ELECTRICAL ENERGY AUDITING AND SAVING OPPORTUNITIES IN TEXTILE INDUSTRIES

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Abstract: - *Energy is one of the main cost factors in the textile industry. Especially in times of high energy price volatility, improving energy efficiency should be a primary concern for textile plants. Focusing on energy utilization assessment and consumption reduction efforts through efficient energy usage, better production management and also introduction of new Technologies significant results can be achieved; saving money on energy bills, improving energy efficiency and maintaining sustainable environment. This paper provides information on Energy auditing, efficiency improvement and efficient energy- technologies and measures applicable to Arbaminch the textile share company (AMTSC) and others. The thesis work includes case studies from textile plants around the world and includes energy savings and cost information when available. Also the present use and management of energy in the textile manufacturing processes are identified and analyzed for the selected plant; a detailed assessment has been taken place on energy consumption and loss. Based on the losses, energy efficiency performance assessments on the major energy intensive equipment's like electric motors and drives, lightings have been done. An analysis of the type and the share of energy used in different textile processes are also included. Subsequently, energy-efficiency improvement opportunities available within some of the major textile subsectors are given with a brief explanation of each measure.*

***Keywords**:* Energy Audit, Energy Efficiency, Energy intensity, Electric motors.

1. INTRODUCTION

Textile Industry is one of the most important industries in the world. The industry suffers from inadequate development planning, which is atypical problem with most of the textile industries. Atypical textile industry structure contains subsections which are occupied by a number of different units working independently. There might be some hidden defects left in the structure that leads to unnecessary energy use.

Few studies have been conducted in the past, which shows that there are many opportunities in textile industries to save energy. In 1988, it was estimated that reduction rates of 16 % in process heat and 8% in power consumption could be achieved in the finish textile industry just like other manufacturing industries by using available technology [1].

The industrial sector in general accounts around 40% of the commercial energy. The electrical and thermal energies are widely used in various equipment's like in water pumps, boilers compressors etc. But there are many problems in the industry sectors to efficiently use their energy. They are not well informed on the concept of energy conservation. Due to this they lose lots of money on energy bills, causes problems on the environment, industries will not be competitive, etc. [2].

The energy distribution and utilization assessment that has done on several industries mostly occur on the thermal energy efficiencies but the electrical energy has also major impact on the industries [3].

Today manufacturers face an increasingly competitive global business environment; they seek opportunities to reduce production costs without negatively affecting product yield or quality. For public and private companies alike, rising energy prices are driving up costs and decreasing value added at the plant. Successful, cost-effective investment into energy-efficiency technologies and practices meets the challenge of maintaining the output of a high quality product despite reduced production costs. This is especially important in the current age, as energy-efficient technologies often include ―additional‖ benefits, such as increasing the productivity of the company or reducing the water and/or materials consumption [4].

Energy efficiency does not mean rationing or having to do without energy rather, energy efficiency means identifying wasteful energy use and taking actions to reduce or illuminate that waste. Production levels should not be affected, only the amount of energy and the expense incurred in generating that production. The objective is to reduce energy costs and consequently increase profitability [5].

2. PROBLEM STATEMENT

There are many problems in the industry sectors to efficiently use their energy. Due to this they lose lots of money on energy bills, causes problems on the environment, industries will not be competitive, etc. Some of the problems for the inefficient use of energy are:

- ✓ The efficiency of most industrial equipment and processing is lower than the expected. This is due to lack of proper replacement, regular maintenance and control.
- ✓ Poor designs and improper installations
- ✓ The high consumption rate of energy which is due to the irrational use of energy, use of inefficient equipment, lack of awareness and knowledge of energy conservation.
- ✓ The cost of energy like petroleum is increasing from time to time as a result high energy costs will occur at the factories, Causes environmental pollutions.
- ✓ The factories will produce poor qualities of products with incomparable costs and hence will not be competitive with the world market.
- ✓ The prevalence of bad management, as the result the factories are in huge loss, the companies are not in a position to satisfy customer requirements. They are poor in handling and utilization of their resources such as manpower, machinery, and materials.

