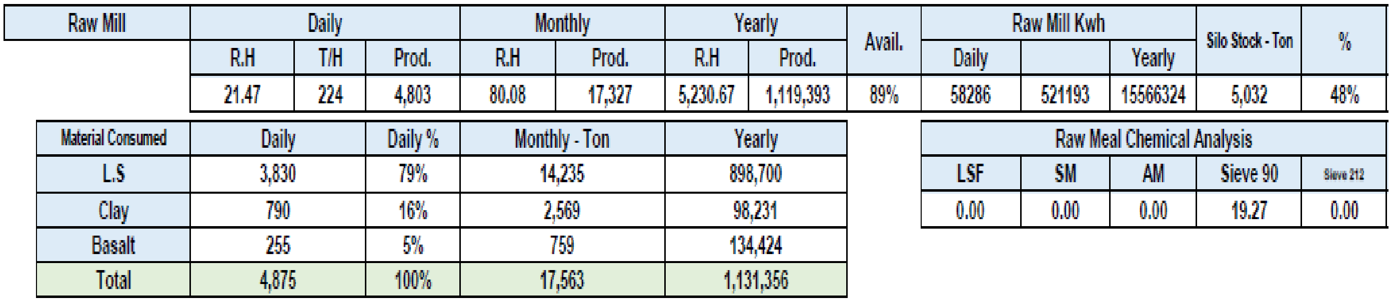
	Kiln								CM1		CM2	
	Run Time		Production	productivity	Coal Consumption				Run HOURS	Production	Run HOURS	Production
	Hr	days	Ton	t/d	Ton			kcal/kg ck	Hr	Ton	Hr	Ton
					Sauth Africa	jimma	petc	SHC				
2013	1413	59	163,658	2,780	21,383.96	5,482.9	0	901	2,549	183,198	718	36,141
2014	2534	106	299,075	2,832	40,400	5805		878	2,936	189,752	2,727	171,090
2015	2422	101	271,550	2,691	0	0	0		2,103	173,421	1,868	150,775
2016	3211	134	371,163	2,774	0	0	0		2,709	191,844	2,663	194,452

Daily, monthly, and yearly Production Report of Dire dawa National Cements are as follows

	Crushers	Daily R.H	Daily T/H	Daily Prod.	Monthly R.H	Monthly Prod.	Yearly R.H	Yearly Prod.	Received Material Daily	Received Material Monthly	Stock - Ton Total	Stock - Ton Uncrushed	Stock - Ton Pile
1	L.S	11.08	435	4822	30.63	13,703	1,895.62	890,613			7,953		7,953
	Clay	-	-	0	-	1,714	-	97,387	926	3,625	79,218	79,100	118
	Basalt	0.00	0	0	0.00	0	315.84	143,560	0	0	131,937	123,776	8,161
	RM Additives	0.00	0	0	0.00	0	0.00	0	0	0	0	0	0
	Total	11.08		4,822	30.63	15,417	2,211.46	1,131,559					
2	Gypsum	4.65	43	200	193.25	707	1,269.81	39,454	244	1,278.56	21,089	21,399	-310
	Rhyolite	7.90	80	634	41	3,494	2,128.06	85,196			-	-	1,588
	Limestone	0.00	0	0	0.00	0	9.83	1,864	0.00	0	-	-	700
	Total	12.55		834	234.17	4,201	3,407.70	126,514					
3	Jimma Coal	0.00	0	0	0.00	0	0.00	0					

LS Crusher Kwh			ADD Crusher Kwh		
Daily	Monthly	Yearly	Daily	Monthly	Yearly
6123	20874	677309	3581	14220	426087

