Project document

on

Electric Motor

Energy Efficiency Standards and Labeling

DANAS Electrical Engineering

June 2015

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Annexes

List of Abbreviations

1.	AC	Alternating Current
2.	AFPC	Automatic Power Factor Control
3.	DC	Direct Current
4.	BPR	Business process re-engineering
5.	CDM	Clean Development Mechanism
6.	CFR	Code of Federal Regulations
7.	CLASP	Collaborative and Standard Program
8.	CM	Centimeters
9.	CO_2 e	Carbon dioxide equivalent
10.	CRGE	Climate Resilient Green Economy Strategy
11.	CSA	Central Statistic Agency
12.	DIN	German Industry Standard
13.	DOE	US Department of Energy
14.	DSM	Demand Side Management
15.	DSP	Digital Signal processing
16.	EE	Energy Efficiency
17.	EEA	Ethiopian Energy Authority
18.	EEM	Energy Efficient Motor
19.	EEMODS	Energy Efficiency in Motor Drive Systems
20.	EEP	Ethiopian Electric Power
21.	EEU	Ethiopian Electric Utility
22.	EFY	Ethiopian Fiscal Year
23.	ERCA	Ethiopian Revenue & Customs Authority
24.	ES	Ethiopian Standard
25.	EU	European Union
26.	GC	Gregorian Calendar
27.	GHG	Green house Gas Emission
28.	GIZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit
29.	GLMP	Global Motor Labeling Program
30.	GTP	Growth and Transformation Plan
31.	GW	Gig watt
32.	GWh	Giga watt hour
33.	HP	Horse Power
34.	HV	High Voltage
35.	IEA	International Energy Agency,
36.	IEC	International Electro Technical Commission
37.	IEC EE	IEC System for Conformity testing and Certification of Electro tech. Eq

38. I^2R Current square times Resistance
39. PF Power Factor
40. JIS Japanese Industrial standard
41. KV Kilo Volt
42. KVAr Kilo Volt Amper reactive
43. KW Kilowatt
44. KWh Kilo watt hour
45. LCC Life cycle Cost
46. LV Low Voltage
47. MCC Motor Control Center
48. MEPS Minimum Efficiency Performance Standard
49. MRA Mutual Recognition Agreements
50. MVARh Mega Volt Amper Hour
51. MW Mega Watt
52. NC National Committee
53. NEMA National Electrical Manufacturers' Association
54. NGO None Governmental Organization
55. NPV Net Present Value
56. PMSM Permanent Magnet Synchronous Motor
57. RMS Root Mean Square Value
58. SDPRP Sustainable Development and Poverty reduction program
59. SNV Netherlands Development Organization
60. TC Technical Committee
61. USA United States of America
62. VAT Value Added Tax
63. VDE German Venderband der Elektro technik
64. VSD Variable speed Drive

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Executive Summary

The Demand for Electrical power has been constantly growing in Ethiopia due to the rapid economic growth, new industrial developments, and the huge electrification programs underway in the country.

The Industrial tariff group (Low voltage, 15 KV and the 132 KV industries) customers of the Ethiopian Electric Utility consumed 2,032GWh in the year 2006 EFY (2013/14GC). There are about 28,242 industrial tariff group customers in 2005 EFY. This constitutes about 33.4% of the total national energy consumption. Based on the Ethiopian Power System Expansion Master Plan Study forecast energy consumption of the Industrial tariff group increases nearly at an average rate of 21% per year for the next ten years.

Electric motors are the most prevalent and energy-intensive machines used in Ethiopian industries and contribute to the bulk of the electrical energy consumption and power demand of the Industrial Tariff group. Electric motors in Ethiopian industries have long years of service, more than 50 years in some factories, and most of them are refurbished and have been repaired and rewound many times. As a result, the efficiency of the electric motors is low. The low efficiency of electric motors affected the electric power supply infrastructure by demanding high power, overloading and effecting frequent power interruptions, outages and voltage drops. Its excessive energy consumption has forced the industries and the power provider to pay for the wasted energy. The causes of the low energy efficiency of the electric motors are: the design limitations, electrical power quality and supply level problems, inadequate maintenance and repair practices, absence of match between motor and motor loads, and the lack of enforcement of existing Ethiopian standards.

Based on the assessment made, the estimated peak power demand and energy consumption including losses due to electric motors are about 337 MW and 1,655 GWh respectively in the year 2015 GC. The power demand of 337 MW requires more than the generating capacity of the biggest power plants of the country. The projected peak power demand and energy consumption of electric motors, including losses, in the year 2024 GC is estimated to be 1,458 MW and 8,338 GWh respectively.

Improving the efficiency of the Electric motors by developing energy efficiency (EE) standard and labeling program will:

- Reduce demand on power, electric supply interruptions and outages, electrical infrastructure congestion, and capital Investment in energy supply Infrastructure,
- Save energy to the industries and the nation, thereby enhancing national economic efficiency by reducing energy bills.

- Strengthen market competition among electric motor importers
- Encourage research and innovation, and
- Assist the country in meeting climate change goals and averting regional pollution

The projected peak power demand reduction and energy savings obtained in 2024 GC as a result of the implementation of Energy Efficiency (EE) standard and labeling program is estimated to be 236 MW and 1,351 GWh respectively. The power demand reduction saves the cost of erecting and running power plant of same size whereas the energy saving has the equivalence of 1,410 thousand tons of cumulative carbon savings. This proves the EE program on electric motors to be an environmental project and contributes a lot in reducing GHG emissions as per the Ethiopia's Climate-Resilient Green Economy strategy (CRGE).

The power demand and energy savings obtained as a result of EE standard and labeling could be used for rural electrification, manufacturing, industrialization, and export programs in meeting the objectives and implementing the strategies for sustained rapid and broad-based economic growth of the Growth and Transformation Plan s(GTPs) of Ethiopia.

In this proposal, the EE problems on the existing industrial motors and the demand for the project are assessed. EE standard and labeling program is developed. The implementation plan, project inputs, project management and institutional details are proposed. The benefits and justifications and the environmental impact, risks and risk counter measures of the project are analyzed. Electric motors main parameters, test procedures, list of testing facilities, operating and sampling procedures have been prepared.

1. Project background

1.1. Problem analysis

1.1.1. Electric Motors

E**lectric motor** is an **electrical** machine that converts **electrical** energy into mechanical energy. The reverse of this would be the conversion of mechanical energy into **electrical** energy and is done by an **electric** generator.

In normal motoring mode, most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force within the motor. In certain applications, such as in the transportation industry with traction motors, electric motors can operate in both motoring and generating or braking modes to also produce electrical energy from mechanical energy.

Found in applications as diverse as industrial fans, blowers and pumps, machine tools, household appliances, power tools, and disk drives, electric motors can be powered by Direct Current (DC) sources, such as from batteries, motor vehicles or rectifiers, or by Alternating Current (AC) sources, such as from the power grid, inverters or generators. Small motors may be found in electric watches. General-purpose motors with highly standardized dimensions and characteristics provide convenient mechanical power for industrial use. Electric motors may be classified by electric power source type, internal construction, application, type of motion output, and so on.

Based on the power supply, electric motors fall into two classes: Alternating Current (AC) or Direct Current (DC). All motor types have the same four operating components: stator (stationary windings), rotor (rotating windings), bearings, and frame (enclosure). Figure 1 overleaf shows the classification of electric motors.

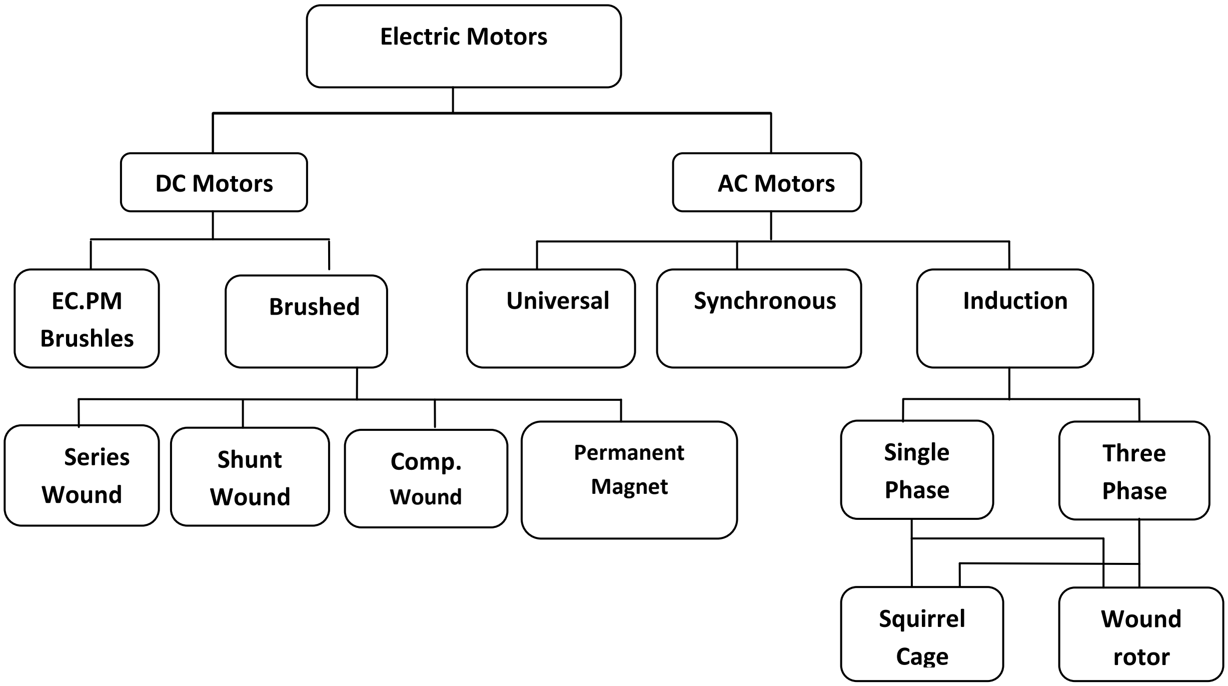


Figure 1. Classification of Electric Motors

Direct-Current Motors

DC motors, as the name implies, use direct-unidirectional, current. Direct current motors are used in special applications where high torque starting or where smooth acceleration over a broad speed range is required.

Alternating current motors

AC motors are further classified into Induction, Synchronous and Universal types. In terms of the AC power source, AC motors can be single phase or three phase. Quantity wise, single-phase motors are the most common type, mainly because many small motors are used for residential and commercial applications in which single-phase power is readily available. However, several operating constraints on these motors limit their widespread use in industrial applications. Integral single-phase induction motors tend to pull large starting currents relative to the motor's size. In general, they operate less efficiently than three-phase motors of comparable size, and are not available in larger sizes.

Induction Motors

Induction motors are the most commonly used prime mover for various equipments in industrial applications. In induction motors, the induced magnetic field of the stator winding induces a current in the rotor. This induced rotor current produces a second magnetic field, which tries to oppose the stator magnetic field, and this causes the rotor to rotate. The 3-phase squirrel cage induction motor is the workhorse of industry; it is rugged and reliable, cheaper, requires less maintenance, and is by far the most common motor type used in industry. These motors drive pumps, blowers and fans, compressors, conveyers and production lines. The 3-phase induction motor has three windings each connected to a separate phase of the power supply.

Synchronous Motors

Special design for "constant speed" at rated horsepower and below and used where maintaining speed is critical when the load change. AC power is fed to the stator of the synchronous motor. The rotor is fed by DC from a separate source. The rotor magnetic field locks onto the stator rotating magnetic field and rotates at the same speed. The speed of the rotor is a function of the supply frequency and the number of magnetic poles in the stator. While induction motors rotate with a slip, i.e., rpm is less than the synchronous speed, the synchronous motor rotate with no slip, i.e., the RPM is same as the synchronous speed governed by supply frequency and number of poles.

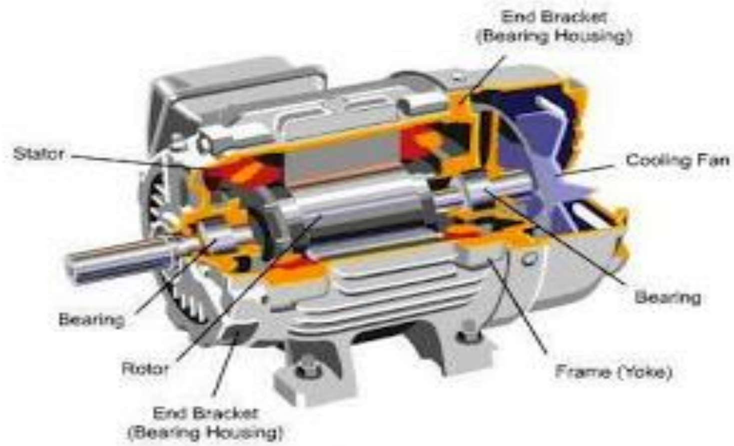
Universal motors

The universal motor is so named because it is a type of electric motor that can operate on both AC and DC power. Universal motors have high starting torque, can run at high speed, and are light weight and compact. They are commonly used in portable power tool and equipment, as well as many household appliances.

1.1.1.1 AC motors

Three phase AC motors are used widely in industrial applications. They consume more than half of all the electricity used in industry. Three phase motors can be found in almost every industrial process, and they often operate continuously to support production processes.

These motors can achieve high efficiencies with favorable torque and current characteristics. The effectiveness and low cost of three-phase motors are major reasons why three-phase power is used so widely in industry. In terms of energy consumption and efficiency improvement opportunities, three-phase motor systems predominate. Over 90% the most common type of motors in use today are induction motors. These motors are squirrel cage induction motor types. Because of their prevalence throughout the industrial (and commercial) sector, three phase induction motors offer a great potential savings opportunity in both energy and operational costs during the motor's useful life. Hence, the main focus of this project document will be the three phase induction motors. The basic parts of AC Motors are shown in Figure 2 overleaf.



Cutaway View of Motor

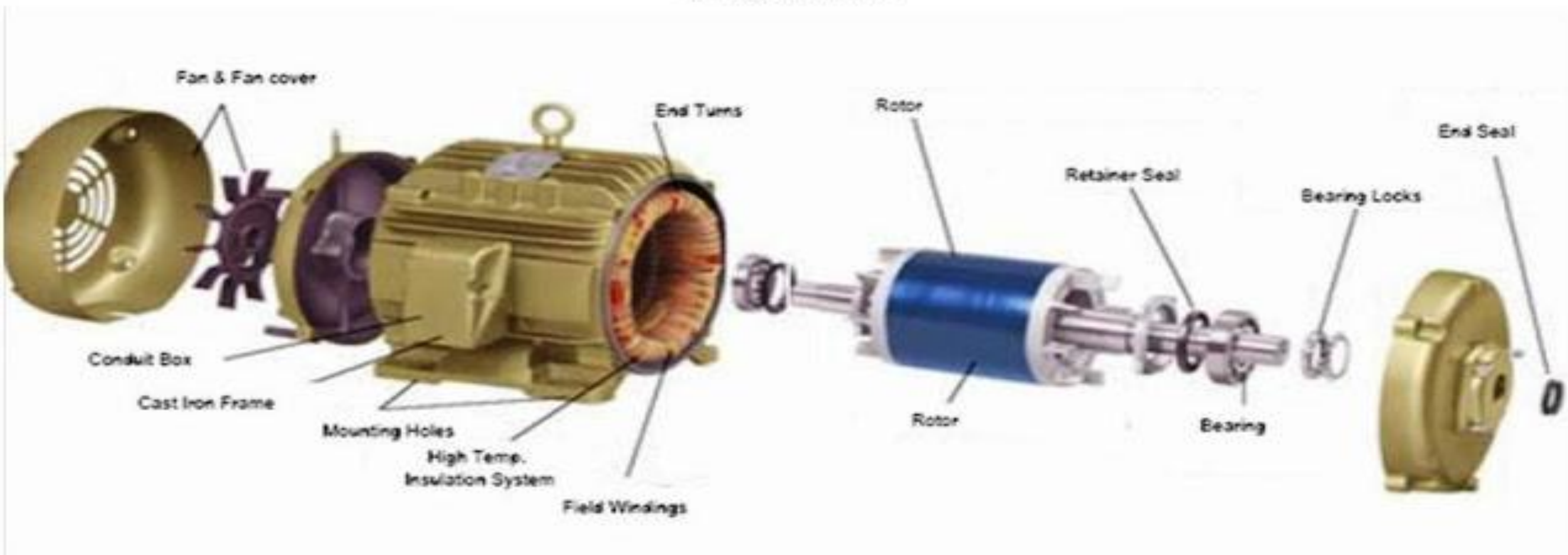


Figure 2. AC Motor Basic Parts

The basic parts for AC motors are as follows:

a. Enclosure.
b. Stator.
c. Rotor.
d. Bearings.
e. Conduit Box.

1.1.1.1.1. Enclosure

The enclosure consists of a frame (or yoke) and two end brackets (or bearing housings). A motor's enclosure not only holds the motor's components together, it also protects the internal components from moisture and containments. The degree of protection depends on the enclosure type. In addition, the type of enclosure affects the motor's cooling. There are two categories of enclosures as follows:

- Open Enclosure.
- Totally enclosed Enclosure.

1.1.1.1.2 Stator

The motor stator consists of two main parts:

A) Stator Core

The stator is the stationary part of the motor's electromagnetic circuit. The stator is electrical circuit that performs as electromagnet. The stator core is made up of many thin metal sheets, called laminations. Laminations are used to reduce energy losses that would result if a solid core were used.

B) Stator (Windings)

Stator laminations are stacked together forming a hollow cylinder. Coils of insulated wire are inserted into slots of the stator core. When the assembled motor is in operation, the stator windings are connected directly to the power source. Each grouping of coils, together with the steel core it surrounds, becomes an electromagnet when current is applied. Electromagnetism is the basic principle behind motor operation. Figure 3 below shows stator and stator windings

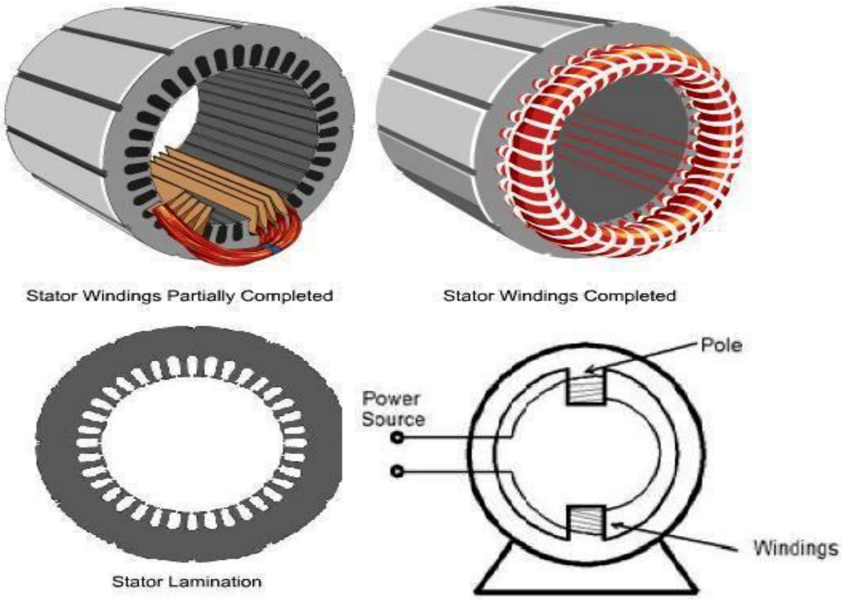


Figure 3. Stator and Stator windings

1.1.1.1.3 Rotor

The rotor is the rotating part of the motor's electromagnetic circuit. Magnetic field from the stator induces an opposing magnetic field onto the rotor causing the rotor to “push” away from the stator field. There are a lot of rotor types like Squirrel cage rotor and wound rotor. Figure 4 shows cutaway view of rotor.

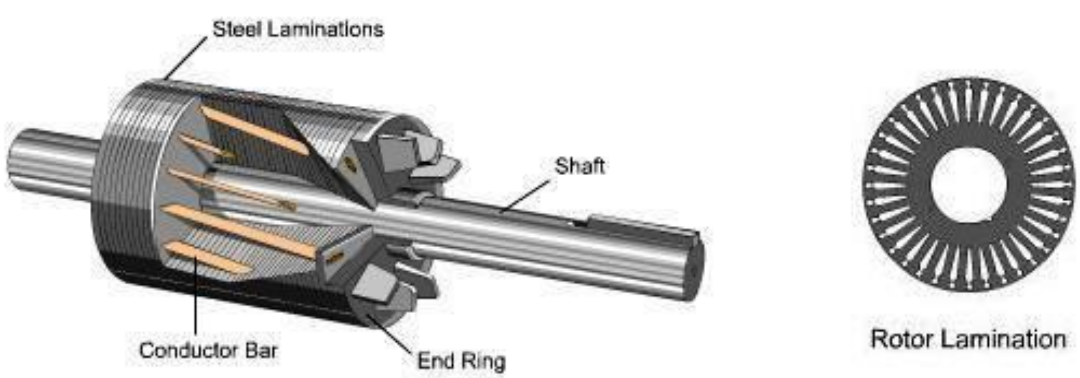


Figure 4. Cutaway view of Rotor

1.1.1.1.4 Bearings

Bearings, mounted on the shaft, support the rotor and allow it to turn. Not all bearings are suitable for every application; a universal, all-purpose bearing does not exist. The choice of bearing arrangement is based on the following qualities:

- Load carrying capacity in the axial and radial direction.
- Over speed and duration.
- Rotating speed.
- Bearing life.

The size of the bearing to be used is initially selected on the basis of its load carrying capacity, in relation to the load to be carried, and the requirements regarding its life and reliability. Other factors must also be taken into consideration, such as operating temperature, dirty and dusty environmental conditions, and vibration and shocks affecting bearings in running and resting conditions. Figure 5 below shows a cross section of three phase induction motor and its main parts

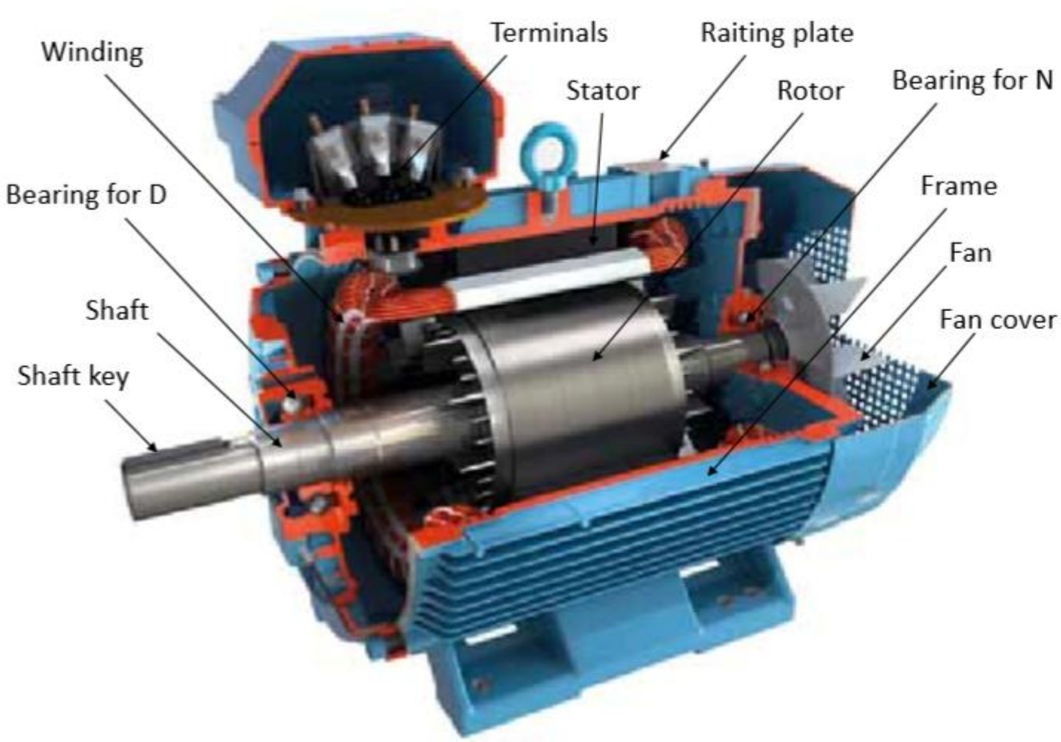


Figure 5 Cross section of cast-iron induction motor

1.1.1.1.5 Conduit Box

Conduit Box is where point of connection of electrical power to the motor's stator windings is made.Figure 6 below shows conduit box of electric motor

Figure 6 Conduit box of electric motor

1.1.1.2 Poles and Synchronous speed of AC motors

The synchronous speed of 3-phase AC motor is the rotation rate of the Stator's rotating magnetic field which is expressed in revolution per minute as

$$N_s = \frac{120x\ f}{p}$$

Where: N_S: synchronous speed in rpm
f: is motors supply frequency in Hz
p: number of magnetic poles

The rotation speeds of the rotating field, or synchronous speeds, according to the number of poles, are given in the table in Table 1 for industrial frequencies of 50 Hz and 60 Hz and one other frequency (100 Hz).

Number of poles	Speed of rotation in rpm		
	50 Hz	60 Hz	100 Hz
2	3000	3600	6000
4	1500	1800	3000
6	1000	1200	2000
8	750	900	1500
10	600	720	1200
12	500	600	1000
16	375	540	750

Table 1. Synchronous speeds of AC motors

It should be noted that in view of the slip, the on- load rotation speeds of induction motors are slightly lower than the synchronous speeds indicated in the table.

1.1.1.3 Electric motor drive system applications and efficiencies

1.1.1.3.1 Motor drive system applications

Motors are used in a myriad of applications, which are broadly categorized as follows:

- Industrial applications: pumps, fans, compressed air delivery, conveyors, motive power for other machinery, etc.
- Building applications: pumps, fans, conveyors, lifts, compressors in heating, ventilation and air-conditioning systems, etc.
- Appliance applications: refrigerators, air conditioners, personal computer and laptop fans, hard drives, cooking appliances, oven fans, extractor fans, garden appliances, pool pumps, etc.

The industries use electric motors for almost all processes. They drive both core industrial processes, like presses or rolls, and auxiliary systems, like compressed air generation, ventilation or water pumping. They are utilized throughout all industrial branches, though the main applications vary. With only some exceptions, electric motors are the main source for the provision of mechanical energy in industry. Efficient utilization of energy in the industrial sector can be better achieved by gradually replacing inefficient electric motors with energy efficient ones. This enables industries to cut their energy costs and become profitable and competitive. Motor drive systems utilize 60 - 70% of industrial energy consumption worldwide (International Energy

Agency, IEA 2007) depending on the type of industrial process and slight differences from country to country. About 90% of the motor population in industries constitutes induction (squirrel-cage rotor) motors. Therefore, when we talk of energy conservation and efficiency of electric motors in industries we talk of squirrel-cage rotor motors, again 90% of which are LT (low tension) motors. Most of the power requirement in industries is utilized by fans, blowers, compressors, pumps, material processing units, conveyors, drives and other larger process specific industrial equipment which use squirrel-cage rotor motors. It is estimated that a full implementation of efficiency improvement options could reduce worldwide electricity demand by about 7 percent (IEA 2008). The estimated share of global motor electricity demand by application is shown in Figure 7 below. Others electric energy customers like service and commercial sectors use electric motors especially for motor driven appliances.

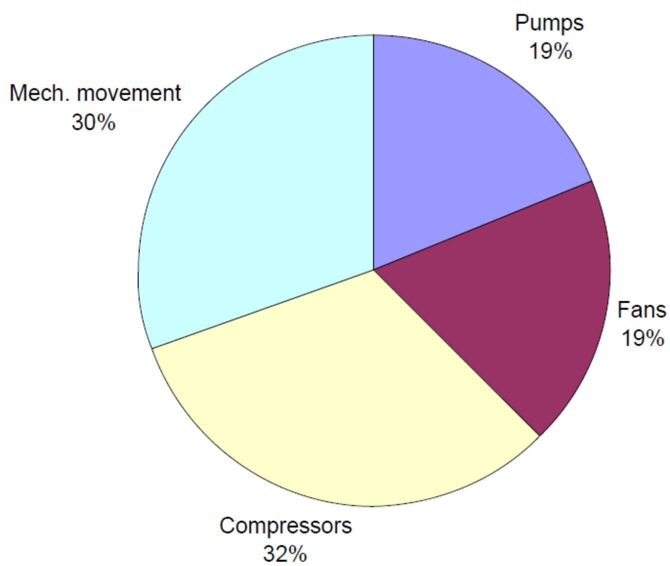


Figure 7 Estimated share of global motor electricity demand by application (2009).