One of the big problems in textile industries is the obsolete machines and equipments. The majority of machine and equipments in the textile industries have been in operation for several decades and without effective maintenance over a long period of time. Shortage of spare parts and accessories is the general problem faced by these enterprises, so they cannot perform timely maintenance and replacement of easily-damaged parts. Because of the poor capacity in supplying accessories by domestic suppliers, parts and spares required by the enterprises mostly depend on import.

This work addresses problems encountered by the textile factories with respect to energy starting from the resources and through energy users equipments like electric motors and drives, spindles, looms, Sewing and Knitting machines, air compressors, etc. and also suggests better solutions to improve the efficiencies of these energy usages.

3. GENERAL OBJECTIVE

The objective of this paper is to identify and analyse the present use and management of energy in the textile manufacturing processes of Arbaminch Textile share company (AMTSC) and to name possible measures to improve the energy performance of the plant.

4. REVIEW OF RELATED LITERATURE

The study required broad knowledge of the issues regarding Energy Auditing and efficiency improvement in industries: power qualities in the industrial systems, and harmonic modelling and simulation techniques, standard limits and requirements, sizing of compensators, and results from previous studies by other researchers. All these information are necessary to address, understand and complete the research. The following sections include brief knowledge of energy audit, power quality and reviews on papers and previous works relevant to this research.

Jatin Gupta [1] provides information on energy-efficient technologies and production measures applicable to the textile industry. The work also includes analysis of an audit conducted on motors of different horsepower in a textile plant and includes energy saving and cost information available. For some measures this report also provides range of savings and payback periods found in under varying conditions. The thesis report analysis is done only on rewound induction motors for its efficiency improvement.

Ali Hasanbeigi et al. [4] The paper aims to contribute to the understanding of energy use in the textile industry by presenting the energy use of textile plants in five major sub-sectors in Iran, i.e. spinning, weaving, wet-processing, worsted fabric manufacturing, and carpet manufacturing. The energy intensity of each plant was calculated and compared against other plants within the same sub-sector. The results showed the range of energy intensities for plants in each subsector. It also showed that energy saving/management efforts should be focused on motor driven systems in spinning plants, whereas in other textile sub-sectors thermal energy is the dominant type of energy used and should be focused on.

For conducting a fair and proper comparison or benchmarking studies, factors that significantly influence the energy intensity across plants within each textile sub-sector (explanatory variables) are explained. Finally, lists of energy efficiency improvement measures observed during the study are presented.

This paper mainly focused on the energy intensities on the plant level; it didn‘t consider analysis on energy loss and money saving on equipment level and doesn‘t consider the barriers on process of manufacturing, energy management and power quality issues.

Amare Matebu [6] On top of providing some background information on the features of textile, this work identified the major components of quality management system (QMS) for textile industries and proposed the appropriate implementation model of quality management system and also provided guidance to the management of textile industries on the application and use of quality management system to improve its overall performance.

Currently, almost all textile industries in Ethiopia are suffering from quality related problems. These problems include: poor performance of products in the export market, low quality and insufficient raw material supply, incompetence in the world market, customer dissatisfaction, low productivity, and poor utilization of the resources. Because of these problems, most of the textile companies in the country are not profitable and most are in a huge loss.

This research work mainly focused on how this loss and low market share in textile companies could be removed with the help of quality management system (QMS).

Eng. Basel Tahseen at el. [7] this work tried to establish a start or a beginning step toward the efficient use of energy and energy conservation opportunities in different industry through conducting energy audit and analysis of industrial consumption in Palestine.

The work identifies the most energy intensive areas of the industries and suggests measures which can be implemented to conserve energy or reduce energy consumption. It was showed that there is a decent potential for energy savings in the audited industrial facilities. On the national level 10 to 20% savings from the total energy consumption in the industrial sector could be achieved by implementing some energy conservation measures on the most energy consumption equipment in the facility such as boilers, compressors, lighting system and low power factor. In addition decreasing the demand on energy that enhancing the national economy, there is a huge reduction in the environmental emissions such as $CO2$ (175 tons) reduction.

