# Energy Auditing and Conservation for Textile industries

# (A Case Study: Else Addis Industrial Development P.L.C)

Zeyede Seifu

A Thesis Submitted to the department of Electrical Power and
Control Engineering,
School of Electrical Engineering and Computing.

Presented in Partial Fulfillment of the Requirement for the Degree of Master’s in
Electrical Power and Control Engineering (Power Systems Engineering)

Office of Graduate Studies
Adama Science and Technology University

July 2023

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**Advisor**: Dr. Tefera Terefe.Y

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# Declaration

I hereby declare that this master thesis entitled "Energy Auditing and Conservation for Textile industries(A Case Study: Else Addis Industrial Development P.L.C)" is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

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## Recommendation

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "Energy Auditing and Conservation for Textile industries(A Case Study: Else Addis Industrial Development P.L.C)" prepared under my guidance by Zeyede Seifu submitted in partial fulfillment of the requirements for the degree of masters of science in electrical power and control engineering. Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

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# Approval Page of M.Sc. Thesis

I, the advisors of the thesis entitled "Energy Auditing and Conservation for Textile industries(A Case Study: Else Addis Industrial Development P.L.C)" and developed by Zeyede Seifu hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the board of examiners of the thesis by Zeyede Seifu have read and evaluated the thesis entitled "Energy Auditing and Conservation for Textile industries(A Case Study: Else Addis Industrial Development P.L.C)" and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of master of science in electrical power and control engineering (Power Systems Engineering).

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Final approval and acceptance of the thesis is contingent upon submission of its final copy to the office of postgraduate studies (OPGS) through the department graduate council (DGC) and school graduate committee (SGC).

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# List of Acronyms and Abbreviations

| | |
|---|---|
| CFM | Cubic Feet per Minute |
| EC | Ethiopian Calendar |
| EEU | Ethiopian Electric Utility |
| ESO | Energy Saving Opportunities |
| ETB | Ethiopian Birr |
| ETIDI | Ethiopian Textile Industry Development Institute |
| ETP | Effluent Treatment Plant |
| GTP | Country Growth and Transformation Plan |
| Kw | Kilowatts |
| KJ | Kilojoules |
| Kwh | Kilowatt hour |
| KVAr | Kilovolt ampere reactive |
| KVA | Kilovolt ampere |
| KV | kilovolts |
| MF | Multiplying Factor |
| PEA | Preliminary Energy Audit |
| TTS | Texcoms Textile Solution |
| VFD | Variable Frequency Drive |

# ABSTRACT

*The textile industry is one of the major energy-consuming industries and retains a recorded the lowest energy utilization efficiency. Energy in the textile industry is mostly used in the form of electricity as a common power source for machinery, heating and ventilating air conditioners, lighting systems, and other equipment a sufficient and reliable supply of energy is needed to develop any country in the world. However, there are problems in the conversion and usage of these energy sources, such as high energy wastage, high cost of energy to convert and use, and high carbon emissions to the environment. Most of the time, it occurs in developing countries such as Ethiopia, which has little knowledge of energy conservation and usage, which makes these developing countries generate higher energy instead of using the existing energy effectively. Industries such as textile, sugar, and cement factories consume a large amount of energy, but do not use it effectively, which results in paying extra money that affects the factory and the country in general. The ELSE Addis Industrial Development PLC uses seed cotton as input and produces lint cotton, different count yarns, and woven grey fabrics as the final product. The eighteen items identified together as energy-saving opportunities have a cumulative payback period of five months at current energy prices. These items account for expected electrical energy savings of 3,150,111.87 kwh, or 18 percent of 2023 plant energy consumption. The annual savings identified at the ELSE Addis Industrial Development PLC through a detailed energy audit indicate the potential of ETB 9,757,192.67385. The Investment required for implementing all the energy-saving opportunities is ETB 1,810,295. Most of the recommended energy conservation measures are those with simple payback periods of less than four months on an overall basis.*

**Key Words**:Energy efficiency, Lint cotton, Woven grey fabrics, Yarns

# CHAPTER ONE

# 1. INTRODUCTION

## 1.1. Background of the Study

Energy is not only an important material basis for the survival and development of humans but also a powerful driving force to promote the development of a national economy. At present, it has been the focus of attention in international political, economic, military, and diplomatic fields. Governments have to establish a reliable, safe, stable, and efficient energy supply security system as a national economic strategy for sustainable development (Chaudhry, January 2022). The consumption of energy is increasing at a fast pace while available resources remain limited. The world over energy resources is getting scarcer and the energy costs are consistently going up. The global need for energy is increasing by more than 2% every year. This may not sound like very much, but it represents almost a doubling of energy consumption over a period of 30 years. Out of the total amount of primary energy, around 80% comes from fossil fuels. The current consumption of fossil fuels, particularly oil, is not sustainable in the long term. Over 3.5 billion tons of crude oil is consumed every year. A major part of this is consumed by the transport Sector, with the industrial sector as the second largest oil consumer. Energy consumption has a significant impact on our natural environment. Recently, a consensus has arisen that there is clear evidence that climate change is caused by human activity, mostly related to the use of energy (P.Nagaveni, August 2019). All but renewable energy sources are depleting, hence energy prices continue to grow as energy reserves shrink. The share of energy costs in total production costs in most industries is rather significant. It is common knowledge that a more efficient use of energy and resources is a relatively quick and painless way to reduce a company's costs and lessen the harmful impact on the environment. Governments around the world have therefore responded by introducing various voluntary and mandatory energy and environmental policies that are changing the business climate and the regulatory environment in which companies operate (Shahidul Islam Khan*, August 26, 2022). There is also growing public pressure and an expectation that businesses should be carried out in a more environmentally responsible manner and that resources need to be used more efficiently. Hence, energy audit and energy management have become strategic issue that has to be dealt with at the highest level within an organization (W.Mungwena1, April 2013). Success depends on understanding organizations' manufacturing operations, the internal and external context for strategy implementation, how energy is used and where, and what the sources of significant conservation impacts are. Based on such an understanding, the critical part is capturing the specific knowledge necessary for converting a strategy from a raw concept into a detailed plan, and ultimately into results. Energy consumption has caused serious environmental pollution because of the increase in global average temperature (GUNTURU*, 06 August 2022). Specifically, the average temperature of the global surface has increased by more than 1.5°C above pre-industrial levels for at least one year, and the sea level has risen by 10–25 cm in the past 100 years. As announced by the UNEP in 2023, global warming is an indisputable fact, which is mostly caused by human activities. Owing to concern with regard to globalization and climate change, the rules of business are changing fast and frequently. Each day seems to bring new technology, a new partner or competitor, or a new way of working. Against such a dynamic and complex backdrop, some things remain constant: a need for the developed and developing world to manage their energy resources and impacts on the environment and to improve energy efficiency continuously and to reduce harmful emissions. Companies operating in either world are required to achieve continual improvement of their energy and environmental performance. When businesses slow down, cost cutting becomes imperative and energy costs and energy and environmental performance suddenly attract greater interest from management. Although energy efficiency and environmental management were supposed to be familiar terms at that time, the implementation of a successful energy and environmental management program in a real industrial environment still proved to be a difficult task for any team assigned to it. Its complexity arose from the need to bring together people, procedures and technologies in order to achieve consistent and lasting performance improvement. The context of energy and environmental management is changing fast, but the basic principles and knowledge that have been essential for years, are still relevant today. The underlying know-how remains stable and valid and provides a solid grounding that needs to be refined from time to time in order to reflect the impact of the changes that occur. This generates a need for continuous learning and creation of new knowledge in order to cope with the challenges of an ever-changing business environment. In industrial energy and environmental management, the focus is not on theory and fundamentals, not even on design considerations, but on managing performance of an existing plant (Ali Hansanbeige, China, 2010.).

Ethiopia is endowed with various energy resources with an estimated annual theoretical energy potential of 954 TWH. The country has approximately 11 large hydropower dams with an annual energy production capacity of 14,296.7 GWH. Although the country has abundant energy resources it is not yet well developed due to lack of capacity and investment. For example, only less than 10% of the total hydropower potential of the country is known to have been utilized so far. Ethiopia is a country which has a great interest to all type of energy. Most Ethiopian people have no access to electricity, especially people living in the rural areas. Ethiopia has been recording two-digit economic growths for the last fifteen years but it is anticipated that it would slow down due to these new challenges. Examining the intensity and rate of growth of the country through industrial energy conservation and its contribution to GTP are of paramount importance (Muahammad Hassan Qaisar, 19 April 2022).

Industrial processes for the textile use large amounts of fuel and electricity. The increases in energy cost and energy consumption force industrial companies and government agencies to use energy more efficiently. Decreasing energy losses and recovering the lost energy are of great importance. In order to optimize energy saving in a company, it is necessary to enhance the awareness, improve the knowledge and obtain the participation and cooperation of everybody involved in the production process (Apeaning, May 2012.). Energy audit is relevant to a wide range of departments within a company to provide continuity for energy saving. Energy efficiency improvements for the textile industry in Ethiopia refer to a reduction in the energy usage for a given energy service (production, heating, lighting, etc.). This reduction in the energy consumption is not necessarily associated to technical changes, since it can also result from a better organization and management or improved economic efficiency in the sector (e.g. overall gains of productivity). Energy efficiency is first of all a matter of individual behavior and rationale of energy consumers. Avoiding unnecessary consumption of energy or choosing the most appropriate equipment to reduce the cost of the energy contribute to decrease individual energy consumption without decreasing individual welfare and production. It is obvious that it also contributes to increase the overall energy efficiency of the national economy (Mandeep Singh & Jatin Gupta, India, 2011).

Energy audit play an important role in identifying energy conservation opportunities in the textile sector, while they do not provide a final answer to the problem, they do help in identifying the potential for energy conservation and inducing the industries to direct their efforts in this area in a focused manner (Masood's, 2013).

An energy audit is an inspection survey and an analysis of energy flows for energy conservation in an industry. It may include a process or system to reduce the amount of energy input into the system without negatively affecting the output. In commercial and industrial real estate, an energy audit is the first step in identifying opportunities to reduce energy expense and carbon footprint (Dr. Devanand Uttam, India,February 2015.).

This energy audit presents the different energy consuming equipment’s in the ELSE Addis Industrial Development PLC and analyzes the recommended energy conservation measures related to energy savings, cost savings and its feasibility which is applicable to this energy consuming equipment’s. Textile industries like ElSE Addis, Consume Huge amount of energy due to prolonged use of equipment’s in efficient way. A well planned and efficient energy utilization scheme for such industries would help to reduce their energy bills and also it enables them to save unnecessary investments to cover up for their energy defects (Kunmakara, 13 March 2023).

Many manufacturing industries of the country do not have new ways to reduce their costs of energy and optimize the operation of their facilities. As a result, energy management and energy conservation have been given low priority and low attention has given to the concept of improving energy efficiency through energy auditing as required (Vivekananda, 2014).

Energy audit is designed to determine where, when, why and how energy is being used. This information can then be used to identify opportunities to improve efficiency, decrease energy costs and reduce greenhouse gas emissions that contribute to climate change. Energy audits can also verify the effectiveness of energy management opportunities (EMOs) after they have been implemented (Gupta, 2015).

Energy efficiency improvements particularly focus on available technology to make such improvements, with some technology options being well-known and proven over many years of application, and some of which may be relatively new and less well-known. Indeed, lack of information is a key barrier to energy efficiency improvements in many situations. However, experience in many countries of supply and demand-side activities shows that plants, buildings and equipment can often be improved substantially through simple low-cost actions (Yohhanes Birhanne, in 2015 GC).

For nations, energy efficiency offers a number of benefits; including improved use of national resources, reduced energy imports, improved balance of trade, conservation of foreign exchange, reduced capital requirements for new energy production facilities, and reduced environmental pollution from energy use and production. Improper energy investment may even slow the rate of national economic growth (Oyedepo, 2018).

A comprehensive study of energy utilization efficiencies of the different utilities of the plant and efficient use of energy and energy conservation in the textile industry through conducting energy audits and energy analysis has been carried out by assessing the energy losses at the selected plant. And finally, based on measurements and collected data, energy saving and efficiency improvement opportunities has been identified and recommended which would greatly apply to all similar industries in the country and elsewhere (Hosseinali Shamsabadi, 6 February 2017.).

#### 1.1.1. Plant description

ELSE Addis industrial Development P.L.C., part of the Else group, is a textile factory in Nazareth (Adama), Ethiopia Built on a 200,000 square meter area, of which 120,000 square meter is indoors. The modern facility is solely export-oriented and was built to meet the highest standards. ELSE Addis Industrial Development PLC was established in 2010 GC at outskirts of Adama City, Oromia Regional State, Ethiopia, producing lint cotton fiber from seed cotton, producing yarn and production of grey fabric. Raw materials, in the form of seed cotton are formed into yarn through ginning, blow room, carding, combing, drawing, spinning, winding, machines. Warping and sizing operations are done for preparation for fabric production in weaving. In the weaving department, the yarn is woven into rolls of cloth.

The facility started production in march 2011. Else Group has also been active in the service industry since the establishment of its construction company in1990. The plant consists of three major mills namely 1. Ginning, 2. Spinning and 3. Weaving. In ginning mill the seed cotton purchased from farm are ginned to separate cotton fiber from seed and the cotton fiber is used in spinning mill or send to market. In spinning two types of process are employed, one is ring spinning and the other open-end spinning. The plant produces grey fabric through two types of processes, one is knitting and another process is weaving.

#### 1.1.2. Working schedule

The operation of the textile plant is broken into a number of process and service areas. While the operation of the spinning and weaving mill as a whole is 24 hours per day, 7 days per week and approximately 351days/year. Ginning is a seasonal business so ginning mill operation is 24 hours per day, 7days per week and approximately 180 days per year.

## 1.2. Statement of the Problem

Industrial plants use large amounts of fossil fuels and other raw materials taken from Earth's natural resources and convert them into products. The use and conversion of primary energy results in waste, emissions, and effluents, which have an impact on all environmental media. Energy is controlled throughout industrial operations to achieve the company's goals by lowering energy consumption and minimizing the impact on the environment owing to the use and conversion of energy, water, and any input materials. Energy shortage is a major global problem. The textile industry is growing rapidly and is one of the energy-consuming sectors in Ethiopia. The ELSE Addis Industrial Development PLC is among the leading textile industries in Ethiopia. It is a composite textile unit that uses both thermal and electrical energy. There are many energy-consuming machineries, such as boilers, steam distribution and utilization systems, motors, lighting, humidification plants, Compressors, Waste collection systems, and process machines. The power consumption is not correlated to the total production owing to energy wastage. Energy audits are concerned with the efficient use of energy, water, and other material resources; waste minimization in manufacturing operations; and continuous improvement in the performance of resource use in a company. Energy audits specifically link and relate energy use to production output, with the aim of achieving the required level of output with the minimum use of energy and other resources.

Textile industries use large amounts of energy for various processes. However, there are problems in the industrial sector in terms of using energy efficiently. As a result, they are forced to pay a large amount of money on their energy bills, which causes problems in the competitive market

Most factories in our country do not have a proper way of utilizing energy, and less attention is being paid to energy auditing. Some of the reasons for this are lack of awareness, lack of skilled human resources in energy management.This thesis focuses on the electrical and thermal energy losses in the Else Addis Industrial Development P.L.C. and the causes, consequences, and techniques for improving the energy efficiency of the materials.

## 1.3. Motivations of the Study

The motivations to do a thesis on energy audit in Else Addis Industrial Development P.L.C Textile Factory are as listed below:

- Increasing in energy costs
- Environmental problems (increase in global warming) due to increase in greenhouse gas emission and resource depletion
- Less profitability of the factory (the factory is not competitive)

Hence this thesis addresses the energy utilization efficiency problems encountered by the textile industries of Ethiopia by identifying possible solutions which would significantly improve their energy consumption with little or no extra investment.

## 1.4. Objectives of the Study

### 1.4.1. General objective

The general objectives of this study is to provide a comprehensive overview of the present energy management and utilization strategies in Else Addis Industrial Development P.L.C Textile and identifying energy conservation opportunities so that to come up with solutions to improve the efficiency of the current energy utilization of the plant.

### 1.4.2. Specific objectives

The specific objectives of this energy audit are as follows:

- Identification of the main energy-consuming components.
- Determine how energy is being used by components and installed systems in the plant.
- Identify the cost-effectiveness of energy distribution for and use in a manufacturing process.
- Estimate the implementation costs and perform cost-benefit analysis using simple payback periods for recommended measures.
- Set an implementation action plan for the identified measures.

## 1.5. Scope and Significance of the Studys

### 1.5.1. Scope of the studys

The energy audit conducted in ELSE Addis PLC focuses on electrical and thermal systems to identify energy saving opportunities that can be employed to reduce specific energy consumption per unit output.

The major energy consuming areas/systems covered during the audit are:

- Boilers and steam/thermic oil distribution systems
- Compressors and compressed air distribution systems
- Compressed air consuming machines and equipment's
- Blowers/Fans
- Pumps
- Lighting System
- Humidification system

### 1.5.2. Significance of the studys

This thesis focuses on Energy audit and conservation in Else Addis Industrial Development P.L.C to improve the product of the factory, minimize energy wastage, to reduce belling cost and to identify the equipment which causes energy waste or loss due to the use of less efficient equipment, improper rewinding of equipment, poor maintenance of equipment, and old types of equipment. Facilities concentrated on this audit are Boiler, Thermo-boiler, Dyeing machine, Air Compressor, Heat transport facilities, and Light lamps.

Through the energy audit, this study was:

- upgrade our knowledge of the use of non-renewable energy resources
- know the cost of energy use and energy use rate
- increase know how on energy use patterns
- study and propose energy waste minimization techniques
- Make changes to the procedure, equipment, and systems to save energy
- Minimize environmental pollution by reducing power generation

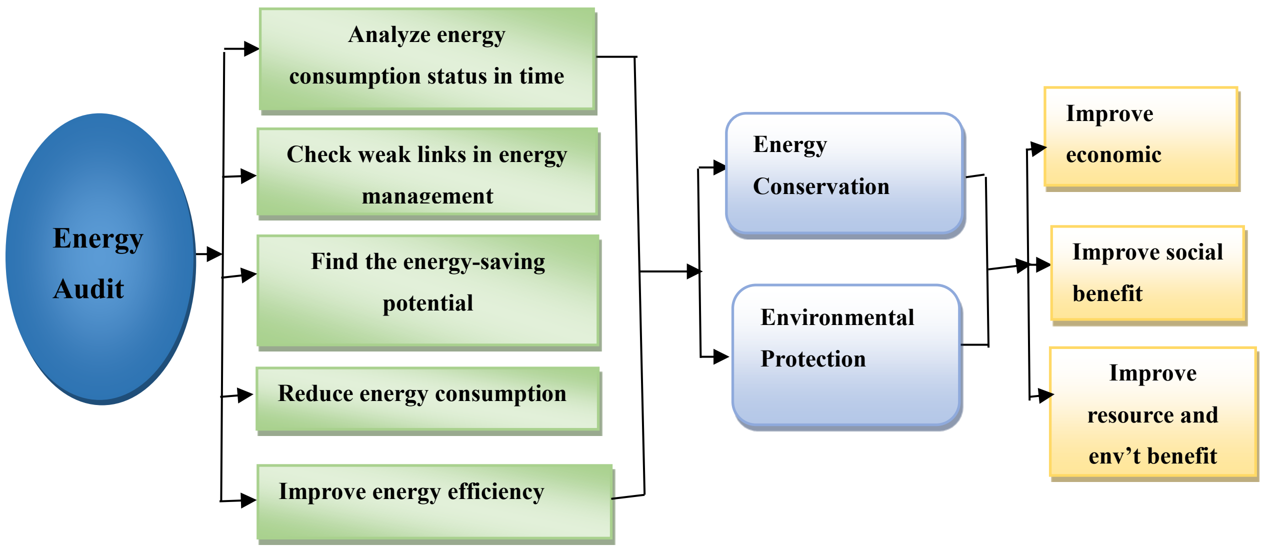


Figure 1 1. The structural framework of energy audit

## 1.6. Delimitation of the Scope

This study had several limitations. The limitation is the lack of cooperation in obtaining important and necessary information and recorded data from the selected location, and it is not possible to know the energy consumption of each production department of the proposed system.