(Sources: De Almeida et al. 2008b; A+B International, 2009(Paul Waide and Conrad U. Brunner. IEA 2011))

Sizes of electric motors vary between motors with less than one kW and large industrial motors with several MW rated power. In recent years, many studies identified large energy efficiency potentials in electric motors and motor systems with many saving options showing very short payback times and high cost-effectiveness. The main barrier especially in developing countries is the initial cost of energy efficient motors. In many cases, burnet motors are rewound and reused even though motor rewinding often reduces its efficiency.

Because of the above trends priority has been given for efficiency standardizing and labeling of industrial electric motors. Especially, product standardizing and labeling of smaller size Induction motors brings power and energy demand savings as these motors are widely used and their efficiencies are lower compared to larger Induction motors. Other motor types such as D.C motors and slip-ring induction motors can be also considered based on their applications.

1.1.1.3.2 Power losses and efficiencies for Standard efficiency motors

Motors existing in the majority of Ethiopian industries are referred to as Standard efficiency motors whereas current technology motors with improved efficiency and performance are known as Energy Efficient Motors (EEMs). Power losses and efficiencies exhibited on the Standard efficiency motors are discussed in the following section

A) Power losses and efficiencies with reference to design

Motor efficiency (η), is a measure of the effectiveness with which a motor converts electrical energy to mechanical energy and is defined as the ratio of the mechanical energy (P_{out}) delivered at the rotating shaft to the electrical energy input (P_{in}) at its terminals. The output power of a motor, mechanical power, is always less than the input power, electrical power, because of non avoidable and avoidable losses. The motor efficiency can be directly determined from measured values of P_{in} and P_{out}. With reference to the design of electric motors, efficiency is determined by the intrinsic losses which can be reduced only by changes in motor design. Intrinsic losses are of two types:

Fixed losses- independent of motor load and **Variable losses** - dependent on load.

i) Fixed losses consist of magnetic core losses, friction and windage losses.

Core Losses: Core losses are those found in the stator and rotor magnetic steel and are caused by hysteresis effect and eddy current effect during 50 Hz magnetization of the core material. These losses are independent of load and account for 20 – 25 % of the total losses.

The hysteresis losses which are a function of flux density are reduced by utilizing low-loss grade of silicon steel laminations. The reduction of flux density is achieved by suitable increase in the core length of stator and rotor. Eddy current losses are generated by circulating current within the core steel laminations. These are reduced by using thinner laminations. Eddy current on laminated iron sheet is shown in Figure 8 below.

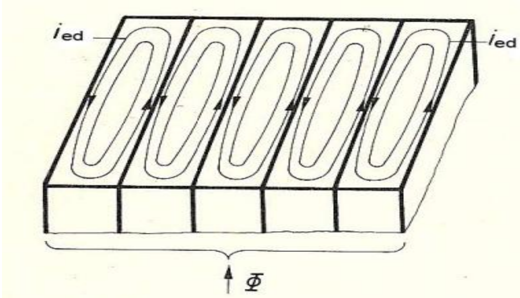


Figure 8. Eddy current on laminated iron sheet

Friction and Windage Losses: Friction and windage losses results from bearing friction, windage and circulating air through the motor and account for 8 – 12 % of total losses. These losses are independent of load. The reduction in heat generated by stator and rotor losses permits the use of smaller fan.

ii) Variable losses

Variable losses consist of resistance losses in the stator and in the rotor and miscellaneous stray losses. Resistance to current flow in the stator and rotor causes heat generation which is proportional to the resistance of the material and the square of the current (I^2R). Stray losses arise from a variety of sources and are difficult to either measure directly or to calculate**,** but are generally proportional to the square of the rotor current.

Stator and Rotor I^2R Losses: These losses are major losses and typically account for 55% to 60% of the total losses. I^2R losses are heating losses resulting from current passing through stator and rotor conductors and are the function of a conductor resistance and the square of current. Resistance of conductor is a function of conductor material, length and cross sectional area. The suitable selection of copper conductor size will reduce the resistance. Reducing the motor current is most readily accomplished by decreasing the magnetizing component of current. This involves lowering the operating flux density and possible shortening of air gap. Rotor I^2R losses are a function of the rotor conductors (usually aluminium) and the rotor slip. Utilisation of copper conductors will reduce the winding resistance. Motor operation closer to synchronous speed will also reduce rotor I^2R losses.

Stray Load-Losses: These losses vary according to square of the load current and are caused by leakage flux induced by load currents in the laminations and account for 4 to 5 % of total losses. These losses are reduced by careful selection of slot numbers, tooth/slot geometry and air gap. The largest contributors to the stray losses are the harmonic energies when the motor operates under load.

Heat-loses: The stator heat-lose $3.I^2_1.R_1$ and the rotor heat lose $3.I^2_2.R_2$ depends up on the load.

Iron-loss (eddy current & hysteresis loss): They are caused by rotating magnetic flux and also they depend on the magnitude and frequency of the flux. Because the magnetic flux is almost independent of the load, the stator iron-loses are also considered as load independent. The rotor-iron loses are negligible because the rotor frequency is very small percent of the stator frequency. The magnetic flux is determined from stator voltage and supply frequency. Therefore, the stator voltage must not exceed the rating voltage in order to limit the iron-loses. Even by reduction of the source frequency the magnetic flux becomes larger than the rating frequency. This situation must be considered during speed control of an induction motor.

Additional loses: They are load dependent and mainly caused by leakage fluxes and harmonic fields. According to DIN VDE 0530, an additional loss of 0.5% of the rating load must be considered at full-load operation. The losses become larger when semiconductor rectifier/inverters are used.

Literatures on Electric motor parameter calculations indicate that for a Standard efficiency motor rated at 5HP (4.53KW), power factor of 0.8 and efficiency of 83%, the total losses above add up to 17%. The breakdown constituted: Stator copper losses - 8%, Rotor copper losses - 2%, Core loss, friction and windage loss - 4% and Stray losses - 3%.(Source: Parameter calculation of 5HP AC Induction motor, School of Electrical engineering, University of Malaysia, 2009)

B) Power losses and efficiencies with reference to performance and operation

Factors which may affect the overall efficiency of electric motors related to performance include power supply quality(including harmonics) and level, poor maintenance practices, system over sizing (proper equipment sizing), the distribution network that feeds the motor (power factor and distribution losses), the transmission and mechanical components, and the match between the load and the motor.

B1) Power supply quality and level

Motor performance is affected considerably by the quality of input power, that is the actual volts and frequency available at motor terminals vis-à-vis rated values as well as voltage and frequency variations and voltage unbalance across the three phases. Motors in different countries must comply with standards set by the respective standards for tolerance to variations in input power quality.

Harmonics:

Under ideal operating conditions, utilities supply pure Sinosoidal waveforms (50 Hz frequency). However there are some loads namely VSDs (Variable Speed Drives) and other power electronic devices, arc furnaces, saturated magnetic cores (transformers, reactors), TVs and computers that cause voltage distortion. The resulting distorted wave form contains a series of sine waves with frequencies that are multiples of the fundamental 50 Hz frequency, the so called Harmonics.

Harmonics increase motor's losses and noise, reduce torque and cause torque pulsation and overheating. Vibration and heat can shorten motor's life by damaging bearings and insulation.

Volltage variation

Induction motors are at times operated on circuits of voltage other than those for which the motors are rated. Under such conditions, the performance of the motor will vary from the rating, as shown in Figure 9 below. The following are some of the operating results caused by small variation of voltage:

- Motor temperature
- Power factor
- Starting torque
- Slip

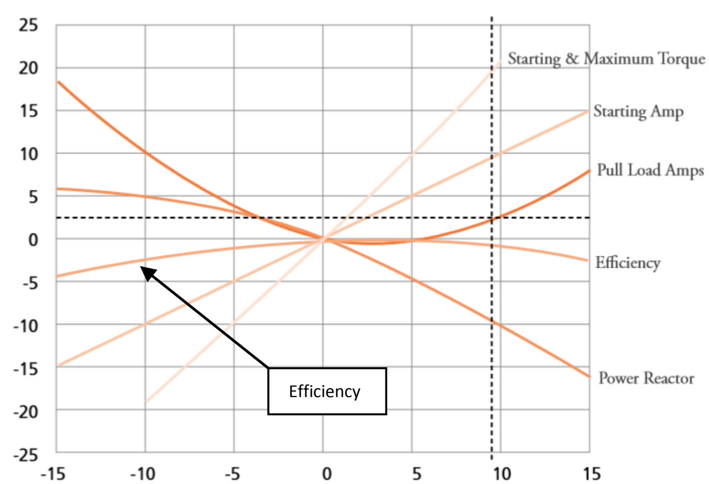


Figure 9. Effect of voltage variations on induction motor character
(Source: Energy efficiency improvements for motor & its drive systems, UNEP, Dec 2011)

From Figure 9, a 10% voltage variation increases motor load by 2.5 – 3.5%, reduce efficiency by 1%, reduce power factor by 10% and etc.

Voltage unbalance

Voltage unbalance (including single phasing) is both a leading cause of motor faliures and a major contributor to energy losses in motors. The subsequent current unbalance that result produce additional losses in the motor. Voltage unbalance, the condition where the voltages in the three phases are not equal, is detrimental to motor performance and motor life. Unbalance typically occurs as a result of supplying single-phase loads disproportionately from one of the phases. It can also result from the use of different sizes of cables in the distribution system

The effect of unbalanced voltages on polyphase induction motors is equivallent to the introduction of a “negative sequence voltage” having a rotation opposite to that occuring with balanced voltages. This negative sequence voltage produces in air gap a flux rotating against rototation of the rotor, tending to produce high currents. The Impacts of voltage imbalance are:

- Increase in winding temperatures. The Increase in winding temperatura causes additional power losses, insulation deterioration and a sigificant drop in motor efficiency.
- Increase vibrations and noise.

Transients: internally as the result of the operation of switching devices, external sources include lightning , electrostatic discharge and nuclear activities.

Undervoltage (occurs when the nominal voltage drops below 90% for more than 1 minute),

Voltage dip (the RMS voltage is below the nominal voltage by 10 to 90% for 0.5 cycle to 1 minute)

Spike ("impulses", or "surges", generally caused by large inductive loads being turned off, or more severely by lightning.)

Overvoltage (occurs when the nominal voltage rises above 110% for more than 1 minute) e.t.c.

All the above problems affect the efficiency of motors by affecting motor current and torques.

B2) Absence of match between load and Motors

Measuring Load

% Loading of the motor can be estimated by the following relation:

$$\% \text{ loading} = \frac{\text{Input power drawn by the motor (kW) at existing load} \times 100}{\text{Name plate full load kW rating / name plate full load motor efficiency}}$$

Motor under loading

The most common practice contributing to sub-optimal motor efficiency is that of under-loading. Under-loading results in lower efficiency and power factor, and higher than necessary first cost for the motor and related control equipment. Under-loading is common for several reasons. Original equipment manufacturers tend to use a large safety factor in motors they select. The user may need this full capacity rarely, resulting in under-loaded operation most of the time. Another common reason for under- loading is selection of a larger motor to enable the output to be maintained at the desired level even when input voltages are abnormally low. Finally, under-loading also results from selecting a large motor for an application requiring high starting torque where a special motor, designed for high torque, would have been suitable. A careful evaluation of the load would determine the capacity of the motor that should be selected.

Most electric motors are designed to run at 50 to 100 percent of rated load. Optimum efficiency is at 75 percent of rated load. Thus, a 10 horse- power (hp) motor has an acceptable load range of 5 to 10 hp; peak efficiency is at 7.5 hp. Under loaded motors, those loaded below 50 percent of rated load, are inefficient and exhibit **low power factor.**

Motor efficiencies at constant RPM will change as the load changes. The efficiency of a typical motor may peak at 75% load, but will drop rapidly below some threshold. Figure 10 shows approximate relationship of motor load and efficiency for different motor ratings.

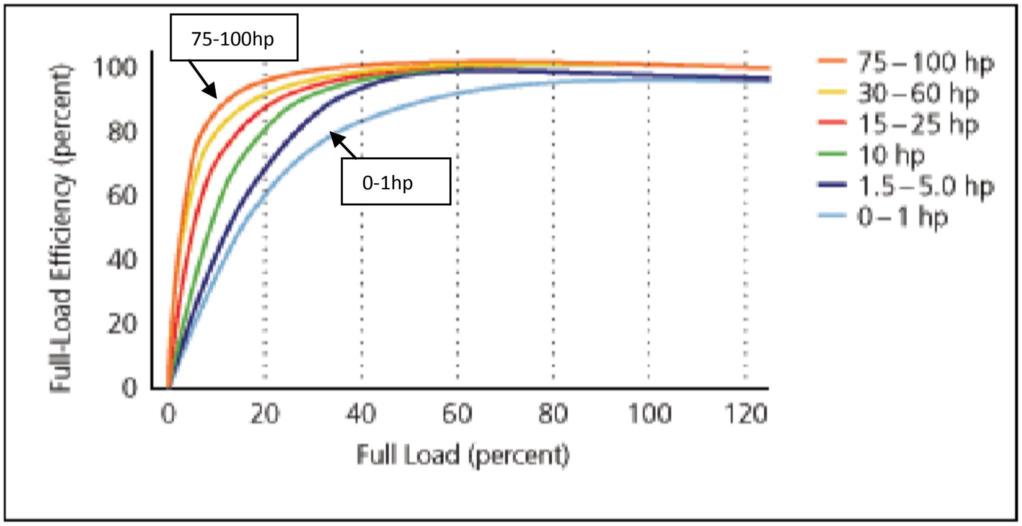


Figure 10. Induction Motor efficiency as a function of load
(Source: Natural resources Canada, 2003)

Power Factor (PF)

Power factor is a measurement of the phase angle lag between electrical voltage and current, with 100% as optimum. Low power factor results in increased electrical distribution system losses. For this reason an increasing number of utilities charge a penalty for low power factor. Replacing under loaded motors with correctly sized motors improves efficiency and raises power factor.

Induction motors are characterized by power factors less than unity, leading to lower overall efficiency (and higher overall operating cost) associated with a plant's electrical system. Capacitors connected in parallel (shunted) with the motor are typically used to improve the power factor. The impacts of PF correction include reduced kVA demand (and hence reduced utility demand charges), reduced I^2R losses in cables upstream of the capacitor (and hence reduced energy charges), reduced voltage drop in the cables (leading to improved voltage regulation), and an increase in the overall efficiency of the plant electrical system. It should be noted that PF capacitor improves power factor from the point of installation back to the generating side. It means that, if a PF capacitor is installed at the starter terminals of the motor, it won't improve the operating PF of the motor, but the PF from starter terminals to the power generating side will improve, i.e., the benefits of PF would be only on upstream side. Figure 11 provides general illustration of how power factor varies with load

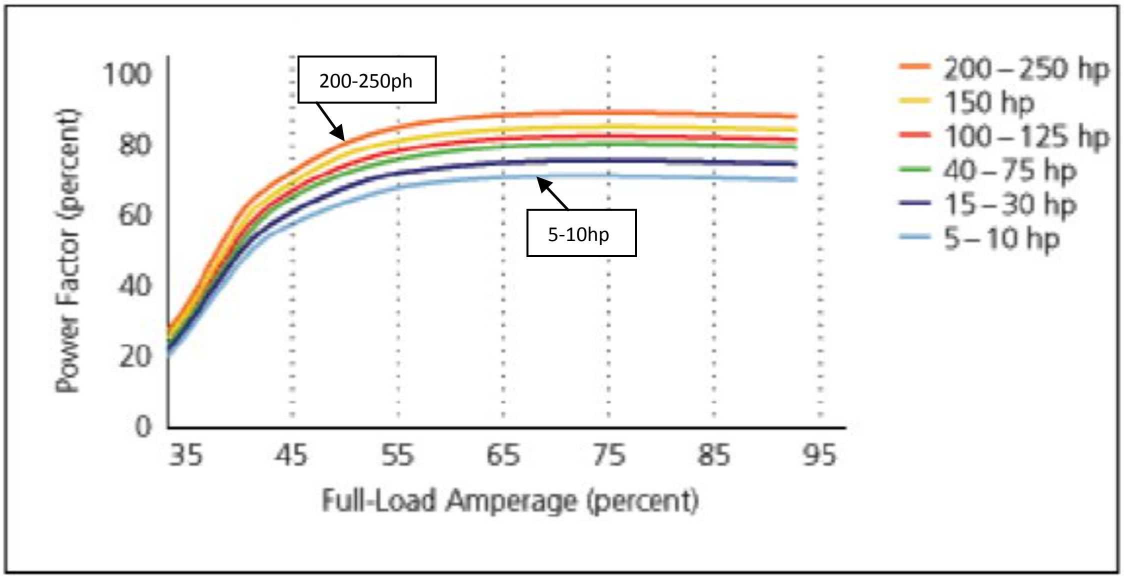


Figure 11. Induction motor power factor as a function of full load amperage (Natural resource Canada 2003)

Motor over loading

Overloaded motors can overheat and lose efficiency. Many motors are designed with a service factor that allows occasional overloading. Service factor is a multiplier that indicates how much a motor can be overloaded. For example, a 10 horse- power motor with a 1.15 service factor can handle an 11.5 horse- power load for short periods of time without incurring significant damage. Although many motors have service factors of 1.15, running a motor above the rated load reduces efficiency, and if done frequently, reduces service life

B3) Inadequate Maintenance and repair practices

Inadequate maintenance of motors can significantly increase losses and lead to unreliable operation. Common abnormalities are: mecahnical misalignment, poor rewinding, improper V belt application, and improper lubrication. For example, improper lubrication can cause increased friction in both the motor and associated drive transmission equipment. Resistance losses in the motor, which rise with temperature, would increase. e.g. excess oil or grease from the motor bearings can enter the motor and saturate the motor insulation, causing premature failure or creating a fire risk. Motor lubrication can save about 1-2 % of energy (R.Saidur, Department of Mechanical engineering University of Malaya, Malaysia)

Providing adequate ventilation and keeping motor cooling ducts clean can help dissipate heat to reduce excessive losses. The life of the insulation in the motor would also be longer: for every 10°C increase in motor operating temperature over the recommended peak, the time before rewinding would be needed is estimated to be halved

Age

Most motor cores are manufactured from silicon steel or de-carbonized cold-rolled steel, the electrical properties of which do not change measurably with age. However, poor maintenance (inadequate lubrication of bearings, insufficient cleaning of air cooling passages, etc.) can cause a deterioration in motor efficiency over time.

Rewinding

It is common practice in industry to rewind burnt-out motors. The population of rewound motors in some industries exceed 50 % of the total population. Careful rewinding can some- times maintain motor efficiency at previous levels, but in most cases, losses in efficiency result. Rewinding can affect a number of factors that contribute to deteriorated motor efficiency: winding and slot design, winding material (size, type, number of turns per coil & coil span), insulation performance, and operating temperature. Figure 12 below shows low slot fill during rewinding.

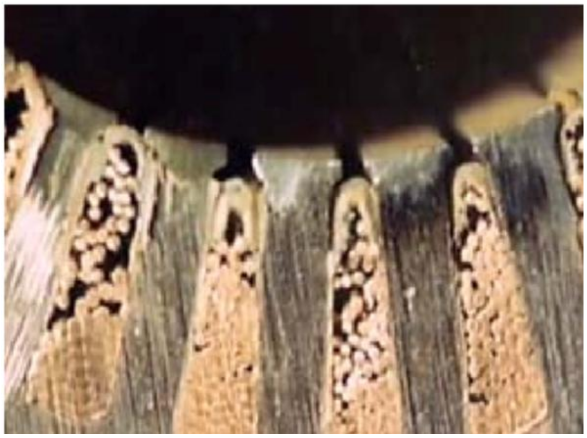


Figure 12. Low and improper stator winding slot fill

For example, a common problem occurs when heat is applied to strip old windings: the insulation between laminations can be damaged, thereby increasing eddy current losses. A change in the air gap may affect power factor and output torque. However, if proper measures are taken, motor efficiency can be maintained, and in some cases increased, after rewinding. Efficiency can be improved by changing the winding design, though the power factor could be affected in the process. Using wires of greater cross section, slot size permitting, would reduce stator losses thereby increasing efficiency. However, it is generally recommended that the original design of the motor be preserved during the rewind, unless there are specific, load-related reasons for redesign.

The impact of rewinding on motor efficiency where there is no control on stripping and rewind could be as high as a decrease in 1% in efficiency. Annex 1 shows test results made (Electrical service apparatuse association Inc. USA .) Ethiopian standard, ES IEC 60034 - 31: 2012, P 23, indicates also that depending upon rewinding practices efficiency of a rewound motor may drop in the range of 1.0% to 2.5% points.

C) Environmental conditions of operations

The operation and life expectancy of a motor depends upon the environmental conditions of operations. These conditions include Insufficient ventilation, high ambient temperature, humidity, excessive moisture, contact with water, dirt, chemicals, mechanical forces. These are primarily influences under the responsibility of the user. Ambient conditions can also have a detrimental effect on motor performance. For example, excessively high temperatures, high dust loading, corrosive atmosphere, and humidity can impair insulation properties; mechanical stresses due to load cycling can lead to misalignment. However, with adequate care, motor performance can be maintained.

Insufficient ventilation or higher ambient temperatura result in higher resistance in the winding. On the average, the efficiency of a motor will decay by 0.2 to 1.0% points from room temperature to its operating tempearture.(ES IEC 60034 -31:2012,P25)

Air quality

In addition to temperature, materials in the air tend to reduce the service life of the motor. These effects can arise due to lack of cooling, corrosion, abrasion, changes in the motor materials, and the probability of explosions.

Dirt and Dusts

Lint and very dirty operating conditions can cause accumulations that interfere with normal ventilation and cooling. Some dusts, such as sand, are abrasive. This can cause excessive wear and may damage the insulation. Motors for these environments generally must be enclosed.

Metallic and carbon dusts may be conductive, causing an electrical short circuit or loss in power. Other dusts, such as grains, are combustible from a spark or the elevated temperatures in a motor. Ignitable fibers, such as cotton and nylon, are also ignitable. These tend to fly in the air. Motors used in the above environments require suitable enclosures.

D) Motor power versus efficiency

Generally the efficiency of A.C and D.C become better as motor power increases. Larger motors have inherently higher rated efficiencies than smaller motors. Motor efficiency depends on the rated power of the motor. Table 1 below shows efficiency of motors vs power rating.

A.C Motor Power [KW]	Efficiency (η) (%)
0.37	66
0.55	73
0.75	74
1.1	76.5
1.5	79
2.2	82
3.7	85
5.5	87.5

Table 1. Efficiency of AC motors versus power rating

1.1.1.3.3 Energy Efficient Motors (EEMs)

Energy-efficient motors (EEM) are motors in which design improvements are incorporated specifically to increase operating efficiency over motors of standard design. Design improvements focus on reducing intrinsic motor losses. Improvements include the use of lower-loss silicon steel, a longer core (to increase active material), thicker wires (to reduce resistance), thinner laminations, smaller air gap between stator and rotor, copper instead of aluminum bars in the rotor, superior bearings and a smaller fan, etc.

EEMs cover a wide range of ratings and the full load efficiencies are higher by 3 to 7 % than Standard motors. In some countries, energy-efficient motors are designed to operate without loss in efficiency at loads between 75 % and 100 % of rated capacity. This may result in major benefits in varying load applications. Energy efficient motors have lower operating temperatures and noise levels, greater ability to accelerate higher-inertia loads, and are less affected by supply voltage fluctuations.

An EEM produces the same shaft output power, but uses less input power than a Standard efficiency motor. A Standard motor is a compromise between efficiency, endurance, starting torque, and initial cost (with strong emphasis on the initial cost). Standard motor generally competes on price, not efficiency. On the contrary, EEM competes on efficiency, not price.

The advantages of EEM include:

- The EEM has a greater efficiency than a standard motors; therefore they have less operating costs.
- EEM has a lower slip so they have a higher speed than standard motors.
- EEM can reduce maintenance costs and improve operations in industry due to robustness and reliability
- increasing productivity.

EEEMs generally have longer insulation and bearing lives, lower heat output, and less vibration. In addition, these motors are often more tolerant of overload conditions and phase imbalance. This results in low failure rates, which has prompted most manufacturers to offer longer warranties for their energy-efficient motors.

Because the favourable economics of EEMs are based on savings in operating costs, there may be certain cases which are generally economically ill-suited to energy-efficient motors. These include highly intermittent duty or special torque applications such as hoists and cranes, traction drives, punch presses, machine tools, and centrifuges. In addition, efficient designs of multi-speed motors are generally not available. Furthermore, EEMs are not yet available for many special applications, e.g. for flame-proof operation in oil-field or fire pumps or for very low speed applications (below 750 rpm). Also, most EEMs produced today are designed only for continuous duty cycle operation. Given the tendency of over sizing on the one hand and ground realities like; voltage, frequency variations, efficacy of rewinding in case of a burnout, on the other hand, benefits of EEM's can be achieved only by careful selection, implementation, operation and maintenance efforts of energy managers.

The International Electro technical Commission (IEC)

IEC is charged with international standards for electric rotating machines, i.e. motors and generators. Representatives from some 45 National IEC Committees (NCs), including 15 countries with observer status, work together on the development of motor standards in the Technical Committee 2 (TC2). The experts come from industry, government, universities, research and testing laboratories, and NGOs. All proposed new and amended standards go through a rigorous system of international scrutiny and are finally decided by voting by the NCs.

Basic characteristics and performance of electric motors are standardized in the IEC standards, the first versions of which were started many years before energy efficiency standards were required: geometry, mounting, protection, vibration and noise.

The IEC energy efficiency classification: IEC 60034-30 in 2008 was based on the advanced efficiency measurement standard in IEC 60034-2-1 and defined the new IE-code with three levels of motor efficiency classification: IE1 Standard Efficiency, IE2 High Efficiency and IE3 Premium Efficiency. It is applicable for electric motors operated on a grid frequency of 50 Hz or 60 Hz, with an output power ranging from 0.75 kW up to 375 kW, and with 2-, 4- and 6-poles. In its revised edition IEC 60034-30-1, enlarges the scope to smaller motors with 0.12 kW up to larger motors with 1000 kW; it also includes 8-pole motors and defines now also the IE4 Super Premium Efficiency level. Figure 13 and Table 2 show the IEC motor efficiency classes.