5. DESCRIPTION OF THE STUDY AREA

The study area (Arbaminch Textile), which was established, in 1991, in Arbaminch Town, located 505km south of the capital Addis ababa, to supply textiles to Hawassa Textile Factory. The factory which was designed primarily to produce polyester and cotton blended woven fabrics, is one of the modern textile factories in the country to date, featuring the latest date-of the art in the manufacture of yarns and high-quality fabrics.

The factory is Equipped with a new and modern spinning technology, open end spinning, the pre-spinning stages of 2nd passage drawing and roving, the post-spinning stage of winding can all be accomplished as just one point. The factory is also equipped with high speed shuttle less rap air loom; each of which fitted with a microprocessor facility to enable the operatives to adjust and configure the required production and machine parameters. Modern air conditioning system, well-equipped physical testing laboratory, an efficient water treatment plant, a complete firefighting and protection system as well as fully organized mechanical, electrical and automotive workshops are its additional aspects of modernity.

6. DATA COLLECTIONS

In The research work on industrial energy Auditing and efficiency improvement at Arbaminch Textile factory, the data collection has been done through different methods:, face to face interviews, direct observation of the companies, telephone, questionnaires and the available documents of the company.

The following tables provides the factory four years of Textile production and energy consumption data and also shows the specific energy consumption, costs of energy per year, energy costs of AMTSC as well as the standard plants taken as a benchmark. And there is electric motor and lighting data obtained from the selected factory.

Table 1: Review of textile production and energy consumption at AMTSC

No	Items	Unit	years (G.C.)			
			2011	2012	2013	2014
1	Yarn Production	kg	1,009,400	1,349,677	1,615,776	2,056,345
2	Gray Fabric Prod.	kg	338,838.76	612,697.8	1,328,025	1,900,500
3	Total production	kg	1,348,238.76	1,962,374.8	2,943,801	3,956,845
4	Elec. consumption	Kwh	10,339,000	10,077,000	10,346,500	12,690,000
5	Fuel consumption	lit	150,766.7	102,572	208,961.5	....
6	Specific elec. Cons	Kwh/kg	7.67	5.14	3.51	3.21
7	Specific fuel. Cons	Lit/kg	0.112	0.1	0.1	....
8	Energy int(elec.)	KJ/kg	27,606.68	18,486.38	12,652.63	11,545.56
9	Energy int(fuel)	KJ/kg	4,487.31	2,097.46	2,848.43	....

Table 1: Energy costs at AMTSC for both electric and furnace oil

Items	unit	Year(G.C)			
		2011	2012	2013	2014
Furnace oil	Birr(ETB)	2,400,495.31	1,621,140.35	3,179,850.26	----------------
Electric energy	Birr(ETB)	4,224,515.4	4,117,462.2	4,227,579.9	5,185,134
Total	Birr(ETB)	6,625,010.71	5,738,602.6	7,407,430.16	5,185,134

Table 2: Production, Energy use, and Energy intensities of three different Spinning and Weaving plants in Iran (A, B, and C are Spinning and D, E are Weaving)

Plant	A	B	C	D	E
Annual production(Tone)	2003	8140	2448	6027	6299
Annual Elec consumption(Kwh)	13,290,450	38,584,206	8,860,300	13,290,450	7,420,040
Annual fuel consumption(GJ)	24,760	57,694	19,808	103,993	67,397
Specific Elec consumption(KWH/KG)	6.6	4.7	3.6	2.21	1.12
Specific fuel consumption(Lit/KG)	0.308	0.177	0.202	0.43	0.267
Elec energy intensity(KJ/KG)	23,760	16,920	12,960	7,920	4,320
Fuel energy intensity(KJ/KG)	12,400	7,100	8,100	17,300	10,700
Total energy intensity(KJ/KG)	36,160	24,020	21,060	25,220	15,020

7. ENERGY LOSES ASSESSMENT AT AMTSC

7.1. Computation of Energy Intensity of the Plant

Energy intensity is the amount of energy consumed to produce a unit amount of product and is a measure of the energy efficiency of the plant. The following graphs show the plot of the energy intensity of the Arbaminch Textile factory from year 2011-2014 G.C and the energy intensity of the selected Textile plants taken as a benchmark. The graph also compares the specific energy of the AMTSC and the selected benchmark textile plants. The selected benchmarks have higher energy efficiency performance as compared to other Textile factories and also they have the same yarn and fabric production technology as AMTSC.