The delimitations for energy audits and conservation in the textile industry include the following:

1. Scope: This study focuses on energy audits and energy conservation measures in the textile industry. It does not include other industries or sectors.

2. Geography: The study was limited to a specific geographic area at the Adama Else Addis Industrial Development P.L.C..

3. Company size: This study focused on a specific size range of textile companies.

4. Type of textile: This study focused on a specific type of textile, such as grain, spinning, and weaving.

5. Available data: This study relied on the availability of data on energy consumption and costs, as well as the availability of information on energy audits and conservation measures in the textile industry.

# CHAPTER TWO

# 2. LITERATURE REVIEW

## 2.1. Theoretical Background

The cost of energy is a significant factor in economic activity, on major factors of production such as land, capital, and labor. The imperatives of energy shortage and wastage call for energy conservation measures, which essentially mean using less energy for the same level of activity.

### 2.1.1. Energy audit

An energy audit can clarify your company's energy consumption and identify areas for potential savings. It can lead to reduced energy use, improved productivity, and opportunities to innovate. An energy audit is an examination, assessment, and investigation of energy flows for energy conservation in a building, process, or system to decrease the amount of energy input into the system without negatively affecting the output(s). It is a necessary commercial tool to save energy and to upgrade the financial state of an organization. An energy audit helps industrial factories or facilities in comprehension how they use energy and help to recognize the areas where waste occurs and where opportunities for improvement exist (Khude, 2011GC.).

A quintessential industrial energy audit control depends on its operation, capacity, type of the factory, the deepness to which the audit is required, and the capability and immensity of energy savings and cost-decreasing desire.

### 2.1.2 Types of Energy Auditing

Energy audits can be carried out from hours to day and day to a year. Energy audit depends upon the time and is classified in the following ways

i. Walk Through survey Audit

ii. Intermediate Audit

iii. Detailed or overall energy Audit

**1. Walk through Audit**

This type of energy audit carries a visual inspection of the plant. During a rapid walk survey, the main concentration is on the energy input and finding the wastage of energy. All the Data collected in this survey can be used for detailed audits. Usually, this type of audit is carried out for hours to a few days. As the time required is short cost involve in auditing is also less. This approach identifies energy waste in a facility, determining how this waste can be eliminated at a reasonable cost within a suitable time frame (Price, (2020)).

**2. Intermediate audit**

This kind of audit is conducted for a detailed survey a. Main aim of this type of audit is to find energy loses and analyze the energy efficiency of the system. This audit provides an overview of general energy conservation measures (ECM). This type of audit is carried out for one week to many months, the time required is high so the cost is high as compared to walking through the audit.

**3. Detailed or overall energy audit**

This type of audit is an overall audit and detailed calculations, analyses, and assumptions are carried out. A detailed survey of systems, as well as subsystems of a building, is done. The energy consumption of all systems is compared with targeted energy consumption. This audit also determines the consumption of electricity, steam, gases, etc (Çay, (2018)).

### 2.1.3. Energy conservation

Energy conservation is the attempt made to decrease the use of energy by using less energy consuming equipment. Energy conservation is a constituent of the abstraction of Eco sufficiency. Eco-sufficiency needs to decrease in the use of energy, and natural resources and in the generation of waste (among which greenhouse gas emissions) in complete terms (Hameed, (2017)).

Energy conservation decreases the energy requirement by different equipment and can result in increased environmental quality, national security, personal financial security, and higher savings (Vivekananda, 2014). It is at the top of the sustainable energy hierarchy and it also decreases energy costs by controlling future resource depression. Energy can be preserved by decreasing wastage and losses, improving efficiency through technological amelioration, and upgrading operation and maintenance. On a global level, energy use can also be reduced by the stabilization of population growth (Syed, (2018)).

### 2.1.4. The different conservation measures

i. **Power factor improvement:** A low power factor is highly undesirable as it causes an increase in current, resulting in additional losses of active power in the power system. For the rating of the motor, if the power factor is improved, the load current can be reduced, thereby reducing the losses.

ii. **Replacement of less efficient motors :** The efficiency curve for high-efficiency motors is usually flatter, so that motor cars be operated at lower loads without appreciably increasing the losses in the motor.

iii. **Installation of soft starter for highly loaded motors :** This results in an improvement in power factor and efficiency and a reduction in power consumption in the motor. it is used for high-starting torque applications

iv. **Energy Efficient Motors**

- Energy efficient motor is best suited for new projects
- When an old motor is rewound more than five times, it can be replaced by an energy-efficient motor

v. **Lighting system:** An efficient lighting system is one, which provides illumination of sufficient quantity and quality for the task being performed at the lowest cost. This depends upon the elements constituting the lighting system i.e., lamps, ballasts, fixtures – lamp holders, starters. From the economic point of view, our focus should be on lamp life and its performance. Using the latest technologies like LED instead of incandescent lamps, Proper illumination with fewer light sources, etc. helps to reduce lighting consumption.

Steps for Energy Conservation using energy audit:

- Visual inspection and data collection
- Observations on the general condition of the facility and equipment and quantification
- Identification/verification of energy consumption and other parameters by measurements
- Detailed calculations, analyses, and assumptions.
- Validation
- Potential energy-saving opportunities medium-term, and long-term measures to be taken for conservation.

## 2.2. Literature Review

To address the problems focused on in this thesis, a literature review and a broad knowledge of the issues regarding energy auditing, conservation, and efficiency improvement opportunities in industries and the methods for resolving these issues as presented below.

**T. Ashokkumar, 2015**:- Studied the energy conservation and efficiency of both electrical and thermal energy. In their study, they suggested three techniques of energy conservation and efficiency-improving methods these techniques are, efficient use of electrical materials, replacing the existing inefficient materials without investment cost, and replacing the existing materials with more efficient materials with less cost. But they did not show the benefits of the new energy-efficient materials over the existing inefficient materials in terms of cost saving, energy saving, carbon emission reduction, and their payback period.

**Eng. Basel Tahseen et.al, 2014** :- Studied an energy audits and energy conservation in different textile factories such as in Palestine and this research points out the most energy-consuming areas of the factory. And it proposed techniques that can save energy waste by applying energy conservation techniques on the most energy-consuming materials such as boilers, thermo boilers, air compressors, lamps, and dyeing machines last, he concludes by using efficient materials 10-20% of the total energy used by the materials can be saved. But this research did not show energy savings, cost savings, and carbon reduction in mathematical form.

**Oyedepo, 2018**:- described energy consumption in food factories, air conditions, and bottling factory and it studies the causes of electrical energy wastes in boilers, thermo boilers, pumps, air compressor, and electric motors. Evaluating the energy usage in these equipment shows 65% of the total electrical energy is used by boiler and thermo boiler and 40-47% of the total electric energy is used by pumps, air compressors, and electric motors. Then by changing the existing less efficient electric motors with efficient motors and by replacing the existing ventilation with good ventilation, it can save a large amount of energy. But this research does not show the amount of energy savings, cost savings, carbon emission reduction, and payback period mathematically.

**Masood's, 2013**:- Studied of 40 energy efficient technologies and methods of improving the energy efficiency of different equipment which results in energy savings, carbon emission reduction, investment cost reduction, and operation and maintenance costs reduction. The research paper shows the techniques and experiences on how to improve the energy efficiency of a textile factory. But it does not include all the equipment in the factory and does not calculate their payback period whether it is cost-wise or not.

**Gupta, 2015**:- Studied the electrical energy audits of induction Motors in a Textile factory. The main aim of studying textile factories is to identify possible energy-saving techniques such as induction motors, dyeing machines, air compressors, and lighting that show high energy loss. After he made a study on the replacement of electric motors with energy-efficient motors, he concludes that replacing the existing inefficient motors with new efficient motors is cost wise and he gets a payback period of 2.6 years.

Generally, a literature review helps to identify the causes of energy waste and the techniques or opportunities used to minimize energy wastage. But this literature doesn't show in mathematical form how much energy is wasted due to inefficient equipment and how much energy is saved due to the newly replaced efficient equipment by calculating the greenhouse gas emission reduction, cost reduction, energy saving, and payback period to know whether the newly replaced equipment is cost-effective or not. They have studied all the problems listed in the statement of the problem, and their improvements and they have shown whether the improving techniques are better than the existing ones or not by calculating energy saving, greenhouse gas emission reduction, cost saving, and payback period of each improvement.

**Muhammad Rusli, 2019**:- presented the single-tuned harmonic filter design as a total harmonic distortion compensator in a 20 kV distribution system. The level of harmonic distortion at the individual level is increased due to non-linear loads. To avoid this the unnecessary level of harmonics a passive filter with 3.465 KVA apparent powers was installed. As a result, the power factor was upgraded from 0.86 to 0.95. To minimize energy usage and potentially increased profits, through production efficiency gains, while procuring the lowest cost and most reliable supplies of power, the authors take of energy efficiency opportunities such as; more productive state-of-the-art technology that improves a facility's competitive edge and improved environmental performance and compliance with environmental and pollution abatement regulations. Hence, applying a successful energy management process in different companies they improve production the efficiency of the plant, maintaining a high energy load factor, and correcting for low power factor.

# CHAPTER THREE

# 3. MATERIALS AND METHODS

## 3.1. Data Collection

Two types of data were used to conduct the research: primary and secondary data. Primary data was collected physically from the production plant and the secondary data were collected based on data from other sources.

A) Primary data collecting methods:

- Industry visits and intensive physical observations
- Questionnaires and check sheets for professionals to identify the energy usage trande in the cases chosen
- Informal interviews with concerned bodies (top level management)

B) Secondary data collecting methods:

- Review of relevant literatures, concerned with energy auding and conservation.
- Manuals, historical documents, and other necessary sources from case companies.
- Economic cost analysis relating to the objectives defined to minimize and eliminate the problems identified.

A comprehensive audit provides a detailed energy project implication plan for the industry since it evaluates all major energy using systems. This type of audits offers the most accurate estimate of energy and cost saving. In a detailed energy audit one of the key elements is the energy balance. This is based on an inventory of energy using system, assumptions of operating conditions and calculations of energy use. This estimated use is then compound to utility bill changes.

Detailed energy audit is carried out in three phases phase:

- Phase I –Site visit and preliminary audit
- Phase II –Detailed Audit
- Phase III – Post Audit Phase

### 3.1.1. Phase I –Site visit and preliminary energy audit

An initial one-day site visit was carried out by the energy team to meet the concerned persons of each department, to familiarize the team with the site and to assess the procedures necessary to carry out the energy audit.

- Discuses with the site's senior managements about the aim of the energy audits.
- Tour the site accompanied by industry representative.
- Explain the purpose of the audit and indicate the kind of information needed during the industry tour.
- Discuss economic guide lines associated with the recommendation of the audit.
- Analyze the major energy consumption data with the relevant personnel.
- Obtain the site drawings where available plant building layout, steam distribution compressed air distribution system, electrical distribution etc.

The outcome of this visit should be:

- To know the expectations of management from the audit.
- To identify the main energy consuming areas/plants items to be survived during audit.
- To identify existing instrumentation and additional metering required prior to auditing. Example for measurement of electricity, steam, oil consumption.
- To plan for audit with time frame.
- To collect macro data of a plant on energy resources and major energy consuming equipment's.
- To build up awareness and support for detailed energy audit.

### 3.1.2. Phase II –Detailed Energy Audit

Once all of the basic data have been collected and analyzed, the audit team tours the entire facility to examine the operational patterns and equipment usage, and collect detailed data on the facility itself as well as on all energy using equipment. Actually, several inspections were made at different times to discover if equipment's are left on unnecessarily, or to target process waste streams that should be eliminated or minimized. These inspections can also help identify maintenance tasks that could reduce energy use. The industry inspection is an important part of the overall audit process. Data gathered on this tour, together with an extensive analysis of these data was result in an audit report that includes a complete description of the time-varying energy consumption patterns of the facility, a list of each piece of equipment that affects the energy consumption together with an assessment of its condition, a chronology of normal operating and maintenance practices, and a list of recommended energy management ideas for possible implementation.

A 12-month Utility bills were collected to evaluate the plant's energy/demand rate structures, and energy usage profiles. Specific energy-consuming systems were measured using different instruments and operational parameters are collected. In-depth interviews with facility operating personnel were conducted to collect the power consumption variation with process parameters and operating conditions and provide a better understanding of major energy consuming systems as well as insight into variations in daily and annual energy consumption and demand.

**Data collected during the detailed energy audit:**

- Source of energy supply.
- Energy cost and tariff data, consumption of electricity, fuel, water, steam, compressed air etc.
- Generation and distribution and usage of compressed air, steam, and water etc.
- Process involved, description of process, technology and capacity of machines used, material flow diagrams, etc.…,
- Energy and material balance data collected.
- Energy consumption by type of energy, by department, by machines, process equipment's, by usage.
- Potential for fuel substitution, process modification, machineries replacements.
- Review of existing energy management producers and energy awareness training programs.
- Quality and raw material usage.
- Capacity utilization.
- Efficiency of process, waste generated and realization of the product.
- Rejection /rework done during the process.
- Quality and types of waste generated in each process.

### 3.1.3. Phase III – Post Audit Phase

After completion of the energy audit, energy saving opportunities has been identified, prepared the list of recommendations to save energy, with regard to overall efficiency of production process, techno economic viability, site conditions and capacity of industry to invest for their implementation. Each energy saving opportunities is explained considering the following points;

- A brief description of each recommended measure.
- Estimated energy saving as well as energy cost reduction.
- Any other saving / advantages regarding the proposal are explained.
- Any known or expected technical risks associated with each measure.
- Tabulated summary of recommendations listed as per their implementation schedule.
- As per energy saving opportunities recommendation they are prioritized, based on the technical viable, financially attractive and action plan are prepared in consultation with industry personal.

Energy action plan should be prepared, the energy action plan lists the ESO, which should be implemented first and suggest an overall implementation schedule. Energy audit is incomplete without monitoring. And it's associated feedback monitoring consisting of collecting and interpreting data. Electrical power consumption and fuel consumption must be evaluated and monitored after additional instruments should be installed in various departments in addition to main metering.

Monitoring should result in more action. Good practice should be replicated. If the gap between planned objectives and actual achievement is large new action should be initiated and result should be monitored. In this way, analysis, action and monitoring was a cycle process.

**Instruments used**

The study was made by implementing and following the audit methodologies discussed above. The data, for the detail energy audit analysis, was collected using measurement instruments available in the industry in addition with following instrument and using practical and scientific methods. The measuring instruments that were used for measuring and collecting data include:

a) **Three Phase Power Analyzer: -** used to measure voltage, current, power factor, kilowatts, Kilovolt ampere,
b) **Infrared Gun Thermometer: -** used to measure temperature from distance
c) **Lux Meter: -** used to measure illumination level.
d) **Sling Hygrometer: -** used to measure dry and wet bulb temperature for calculating Relative Humidity
e) **Vane Anemometer: -** used to measure air velocity
f) **Digital Manometer: -** used to measure positive and negative pressure etc.
g) **SPSS software:-** used to analyse the energy saving opportunities

## 3.2. Textile Production Process

The production process involved in ELSE Addis Industrial Development PLC is explained below. A flowchart of the processes is given to help better understand manufacturing sequences and process steps. ELSE Addis Industrial Development PLC major production processes generally can be categorized into three main categories:1) Ginning 2) Yarn Spinning3) Weaving

### 3.2.1. Ginning

In ELSE Addis Industrial Development PLC, the ginning operation is done in ginning mill. The seed cotton is purchased from the farm and trailers transport cotton from the field to the ginning mill and stored in seed cotton go down. A high-pressure fan conveys seed cotton through the first seed cotton cleaner, which loosens the cotton and removes fine particles of foreign matter (e. g., leaf trash, sand, and dirt). In the second cleaner, large pieces (e. g., sticks, stems, and burs) are removed from the cotton by a different process, referred to as "extracting". These machines remove burs, sticks, stems, and large leaves, pneumatically conveying them to the trash storage area. The cotton is pneumatically conveyed to the next processing step. Typically, all conveying air is cleaned by a cyclone before being released to the atmosphere. After cleaning, the cotton enters to the extractor/feeders at a controlled rate. The extractor/feeders drop the cotton into the gin stands at the recommended processing rates. Typically, the air from this system is routed through a cyclone and cleaned before being exhausted to the atmosphere. Seed cotton enters the gin stand. The seed cotton is then drawn into the roll box, where fibers are separated from the seeds. After all the fibers are removed, the seeds slide down the face of the gin and fall to the bottom of the gin stand for subsequent removal by screw conveyors to storage. Cotton lint is removed from the seed and then fell on the belt conveyor and conveyed to the lint cleaning system for final cleaning and combing. Then cleaned lint send to hydraulic bale press for baling. In this department the electrical power is main source of energy input.

### 3.2.2. Yarn production

In ELSE Addis Industrial Development PLC Yarn formation is done in spinning plant. Two types of spinning process are used 1. Ring spinning, 2. Open end spinning (rotor spinning). Before entering the spinning machine pre-spinning processing i.e., preparatory takes place. This includes opening the fiber in bales, mixing the fibers, cleaning, arranging, and paralyzing the fibers, drafting, and twisting of the fibers into a sliver. For this process different types of machines are used like openers, beaters, carding, comber, drawing, and simplex. In order to collect the waste from the machines automatic waste collection systems are used. Humidification plants are used to improve and maintain the relative humidity, temperature and housekeeping. The sliver is sent to spinning machine to make it yarn. After making the yarn in spinning the cops are sent to winding machine (Auto cone) to make cone. In this department the electrical power is main source of energy input.

### 3.2.3. Fabric production

The looms are used in weaving to produce fabrics employed in ELSE Addis industrial development plc. Weaving is performed on modern machines like air jet shuttle less looms. Fabrics are formed in loom weaving by interlacing one set of yarns with another set oriented crosswise. In the weaving operation, the length-wise yarns that form the basic structure of the fabric are called the warp and the crosswise yarns are called the filling, also referred to as the weft. While the filling yarns undergo little strain in the weaving process, warp yarns undergo much strain during weaving and must be processed to prepare them to withstand the strain. Before weaving, warp yarns are first wound on large spools, or cones, which are placed on a rack called a creel in warping machine. The warp yarns are then unwound and passed through a sue solution (sizing) before being wound onto a warp beam in a process known as beaming. The size solution forms a coating that protects the yarn against snagging or abrasion during weaving. In EAID PLC warp beam are sized in modern sizing machine. To maintain relative humidity in the weaving department fully automated humidification plants are installed. Electrical power is main input energy and diesel are used in boiler as fuel for preparing the size and drying in sizing machine and grey fabric is mainly produced.


Figure.3. 1.Sequence of operation in textile process

## 3.3. Preliminary Energy Audit

The Preliminary Energy Audit (PEA) includes collection of the following types of information:

- Energy used by the plant (fuel type and source delivered)
- Costs of the different kind of energies
- Inventory of major energy-consuming equipments in the plant

- Operating schedules of major departments
- Details on the current energy management program

The PEA data was used to develop a plan for the instrument measurements of major energy-consuming plant equipment.