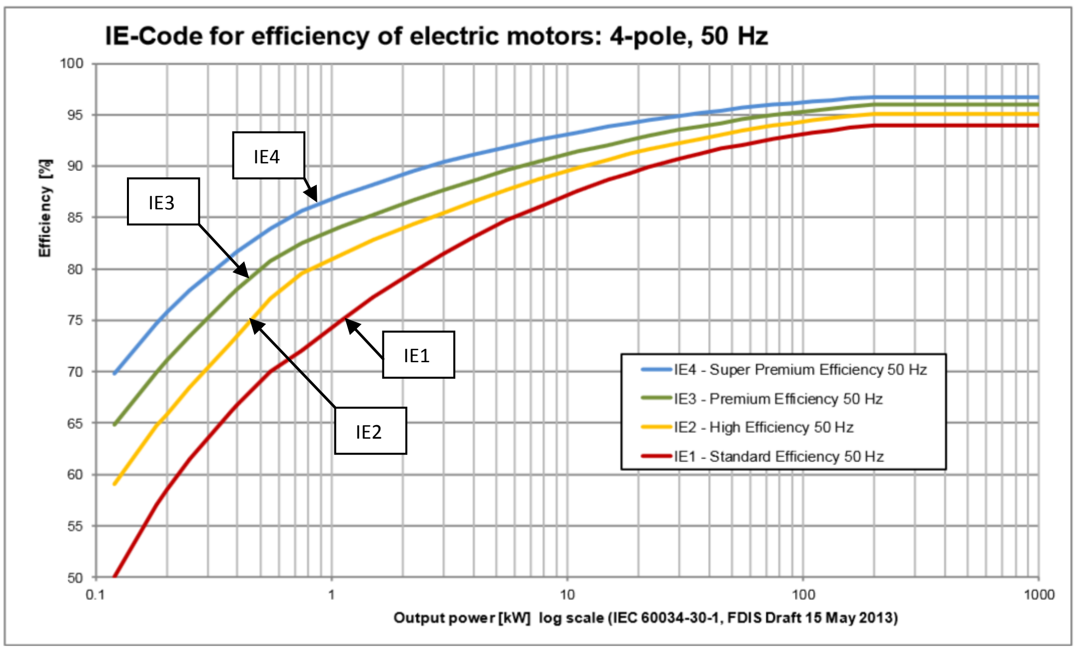


Figure 13. Standard versus high efficiency motors

Output	IE1				IE2				IE3				IE4			
KW	**2 Pole**	**4 Pole**	**6 Pole**	**8 Pole**	**2 Pole**	**4 Pole**	**6 Pole**	**8 Pole**	**2 Pole**	**4 Pole**	**6 Pole**	**8 Pole**	**2 Pole**	**4 Pole**	**6 Pole**	**8 Pole**
0.12	45.0	50.0	38.3	31.0	53.6	59.1	50.6	39.8	60.8	64.8	57.7	50.7	66.5	69.8	64.9	62.3
0.18	52.8	57.0	45.5	38.0	60.4	64.7	56.6	45.9	65.9	69..9	63.9	58.7	70.8	74.7	70.1	67.2
0.20	54.6	58.5	47.6	39.7	61.9	65.9	58.2	47.4	67.2	71.1	65.4	60.6	71.9	75.8	71.4	68.4
0.25	58.2	61.5	52.1	43.4	64.8	68.5	61.6	50.6	69.7	73.5	68.6	64.1	74.3	77.9	74.1	70.8
0.37	63.9	66.0	59.7	49.7	69.5	72.7	67.6	56.1	73.8	77.3	73.5	69.3	78.1	81.1	78.0	74.3
0.40	64.9	66.8	61.1	50.9	70.4	73.5	68.8	57.2	74.6	78.0	74.4	70.1	78.9	81.7	78.7	74.9
0.55	69.0	70.0	65.8	56.1	74.1	77.1	73.1	61.7	77.8	80.8	77.2	73.0	81.5	83.9	80.9	77.0
0.75	72.1	72.1	70.0	61.2	77.4	79.6	75.9	66.2	80.7	82.5	78.9	75.0	83.5	85.7	82.7	78.4
1.1	75.0	75.0	72.9	66.5	79.6	81.4	78.1	70.8	82.7	84.1	81.0	77.7	85.2	87.2	84.5	80.8
1.5	77.2	77.2	75.2	70.2	81.3	82.8	79.8	74.1	84.2	85.3	82.5	79.7	86.5	88.2	85.9	82.6
2.2	79.7	79.7	77.7	74.2	83.2	84.3	81.8	77.6	85.9	86.7	84.3	81.9	88.0	89.5	87.4	84.5
3	81.5	81.5	79.7	77.0	84.6	85.5	83.3	80.0	87.1	87.7	85.6	83.5	89.1	91.1	88.6	85.9
4	83.1	83.1	81.4	79.2	85.8	86.6	84.6	81.9	88.1	88.6	86.8	84.8	90.0	90.4	89.5	87.1
5.5	84.7	84.7	83.1	81.4	87.0	87.7	86.0	83.8	89.2	89.6	88.0	86.2	90.9	91.9	90.5	88.3
7.5	86.0	86.0	84.7	83.1	88.1	88.7	87.2	85.3	90.1	90.4	89.1	87.3	91.7	92.6	91.3	89.3
11	87.6	87.6	86.4	85.0	89.4	89.8	88.7	86.9	91.2	91.4	90.3	88.6	92.6	93.3	92.3	90.4
15	88.7	88.7	87.7	86.2	90.3	90.6	89.7	88.0	91.9	92.1	91.2	89.6	93.3	93.9	92.9	91.2
18.5	89.3	89.3	88.6	86.9	90.9	91.2	90.4	88.6	92.4	92.6	91.7	90.1	93.7	94.2	93.4	91.7
22	89.9	89.9	89.2	87.4	91.3	91.6	90.9	89.1	92.7	93.0	92.2	90.6	94.0	94.5	93.7	92.1
30	90.7	90.7	90.2	88.3	92.0	92.3	91.7	89.8	93.3	93.6	92.9	91.3	94.5	94.9	94.2	92.7
37	91.2	91.2	90.8	88.8	92.5	92.7	92.2	90.3	93.7	93.9	93.3	91.8	94.8	95.2	94.5	93.1
45	91.7	91.7	91.4	89.2	92.9	93.1	92.7	90.7	94.0	94.2	93.7	92.2	95.0	95.4	94.8	93.4
55	92.1	92.1	91.9	89.7	93.2	93.5	93.1	91.0	94.3	94.6	94.1	92.5	95.3	95.7	95.1	93.7
75	92.7	92.7	92.6	90.3	93.8	94.0	93.7	91.6	94.7	95.0	94.6	93.1	95.6	96.0	95.4	94.2
90	93.0	93.0	92.9	90.7	94.1	94.2	94.0	91.9	95.0	95.2	94.9	93.4	95.8	96.1	95.6	94.4
110	93.3	93.3	93.3	91.1	94.3	94.5	94.3	92.3	95.2	95.4	95.1	93.7	96.0	96.3	95.8	94.7
132	93.5	93.5	93.5	91.5	94.6	94.7	94.6	92.6	95.4	95.6	95.4	94.0	96.2	96.4	96.0	94.9
160	93.8	93.8	93.8	91.9	94.8	94.9	94.8	93.0	95.6	95.8	95.6	94.3	96.3	96.6	96.2	95.1
200	94.0	94.0	94.0	92.5	95.0	95.1	95.0	93.5	95.8	96.0	95.8	94.6	96.5	96.7	96.3	95.4
250	94.0				95.0			93.5				94.6	96.5	96.7	96.5	95.4
315	94.0							93.5				94.6	96.5	96.7	96.6	95.4
355	94.0							93.5				94.6	96.5	96.7	96.6	95.4
400	94.0							93.5				94.6	96.5	96.7	96.6	95.4
450	94.0							93.5				94.6	96.5	96.7	96.6	95.4
500-1000	94.0							93.5				94.6	96.5	96.7	96.6	95.4

Table 2. EEM minimum 50 Hz efficiency values defined in IEC/EN 60034-30-1:2014
(based on test methods specified inIEC 60034-2-1:2014)

1.1.2 Electric motors employed in Ethiopian factories and their limitations

1.1.2.1 Survey on Electric Motors

Survey has been made on electric motors at twelve sample factories listed in Table 3 below. The factories have been selected from different industrial sectors in the country.

No	Type of Factory	Name of factory	Main product
1	Sugar factory	Wonji Showa Sugar factory	Sugar
2	Leather processing factory	ELICO	Leather processing
3	Cement factory	Muger cement factory	Cement
4	Textile factory	AYKA Addis Textile	Garment and Textile
5	Metal factory/Ega sheet factory	Kality Metal production	Steel, Ega sheet
6	Tire factory	Horizon Addis Tyre	Tyre
7	Beer factory	BGI Ethiopia	Beer
8	Soft drink factory	East Africa Bottling(Coca Cola)	Coka Cola
9	Flour grinding mills	Fafa food complex	Food products
10	Furniture and Wood factory	3F Furniture	Furniture
11	Chip wood factory	ECAFCO	Chip wood, door and window frames
12	Plastic Factory	Excel Plastic Factory	PVC pipes

Table 3. List of factories surveyed

Electric motor data including type, phase, power, current, voltage, frequency, speed, power factor and country of origin; and factory energy consumption including active and reactive power, maximum demand have been collected. The levels of rewinding, repair and maintenance practice on motors and factory power factor correction equipment installation have also been surveyed.

Further more, seven electric motor Importers and six maintenance service providers have been interviewed. Data of motor import from Ethiopian revenue and customs authority (ERCA) has been assessed. Summary of factories electric motor data, list of Importers and maintenance service providers are presented in Annex 2 and 3 respectively.

1.1.2.1 Existing motors and efficiency limitations

Most factories in Ethiopia use electric motors which have been in service for many years, in some case installed during the establishment of the factories. Even though not documented, many factories have been installed using refurbished motors and integrated motor drives. As a result, these factories operate with old and many times rewound motors having low energy efficiency.

The core problem of existing electric motors in Ethiopia is that they operate at low energy efficiency. The causes low of energy inefficiency are mainly attributed the design and manufacturing of the motors including import of substandard products, inadequate maintenance and rewinding practices, electric power fluctuations related problems, motor loading problems and absence of standards. The core problem, causes and the effects of low efficiency of existing electrical motors are indicated in Figure 14, overleaf.

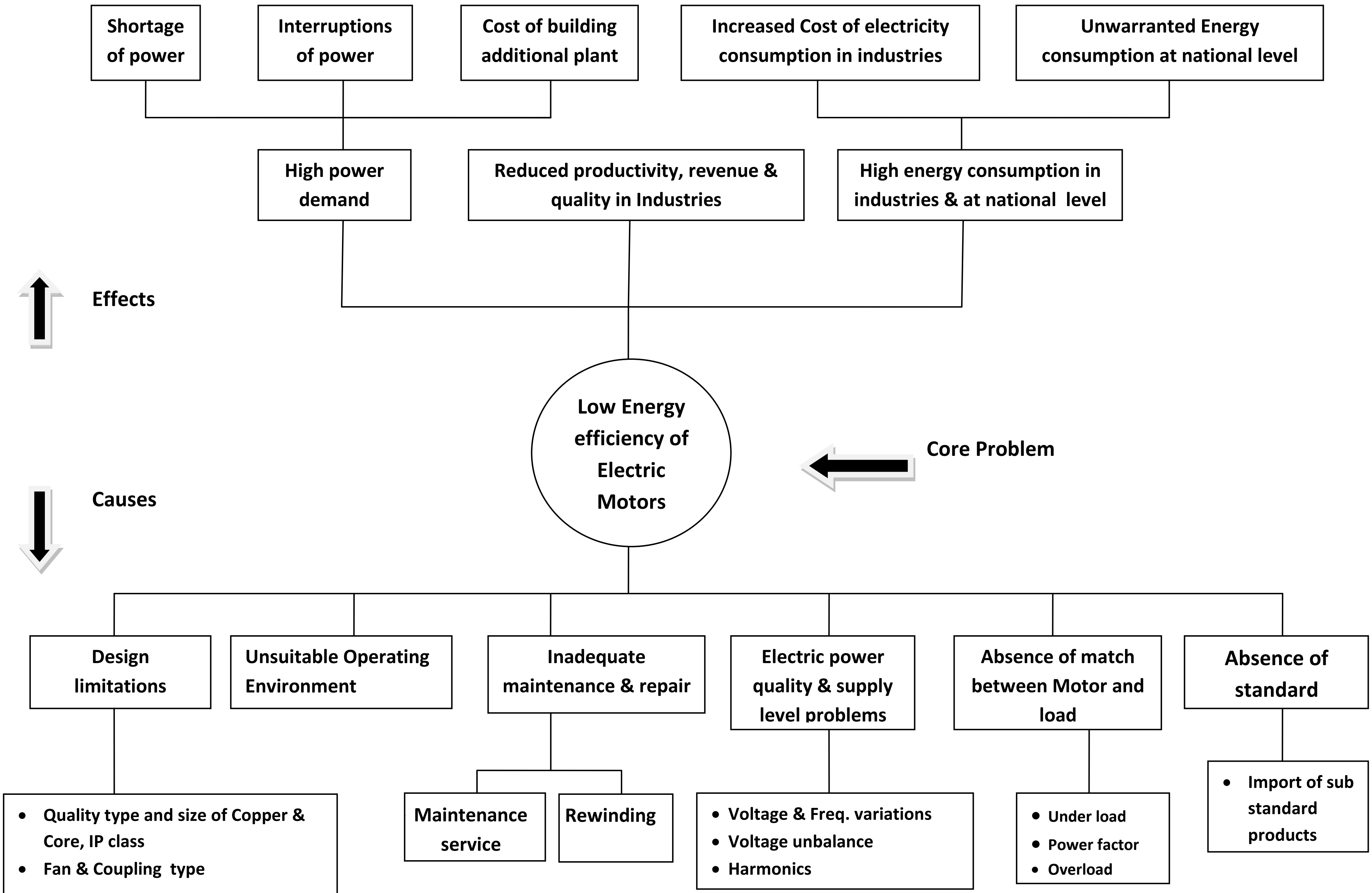


Figure 14. Electric Motor Problem Tree

1.1.2.2 Causes of energy inefficiency

1.1.2.2.1 Inherent Design limitations

Almost all industrial installations in Ethiopia operate with imported Standard efficiency motor types designed and manufactured many years ago. E.g. there are motors with over 50 year's service at factories like ECAFCO and ELICO. The service year of motors at the representative factories surveyed range from 3 to 58 years. The motors have long years of service and have received repetitive repair services. As discussed under 1.1.1.3.3 A, ii, above, these motors have inherent design and manufacturing limitations which reduce the efficiency of the motors by about 17%.

Based on the survey, there are few recent factory installations using new imported electric motors integrated with the motor drives and machineries at Ayka addis Textile, Coca Cola factories (partially), and Wonji Sugar factory.

The energy efficiencies of the motors for the representative factories has been calculated using nameplate data, shaft power (output power) and the electrical power input.

$$\eta = \frac{\text{Mechanical power out put(shaft power) x100}}{\text{Electrical input power}}$$

Details of Nameplate data of motors per factory have been collected and summary of the types of motors, weighted average power of the motors, % of Motor Pole, along with the weighted average energy efficiency is presented in Annex 2. The detailed data is sumbitted as a separate document/file. The overall summary of the data is presented in Table 4 overleaf.

Name of Factory	Motor Type	Phase	Motor Type	Motor Pole	Qty	% of Motor pole	% of Qty	Weighted Average Power of motors (KW)	Weighted Average efficiency of the motors (%)
All surveyed factories	AC	Three	Induction	2	1298	29.76%	74.9%		
				4	2708	**62.08%**		**16.2**	**80.20%**
				6	251	5.75%			
				8	99	2.27%			
				10	2	0.05%			
				12	4	0.09%			
				unknown	163				
			Synchronous		0				
			Universal		170		2.8%		
			High Voltage		48		0.8%		
		Single			1290		21.3%		
	DC				11		0.2%		
Total					**6044**	**100.00%**	**100.00%**		

Table 4. Summary of factory eclectic motors data

From Table 4, 99.8% of the motors in the factories are AC motors. 78.5% are three phase types. 74.9% are three phase induction motors. By type of pole, 62.08% are 4 pole machines whereas 29.76% are 2 pole types.

As the 4 pole motors constitute bigger portion of the factory motors, efficiency comparison, energy and demand saving estimates in subsequent sections of this report will be based on these types of motors. The total weighted average power of the 4 pole motors is 16.2 KW (21.7HP), the weighted average efficiency being 80.20 %.

The estimated laboratory test result discussed under 1.1.1.2.2, A) above indicated an efficiency level of 83% for 5HP motor. Efficiency for 21.5 HP motor is expected to have been higher than that of 5 HP as motor efficiency increases with motor power rating.

1.1.2.2.2 Power supply quality and level

There are no records at factory level for the case of incoming power quality and level. The occurrence and levels of voltage variance, unbalance, transients, and spikes are not recorded. Technicians in the surveyed factories have expressed the problems exist.

Standard and Walkthrough Energy audits are being made at Ethiopian factories by Ethiopain Energy Authority (EEA). The EEA walkthrough audits have confirmed that records on the electrical power quality and level affecting motor efficiency are not recorded at all in the factories. Detail energy audit have been undertaken by EEA and The Energy and Resources Institute (TERI), Banglore, in 2014 at four factories: Muger cement factory, Fincha suger factrory, Akaki Metal factory and Bahir Dar textile factory. The findings and recommendations as related to power quality and level at Muger cement factory as “short term measures” are: Reduction of the unbalance voltage and current level in the plant, and higher feeding voltage at ond and lower feeding voltage levels at the water treatment plant in the factory. No related problems have been indicated in the other factories.

It is common to see supply voltage levels reduce by about 5% to 10% from the nominal in the daily routines of measurements we make for electrical works in Ethiopia. If we take 5% as a minimum, it will reduce motor efficiency by about 1% as could be seen from the graph in Figure 9 , Effect of Voltage Variations on Induction Motor Characteristics.

1.1.2.2.3 Inadequate maintenance practices

A) Factory level maintenance.

Based on the survey made on the twelve sample factories, five factories have outsourced maintenance of the motors and seven factories maintain at their own workshops. All factories are not in possession of maintenance history record of motors which shall indicate the design specifications, maintenance and repair levels and dates, cost of maintenance to date etc. per motor. Repair is made on motors upon the request of the operators. Motors are repaired and delivered to the store for replacements. Record on on motors could indicate the original factory data on winding details, power rating etc.

The repairs made are recorded in few factories for property and financial control purposes or machinery control only. There are no Life Cycle Cost (LLC) evaluations made on electric motors as records are not available and hence cost of repairs and operation could go beyond purchase cost of new motors. Record on motors could have indicated the original factory data.

The main reasons technicians described for motor failures due to maintenance are:

- The negligence or being unaware of operators on the symptoms of motor problems. As a result early actions could not be taken
- In appropriate use of motor starting Star-Delta switches
- Poor quality motors parts for maintenance in the market
- Maintenance of Motors without Nameplate data. Nameplates are painted, damaged or removed from motors in most cases. There are a total of 305 motors without Nameplate data noticed in the twelve factories during the survey made.

Rewinding

Seven of the factories have estimated motor rewind frequencies to be from 3 to 76 motors per year. Five of the factories have no record at the technical unit level.

Based on the interviews made with factory maintenance workshops and private motor repair shops, there are different winding coil types, sizes and qualities like copper and Aluminium alloy, Aluminium painted copper and copper painted steel wires in the market which have adverse impact on a rewound motors efficiency and operation.

Based on the above, motor rewinding practices, it can be estimated that efficiency of motors in Ethiopian factories reduces by at least 1 to 2.5%.

Bearing Lubrication

Technicians in the older factories explained that there are bearing problems related to the type and quality of grease they use, over and under lubrication and the lack of skilled technicians. These problems have caused case motors overheat. Based on the above problems, international experience and the age of the motors, it is estimated that lack of proper lubrication on Ethiopian factory motors would contribute to 2 % decrease in efficiency.

Preventive maintenance

Few factories have preventive maintenance schedule. Maintenances are carried out regularly at Wonji Showa Sugar factory during the rainy season, during low production and during power interruption in other factories.

Preventive maintenance improves the efficiency of electrical motors and prolongs their life. Studies indicate that the savings associated with the regular motor preventive maintenance program could range from 2% to 3% of total motor system energy use.

B) Maintenance at private firms

Six main maintenance service providers listed in Annex 3 have been contacted to assess the level of maintenance practices on electric motors in Ethiopia. The following are summary of findings from the interviews made.

- Quantity of motors repaired in descending order
  - By number of phases: Three phase, Single phase.
  - By type of motors: Induction, Single phase, DC motors

- Country of origin of motors repaired in descending order
  - China (70 to 95%)
  - Italy, Germany (old motors), Turkey and India.
  - New German and Italian motors made under licences in China.

- Most common electric maintenance problems encountered in descending order
  - Winding problems : burning due to overvoltage, overload
  - Mechanical problems
  - Winding Insulation paper short circuit

- Most common application of motors repaired
  - Varied depending on their customers. Common are wood work machines, hollow block machine, milling machines, flour grinding machines, compressors, water pump motors and other Industrial motors

- Nameplates of motors
  - 90% and above of motors have nameplates. However, the nameplate motor power does not correspond to actual motor capacity. Service providers estimate motor capacity by measuring Stator internal diameter and coil diameter. Motor No-load test is not made.

- Challenges faced on motor repair and maintenance of motors

  - Customers bringing motors having Nameplate data discrepancy with actual motor power are advised about the incorrect values on the Nameplates. However motor winding burns after short periods of rewind as motor power doesn’t match the load. Customers allegedly associate the problem with rewinding service quality, which is not the case.

- Use of inferior winding coils: reduced coil quality in place of pure copper, coil diameter, insulating paper. There are grades of winding coils from A to D. Most motor re-winders use grade C or D coils due to the problem that customers (usually technical people are not assigned to purchase motor products and services) do not appreciate and want to pay for the quality standard coils.
- Allegedly, motor maintenances are carried out by unqualified personnel at places like Chid Tera, Addis Ababa. Replacement of partial burned winding coils and sub optimal maintenance practices are carried out which critically impair the efficiency of motors maintained.

- Motor rewind cost

  - About 460 Birr including VAT per Kg of winding wire. The weight of re-winding coil is estimated based on motor size and from experience on paer capacity of similar motor maintenances made earlier. E.g. 0.75 kW – 1.5 Kg, 4 Kw – 3 Kg, 30Kw – 22 to 23 Kgs of coil respectively .
  - Cost changes for higher capacity motor depending on the status of motor to be repaired and consumption of varnish and pape

Considering the above electric motor maintenance and repair practices it could be estimated that due to inadequate maintenance of motors in the country there would be reduction of efficiency of about 2.5%.

1.1.2.2.4 Absence of match between load and Motors

The level of load mismatching of motors cannot be easily assessed. It requires detail measurement to verify that a motor has been under loaded or overloaded.

Power factor for Industries under the Industrial HV and LV tariff group of EEU has been computed from the Active and Reactive energy consumption data (presumably partial data) of 2014 as summarised in Table 5 overleaf. Detail data is annexed as a separate document/file.

Description	Amount
Active power consumption (MWh)	1,311,545
Reactive power consumption (MVARh)	1,616,479
Tan θ (Active power/ Reactive power)	1.23
θ	50.9°
Cos θ(Power factor)	0.63
Power factor penalty counts out of 91,549 Bills	18,630

Table 5.Power factor for the Industrial HV and LV tariff group of EEU, 2014

From the EEU data, the overall power factor is 0.63, and 18,630 bills out of 91,549 or 20.3% of the industrial customer bills have power factor penalties. These some how indicate motors are running under load. The low power factor of the Industrial Tariff roup consumption in Ethiopia could be ascribed to the fact that electric motors are operating at under load. It is generally accepted that electric motors consume about two thirds of industrial energy consumption. Generally speaking load mismatch exists in Ethiopian factories.

The total motor load in a facility is usually a major factor in determining the system power factor. The power factor of induction motor decreases as the load decreases. From ES IEC 60034-31:2012, Figure 3 (Typical efficiency Versus load curve) and Figure 4 (Typical power factor Vs load curve), for a typical average motor power 15 KW, at a power factor of 0.63 the load factor is estimated to be about 45%. This in turn corresponds to a drop in efficiency of more than 1 % as compared to full load efficiency.

Detail and Walkthrough Energy audits being made by EEA and Teri, The Energy and resource Institute, Banglore, in 2014 at four factories: Muger cement factory, Fincha suger factrory, Akaki metal factory and Bahirdar textile factory recommended power factor improvements as indicated below:

- Muger cement factory: Medium term measures. Electrical System. Installation APFC control panel and additional kVAr banks in Line 1 & 2 MCC panel room.
- Fincha Sugar Factory: Long term measures. Installation APFC control panel and additional kVAr banks in old sugar plant MCC panel room.
- Kaliti Metal Factory Medium term measures. Electrical System. Rectifications APFC control panel and additional kVAr banks.

- Bahir dar Textile: Medium term measures. Electrical System Installation APFC control panel and additional kVAr banks in metering 1 & 2 MCC panel room, Steam generation and distribution.

1.1.2.2.5 Unsuitable Operating Environment

Electric motor failure rates at Ayika Textile has been found to be higher tan all other factories. The reason is accumulation of lint and humidity in the motors. Ingress of wáter has also been mentioned as one of the reason of motor failures. There are high temperature levels in factories like Ayka Addis Textile factory.

It is well understood that impacts like excessively high temperatures, high dust loading, corrosive atmosphere, and humidity can impair insulation properties of motor windings and related mechanical stresses. However, the impact of efficiency reduction on the electric motors due to the operating environment needs detailed study at the respective factories.

As per the Ethiopian standard, ES IEC 60034-31:2012, page 25, insufficient ventilation or high ambient temperatures result in higher resistance in the winding. The efficiency of a motor will decay on the average by 0.2 to 1.0% points from room temperature to its operating temperature.

1.1.2.2.6 Absence of standard on electric motors and motor parts

Lack of quality control upon import by responsible body, and as a result, import of substandard electrical motors is one of the causes of having lower efficiency motors in Ethiopia. A learned from the importers and maintenance service providers, sub standard electric motors and parts are being imported and operated in industries and private manufacturing firms.

A) Electrical motor imports

Seven importers have been interviewed whose list is presented in Annex 3. Below is summary of the interviews made.

- Types of electric motors imported in descending order of quantity.
    - Three phase, Induction
    - Single
- Country of origin of import in descending order of quantity.
    - China(including Chinese motors produced under Italian licence)

  - Italy
- All imported motors are new.
- Most common motor power ratings imported in descending order for quantity of motors
  - 20 HP, 3 phase
  - 25 HP, 3 phase
  - 10HP, 3 phase
  - 3 - 4 HP, 1 phase
- Most common application of the motors imported in descending order for quantity
  - Flour grinding machine, 3 phase. There is increasing demand due to replacement of diesel grinding machines by electric motor types as a result of the faster rural electrification.
  - Industrial machine , 3 phase
  - Milling (Metal cutting) machine, 3 phase. Increasing demand due to the booming of housing construction.
  - Wood working machine, 1 phase
  - Block machine, 1 phase
- All imported motors posses nameplates
  Two of the importers have included the names of their company on the nameplate (usually manufacturer's name is engraved on nameplates instead) of the motors they import to enable them distinguished from other sub optimal products they believe exist in the market, and for after sales service and marketing purposes.
- International or national standard to which motors imports are referenced.
  All importers do not have idea about standards on motors and they don't require their suppliers to meet standards. The packing list of one importer mentions "Standard Code: IEC 60034-1:2004". However, it doesn't specify the specific IEC efficiency class which the motor meets or the IEC efficiency class is not affixed to the motors. The "CE" mark for the IEC labelling and the standard reference number of the exporting country have been written on the nameplate of one of the motors.
- Most common energy efficiency related problems encountered by importers.
  - No reference to check the quality, power output and standard of motors imported. Motor imports are based on the trust on the exporting company.
  - Customers complain that newly purchased motors burn out, overheat and couldn't move drives. These motors are believed to be energy inefficient and have windings other than copper, in many cases copper painted steel coils, and the nameplate power rating is much higher than the actual power the motor can deliver.
  - Allegedly, there are imports whose origin are not known and sold at road sides, and assembly of motors carrying nameplates of EU origins.

1.1.2.2.7 Summary efficiency limitations

Considering the above limitations, causes of energy in efficiency, performance and operation of electric motors in Ethiopia, the current level of efficiency of electric motors could be estimated as follows.

Causes of Efficiency Limitations	Efficiency reductions (%)
Inherent Design limitations (100%-80.20%), Table 4	19.80
Power supply quality and level	1.00
Inadequate maintenance practices	2.50
Absence of match between load and Motors	1.00
Unsuitable Operating Environment	1.00
Total efficiency reductions	**25.30**

Table 6. Electric motor efficiency reductions

From the above table, it can be deduced that the average energy efficiency of electric motors in Ethiopian factories is about 100% - 25.30% = 74.70%.

The estimated energy efficiency of the electric motors obtained for the sample factories could be compared with the international reference standards efficiency levels of IEC EEM in Figure 13 and Table 2. The comparison is presented in Table 7 below. The difference in efficiency with the IEC levels indicates Ethiopian factories operate with low efficiency electric motors.

Description	Average Motor power(KW)	Motor design efficiency level(%)				
		Motor Pole NO.	IEC1	IEC2	IEC3	IEC4
IEC	Avg of 15 & 18.5 = 16.75	4	89.00	90.90	92.35	94.05
Average for Ethiopian Factories	16.2	4	74.70	74.70	74.70	74.70
Difference of efficiency to Ethiopian factory motors			**14.30**	**16.20**	**17.65**	**19.35**

Table 7. Efficiency difference between Ethiopian factory and IEC standard IE 1 motors

The efficiency level difference between the lowest IEC1 level and average estimate for Ethiopian motors is about 14.30%.