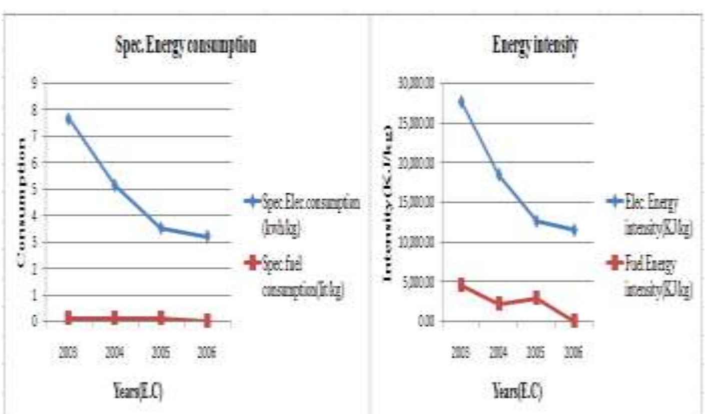

Figure 1: The specified energy and the energy intensity of AMTSC

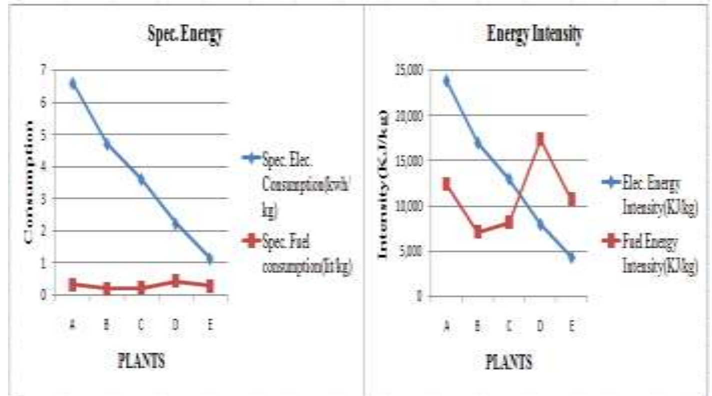

Figure 2: The specified energy and the energy intensity of selected plants

The Annual Electric energy intensity at AMTSC in the year's 2003 to 2006 E.C. ranges from 3.21Kwh/kg to 7.67Kwh/kg for Yarn and Fabric production with an average energy intensity of 4.88Kwh/Kg. The Total Electric energy intensity of various plants taken as bench mark shown in Fig 3-2, gives an average energy intensity of 3.65Kwh/Kg. Hence a difference of 1.23Kwh/Kg exists between the average practice and what exists at AMTSC.

With regards to fuel energy intensity of AMTSC in the year 2003 to 2005 E. C. it ranges between 2,097.46KJ/kg to 4,487.31KJ/kg of Yarn and Fabric production with average intensity of 2,358.3KJ/kg. The Total fuel energy intensity of various plants taken as bench marks shown in Fig 3-2, give average energy intensity of 11,120 KJ/kg

7.2. Explanation of the results

It can be seen that from the analysis of the energy intensity of AMTSC, there is a difference between the Electric energy intensity of AMTSC as compared to the selected benchmarks plant experience. This shows that there is an actually a room for improving the energy efficiency of the plant. The following calculation shows clearly how much the company is actually spending for energy which was not necessary.

- Annual Average production of Yarn and fabric 2,552,814.9Kg per year.
- Cost of electricity (R) = 0.4086 birr per/kWh.
- Cost of fuel oil = 16.0 birr/per lit. (2005 E.C.)
- Specific heat of fuel oil = 40,128KJ/lit.
- Difference in electricity energy intensity = 1.23Kwh/Kg
- Annual cost due to inefficient use of electric energy intensity = electric consumption in KWH × cost of electricity.

= energy int (KWH / Kg) × production (kg) × cost of electricity (Birr / KWH)

= 1,282,988 Birr per year.

The fuel energy consumption is very good relative to the bench mark plants selected; however it is good the company totally left the fuel furnace and use Electric boiler machine for better cost minimization. Doing this the company saves about 1,800,371.5 birr every year.