The major process and service departments within the plant are:

- Ginning mill
- Automatic waste collection and humidification systems
- Lighting system
- Compressors and compressed air systems
- Electrical distribution and motors
- Spinning and weaving operations
- Boiler plant and steam distribution

**3.3.1. Electrical systems**

Electrical power enters the plant in an area adjacent to the main gate. EAID PLC has one EEU high tension service connections. In the EEU room metering set and switch gear are installed. There are 5 numbers of transformers installed for serving different departments. These transformers are installed near the load centre like one at Ginning (1,000kva), second at preparatory for spinning (1,600KVA ), third at spinning (2,500 KVA), fourth near compressor room(1,600KVA) and fifth at weaving department(1,600KVA ). These transformers get the HT supply from the EEU switchgear room through High tension cables. The table below shows the capacity of transformer and serving departments.

Table 3 1: Capacity of transformers and their serving departments

| S/N | Capacity of transformer in KVA | Feeding to Department |
|---|---|---|
| 1 | 1000 | Ginning |
| 2 | 1600 | Preparatory for Spinning |
| 3 | 2500 | Spinning |
| 4 | 1600 | Weaving |
| 5 | 1600 | Compressor |
| | **Total capacity=8300KVA** | |

### 3.3.2. Energy Consumption and Cost

Electricity is mainly used by the ELSE Addis Industrial Development PLC, primarily for motor drives and boilers. Electricity was purchased from an Ethiopian eclectic utility (EEU). The marginal cost for electricity up to April 2023 is Birr 1.1930 per kilowatt hour, and the demand charge is Birr 147.54/kva per month. A power factor penalty is included in the tariff for industrial users with a power factor less than 0.95; since the ELSE Addis Industrial Development PLC maintains a low power factor, it pays for the penalty.

Table 3 2: Month wise electricity consumption for the year 2022- 2023 and costs (as per invoice)

| Month | KWH Consumption | KVARH Consumption | Consumption charge(birr) | Demand charge(birr) | PF charge | Total cost in Birr as per EEU invoice |
|---|---|---|---|---|---|---|
| May 2022 | 972,000 | 564,000 | 1,159,596.00 | 311,604.48 | 12,631.33 | 1,483,885.81 |
| June 2022 | 1,260,000 | 756,000 | 1,503,180.00 | 300,981.60 | 14,920.06 | 1,819,135.66 |
| Jully 2022 | 1,368,000 | 804,000 | 1,632,024.00 | 306,293.04 | 13,454.79 | 1,951,825.83 |
| August 2022 | 2,581,560 | 1,450,320 | 3,079,801.08 | 760,303.13 | 24,560.79 | 3,864,782.00 |
| September 2022 | 1,305,360 | 750,840 | 1,557,294.48 | 354,096.00 | 13,548.83 | 1,924,993.31 |
| October 2022 | 1,559,160 | 914,040 | 1,860,077.88 | 370,384.42 | 16,020.35 | 2,246,536.65 |
| November 2022 | 1,511,520 | 909,840 | 1,803,243.36 | 376,381.10 | 19,005.82 | 2,198,884.28 |
| December 2022 | 1,497,720 | 16,730.74 | 1,786,779.96 | 368,082.79 | 16,730.74 | 2,171,647.49 |
| January 2023 | 1,522,080 | 909,000 | 1,815,841.44 | 377,112.24 | 18,207.44 | 2,211.215.12 |
| February 2023 | 1,415,760 | 860,160 | 1,689,001.68 | 384,548.26 | 20,415.06 | 2,094,019.00 |
| March 2023 | 1,582,200 | 999,360 | 1,887,564.60 | 373,217.18 | 24,070.98 | 2,284,906.76 |
| April 2023 | 1,333,920 | 978,960 | 1,591,366.56 | 371,623.75 | 43,243.86 | 2,006,288.17 |
| **Total** | **16327080** | **9913250.74** | **21,365,771.04** | **4,654,627.99** | **236,810.05** | **26,257,209.08** |

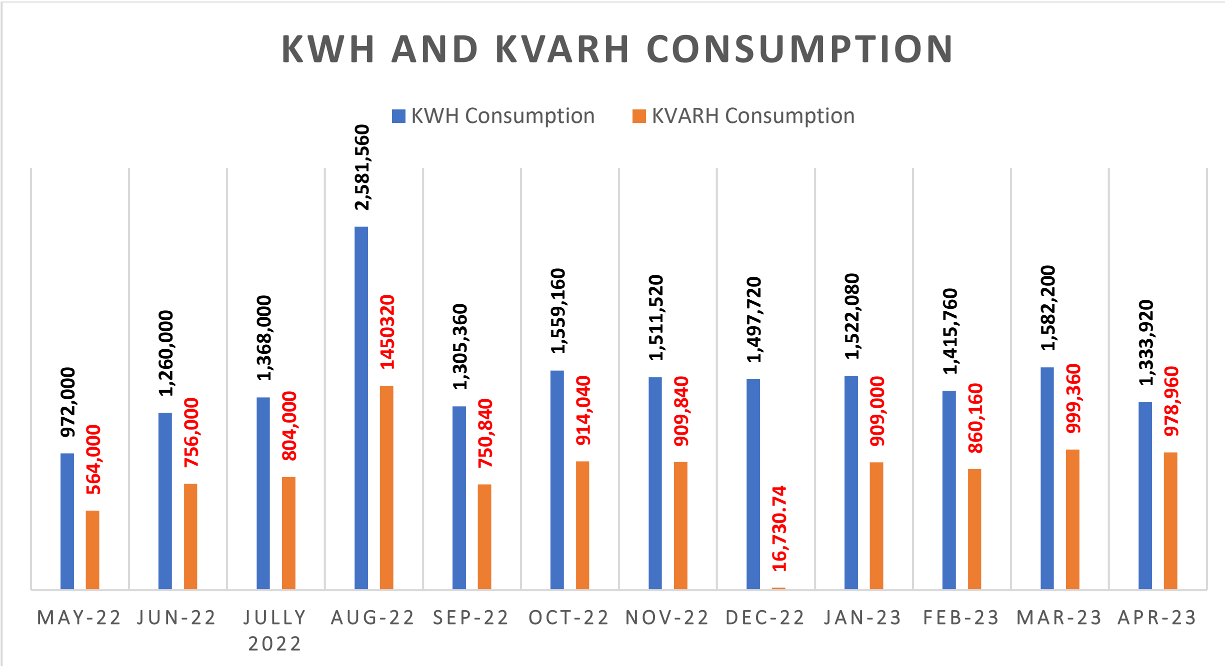


Figure.3. 2.KWH and KVARH Consumption of the Factor for each month

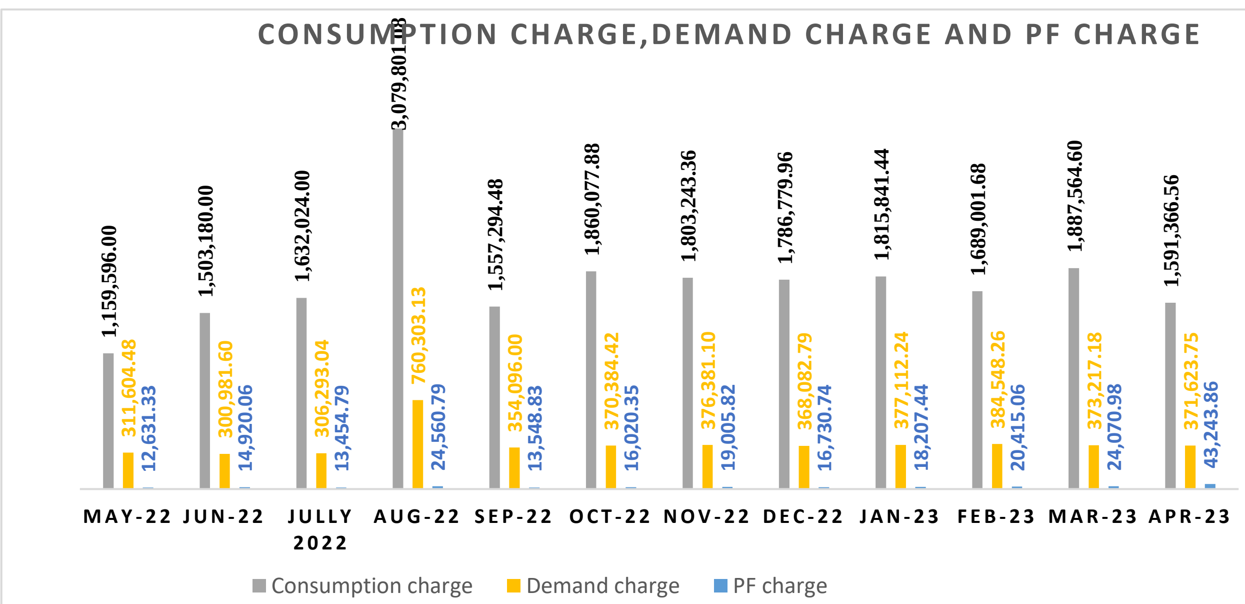


Figure.3. 3.Consumption charge,Demand charge and Pf charge of the Factor for each month

## 3.4. Detailed Energy Audit

The following section explains the general findings and source of energy wastage during the detail energy audit in ELSE Addis Industrial Development PLC. The data for the detail energy audit have been collected by measurements done during the audit at different time periods, physical nature of machines, production methods, ambient conditions, observations, interviews, and available records, etc.,

### 3.4.1. Energy management program

ELSE Addis Industrial Development PLC has not done energy audit previously and currently doesn`t have established energy management program. There are no methods used for monitoring, controlling and verification of energy usage by the boilers, process machines, utility machines, etc… There is no proper recording system for inventory of machines and motors, maintenance details of motors, etc…

### 3.4.2. Major energy systems and observations

**Electrical power distribution**

ELSE Addis Industrial Development PLC has five Step-down transformers and they are placed in different load centres. Each transformer is controlled by HT breaker and as well as MV panel breaker and separate feeder for each Sub switch boards. The MV panel consists of meters that are capable of measuring all electrical parameters. MV panel also consists of Automatic power factor controller and capacitors. All APFC are not working due to some problem. During audit it is identified that these meters are not properly utilized. It is recommended to correct all the APFCs to make it operational. Utilize the energy meters and make it record the power consumption and distribute the data to relevant departments to compare the energy consumption with production particulars and for taking necessary action for reducing the energy consumption. During the plant is stopped partially for most of the day due to incoming low voltage (347 Voltage) problem it cause low productivity, low capacity utilization and component failure. It is recommended to take the matter to EEU for necessary action to improve the stabilized voltage.

**Ginning:** In ginning the seed cotton (raw material) is fed into the material transport pipe by manually in the cotton storage area. This is the round pipe and the feeding also non uniform. Due to this the ginning processing machine are running idle. There is no monitoring for material feed and also avoiding idle running. It is recommended to modify the suction pipe as like hood and perforated table for material feed and assure the uniform material feed and avoid the machine idle running.

**Boiler plant:** Boiler plant utilization can be improved by installing water treatment plant to maintain proper TDS level to avoid scale formation in the diesel fired boiler. Recently there is no data available about feed water TDS, etc. Currently there is one boiler used for generating steam for sizing preparation and drying in the sizing machine.

Make-up water is supplied to the boiler feed water tank. The Condensate water from process is collected and sent to feed water tank. It is recommended that the feed water tank be insulated to avoid heat loss.

There is no flow meter for water supplied to the boiler. One steam flow meter is installed but it is not working. There is no gauge / flow meter for diesel consumption. It is recommended that calibrate the diesel storage tank and place scale for monitoring the hourly consumption of diesel. Since the steam flow meter is not working, it needs corrective maintenance to be operational. Install water flow meter for water consumption in the boiler.

Steam is generated at higher pressure (5.75 bar) than the process requirement, which should be optimized.

Finally, it is recommended that the boiler operators undergo additional training. This recommendation should not be interpreted as a criticism of the boiler room staff. While the staff operates the boilers to a high standard at present, additional training allows for more efficient boiler operation.

**Steam Distribution and Condensate Return System:** The Steam is distributed at boiler pressure to the point of use. The Condensed steam is returned to the boiler house and connected to feed water tank. In some location the pipes and valves are not insulated. Although steam traps were found to be in good condition their maintenance program with regular steam trap testing should be instituted.

**Compressor plant:** Four oil screw compressors are installed and connected to common header and is connected to receiver tanks (two tanks are in parallel). From the receiver tank the compressed air is sent through the pre filters to the refrigerant air driers (4 Numbers). Air driers are installed in parallel; the input and output of the air driers are connected through headers. The output of the air driers is sent to the distribution header through post filters. From the header the air is distributed to production department machines through overhead ring main pipe line system.

It is identified that the installation of equipment's in the compressor room are not up to the standard and the number of compressors running are more than the process requirement. The pipes, headers and receiver tank all are covered with thermal insulation. It is not the best practice. It is recommended to remove the insulation in all system except the exhaust duct.

It is recommended to install the pressure gauge in the distribution header to monitor the pressure loss across the drier and filters. Provide the roof ventilator in compressor room to remove the hot air. Extend the height of the exhaust air duct of compressors to avoid the hot air intake by the compressor. Provide louvers in the south side of the room to get the cool air as well as reduce the temperature in the compressor room. In future any major modifications is proposed at that time shift the compressor room other side of the road and provide all sides with louvers for cool and clean air for compressor.

The air leakage study shows more leakage is in the distribution side. Compressed air leaks are sources of energy waste, hence arrest the leakage to save energy.

The compressor cooling air, which comes from the compressor, has high heat content. So there is a possibility to use it for boiler feed water heating or for heating space heating in the weaving department. Additionally, a regular compressed air system inspection and repair program should be established.

**Lighting:** In ELSE Addis Industrial Development PLC 48 watts /lamp with electronic ballast florescent tube fittings are used in all departments. During the audit many machines were not working but lightings are kept on those unwanted areas. In ginning ample sun light is available and, in those areas, also the lightings are kept on. In the lighting distribution board, no identification are given to /mcb/ switch for controlling lighting circuit. It is recommended to prepare awareness creation program and make the employees switch off the lights during unwanted times.

**Humidification:** ELSE Addis Industrial Development PLC has nine humidification plants which are blow room -1no, carding -1no, Roving -1 no, Spinning -2nos, OE spinning (rieter)-1no, OE spinning and autoconer -1 no, Weaving -2nos. All the plants are having some problems (pump problem, electrical problem, etc..,) and maintenance is not carried out up to the standard (trenches are full of fluff, eliminator and louvers are blocked in air washer, Spray nozzles and water strainers are blocked and no water spray, etc..,). The humidification plant serving to OE spinning (Reiter) is placed on first floor and its air washer tank has more water leakage. Due to this the water is not filled in the tank and there no water spray is done and causes low relative humidity in the department. Many machines are not running in the spinning as well as in weaving mills. It is recommended to improve the maintenance of all the humidification plants and improve the monitoring mechanism of the plants. Depending on the machines running inside the plant, humidification plants operation to be optimized to save energy. Rectify the water leakage problem in OE (rieter) spinning humidification plant and maintain proper RH in the department. The pumps are operating at low speed. Due to this there is no water spray in the air washer. It is recommended to optimize the pump speed for proper spray to improve RH%. In humidification plant and Automatic waste collection system some motors are running idle unnoticed. It is recommended that indication lamps should be installed inside in the respective departments to give awareness about the running status of the motors.

# CHAPTER FOUR

# 4. RESULTS AND DISCUSSIONS

## 4.1. Energy Saving Opportunity

### 4.1.1. Effective usage of energy meter

**Present status**

The EAID PLC obtains an electric supply at 15 KV from the EEU. It had one service connection and five transformers. The transformers were installed near the load center at different locations of the plant. Each transformer has its own MV panel consisting of a switchgear and feeders. This panel is also fitted with a multi-function meter to measure voltage, current, power factor, kilo watts and kilowatt-hour, etc.; currently, the plant is not properly utilizing these meters, record the power consumption of individual mills, and cost for each mill is done on approximation.

**Recommendation:** Energy costs for producing quality goods are constantly increasing. The conservation and efficient management of energy have become very important to maintain industry productivity, profitability, and competitiveness. Hence, it is desirable to design an instrument system to monitor and control actual energy consumption patterns in textile mills. The system could provide an excellent tool to mills for planning energy costs in their production and setting the process parameters to manage consumption with a high degree of efficiency. The energy consumption depends on the machines and the desired quality of the product. Different types of machines are used, from ginning to weaving, for which energy consumption varies from machine to machine and their present conditions.

Meters were used to measure the flow of steam, water, oil, and electricity. This type of measurement is sometimes referred to as metering.

The important uses of the measuring and monitoring equipment are as follows:

- Determine where energy is being used and how much. This is achieved by measuring the energy delivered or consumed.
- Assess the current operation and determines where it should be modified.
- Establish energy performance goals.

- Implement operating improvement and compare the results on a continuous basis with the previous operation. Measurement data is required to evaluate performance improvements. The improvement might also include the addition of automatic controls and these devices depend upon good measurement.
- Formalize the process of collecting energy related data to track the energy utilization and make meaningful comparisons with the previous use of energy. This is the basis of an energy accounting system and the source of all this data originates from measuring and metering equipment.
- Measurement of data is used to assess the effectiveness of energy use in the operation equipment and processes. The function of data gathering interpretation and analysis called monitoring.

Measurement and monitoring benefits:

- Facilitates decision making related to improving operations
- Permits constancy of operation even with personnel who do not have much of experience
- Operating equipment performance can be calculated to expose misuse of energy.
- Forms the basis for good manual control of equipment and processes
- Automatic control would not be possible without the measuring element which determines the value of the process variables such as speed, temperature, flow, Pressure and electricity. Similarly, more complex processes could not be optimized to save energy without reliable data.

It is recommended to utilize these meters, record and monitor the energy consumption of each mill and compare with production and other data on daily basis and analyse for possibility losses and optimum operation of machines and equipment's.

**Cost benefit analysis**

***Saving:***

$$\text{Expected Energy saving per year} = \text{Annual energy consumption x 1\%} \quad (4.1)$$

$$=16{,}327{,}080 \text{ x } 1\%$$

=163,270.80kwh

Cost saving per year @Birr 1.1930 /Kwh = 163270.80 x 1.1930 = Birr 194,782.0644

*Investment:* = Nil

*Simple Payback period:* = Immediate

**Benefits and investment**

By implementing this study EAID PLC can save Birr 194,782.0644 per annum. The Investment required for implementation is nil with immediate payback period.

### 4.1.2 Improving the power factor of the plant

**Present status**

EAID PLC has present power factor of 0.87 against the required power factor of above 0.95. It has one service connection and five transformers. The transformers are installed near the load centre at different locations of the plant. Each transformer has its own MV panel consists of switchgear and feeders. These panels also consist of Automatic power factor controllers and necessary capacitors. Out of the five, two controllers are removed and others under repair. I am also informed by factory that few capacitors are failed. Currently, the plant is not properly utilizing these APFC units.

**Recommendation:**

Motors and lights cause reduction in power factor because of the nature of their operation. Power factor correction circuitry is often installed to bring this close to unity, so excess Kva charges can be avoided. EAID PLC has average maximum power factor of 0.87 as against requirement of 0.95.

Average Maximum demand reached during 2023=2,755.84 kva at 0.87 power factor

Load in Kilowatts =2,755.84 x 0.87=2,397.58

Expected Maximum demand at 0.95 power factor =2,397.58 / 0.95 =2,523.77 kva

**Cost benefits analysis:**

***Saving:***

Demand reduction in Kva =2,755.84 -2,523.77 = 232.07kva

Cost saving per year @Birr.85.035/kva (At present tariff) = 232.07 x 85.035=19,734.171/ month

Cost saving per year =19,734.171 x 12=Birr 236,810.05

Investment:

Material and labour cost for repairing Controller and capacitor (Lump sum) =Birr 50,000

Payback period = (50,000 / 236,810.05) X 12 = Less than 3 month

**Benefits and investment**

By implementing this study EAID PLC can save Birr 236,810.05 per annum. The Investment required for implementation is Birr 50,000 with payback period of less 3 months.