Many countries have implemented regulations which prohibit the installation and use of the types of motors operating in Ethiopia and have put time frames for the introduction MEPS based on the more efficient IEC2, and IEC3 EEMs. The following 40 countries (including EU 27) have adopted mandatory MEPS, individually set at IEC1, IEC2 or eventually at IEC3 levels with a dedicated time plan for the upgrade (see Table 8). All of these countries use the IEC-Code in IEC 60034-30 as a reference and the respective procedure to establish efficiency classes for electric motors. Ethiopia has also adopted this standard.

No.	Country adopted IEC mandatory MEPS
1	Australia
2	Brazil
3	Canada
4	China
5	Costa Rica
6	European Union (27)
7	Israel
8	Korea South
9	Mexico
10	New Zealand
11	Switzerland
12	Taiwan
13	Turkey

Table 8. Motor MEPS countries (2013)

1.1.3 Efforts made to improve the energy efficiency of electric motors

There have been studies made by individuals in Ethiopia to improve the EE of electrical motors as listed below.

A) The thesis “Energy Distribution and Utilization Assessment in Industries (Case Study at Mugher cement factory, MCF)” has been prepared by Alebachew Tilahun, in partial fulfillment of the requirement for the degree of masters in electrical engineering, Addis Ababa University, July 2011. The thesis analysed energy efficiency problems on electric motors and recommended replacing of standard motors with EEMs.

B) Yibeltal Abiye has prepared a thesis “Energy Audit of Sebeta Alcohol and liquor factory” in December 2011, as Partial fulfillment of the requirements of the Degree of Masters of Science in Mechanical Engineering (Thermal Engineering Stream). The thesis asserts that the factory uses thermal and electric energy inefficiently and concluded there is absence of awareness on the factory workers regarding energy management and there are motors with low load factors.

C) The thesis by Henock Birhane, “DSP based implementation of field weakening on Synchronous motor for high speed operation” has been prepared in partial fulfillment of the requirement for the degree of Masters in Electrical engineering. This thesis presents development of field weakening control for Permanent Magnet Synchronous Motor (PMSM) using demagnetizing component of stator current. The work shows that the highly efficient permanent magnet synchronous motors can be controlled using field oriented control and the air-gap flux can be weakened using the direct-axis component current for wide speed range.

D) Gashaw Tilahun, in partial fulfillment of the requirement for the degree of Masters in Electrical engineering, has prepared a thesis “Implementation of Mechanical Sensor less Control of BLDC Motor with back EMF methods in DSP”. The thesis recommends continuation of the work on what has been done.

E) The Thesis “DSP based vector control of induction motor” has been prepared by Abreham Belay, in of the requirement for the degree of Masters in Electrical engineering, in 2007. In this thesis Vector control of Induction Motor using DSP board, type TMS320LF2407 from Wintech digital instruments has been studied and implemented. This new family of DSP controllers enables cost-effective design of intelligent controllers for Induction motors, which can yield enhanced operation, fewer system components, lower system cost and increased efficiency. The vector control Algorithm maintains efficiency in a wide speed range and processes the dynamic model of the Induction Motor.

1.2 Demand Assessment

1.2.1 Industrial developments in Ethiopia

The manufacturing industry in Ethiopia began to appear in the 1950’s. Modern industry commenced to emerge mainly in the second half of the 1950’s and 1960’s with import substitution as the main goal.

Currently there are 2170 medium and large industries established in Ethiopia. More than 40% of the manufacturing industries are located in Addis Ababa followed by Oromiya region with 23%, and 11% in Amhara, 11% in SNNP, 9 % in Tigray, 3.23% in Dire Dawa, 1.01% in Harari, 0.6% in Somali, 0.37% in Afar, 0.09% in Benshangul and 0.05% in Gambella regional states. (CSA 2010/11).

1.2.2 Electric motors power demand and energy consumption

Two different approaches could be used to estimate the number of electric motors and the associated demand of electric motors. A top-down approach and A bottom-up approach (Paul Waide and Conrad U. Brunner. IEA 2011)

A top-down approach: The methodology applied involves estimatioinng all non motor electricity uses and assuming the residual part of total electricity consumption of the country is that used by electric motors.

A bottom-up approach: The national energy use of electric motors is calculated based on estimates of the average size, efficiency, running hours and load factor the motor stock.

1.2.2.1 Top-down approach to estimate power demand and energy consumption

1.2.2.1.1 Electric Motor energy consumption

Data from the Ministry of water and energy showing energy consumption of the country by Tariff group for the year 2013/14 (2006 EC) excluding the tariff groups Exports and Own consumption is presented in Table 9 overleaf.

No	Tariff group	Consumption(MWh)	% of consumption
1	Industry	2,032,476.20	33.4%
2	Commercial	1,612,983.23	26.5%
3	Domestic(households)	2,374,628.13	39.0%
4	Street light	24,847.30	0.4%
5	Others(Auxiliary and Pre paid)	42,399.68	0.70%
Total		**6,087,334.54**	**100.00%**

Table 9. Electricity consumption by tariff group for the year 2013/14(2006EC)

There are no studies in Ethiopia as to the consumption of electric motors in the industries. Research based studies made globally indicate that electrical motors in industries consume about two third or 64% of industrial power consumptions (Sources: IEA statistics, 2006; A+B International, 2009, Paul Waide and Conrad U. Brunner. IEA 2011) as shown in Figure 15 below.

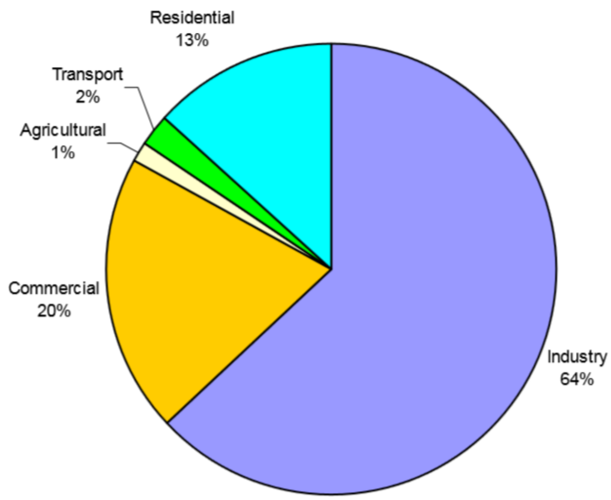


Figure 15. Estimated electricity demand for all electric motors by sector

Using the IEA reference percentage and the industrial consumption Table 9 above, the energy consumption of industrial application electric motors in Ethiopia for the year 2013/2014(2006 EFY) is estimated to be 2,032,476.20 MWh x 64% = 1,300,784.77 MWh or 1,301GWh. This amounts to 21.3 % of national energy consumption and indicates how energy demanding electric motors are.

There are factories in Ethiopia which use additional power from Diesel generating sets as power supply from the Ethiopian Electric Utility doesn't fulfill their requirement. Factories like Ayka Addis Textile, 3F, Excel plastic and East Africa Bottling (Coca cola) are examples. Besides, there are many commercial firms like flour grinding machines houses using electric motors whose bill is covered under the Commercial Tariff group of EEU. Furthermore, sugar factories generate and use electricity from their by-products and their bill doesn't show the actual consumption from the EEU. Hence, it expected that electric motors consume more than 21.3% of the national energy consumption.

1.2.2.1.2 Electric Motor Peak power demand

The load demand profile of EEU from April/2014 up to December/2014 has been referred to. The maximum peak load including load shedding occurred in

December/2014, which is 1447.50 MW. The peak demand is believed to include the tariff groups of Exports and Own consumption of EEU. The peak power demand for electric motors could be estimated by using the national industrial tariff consumption percentage, 28.84% indicated in Table 10 below, and the consumption percentage of electrical motors in industries, 64%. Hence, peak power demand is estimated to be = 1447.50 MW x 28.84% x 64% = 267 MW.

No	Tariff group	Consumption(MWh)	% of consumption
1	Industry	2,032,476.20	28.84%
2	Commercial	1,612,983.23	22.89%
3	Domestic(households)	2,374,628.13	33.70%
4	Street light	24,847.30	0.35%
5	Prepaid	42,399.68	0.60%
6	Own consumption	5,209.17	0.07%
7	Exports	954,159.26	13.54%
Total		**7,046,702.97**	**100.00%**

Table 10. Percentage of energy consumption by tariff group

The peak demand estimation has been based on the industrial tariff consumption percentage of 28.84%. This is very low as compared to the consumptions of other countries having better industrial developments. The share of the industrial tariff consumption is expected to rapidly rise in Ethiopia as the manufacturing sector is booming and being given much attention. Hence, the peak power demand and energy consumption due to electric motors is expected to increase rapidly in the coming years.

Relating the energy consumption to peak demand indicates the average working hours of the factories, which is 1,301GWh/267MW = 4,862.2 hours per year, and 13.3 hrs per day. This figure appears reasonable as most of the factories surveyed operate 24 hours a day.

1.2.2.2 Bottom-up approach to estimate power demand and energy consumption

Estimating the national power demand and energy consumption for electric motors in the industrial sector is challenging due to the limited data available. Estimation by bottom-up approach requires multiplying the electric power of the installed motors by the number of hours of operation time per year,

The electric power is determined from the nameplate data (shaft output power) of the motors by applying load factor (the ratio of the load that a motor drives during operation to the full load). Operation time per year shall be determined by the type of motor production and use of motor which may be continuous duty or intermittent or production dependent. Estimation of number of motors, load factor and operation time per year would lead to gross error in the absence of the relevant data and hence the bottom-up approach is not employed for estimation of demand.

Data collection has been made in twelve sample factories on types, quantity, and power consumption and other details of electric Motors. Summary is presented in Annex 2.

Data indicating the number of factories in the country is not available at the Ministry of Industry. The number of similar factories within the sector of the sample factories has been obtained from Institutes under Ministry of industry is shown in Table 11 overleaf. The number of similar factories, which are export oriented factories, may not be identical, regarding number, type and size of electric motors. Example is Ayka Addis Ethiopia which is a large factory encompassing factory for packaging materials and thousands of motors. The table shows rough estimation of total number of motors. There are factories which do not fall within the listed categories too.

No	Type of Factory	Name of factory	No of Electrical Motors	%	Estimated No of similar factories	Estimated No. of electrical motors
1	Sugar factory	Wonji Showa Sugar factory	619	10.30%	4	2,476
2	Leather processing factory	ELICO	57	0.95%	73	4,161
3	Cement factory	Muger cement factory	536	8.95%	21	11,256
4	Textile factory	AYKA Addis Textile	3461	57.80%	86	297,646
5	Metal factory	Kaliti metal production	117	2.00%	70	8,190
6	Tire factory	Horizon Addis Tyre	301	5.00%	1	301
7	Beer factory	BGI Ethiopia	261	4.40%	6	1,566
8	Soft drink factory	East Africa Bottling(Coca Cola)	319	5.30%	14	4,466
9	Flour grinding mills	Fafa food complex	123	2.00%	15	1,476
10	Chip wood factory	ECAFCO or 3F	67	1.10%	56	3,752
11	Plastic Factory	Excel Plastic Factory	129	2.20%	49	6,321
	Total		**5,990**	**100%**	**455**	**341,611**

Table 11. Estimation of total number of motors country wise

The top-down approach methodology appears to be more realistic to estimate the power and energy consumption demand of electric motors and hence the results will be employed to demand forecast in subsequent sections.

1.2.3 Electric motors import

Summary of eclectic motors Imported in the year 2014 obtained from Ethiopian Revenue and Customs (ERCA) is shown in Table 12 below. The country of origin of the imported motors has been summarized as in Table 13 overleaf.

No	Motor power	Quantity	% of Quantity	CIF(Birr)	Tax(Birr)	Total(Birr)
1	AC motor Multi-phase <750w	443	2.83	17,900,503.31	2,666,139.46	20,566,642.77
2	AC motor multi- phase >750w<75kw	10,504	67.06	57,796,767.93	18,510,657.25	76,307,425.18
3	AC motor multi phase >75kw	554	3.54	118,793,953.53	16,186,645.08	134,980,598.61
4	AC motor single phase	4,162	26.57	25,885,247.63	3,048,866.55	28,934,114.18
	Total	**15,663**	**100**	**220,376,472**	**40,412,308**	**260,788,781**

Table 12. Electric motors Imported in the year 2014

(original data source ERCA, www.erca.gov.et)

No	Country of Origin	Quantity				Total	Percentage
		Motor power<750w	Motor power 750w<75kw	Motor power >75kw	Single phase		
1	Andorra				1	1	0.01%
2	Austria		1			1	0.01%
3	Belgium				2	2	0.01%
4	Brazil	2		3	4	9	0.06%
5	Canada			10		10	0.06%
6	China	172	9,923	237	3537	13869	**88.55%**
7	Czech rep		14	6	10	30	0.19%
8	Djibouti				1	1	0.01%
9	France	1	6			7	0.04%
10	Finland		1			1	0.01%
11	Germany	39	151	3	1	194	1.24%
12	Hong Kong				2	2	0.01%
13	India	171	133	118	114	536	3.42%
14	Indonesia	2				2	0.01%
15	Ireland		2			2	0.01%

No	Country of Origin	Quantity				Total	Percentage
		Motor power<750w	Motor power 750w<75kw	Motor power >75kw	Single phase		
16	Italy	9	186	82	21	298	1.90%
17	Japan	16		1		17	0.11%
18	Kenya		1			1	0.01%
19	Korea Republic			6		6	0.04%
20	Nether land			1		1	0.01%
21	Philippines		8			8	0.05%
22	Poland		1	8		9	0.06%
23	Saudi Arabia				1	1	0.01%
24	Spain		2	63	10	75	0.48%
25	Sweden	1	1	1		3	0.02%
26	Switzerland	3		1		4	0.03%
27	Turkey	9	70	10	5	94	0.60%
28	United Arab Emirates	2	1		452	455	2.90%
29	United Kingdom	15	3	1	1	20	0.13%
30	United States	1		3		4	0.03%
31	Unknown					0	0.00%
TOTAL		**443**	**10504**	**554**	**4162**	**15663**	**100.00%**

Table 13. Country of origin of imported motors in the year 2014

(original data source ERCA, www.erca.gov.et)

Tables 12 and 13 above show that in the year 2014 (2005/2006 EFY) three phase and single phase AC motors constitute 73.43% and 26.37% of the total import respectively. 88.55% of the import is from China and the overall value of AC motors imported is about 261 Mill Birr.

1.2.4 Demand forecast

1.2.4.1 Data from Ethiopian Power system Expansion Master plan Study

Data from Ethiopian Power system Expansion Master Plan Study has been used to forecast the power and energy demand for electric motors.

Data for 10 years period on Industrial tariff group from Ethiopian Power system Expansion Master plan Study load forecast report, Appendix E, E2 and E4, for the High and Low demand forecast, and Appendix E, E13 and E14 for loss percentages, both for Energy consumption and Power Demand, is presented in Tables 14 to 17 overleaf.

From Tables 14 and 15, average growth of the High and low case energy sales demand forecast will be 21%. Whereas from Tables 16 and 17, the average growth of the High and low case Power demand forecast is 18.58%.

	Year										
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Consumption (GWh)	4,397	6,758	9,717	13,397	16,972	19,645	21,655	24,001	27,650	29,128	30,799
% growth		53.7%	43.8%	37.9%	26.7%	15.7%	10.2%	10.8%	15.2%	5.3%	5.7%
% energy losses	29.9%	27.2%	23.8%	20.5%	17.5%	16.0%	15.9%	15.7%	15.6%	15.5%	15.3%
Total energy supplied (GWh)	5,712	8,596	12,030	16,143	19,942	22,788	25,098	27,769	31,963	33,643	35,511
Average % High growth, 2015 – 2024 = 22.5%											

Table 14. High Case - Industrial Tariff Group Energy consumption and loss forecast

	Year										
Description	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Consumption (GWh)	3,422	5,047	7,095	9,636	12,077	13,881	15,064	16,443	18,050	18,280	18,513
% growth		47.5%	40.6%	35.8%	25.3%	14.9%	8.5%	9.2%	9.8%	1.3%	1.3%
% energy losses (GWh)	29.9%	27.2%	23.7%	20.5%	17.8%	16.0%	15.9%	15.7%	15.6%	15.5%	15.3%
Total energy supplied (GWh)	4,444	6,420	8,784	11,611	14,191	16,102	17,456	19,031	20,867	21,109	21,353
Average % Low growth, 2014-2024= 19.4%											

Table 15. Low case - Industrial Tariff Group Energy consumption and loss forecast

Description	Year										
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Maximum demand (MW)	800	1,199	1,669	2,230	2,744	3,129	3,445	3,813	4,386	4,615	4,873
% growth		49.9%	39.2 %	33.6 %	23.0 %	14.0 %	10.1%	10.7%	15.0 %	5.2%	5.6%
% Power losses	27.9 %	26 %	24 %	21 %	19 %	18%	18%	18 %	18 %	18%	18%
Total Maximum demand supplied (MW)	1,023	1,511	2,063	2,703	3,265	3,689	4,062	4,496	5,167	5,432	5,736
Average High growth, 2014-2024 = 20.64%											

Table 16. High case Industrial Tariff group Maximum power demand and loss forecast for the year 2014 – 2024

Description	Year										
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Maximum demand Consumer level (MW)	1,303	1,724	2,210	2,775	3,308	3,797	4,230	4,674	5,161	5,501	5,842
% growth		32.3%	28.2%	25.6%	19.2%	14.8%	11.4%	10.5%	10.4%	6.6%	6.2%
% Power losses	28.0%	26.1%	23.8%	21.4%	19.1%	18.1%	18.1%	18.0%	17.9%	18.0%	18.0%
Total Maximum demand supplied (MW)	1,668	2,174	2,736	3,369	3,940	4,484	4,996	5,520	6,085	6,491	6,894
Average Low growth, 2014-2024 =16.52 %											

Table 17. Low Case - Industrial Tariff group Maximum power demand and loss forecast for the year 2014 – 2024

1.2.4.2 Forecast electricity consumption of Electric Motors

Table 18 overleaf shows the forecast consumption for Electric motors during the next 10 years. Growth is assumed increase annually based on the average growth rate of Ethiopian Power system Expansion Master plan Study for the High and Low consumption forecast of Industrial Tariffs as in the years 2014 to 2024 - 21%. The energy demand of electric motors for the year 2024 including losses is estimated to be 8,338 GWh.

1.2.4.3 Forecast electricity power demand of Electric Motors

Forecast power demand for Electric motors during the next 10 years is shown in Table 19 overleaf. Growth is assumed increase annually based on the average growth rate of Ethiopian Power system Expansion Master plan Study for the High and Low consumption forecast of Industrial Tariffs as in the years 2014 to 2024 – 18.58%. The Power demand of electric motors for the year 2024 including losses is estimated to be 1,458 MW.

Description	Year									
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Consumption (GWh)	1,301	1,574	1,904	2,304	2,788	3,374	4,082	4,940	5,977	7,232
% energy losses (GWh)	27.2%	23.8%	20.5%	17.5%	16.0%	15.9%	15.7%	15.6%	15.5%	15.3%
Total Consumption and losses (GWh)	1,655	1,948	2,295	2,708	3,235	3,910	4,725	5,711	6,902	8,338
Losses(GWh)	354	374	390	404	446	536	643	771	925	1,106

Table 18. Energy consumption forecast of electric motors scenario for next 10 years, 2015 – 2024

Description	Year									
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Peak demand power(MW)	267	317	376	445	528	626	743	881	1,044	1,238
% power losses	26.0%	23.6%	21.2%	19.0%	17.9%	17.9%	17.9%	17.8%	17.7%	17.7%
Total peak demand and losses(MW)	337	392	455	530	623	739	876	1,038	1,229	1,458
Losses(MW)	69	75	80	85	95	112	133	157	185	219

Table 19. Peak power demand forecast of electric motors scenario for next 10 years, 2014 – 2024

1.2.5 Demand summary

Currently, the energy consumption of industrial application electric motors in Ethiopia amounts to about 21.3 % of the national energy consumption. The peak power demand and energy consumption of electrical motors including losses for the year 2015 are estimated to be 1,655 GWh and 337 MW respectively. There will be peak power demand of 1,458 MW and energy demand of 8,338 GWh including losses in the year 2024 attributed to the use of Electric motors. Hence, electric motors are currently the most energy demanding in the nation and there is a huge power demand and energy consumption imposed on the electric generation and distribution infrastructure due to these machines.

The inherent design and the performance and operation of the motors have made the electrical motors to be energy inefficient and demand more power and consume much energy.

A study has been made by Ethiopian Electric Agency, Hifab Oy and Ethiopian Society of Electrical Engineers, produced a report on 26.10.2012 titled “Demand side management for climate change, adaption for the Ethiopian power sector”. The study highlighted there could be a theoretical potential energy saving of 10 to 30 % in Ethiopian industries and commercial /public sector.

Implementation of EE standards and labeling on electric motors would curb the above problems significantly by encouraging the development, marketing and sale of energy-efficient products. The saving on energy consumptions could be used for electrification of the rural areas, expansion of industries or sold to neighboring countries. It has been seen that the recent replacement of Incandescent lamps by the energy efficient fluorescent lamps in Ethiopia had brought 100 MW power demand and energy cost saving to the households and the nation. Implementing energy efficiency standards and labeling program of electric motors would bring greater benefit.

It is the experience of many countries that governments have succeeded in slowing the growth of demand of electricity use and CO_2 emissions from the use of such machines through carefully targeted labeling and standardization programs. The labeling and standardization programs can also re-enforce other policies to promote the use of energy-efficient products.

1.3 Stake holder analysis

1.3.1 Major stakeholders

Major stakeholders in the development and implementation of national EE standard and labeling program for electric motors with their respective roles have been identified and listed in Table 20 below. The stake holders are differentiated as primary, secondary and external based on their interests, their potential impact on the program, and the relative priority of their interest.

No	Stakeholder's Name	Role	Interest	Potential project Impact (+, _, ?)	Relative priorities of interest(1 =high, 5 = low)
1	**Primary**				
1.1	Industries	Partners in the standardization and labeling	- better productivity and less down time due to acquiring of efficient electric motors	+	1
			-higher initial cost of energy efficient motors	_	1
			-purchase of standard (less efficient) electric motors to continue	_	1
1.2	Electric Motor importers	Partners in the standardization and labeling	- Better market opportunities	+	1
			-Types and qualities of electric motors imports as used to be	_	1
			-decrease in market mix	_	1
			-additional expenses which may be incurred and bureaucratic challenges due to the standardization and labeling	_	1
1.3	Electric Motor maintenance service providers	Partners in the standardization and labeling	- Better market opportunities	+	1
			-Better customer satisfaction in using standard repair and maintenance materials	+	1
1.4	Ethiopian Energy Authority	Partners in the standardization and labeling	-successfulness of the program-- -reduced power demand -reduced energy consumption	+	1
1.5	Ethiopian Electric Utility	Partners in the standardization and labeling	-reduced power demand -reduced energy consumption	+	1
1.6	Ethiopian Electric Power	Partners in the standardization and labeling	-reduced power demand -reduced energy consumption	+	1
2	**Secondary**				
2.1	Addis Ababa, Diredawa and regional Energy bureaus(under whose authority factories lie)	Coordinate project and report the achievements	-successfulness of the program	+	1

No	Stakeholder's Name	Role	Interest	Potential project Impact (+, _, ?)	Relative priorities of interest(1 =high, 5 = low)
3	**External**				
3.1	Addis Ababa trade and Industry	Registration of Importers and maintenance service providers	- successfulness of the program	+	2
3.2	Parliament	Follow up the overall activity of the project	successfulness of the program	+	2
3.3	Ministry of Water Irrigation and Energy	Follow up the overall activity of the project	successfulness of the program	+	2
3.4	Ministry of Finance and Economic Development	Allocate budget for the project	successfulness of the program	+	2
3.5	Regional states Trade and Industry bureau	Registration of factories	successfulness of the program	+	2
3.6	Ministry of Trade	Registration of importers and maintenance service providers	successfulness of the program	+	2
3.7	Ethiopian Standard Agency	Electric motor Standard and enforcement of the standard	successfulness of the program	+	2
3.8	Ethiopian Conformity Assessment Enterprise	Avail testing facility as per agreement with EEA, test samples and provide test report	successfulness of the program	+	2
3.9	Ministry Science and Technology	Follow up research developments	successfulness of the program	+	2
3.10	Donors	Supports the project financially	successfulness of the program	+	3

Table 20. List of Major stakeholders

1.3.2 Factories.

List of factories in industrial sectors, Annex 3, has been organized from the data obtained at Institutes under Ministry of industry. The factories listed are those which are export oriented only. Complete data covering all factories is not available. Non export factories have been included in the list regarding soft drink and plastic factories.

Ethiopian factories acquire electric motors assembled with machineries which may be used or new ones. Motor replacement during failure is through local purchase or direct order from supplying company. Maintenance service is mainly at the factories own workshops except for few of them.

From the survey made it was deduced that the factories use motors of different years of service (two to fifty eight years), country of origin (about 15 countries), and power capacity(ranging from 33.5 W to 2,500 KW), and efficiency level (ranging from 50% to 95%).

Factories are the main stakeholders of the program. The concerns and interests of factories are:

- Better productivity and less down time due to acquiring of efficient electric motors
- Better supply of power as some of them use own diesel generating sets due to shortage of power.
- Introduction of standards and labeling on electric motors would come with higher initial cost of energy efficient motors and hence cost of acquiring replacement motors will be higher. This may encourage them to continue purchase of standard (less efficient) electric motors.

1.3.3 Importers.

Importers are the main stake holders in the program and the energy efficiency standards and labeling program is directly applied on the imported electric motors only as there are no local motor manufacturers and assemblers in Ethiopia. They shall participate as partners in the development of the EE and labeling program right from the beginning for the project to be successful.

The concerns and interests of importers are:

- Better maintenance market opportunities for those importing standard products
- The program may prohibit import of sub standard products and save them from the abnormal market price competitions with importers of inferior quality products.
- Expectation of price increase due to meeting standards and labeling requirement during import purchase as opposed to their former experience of import.
- Decrease in market mix as the level of efficiency of motors imported will be defined by the standards and labeling
- Perceived fear of additional expenses which may be incurred and bureaucratic challenges due to the standardization and labeling
- The standardization and labeling program is quite important to their business
- They have to participate in the process in order to keep their interests and avoid the import problem which may arise due to the shortening of the lead time in the implementation of the standardization and labeling program.
- The standardization and labeling may not be implemented and perceived fear of may be designed to benefit certain group of importers.

1.3.4 Maintenance service providers.

Maintenance service providers are the primary stake holders in the program. Their concerns and interests are:

- Improved and simplified maintenance works in that standardization may bring latest technology motors
- Increased customer satisfaction.
- The standardization and labeling program is quite important to their business in that it may establish winding coil types and sizes to avoid the varying quality of rewinding service in the country and set the discrepancy they encounter often between nameplate power and actual power of the motors.
- They have to participate in the process in order to keep their interests.
- Importers shall import better standard motors to avoid the poor level of maintenance problem they observe on motors coming to them for maintenance.

1.4 Policy context and Implications

The energy efficiency and conservation activities are among the activities prioritized by the government in the draft national Growth and Transformation Plan (GTP - 2) , GTP-1, the Climate Resilient Green Economy (CRGE) strategy and the National Energy policy to save huge amount of energy in the country. As the energy loss and power demand in this country are very big, considerable economic, social and environmental benefits can be obtained from the energy and power savings emanating from the implementation of the project.

Ethiopia's objectives and strategies for sustained rapid and broad-based economic growth are dependent, among others, on the GTP 1's strategic pillars of :

- Sustained rapid and equitable economic growth,
- Maintaining agriculture as major source of economic growth,
- Creating for the industry to play key role in the economy, and
- Enhancing expansion and quality of infrastructure development

Electricity plays a decisive role to achieve the objectives and implement the strategies of the GTP 1 indicated above.

The objectives to be met under the draft GTP-2 (2008-2012 EFY) of EEA are to inculcate the energy efficiency, conservation and use. The major goals to be achieved are reproduced below.

Goal 3. To save 1,165 GWh at the end of the GTP-2 period by implementing energy efficiency and conservation works through detail audits, walkthrough audits, public awareness and energy meter inspection

Goal 4. Public awareness works to the community on energy efficiency and conservation

Goal 5. Implement energy efficiency labeling program (on lamps, locally made stoves and Motors, Mitads, Refrigerator and Electric motors).