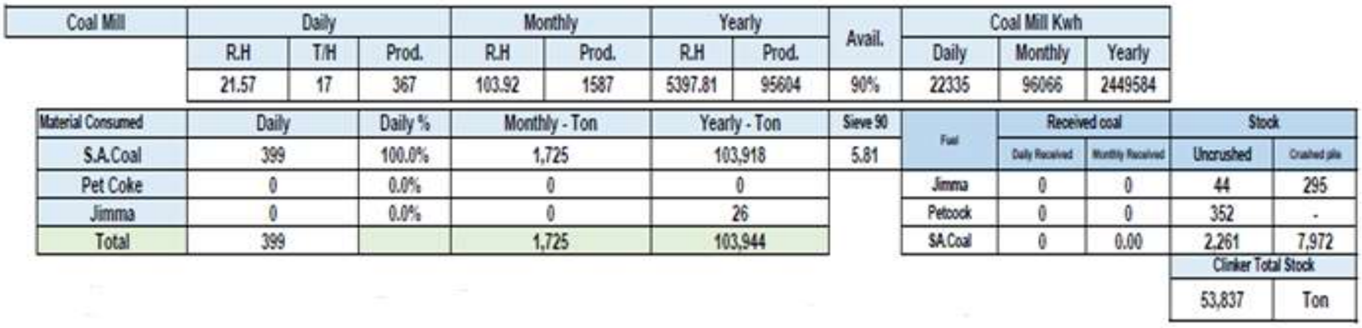
Table 1 crusher



Raw Mill	Daily			Monthly		Yearly		Avail.	Raw Mill Kwh			Silo Stock - Ton	%
	R.H	T/H	Prod.	R.H	Prod.	R.H	Prod.		Daily		Yearly		
	21.47	224	4,803	80.08	17,327	5,230.67	1,119,393	89%	58286	521193	15566324	5,032	48%

Material Consumed	Daily	Daily %	Monthly - Ton	Yearly
L.S	3,830	79%	14,235	898,700
Clay	790	16%	2,569	98,231
Basalt	255	5%	759	134,424
Total	4,875	100%	17,563	1,131,356

Raw Meal Chemical Analysis				
LSF	SM	AM	Sieve 90	Sieve 212
0.00	0.00	0.00	19.27	0.00

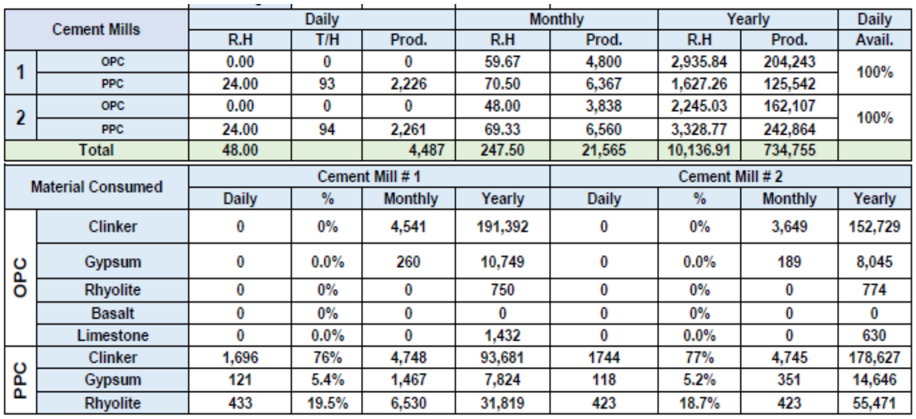


Coal Mill	Daily			Monthly		Yearly		Avail.	Coal Mill Kwh		
	R.H	T/H	Prod.	R.H	Prod.	R.H	Prod.		Daily	Monthly	Yearly
	21.57	17	367	103.92	1587	5397.81	95604	90%	22335	96066	2449584

Material Consumed	Daily	Daily %	Monthly - Ton	Yearly - Ton	Sieve 90
S.A.Coal	399	100.0%	1,725	103,918	5.81
Pet Coke	0	0.0%	0	0	
Jimma	0	0.0%	0	26	
Total	399		1,725	103,944	