### 4.1.3 Avoid idle running of machines in Ginning Mill

**Present status:** EAID PLC has Ginning mill consists of pre cleaner, fine cleaner, gin stands, lint cleaner and fans for transport of seed cotton as well as waste (trash, dust etc..,)and cyclone. These are connected in sequence. Now the material is feeding from the seed cotton storage go down by manually. The material feeding is non uniform and there is no monitoring on material feeding. This causes the idle running of the machines in ginning mill for long period.

**Problems:** Now the seed cotton is feeding done manually into round pipe continuously, it is cumbersome and makes the person very tired.

When the person goes out for personal reasons there is no material feed and entire process run as idle.

The material feeding is non uniform and productivity is less.

**Recommendation:** It is recommended to modify the suction hood for improve the suction and install the conveyor type material feed table for seed cotton and install photocell type controller in the material feed pipe line and make a control system in such a way that the subsequent machines should be stopped if there is no material delivery.

**Cost benefits analysis:**

***Saving:***

Number of hours machines are running idle per day (Average)= 3 hours based on observation during Energy audit.

Actual power of machines running idle =260 kw

Energy saving due to idle running/day =260x 3= 780 kwh

Energy saving per year (ginning 6-month operation) =780 x 180=140,400kwh

Cost saving per year =140,400 x 1.1930 = Birr 167,497.2

***Investment:***

Installation of conveyor and hood modification = Birr 75,000

Installation of photocell = Birr 15,000

Total investment = Birr 90,000

***Simple payback period*** = (90,000/167,497.2) x12 = Less than 7 months

**Benefits and investment:**

By implementing this study EAID PLC can save Birr 167,497.2 per annum. The Investment required for implementation is Birr 90,000 with payback period of less than 7 month.

#### 4.1.4. Insulating the feed water tank in boiler room

**Present status:** EAID PLC has one steam boiler (1,455Kcal/HR) which uses diesel as fuel. The steam is used for preparation of size and drying purpose in sizing machine. In the boiler room one feed water tank is installed. It gets water from outside and the condensate is collected in this tank. Now the tank is not insulated and there is heat loss.

**Recommendation:** There is a substantial amount of heat loss from the feed water tank. Therefore, it is recommended to insulate the tank to decrease energy wastage through radiation and convection.

**Cost benefit analysis**

***Saving:***

Size of the tank:

Diameter of the tank = 1.3 meters

Length of tank = 2.5 meters

Surface Area of tank (A) = (2x π x r x h) + 2 x π x$r^2$ (4.2)

Where: r =radius and h= Height

Area of tank = (2 x 3.147 x 0.65x 2.5) + (2 x 3.147x$0.65^2$) = 12.86$m^2$

Total heat loss ($Q_t$) = $Q_s$ x A (4.3)

$Q_s$ = [10 + ($T_s$ - $T_a$) / 20] x ($T_s$ - $T_a$) x 4.18 4.4)

Where

$Q_S$ = surface heat loss in KJ/ (hr.m)

A =surface area

$T_S$ = temperature in $^0$c

$T_A$ =ambient temperature in $^0$c

$Q_s$ = [(10+ (90-25))/20] × (90-25) ×4.18 = 1,018.88 KJ/ (hr.m)

Total heat loss =1,018.88 x 12.86 = 13,102.8 KJ

Total heat loss per year = 13,102.8x16x351= 73,585,324.8 KJ/ year

Calorific value of diesel fuel = 36,000KJ/Litter

Saving in diesel by insulation = 73,585,324.8/ 36,000 = 2,044 litter

**Cost saving per year**

@ birr62 / litter of diesel = 2,044x 62 = Birr 126,728

***Investment:***

Cost of Insulation @ Birr3250/$m^2$ =12.86X3250=41795

Labour charges for installation = Birr 5,000

Total = Birr 46,795

***Simple pay back*** = (46,795 ⁄ 126,728) ×12 ≈less than 5 month

**Benefits and investment:** By implementing this study EAID PLC can save Birr 126,728 per annum. The Investment required to implement this proposal is Birr 46795 with the payback period of less than 5 month.

### 4.1.5. Switch off the lighting in no production areas

**Present status:** Presently EAID PLC has 1 X 58 watts of electronic ballast florescent fittings in all departments for lighting. It was found that lightings are switch on in those places where the machines are stopped (comber, ring frame 15nos, Weaving -36looms). The identification of lighting circuit is not marked in lighting distribution board. The operators have no awareness to switch off the light during unwanted period.

**Recommendation:** It is recommended to switch off the lamps in the unwanted areas. Create the awareness among operators for proper utilization of electric lighting to save energy. Give the identification marks for each lighting circuit in lighting distribution board.

**Benefits**

- Very good energy reduction.
- The replacement of lamp is extended
- Maintenance and bulb replacement cost is reduced

**Cost benefit analysis**

***Savings:***

Number of fittings installed =1750

No of fittings possible to switch off =310

Wattage of fitting = 58 watts

Expected lighting power saving in kilo watts by switch off =310 X 58 /1,000 =17.98 Kw

Energy saving in Kwh per year by switch off =17.98 X 24 X 351= 151,463.52kwh

Cost saving @Birr 1.1930/ Kwh =151,463.52 X 1.1930 = Birr 180,696

***Investment:*** = Nil

***Simple Payback period:*** = Immediate

**Benefits and investment:** By implementing this study EAID PLC can save Birr 180,696 per annum. The Investment required for implementation is Nil with immediate payback period.

### 4.1.6 Optimize the fan speed in ginning mill

**Present status:** EAID PLC has 4 numbers of high-capacity fans in ginning. They are fan no1- seed cotton transport from storage area to pre cleaner, fan no 2-material transport fan for transport from fine cleaner to distributors for gin stands, fan no-3 trash fan for fine cleaner, fan no 4-condensor of the bale press. These fans discharge air is connected to cyclone. These fans speed is selected based on full production capacity of plant. Now the plant is running partially, the present fan speed is higher than the requirement.

**Recommendation:** It is recommended to optimize the fan speed by changing the pulley ratio for saving energy.

**Cost benefits analysis:**

***Savings:***

Actual kilo watts of fans: Fan 1= 49kw

Fan 2 =18.4kw

Fan 3 =22kw

Fan 4 =17.18kw

**Total =106.58kw**

As per affinity law $\text{power}_{\text{final}} = \text{Power}_{\text{initial}} (\text{speed}_{\text{final}} / \text{Speed}_{\text{initial}})^3$ (4.5)

When the speed is reduced by 10% the power is reduced by 27%

Expected kilowatts after reduction of speed by 5% (we may reduce more than ) power reduced by 14%

| | |
|---|---|
| Fan 1 | =42.14 |
| Fan 2 | =15.82 |
| Fan 3 | =18.92 |
| Fan 4 | =14.77 |
| **Total** | **=91.65** |

Energy saving per year = 91.65 x 16 x180 =263,952 kwh

Cost saving per year @ birr.1.1930/kwh =263,952 x 1.1930 =Birr 314,895

***Investment:***

Cost of pulley per piece = Birr 3,000

Number of pulley required to change =4

Labor cost for changing the pulley =2000 Birr

Total cost =14,000 Birr

***Payback period*** = (14,000/314,895) x 12 =Less than 1 month

**Benefits and investment:** By implementing this study EAID PLC can save Birr 314,895 per annum. The Investment required for implementation is Birr 14,000 with payback period of less than 1 month.

### 4.1.7 Replace the existing V belt by cogged belt for fans in ginning mill

**Present status:** EAID PLC has 5 numbers of fans in ginning. They are fan no1- seed cotton transport from storage area to pre-cleaner, fan no 2-material transport fan for transport from fine cleaner to distributors for gin stands, fan no-3 trash fan for fine cleaner, fan no 4-condensor of the bale press, fan 5- trash for pre-cleaner. These fan's discharge air is connected to cyclone. These fans speed is selected based on full production capacity of plant. Now the plant is running partially, the present fan speed is higher than the requirement.

**Recommendation:** It is recommended to replace the existing v belts by cogged v belts. Optimize the fan speed by changing the pulley ratio for saving energy. The majority of belt drives use V-belts, which use a trapezoidal cross section to create a wedging action on the pulleys to increase friction and improve the belt's power transfer capability. Joined or multiple belts are specified for heavy loads. V-belt drives can have a peak efficiency of 95% or more at the time of installation. Efficiency is dependent on pulley size, pulley wear, V-belt alignment, transmitted torque, under or over sizing belts for load requirements. Efficiency can deteriorate by as much as 5% over time if slippage occurs because the belt is not periodically re-tensioned. The most important operational and maintenance issue in a V-belt drive is its tension. If belts are too loose, they tend to vibrate, wear rapidly, and waste energy through slippage. If belts are over-tightened, they show excessive wear. An increased belt load may shorten bearing life through excessive lateral loading and could result in shaft failure. A notched belt has grooves or notches that run perpendicular to the belt's length, which reduces the bending resistance of the belt. Notched belts can use the same pulleys as cross-section standard V-belts. They run cooler, last longer, and are about 2% more efficient than standard V-belts.

**Cost benefits analysis:**

***Savings:***

| | | |
|---|---|---|
| Actual kilo watts of fans | Fan 1 | =49kw |
| | Fan 2 | =18.4kw |
| | Fan 3 | =22kw |
| | Fan 4 | =17.18kw |
| | **Total** | **=106.58kw** |

Reduction in power by using cogged v belts =106.58 x 5% =5.33

Energy saving per year by belt replacement = 5.33 x 16 x180 =15,350kwh

Cost saving per year @ birr.1.1930/kwh =15,350 x 1.1930 =Birr 18,312.55

***Investment*** =Nil

***Payback period*** *= Immediate*

**Benefits and investment:** By implementing this study EAID PLC can save Birr 18,312.55 per annum. The Investment required for implementation is Nil with immediate payback period.

**4.1.8. Arrest leakages in compressed air distribution system**

**Present status:** Currently EAID PLC has four numbers oil flooded screw compressor of capacity (FAD) of each 1,408 CFM. In which one compressor is under maintenance, one compressor as stand by and two oil free screw compressors are running at a time to meet the compressed air requirement of Air jet weaving machines, and spinning. During the energy audit survey the leak test in the entire compressed air distribution system and the details of leak test conducted are enclosed.

**Measurement method:** All the connected machines were stopped and the compressed air distribution line was fully charged at the time of leak test. The energy team conducted the leak test after the mill was shutdown. One screw compressor (1,408 CFM) was set at a cut off pressure of 7.0 kg/cm2 and cut in pressure of 6.5 kg /cm2 and started when all the connected machines were stopped and only weaving department valve is open and spinning valve closed. This compressor has 48.71sec (avg) off time and 44sec (avg) on time. It was found that the compressed air leakage is 47% of compressor capacity, i.e. 661.7cfm. It is recommended to take steps to reduce the compressed air leakages below 5%.

Table 4 1: Compressed air leakage test

| **S.No** | **Compressor number** | **Set Pressure** | | **Average On time in sec** | **Average Off time in sec** |
|---|---|---|---|---|---|
| | | **Cut in pressure in kg/cm$^2$** | **Cutoff pressure in kg/cm$^2$** | | |
| **1** | Compressor no 4 | 6.5 | 7.0 | 44 | 48.71 |

Conclusion: Compressed air leakage is more than 47%

**Cost benefit analysis**

**Saving:**

No. of compressors used =one

Motor Rating of compressor =250 KW

Average operating load of compressor =236 KW

Total % air leakage as per test (weaving only) =47%

Allowable leakage Standard =5%

Estimated energy saving by arresting air leakage =236 x 0.47 x 24 x 351 = 934,390.08 kwh x 1.1930

Estimated cost saving per year =Birr 1,114,727.27

**Investment:**

Investment required for spares and man power = Birr 726,000/

**Payback period** = (726,000/1,114,727.4) x 12 = 8 months

**Benefits and investment:** By implementing this study EAID PLC can save Birr **1,114,727.27** per annum. The Investment required for implementation is Birr 726,000 with payback period of less than 8 month.

### 4.1.9 Optimize the running of air driers in compressor room

**Present status:** Currently EAID PLC has four numbers oil flooded screw compressor of capacity (FAD) of each 1,408 CFM. In which one compressor is under maintenance, one compressor as stand by and two oil free screw compressors are running at a time to meet the compressed air requirement of Air jet weaving machines, and spinning. It also has four numbers of refrigerated air drier of capacity each 1766 cfm of air flow. All air driers are connected in parallel. Now one air drier is under repair and other three air driers are running. In compressor room all pipes, headers, and receiver tank are insulated. The driers are running at dew point temperature of 7.5-8 Deg C.

**Recommendation:** It is not advisable or best practice for providing insulation for pipes, header, and receiver tanks in compressed air pipes. Due to the insulation, the compressed air is not cooled in ambient air, and hot compressed air from the compressor is directly sent to the air drier. This make over load the air drier and as well as the dew point temperature is higher than the required (below 3 Deg C). Now the running air drier total capacity is (1,766 x 3=5,298cfm (88%higher) against the actual compressed air flow of 2,816 cfm. It is recommended to remove the insulation in all components except the exhaust air duct from compressors and provide a roof vent to exhaust hot air from a room and stop the one air drier.

**Cost-benefit analysis**

**Saving:**

| | |
|---|---|
| Actual load of air driers | Drier no1= Under maintenance |
| | Drier no 2 =5.4 kw |
| | Drier no 3 =5.4kw |
| | Drier no 4 =6.8kw |

Energy saving per year by stopping one air drier =5.4 x 24 x 351= 45,489.6kwh

Cost saving per year =45,489.6 X 1.1930birr =Birr 54,269.1

**Investment:**

Number of roof vent required to installed =5

Cost of roof vent =Birr 5,500/piece

Total cost = Birr 27,500/

**Payback period** = (27,500/ 54,269.1) x12=Less than 6 month

**Benefits and investment:** By implementing this study EAID PLC can save Birr 54,269.1per annum. The Investment required for implementation is Birr 27,500 with payback period of Less than 6 month.

#### 4.1.10 Waste heat recovery from screw compressor

**Present status:** EAID PLC has four number of screw compressor and free air delivery of each compressor is 1,408 cfm and each has installed capacity of main motor is 250 kw and actual power of compressor is 236kw at delivery pressure of 7 bar. Now the hot air (by the cooling of compressor) sends out to outside through Galvanized sheet duct. The compressor is running at approx. 130 0C. The hot air has more heat energy and it is not used in any way.

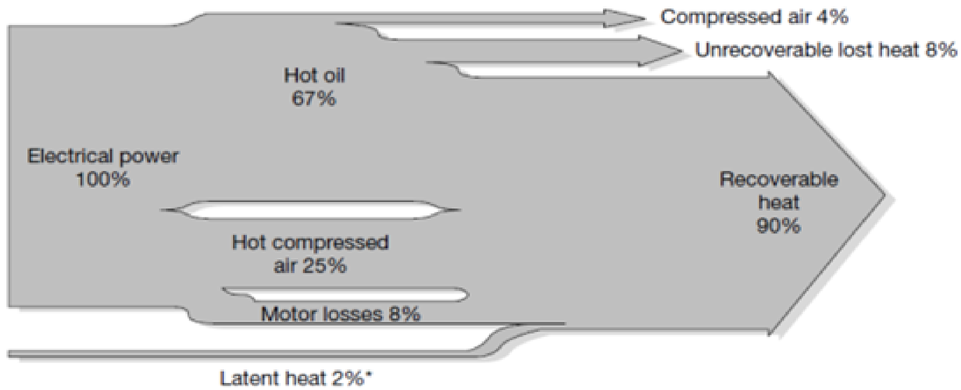


Figure.4. 1.Energy balance in screw compressors

**Recommendation:**The rise in energy prices is an unwelcome reality in today's manufacturing and business environment. And while the rate of price increases for natural gas, heating oil and electricity may vary from year to year, the upward trajectory is clear. Energy cost reduction strategies are vital to staying competitive. One important way operational efficiencies can be increased is by harnessing heat from compressed air systems, which make up a significant share of industrial energy consumption the air that enters a compressor at atmospheric pressure has a base level of energy content. After the compression process increases the air pressure and raises its temperature, the energy becomes available for transfer. The heat must be removed to maintain proper compressor operating temperatures and to cool the compressed air to make it suitable for plant use. The heat generated by compressed air systems can be a very good source of energy savings. In fact, nearly all (96%) of the electrical energy used by an industrial air compressor is converted into heat.

Too often, that heat is simply ejected into the ambient environment through the compressor cooling system. While over 90% of the energy input to compressors is lost as heat, it is usually at a relatively low Grade for process work. It is, however, commonly at temperatures suitable for building services and other applications. Recovering this heat can prove highly cost-effective, reducing overall energy bills and also benefiting the environment. Heat recovery is not the main purpose of an air compressor system and it should not affect the normal operation of the compressor. Significant energy cost savings can be made by recovering heat from air compressors. In general, the capital cost of the additional equipment necessary to recover the waste heat is relatively modest, providing a quick return on investment.

In EAID PLC this hot air may be used for preheating the boiler feed water by using heat exchanger or send it to the humidification plant during winter season.

**Cost benefits analysis:**

**Saving:**

Capacity of compressor =1,408 CFM

Actual power during load condition =236kw

Cooling air flow (Approx.) =15,800 cfm

Heat available in Kcal /hr =202,912.8

Energy available in kcal per year =202,912.8 X 16 X 351 =1,139,558,284.8

In this if we get supposed to get only 50% for heating the boiler feed water, energy reduction in electric boiler =1,139,558,284.8X 0.4 = 455,823,313.92

Heat content in Diesel fuel = 9,657 kcal liter

Diesel fuel saving per year from one compressor = (4,558,284.92 / 9657) = 47,201 liters

Diesel saving per year from two compressor = 47,201 x 2= 94,402 liters

Cost saving @ birr.62/ liter of diesel = Birr 5,852.924

**Investment:** Heat exchanger, Dampers, Duct fabrication and erection, pipe and Insulation lining from boiler house to compressor room.

For feed water (approx. 150Metre) =Birr 600,000

**Simple Payback period** = (600,000/5,852.924) X 12 = Less than 2 month

**Benefits and investment:** By implementing this study EAID PLC can save Birr 5,852.924 per annum. The Investment required for implementation is Birr 600,000 with payback period of less than 2 month.

**4.1.11 Arrest the leakage in automatic waste collection system of carding machines**

**a. Present status:** EAIDPLC has two waste collection units for carding department. There are 24 numbers are installed. Each filter unit serves 12 cards. In the filter unit the main fans are centrifugal fan. In filter unit number I it is found that the main fans' concrete bed broken and also the door fixing (wall) area of the room has also no hole. Due to the above problems, there is more circulation of suction air and leads to inefficient operation and more power consumption. Now both filters have same suction pressure.

**b. Recommendation:** It is recommended to make the foundation to be correct and also the wall of the room make to be leak proof. No

**c. Cost benefit analysis**

**1. Saving:**

Installed capacity of main fan motor

Of Filter 1 and filter 2 = 75 kw each

Actual power of the main fan motor 1 = 54kw

Actual power of the main fan motor 2 =40Kw

Difference in energy consumption =14kw

Energy saving per year by make the

Filter room leak proof =14 X 22 X 351 = 108,108 kWh/year

Cost saving per year = 108,108 X 1.1930=Birr 128,972.844

**2 Investment:**

Material and labor for the civil work = Birr 7,000

**3 Simple Payback period** = (7,000/ 128,972.844) x 12=Less than one month

**d. Benefits and investment:** By implementing this study EAID PLC can save Birr 128,972.844 per annum. The Investment required for implementation is Birr 7,000 with payback period of less than one month.

### 4.1.12 Avoiding idle running of central suction fan for overhead cleaners

**a. Present status:** EAID PLC has 20 frames numbers ring spinning frame and each machine has one overhead travelling cleaner. Now five ring frames are running. For these overhead cleaners two numbers of central waste collection systems are installed. Each system serving 10 overhead cleaners. The central suction fans for collecting waste from overhead cleaner's discharge collection box. Now the only 3 overhead cleaners are not running due to want of spares and maintenance problem but the two central waste collections are continuously running condition.