In the Climate-Resilient Green Economy (CRGE), The plan: To follow a green growth path that fosters development and sustainability, The CRGE initiative follows a sectoral approach and has so far identified and prioritized more than 60 initiatives, which could help the country achieve its development goals while limiting 2030 GHG emissions to around today's 150 Mt CO 2e – around 250 Mt CO 2e less than estimated under a conventional development path. The green economy plan is based on four pillars:

1. Improving crop and livestock production practices for higher food security and farmer income while reducing emissions
2. Protecting and re-establishing forests for their economic and ecosystem services, including as carbon stocks
3. Expanding electricity generation from renewable sources of energy for domestic and regional markets
4. Leapfrogging to modern and energy-efficient technologies in transport, industrial sectors, and buildings.

The energy policy of Ethiopia, section 6, 6.3, Energy conservation Efficiency, states that the government's industrial energy policy is to improve the efficiency of industrial equipment to conserve and reduce energy consumption.

Demand for Electrical power has been constantly growing in Ethiopia due to the rapid economic growth and the huge electrification programs underway in the country. The number of grid connecting rural villages is also increasing at faster rate. The neighboring countries are also requesting bulk power from Ethiopia as the Electricity potential is huge and promising for the growth of the region.

As per the GTP1 and GTP2's strategic directions, to keep the power supply consistent with the national and regional need, EEP shall invest huge amount of money in the construction of new hydro and other sources. Transmission and distribution networks shall also be upgraded to accommodate the growing energy demand. Private investors are also expected to invest in the sector as the new energy proclamation opens an opportunity for them. In this regard, EEA shall ensure a cost effective, high quality supply of energy, as well as energy efficiency and conservation in implementing the GTP's and the CRGE's strategies.

The Ethiopian Industry Development Roadmap, 2014, states that the share of the manufacturing sector to the GDP is targeted to reach ultimately 17 % by the end of 2025. To ensure faster and sustained development of the industrial sector, favorable conditions shall be created for industry to play a key role in the economy. To bring about manufacturing sector transformation, five development directions are envisaged. These are:

- Upgrading and capacity enhancement of major priority industries,
- Diversification of manufacturing sector to new sectors,
- Enterprise cultivation,
- Private and public investment, and
- Industrial zone development.

Furthermore, the four strategic pillars on which the Ethiopian industry development depends are:

- Sustaining the manufacturing sector's contribution to industry and economic growth ,
- Ensuring balanced regional industrial development ,
- Integrating the Ethiopian industries into regional and global market and development , and
- Pursuing both Export-Led and Import Substitution Industrialization.

The industrial development target envisaged above are planned to be attained in three developmental phases.

Investing in the construction of new infrastructure alone cannot guarantee reliable supply as the efficiency of connected loads is very low and causes huge power losses in the system. The huge power losses in the supply system cause inefficient operation of the appliances connected by causing additional voltage drops.

The industrial tariff group of EEU is the major energy consuming tariff group in the 2006 EFY, consuming about 28.84% of the energy consumption of the country. Electric motors are the most energy consuming industrial machine used in the country. The EE of existing electric motors in Ethiopia is believed to be on a lower side. The power demand and energy consumption caused by electric motors affects the power supply infrastructure by overloading and effecting frequent power interruption, outages and voltage drops. It is estimated that the peak power demand and energy consumption of electrical motors including losses for the year 2015 are estimated to be 337 MW and 1,655 GWh respectively. There will be an estimated peak power demand of 1,458 MW and energy demand of 8,338 GWh including losses in the year 2024 . Hence, there is a huge amount of electric energy consumption and power demand from electrical a national level.

EE labeling and standardizing would result in the improvement of the EE of electric motors. These in return reduces capital Investment in energy supply Infrastructure, benefits the industries by reducing energy bill, reduces electric power supply network congestion, saves electrical energy and strengthens competitive markets, and enhance economic efficiency of the country. The EE standard and labeling on Electric motors shall be a priority and urgent issue to be addressed in Ethiopia.

The energy savings obtained as a result of EE standard and labeling could be used for rural electrification, manufacturing, industrialization, and export programs contributing to the sustained rapid and broad – based economic growth of the country.

2 Project Objectives and rationale

2.1 Project Objectives

In the year 2013/2014 the industries in Ethiopia shared 28.84 %(2,032 GWh) of the national energy consumption. Electric motors are one of the most used industrial machines in the country and constituted about 64% (1,301GWh) of the Industrial energy consumption. This amounts to 21.3 % of national energy consumption. It is estimated that electric motors demand about 18.46% (267 MW) of the total peak power demand of the country.

The core problems of the existing electric motors are the low inherent design efficiency and the reduced efficiency due to performance and operational factors. The objectives of the project are to reduce the following impacts created due to the high electric power and energy demand of electric motors:

- Existing and future power demand on electric power generating, transmission and distribution networks,
- Existing and future cost of building and operating additional electric power generating, transmission and distribution networks,
- Power outages, interruptions and voltage drops.
- Cost of electricity bill on industries
- Unwarranted energy consumption at national level

2.2 Project rationale

The energy efficiency limitations on the existing Industrial motors have been in existence for over a period of 58 years, since the establishment of the oldest factories in Ethiopia. Energy efficient motors are not available in the surveyed Ethiopian industries and didn't penetrate the market thus far due to various reasons. Machinery fixed and stand alone electric motors are being imported to the country and their energy efficiency standards and levels are not known. Hence, developing EE standard and labeling on electric motors would be the only option to solve the current problem.

Energy-Efficiency Labels and Standards on electric motors:

- Reduce capital investment in energy supply Infrastructure
- Enhance national economic efficiency by reducing industrial energy bills
- Enhance consumer welfare
- Empower buyers of electric motors to include EE in their choice and decision.
- Strengthen Competitive Markets
- Meet Climate-Change Goals
- Avert Urban/Regional Pollution

3 Project development, activities and Implementation plan

3.1 Project Log frame and Activity

Narrative Summery	Objectively verifiable Indicators	Means of Verification	External factors Risks and Assumptions
Goal			
Energy consumption of electric motors, electric power demand, electric network overloading and frequent power interruptions reduced, energy saved, GHG emissions and Climate Change problems reduced	Reduced network load and power interruptions, reduced customer complaints, reduced emissions and climate change problems	Survey at EEU/EEP and different categories of customers	Government support and commitment
Purpose			
Industries becomes energy efficient and competitive by reducing power demand and energy losses caused by different models of electric motors through development of Minimum Efficiency Performance Standard and energy efficiency labeling program.	Reduced power demand and energy losses, performance standard set, energy efficiency label developed	Survey at EEU/EEP, EEA and industries and importers	Full participation and commitment of major stakeholders
Output 1:			
Awareness created on Energy efficiency standards and labeling of electric motors through advertising and promotions and stake holders engagement	Public and stakeholders attitude changed towards electric motors standard and labeling	Evaluations and surveys on stakeholders	Successfulness of the promotion program
Activity 1. 1:			
Prepare and disseminate printed materials	Number and content of printed and distributed materials	Data from EEA , Public relation and Finance Directorate	Successfulness of the promotion program
Activity 1.2			
Promote on TV and Radio	Number and content of TV and Radio spots produced and launched	Data from EEA , Public relation and Finance Directorate	Successfulness of the promotion program
Activity 1.3			
Prepare Question & Answer program on ETV	Number and content of Q&A programs launched	Data from EEA, Public relation and Finance Directorates	Successfulness of the promotion program
Activity 1.4			
Prepare workshops and engage Stake holders	Number and type of stakeholders engaged	Stake holder participant list and Data from EEA Public relation Directorate	Full participation and commitment of stakeholders
Outputs 2:			
Defined services and recruited local consultant for implementation of the project	Local Consultant TOR prepared and consultant recruited	Copy of TOR	Availability of Capable local Consultant
Activity 2.1			
Local consultant hired	Local Consultant signed agreement	Copy of contract document	Availability of Capable local Consultant

Activity 2. 2			
implementation plan developed and services provided by Consultant of the project	Concrete supports obtained	Copy of contract document	Capability of the consultant
Output 3			
Testing capability developed	Testing facility procured and testing laboratory selected	Data from EE and conservation Directorate	Government support
Activity 3. 1:			
Agreement signed with selected testing laboratory and setup Project taskforce	Signed Agreement or MoU	Data from EE and conservation Directorate	Availability of capable testing laboratory and personnel
Activity 3.2			
Testing equipment specification prepared	Testing equipment specification prepared	Data from EE and conservation Directorate	Availability of capable personnel
Activity 3.3			
Testing equipment procured and installed	Number of Testing equipment procured	Data from EE and conservation Directorate and selected laboratory	Successfulness of equipment procurement
Activity 3.4			
Testing personnel Trained	Training offered	Data from selected lab.	Availability of training
Output 4			
Determination and endorsement of MEPS			
Activity 4.1			
Electric motor types/ ranges for labeling selected	Data of electric motor types/ranges selected	Data from EEA EE &C and Public Relations Directorate	EEA's capacity
Activity 4.2			
MEPS determined and endorsed	Data on MEPS	Data from EEA EE &C and Public Relations Directorate	EEA's capacity
Output 5			
Labeling logo with electric motor specific parameters adopted, Stake holders comments incorporated			
Activity 5.1			
Labeling logo adopted	Logo adopted	Data from EEA EE &C and Public Relations Directorate	EEA's capacity
Activity 5.2			
Stakeholders comments on final labeling logo incorporated	Final logo adopted	Data from EEA EE &C and Public Relations irectorate	EEA's capacity
Output 6			
Electric motor national standard disseminated			

Activity 6. 1			
Standards disseminated	No. of Standards distributed	Data from EEA Public Relations Directorate and site visits	EEA's capacity
Output 7			
Testing of samples			
Activity 7.1			
Sampling method determined	Available sampling method	Information from selected lab	Lab capacity
Activity 7.2			
Samples collected	Data of samples	Information from selected lab	Lab capacity
Activity 7.3			
Samples tested	Data of tested samples	Information from selected lab	Lab capacity
Activity 7.4			
Test report prepared	Test report available	Information from selected lab	Lab capacity
Activity 7.5			
Test result announced	Publicized test result	Information from selected lab	Lab capacity
Activity 7.6			
Labeling program implemented	Test program implementation	Data from EEA EE &C and Public Relations Directorate	EEA capacity
Output 8			
Program monitoring and evaluation			
Activity 8.1			
Monitoring & Evaluation plan prepared	M&E plan available	Data from EEA EE &C and Public Relations Directorate	EEA's capacity
Activity 8.2			
Program measured, verified and evaluated	Evaluated program	Data from EEA EE &C and Public Relations Directorate	EEA's capacity
Activity 8.3			
M, V& E Report prepared	Prepared report	Data from EEA EE &C and Public Relations Directorate	EEA's capacity

Table 21. Project log frame

3.2 Electric motor Energy Efficiency labeling

3.2.1 Labeling Program

Energy efficiency labeling programs aims to shift markets for energy-using products and appliances toward greater energy efficiency. The programs help consumers understand which products are most efficient and what the benefits of this efficiency are. Labels not only influence consumers to choose more efficient products but also create competition among manufacturers to produce and market the most energy-efficient models, which engages retailers in promoting efficiency. Labels can best promote efficient products by linking energy efficiency and high-quality performance.

3.2.2 Benefits of the labeling program

Energy-efficiency labels are informative labels that are affixed to manufactured products and describe a product's energy performance (usually in the form of energy use, efficiency, or energy cost) to provide consumers with the data necessary for making informed purchases.

Benefits of labeling EE labeling are:

- Encourages competition among manufacturers
- Allows consumers to compare the EE of different types of electric motors available on the market
- Contributes also for future development and implementation of endorsement labeling program

The government has already laid policy instruments for the implementation of EE and conservation measures to minimize huge amount of energy losses and introduce energy efficient technologies for locally manufactured as well as imported electrical appliances. But to undertake those measures energy-efficiency standards or procedures that prescribe the energy performance of locally manufactured or imported products, which sometimes even prohibit the sale of products that are less energy efficient than the minimum standard, must be available.

The Energy Efficiency standard under development will fix Minimum Energy Performance standard, which is the basis of EE labeling of electric motors. It prescribes minimum efficiencies (or maximum energy consumption) those manufacturers must achieve in the product, specifying the energy performance but not the technology or design details of the product. It will motivate and also force producers of energy efficient models of electric motors. Those energy efficient products shall be assigned EE labels, whose grades and types will be prepared and indicate the efficiencies/energy consumption of the product.

3.2.3 Assessment of political, institutional and Cultural factors

The first step in the development and implementation of EE standards and labeling program is to assess how local cultural, institutional, and political factors are likely to influence/affect the adoption and effectiveness of such programs, because there are many factors and actors as this product is highly integrated to cultures of many societies in Ethiopia. Its economic and cultural impact and benefits are also very high as it touches electric motor manufacturers, importes, and retailers. This indicates that the decision of this labeling program needs attention of the government, because those factors could facilitate or hinder the effectiveness of this program.

International experience shows that there may be greater resistance from influential stakeholders to the labeling programs. In Ethiopia the situation can be even worst compared to the International one. Therefore, time and education may be required for people to accept benefits claimed for energy-efficiency labeling program and standards. People must be aware to accept that the programs are economically beneficial to the consumer and for the country in general and do not decrease consumer's choice of products or, even, if designed effectively, energy-efficiency standards and improved products can make local businesses more profitable in the long run. Generally in Ethiopia pilot/voluntary labeling programs shall be implemented at least for the first three to five years for smooth implementation of the program.

3.2.4 Harmonization of labels

The labeling program currently focuses only on electric motors. As we know electric motors are widely used among Ethiopian industries, in neighboring countries or other countries like USA, Canada, and Germany and Arab countries. The labeling grades or types used for products like Injera mitads and refrigerators or other import products which may be considered in the labeling program may be used for electric motors. Hence, harmonization of labels with the international or regional labels is very important and must be taken in to consideration.

Therefore, where products are compared using labels such as stars, numbers, letters or colored bar charts, algorithms for EE need to be tailored to International, regional or national markets based on currently available test procedures used to determine energy consumption of the labeled appliances. Mutual recognition agreements (MRAs), are useful to implement labeling programs, because common harmonized test procedures and a universal efficiency categorization scheme are also very important to facilitate trade between involved countries and reduce the cost of regulation.

3.2.5 Global labeling and standardization program on electric motors.

3.2.5.1 IEC EE/NEMA Labeling Efforts.

Over the past twenty years the motor industry and the IEC EE (IEC System for Conformity testing and Certification of Electro technical Equipment)/NEMA (National Electrical Manufacturers Association) have made significant efforts to provide more energy efficient motor products to improve electric motor energy performance. The main stimulants to increase the demand for these energy efficient motors have been MEPS (Minimum Energy Performance Standards) and national energy efficiency regulations. Currently there are over 15 national or regional global energy efficiency regulations for motor energy efficiency with many more in development.

One of the major obstacles for motor manufacturers is navigating the various rules and regulations at the national and regional levels. While many of these regulations have similar registration processes, each one varies from the other. Below are important considerations in the typical motor energy efficiency regulation process.

- Motor Efficiency Test Standard
- Product Definition (Scope of Regulated Motors)
- Test Laboratory Qualification
- Registration and Certification
  - Minimum number of test samples
  - Labeling or Product Marking (Nominal Efficiency Definition – National Differences)
  - MEPS (Minimum Energy Performance Standard)

Many countries have implemented the above mentioned standards and regulations, but there are inconsistencies in implementations, which resulted in limiting the customer's choices for compliant high efficiency motors. Lastly, most of these regulations lack a robust enforcement or verification policy to ensure compliant motors stay compliant and restrict nonregistered motors from entering the marketplace.

Fruitful efforts have been made between NEMA and IEC EE to jointly develop a "Global Motor Efficiency Labeling Program". This joint proposal between NEMA and IECEE is intended to address the multitude of difficulties that motor manufacturers face when complying with the various global country regulations for motor efficiency. Many countries (US, Canada, Mexico, Brazil, Argentina, European Union, India, China, Russia, Australia, Japan, Korea, etc.) have existing motor efficiency regulations but can vary greatly when it comes to the test standards, laboratory accreditation, certification process and labeling requirements. This joint proposal will determine consistencies in these requirements and establish a global set of harmonized requirements from the laboratory accreditation to the test standards and finally the certification process and the final motor labeling.

In 2010 NEMA attempted to address this lack of enforcement issue with the development and subsequent release of the NEMA Premium License program. This voluntary motor efficiency program provides a certification program based upon the US DOE (Department of Energy) motor energy efficiency regulation codified in the Code of Federal Regulations (CFR) at 10 CFR Part 431. The major item that NEMA attempted to address with this program was the installment of the verification testing process. Each year NEMA randomly selects a motor rating and then instructs the participating members to provide this motor sample from their distribution network to an independent third party motor test laboratory for verification testing. If the motor sample is found to be non-compliant as marked, the manufacturer faces the penalties of the program which can result in fines and revocation of the NEMA Premium license as a participating member. One additional feature of the program is the ability for each member to challenge another participating member or other motor manufacturer not participating in the program. If the challenged motor manufacturer is validated as compliant then the challenger must pay the administrative and testing costs for the challenge. This program has been a global success with 17 global motor manufacturers participating.

The NEMA Premium License program is currently the leading global motor efficiency labeling program and was the first such program to develop requirements for verification testing after initial certification. An international task force has been formed to convert the NEMA Premium License program into an IEC globally accepted motor labeling program. This international task force consists of members of both NEMA and IEC standards organizations along with an international list of motor manufacturers.

3.2.5.2 Global Motor Efficiency Program

In the effort to continue the benefits of the program's success NEMA began looking for ways to expand the global reach of the NEMA Premium License. Following the 2011 EEMODS (Energy efficiency in Motor Drive Systems) conference in Washington DC, NEMA, CLASP (Collaborative Labeling and Standards Program) and IEC EE members informally met to discuss efforts to develop a "Global Motor Efficiency Program" or GMLP. The discussion focused on the following key issues that need to be addressed for a successful program.

- Lack of common certification process (registration, sample selection, test laboratory requirements, test standards, efficiency levels and efficiency marking)
- Lack of globally recognized label or mark for motor efficiency
- Lack of enforcement policy (verification testing and border enforcement)
- Global certification program that can be adopted by developing nations and regions

- Benefits to existing national and regional regulations to alternatively accept a globally recognized efficiency program

Shortly after the initial meeting between NEMA and IEC EE it was clear that both organizations were looking to develop similar programs to address the same concerns around energy efficiency certification, compliance and enforcement. After a series of informative discussions it was decided to work towards development of an IEC EE conformity assessment scheme based solely around the NEMA Premium License. The IEC EE currently operates the globally recognized CB (Certification Body) Scheme in addition to other associated programs such as IEC Ex(IEC system for certification to relating to equipment for use in explosive atmosphere). The CB Scheme is the only globally recognized conformity assessment scheme and is widely accepted in all parts of the world for electrical and electronics products with over 50 countries participating. After those initial discussions between NEMA and IEC EE it was decided this program would be best developed under the IEC EE organization by forming different working groups.

3.2.5.3 IEC EE Standards

The IEC working groups composed of global team of motor manufacturers, certifying bodies and other interested participants, GMLP (Global Motor Labeling Program) developed an internationally applicable testing Standard IEC 60034-2-1 for electric motors and a classification scheme IEC 60034-30-1 with four levels of motor efficiency ("IE-code"):

- IE1 Standard efficiency, IE2 High efficiency, IE3 Premium efficiency and IE4 Super premium efficiency.

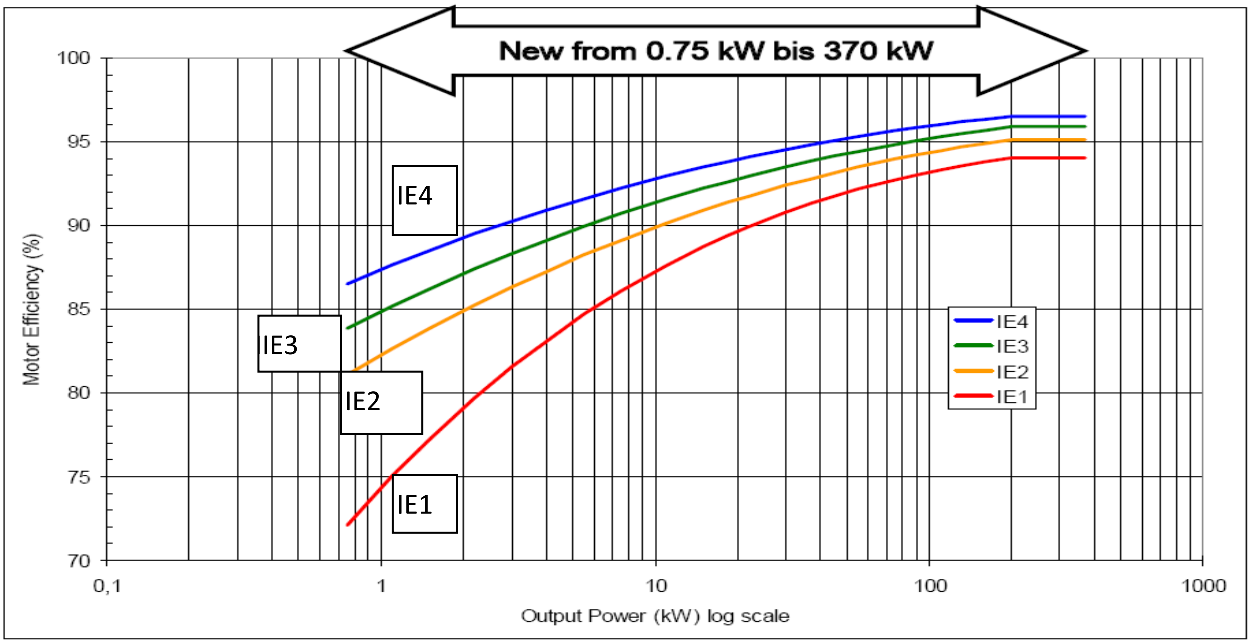


Figure 16. The IE-code and its efficiency levels of Electric motors

The IE-code and its efficiency levels create a basic vocabulary for governments to determine the efficiency level for their Minimum Energy Performance Standards (MEPS).

- The European Union sets motor MEPS levels (Directive 640/2009) at IE3 (or IE2 in combination with a variable frequency drive) from 2015 for smaller motors and from 2017 covering also larger motors.
- The USA was the first country in the world to set MEPS for motors. In 1997 (Energy Policy Act) the minimum required level was set at the equivalent of IE2. In 2007 (Energy Independence and Security Act) MEPS were raised to the equivalent of the IE3 level (NEMA Premium). NEMA Premium and IE3 are coordinated as efficiency levels, the USA currently recognizes in its legal requirements the national testing standard IEEE 112B and the Canadian test standard CSA390 but not yet the IEC test Standard IEC 60034-2-1 (the differences are minimal).
- Australia and New Zealand set MEPS levels at IE2 in 2000 (AS/NZS 1359.5-2000), effective since 2001 based on the IEC test Standard IEC 61972 from 2002 (a predecessor of IEC 60034-2-1).
- China decided in 2002 (GB 18693) for small and medium three-phase asynchronous motors to start with motor MEPS. The standard has been updated since in 2006 and 2012 to harmonize with IEC Standards and to move the MEPS level step by step from IE1 to IE2 and IE3.

- Japan decided to harmonize its national JIS (Japanese Industrial standard) with IEC efficiency classes and to include electric motors at the IE2 and IE3 level in its Top runner programme in 2014.
- India has endorsed MEPS for energy efficient electric motors with IEC grades IE2 since 2012. But there is no local testing requirement as those motors are directly imported from original equipment manufacturers such as Gear motors. In this case, energy efficiency labeling logo assignment is done by the manufacturer.
- In Countries such as Australia and Brazil local testing is mandatory, whether the motors are being imported or locally manufactured.

Regulations for assignment of labeling logo differ from country to country. For example it is not mandatory in countries like Canada, India and Australia, but it is mandatory in countries like China or Brazil. In Europe the European Quality Mark (Logo) “CE” with following Information marked on or near the rating plate of the motor according to the Product Information Requirements on Motors of the Regulation 640/2009/EC is used:

1. Nominal efficiency (η) at the full, 75 % and 50 % rated load and voltage (V);
2. Efficiency level: IE2 or IE3;
3. The year of manufacture.

Many countries use their own national test standards while at the same time also reference the international test Standard IEC 60034-2-1. Today, countries consuming more than 70% of the global electricity have set MEPS for motors either on IE2 or by 2015/17 on IE3 level. This is a high level of international harmonization for a globally traded product, recognizing at the same time that MEPS levels can be different according to the market situation of countries. The barriers to trade are reduced through the transparent nomenclature and definitions of the IE-code (MEPS levels at IE1, IE2 or IE3).

3.2.6 Product performance standard for electric motors

Energy efficiency labeling of electric motors would reduce capital investment in energy supply Infrastructure, enhance economic efficiency of the country by reducing demand on power and energy and benefit especially manufacturing industries and big consumers by reducing energy bill, and strengthening competitive markets. Therefore, implementation of comprehensive integrated policy package, regulatory and non regulatory policy measures described below are needed to harness benefits obtained from energy efficiency labeling and standardizing of electric motors.

3.2.6.1 Comprehensive integrated policy package

For the development and implementation of successful energy efficiency standards and labeling program of electric motors, as a first measure, Ethiopia like other countries shall consider adopting IEC EE and labeling standards as mandatory MEPS, subject to due process and cost effectiveness analysis. These standards should apply to as many types and sizes of electric motors. For this purpose implementation of regulatory and non regulatory measures as described below are mandatory.

3.2.6.1.1 Regulatory policy measures

a) MEPS should be introduced in line with international best practice for all major classes of electric motors. These requirements should apply to motors sold individually or integrated into pre-packaged electric motor-driven systems, and should apply to motors with as wide a range of output power as is practicable (100 W to 1 000 kW).

b) Regulatory measures, such as MEPS and energy labeling, should be introduced for packaged integrated motor driven energy end uses between 100 W and 1 000 kW, including fans, pumps, circulation pumps and compressors that are produced in sufficiently large volumes to have significant energy consumption.

c) The Ethiopian Energy Authority, the Ethiopian Standards Agency and other policy makers should ensure that energy performance test procedures are developed for all motor types that use significant amounts of electricity.

d) The Ethiopian Energy Authority, the Ethiopian Standards Agency and policy makers should commission the development and application of energy performance test procedures to cover other essential components of electric motor driven systems, including transmissions, gears and system control devices (e.g. VFDs). In addition, efforts should be made to develop energy performance test procedures and guidelines that apply to whole electric motor system applications, such as utility water pumping, lifts (elevators), escalators, conveyors, grinding mills etc.

e) The Ethiopian Energy Authority should explore the feasibility of developing minimum energy performance standards for certain classes of gears and transmissions to discourage (and later prohibit) the use of inefficient solutions such as worm gears and V-belts.

3.2.6.1.2 Non regulatory policy measures

a) Large scale awareness programmes should be developed and put in place to inform industrial and commercial electricity users of the significant savings potentials obtained through the use of efficient electric motor-driven systems. These programmes should target those responsible for procurement of electric motors and motor-driven systems, including operations and maintenance managers, production and plant managers, and company executives and decision makers responsible for overall company policy on energy, carbon and cost reduction.

b) Incentive schemes should be developed and applied to encourage adoption and use of best practice motor sizing, management and integration, including the appropriate use of VFDs. These should be targeted at the systems producing the highest benefit, namely for pumps, fans and other applications with variable mechanical loads (where torque increases nearly as the square of the rotational speed of the motor). In most cases, cost- effective savings can also be achieved when VFDs are used for conveyors, hoists, escalators and similar applications (where torque is more or less independent of the motor speed). Incentive schemes are also likely to be beneficial for these applications.

c) Capacity building efforts should be substantially expanded to create permanent support structures, at a scale sufficient to support ongoing needs in the domain of energy efficient electric motor driven systems.

d) Market monitoring should be established at defined intervals, to support national regulation and incentive programmes with market transformation data.

3.2.7 Implementation of the labeling program

For the implementation of this program procedures and guidelines such as product sampling procedure, testing Procedure (test methods), and House keeping procedure, testing facility & measuring devices have been adopted from international standards and annexed. Annexes 5 to 9.