8. BREAKDOWN OF ENERGY USE BY TEXTILE PROCESS

Breakdown of electrical energy is done on the bases of the part of energy consumed by different section of the plant. In these different sections of the textile industry, the electricity is used for production, lightening, HVAC, etc.

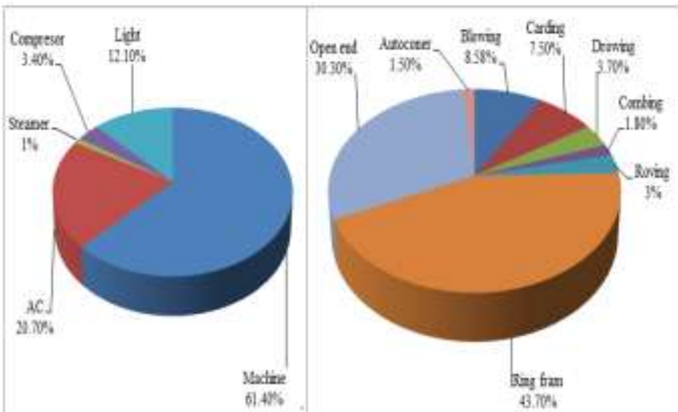

Figure 3: Breakdown of the final energy use in a spinning plant

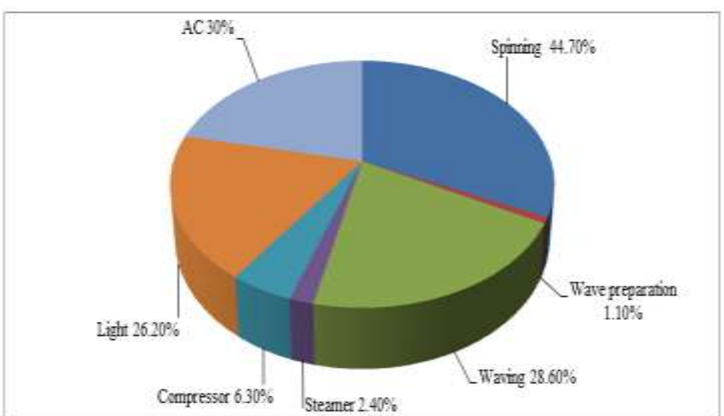

Figure 4: Breakdown of typical electricity use in composite plant (spinning-weaving)

9. CAUSES OF MAJOR ENERGY LOSSES AND THEIR ENERGY SAVING OPPORTUNITIES IN TEXTILE PLANT

Based on the walk-through audit conducted in the plant as well as information from the collected data, the major power consuming areas in the textile plant that have high energy saving opportunities are lightings, ring frame parameters, rewound motors, electrical networks, air conditioners and air compressors. Energy efficiency improvements for the textile industry refers 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 [8].

9.1. Assessment of Lighting Systems

The lighting data of each department of the factory is collected and analyzed. Totally there are around 3188 florescent lamps of which 248 are 40W and 2940 are 78W lamp ratings (LR) and are currently installed in the factory. The total installed capacity of the lighting system is about 239.24KW and a daily energy consumption of 5,741.76KWH. The actual florescent lamps required (ALR) in the factory should be around 2938 lamps. Therefore there are unnecessary lamps installed. There are a significant energy differences (ED) between the energy utilization (EU) due to currently install florescent lamps and the actual energy required(ER). This shows that there are energy losses due to lighting systems in the factory.

By Improving the Installation System **t**here must be sufficient and appropriate illumination for varieties of operation in the factory. The illumination required for various operations and the luminous intensity of various lamps are given in the appendix. As explained in section 9, currently, there are 3188 lighting points installed in the factory all fitted with 40W and 78w fluorescent lamps. In certain office segments the illumination is not significant and additional lamps need to be installed to bring the appropriate brightness. On the other hand, there is more than sufficient illumination in the other offices indicating possibility of reducing the number of lamps installed in these offices. After the appropriate illumination has been checked, only 2938 lamps or 365 lamps of 40W ratings and 2573 lamps of 78W ratings would be required. This results in total reduction of 250 lamps which is equivalent to 23.95KW of power. It also results in energy saving of 209,802KWH/y and in money savings of 85,725 Birr annually.