**b. Recommendation:** The two centralized system are designed for 20 overhead cleaner. It is not energy efficient to run system only for two fans. It is recommended to stop the system and collect the waste from the collection box manually periodically.

**c. Cost benefit analysis**

**1 Saving:**

Actual energy consumption of central waste collection system 1=1 kw

Actual energy consumption of central waste collection system 2 =1.59 kw

Total=2.59kw

Energy saving per year =2.59 X 24 X 351= 21,818.16 kwh

Cost saving per year = 21,818.16X 1.1930=Birr 26,029.065

**2 Investment** =Nil

**3 Payback period** =Immediate

**d. Benefits and investment:** By implementing this study EAID PLC can save Birr 26,029.065 per annum. The Investment required for implementation is Nil with immediate payback period.

### 4.1.13 Installation of indication lamps for avoiding idle running of motors in humidification and automatic waste collection systems

**a. Present status:** EAID PLC has 2 numbers of waste collection system for blow room, 2 numbers of waste collection system for carding and 1 number waste collection system for comber section. 3 numbers of humidification plants for preparatory of spinning, 2 numbers of humidification plants for spinning, 2 numbers of humidification plants for open end spinning and winding section, 1 humidification plants for knitting and 2 numbers of humidification plants for weaving department. The running statuses of the motors are not noticed in the production area. So, many motors are possible to run in idle conditions without any requirement.

**b. Recommendation:** Install indication lamps for each motor in the production area and make wiring in such a way that the lamps indicate the actual working condition. This gives a clear picture for the operators about the running motors and switches off the unnecessary running motors.

**c. Cost-benefit analysis**

**1 Saving:**

Total Actual load in kilowatts of motor = 545kw

Expected Energy saving per year@ 3% =545 x 0.03 x 22 x 351= 126,254.7 kwh

Cost saving per year 126,254.7 X 1.1930Birr =birr 150,621.86

**2 Investment (lump sum):**

Total required indication lamps units' installation =14

Installation cost per unit =Birr 9,000

Total cost =14 x 9,000=126,000

**3 Payback period** = (126,000 /150,621.86) X 12 =less than 10 month

**d. Benefits and investment**

By implementing this study EAID PLC can save Birr 150,621.86 per annum. The Investment required for implementation is Birr 126,000 with payback period of less than 10 month.

**4.1.14 Installation of sub-meter for processing machines**

**a. Present status:** EAID PLC has One EEU supply. Each meter records the Kwh and Kvarh energy consumption of the industry. It has 5 energy meters placed at ginning, preparatory of spinning, spinning, compressor, weaving departments. It has 2 numbers of waste collection system for blow room, 2 numbers of waste collection system for carding and 1 number waste collection system for comber section. 3 numbers of humidification plants for preparatory of spinning, 2 numbers of humidification plants for spinning, 2 numbers of humidification plants for open end spinning and winding section, 1 humidification plants for knitting and 2 numbers of humidification plants for weaving department. There is no energy meter for measuring the power consumption of individual processes or machines.

**b. Recommendation:** The energy costs to produce quality goods have been constantly increasing. The conservation and efficient management of energy has become very important to keep the industry productive, profitable, and competitive. Hence, it was desired to design an instrument system to monitor and control the actual energy consumption pattern in textile mills. The system could provide an excellent tool to mills for planning energy costs in their production and setting the process parameters in order to manage the consumption with a high degree of efficiency. The consumption of energy depends on machines as well as the desired quality of the product. There are different types of machines being used to spin the yarns to finishing of fabric and garments for which energy consumption varies from machine to machine and their present conditions.

Meters are used to measure the flow of steam, water, oil and electricity. This form of measurement is sometimes referred to as metering.

The important uses of measuring and monitoring equipment are as follows:

- Determine where energy is being used and how much. This is achieved by measuring the energy delivered or consumed.
- Assess the current operation and determines where it should be modified.
- Establish energy performance goals.
- Implement operating improvement and compare the results on a continuous basis with the previous operation. Measurement data is required to evaluate performance improvements. The improvement might also include the addition of automatic controls and these devices depend upon good measurement.
- Formalize the process of collecting energy related data to track the energy utilization and make meaningful comparisons with the previous use of energy. This is the basis of an energy

accounting system and the source of all this data originates from measuring and metering equipment.

- Measurement of data is used to assess the effectiveness of energy use in the operation equipment and processes. The function of data gathering interpretation and analysis called monitoring.

Measurement and monitoring benefits:

- Facilitates decision making related to improving operations
- Permits constancy of operation even with personnel who do not have much of experience
- Operating equipment performance can be calculated to expose misuse of energy.
- Forms the basis for good manual control of equipment and processes
- Automatic control would not be possible without the measuring element which determines the value of the process variables such as speed, temperature, flow, Pressure and electricity. Similarly, more complex processes could not be optimized to save energy without reliable data.

**c. Cost benefits analysis:**

**1 Saving:**

Total energy consumed per year (Average) =17,424,000kWh

Expected energy saving @ 2.5 % of total energy =17,424,000 X 0.025 =435600 kWh

Cost saving per year @ Birr 1.1930 / kwh = 435,600X 1.1930 =Birr 519,670.8

**2 Investment:**

Number of energy meters planned in 1st phase =6

(Blow room filter and humidification plant -1,

Carding filter and humidification plant -1,

Roving humidification-1, spinning humidification-1,

Open end and winding humidification-1

Weaving humidification-1)

Installation cost including current transformer and

Energy meter @Birr 7,500/ set =6 X 7,500 =Birr 45,000

Installation of diesel flow meter =Birr 25,000

Total cost =Birr 70,000/

**3 Simple Payback period** = (70,000/519,670.8) X 12 =Less than 2 month

**d. Benefits and investment:** By implementing this study EAID PLC can save Birr 519,670.8 per annum. The Investment required for implementation is Birr 70,000 with payback period of less than 2 month.

**4.1.15. Optimize the air quantity in supply air plant for blow room department**

**a. Present status:** EAID PLC has one number of supply air plant consists one supply fan and one pump. The exhaust is done through the waste air from department machines and connected to waste collection system. This waste air is sent through the rotary filter. This air is used as recirculation or sent outside. Louvers, eliminators and nozzles are blocked. Water spray and plant maintenance is not proper. Rotary filter's felt cloths are missing and waste is transferred to supply air plant.

**b. Recommendation:** The present total running load in blow room department is 60kw.It is recommended to adjust the blade angle of supply air fan to reduce the supply air quantity reduced. It is recommended to clean the louvers, eliminators and nozzles and provide the felt cloth in the rotary filter of waste collection system.

**c. Cost benefit analysis**

**1 Saving:**

Total Actual load in Blow room department = 65kw

Actual load in supply fan =14kw

Expected Energy saving by reducing the air quantity by 25% =4Kw

Expected energy saving per year =4 x 22x351= 30,888 kwh

Cost saving per year = 30,888 X 1.1930 = Birr 36,849.4

**2 Investment (lump sum)**=Nil

**3 Payback period**=Immediate

**d. Benefits and investment:** By implementing this study EAID PLC can save Birr 36,849.4 per annum. The Investment required for implementation is Nil with immediate payback period.

**4.1.16 Optimize the air quantity in supply air and exhaust air plant for Roving department**

**a. Present status:** EAIDPLC has one supply and one exhaust air plant serving comber, drawing and roving machine sections. The supply air plant consists two fans and one pump. Exhaust air plant consists of two fans with rotary filter. The comber section and 4 roving machines are not working. The exhaust air duct of comber waste collection system is connected to exhaust air plant. Louvers, eliminators and nozzles are blocked. Water pump is not working and plant maintenance is not proper. Exhaust air trenches are full of fluff. Traverse motion of nozzles on the rotary filter is not working.

**b. Recommendation:** The present total running load in roving room department is 95kw.It is recommended to adjust the blade angle of supply air fans and exhaust air fans to reduce the air quantity. It is recommended to clean the louvers, eliminators, nozzles and rectify the problem in pump. Provide dummy to supply air duct and exhaust trench of comber section. Provide dummy for the diffuser of supply air duct in the place of no machine areas of roving department. Provide dummy in the exhaust duct of comber waste collection system. Clean the exhaust trench periodically and correct the traverse motion of rotary filter's nozzle.

**c. Cost benefit analysis**

**1 Saving:**

Total Actual load in roving department = 112kw

Actual load in supply fan =15.5+16.5=32kw

Expected Energy saving by reducing the air quantity by 50% =16Kw

Actual load of exhaust air fans =11.13+11.59= 22.72

Expected Energy saving by reducing the exhaust air quantity by 20% =6.32

Total power saving =16 +6.32 =22.32

Expected energy saving per year =22.32 x 22x351 = 172,355.04 kwh

Cost saving per year = 172,355.04 X 1.1930 =Birr 205,620

Investment (lump sum) Fabrication for making dummies =Birr 20,000/

**2 Payback period** = (20,000/ 205,620 ) x 12 = Less than 2 months

**d. Benefits and investment:** By implementing this study EAID PLC can save Birr 205,620 per annum. The Investment required for implementation is Birr 20,000 with payback period of less than 2 months.

**4.1.17 Optimize the air quantity in supply air and exhaust air plant for spinning department**

**a. Present status:** EAIDPLC has two supplies and two exhaust air plant serving ring spinning department. Each supply air plant consists three fans and one pump. Each Exhaust air plant consists of three fans with rotary filter. The spinning department consists of 20 ring frames out of which 6 machines are running. In exhaust plant-A one fan is allotted for open end spinning department. Eliminators and nozzles are blocked. Plant maintenance is not proper. Exhaust air trenches are full of fluff. Traverse motion of nozzles on the rotary filter is not working. During the audit in supply plant-A one fan, in exhaust plant-A 2fans and in exhaust plant-B one fan is not working.

**b. Recommendation:** The present total actual running load in spinning room department is 125kw. It is recommended to adjust the blade angle of supply air fans and exhaust air fans to reduce the air quantity. It is recommended to clean the louvers, eliminators, nozzles and improve the water spray in air washer. Provide dummy diffusers in supply air duct and slit grills in exhaust trench in non-machine running places in spinning department. Clean the exhaust trench periodically and correct the traverse motion of rotary filter's nozzle. At present the exhaust fans 3 numbers are stopped condition. So, no need to run at present spinning department load.

**c. Cost benefit analysis**

**1 Saving:**

Total Actual load in spinning department = 135kw

Actual load in supply plant -A =24.33kw

Actual load in supply plant –B =46.44kw

Total load =70.73kw

Expected Energy saving by reducing the air quantity by 60% =42Kw

Present Actual load of exhaust air fans =28.14

Expected energy saving per year =42 x 22x351 = 324,324 kwh

Cost saving per year = 324,324 X 1.1930 =Birr 386,919

**2 Investment (lump sum):**

Fabrication for making dummies =Birr 25,000

**3 Payback period:** = (25,000/ 386,919) x 12 = Less than 1 months

**d. Benefits and investment:** By implementing this study EAID PLC can save Birr 386,919 per annum. The Investment required for implementation is Birr 25,000 with payback period of less than 2 months.

**4.1.18 Optimize the air quantity in supply air and exhaust air plant for weaving department**

**a. Present status:** EAIDPLC has two supply and four exhaust air plant serving weaving department. Each supply air plant consists two fans and one pump. Each Exhaust air plant consists of one fan with rotary filter. The spinning department consists of 64 air jet looms out of which 43 machines are running. Eliminators and nozzles are blocked. Plant maintenance is not proper. Exhaust air trenches are full of fluff. Traverse motion of nozzles on the rotary filter is not working. All fans are having V- belt drive arrangements.

**b. Recommendation:** The present total actual running load in weaving department is 115kw.It is recommended to reduce the speed by pulley changing in supply air fans and exhaust air fans to reduce the air quantity. It is recommended to clean the louvers, eliminators, nozzles and improve the water spray in air washer. Clean the exhaust trench periodically and correct the traverse motion of rotary filter’s nozzle.

**c. Cost benefit analysis**

**1 Saving:**

Total Actual load in weaving department = 115kw

Actual load in supply plant -A =6.7 +9.9=16.6 kw

Actual load in supply plant –B =19.8+11.48=31.28kw

Total load =47.88kw

Expected Energy saving by reducing the air quantity by 60% =42Kw

Actual load in exhaust plant – A1 =4.64kw

Actual load in exhaust plant –A2 =4.95kw

Actual load in exhaust plant –B1 =6.65kw

Actual load in exhaust plant –B2 =6.62kw

Total exhaust plant load =22.86kw

Expected energy saving per year by supply air plant reducing the fan speed for 60% air quantity reduction =28 x 22x351 = 216,216 kwh

Cost saving per year = 216,216 X 1.1930 =Birr 257,946

**2 Investment:**

Cost of pulley =Birr 2,000 per pulley

Number of pulleys required =4

Total investment =Birr 8,000/

**3 Payback period:** = (8,000/257,946) x 12 = Less than 1 month

**d. Benefits and investment:** By implementing this study EAID PLC can save Birr 257,946 per annum. The Investment required for implementation is Birr 8,000 with payback period of less than one month.

Table 4 2.Energy saving opportunities

| S/ No. | Description | U/M | Energy saving per year | Savings In Birr | Investment In Birr | Pay Back Period in months |
|---|---|---|---|---|---|---|
| 1 | Effectively usage of energy meter | Kwh | 163270.8 | 194,782.06 | 0 | 0 |
| 2 | Improving the power factor (power demand reduction) | Kva | 232.07 | 19,734 | 50,000 | 3 |
| 3 | Avoid the idle running of machines in Ginning mill | Kwh | 140,400 | 167,497 | 90,000 | 7 |
| 4 | Insulating the un-insulated feed water tank in boiler room (Diesel saving) | Liter | 2,044 | 126,728 | 46795 | 5 |
| 5 | Switch off the lighting in no production areas | Kwh | 151,463 | 180,695.36 | 0 | 0 |
| 6 | Optimize the fan speed in ginning mill | Kwh | 263,952 | 314,894.74 | 14,000 | 1 |
| 7 | Replace the existing V belt by cogged belt for fans in ginning mill | Kwh | 15,350 | 18,312.55 | 0 | 0 |
| 8 | Arrest leakages in compressed air distribution system | Kwh | 934,390 | 1,114,727.27 | 726,000 | 8 |
| 9 | Optimize the running of air driers in compressor room | Kwh | 45,490 | 54,269.57 | 27,500 | 6 |
| 10 | Waste heat recovery from screw compressor (diesel saving) | Liter | 94,402 | 5,852,924 | 600,000 | 2 |
| 11 | Arrest the leakages in automatic waste collection system no 1 of carding machines | Kwh | 108,108 | 128,972.84 | 7,000 | 1 |
| 12 | Avoid idle running of central suction fan for overhead cleaners | Kwh | 21,818 | 26,028.87 | 0 | 0 |
| 13 | Installation of indication lamps for avoiding idle running of motors in humidification and automatic waste collection system | Kwh | 126255 | 150,622.22 | 126,000 | 10 |
| 14 | Installation of submeters for processing machines | Kwh | 435,600 | 519,670.80 | 70,000 | 2 |
| 15 | Optimize the air quantity in supply air plant for blow room department | Kwh | 30888 | 36,849.38 | 0 | 0 |
| 16 | Optimize the air quantity in supply and exhaust air plant for roving department | Kwh | 172355 | 205,619.52 | 20,000 | 2 |
| 17 | Optimize the air quantity in supply and exhaust air plant for spinning department | Kwh | 324,324 | 386,918.53 | 25,000 | 1 |
| 18 | Optimize the air quantity in supply air plant for weaving department | Kwh | 216216 | 257,945.69 | 8,000 | 1 |
| **Total** | | | **3,246,557.87** | **9,757,192.67** | **1,810,295.00** | **4- (Average)** |