The development of testing capability must be given priority, because in the implementation of labeling program besides sample collection, sample storage, measurements, tests and data storage take major stakes. Therefore, the Ethiopian Energy Authority shall establish its own testing laboratory with sufficient equipment and personnel or must out source this activity to already established and experienced laboratories such as the Ethiopian Conformity Assessment Enterprise.

In Ethiopia, a Quality Mark (Logo), with the following Information marked on the electric motor nameplate can be used:

1. Nominal efficiency (η) at the full, 75 % and 50 % rated load and voltage (V);
2. Efficiency level: IE1, IE2 or IE3;
3. The year of manufacture.

3.2.8 Monitoring the labeling program

Monitoring the implementation of the labeling program is one way of assuring the success of the program. There must be clear guideline on the utilization of Quality Mark. The authority shall also assure, whether the Quality Mark is properly used. Options to penalize those who use the Quality Mark illegally shall be in place. To assess whether energy labels are effective, a policy maker can ask three basic questions:

- Are consumers aware of the label?
- Do they understand it?
- Do they change their behavior because of it?

Placement of an energy label on a product is only the first step in attempting to influence consumers' purchase decisions. Research has shown that education and promotion are valuable aids in making the label effective. Promotional marketing is most effective when consumers are subject to numerous, consistent messages regarding EE, not just as part of the energy-labeling program but also in other related energy programs that may be running in parallel. These repeated messages reinforce a culture of EE among industries and help to create an energy-efficiency ethics within the country.

To make the energy sector beneficiary from standardizing and labeling of electric motors, a three and half year's program has been proposed for the development and implementation of the energy efficiency standardizations and labeling. An action plan with budget allocated for the program along with responsible authorities has been proposed under Section 4.

3.3 Product national standard for electric motors

3.3.1 The adopted product national standard

The benefits of Standardizing of electric motors are:

- For producers to affirm their product quality and drive innovation;
- For industries, importers, investors, donors, and policymakers to have a credible basis for comparing product performance and quality;
- And for all stakeholders to have a common terminology for communicating, understanding, and improving product performance and adoption.

Ethiopia has adopted the following IEC standards which can be used for electric motor EE standards.

1. ES IEC 60034-1:2012 1 Edition, Rotating Electrical Machines - Part 1: Rating and Performance
2. ES IEC 60034-2:2012 1 Edition, Rotating Electrical Machines - Part 2-1: Standard Method For Determining Losses and Efficiency From Tests (Excluding Machine For Traction Vehicles)
3. ES IEC 60034-30:2012 1 Edition, Rotating Electrical Machines – Part 30 - Efficiency Classes of Single Speed Three phase Cage Induction Motors (IE - Code)
4. ES IEC 60034-31:2012 1 Edition, Rotating Electrical Machines – Part 31 - Selection of Energy Efficient Motors Including Variable Speed Application - Application Guide

3.4 Monitoring the implementation of the EE labeling and Standard

The Ethiopian Energy Authority is the body responsible for the promotion, dissemination, and full implementation and follow-up of the product national standard. It must promote the developed standard to major stake holders specially importers, so that they can take care of further import of substandard products.

The Authority shall not work only on the promotion and dissemination of the Product National Standard, but also on the trainings and supports Industries and importers shall get for proper implementation of the standards. Huge amount of budget and activities are expected from the Authority for the training Industry technical staffs and importers.

The fulfillments of the above supports by the Government/Authority will speed up the implementation of the national standard.

Monitoring of post standard labeling program but shall involve measurement, verification, and evaluation. In this process proper utilization of the Quality Mark (logo) must be ensured by the regulator and if not appropriate legal measures shall be taken to protect abuse practices.

3.4.1 Measurement and Verification

The integrity of energy-performance information for Electric Motors covered by standards is a primary requirement for a successful standards-setting and labeling program. All standards-setting and labeling programs rely on measuring and accurately declaring the energy consumption and energy efficiency of the Motors. Without a means of measuring electric motors energy performance, it is impossible to launch a meaningful standards-setting and labeling program. It is also essential that electric motors energy performance be measured in a consistent way and that the values reported within the program are accurate. Following are major steps to be accomplished during the measurement and verification process.

1. Assess options and competencies for testing Products
2. Assess accreditation options for verifying the competence of testing facilities and legitimizing test results
3. Assess certification program options for validating that products comply with standards and label requirement
4. Establish a verification regime for declaring and verifying that importers and industries are complying with standards and label requirement
5. Establish a compliance regime for ensuring that importers and industries are complying with standards and labeling requirements

3.4.2 Evaluation

Program evaluations quantify impacts and benefits in concrete terms, which can be the main evidence of the need to support the programs. Measuring impacts can justify allocation of resources to the program and demonstrate the need for funding that is sufficient to make the program effective. Steps to be followed are:

1. Plan the evaluation and set objectives
2. Identify resource and data needs and collect data
3. Analyze data
4. Apply evaluation results

4 Project work plan and costs

4.1 Project Work plan

Outputs	Year	First year												Second year												Third year												Fourth year					
	Months	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Outputs 1	**Activities**																																										
Awareness created on Energy efficiency standards and labeling on electric motors through advertising and promotions and stake holders engagement																																											
	Activity 1.1																																										
	Prepare printed materials and distribute																																										
	Activity 1.2																																										
	Promote on TV and Radio																																										

Outputs	Year	First year												Second year												Third year												Fourth year					
	Months	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
	Activity 1.3																																										
	Prepare Question & Answer program on ETV																																										
	Activity 1.4																																										
	Engage Stake holders /workshop																																										
Output 2	**Activities**																																										
Defined services and hire consultant for implementation of the project																																											
	Activity 2. 1																																										
	Hire Local consultant																																										
	Activity 2. 2																																										
	Consultant develops implementation plan of the project and provide the service																																										

Outputs	Year	First year												Second year												Third year												Fourth year					
	Months	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Output 3	**Activities**																																										
Developed testing capability																																											
	Activity 3. 1																																										
	Agreement signed with selected testing laboratory and setup Project taskforce																																										
	Activity 3.2																																										
	Prepare Testing equipment specification																																										
	Activity 3.3																																										
	Procure and install Testing equipment																																										
	Activity 3.4																																										
	Testing personnel trained																																										

Outputs	Year	First year												Second year												Third year												Fourth year					
	Months	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Output 4	**Activities**																																										
Determination and endorsement of MEPs																																											
	Activity 4. 1																																										
	Selection of electric motor types/ ranges for labeling																																										
	Activity 4. 2																																										
	Determination & Endorsement of MEPs																																										
OUTPUT 5	**Activities**																																										
Adoption of labeling logo																																											
	Activity 5.1																																										
	Adoption of labeling logo with electric motor specific parameters																																										
	Activity 5.2																																										
	Stakeholders comments on final logo																																										

Outputs	Year	First year												Second year												Third year												Fourth year					
	Months	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Output 6	**Activities**																																										
Disseminate product national Standard																																											
	Activity 6.1																																										
	Dissemination of standards																																										
Output 7	**Activities**																																										
Testing of samples																																											
	Activity 7.1																																										
	Sampling method determined																																										
	Activity 7.2																																										
	Samples collected																																										
	Activity 7.3																																										
	Samples tested																																										
	Activity 7.4																																										
	Test report prepared																																										
	Activity 7.5																																										
	Test result announced																																										

Outputs	Year	First year												Second year												Third year												Fourth year					
	Months	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
	Activity 7.6																																										
	Implementation of labeling program																																										
OUTPUT 8	**Activities**																																										
Program monitoring and evaluation																																											
	Activity 8.1																																										
	Prepare Monitoring & Evaluation plan																																										
	Activity 8.2																																										
	Measure, Verify and Evaluate the program																																										
	Activity 8.3																																										
	Preparation of M, V& E Report																																										

Table 22. Project Work plan

4.2 Project Cost

	Years	First year	Second year	Third year	Fourth year
Outputs	**Activities**				
Outputs 1:					
Awareness created on Energy efficiency standards and labeling on electric motors through advertising and promotions and stake holders engagement					
	Activity 1.1				
	Prepare printed materials and distribute	750,000.00			
	Activity 1.2				
	Promote on TV and Radio	1,000,000.00	1,000,000.00		
	Activity 1.3				
	Prepare Question & Answer program on ETV	680,000.00			
	Activity 1.4				
	Engage Stake holders	300,000.00	200,000.00	200,000.00	200,000.00
Output 2					
Defined services and hire consultant for implementation of the project					
	Activity 2. 1				
	Hire Local consultant	30,000.00			

	Years	First year	Second year	Third year	Fourth year
Outputs	**Activities**				
	Activity 2. 2				
	Consultant develops implementation plan of the project and provide the service	500,000.00	500,000.00	500,000.00	340,000.00
Output 3					
Developed testing capability					
	Activity 3. 1				
	Agreement signed with selected testing laboratory and setup Project taskforce	150,000.00			
	Activity 3.2				
	Prepare Testing equipment specification	50,000.00			
	Activity 3.3				
	Procure and install Testing equipment		7,000,000.00		
	Activity 3.4				
	Testing personnel trained		475,000.00		
Output 4					
Determination and endorsement of MEPs					

	Years	First year	Second year	Third year	Fourth year
Outputs	**Activities**				
	Activity 4. 1				
	Selection of electric motor types/ ranges for labeling	25,000.00			
	Activity 4. 2				
	Determination & Endorsement of MEPs	335,000.00			
OUTPUT 5					
Adoption of labeling logo					
	Activity 5.1				
	Adoption of labeling logo with electric motor specific parameters	50,000.00			
	Activity 5.2				
	Stakeholders comments on final logo	200,000.00			
Output 6					
Disseminate product standard					
	Activity 6.1				
	Dissemination of standard		160,000.00		
Output 7					
Testing of samples					
	Activity 7.1				
	Sampling method determined		50,000.00		

	Years	First year	Second year	Third year	Fourth year
Outputs	**Activities**				
	Activity 7.2				
	Samples collected		100,000.00		
	Activity 7.3				
	Samples tested		650,000.00	650,000.00	
	Activity 7.4				
	Test report prepared		134,000.00	1 34,000.00	
	Activity 7.5				
	Test result announced			50,000.00	
	Activity 7.6				
	Implementation of labeling program				300,000.00
OUTPUT 8					
Program monitoring and evaluation					
	Activity 8.1				
	Prepare Monitoring & Evaluation plan	100,000.00			
	Activity 8.2				
	Measure, Verify and Evaluate the program	50,000.00	80,000.00	80,000.00	40,000.00
	Activity 8.2				
	Prepare M, V & E report	10,000.00	10,000.00	10,000.00	10,000.00
Total/year		**4,140,000.00**	**10,359,000.00**	**1,624,000.00**	**890,000.00**
Total project Budget		**17, 013,000.00**			

Table 23. Project cost

5 Project management organizational and Institutional context

EEA is the implementing agency of the electric motors EE standards and labeling program. The organizational and institutional setting of EEA is assessed as follows.

5.1 Institutional setting and legal frame work

a. The EEA is mandated by the Proclamation on Energy, proclamation No. 810/2013, on EE regulation and conservation works in Ethiopia. Article 19, 2, of the proclamation states that Energy efficiency and conservation activity may be regulated through the application of anyone or more of the following, as may be appropriate: a) minimum energy efficiency standard; b) energy efficiency labeling codes. Article 20 also states that under National Energy Efficiency and Conservation Strategies and Programs: the Authority shall develop and implement national energy efficiency and conservation strategies and programs. The draft energy regulation operation directive derived from the proclamation is on the process of ratification.
b. The implementation of the electric motors EE standards and labeling program are within the mandate of EEA. However, the implementation of the program necessarily needs the ratification the energy regulation operation directive. Even though it is proposed that the EE standard and labeling program commences with voluntary participation of the producers, it eventually proceeds to mandatory participation and compliance requirement to the standards to be developed. The energy regulation directive is required to enforce the implementation of the program and is assumed to be ratified soon.

5.2 Organizational capacity assessment

5.2.1 Existing organizational structure of EEA

EEA is established under Ministry of Water, irrigation and Energy and headed by a Director General. According to the Human Resource Directorate of EEA, the current structure of EEA, indicated overleaf, is subject to approval and staffs have been assigned based on it. It is anticipated that the board of directors which oversees EEA will be established. BPR based staff assignment has been implemented in the 2002 EFY. The organizational structure and manpower assignment of EEA is under study and there could be revisions based on the result. There are 11 directorates and two offices under the current structure of EEA. Figure 17, overleaf, shows the current organizational structure of EEA

Hierarchical Structure of the Ethiopian Energy Authority

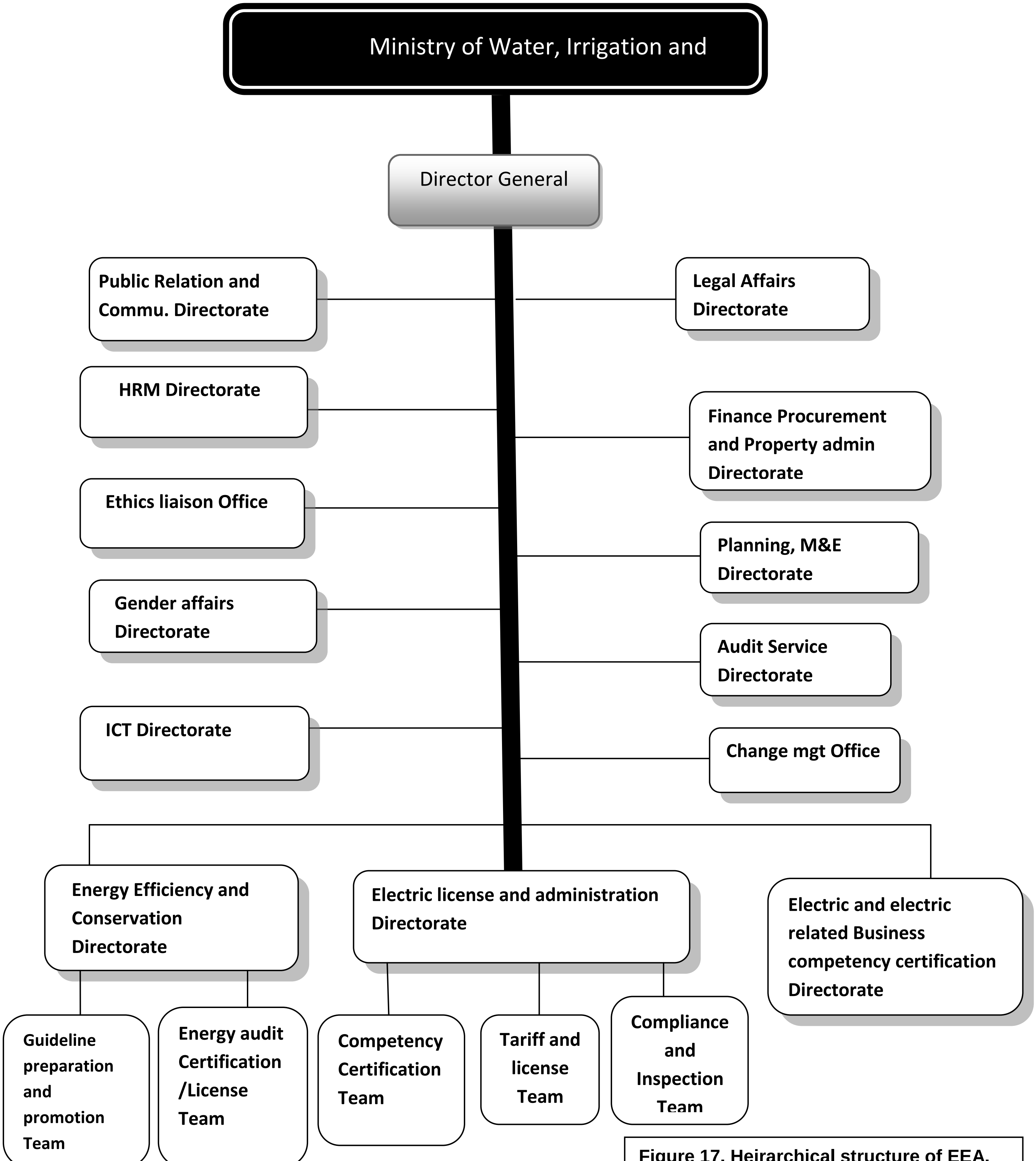


Figure 17. Heirarchical structure of EEA.

5.2.2 Proposed organization for the implementation of the EE standards and labeling program.

As indicated in earlier sections of this project proposal, the EE program involves the development of efficiency standards and labeling and engages different types of stake holders including industries, manufacturers, importers, maintenance service providers, government institutions, and regional state bureaus. Lots of activities are expected to be carried out with the stakeholders to achieve the desired goals of the program.

The EE and Conservation Directorate, being one of the core business processes, is tasked with the responsibilities of regulating EE and conservation activities in the country. Currently there are two teams under the directorate: Guideline preparation and promotion Team and Energy audit certification/license Team. Seven staffs including one Director, five junior graduate engineers, one management graduate and a secretary are assigned to the directorate.

The EE and Conservation Directorate is the appropriate department to execute the EE efficiency program on electric motors effectively. However, based on the existing structure, the number of staffs and the volume of work at hand, it appears that the Directorate would not be able to handle the EE efficiency program on electric motors effectively. As indicated under section 3, It is proposed that the implementation of EE standards and labeling of EE program electric motors takes about three and half years.

Two options of organization have been proposed:

a. Establishing Project management Unit under EEA, or
b. Hosting the program within EEA structure but out sourcing the processes of performance and product standard, and measurement and verification part of the program.

Pros and cons of the two organizational options.

Establishing Project management Unit under EEA has the advantages of centering activities around the project goals, rapid decision making, and facilitation of communication. The disadvantages include: duplication of inputs with other parts of the organization, removing staffs from functional groupings reduces the amount of support they receive.

Hosting the program within EEA structure but out sourcing part of the project processes is highly flexible in that inputs can change rapidly and readily with regard to project demand, staffs remain within their functional groupings, can easily be disbanded upon project completion and allows for efficient resource use. The disadvantages of this option will be it costs higher, takes time and process to assign the service provider.

Considering the above, hosting the program within EEA structure but out sourcing part of the processes is proposed.

5.2.3 Capacity building activities.

The EE program on electric motors is proposed to be accomplished by hosting the program within EEA structure but out sourcing part of the processes. The EE and Conservation Directorate shall be assigned as counterpart to the process.

Training on EE standards and labeling shall be given to the staffs of the EE and Conservation Directorate in order to enhance their capacity for the post the project period labeling program and future projects. Energy bureaus of Addis Ababa and Diredawa cities and regional states are expected to implement and co ordinate the program and hence need basic training on EE.

6 Project benefits and justifications

Improvement in the EE of an electricity consuming product like motors reduces the amount of power demand energy that the machine uses. If the machine consumes electricity and operates at times of peak power demand, the improved efficiency also reduces demand for new power plants. The investment that would be required for new power plants is vastly more expensive than the increased cost of designing and manufacturing energy-efficient components for the energy-consuming machines that these power plants service. Studies and analysis showed that improvements in EE avert projected energy demand and capital investments in power plants, transmission lines. At the time, these efficiency improvements could have cost little. In other words, efficiency labels and standards are a highly cost-effective way to reduce future investments in expensive power plant construction, freeing capital for more economically advantageous investments in the energy sector, or basic health and educational services.

6.1 The benefits of the EE standards and labeling

The benefits of the EE standards and labeling of electric motors include:

- Power demand reduction and reduction of capital investment in energy supply infrastructure.
- Reduction on power supply infrastructure overloading, frequent power interruption, outages and voltage drops
- National economic efficiency by reducing energy bills.
- Strengthening of market competition among industries
- Encouragement of research and innovation
- Assist the country in meeting climate change goals and averting regional pollution

6.2 Power demand reduction

6.2.1 Power demand reduction at national level

As indicated under Section 1.2.3, Table 13, 88.55 % of Electric motor imported are from China. Reference to the catalogue of at one of the interviewed importers indicated that the EE of motors imported from China is between the IE1 and IE2 efficiency levels; although this has to be verified through test. For the purpose of determining the benefit of EE standards and labeling on electric motors in Ethiopia the IE2 level is compared to the current estimated efficiency level of Ethiopian Industrial motors.

From Section 1.1.2.3.7, Table 7, for the average motor power of 16 KW there is EE difference of 16.2% between IE 2 and the estimated industrial motors' efficiency. Hence, the peak demand reduction (power generation, transmission and distribution) for electric motors for the year 2015 could be estimated to be 337 MW (Table 19) x 16.2% = 55 MW.

Power demand saving for the next 10 years if EE standards and labeling on electric motors is implemented and MEPS is set at IE 2 level is forecast as shown in Table 24 overleaf.

6.2.2 Power demand reduction at factory level

At a factory level power demand will reduce by efficiency improvement to IE 2 level, 16.2%. This reduces significantly the Maximum power demand penalties and improves the power factor at the factories.

6.3 Energy savings obtained

6.3.1 Energy savings at factory level

The EEU industrial tariff group is sub divided into Low voltage, 15 KV and 132 KV. At a factory level energy consumption will reduce by efficiency improvement to IE 2 level, 16.2%. The energy consumption charge reduces by 16.2%. depending on the tariff group of the specific factory.

6.3.2 Energy savings at national level

Referring to Table 18, there could be up to 1,655GWh x 16.2% = 268 GWh saving. The EEU industrial tariff group is sub divided into Low voltage, 15 KV and 132 KV. The low voltage Industrial tariff constitutes about 73% of the industrial tariff group consumption. The price rate of the low voltage category is 0.5778 Birr/Kwh. Hence, there could be an estimated 268GWh x 0.5778 Birr/Kwh = 154.8.2 Million birr saving in the year 2015 only.

Based on the above, the energy saving for the next 10 years was forecast as shown in Table 25 overleaf.

The power demand and energy saving indicated in Tables 24 and 25 overleaf could be used for electrification, manufacturing and export. There will be significant CO_2 savings in the case of which the energy saved is sold to neighboring countries where electricity generation is oil based.

Ref.	Description	Year 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
A	Peak demand power(MW)	267	317	376	445	528	626	743	881	1,044	1,238
B	% power losses	26.0%	23.6%	21.2%	19.0%	17.9%	17.9%	17.9%	17.8%	17.7%	17.7%
C	Total peak demand and losses(MW), (A/(1-B))	337	392	455	530	623	739	876	1,038	1,229	1,458
D	Power Losses(MW), (AxB)	69	75	80	85	95	112	133	157	185	219
E	Power demand saving (MW), (Cx 16.2%)	55	63	74	86	101	120	142	168	199	236

Table 24. Power demand saving scenario of electric Motors for the next 10 years, 2015 to 2024

Ref.	Description	Year 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
A	Consumption (GWh)	1,301	1,574	1,904	2,304	2,788	3,374	4,082	4,940	5,977	7,232
B	% energy losses (GWh)	27.2%	23.8%	20.5%	17.5%	16.0%	15.9%	15.7%	15.6%	15.5%	15.3%
C	Total Consumption and losses (GWh),(A/(1-B))	1,655	1,948	2,295	2,708	3,235	3,910	4,725	5,711	6,902	8,338
D	Energy Losses(GWh), (AxB)	354	374	390	404	446	536	643	771	925	1,106
E	Energy saving(GWh), (Cx16.2%)	268	316	372	439	524	633	765	925	1,118	1,351

Table 25. Energy demand saving scenario of electric Motors for the next 10 years, 2015 to 2024

6.4 Strengthening of competition among producers

Energy-efficiency standards and labeling on electric motors lead to the importation of improved products and make local businesses more profitable in the long run and more competitive in the local marketplace.

6.5 Assist in reducing environmental pollution and averting regional pollution

6.5.1 Averting regional pollution due to electricity generation

Ethiopian electricity generation is mainly based on the hydro – electricity and CO_2 releases are limited to the relatively smaller Diesel power plants. However, Ethiopia is exporting electricity to neighboring countries and the energy savings in Ethiopia increase the potential to export where it replaces mainly oil based power generation like in Sudan, Djibouti and Kenya. The CO_2 savings in these countries is considered as Ethiopia's contribution to the reduction of regional pollution. The saving of electrical energy due to EE standards and labeling of electric motors at national level could be exported. In such cases, the CO_2 savings for the regional countries will be a sizable amount. Table 26 shows the estimated annual and cumulative CO_2 savings assuming that the energy saved is exported to the neighboring countries. The CO_2 savings is calculated based on the base line emission data of the Ethio-Kenya power interconnection project which is 5.71x10-4 metric tons CO_2 /KWh.

Ref.	Description	Year									
		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
A	Energy saving(GWh)	268	316	372	439	524	633	765	925	1,118	1,351
B	Annual CO_2 savings (1000 tons)	153	180	212	250	299	362	437	528	638	771
C	Cumulative CO_2 savings (1000 tons)		333	392	463	550	661	799	965	1,167	1,410

Table 26. Estimated annual and cumulative CO_2 savings

6.6 Monetized benefits of the EE standard and labeling program

6.6.1 Framework for Cost - Effectiveness Evaluation

The typical approach for quantifying the benefits of energy efficiency is to forecast long-term "avoided costs," defined as costs that would have been spent if the energy efficiency savings measure had not been put in place.

6.6.2 Choosing which benefits to include

There are two main categories of avoided costs: energy-related and capacity-related avoided costs. Energy-related avoided costs involve market prices of energy, losses, and other benefits associated with energy production such as reduced air emissions (for diesel power plants) and water usage. Capacity-related avoided costs involve infrastructure investments such as power plants, transmission and distribution lines, dams, and tunnels. Environmental benefits make up a third category of benefits that are frequently included in avoided costs. Saving energy reduces air emissions including GHGs, and saving capacity addresses land use and site related issues such as new transmission corridors and power plants.

6.6.3 Net Present Value

A significant driver of overall cost-effectiveness of energy efficiency is the discount rate assumption. Cost-effectiveness test compares the Net present Value (NPV) of the annual costs and benefits over the life of an efficiency measure or program. Typically, energy efficiency measures require an upfront investment, while the energy savings and maintenance costs accrue over several years.

The benefits from the EE standards and labeling are monetized as shown in Table 27–Scenario 1, below. The following equivalences and assumptions have been employed.

- Peak power demand saving – 1100USD/KW or 22,000 Birr/KW for Hydro power station, including costs of power plant erection, transmission and distribution based on Ethiopia's Climate-Resilient Green Economy Green economy strategy (CRGE)-GHG emissions Baseline.
- Energy saving (If used for export) – 7 USD/KWh or 140 Birr /KWh, based on Ethiopian Power system Expansion Master plan Study - Volume 5, Financial Assessment and Tariff Impact
- The benefit accrued due to EE standards and labeling program is assumed to materialize in the year 2011EFY, after the full implementation of the program.

- The operating cost after the three and half years program would continue at 50 % amount.
- Discount rate of - 10%

Table 28 -Scenario 2, shows monetized benefits assuming energy saving is used for domestic consumption at the rate of 0.5778 Birr/KWh, other assumptions in Table 27 remaining the same.

No.	Cost/Revenue (Mill Birr)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1	**Cost**										
1.1	Fixed assets	-	7.00								
1.2	Operating costs	4.14	3.36	1.62	0.89	0.45	0.45	0.45	0.45	0.45	0.45
	Total cost	**4.14**	**10.36**	**1.62**	**0.89**	**0.45**	**0.45**	**0.45**	**0.45**	**0.45**	**0.45**
2	**Revenue**										
2.1	Peak Power demand saving				1,892.00	2,222.00	2,640.00	3,124.00	3,696.00	4,378.00	5,192.00
2.2	Energy saving (If used for export)				61,460.00	73,360.00	88,760.00	107,100.00	129,640.00	156,660.00	189,280.00
	Total Revenue	**-**	**-**	**-**	**63,352.00**	**75,582.00**	**91,400.00**	**110,224.00**	**133,336.00**	**161,038.00**	**194,472.00**
3	**Net Revenue**	**(4.14)**	**(10.36)**	**(1.62)**	**63,351.11**	**75,581.55**	**91,399.55**	**110,223.55**	**133,335.55**	**161,037.55**	**194,471.55**
4	**Discount rate**	10%									
5	**Net present value**	**391,535.33**									

Table 27. Monetized benefits of the EE standard and labeling program of electric motor – Scenario 1.