Replacing T-12 Tubes with T-8 Tubes In many industries including Arbaminch textile factory T-12 tube florescent lamps have been found. A T-12 tube refers to the diameter in 1/8 inch increment (T-12 means 12/8 inch or 3.8 cm diameter tubes). The initial output and energy consumption of these lights is high. These also have extremely poor efficiency, lamp life, lumen depreciation, and colour rendering index. Because of these maintenance and energy costs of T-12 tubes are high. Replacing T-12 lamps with T-8 (smaller diameter) lamps approximately doubles the efficiency of the former. Also, T-8 tubes generally last 60% longer than T-12 tubes, which lead to savings in maintenance costs. Typical energy savings from the replacement of a T-12 lamp by a T-8 lamp are around 30%. [12]

As we have been discussed earlier, there are 3188 lamps currently installed in the factory indicating that there are 3188 T-12 fluorescent tubes. After the corrected installation, however, only 2938 lighting points would be required. Replacing these 2938 T-12 lamp tubes with T-8 lamps tubes, therefore, we obtain:

Power demand saving (PDS):

$$PDS = \left(\frac{0.3 \times ALR \times LR}{1000}\right) = \left(\frac{0.3 \times 365 \times 40}{1000}\right) + \left(\frac{0.3 \times 2573 \times 78}{1000}\right)$$

$$= 64.6KW$$

Energy Saving (ES):

$$ES = (0.3 \times ER \times 365) = 548{,}073.78KWH$$

Birr Saving (BS):

$$BS = ESR = 548{,}073.78KWH/year \times 0.4086\ Birr/KWH$$

$$= 223{,}942.95\ Birr/year$$

9.2. Energy Efficiency Opportunities in Electric Motors

When planning to improve the efficiency of the motor system in an industry, a system' approach incorporating pumps, compressors, and funs must be used in order to attain optimal savings and performance. Consideration with respect to energy use and energy saving opportunities for a motor system are discussed below.

9.2.1. Monitoring and management of electric motors

It is very important to introduce monitoring and management systems for motors to maximise the energy saving initiatives.

- Make an inventory of motor systems, this will provide a clear framework for identifying and prioritizing actions and also give history of each motor, which is useful for deciding whether to repair or replace when problems occur.
- Measure the power consumed by each motor an ''hours-run'' meter , a clamp-on ammeter, and a portable power logging device, as well as permanent kilowatt-hour metering
- Analyse and monitor the condition of each component to predict the risk of failure by using vibration analysis, oil analysis and thermo graphic surveys.
- Creation of a motor survey and tracking program.
- Development of guidelines for proactive repair/replace decisions.
- Preparation for motor repair by creating a spares inventory.
- Development of a purchasing specification.
- Development of a repair specification.
- Development and implementation of a predictive and preventive maintenance program

9.2.2. Install High Efficiency Motors In Place of Lower Efficiency Motors

Replacing a standard motor with a high efficiency alternative can cost about 10–20% more but this additional capital cost will be quickly offset by lower running costs. The higher the motor's efficiency, the lower the input kW for a given mechanical shaft load. Small efficiency improvements can often make economic sense for equipment that operates for thousands of hours per year, and even replacing an operating motor with a premium efficiency model may have a low payback period.

For example, if we evaluate the compressor main drive motor (GA22) of 55KW which exist in AMTSC to the energy efficient motor model from the motor master plus software catalogue, the following outcome will be obtained.