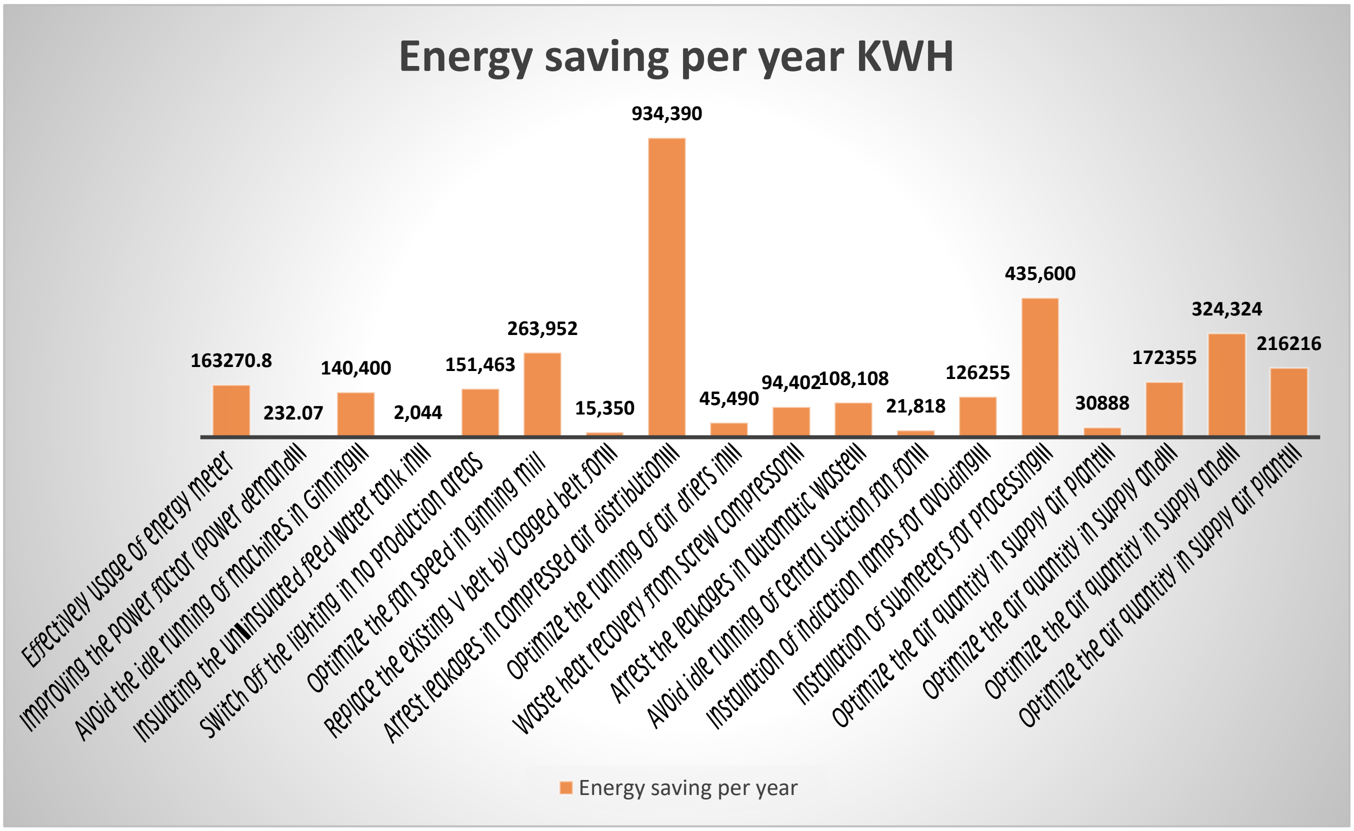


Figure.4. 2.Shows Energy Saving in KWH using different Saving opportunities

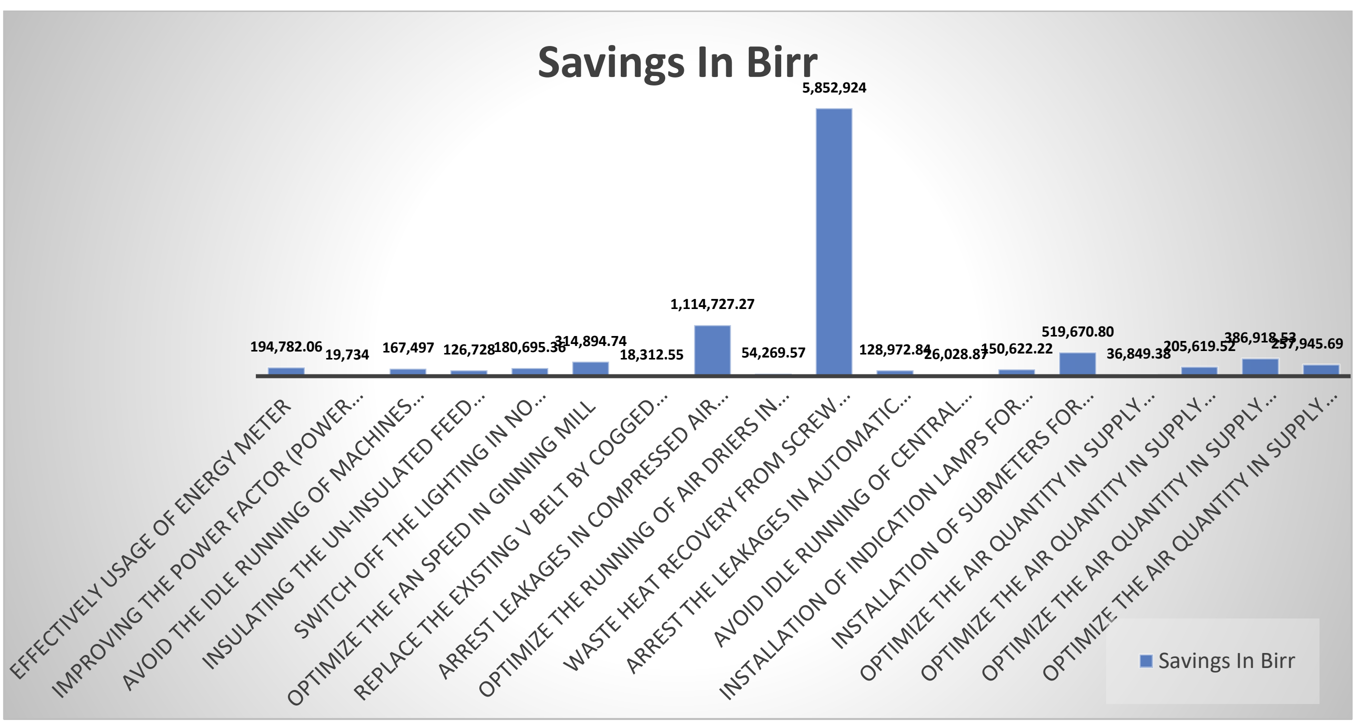


Figure.4. 3.Shows Energy Saving in birr using Saving opportunities

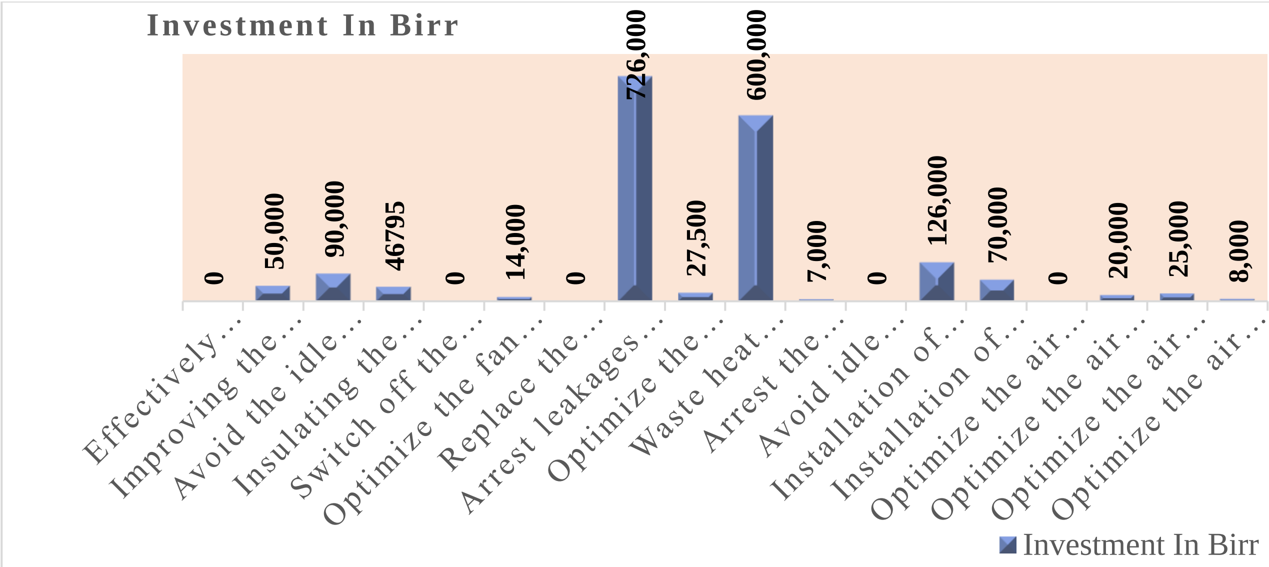


Figure.4. 4.Shows Investment needed for each Saving opportunities

## 4.2. Stastical Analysis

### 4.2.1. Descriptive Statistics of Variables

Descriptive statistic of means and standard deviations were obtained from the independent and dependent variables. The descriptive analysis is used to look at the data collected and describe that information. Mean value provides the idea about the central tendency of the values of a variable. On the other hand, Standard deviation gives the idea about the dispersion of the values of a variable from its mean value.

Table 4 3. Descriptive statistics analysis

| | Energy Saving Opportunity | Energy saving per year | Savings in Birr | Investment in Birr | Pay Back Period in months |
|---|---|---|---|---|---|
| N | 18 | 18 | 18 | 18 | 18 |
| Mean | | 180364.3 | 542066.2 | 100571.9 | 2.7222 |
| Std. Deviation | | 222045.3 | 1350332.4 | 208731.1 | 3.12119 |
| Variance | | 49304139677 | 1823397755009 | 435686549320 | 9.742 |
| Skewness | | 2.550 | 4.002 | 2.621 | 1.165 |
| Kurtosis | | 7.847 | 16.460 | 5.928 | 0.247 |

a. Multiple modes exist. The smallest value is shown

Kurtosis is used to measure the peakiness of the curve of the frequency distribution (Kothari, 2004). The index of skewness takes the value zero for a symmetrical distribution. A positive skewness value indicates right skew while a negative value indicates left skew. The kurtosis index measures the extent to which the peak of a unimodal frequency distribution departs from the shape of normal distribution. A value of zero corresponds to a normal distribution; positive values indicate a distribution that is more pointed than a normal distribution and a negative value a flatter distribution. As shown in table above, all items show close to normal distribution considering the criteria proposed by George and Mallery (2010) of Skewness and kurtosis values between -2 and 2. In general, the normal distribution makes a straight diagonal line, and the plotted residuals are compared with the diagonal (Hair, et al., 1998). Therefore, the data used in this study was normally distributed.

Figure 4.5 to 4.7 below shows the frequency distribution of the standardized residuals compared to a normal distribution. As you can see, although there are some residuals (e.g., those occurring around 0) that are relatively far away from the curve, many of the residuals are fairly close. Moreover, the histogram is bell shaped which lead to infer that the residual (disturbance or errors) is normally distributed. Thus, no violations of the assumption normally distributed error term.

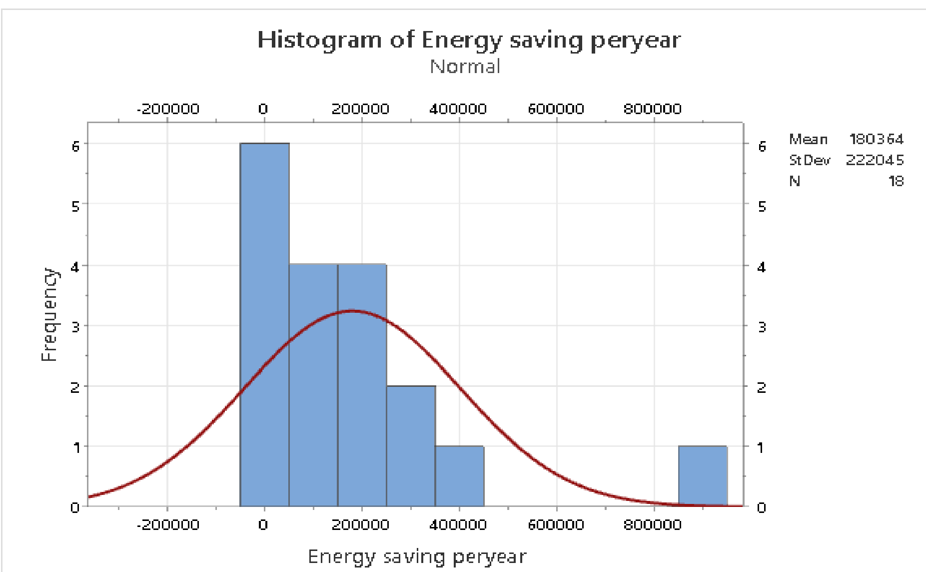


Figure.4. 5. Energy saving histogram distribution

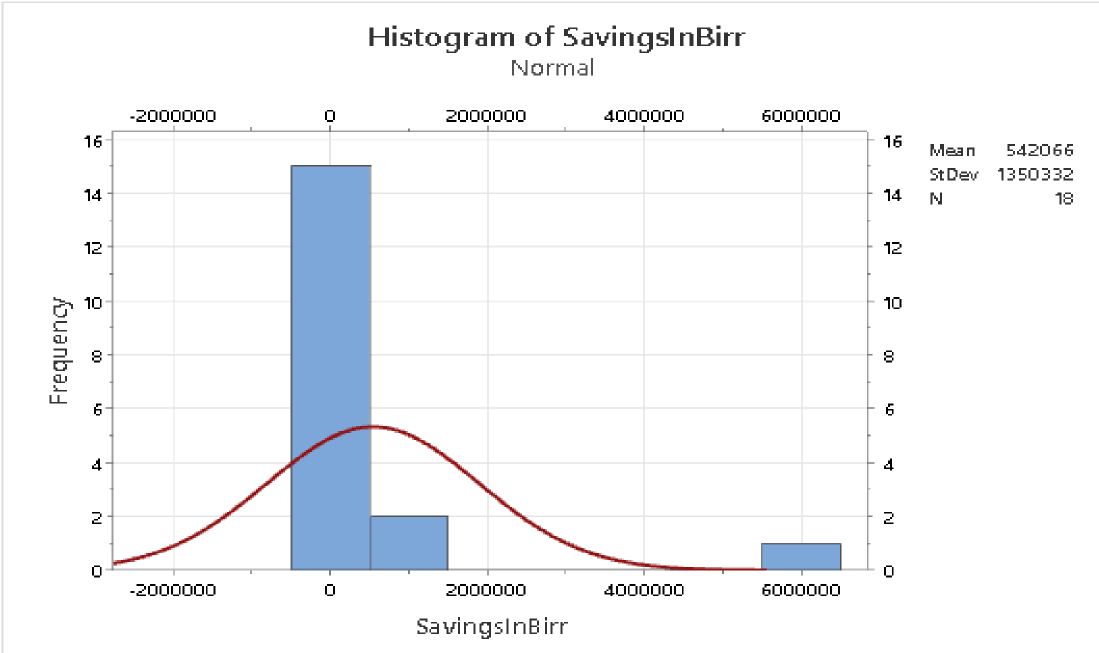


Figure.4. 6.Saving in birr histogram distribution

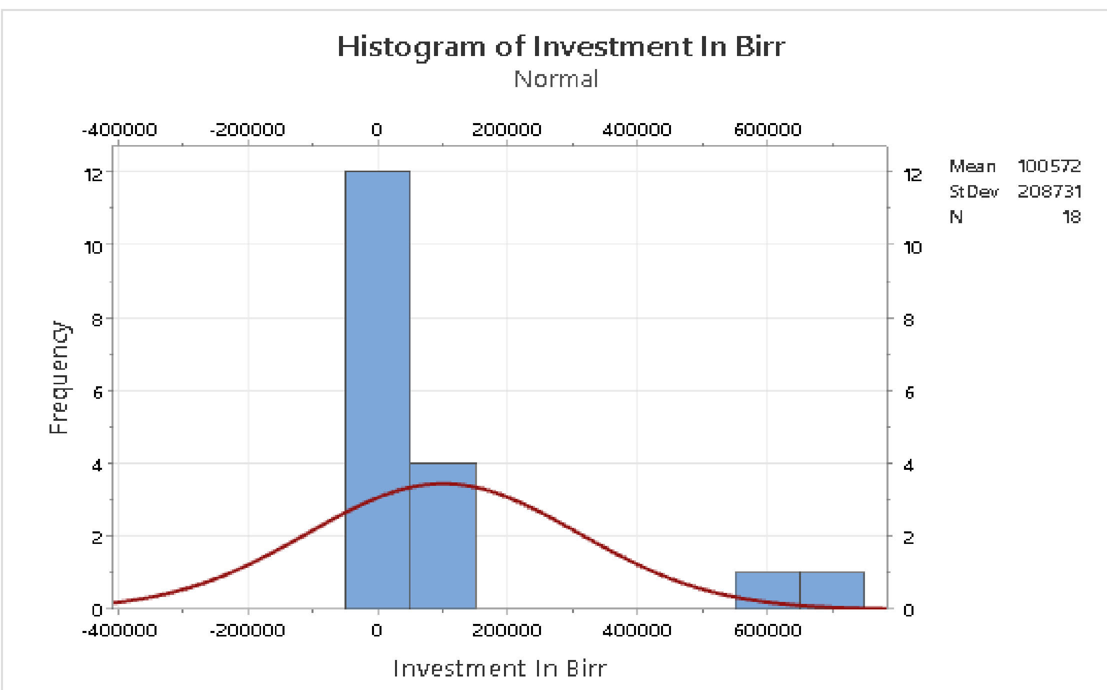


Figure.4. 7.Investement in birr histogram distirbution

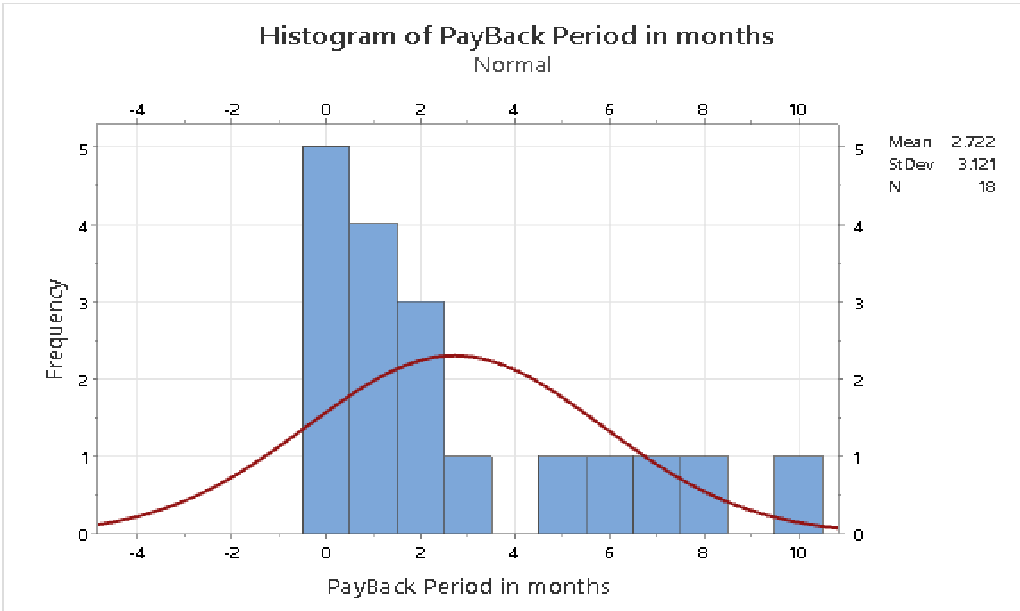


Figure.4. 8.Payback period histogram distirbution

### 4.2.2. Correlation of the dependent and independent variables

The correlation of the variable is measured by Pearson correlation coefficient. The result of the Pearson correlation is presented on the following table and interpreted by the guideline suggested by Field (2005), he mentioned that the Pearson correlation coefficient is shown the relationship and direction between the predictor and outcome variable. And, their relationship is measured in the range of 0.1 to 0.29 is weak relationship, 0.30 to 0.49 is moderate, above 0.50 show strong relationship; while the positive and negative sign is telling us the direction of their relationship.

Table 4 4.Correlations analysis

| Correlations | Energy saving per year | Savings in birr | Investment in birr | Payback period in months |
|---|---|---|---|---|
| Energy saving per year | 1 | 0.094 | 0.618** | 0.296 |
| Savings in birr | 0.094 | 1 | 0.718** | 0.004 |
| Investment in birr | 0.618** | 0.718** | 1 | 0.429* |
| Payback period in months | 0.296 | 0.004 | 0.429* | 1 |

**. Correlation is significant at the 0.01 level (1-tailed), *. Correlation is significant at the 0.05 level (1-tailed).

The Pearson's correlation coefficient should be between -1 and 1. The proximity to 1 despite the sign showed the strength of the relationship. Coming to the variables in this study the correlation coefficient between energy saving per year and investment in birr is r =0.618 that falls within the range r = 0.50 to 1.0, a sign of strong relationship. With regard to the direction of the relationship both variables have a positive sign that dictates a positive change in the independent variable can result in a positive change in the dependent variables. When we assess the level of significance, there is significant relationship between the independent variable and dependent variable. This is witnessed by *p* values and *p* = 0.01 level. Also savings in birr and Investment in birr ( r =0.718), Investment in birr and savings in birr ( r =0.718), and Investment in birr and Energy saving per year ( r =0.618), are positively correlated to each other at *p* = 0.01segnificant leve.

## 4.3 General Findings, Observation and Recommendation During Energy Audit& Tips for Energy Conservation

### 4.3.1 Ginning

1. The seed cotton is feed from seed cotton go-down by person. During the energy audit I found that there is no accountability and monitoring mechanism for feeding the raw material. This causes more idle running of machines.

Figure.4. 9.Seed cotton preparation for removal of sand

It is recommended to install feed hood in place of necked pipe to improve the material feed.

Install perforated top table for feeding the seed cotton for better removal of sand and stone etc.

2. There is no indication for electrical power distribution for machineries and lightings.

Figure.4. 10.power distribution circuit Breaker

3. Belt guards are not provided for the fan for trash in the pre- cleaner machine and all other fans running in the waste go-down.


Figure.4. 11.pre- cleaner machine

4. There is no proper preventive maintenance carried out and no records.

Figure.4. 12.Ginning Department

5. The energy meter is available in the medium voltage panel board of the transformer.

Take necessary actions to correct the energy meter for daily monitoring of energy consumption and compare with production data to improve energy efficiency.

6. The lighting are in on condition even bright sun light is available

### 4.2.2 Spinning

1. There are twenty ring frames installed. Each machine has one overhead travelling cleaner, but only three of them are in working condition and in the rest of OHTC the motor or any other components are removed. For these 20 OHTC two fans are used for central waste collection system and they are working.

***Recommendation:*** Switch off the two fans and manually collect the waste from OHTC as in roving machines

**a) <u>Lighting:</u>**

1. Many numbers of machines are not working but, the lightings are switched-on in unproductive machine areas.

***Recommendation:*** Switch-off the lights and remove the light bulbs in unwanted areas. There is no identification for controlling switch in the lighting distribution board for easy control of each lighting circuit. Electrical department shall identify each circuit and train the operators to switch-off the lights.