No.	Cost/Revenue (Mill Birr)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1	**Cost**										
1.1	Fixed assets	-	7.00								
1.2	Operating costs	4.14	3.36	1.62	0.89	0.45	0.45	0.45	0.45	0.45	0.45
	Total cost	4.14	**10.36**	**1.62**	**0.89**	**0.45**	**0.45**	**0.45**	**0.45**	**0.45**	**0.45**
2	**Revenue**										
2.1	Peak Power demand saving				1,892.00	2,222.00	2,640.00	3,124.00	3,696.00	4,378.00	5,192.00
2.2	Energy saving (If used for domestic consumption)				253.65	302.77	366.33	442.02	535.04	646.56	781.19
	Total Revenue	**-**	**-**	**-**	**2,145.65**	**2,524.77**	**3,006.33**	**3,566.02**	**4,231.04**	**5,024.56**	**5,973.19**
3	**Net Revenue**	**(4.14)**	**(10.36)**	**(1.62)**	**2,144.76**	**2,524.32**	**3,005.88**	**3,565.57**	**4,230.59**	**5,024.11**	**5,972.74**
4	**Discount rate**	10%									
5	**Net present value**	**12,564.21**									

Table 28. Monetized benefits of the EE standard and labeling program of electric motor – Scenario 2.

7 Assessment of environmental and social impact.

7.1 Environmental advantages of the project

The EE standards and labeling of electric motors is an environmental project. As mentioned under Section 2 and Section 6 of this report the objectives and benefits of the project include averting regional pollution due to electricity generation.

As presented under section 6.3.2 above, the energy savings from the implementation of EE standards and labeling of electric motors at national level would result in the saving of large amount power demand energy. The saving on energy could be used for rural electrification, manufacturing, education, health and export. This will also provide clean cooking fuel to the community and also encourage migration from using diesel grinding machines to electric motor driven ones in rural areas.

Ethiopia currently exports power to neighboring countries. As indicated under 6.8.2 above, the export could replace the demand for electrical energy which may have been generated by oil power plants.

7.2 Social values of the project

- EE standards and labeling on electric motors could enhance the welfare of the industrial workers as the productivity and profit margins of factories increases. As Implementation of EE strengthens, competition among importers increases and the price of motors will go down.

- Introduction of the EE program would bring saving of electrical energy which could be used to supply electricity to many more rural areas.

8 Financial plan

The possible sources of finance for the program are:

1. Equity capital. The government, represented by the primary stake holders: Ethiopian Energy authority, Ethiopian Electric power and Ethiopian electric utility shall outlay capital project budget.
2. Recurrent revenue or grant. From Clean Development Mechanism (CDM) financing where industrialized countries with greenhouse gas reduction are committed to invest in projects that reduce emissions in developing countries as an alternative to more expensive emissions reduction in their

own countries or donations obtained from NGOs working actively in the energy sector like GIZ, SNV or other NGOs involved in the carbon trade.

3. Service charges. Collected from producers for labeling services in the standard and labeling program.

The project is urgent for the nation and is scheduled to start in 2015. As searching for donors may take years to get appropriate funding, it is suggested that the government shall allocate sufficient capital budget for this project. In the mean time supports of external donors can be sought for further financing of the program.

The equity capital from the government and possible grant from CDM finance shall cover the initial cash outlay required for the EE and standards program. EEA shall execute the program within the existing structure. The operating costs could be covered by the government and recurrent revenue sources and the service charges collected from importers. Considering the schedule above, it is anticipated that there will be positive cash flow throughout the program period.

The financial viability of the EE standards and labeling program for electric motors requires that the cash balance shall meet all financial commitments of the program from creating public awareness up to monitoring and evaluation for three and half years.

9 Arrangement for project Hand over

As indicated under section 5.2.2, it is proposed that the project is carried out under EEA, outsourcing certain processes. The development of standards and the labeling program takes about three and half years. It has also been proposed that the staffs of the EE and Conservation Directorate shall work as counterparts with the outsourced service providers. During the standard and labeling program, it is proposed that the EE and Conservation Directorate takes over and manage the project operations. After having worked on the motors EE program for three and half years, the EE and Conservation Directorate would be able to manage the operations and monitoring of the standard and labeling program.

10 Assumptions, risks, and risk management.

10.1 Assumptions

Important assumptions to achieve project purpose are:

- Stable economic growth of the country is maintained
- Appropriate amount of budget is allocated for the program
- Appropriate number of staff is allocated to The Project management Team and the EE and conservation Directorate of EEA.
- Effective public awareness creation is made on the importance of standardizing and labeling motors. Based on the survey made, the majority of importers, maintenance service providers and factories have the impression that EE standards and labeling would benefit their business. However, there are number of importers having negative attitude to the program.
- Training the importers, maintenance service providers, technical managers and purchasers of motors on electric motor energy efficiency standards and labeling is a pre condition and mandatory requirement for the successfulness of the program.

10.2 Risks and risk management

The risks identified, their impact and probability and the counter measures to be taken are indicated in the Table 29 below.

No.	Risk description	Impact & probability	Counter measure/Management response
1	Importers not willing to implement the EE program	The implantation of new regulations resulting in additional costs to importers is usually a great concern and a central issue in the discussions between the implementing agency and the imorters. However, the proposed project will take into account the financial situation of the producers and will be designed to move forward with the development of EE labels and standards	A comprehensive awareness raising plan to allow the full participation of the private sector in the project implementation

2	Factories and users not interested in purchasing Motors with a high initial cost	End users do not understand the EE process and avoid purchasing Energy efficient models owing to their higher initial costs. While the project can not eliminate the potential higher initial costs of energy efficient motors for buyers who prefer to spend less money for less efficient models, label development will be accompanied by substantial efforts in information dissemination, consumer education, retail - directed educational materials, and other activities to both raise awareness of the labels and to educate buyers on the benefits of EE purchasing.	Awareness campaign during project implementation by public and private sector partners.
3	Low technical capacity	Successful implementation of the project requires increase in the technical capacity of EEA staff, Project Management Unit and adequate capacity in the private sector. The project will seek to mitigate this risk by providing sufficient capacity building support to the Project Management Unit in developing the necessary in – house technical skills and by providing specific training.	A series of capacity building activities to help remove technical barriers to the development and implementation of EE

Table 29. Risks, impact and probability and counter measures

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Annex 1.
Electric motor rewinding tests Results

(Source: Motor repair impacts on efficiency. Austine Bonnette, Electrical Apparatus service Inc., USA)

Stage 1. Motors rewound with no specific control on stripping or rewind

Motor description	Efficiency before rewind	Efficiency after rewind	Efficiency change*	Winding before	Winding after	comments
			-1.00%			Bearing re greased
			-0.80%			Drive end bearing cleaned
			-0.60%			Both bearing cleaned
1A 100 hp,60Hz,4 pole	94.10%	93.10%	-0.50%	3TC-1L	3TC-1L	Bearing changed
2B 100 hp,60Hz, 4 pole	92.90%	92.40%	-0.50%	L-2L	L-2L	575 Volt machine
			-1.00%			Bearing re greased
			-0.50%			Drive end bearing cleaned
3c 100 hp, 60 Hz, 2 pole	94.50%	93.50%	-0.50%	GC-2L	L-2L	Both bearing cleaned
4D 100hp, 60 Hz ,2 pole	95.00%	94.50%	-0.50%	L-2L	L-2L	
5E 150 hp, 60 Hz ,2 pole	92.30%	92.00%	-0.30%	L-2L		
7B 150 hp, Hz ,2 pole	93.70%	93.30%	-0.40%	L-2L		

Stage 2 . Motors rewound with control on rewind process

Motor description	Efficiency before rewind	Efficiency after rewind	Efficiency change*	Winding before	Winding after	comments
6F 150 hp, 60 Hz ,2 pole	94.40%	94.30%	-0.10%	L-2L	L-2L	
9E 60 hp, 60 Hz ,2 pole	90.10%	89.90%	-0.20%	L-2L	L-2L	No core cleaning
10D 125 hp, 60 Hz ,4 pole	95.40%	95.20%	-0.20%	L-2L	L-2L	
11F 200 hp, 60 Hz ,2 pole	96.40%	96.30%	-0.10%	L-2L	L-2L	
14H 55KW, 50 Hz ,4 pole	89.90%	89.20%	-0.70%	2TC-1L	L-2L	Defective core (OEM)
16H 150 KW, 50 Hz ,4 pole	95.40%	95.60%	0.20%	GC-2L	L-2L	
18G 55 KW, 50 Hz ,4 pole	94.20%	94.20%	0.00%	3TC-1L	3TC-1L	
19H 132 KW, 50 Hz ,2 pole	93.00%	93.00%	0.00%	2TC-2L	L-2L	
20H 45 KW, 50 Hz ,2 pole	93.90%	93.90%	0.00%	3TC-1L	3TC-1L	
21J 75 KW, 50 Hz ,2 pole	93.70%	93.90%	0.20%	GC-2L	L-2L	

High Voltage motors

Motor description	Efficiency before rewind	Efficiency after rewind	Efficiency change*	winding before	winding after	comments
23K 225KW,Hz, 4 pole 3300 volts	95.70%	95.50%	-0.20%	L-2L	L-2L	

Stage 3 Multiple rewinds under controlled conditions

Motor description	Efficiency before rewind	Efficiency after rewind	Efficiency change*	winding before	winding after	comments
8C 200 hp, 60 Hz ,4 pole	95.70%	95.10%	-0.60%	GC-2L	GC-1L	1St rewind
		95.60%	-0.10%		L-2L	2nd rewind
12F 150 hp, 60 Hz ,2 pole	95.90%	95.90%	0.00%	L-2L	L-2L	1St rewind
		95.90%	0.00%		L-2L	2nd rewind
		95.80%	-0.10%		L-2L	3rd rewind
13G 110KW, 50 Hz ,4 pole	94.80%	94.60%	-0.20%	3TC-1L	3TC-1L	1St rewind
		94.60%	-0.20%		GC-1L	2nd rewind
15J 75 KW, 50 Hz ,4 pole	93.00%	93.60%	0.60%	GC-2L	L-2L	1St rewind
		93.60%	0.60%		L-2L	2nd rewind
		93.70%	0.70%		L-2L	3rd rewind
17H 5.5KW, 50 Hz ,4 pole	86.70%	86.90%	0.20%	2TC-1L	L-2L	5 burn outs at 360° c 1 rewind only
22 5.5KW, 50 Hz ,4 pole	83.2	84.00%	0.80%	2TC-1L	L-2L	5 burn outs at 360° c 1 rewind only

Key to winding configuration abbreviations

3TC-1L…….Three tier concentric……………………………………………………………1 coil side per slot
2TC-1L…….Two tier concentric………………………………………………………………1 coil side per slot
2TC-2L…….Two tier concentric………………………………………………………………2 coil side per slot
L-2L ………..Lap winding ………………………………………………………………………..2 coil side per slot
GC-2L ... concentric coil groups placed in slots in rotational sequence…...2 coil side per slot
GC-1L …concentric coil groups placed in slots in rotational sequence…….1 coil side per slot

LOSS ANALYSIS

1. The efficiency Variation for Stage 1 rewind from -0.3% to -0.5%
2. The efficiency Variation for Stage 2 rewind from -0.7% to +0.2%
3. The efficiency Variation for Stage 3 rewind from -0.6% to +0.8%
4. The losses affected were:

Copper loss- Due to lack of control of mane length of turn.
Stray loss-Due to stripping damage but influenced by tooth design.
Core loss-Due to burn out process.
Friction loss-Due to over-greasing bearings.

5. The best results were obtained in stages 2 and 3 when process controls were implemented
6. Stripping the motor, if burned out at too low a temperature, may increase the stray loss.
7. Copper content of winding, coil geometry and winding pattern must be controlled to reduce stator I^2R losses.

Annex 2.

Summary of factory electric motor data

No	Name of Factory	Motor Type	Phase	AC Motor Type	Motor Pole	Qty	% of Motor pole	% of Qty	4 pole Average Power of motors (KW)	4 pole Average efficiency of motors (%)
1	ECAFCO	AC	Three	Induction	2	15	28.30%	98.18%		
					4	35	66.04%		8.68	79.36%
					6	2	3.77%			
					8	1	1.89%			
					10	0				
					12	0				
					unknown	1				
				Synchronous		0				
				Universal		0				
				High Voltage		0				
			Single			1		1.82%		
		DC				0				
	Subtotal					**55**	**100.00%**	**100.00%**		
2	FINFINE FURNITURE FACTORY(3F)	AC	Three	Induction	2	27	57.45%	83.58%		
					4	19	40.43%		2.82	74.74%
					6	1	2.13%			
					8	0				
					10	0				
					12	0				
					unknown	9				
				Synchronous		0				
				Universal		3		4.48%		
				High Voltage		0				
			Single			8		11.94%		
		DC				0				
	Subtotal					**67**	**100.00%**	**100.00%**		
3	FAFA FOODS S.C	AC	Three	Induction	2	29	26.36%	97.56%		
					4	73	66.36%		6.68	76.92%
					6	6	5.45%			
					8	2	1.82%			
					10	0	0.00%			
					12	0	0.00%			
					unknown	10				
				Synchronous		1		0.81%		
				Universal		0				
				High Voltage		0				
			Single			2		1.63%		
		DC				0				

No	Name of Factory	Motor Type	Phase	AC Motor Type	Motor Pole	Qty	% of Motor pole	% of Qty	4 pole Average Power of motors (KW)	4 pole Average efficiency of motors (%)
	Subtotal					**123**	**100.00%**	**100.00%**		
4	KALITY METAL PRODUCTION FACTORY	AC	Three	Induction	2	28	26.67%	94.87%		
					4	71	67.62%		6.93	78.63%
					6	2	1.90%			
					8	4	3.81%			
					10	0	0.00%			
					12	0	0.00%			
					unknown	6				
				Synchronous						
				Universal						
				High Voltage						
			Single							
		DC				6		5.13%		
	Subtotal					**117**	**100.00%**	**100.00%**		
5	EAST AFRICAN BOTTLING	AC	Three	Induction	2	93	39.08%	97%		
					4	138	57.98%		6.27	76.63%
					6	7	2.94%			
					8	0				
					10	0				
					12	0				
					unknown	71				
				Synchronous		0				
				Universal		6		2%		
				High Voltage		0				
			Single			4		1%		
		DC				0				
	Subtotal					**319**	**100.00%**	**100.00%**		
6	HORIZON ADDIS TYRE	AC	Three	Induction	2	46	16.79%	95.68%		
					4	155	56.57%		28.59	82.12%
					6	21	7.66%			
					8	52	18.98%			
					10	0				
					12	0				
					unknown	14				
				Synchronous		0				
				Universal		2		0.66%		
				High Voltage		6		1.99%		
			Single			2		0.66%		
		DC				3		1.00%		
	Subtotal					**301**	**100.00%**	**100.00%**		

No	Name of Factory	Motor Type	Phase	AC Motor Type	Motor Pole	Qty	% of Motor pole	% of Qty	4 pole Average Power of motors (KW)	4 pole Average efficiency of motors (%)
7	BGI ETHIOPIA	AC	Three	Induction	2	92	37.25%	96.17%		
					4	149	60.32%		6.93	79.46%
					6	6	2.43%			
					8	0				
					10	0				
					12	0				
					unknown	4				
				Synchronous		0				
				Universal		4		1.53%		
				High Voltage		0				
			Single			6		2.30%		
		DC				0				
	Subtotal					**261**	**100.00%**	**100.00%**		
8	AYKA ADDIS TEXTILE	AC	Three	Induction	2	803	39.62%	59.81%		
					4	1142	56.34%		5.53	77.72%
					6	82	4.05%			
					8	0				
					10	0				
					12	0				
					unknown	43				
				Synchronous		0				
				Universal		151		4.36%		
				High Voltage		0				
			Single			1240		35.83%		
		DC								
	Subtotal					**3461**	**100.00%**	**100.00%**		
9	EXCEL PLASTIC FACORY	AC	Three	Induction	2	32	26.45%	95.35%		
					4	81	66.94%		21.59	78.43%
					6	8	6.61%			
					8	0				
					10	0				
					12	0				
					unknown	2				
				Synchronous		0				
				Universal		0				
				High Voltage		0				
			Single			6		4.65%		
		DC				0				
	Subtotal					**129**	**100.00%**	**100.00%**		

No	Name of Factory	Motor Type	Phase	AC Motor Type	Motor Pole	Qty	% of Motor pole	% of Qty	4 pole Average Power of motors (KW)	4 pole Average efficiency of motors (%)
10	MUGHER CEMENT FACTORY	AC	Three	Induction	2	91	18.42%	92.72%		
					4	324	65.59%		39.50	87.16%
					6	55	11.13%			
					8	24	4.86%			
					10	0				
					12	0				
					unknown	3				
				Synchronous		0				
				Universal		0				
				High Voltage		32		5.97%		
			Single			5		0.93%		
		DC				2		0.37%		
	Subtotal					**536**	**100.00%**	**100.00%**		
11	WONJI/SHOA SUGAR FACTORY	AC	Three	Induction	2	34	5.63%	97.58%		
					4	492	81.46%		30.26	83.03%
					6	61	10.10%			
					8	11	1.82%			
					10	2	0.33%			
					12	4	0.66%			
					unknown	0				
				Synchronous		0				
				Universal		3		0.48%		
				High Voltage		10		1.62%		
			Single			2		0.32%		
		DC				0				
	Subtotal					**619**	**100.00%**	**100.00%**		
12	ELICO	AC	Three	Induction	2	8	19.05%	73.68%		
					4	29	69.05%		0.00	84.46%
					6	0	0.00%			
					8	5	11.90%			
					10	0				
					12	0				
					unknown	0				
				Synchronous		0				
				Universal		1		1.75%		
				High Voltage		0				
			Single			14		24.56%		
		DC				0				
	Subtotal					**57**	**100.00%**	**100.00%**		

No	Name of Factory	Motor Type	Phase	AC Motor Type	Motor Pole	Qty	% of Motor pole	% of Qty	4 pole Average Power of motors (KW)	4 pole Average efficiency of motors (%)
	All factories	AC	Three	Induction	2	1298	29.76%	74.87%		
					4	2708	**62.08%**		**16.2**	**80.20%**
					6	251	5.75%			
					8	99	2.27%			
					10	2	0.05%			
					12	4	0.09%			
					unknown	163				
				Synchronous		0				
				Universal		170		2.81%		
				High Voltage		48		0.79%		
			Single			1290		21.34%		
		DC				11		0.18%		
	Grand total					**6044**	**100.00%**	**100.00%**		

Annex 3.

List of electric motor importers and maintenance service providers

1. List of Electric Motor Importers

NO	Name of Importer	Address			Contact Person	Telephone
		Region	Woreda	H.no		
1	Tafesse Abebe and His Sons p.l.c	Adiss Ababa/ Atkilt tera	0 1	489	Ato NitsuhSew Tafesse	0111-11-71-53
2	Mesfin Tewelde	Adiss Ababa /Atkilt tera	2	418	Mesfin Tewelde	0911209529
3	Ismael Ahmed Ture	Adiss Ababa/ Atkilt tera	1	561	Seid/Welid	011-555-101
4	Zewde Liyew and His Sones p.l.c	Adiss Ababa/ Atkilt tera	2	758	Mignot	0911191550
5	Jimma Enterprise p.l.c	Adiss Ababa/Atkilt	1	550	Dawit	011-15-630-82
6	Ture p.l.c	Adiss Ababa/Mercat	2	8068	-----	011-275-62-79
7	*Abulkhase p.l.c*	*Adiss Ababa/cinema*	*8*	*266*	*Ahmed Abubeker*	*011-275-16-67*

2. List of electric motor maintenance service providers

NO	Name of Maintenance	Address			Contact Person	Telephone
		Region	Woreda	H.no		
1	Grous Electrical Engineering	A.A/Arada	1	439	P.D Valeudis	0111115355
2	Electro Mece Engineering	A.A/Global hotel	2	3	Ephrem Hailu	0114671688
3	Girma Baheta	A.A/ Legehar	7	631	Solomon	011-5-1539-43
4	Taye G/hiwot	A.A/Saris addiss sefer	6	1619	Taye G/hiwot	0114-4212-02
5	Bele Electric motor repair	A.A/Ayer tena girar sefer	4	---	Belete Legese	0912038530
6	Behailu W/yohanes	A.A/Kirkos church	10	110/ ለ	Dereje	0913863577

Annex 4.

List of Factories in Industrial Sectors

1. Wood Industries

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
1	MIR GO Wood Material Plc		Addis Alem		0911394242	
2	Rasiel Furniture	A.A	Kality 07		0913549113/ 0910471168	
3	Kality Construction Material Production	A.A	Kality 07,4No Mazoriya	0114349192/ 0114352148		
4	Oumer Yimaz		Greji -Rba		0910903633/ 0910359626	Mr.Oumer Yilmaz
5	Ateniyas Hauos and office Material		Legetafo		0931198261	
6	Wood Master		Legetafo		0911398989	Ato Fasil
7	Ethiopia Compersato Factory		Torhayiloch -Betel		0911205572	Yeshwerk
8	Wanza Furniture Industry (*MIdrock*)	A.A	Lideta	114334356		Ato Tesfa
9	Awash Chip wood Factory		Hawasa	462206387		
10	Ethio Dutch Factory		Debre-zeit		0911491045	Ato Daniel Gebre
11	ECAFCO		Saris	114420675		Ato Degefa
12	Dana International Trading	A.A	Kality Gebrel		0911235060	Manishe
13	Amwaj Industry		GIBI Factory (Dukem office)		0912506430	
14	Debre Berhan Wood Processing Plc	Amhara	Debre-birhan		0911407799	
15	Dr. Legesse Demise Construction input		Debre-zeit		910320388/ 0911412655	
16	Shenghlia xu(manufacturing of Wood Product)		Alem gena		924872229	
17	AL maab furniture				911252426	
18	Tsehai general Trading	Oromia	Dire Dawa		915735638	Mr.Salomon
19	Niyala wood Product Factory				911207567	Ato Afework
20	S.N.S Furniture				911547419	Ato Fekeru Hayilu
21	HN Furniture					
22	METEC				911696327	Ato Daniel
23	Haron family Furniture				911212653	Ato Muksin Bedewie
24	3f Furniture				913907979	Ato Brehanu
25	ECAFCO				913677956	Ato Degefa
26	Uni Furniture				911209659	Ato Tefery
27	Wanza Furniture			115517999		
28	Sahle Furniture				930099687	Colenel Abebe
29	Sabel Furniture					

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
30	Ethiopia Compersato Campany				911205572	Yeshwerk Weldher
31	Cofert Furniture					
32	GM Furniture					
33	Wood Master				911398989	Ato Fasil
34	St George wood work				114420690	Klawdiwo
35	Heng sen lumber manufacturing plc				912729608	Bekalu Negusie
36	Harot family					
37	Endale & His family			111111212	922960361	Ato Shifraw Tades
38	Ateniyas House and office Material				931198261	
39	Awash Chip wood Factory			462206387		
40	Orix International plc				911211211	Ato Samuel
41	Kahn industry plc				911858153	Mr. Kahn
42	Rasiel Furniture				913549113/ 910471168	
43	Nayil Industrial & Commercial Sh.co			114665452	911212045	Ato Tsegaye
44	Techale Haile general metal & wood work Sh.co			114391392	911207465	Ato Dereje
45	Semart Business Group Sh.co				911220886	Ato Dawit Alemu
46	Gemetry Luji Varnero Empipereza Contracziyoni			115514511		
47	Satelait House and Office Material Sh.co				911239859	
48	Ethio Dech Furniture				911491045	Ato Daniel
49	Amwaj Industry plc				912506430	
50	Debre Berhan Wood Processing Plc				911407799	
51	Dr. Legesse Demise Construction input				910320388/ 0911412655	
52	MIR GO Wood Material Plc				911394242	
53	Shenghlia xu(manufacturing of Wood)				924872229	
54	Machew Particle Board				0914300731/ 0913778813	
55	Harot family					
56	Waryt Mulu Tilahun					

2. Metal Industries

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
1	Sintec Ethiopia PLC			0116478787/88		
2	Kasma Engineering PLC				0921306343/ 0924370264	
3	Nehmia Engineering PLC			114671463	911221741	
4	Walia Metal Industry PLC			113871074	911547460	
5	Ethio Balestra Factory PLC			114403632	911153931	
6	Tectra Engineering PLC			0114392420/21	911207200	
7	Oromiya Steel Mill PLC			0115522681/2731		
8	Kaliti Metal Factory				911220036	
9	Belaiab Motors PLC			114340454		
10	Habesha Steel Mill PLC				911203600	
11	Feric Belt Metal Processing & Manufacturing PLC				911529185	
12	Efesol Technology PLC			116523282	911239309	
13	Euro Cable PLC			114390069	911882988	
14	Okfa Metal Manufacturing PLC			914759900	914759900	
15	Mame Steel Industry PLC			0114393433/3585	911510635/ 0911507575	
16	Stili R.M.IPLC			114394296	911235937 /0911220305	
17	Abysinia Integrated Steel			116639755	913325236	
18	Ethiopia Metal Melting Factory			114342465		
19	Kaliti Balestra Production Factory PLC			114390296	911207375	
20	Ethiopia Steel Profiling Construction			0114334771/69	911490809	
21	Eastern Steel PLC			0920600072/ 0113726966		
22	Amiyo Engineering PLC			114168266	911222641	
23	Mesfin Industrial Engineering			0116298557/ 0116298562/51		
24	N.A. metal & Engineering PLC				911515094	
25	Osaka Steel PLC			114190039		
26	Elswedy Cable PLC				91364463	
27	Seni steel PLC			116616164	912600357	
28	Art Steel PLC				912982244	
29	Hadid trading PLC				911114480	
30	Mohan wine Industry PLC				911820814	
31	Kolfe House hold Furniture PLC			112791643	911209331	
32	H.H. Steel Section PLC				912132829	

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
33	Lejo Aluminum PLC			115153466		
34	Getachew Siyoum House hold furniture			115531580	911161003	
35	Nigat Mechanical Engineering			0116463040/41	911221741	
36	Techale Metal PLC			0114390233/ 0114391392		
37	Awash Auto Battery				910463373	
38	Interafrica Extrusion PLC				913573808	
39	Maru Metal Industry PLC			114392037	911650437	
40	C&E Brothers PLC				0911443662/09 11490784	
41	Pasqua Jusepe PLC			114660760	911207294	
42	KG Engineering PLC				912962835	
43	Ethiopian Steel PLC				913013326	
44	Gift Nail Factory PLC			114391726	0911650437/09 11921371	
45	Akaki Kaliti metal PLC			114342323	911896457	
46	Alemgenet ega sheet PLC			114195959	923307306	
47	Nasichiev metal PLC				911460531	
48	Nehmia metal Factory PLC			114671464		
49	Asmen metal Factory PLC			911050385	911919123	
50	Betel Engineering				911358629	
51	Sunrise			114420557		
52	Gatepro			114401068		
53	BMT PLC					
54	Zenebe Frew					
55	EGCSO					
56	DH Geda PLC				911462760	
57	Pagrec Ethiopia PLC				912205538	
58	Yesu					
59	Beza Industry					
60	Beyo					
61	Ethiopia Korki & Tasa Production			114390244		
62	Lifan Motors					
63	Ethiopia Steel					
64	Huwano Manufacturing				911006663	
65	Adma Steel PLC				911491493	
66	AMCE PLC			116463350		
67	Alem Steel			0913204414/ 0118102436		
68	Getachew Siyoum				911161003	
69	Akaki Metal factory					
70	Techno mobile				911736323	