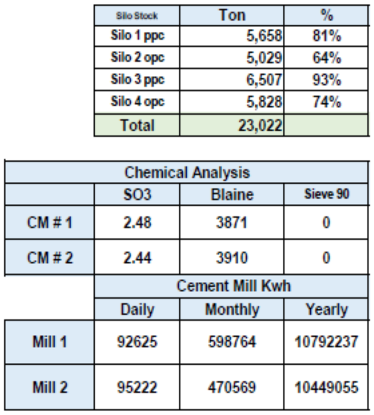
Fuel	Received coal		Stock	
	Daily Received	Monthly Received	Uncrushed	Crushed pile
Jimma	0	0	44	295
Petcock	0	0	352	-
SA.Coal	0	0.00	2,261	7,972

Clinker Total Stock	
53,837	Ton



Cement Mills		Daily			Monthly		Yearly		Daily
		R.H	T/H	Prod.	R.H	Prod.	R.H	Prod.	Avail.
1	OPC	0.00	0	0	59.67	4,800	2,935.84	204,243	100%
	PPC	24.00	93	2,226	70.50	6,367	1,627.26	125,542	
2	OPC	0.00	0	0	48.00	3,838	2,245.03	162,107	100%
	PPC	24.00	94	2,261	69.33	6,560	3,328.77	242,864	
Total		48.00		4,487	247.50	21,565	10,136.91	734,755	

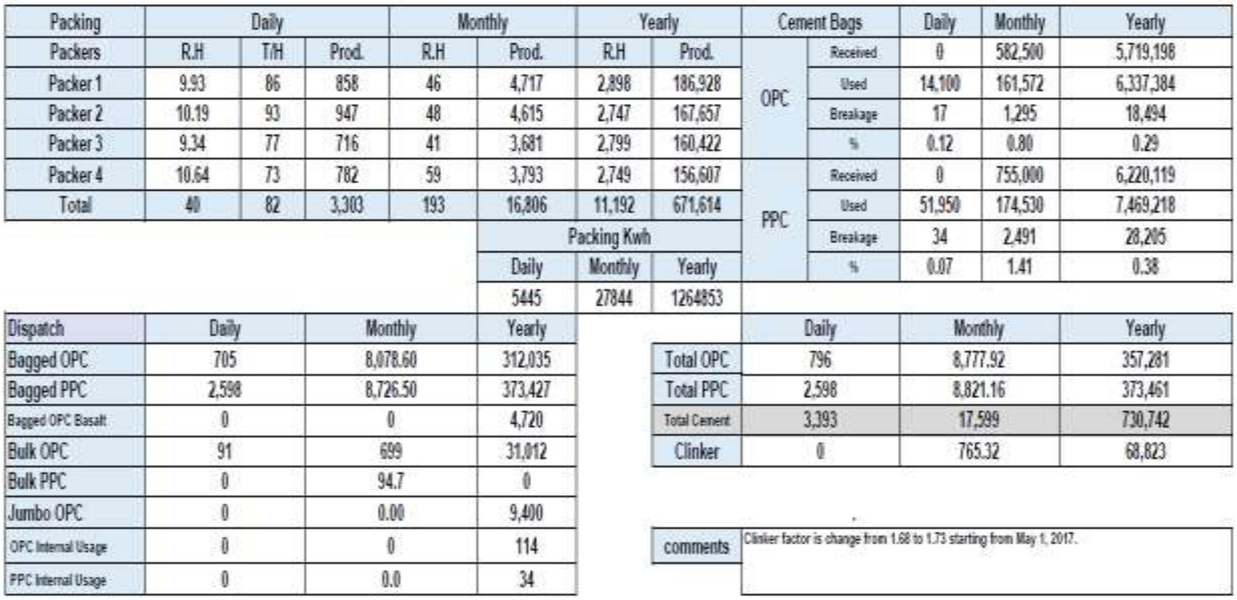
Material Consumed		Cement Mill # 1				Cement Mill # 2			
		Daily	%	Monthly	Yearly	Daily	%	Monthly	Yearly
OPC	Clinker	0	0%	4,541	191,392	0	0%	3,649	152,729
	Gypsum	0	0.0%	260	10,749	0	0.0%	189	8,045
	Rhyolite	0	0%	0	750	0	0%	0	774
	Basalt	0	0%	0	0	0	0%	0	0
	Limestone	0	0.0%	0	1,432	0	0.0%	0	630
PPC	Clinker	1,696	76%	4,748	93,681	1744	77%	4,745	178,627
	Gypsum	121	5.4%	1,467	7,824	118	5.2%	351	14,646
	Rhyolite	433	19.5%	6,530	31,819	423	18.7%	423	55,471