2. In drawing department one electronic balance is connected to in the one lighting circuit. Because of this the one is switched-on for giving supply to the electronic balance.

***Recommendation:*** Provide separate supply to the balance and switch-off the lighting circuit.

**b) Carding:**

1. Six carding machines are stopped because of spares but the cards are connected to the waste collection lines.

***Recommendation:***Make it shut off the suction air by closing the dampers.

2. The carding machines chute exhaust is connected through the fan and connected to the waste collection unit. Currently the fans are not running.

***Recommendation:*** If the fan is not required remove it and connect the chute exhaust direct to the filter unit.

**4.2.3. Humidification plant and waste collection system**

**1) Blow room:** Maintenance of humidification plants is not satisfactory

a) Louvers are blocked and not cleaned

b) Pump motor bearing worn out

c) Felt cloth mixing in the rotary filter.

d) Nozzle drive mechanism is not proper in the rotary filter

e) Waste screen filters are blocked and not fixed properly.

**2) Carding, waste collection system and humidification plant**

a) Water Screen filter not proper.

b) Felt cloth mixing in the rotary filter.

c) Dust fan bearing failed.

d) More dust in the filter room area.

e) Carding line one waste collection system main fan bed is broken and the wall near the door of the fan room is broken. It makes more air leakage as well as re-circulation of air and makes it more energy consumption.

**3) Roving humidification plant**

a) More fluff in the exhaust trench and it is not properly cleaned.

b) Water pump is under repair.

c) Louvers are blocked.

d) Rotary filter nozzle traverse function is not working. Comber waste collection system's exhaust is connected to this plant. Now the comber machines are running so make it provide dummy for this duct.

**4.2.4. Ring spinning A & B plant**

**1) Plant A:**

a) Rotary filter Nozzle Traverse motion is not working

b) Exhaust trench is full of waste

c) Two exhaust fans are not working out of three

**2) Plant B:**

a) Rotary filter No 1's Nozzle traverse motion is not working

Run the pumps at optimum speed to get proper water spray. Now the pumps are running at 10HZ.i.e., approximately the pump speed is 300rpm. So, the water spray in the air washer is not proper.

The nozzles and eliminator are fully blocked. It is recommended to clean the eliminators, louvers and nozzles periodically.

One exhaust fan not work out of three.

**Open end spinning humidification plant**

- ⇨ Now the Humidification plant is placed in the first floor. It is prefabricated one. Now the plant operation is not proper. When the water is filled in the tank it comes out due to leakage. The plant is running without water spray and RH is not maintained in the department. It is recommended to make leak proof or shift it to ground floor.

**Open end and winding humidification**

- ⇨ One supply fan is not working due to contactor problem.
- ⇨ Exhaust trench is full of dust. Not properly cleaned.
- ⇨ Nozzle drive for rotary filter is not working.
- ⇨ Nozzle hose is broken.

**4.2.5. Weaving**

**a) Weaving humidification plant**

- ⇨ Rotary filer nozzle traverse motion is not working in both plants.
- ⇨ Trench and filer room are full of fluff.
- ⇨ Supply air plants are not cleaned. Louvers are blocked, water spray is not proper.

⇨ Corrective and preventive actions are not proper to set right the problems. Example: plant no2 the exhaust fan motor's belt comes out from the pulley.

Figure.4. 13.Pictures of present condition of humidification plants

**b) General points for humidification plants**

a) There is no proper identification in the electric panel for each motor.

b) The wirings are not proper.

c) There is no record available for the maintenance and works are carried out by the operators.

d) The plants are having the maintenance schedule but not properly followed. There is no monitoring the works carried out by the operator.

e) There is closer watch required for the maintenance and operation of the plants.

f) Now the RH and temperature controlled through centralized controller and it is handled by the plant operator. Create the documents for department temperature & RH and get approval from shift in charge.
g) Create the document for maintenance and history record for the plant.
h) Install indication lamps for humidification and waste collection plants for the working status of motors in the production department.
i) Provide compressed air points for all plants for cleaning the rotary filters.
j) Establish 5s principle for fixed point photography covering the all elements of humidification plants.

### 4.2.6. Compressors and compressed air distribution system

- ✓ Now Insulations are provided for header pipes and receiver tank. There is no need of insulation for this system. This make overload the refrigerated air drier.

Figure.4. 14.Compressors and compressed air distribution system

- ✓ Remove the insulation
- ✓ The hot air exhaust duct of compressors should be raised above the roof.
- ✓ Install more louvers in the south side wall of compressor room.
- ✓ Install the pressure in the distribution header to know about the pressure loss across the filters and driers.
- ✓ Compressed air leakage is more than 60% by checking through one compressor.

***Recommendation:*** Implement the monthly compressed air leakage management program to arrest the leakage and save the energy.

- ✓ There is no records available for maintenance of compressors and air driers etc..

Compressed air is used for floor and personnel cleaning.

***Recommendation:*** Make necessary action to restrict the usage of compressed for floor cleaning.

- ✓ Transformer no 4 is feeding to compressor, weaving and office lighting. The energy meter is available for this transformer. But the power consumption is not recorded

***Recommendation:*** Make use of this energy meter for daily monitoring the energy consumption of compressor and take necessary action to reduce the energy consumption.

- ✓ Install roof ventilator for exhausting hot air from the compressor room
- ✓ Lighting is not sufficient for compressor room.

**Electrical**

- There are no records for preventive maintenance of motors and machine electric system.
- There is no log book for power consumption and problems attended by the electricians.
- There is no identification of supply feeding to the machines in all panel boards.
- There is no proper duties and responsibilities for electrical department persons.
- There is no record for history of motors.
- The energy meters are available for transformers installed in all departments. But it is not used

***Recommendation:*** Make it correct for proper function and create the log book for shift wise monitoring of voltage, current, power factor, KWH, etc..,

- Already the Automatic power factor controller, capacitor and contactors are installed in each transformer MV panel.

***Recommendation:*** Take necessary action for functioning.

**Boiler house**

- Insulate the feed water and condensate tank to avoid heat loss from the tank and reduce the fuel consumption.

- There is no flow meter for water and diesel consumption. Already the steam flow meter is installed but it is not working.

***Recommendation:*** Install flow meter for feed water and calibrate the diesel tank for micro level scale for taking hourly fuel consumption and water consumption. Also make it correct the flow meter for steam.

**General:**

- It is recommended to fire sprinkler system for cotton go-down in the main plant. As well as seed cotton go-down in ginning plant.
- Create energy management team with participants of all department heads and review the energy consumption on monthly basis.

## 4.3. Tips for energy conservation

**Boilers :**

- Preheat combustion air with waste heat

(*22 0C reduction in flue gas temperature increases boiler efficiency by 1%*)

- Use variable speed drives on large boiler combustion air fans with variable flows.
- Burn wastes if permitted.
- Insulate exposed heated oil tanks.
- Clean burners, nozzles, strainers, etc.
- Inspect oil heaters for proper oil temperature.
- Close burner air and/or stack dampers when the burner is off to minimize heat loss up the stack.
- Improve oxygen trim control (e.g. limit excess air to less than 10% on clean fuels).

*(5% reduction in excess air increases boiler efficiency by 1% or: 1% reduction of residual oxygen in stack gas increases boiler efficiency by 1 %.)*

- Automate/optimize boiler blow down. Recover boiler blow down heat.
- Use boiler blow down to help warm the back-up boiler.

- Optimize de aerator venting.
- Inspect door gaskets.
- Inspect for scale and sediment on the water side

(*A 1mm thick scale (deposit) on the water side could increase fuel consumption by 5 to 8%*)

- Inspect for soot, fly ash, and slag on the fire side

*(A 3mm thick soot deposition on the heat transfer surface can cause an increase in fuel consumption to the tune of 2.5 %.)*

- Optimize boiler water treatment.
- Add an economizer to preheat boiler feed water using exhaust heat.
- Recycle steam condensate.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple boilers.
- Consider multiple or modular boiler units instead of one or two large boilers.
- Establish a boiler efficiency-maintenance program. Start with an energy audit and follow-up, then make a boiler efficiency-maintenance program a part of your continuous energy management program.

**4.3.1. Steam System**

- Fix steam leaks and condensate leaks

*(A 3 mm diameter hole on a pipe line carrying 7 $kg/cm^2$ steam would waste 33 kilo litters of fuel oil per year)*

- Accumulate work orders for repair of steam leaks that can't be fixed during the heating season due to system shutdown requirements. Tag each such leak with a durable tag with a good description.
- Use back pressure steam turbines to produce lower steam pressures.
- Use more-efficient steam de superheating methods.
- Ensure process temperatures are correctly controlled.
- Maintain lowest acceptable process steam pressures.

- Reduce hot water wastage to drain
- Remove or blank off all redundant steam piping.
- Ensure condensate is returned or re-used in the process

*(6 $^{0}$C raise in feed water temperature by economizer/condensate recovery corresponds to a 1% saving in fuel consumption, in boiler)*

- Preheat boiler feed-water.
- Recover boiler blow down.
- Check operation of steam traps.
- Remove air from indirect steam using equipment

(*0.25 mm thick air film offers the same resistance to heat transfer as a 330 mm thick copper wall*)

- Inspect steam traps regularly and repair malfunctioning traps promptly.
- Consider recovery of vent steam (*e.g. -- on large flash tanks*).
- Use waste steam for water heating.
- Use an absorption chiller to condense exhaust steam before returning the condensate to the boiler.
- Use electric pumps instead of steam ejectors when cost benefits permit
- Establish a steam efficiency-maintenance program. Start with an energy audit and follow-up, then make a steam efficiency-maintenance program a part of your continuous energy management program.

**4.3.2. Insulation**

- Repair damaged insulation
- *(A bare steam pipe of 150 mm diameter and 100 m length, carrying saturated steam at 8 kg/cm$^2$ would waste 25,000 liters furnace oil in a year.)*
- Insulate any hot or cold metal or insulation.
- Replace wet insulation.

- Use an infrared gun to check for cold wall areas during cold weather or hot wall areas during hot weather.
- Ensure that all insulated surfaces are claded with aluminum
- Insulate all flanges, valves and couplings
- Insulate open tanks

*(70% heat losses can be reduced by floating a layer of 45 mm diameter polypropylene (plastic) balls on the surface of 90 $^{0}$C hot liquid/condensate).*

**4.3.3. Waste heat recovery**

- Recover heat from flue gas, engine cooling water, engine exhaust, low pressure waste steam, drying oven exhaust, boiler blow down, etc.
- Recover heat from incinerator off-gas.
- Use waste heat for fuel oil heating, boiler feed water heating, outside air heating, etc.
- Use chiller waste heat to preheat hot water.
- Use heat pumps.
- Use absorption refrigeration.
- Use thermal wheels, run-around systems, heat pipe systems, and air-to-air exchangers.

**4.3.4. Electricity Distribution System**

- Optimize the tariff structure with utility supplier
- Schedule your operations to maintain a high load factor
- Shift loads to off-peak times if possible.
- Minimize maximum demand by tripping loads through a demand controller
- Stagger start-up times for equipment with large starting currents to minimize load peaking.
- Use standby electric generation equipment for on-peak high load periods.
- Correct power factor to at least 0.90 under rated load conditions.
- Relocate transformers close to main loads.
- Set transformer taps to optimum settings.
- Disconnect primary power to transformers that do not serve any active loads

- Consider on-site electric generation or cogeneration.
- Export power to grid if you have any surplus in your captive generation
- Check utility electric meter with your own meter.
- Shut off unnecessary computers, printers, and copiers at night.

**1) Motors:**

- Properly size to the load for optimum efficiency.

*(High efficiency motors offer of 4 - 5% higher efficiency than standard motors)*

- Use energy-efficient motors were economical.
- Use synchronous motors to improve power factor.
- Check alignment of belts and pulleys.
- Provide proper ventilation

*(For every 10 $^{o}$c increase in motor operating temperature over recommended peak, the motor life is estimated to be halved)*

- Check for under-voltage and over-voltage conditions.
- Balance the three-phase power supply.

(*An imbalanced voltage can reduce 3 - 5% in motor input power*)

- Demand efficiency restoration after motor rewinding.

*(If rewinding is not done properly, the efficiency can be reduced by 5 - 8%)*

**2) Drives:**

- Use variable-speed drives for large variable loads.
- Use high-efficiency gear sets.
- Use precision alignment.
- Check belt tension regularly.
- Eliminate variable-pitch pulleys.
- Use flat belts as alternatives to v-belts.
- Use synthetic lubricants for large gearboxes.
- Eliminate eddy current couplings.

- Shut them off when not needed.

**3) Fans:**

- Use smooth, well-rounded air inlet cones for fan air intakes.
- Avoid poor flow distribution at the fan inlet.
- Minimize fan inlet and outlet obstructions.
- Clean screens, filters, and fan blades regularly.
- Use aero foil-shaped fan blades.
- Minimize fan speed.
- Use low-slip or flat belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable fan loads.
- Use energy-efficient motors for continuous or near-continuous operation
- Eliminate leaks in ductwork.
- Minimize bends in ductwork
- Turn fans off when not needed.

**4) Blowers:**

- Use smooth, well-rounded air inlet ducts or cones for air intakes.
- Minimize blower inlet and outlet obstructions.
- Clean screens and filters regularly.
- Minimize blower speed.
- Use low-slip or no-slip belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable blower loads.
- Use energy-efficient motors for continuous or near-continuous operation.
- Eliminate ductwork leaks.
- Turn blowers off when they are not needed.

5) **Pumps:**

- Operate pumping near best efficiency point.
- Modify pumping to minimize throttling.
- Adapt to wide load variation with variable speed drives or sequenced control of smaller units.
- Stop running both pumps -- add an auto-start for an on-line spare or add a booster pump in the problem area.
- Use booster pumps for small loads requiring higher pressures.
- Increase fluid temperature differentials to reduce pumping rates.
- Repair seals and packing to minimize water waste.
- Balance the system to minimize flows and reduce pump power requirements.

6) **Compressors:**

- Consider variable speed drive for variable load on positive displacement compressors.
- Use a synthetic lubricant if the compressor manufacturer permits it.
- Be sure lubricating oil temperature is not too high (*oil degradation and lowered viscosity*) and not too low (*condensation contamination*).
- Change the oil filter regularly.
- Periodically inspect compressor intercoolers for proper functioning.
- Use waste heat from a very large compressor to power an absorption chiller or preheat process or utility feeds.
- Establish a compressor efficiency-maintenance program. Start with an energy audit and follow-up, then make a compressor efficiency-maintenance program a part of your continuous energy management program.
- Install a control system to coordinate multiple air compressors.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple air compressors.
- Avoid over sizing -- match the connected load.
- Load up modulation-controlled air compressors. (They use almost as much power at partial load as at full load.)
- Turn off the back-up air compressor until it is needed.

- Reduce air compressor discharge pressure to the lowest acceptable setting.

*(Reduction of 1 kg/cm$^2$ air pressure (8 kg/cm$^2$ to 7 kg/cm$^2$) would result in 9% input power savings. This reduce* compressed air leakage rates by 10%)

- Use the highest reasonable dryer dew point settings.
- Turn off refrigerated and heated air dryers when the air compressors are off.
- Use a control system to minimize heatless desiccant dryer purging.
- Minimize purges, leaks, excessive pressure drops, and condensation accumulation.

*(Compressed air leak from 1mm hole size at 7 kg/cm$^2$ pressure would mean power loss equivalent to 0.5 kW).*

- Use drain controls instead of continuous air bleeds through the drains.
- Consider engine-driven or steam-driven air compression to reduce electrical demand charges.
- Replace standard v-belts with high-efficiency flat belts as the old v-belts wear out.
- Use a small air compressor when major production load is off.
- Take air compressor intake air from the coolest (but not air conditioned) location.

*(Every 5$^0$C reduction in intake air temperature would result in 1% reduction in compressor power consumption)*

➢ Use an air-cooled after cooler to heat building makeup air in winter.

➢ Be sure that heat exchangers are not fouled (e.g. with oil).

➢ Be sure that air/oil separators are not fouled.

➢ Monitor pressure drops across suction and discharge filters and clean or replace filters promptly upon alarm.

➢ Use a properly sized compressed air storage receiver.

- Consider alternatives to compressed air such as blowers for cooling, hydraulic rather than air cylinders, electric rather than air actuators, and electronic rather than pneumatic controls.
- Use nozzles or venture-type devices rather than blowing with open compressed air lines.
- Check for leaking drain valves on compressed air filter/regulator sets. Certain rubber-type valves may leak continuously after they age and crack.
- In dusty environments, control packaging lines with high-intensity photocell units instead of standard units with continuous air purging of lenses and reflectors.
- Establish a compressed air efficiency-maintenance program. Start with an energy audit and follow-up, then make a compressed air efficiency-maintenance program a part of your continuous energy management program.

**7) Lighting:**

- Reduce excessive illumination levels to standard levels using switching; de lamping, etc. (*Know the electrical effects before doing de lamping*).
- Aggressively control lighting with clock timers, delay timers, photocells, and/or occupancy sensors.
- Install efficient alternatives to incandescent lighting, mercury vapor lighting, etc. Efficacy (lumens/watt) of various technologies range from best to worst approximately as follows: low pressure sodium, high pressure sodium, metal halide, fluorescent, mercury vapor, incandescent.
- Select ballasts and lamps carefully with high power factor and long-term efficiency in mind.
- Upgrade obsolete fluorescent systems to Compact fluorescents and electronic ballasts
- Consider day lighting, skylights, etc.
- Consider painting the walls a lighter color and using less lighting fixtures or lower wattages.
- Use task lighting and reduce background illumination.
- Re-evaluate exterior lighting strategy, type, and control. Control it aggressively.

- Change exit signs from incandescent to LED.

**8) DG sets (when available):**

- Optimize loading
- Use waste heat to generate steam/hot water /power an absorption chiller or preheat process or utility feeds.
- Use jacket and head cooling water for process needs
- Clean air filters regularly
- Insulate exhaust pipes to reduce DG set room temperatures
- Use cheaper heavy fuel oil for capacities more than 1MW

**9) Water & Wastewater:**

- Recycle water, particularly for uses with less-critical quality requirements.
- Recycle water, especially if sewer costs are based on water consumption.
- Balance closed systems to minimize flows and reduce pump power requirements.
- Eliminate once-through cooling with water.
- Use the least expensive type of water that satisfy the requirement.
- Fix water leaks.
- Test for underground water leaks. (It's easy to do over a holiday shutdown.)
- Check water overflow pipes for proper operating level.
- Automate blow down to minimize it.
- Provide proper tools for wash down -- especially self-closing nozzles.
- Install efficient irrigation.
- Do not use a central heating system hot water boiler to provide service hot water during the cooling season -- install a smaller, more-efficient system for the cooling season service hot water.
- Consider the installation of a thermal solar system for warm water.
- If water must be heated electrically, consider accumulation in a large insulated storage tank to minimize heating at on-peak electric rates.
- Use multiple, distributed, small water heaters to minimize thermal losses in large piping systems.

- Use freeze protection valves rather than manual bleeding of lines.
- Consider leased and mobile water treatment systems, especially for de-ionized water.
- Seal sumps to prevent seepage inward from necessitating extra sump pump operation.
- Install pretreatment to reduce TOC and BOD surcharges.
- Verify the water meter readings. (You'd be amazed how long a meter reading can be estimated after the meter breaks or the meter pit fills with water!)
- Verify the sewer flows if the sewer bills are based on them

**10) Miscellaneous:**

- Meter any unmetered utilities. Know what normal efficient use is. Track down causes of deviations.
- Shut down spare, idling, or unneeded equipment.
- Make sure that all of the utilities to redundant areas are turned off -- including utilities like compressed air and cooling water.
- Install automatic control to efficiently coordinate multiple air compressors, chillers, cooling tower cells, boilers, etc.
- Renegotiate utilities contracts to reflect current loads and variations.
- Consider buying utilities from neighbors, particularly to handle peaks.
- Leased space often has low-bid inefficient equipment. Consider upgrades if your lease continue for several more years.
- Adjust fluid temperatures within acceptable limits to minimize undesirable heat transfer in long pipelines.
- Minimize use of flow bypasses and minimize bypass flow rates.
- Provide restriction orifices in purges (nitrogen, steam, etc.).
- Eliminate unnecessary flow measurement orifices.
- Consider alternatives to high pressure drops across valves.
- Turn off winter heat tracing that is on in summer.