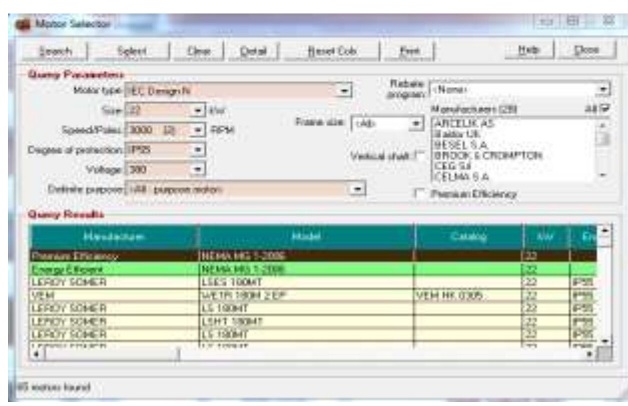

Figure 5: Energy efficient motor selection

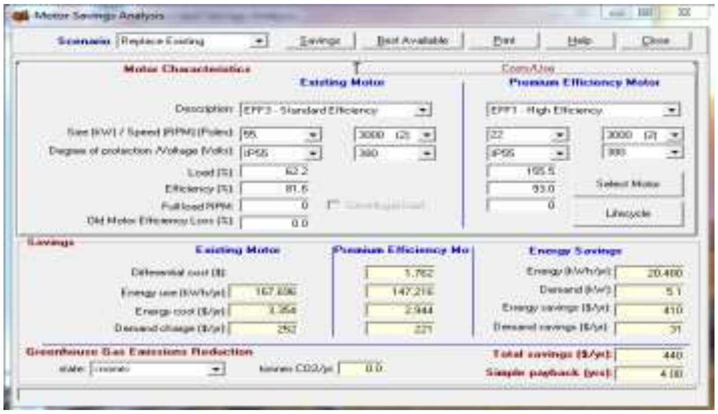

Figure 6: Motor saving analysis

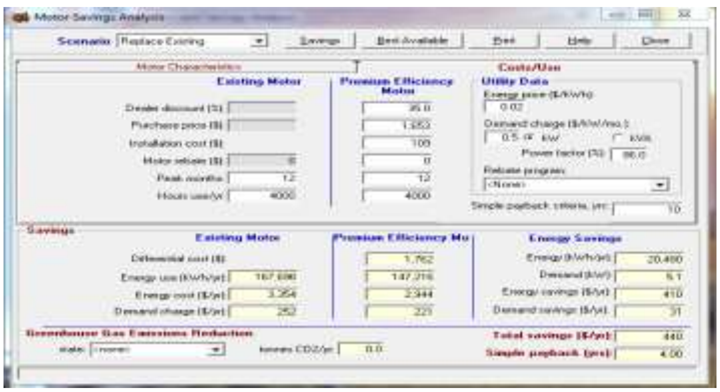

Figure 7: Utility Costs/Use Data

Table 9: Summary of Motor saving analysis

Motor Savings Analysis - Replace Existing — Page: 1

INPUTS

Motor Characteristics

	Existing Motor		Premium Efficiency Motor	
Description:	EFF2 - Improved Efficiency		EFF1 - High Efficiency	
Size (kW) / Speed (RPM) (Poles):	55.0 kW	3000 RPM	22.0 kW	3000 RPM
Degree of protection /Voltage (Volts):	IP55	380 Volts	IP55	380 Volts
Load (%):	62.2		155.5	
Efficiency (%):	81.6		93.0	
Full load RPM:	0 RPM		0 RPM	
Centrifugal load:	False			
Old Motor Efficiency Loss (%):	0			

Costs/Use

	Existing Motor	Premium Efficiency Motor	Utility Data	
Dealer discount (%):	N/A	35	Energy price ($/kWh):	0.02
Purchase price ($):	N/A	1,653	Demand charge ($/kW/mo.):	0.5
Installation cost ($):	N/A	109	Power factor (%):	N/A
Motor rebate ($):	N/A	0	Rebate program:	-None-
Peak months:	12	12	Simple payback criteria, yrs:	10
Hours use/yr:	4000	4000		

RESULTS - SAVINGS

	Existing Motor	Premium Efficiency Motor	Energy Savings	
Differential cost ($):		1,762	Energy (kWh/yr):	20,480
Energy use (kWh/yr):	167696	147216	Demand (kW):	5.1
Energy cost ($/yr):	3,354	2,944	Energy savings ($/yr):	410
Demand charge ($/yr):	252	221	Demand savings ($/yr):	31
Greenhouse Gas Emissions Reduction			Total savings ($/yr):	440
state:		tonnes CO2/yr: 0.00	Simple payback (yrs):	4.0

Table 4 summarizes the motor saving analysis and the figures 5 to 7 are sample outputs of the software. The energy saving and back pay period columns explain the kilowatt hour energy savings per year and the number of years required to recover the investment in energy efficient motors respectively.