Silo Stock	Ton	%
Silo 1 ppc	5,658	81%
Silo 2 opc	5,029	64%
Silo 3 ppc	6,507	93%
Silo 4 opc	5,828	74%
Total	23,022	

Chemical Analysis			
	SO3	Blaine	Sieve 90
CM # 1	2.48	3871	0
CM # 2	2.44	3910	0

	Cement Mill Kwh		
	Daily	Monthly	Yearly
Mill 1	92625	598764	10792237
Mill 2	95222	470569	10449055



Packing	Daily			Monthly		Yearly	
Packers	R.H	T/H	Prod.	R.H	Prod.	R.H	Prod.
Packer 1	9.93	86	858	46	4,717	2,898	186,928
Packer 2	10.19	93	947	48	4,615	2,747	167,657
Packer 3	9.34	77	716	41	3,681	2,799	160,422
Packer 4	10.64	73	782	59	3,793	2,749	156,607
Total	40	82	3,303	193	16,806	11,192	671,614

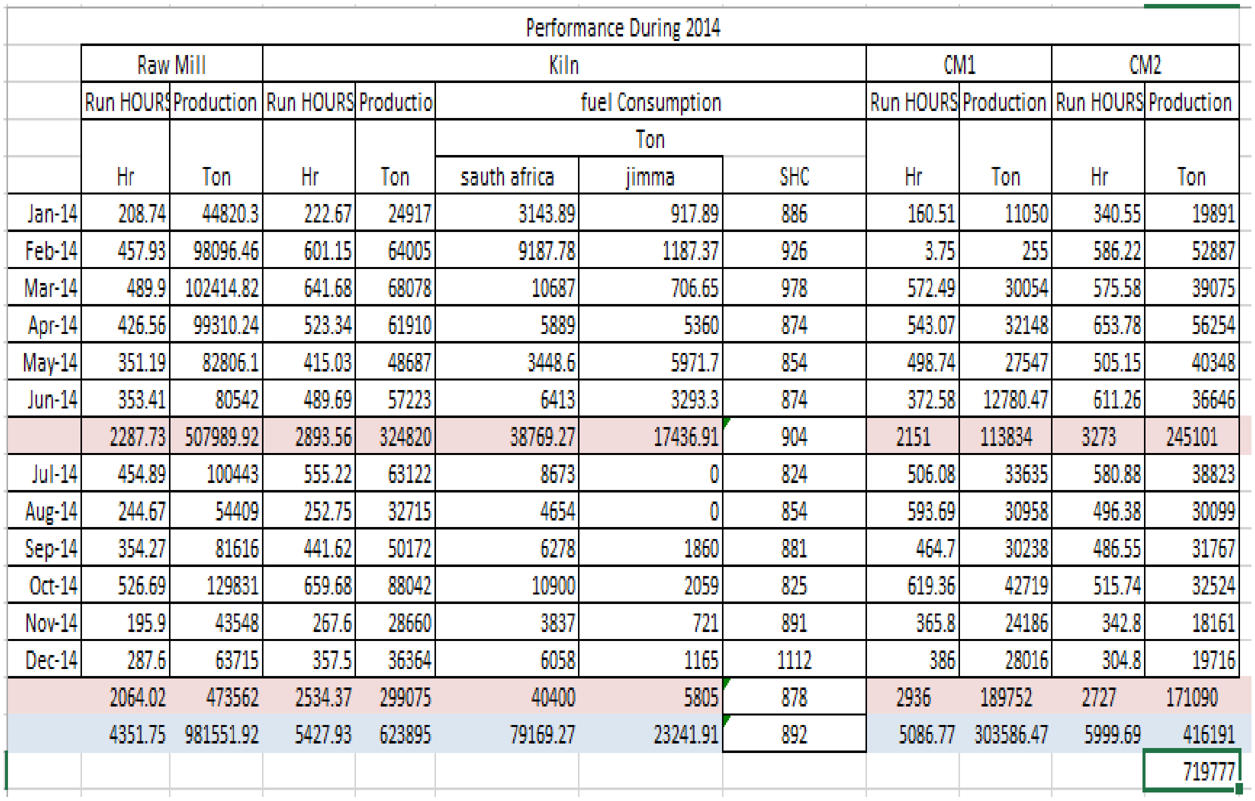
Packing Kwh		
Daily	Monthly	Yearly
5445	27844	1264853