The results and discussion for energy audits and energy conservation in the textile industry could include:

1. Energy audits: The study find that textile companies can benefit from conducting energy audits to identify areas of energy waste and opportunities for improvement. The study guides how to conduct an energy audit, including the use of energy management systems (EMS) and energy monitoring and targeting (M&T) tools.

2. Energy conservation measures: The study identifies a range of energy conservation measures that textile companies can implement to reduce energy consumption and costs. These measures include improving insulation, optimizing lighting and HVAC systems, and using energy-efficient equipment and machinery.

3. Economic benefits: The study find that energy conservation measures can result in significant cost savings for the companies.

4. Environmental benefits: The study also find that energy conservation measures can result in environmental benefits, such as reduced greenhouse gas emissions and improved air and water quality.

5. Challenges and barriers: The study identifies challenges and barriers for implementing energy conservation measures in the textile industry, such as lack of awareness and knowledge, lack of financial resources, and resistance to change.

6. Policy and regulatory framework: The study provides an overview of the policy and regulatory framework related to energy audits and energy conservation in the textile industry, and make recommendations for policy and regulatory changes to support energy conservation efforts.

7. Future research: The study identifies areas for further research, such as the effectiveness of different energy conservation measures in the textile industry, the role of employee engagement and training in energy conservation efforts, and the potential for renewable energy sources in the textile industry.

Overall, the results and discussion of the study was provide valuable insights for textile companies looking to improve their energy efficiency and reduce their environmental impact, as well as for policymakers and regulators seeking to support energy conservation efforts in the industry.

# CHAPTER FIVE

# 5. CONCLUSIONS AND RECOMMENDATIONS

## 5.1. Conclusions

In conclusion, energy auditing and conservation in textile industries is an important issue that requires attention from both the industry and policymakers. The textile industry is a significant energy consumer and contributor to greenhouse gas emissions, making it essential to implement energy-saving measures. Energy auditing and conservation initiatives provide a framework for identifying and quantifying energy consumption patterns, identifying areas of energy waste, and developing strategies for reducing energy consumption. Energy conservation measures can also lead to improvements in the quality of production processes and products, as well as improve the overall sustainability of the industry. Therefore, it is crucial for textile industries to prioritize energy auditing and conservation as part of their overall sustainability strategy.

In this Energy Efficiency Audit Study:-

- Different Energy Efficiency Equipment and Energy Saving Departments in the ELSE Addis Industrial Development plc were analysed.
- The economic analysis was based on a simple payback period of less than five month for the investment made.
- The majority of the measures were low-cost measures with short payback periods.
- By implementing these measures, the plant can save energy **per year in KWH=3150111.87 and Diesel Saving in Letters=3150111.87.**
- Genarally the plants Annual Savings **ETB= 9,757,192.67** with a short payback period and investment required for implementation **ETB =1,810,295.**
- By implementing these measures, the plant can save energy to increase and enhance its production capacity as well as competitiveness in the global market.

## 5.2. Recommendation

Energy is vital in the production of Textile. The cost of energy directly affects the price of Textile. This has a direct effect on the Competitiveness of the factory. Reducing the energy wastage and improving the energy efficiency leads to increase the productivity and the competitiveness of the factory. Based on the energy audit in this textile plant, it is recommended to take the following measures in order to decrease the energy waste and cost.

- Should increase awareness of energy issues and energy conservation concern within the professional, semiprofessional and for all workers as a whole.
- Implement ISO 50001 energy management system
- Should support utilization of renewable energy sources especially solar power as sun-shine is abundant and clean source of energy.
- Should improve house-keeping measures in all area like in lighting facilities such as;
  - Always turning off lights when they are not needed. This can be achieved by using stickers or reminders to make employees more aware.
  - Regular maintenance checks of the lighting especially cleaning of lamps to remove dirt.
  - The use of daylight to maximize the advantage to reduce lighting should be encouraged.
- Should introduce energy management systems and guidelines that help in development and implementation of key process technologies that aid in reduction of energy consumption and energy cost.

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# Appendices

## 1.Actual power consumption of machines:

| Department | Operation | Machine Name | Number of Machine | Actual Load in KW | Remark |
|---|---|---|---|---|---|
| Ginning | Cleaner | Pre-cleaner | 1 | 5.6 | |
| | | Pre-cleaner trash fan | 1 | 6.9 | |
| | | Fine cleaner | 1 | 28.13 | |
| | Press machine | Bale press | 1 | 25.11 | |
| | | Fan for bale press | 1 | 17.18 | |
| | | Lint cleaner | 2 | 15 | |
| | | Screw conveyor | 2 | 11 | |
| | | Belt conveyor | 2 | 46 | |
| | | Bucket elevator- | 1 | 75 | |
| | | Jin stand | 40 | 160 | |
| | Ginnery | Fan | 2 | 0.74 | |
| | | Distributor | 1 | 37 | |
| | | Material transport fan for seed cotton transport to pre cleaner | 4 | 49.00 | |

| | | | | |
|---|---|---|---|---|
| | | Fan for material transport from fine cleaner to Ginning department | 1 | 18.4 |
| | | Ginning machine no 1 | 1 | 1.86 |
| | | Ginning machine no 1 | 1 | 1.73 |
| | | Trash Fan for fine cleaner | 1 | 22.00 |
| | Cleaner | Re-cycle machine | 1 | 100 |
| | Blow-Room line one(1) | Blendomat | 1 | 2.03 |
| | | Fan motor | 1 | 3.52 |
| | | Lvsa1 | 1 | 3.41 |
| | | Maxflow | 1 | 0.56 |
| | | Multimixer | 1 | 3.32 |
| Spinning | | Cleanomat | 1 | 2.9 |
| | | Securomat | 1 | 9.04 |
| | | Lvsa 2 | 1 | 3.19 |
| | | Blend mat | 1 | 1.83 |
| | | Fan motor | 1 | 3.3 |
| | | Lvsa1 | 1 | 2.57 |

| | | | |
|---|---|---|---|
| Blow-Room line Two(2) | Maxflow | 1 | 0.97 |
| | Multimixer | 1 | 3.4 |
| | Cleanomat | 1 | 2.93 |
| | Securomat | 1 | 11.32 |
| | Lvsa 2 | 1 | 4.37 |
| Filter | Line 1 filter main fan | 1 | 13.14 |
| | Line 1 filter main fan | 1 | 8.7 |
| Carding Room | Card cylinder | 24 | 5.22 |
| | Suction fan | 24 | 6.05 |
| | Licker | 24 | 54.08 |
| | Flat rod | 24 | 37.00 |
| | Flat drive | 24 | 3.39 |
| | Doffer | 24 | 4.41 |
| | Feed Roll | 24 | 12.67 |
| | Fan drive | 24 | 18.9 |
| | Card line 1 filter main motor | 1 | 54 |
| | Card line 2 filter main motor | 1 | 37 |
| Drawing | Draw frame | 3 | 3.39 |

| | | | | |
|---|---|---|---|---|
| | | Draw frame | 8 | 4.41 |
| | Roving | Zinser make | 1 | 12.67 |
| | | Zinser make 1200 spindles no 5 | 1 | 18.9 |
| | | Zinser make 1200 spindles no 6 | 1 | 20.08 |
| | winding | Overhead cleaner central suction fan no 1 | 1 | 1.00 |
| | | Overhead cleaner central suction fan no 2 | 1 | 1.59 |
| | | Number of drums -60 No 5 | 1 | 25 |
| | Opening | Auto coro no 1 | 1 | 56.67 |
| | Purification | Rieter no 2 | 1 | 44.85 |
| | | Rieter no 6 | 1 | 54.65 |
| | | Rieter no 7 | 1 | 67.64 |
| Weaving | Warping | Chain motor | | |
| | | Beam-rotating motor | | |
| | | Beam out/in motor | | |
| | | Door Opening | 1 | 0.3 |
| | Re-Winding | | | |

| | | | | |
|---|---|---|---|---|
| Sizing | Chemical transfer motor | 5 | 50 | |
| | Chemical mixing motor | 2 | 4 | |
| | Yarn Transfer | 4 | 26 | |
| | Beam rotate main | 1 | 22 | |
| | Beam rotate small | 1 | 7.5 | |
| | Door Opening | 1 | 0.3 | |
| Boiler | Pump motor | 2 | 6 | |
| | Fan motor | 1 | 2 | |
| Loom machine | Loom no 204 | 1 | 2.4 | Single width |
| | Loom no 205 | 1 | 2.7 | Single width |
| | Loom no 307 | 1 | 2.25 | Double width |
| | Loom no 314 | 1 | 2.12 | Double width |
| Compressor | Screw compressor 1 | 1 | - | Under repair |
| | Screw compressor 2 | 1 | 215 | |
| | Screw compressor 3 | 1 | 231 | |
| | Screw compressor 4 | 1 | 236 | |
| | Dryer | 1 | - | Not working |
| | Dryer | 1 | 5.4 | |
| | Dryer | 1 | 5.4 | |
| | Dryer | 1 | 6.8 | |

| | | | | |
|---|---|---|---|---|
| Humidification Plant –Blow room | Supply fan | 1 | 13.9 | |
| Humidification Plant –carding | Supply fan | 1 | 16.03 | |
| Humidification Plant –Roving | Supply fan no 1<br>Supply fan no 2<br>Exhaust fan no 1<br>Exhaust fan no 2 | 4 | 15.57 +<br>16.53+<br>11.13+<br>11.59 | |
| Humidification Plant A–Spinning | Supply fan no 1<br>Supply fan no 2<br>Supply fan no 3<br>Exhaust fan no 1<br>Exhaust fan no 2<br>Exhaust fan no 3 | 6 | 0+<br>12.33+<br>12.01+<br>12.65+<br>0+<br>0 | Supply fan 1, Exhaust fan 2 &3not working |
| Humidification Plant B–Spinning | Supply fan no 1<br>Supply fan no 2<br>Supply fan no 3<br>Exhaust fan no 1<br>Exhaust fan no 2<br>Exhaust fan no 3 | 6 | 14.74+<br>13.59+<br>18.29+<br>13.35+<br>15.49+<br>0 | Exhaust fan no 3 not working |
| Humidification Plant–OE Spinning (Rieter ) | Supply fan no 1<br>Supply fan no 2 | 2 | 7.8+<br>5.7 | |
| Humidification Plant–OE Spinning & Autoconer | Supply fan no 1<br>Supply fan no 2<br>Exhaust fan no 1<br>Exhaust fan no 2 | 4 | 0+<br>13.27+<br>13.4+<br>19.22 | Supply fan no 1not working |

| | | | | |
|---|---|---|---|---|
| | Humidification Plant no 1– Weaving | Supply fan no 1 | | 6.74+ |
| | | Supply fan no 2 | | 9.93+ |
| | | Exhaust fan no 1 | 4 | 4.64+ |
| | | Exhaust fan no 2 | | 4.95 |
| | Humidification Plant no 1– Weaving | Supply fan no 1 | | 19.81+ |
| | | Supply fan no 2 | 4 | 11.48+ |
| | | Exhaust fan no 1 | | 6.65+ |
| | | Exhaust fan no 2 | | 6.62 |

**2.Specific energy saving opportunities identified through audit**

| **S/No.** | **Description** | **U/M** | **Energy saving per year** | **Savings In Birr** | **Investment In Birr** | **Pay Back Period in months** |
|---|---|---|---|---|---|---|
| **1** | Effectively usage of energy meter | Kwh | 163270.8 | 194,782.06 | 0 | Immediate |
| **2** | Improving the power factor (power demand reduction) | Kva | 232.07 | 19,734 | 50,000 | 3 |
| **3** | Avoid the idle running of machines in Ginning mill | Kwh | 140,400 | 167,497 | 90,000 | 7 |
| **4** | Insulating the un-insulated feed water tank in boiler room (Diesel saving) | Liter | 2,044 | 126,728 | 46795 | 5 |
| **5** | Switch off the lighting in no production areas | Kwh | 151,463 | 180,695.36 | 0 | Immediate |
| **6** | Optimize the fan speed in ginning mill | Kwh | 263,952 | 314,894.74 | 14,000 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **7** | Replace the existing V belt by cogged belt for fans in ginning mill | Kwh | 15,350 | 18,312.55 | 0 | Immediate |
| **8** | Arrest leakages in compressed air distribution system | Kwh | 934,390 | 1,114,727.27 | 726,000 | 8 |
| **9** | Optimize the running of air driers in compressor room | Kwh | 45,490 | 54,269.57 | 27,500 | 6 |
| **10** | Waste heat recovery from screw compressor (diesel saving) | Liter | 94,402 | 5,852,924 | 600,000 | 2 |
| **11** | Arrest the leakages in automatic waste collection system no 1 of carding machines | Kwh | 108,108 | 128,972.84 | 7,000 | 1 |
| **12** | Avoid idle running of central suction fan for overhead cleaners | Kwh | 21,818 | 26,028.87 | 0 | Immediate |
| **13** | Installation of indication lamps for avoiding idle running of motors in humidification and automatic waste collection system | Kwh | 126255 | 150,622.22 | 126,000 | 10 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **14** | Installation of submeters for processing machines | Kwh | 435,600 | 519,670.80 | 70,000 | 2 |
| **15** | Optimize the air quantity in supply air plant for blow room department | Kwh | 30888 | 36,849.38 | 0 | Immediate |
| **16** | Optimize the air quantity in supply and exhaust air plant for roving department | Kwh | 172355 | 205,619.52 | 20,000 | 2 |
| **17** | Optimize the air quantity in supply and exhaust air plant for spinning department | Kwh | 324,324 | 386,918.53 | 25,000 | 1 |
| **18** | Optimize the air quantity in supply air plant for weaving department | Kwh | 216216 | 257,945.69 | 8,000 | 1 |
| **Total** | | | **3,246,557.87** | **9,757,192.67** | **1,810,295.00** | **4.00** |

Annual Savings : ETB ***9,757,192.67***

Investment required for implementation : ETB 1,810,295

Over all payback period : Less than ten months

**3.Implementation Action plan**

| SL. NO. | ITEM | TIME FRAME | ACTION REQUIRED |
|---|---|---|---|
| 1 | Effectively usage of energy meter | 1month | |
| 2 | Improving the power factor | 3month | |
| 3 | Avoid the idle running of machines in Ginning mill | 1month | |
| 4 | Insulating the un-insulated feed water tank in boiler room | 1month | |
| 5 | Switch off the lighting in no production areas | Immediate | |
| 6 | Optimize the fan speed in ginning mill | 1month | |
| 7 | Replace the existing V belt by cogged belt for fans in ginning mill | 1month | |
| 8 | Arrest leakages in compressed air distribution system | 6months | |
| 9 | Optimize the running of air driers in compressor room | 1 month | |
| 10 | Waste heat recovery from screw compressor | 6months | |
| 11 | Arrest the leakages in automatic waste collection system no 1 of carding machines | 1month | |
| 12 | Avoid idle running of central suction fan for overhead cleaners | Immediate | |
| 13 | Installation of indication lamps for avoiding idle running of motors in humidification and automatic waste collection system | 4month | |
| 14 | Installation of sub meters for processing machines | 5 months | |
| 15 | Optimize the air quantity in supply air plant for blow room department | Immediate | |
| 16 | Optimize the air quantity in supply and exhaust air plant for roving department | 1 month | |
| 17 | Optimize the air quantity in supply and exhaust air plant for spinning department | 1 month | |
| 18 | Optimize the air quantity in supply air plant for weaving department | 1 **month** | |

## 4. Monthly Power Consumption of the factory

[illegible]

Registered Office:
Piassa,Deguale square,
P.O. box 1233, AddisAbaba, Ethiopia

Ethiopian Electric Utility

Tin No. 0041052177

ETHIOPIAN ELECTRIC UTILITY

**Print Date: 01.06.2023**

| BILLING ADDRESS | | SUPPLY DETAILS | | CURRENT DUE DETAILS | |
|---|---|---|---|---|---|
| Business Partner ID | 2002024273 | Consumer CA No. | 100001571475 | Meter Reading Type | [illegible] |
| Full Name | Riders Trading and | Contract No | 7001853020 | Bill Type | [illegible] |
| | | Legacy ACC No | 3065770 | Bill No | [illegible] |
| Billing Address | | Supply (Premise) Add. | | Invoice Date | 04-MAY-22 |
| Region | OROMIA | Kebele | 13 (CSC 1) | Bill Month | [illegible] |
| Zone | NAZARETH_SC1 | Block/Floor No | 027900/0/0/ | Portion | [illegible] |
| City/town | ORO_ADAMA | House No | | Bill Period | [illegible] |
| Sub City | NAZARETH_SC1 | Landmark | | Bill Days | 30 |
| Woreda | | Premise Tel No | | | |
| Kebele | 13 (CSC 1) | Region | 08 | | |
| Block/Floor No. | 027900/0/0/ | District Office | BA | | |
| House Number | New | CSC | BA01 | | |
| Near to (Landmark) | Behind MOINCO | Call Centre / CSC Phone | 905 | | |
| Tel. / Mobile Number | 0910744445 | Tariff Category | ICS-HT_IND | | |
| Fax No | | Route / MRU No. | /BA01B050 | | |
| E-mail | | Walking Sequence | | | |

| Last Invoice Value | Last Payment Made | Current Invoice Value | Net Due Amount | Due Date |
|---|---|---|---|---|
| 1,893,617.64 | 0.00 | 1483885.81 | 1,483,885.81 | 11-MAY-22 |

| METER DETAILS | | DETAILS OF CONSUMPTIONS | | | | | |
|---|---|---|---|---|---|---|---|
| | | Items | Unit | Current Reading | Previous Reading | Multiplication factor | Current Consumption |
| Sanction Load | 9000.00 | | | | | | |
| Power Factor | 0.8649385 | | | | | | |
| Pole No. | | Active | KWH | 18009.0000 | 17928.0000 | 12000.00 | 972000.000 |
| Cycle No. | 05 | Re-active | KVARH | 6056.0000 | 6009.0000 | 12000.00 | 564000.000 |
| Energization Date | 24.02.2011 | | | | | | |
| Meter Type | Active-Reactive | Max Demand | KW | 0.1760 | | 12000 | 2112.000 |
| Supply Type | Low Voltage | | | | | | |
| Meter Number | 4R1A122 | | | | | | |
| Meter Constant | 0.0000 | | | | | | |

| DETAILS OF PAYMENT | | | |
|---|---|---|---|
| Titles | Units Consumed | Rate | Amount |
| Charges (A) | | | |
| Consumption Charge | 972,000.0000 | | 1,159,596.00 |
| | 972,000.0000 | 1.1930 | 1,159,596.00 |
| Service Charge | | 54.0000 | 54.00 |
| Demand Charge | 2,112.0000 | 147.5400 | 311,604.48 |
| PF Charge | | | 12,631.33 |
| Subsidy / Discount (B) | | | |
| Other Dues (C) | | | |
| Current Month Dues Payable (A) + (-B) + (C) | | | 1,483,885.81 |
| Net Amount Payable for this Month | | | 1,483,885.81 |

| Details of Security Deposit | | | |
|---|---|---|---|
| Date | Deposit Type | Purpose of Deposit | Amount |
| 08.09.2010 | New Connection Security Deposit | 78393339 | 212,000.00 |
| Total | | | 212,000.00 |