To buy an energy efficient motor for air Compressor found in the utility, the company should have 1653 dollars to purchase the motor, 109 dollar for the installation. But these costs will be back after 4 years of operation with energy savings of 20,480kwh per year and money savings of 440 dollars per year.

Another example, to buy an energy efficient motor for main motor drive found in Ring frame, it needs 337 dollars to purchase the motor, 65 dollar for the installation. But these costs will be back after 3.16 years of operation with energy savings of 5,914kwh per year and money savings of 127 dollars per year. Therefore, this method should be implemented in the factory to use electric energy more efficiently.

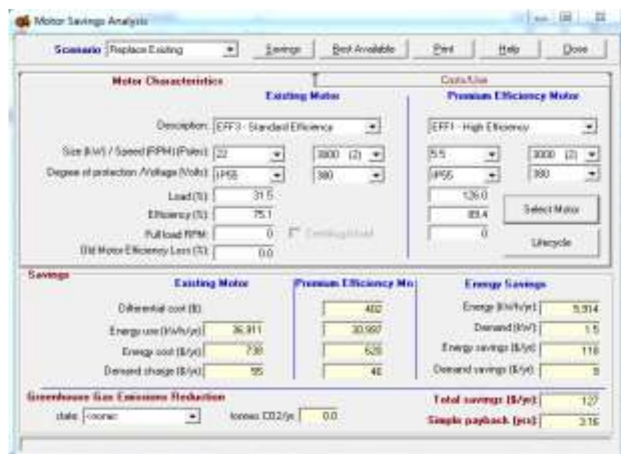

Figure 8: Motor saving analysis

10. CONCLUSION AND FUTURE WORK

In general, energy in Arbaminch the textile industry is mostly used in the forms of electricity, as a common power source for machinery, cooling and temperature control systems, lighting systems, steam generation, office equipment, etc.

Figure 3 shows the distribution of energy consumption in different section of the spinning department in AMTSC. These sections include the blowing, carding, drawing and ring frame. The ring frame and the open end have the highest energy consumptions. And also in the composite process spinning consumes the greatest share of electricity (44.7%) followed by weaving (weaving preparation and weaving) (29.7%). Based on the results obtained in section 7 where

Some analysis have been done on energy intensity of the plant and comparisons have been made with benchmark factories, still there are many possible energy saving areas in the textile Plants.

Using motor master+ international software, it has been seen that a huge energy can be saved in replacing energy efficient motors with the standard motors with small payback periods. And also Results of energy saving in the lighting systems were obtained through improving the installation systems, replacement of accessories, use of energy efficient lamps, and an efficient use of day lighting.

11. ACKNOWLEDGMENT

First and foremost, I take this opportunity to give glory to the almighty God, without whom the completion of this work would have been impossible. Besides, I would like to acknowledge Arbaminch Textile factory for their all kind of support, especially the electrical and electronics Department workers who helped me in collecting the necessary data for my work. The last but not the least appreciation is to Arbaminch electric utlity.

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APPENDIX

A: Luminous Intensity and Life time of Various Lamps

NO.	Lamp type	Luminous Intensity (Lumens/watt)	Relative Efficiency based on HPS	Lamp Life(hrs)
1	Incandescent	8-18	19%	1000-2000
2	Tungsten -Halogen Lamps	18-24	77%	2000-4000
3	Fluorescent tube	60-85	65%	5000
4	LED Lights	70-120	92%	50000-100,000
5	High Pressure Hg vapour lamps	50-60	46%	16,000-24,000
6	High Pressure Na Lamps(HPS)	75-130	100%	24,000
7	Low Pressure Na	100-200	-------	16,000
8	Compact Fluorescent Light(CFL)	45	46%	7000-10,000

B: Illuminations Required in various Working Station

NO.	Working Station	Average ILLuminance required(LUX)	Remark
1	office	500	
2	Canteens	150	
3	Boiler and pump houses	20-100	
4	spinning	150 - 450	
5	knitting	300-750	
6	Weaving	200-700	
7	Grey cloth inspection	700-1000	
8	Final inspection	700 - 1000	
9	Work shops	200-750	
10	Clock rooms, Entrances, corridors, stairs	100	