Cement Bags		Daily	Monthly	Yearly
OPC	Received	0	582,500	5,719,198
	Used	14,100	161,572	6,337,384
	Breakage	17	1,295	18,494
	%	0.12	0.80	0.29
PPC	Received	0	755,000	6,220,119
	Used	51,950	174,530	7,469,218
	Breakage	34	2,491	28,205
	%	0.07	1.41	0.38

Dispatch	Daily	Monthly	Yearly
Bagged OPC	705	8,078.60	312,035
Bagged PPC	2,598	8,726.50	373,427
Bagged OPC Basalt	0	0	4,720
Bulk OPC	91	699	31,012
Bulk PPC	0	94.7	0
Jumbo OPC	0	0.00	9,400
OPC Internal Usage	0	0	114
PPC Internal Usage	0	0.0	34

	Daily	Monthly	Yearly
Total OPC	796	8,777.92	357,281
Total PPC	2,598	8,821.16	373,461
Total Cement	3,393	17,599	730,742
Clinker	0	765.32	68,823

comments	Clinker factor is change from 1.68 to 1.73 starting from May 1, 2017.



Performance During 2014

	Raw Mill		Kiln					CM1		CM2	
	Run HOURS	Production	Run HOURS	Productio	fuel Consumption			Run HOURS	Production	Run HOURS	Production
					Ton						
	Hr	Ton	Hr	Ton	sauth africa	jimma	SHC	Hr	Ton	Hr	Ton
Jan-14	208.74	44820.3	222.67	24917	3143.89	917.89	886	160.51	11050	340.55	19891
Feb-14	457.93	98096.46	601.15	64005	9187.78	1187.37	926	3.75	255	586.22	52887
Mar-14	489.9	102414.82	641.68	68078	10687	706.65	978	572.49	30054	575.58	39075
Apr-14	426.56	99310.24	523.34	61910	5889	5360	874	543.07	32148	653.78	56254
May-14	351.19	82806.1	415.03	48687	3448.6	5971.7	854	498.74	27547	505.15	40348
Jun-14	353.41	80542	489.69	57223	6413	3293.3	874	372.58	12780.47	611.26	36646
	2287.73	507989.92	2893.56	324820	38769.27	17436.91	904	2151	113834	3273	245101
Jul-14	454.89	100443	555.22	63122	8673	0	824	506.08	33635	580.88	38823
Aug-14	244.67	54409	252.75	32715	4654	0	854	593.69	30958	496.38	30099
Sep-14	354.27	81616	441.62	50172	6278	1860	881	464.7	30238	486.55	31767
Oct-14	526.69	129831	659.68	88042	10900	2059	825	619.36	42719	515.74	32524
Nov-14	195.9	43548	267.6	28660	3837	721	891	365.8	24186	342.8	18161
Dec-14	287.6	63715	357.5	36364	6058	1165	1112	386	28016	304.8	19716
	2064.02	473562	2534.37	299075	40400	5805	878	2936	189752	2727	171090
	4351.75	981551.92	5427.93	623895	79169.27	23241.91	892	5086.77	303586.47	5999.69	416191
											719777