3. Leather Industries

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
1	Addis Abeba Sh.Co	Addis Ababa	Asco	115547188	911201455	Ato Endris Ebrahim
2	Hora Leather P.L.C	Oromia	D/Zeyit/ Mojo	113724554	911201385	Ato Mohamed Endris
3	Crystal Leather Sh.Co	A.A	Kality	118601782	11513894	Ato Solomon G/hiwot
4	China Africa Leather Production	Oromia	Sululta	111860466	912157993/ 0922750810	Mr.He Mingliang
5	Mojo Leather Sh.Co	Oromia	Mojo	112756443	911506005	Redman Bedada
6	Kolba Leather P.L.C	Oromia	Mojo	114168759	911210754	Ato Ayele Degene
7	Batu Leather P.L.C	A.A	Kality	0114421451/52	911212801	Ato Tatek Yirga
8	Mesako Global Leather P.L.C	Oromia	Mojo	0111568119/64	911212678	Ato Msefen Sahle
9	Bahir dar Leather	Amhara	Bahrdar	115159040	911200997	Ato Yigezu Asefa
10	Ethiopia Leather Sh.Co	Oromia	Mojo/Ejersa	115513691	911230664	Dagachew Demelash
11	Sheba Leather Industry P.L.C	Tigray	Wokro	115506120	914301119	Ato Tesfit Fshayo
12	Bale Leather P.L.C		Saris	115536593	911204924	Mr. Salpe Nalvandia
13	Friend Ship Leather			113710903	921881891	Mr.Yann Ching
14	Ethio Leather /Elico P.L.C	A.A	Saris	114400773	911200948	Ambassader Bruk Debebe
15	Combolcha Leather Sh.Co	Amhara	Combolcha/ Welo	115540748/ 0115514075	914310063	Ato Yikunoamlak Abera
16	Gelan Leather P.L.C	Oromia	Mojo	111574701	911205562	Ato Ahmed Nuru
17	Dre Industry P.L.C		Wimget	112756443	911201154	Ato Haji Bedada Chali
18	Hafed Leather P.L.C	Oromia	Sbeta	111564640	91111219331	Ato Husen Feyisa
19	Merso Leather Production P.L.C	Amhara	Mersa/Welo	112756443	913426604	Ato Ayenew Degu
20	Waliya Leather & Leather Production P.L.C	A.A	Kality	114422367	911207331	Ato Alemayehu Smegn
21	Est Aferica	Oromia	Mojo	116180504	935402159	Eskedar
22	Debrebrehan Leather P.L.C	Amhara		115157114	911204531	Ato Germa Belacew
23	Faride Leather Factory	Oromia	Mojo	116634885	913119005	Mr. Ramish Baboo
24	United Vasan Leather Factory	Oromia	Mojo	112756443	911727447	Mr. Vellor M.idris
25	Alabesha Leather Factory	Amhara	Bahirdar		930013878	Ato Wesen Hayil Mariyam
26	New Wing Addis Leather Factory	A.A	Saris		911474563	Mr.Evano Mesfin
27	Zhing Zahnig/Koka Addis Leather Factory	Oromia	Mojo		920243888	Ato Negatu
28	Debre birehan Leather Factory	Amhara	D/Berehan		911208776	Abebe Teklu

No	Factory Name	Address	Location	Address Office Tel	Phone no	Contact Person
29	Blu Nail /Gafar Leather Factory P.L.C	A.A	Sebeta	113380600	911206130	Ato Jafar Mustefa
			3.1 Shoes Factories			
30	Anbesa Shoes Factory	A.A	Ledeta	112754269	911205229	Ato Solemon Temechach
31	Bostex Shoes Factory	A.A	Keraniyo	114401677	911110848	Betelhem Teahun
32	Kristal Shoes Factory	A.A	Kality	116631011	911314735	
33	Fontenina/Elico Shoes Factory	A.A	Akaki	114422525	911636302	Ato Tamerat
34	Jorje Shoes Factory	A.A	Keraniyo		933702612	Mr. Cawle
35	Hujeyan International Shoes	Oromia	Dukem	114370297	923724924	Mr. Keven
36	Jemayica /Testfu Beyene Shoes Factory	A.A	Saris	114421055	911204524	Ato Tesfaye Beyene
37	Kangaro Zege Shoes Factory	A.A	Saris	116293464	913254690	Efrem Yirga
38	Moderen Zege Shoes Factory	A.A	Kality	114390979	911208767	Bekele G/hiwot
39	New Wing Ara Shoes Factory	A.A	Saris	114401677	911137674	Mr. Renzo Bertini
40	Alberet	A.A	Akaki Kality		930101277	Frew Kebede
41	Picock Shoes /Dire Industry P.L.C	A.A	Saris	112756443	911201153	Ato Alias Bedada
42	Ramse/Elfenesh Zelalem Shoes Factory	A.A	Saris	114425295	911246938	Zelalem Habte
43	Ras Dashen ShoesFactory	A.A	Saris	116293167	911883337	Ato Gezachew Negash
44	Sheba Leather Industry Shoes Factory	Tigray	Wukro	112506120	914301119	Ato Tesfit Fsehayo
45	Tkur Abay	A.A	Asco	112701803	911208776	Abebe Tekle
46	Walia Shoes Factory	A.A	Kality	114422367	911933642	Alemyehu Semegn
47	Parck Shoes & Leather Production Factory	A.A		114195211	911529092	Semeneh Tesema
48	Ethio Footwear Cluster Shoes Factory	A.A	Yeka /Shala	0116612447/48		Ato Phowlos Endeshaw
49	Mohan Shoes Factory	Oromia	Gelan	116620329	911529656	Mr. Harsh
			3.2 Leather products & material			
50	Pitard product Manufacturing Sh.Co	A.A	Saris	114425589	911201450	Ms. Tsedeniya Mekibeb
51	Ato Kesiler Leather Guant P.L.C	Amhara	Gonder	581114248	918350326	Ms. Minayesh
52	Dev Empex Guant Factory	Amhara	Bahirdar	588209214	911200997	Ato Gezachew Asefa
53	Yezich Alem Meaza Shoes & Leather Exporter					Ato Dagnachwe Abebe
54	Pitard Global Sourcing Sh.Com	A.A	Saris	114425589	911635644	Mr. Pittards & Ato Tshom
55	Universal Leather Products Sh.Com	A.A	Saris Abo	114655152	115547185	Ms. Zewditu

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
56	Modern Zege Leather Products P.L.C	A.A	Akaki Kality	111157279	911208767	AtoBekl G/hiwot
57	Saint Merriam Leather	A.A	Stadium	115526476	911198987	MenebreTamerat
58	K&T Leather Products P.L.C	A.A	Stadium	112777230	911663168	Mr. Kinde Arfaso
59	Endu Leather Craft	A.A	Keraniyo	113715195	911648589	Ato T/marriame G/hiwot
60	General Leather Gods Maker	A.A	Meskles feiuare	115154374	911117597	Temsegen Zewdu
61	Abysina Leather	A.A	Stadium	115526898	911230527	Ato Abrahm Bellachw
62	Bathera Leather Products P.L.C	A.A		115558940	911515559	Mr. Maimum/Ato Mesai
63	Fiker Leather Products P.L.C	A.A			911244567	Ato Fikret Negashe
64	Libtor Leather Spector P.L.C	A.A			911002959	Ato Zelalem
65	Entoto Betarsana P.L.C	A.A		118965097		Wr. Betleheme
66	Dagi -Air Leather Products	A.A			911239324	Ato Dageme Ermiyas
67	Mt Leather Products	A.A			911647008	Ato Zelalme
68	KoroJo Leather Products P.L.C	A.A			911955747	Ato Tadese G/Tsadik
69	Grume Leather Enterprise	A.A			911949745	Wr. Gerumneshe
70	Brimiro Leather Products	A.A			911208262	Ato Berehanu & Wr. Meron
71	Fitum Leather Rodaks	A.A				Fitune
72	Sami Mohammed	A.A				Sami Mohamed
73	Henoki Addis Manufacturing Sh.Com	A.A		113362010	912422678	Mr. Youngil Song

4. Textile Industries

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
1	SelenDawa Textile S.C.	DireDawa	DireDawa	0116611515 0112511252	0935404515	Mr.Yavuz
2	Almeda Textile P.L.C.	Tigray	Adwa	0347711483 0347711543	0911208620	Mr.Teklewoini G/Egziabher
3	Arbaminch Textile S.C.	SNNPR	GamoGofa	0468110409	0911218748	Mr.Mustafa Sultan Mr.Ashreka Siraj
4	Awassa Textile S.C.	SNNPR	Awassa	0115518900	0911204398	Mr.Mekonnen Betre
5	Ayka Addis Textile P.L.C.	Oromia	Oromiya Special Zone	0113871179 0116616951	0911507732 0911522641	Mr.Darial Tandego Mr.Amare T/Mariam
6	Bahirdar Textile S.C.	Amhara	Bahidar	0582200104	0911523931	Mr.Abay Melaku

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
7	Else Addis Industrial Development P.L.C.	Oromia	East Showa	0116632837 0116632845 0116632847	0910875717 0911215099	Mr.Delk Durular Mr.Getachew Hadush
8	Kombolcha Textile S.C.	Amhara	Kombolcha	0335510211 0335510103	0911213135 0911882383	Mr.Mustefa Jemal
9	Kebire Interprise(Maa Garment and Textile)P.L.C.	Tigray	Mekele	0344420188	0914310962	Mr.Mehari Mebratu
10	Yirgalem Addis Textile P.L.C.	Addis Ababa	Nifas Silk Lafto	0114431252 0114422300	0911527264 0911527265	Mr.Ermiyas Alemu Mr.Nahom Aron
11	Nas Foods DireDawa Textile Factory P.L.C.	Diredawa	Diredawa	0251113488	0911250718	Mr.Fekadu G/Hiwot Mr.Ermiyas Wordework
12	SayginDima Textile S.C.	Oromia	Oromia Special Zone	0113383969	0928383838 0911513568	Mr.Fantih Ahamit
13	Engels Cotton and Textile Production P.L.C.	Oromia	Oromia Special Zone		0930034122	Mr.Aron
14	Woinu Curtain(Ethio-Japan Naylon Textile S.C.)	Oromia	East Shoa	0115509065 0115153333	0911206844 0911689012	Ms.Woinshet Shoatsegaw Ms. Mebiratu G/medihin
15	Al-Asr Industries P.L.C.	Oromia	Oromia Special Zone	0116188987	0913057547 0911513917	Mr.Shangary Ali Mr.Afizale
16	Al-Mehdi Industries P.L.C.	Oromia	Oromia Special Zone	0116616834 0116616835 0116616836	0911405170 0913574484	Mr.Asad Ali Mr.Mohammed Kasim
17	Crown Textile and Weaving P.L.C.	Oromia	Oromia Special Zone	0114370834 0114370836	0911505132 0912004344	Ms. Mulunesh Abreham Mr.Minilik Mulualem
18	KK Textile P.L.C.	Addis Ababa	Akaki Kality	0114342675		Mr.Faris Hiruy
19	Mahiver Textile P.L.C.	Addis Ababa	Nifas Silk Lafto	0112764183	0911204263	Anisha Industrial Band
20	Sudako International Textile P.L.C.	Addis Ababa	Nifas Silk Lafto	0114423839 0114423846	0922428115 0922488581	Mr. Muaz Mohammed Mr.Tsadik Abubeker
21	Noya Textile S.C.	Oromia	Oromia Special Zone	0114667743	0911252538 0913567408	Mr.Pola
22	D.H. Geda Blanket Factory P.L.C.	Addis Ababa	Akaki Kality	0111638156 0116638158	0911242498 0911600631	Mr.Yohannes Tefera Mr.Yosef Melese
23	Ferke Factory P.L.C.	Addis Ababa	Akaki Kality		0911693242	Mr.Numery
24	M.N.S. Manufacturing P.L.C.	Oromia	Oromia Special Zone		0924871290	Mr.Mahemud
25	Huaxu Textile Industry P.L.C.	Amhara	Kombolcha			Mr.Elias
26	Abem(Birhanu Sahile) Garment P.L.C.	Addis Ababa	Nifas Silk Lafto	0114197697/98	0911205590	Mr.Kinfe Sahilu Mr.Degu Getahun
27	Addis Garment S.C.(Augusta)	Addis Ababa	Lideta	0113711791 0113715216	0911221792 0911889989	Ms.Juliyana Zakota Mr. Erkie Mitiku

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
28	Akaki Garment S.C.	Addis Ababa	Akaki Kality	0114340693 0111340154	0911211135 0911220457	Mr Getachewu Biratu Mr.Biruk Getachew
29	Ambassador Garment and Trading P.L.C.	Addis Ababa	Bole	0116464303	0913220333	Mr.Seid Mohammed Mr.Gizatie Worku
30	Asbem Industries P.L.C.	Oromia	Oromia Special Zone	0116616603 0118603093	0911405983 0911523003 0910248094	Mr.Abiyu Gidey Mr.Melku Tegegn
31	BM Ethiopia Garment and Textile S.C.	Addis Ababa	Nifas Silk Lafto	0114423455	0923020996	Mr.Eliyas Mashesha
32	Concept International Ethiopia P.L.C.	Addis Ababa	Nifas Silk Lafto	0114422602 0114421874	0911227325 0920575637	Ms.Lili Biratu Mr.Henus Haile
33	Eliyas Textile and Garment Factory P.L.C.	Addis Ababa	Addis Ketema	0115156313	0911227515 0911240414	Mr.Eliyas Tesfaye Mr.Abreham Tesfaye
34	EMD Garment P.L.C.	Addis Ababa	Lideta	0113212907 0111558239	0911216116 0911636741	Mr.Eliyas Mulugeta Mr.Meaza Mamo
35	Feleke Garment P.L.C.	Addis Ababa	Nifas Silk Lafto	0114196167 0114196169	0912320764 0911203033	Mr.Mehtsentu Feleke Mr.Nebiyu Zebeamen
36	Haya Garment Manufacturing P.L.C.	Addis Ababa	Nifas Silk Lafto		0911656526	Mr. Zelalem
37	Garment Evolution P.L.C.	Addis Ababa	Bole	0116463767	0911638783	Mr.Yonas Workineh
38	GG Super Garment P.L.C.	Oromia	Oromia Special Zone	0114337500 '0114337501	0911211135 0911220457	Mr.Getachew Biratu Mr.Biruk Getachew
39	GMM Garment P.L.C.	Addis Ababa	Nifas Silk Lafto	0114197374 0114197375	0911520205	Mr.Zewolde T/abe
40	Gullele Garment P.L.C.	Addis Ababa	Gullele	0112702266 0112702005	0911216759	Mr.Birhanu Lake
41	Haile Garment P.L.C.(HG)	Addis Ababa	Nifas Silk Lafto	0114198130	0911206243 0911001832	Mr.Haile G/Egziabher Ms.Firewoine Kifile
42	Knit To Finish P.L.C.(Garment Express)	Oromia	Oromia Special Zone	0114450038 '0114450039	0911202271 0911400499	Dr.Worku Zewude Ms. Zinash Zewudu
43	Lucy Garment Industry P.L.C.	Addis Ababa	Nifas Silk Lafto	0114426188 0111525285	0911201832 0911221193 0911045652	Mr. Mikiyas Hailu Mr.Tamirat W/Gebriel
44	Mantel Garment P.L.C.	Addis Ababa	Akaki Kality	0114392761	0911204405 0921736879	Mr.Alehegn Assefa Ms.Frehiwot Abebe
45	Mitch Garment P.L.C.	Addis Ababa	Nifas Silk Lafto		0923775349	Mr.Keven Alovor
46	Nazareth Garment S.C.	Oromia	East Shoa	022 112 3427 0115516880	0911231077 0911201608	Mr. Darge Getahun
47	NovaStar Garment Factory P.L.C.	Oromia	Oromia Special Zone	0114450222	0910238851	Mr.Birhanu Sisay

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
48	Oasis Abyssinia P.L.C.	Addis Ababa	Nifas Silk Lafto	0114404898	0911204884	Mr.Yilikal Bisenebet
49	Progress Garment Factory P.L.C.	Addis Ababa	Bole	0116460917	0911202231	Mr.Abdulwahid Mohammed
50	Soney Garment Textile and General Trading P.L.C.	Addis Ababa	Lideta	0115501839	0911208822 0911208869	Mr.Endalikachewu Taye Mr.Solomon Endale
51	Tehut Knitting and Garment P.L.C.	Addis Ababa	Akaki Kality	0911643338		Mr.Alemayehu Tafesse
52	Vitcon Garment P.L.C.	Addis Ababa	Bole	0116292365	0911237853	Mr.Goshu Negash
53	Wossi Garment Design Factory P.L.C.	Addis Ababa	Nifas Silk Lafto	0114422440	0911405016	Mr.Wossen Hailu
54	Wow Garment P.L.C.	Oromia	Oromia Special Zone	0116520218 0114450239	0911400992 0911213763	Mr.Abduraman Aman
55	Yabetse Garment P.L.C.	Addis Ababa	Nifas Silk Lafto		0911208562	Mr.Adane Eketa
56	Yonis Garment P.L.C.	Addis Ababa	Nifas Silk Lafto	0114403450	0911515050	Mr.Solomon Debebe
57	Village Industry P.L.C.	Addis Ababa	Nifas Silk Lafto	0114404864	0930098261	Mr.Kamilono Kelami Mr.Tewodros Shumiye
58	Big M Garment and Apparel P.L.C.	Addis Ababa	Akaki Kality	0114423559	0911212171 0911212181	Mr.Eliyas
59	Desta Garment(Bekimar) Industries P.L.C.	Addis Ababa	Bole	0116299953	0911203668	Mr.Eyob Bekele
60	Adama Development P.L.C.	Oromia	East Shoa	0221100746	0912609903 0911713656	Mr.Feleke Bekele Mr.Robel Wondimu
61	Edget Spinning Factory P.L.C.	Addis Ababa	Nifas Silk Lafto	0113711988 0113202008		Ms.Mulunesh Abreham Mr. Minilk Mulualem
62	Etur Textile P.L.C.	Oromia	East Shoa	0116634081	0930014027	Mr.Useman
63	Omo Valley Cotton Ginning P.L.C.	Addis Ababa	Akaki Kality	0114395912	0911387964	Mr.Tewodros Tessema
64	Arbaminch Cotton Ginning P.L.C.	SNNPR	GamoGofa	0468813070	0911813032	Mr.Desalegn Bantie
65	Awash Cotton Ginning P.L.C.	Afar	Melkaworere		0911037324 0911253937	Mr.Mahimud Amir Mr.Dereje Zeleke
66	Des Cotton Ginning P.L.C.	Amhara	Goder	0581140426	0918350033	Mr.Tewodros Zerihun
67	GebreSelam Cotton Ginning P.L.C.	Oromia	Oromia Special Zone		0911507338	Mr.G/Selam Gebiru
68	Haji Nur Hussien Kassie Cotton Ginning Factory P.L.C.	Amhara	Goder	0581140562	0918350458	Haji Nure Hussen Kassie
69	Middle Awash Cotton Ginning P.L.C.	Afar	Melkaworere		091176119	Mr.Mesay Abebe
70	Agrocot Cotton Ginning P.L.C.	Oromia	East Shoa	0112138902	0911213501	Mr.Kebede Wusane

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
71	Shoa Cotton Ginning P.L.C.	Addis Ababa	Akaki Kality	0114390105		
72	Lucy International Cotton Ginning P.L.C.	Afar			0911401180	Mr.Yishak Kifle
73	Studio3D Cotton Ginning P.L.C.	Oromia	East Shoa		0912166460	
74	Ture Cotton Ginning P.L.C.	Addis Ababa	Akaki Kality	0114393865 0114393272		Mr.Wuhib Ture
75	Don Door Handi-Craft P.L.C.	Addis Ababa		0115525523	0911204280 0911542095	Mr.Mahamud Hassen Mr.Tamirat Seyum
76	Muya Ethiopia P.L.C.(Sara Abera Garment)	Addis Ababa	Gullele	0111234015	0911664820	Mr.Ayele Negash
77	Nigist Ethiopia P.L.C.	Addis Ababa	Nifas Silk Lafto	0111728080 0115539773 0115539775	0911208405 0912172053	Mr.Sammay Mohammed Mr. Endalikachew Diressa
78	Saba Silk/Saba Har P.L.C.	Addis Ababa	Nifas Silk Lafto	0113215112 0113215113 0111711786	0911217948 020736498	Ms.Kazi Mareshal Mr.Shiferaw Nigussie
79	Trio Craft P.L.C.	Addis Ababa	Nifas Silk Lafto	0114440075 0116297060 0114400752	0911679359 0911641949	Ms.Aster Kassa Ms. Elizabeth Kassa
80	Sami Mohammed Abdela Export P.L.C.	Addis Ababa	Nifas Silk Lafto	0115539775	0912172053 0911208405	Mr. Sami Mohammed
81	Mulat Garment P.L.C	Addis Ababa		0114403614 0114403615		
82	Tariku Argaw textile and Garment P.L.C	Addis Ababa	Nifas Silk Lafto		911220109	
83	Tuafi international Garment Factory	Addis Ababa	Akaki Kality			
84	Sky Tex Garment	Addis Ababa	Nifas Silk Lafto			
85	Rose ethiopia Garment Factory	Addis Ababa	Nifas Silk Lafto			
86	Rekeki Girma Garment Factory	Oromia	Mojo			

5. Cement Factories and Projects

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
1	Abysinia Cement Plc.	Oromia		116639755/	0913325236/ 0911217235	Mr. Rajash Mr. Abebe
2	National Cement Sh.Co..	Dire Dawa		118400268/ 0114421951/42 / /0251123792/ 0251113445	0911807914/ 0913987481	Eng. Baso Mr. Sewnet Abeje
3	Red Fox International business Plc.	Oromia(Near of Nazreth)		221190943/	912072923	

No	Factory Name	Address	Location	Address Office Tel	Phone no	Contact Person
		Qoboltu				
4	Zhangeshan Cement Plc.	Dukem			0911562131/ 0920600078/ 0920600076	Mr.Hagos
5	Jema Cement Plc.	Muketuri		116621331/	911510508	Mr Fitsum
6	Derba Midroc Cement Plc.(Dejen Project)	Dejen		115534957/	911485809	Mr. Tadesse
7	Debresina Business & Industry Plc.	Holeta		0116457009/	0911687011/ 0911243695	Mr.Solomon
8	Huang Shang Cement Plc.	Mojo		116623609	0911979268/ 0910903067/	Mr.Lio
9	Pioneer Cement Plc.	Dire Dawa - MelkaJebu du			0911048493/ 0911690337	Ms. Ma
10	Hua Yu Cement Plc.	Nazreth			911646268	Mr. Michael
11	Mugher Cement Enterprise	Muger&Ta tek		0114425140/	0911207371/ 911207580/ 0911692335	Mr.Elias Mr.Mehari
12	Mesobo Cement Factory	Mekele		344409600/ 034409270	911454073	Mr. Ahmed
13	Ture Dire Dawa Cement	Melka Jebud		112756279/	911226305	Mr.Wuhib
14	East Cement Plc.	Fitche		0113726974/ 0113726966	911562131/	Mr.Hagos
15	Derba Midroc Cement Plc.(Main Project)	Derba		115510733		Mr. Haile Asegide
16	Ethio-Cement Plc.	Chancho			911683361 /911207185	Mr.Tesfaye/End ale
17	C.H Clinker Manufacturing Plc.	Gebre Guracha			911979268	Mr.Lio
18	Enchini Bedroc Cement Plc.	Enchini			913548398/ 0921396628/ 0923157798/ 0920721533	Ms. Lina
19	National Cement Sh.Co.(new)	Dire Dawa		251122461	911603245	Mr.Frew
20	Habesha Cement Sh.Co.	Holeta		118601315/		Mr. Mesfin
21	Dangote Industrial Plc.	Muger-Ada Berga			911239288	Mr. Teshome

6. Food and Beverage Industries

No	Factory Name	Address	Location	Address Office Tel	Phone no	Contact Person
1	Selete Hulling plc	Oromia	legetafo	0118 60 21 68	0911 20 14 92	Mr Ben
2	Depasa agro plc	Oromia	tatek/ burayu	118602168	0911 22 36 19	Elias Geneti
3	Ambasel Trading house	Amhara	Gonder	0114 66 61 45		Mulugeta Bogale GM
4	Hilina Enriched food PLC	Oromia	Legetafo	0116519909/1 3/15	911252282	Belete Beyene GM

No	Factory Name	Address	Location	Address Office Tel	 Phone no	 Contact Person
5	Imco Agro industry	Addis Ababa	A.A/ kality	116466129	911515121	Mr Thomas GM
6	Kality Food Share Company	Addis Ababa	Kality Sub city	+251-114390144/57		Getu Kebede
7	FAFA Food Share Company	Addis Ababa,	Saris Abo	+251-114421755		Deresse Kassa
8	K.O.J.J Food complex PLC	Addis Ababa,	Asco	251-112704144		Kassa Oma
9	NAS Foods Company	Oromia	Legetafo	+251-118605347		Ali Nesiredin
10	Healthcare Food PLC	Addis Ababa	Kality	+251-114390854	911207722	
11	Hora Food Company	Oromia	Alemgena	2.51114E+11	251-911206043	
12	Dire Dawa Food Complex	Dire Dawa,	Dire Dawa,	+251-251114020		Zeratsion Tsegaye
13	Brothers Food Complex	Oromia	Adama			Jemal Seid
14	Kebron Food Complexes	Oromia,	Burayu	+251-112842045/46		Bisrat Tadesse
15	ASTCO Food Complexes plc	Addis Ababa	Kality	+251-0114342034	251-911238689	Saeed Salem
16	DH GEDA Food Complexes plc	Addis Ababa	Gerji	116614765		
17	AH-WAN Food Complexes plc	Oromia	Adama	-221118387		Ali Ahemed
18	Universal Food Complexes plc	Addis ababa	kality	-114393389		Teferi Yirga
19	TM Food Complexes plc	Addis ababa	kality	-911253631		
20	Testy food plc	Addis ababa	Gerj	+251-0116299951-53		
21	Et –Teff flour factory and injera bakery	Addis Ababa	kality,	114391500		Akalu Alemu
22	Mama Fresh Injera plc	Addis Ababa	kera,	930013711	911487359	Hailu Tessema
23	Ajora-Agro Industry Enterprise	SNNPR	kebata tembaro	2.51463E+11	913119497	Aynalem Massebo
24	Yoni International plc	Addis Ababa	Arada	911518050	911206279	Hashewa Abduke
25	Girma Abera & his son plc	Addis Ababa		911615564		Girma abera
26	Mulat Abegaz edible oil factory	Addis Ababa	Gurd shoal	111243033	911615564	Getachewu desta
27	Addis Modjo edible oil factory	Addis Ababa	gotera	114421273	0911-206733	Ato Mengesha
28	Hamaresa edible oil Share Company	Herari	Hamaresa	915330075		
29	Bahir Dar edible oil Share Company	Amhara	bahir dar	058-2200755/ 058-2200333		Mr. Eyob Woretaw
30	Nazareth edible oil factory	Oromia	Adama	022-1111300/ 022-1112476	0911-614146	Ato Takele Asefa
31	Adama Edible Oil Factory	Oromia	Adama	022-1112752	0911-813501	Ato Anbese Asrat
32	Ashiraf agricultural and ind. plc	Oromia	Adama	022-1112753	0911-813501	Ato Anbese Asrat
33	Beza Agro Industry Plc	Oromia	Adama	115505099	911201686	Hailegiorgis

No	Factory Name	Address	Location	Address Office Tel	Phone no	Contact Person
						Demissie
34	Dima Honey processing & Beekeeping Development plc.	Tigray	Adigrat	344454624		
35	Apinec Agro Industry plc	Kaffa	Illubabur	911407360		Wubishet Adugna
36	Tutu and Her family Plc	Addis Ababa	Gurd Shola	116457180	911433163	Eyob Asefa
37	Upper Awash Agro Processing Plc	Oromia	Merti			Haile Meskel
38	Piko Juice Factory Plc	Addis Ababa	Akaki	0114 39 01 07/ 0114 39 21 99/ 0913359979	911507573	Ziad Chahwan/ Biruk Habtamu
39	Africa Juice Tibila S.co	Oromia	Tibila	0221 19 12 03	09 11 49 07 63/ 09 11 46 31 29	Dr. Abayineh Esayas
40	Great Abyssinia Plc	Addis Ababa	French Legassion	116630131		
41	Aster Bunna	Addis Ababa	Kirkos	0115159315/ 0115500913/ 0911218908		Aster Mengesha
42	Bashenfer Trading PLc.	Addis Ababa	Gurji-yerer ber	0116463821/22/ 23 911219900		Tariku Ahmed
43	Tomoca Coffee Plc	Addis Ababa		0111111781/83 /911515616		Wondwossen Meshesha
44	Ethio Agri Ceft Plc		Gumero & WushWush	935401372	911356125	Esayas Kebede
45	East Africa Agri Business Plc	Oromia	Chewaka	911486686		Henok
46	Addis International Catering	Addis Ababa	Bole Internation al Airport	116620099	911508538	Makida Yohanes
47	B.G.I Ethiopia Private Limited Company	Addis Ababa	Mexico	+251 115503816		Mr Zerom Gezaheng
48	Meta Abo Brewery S.C (Diageo)	Oromia	Sebeta	+251 113383110/119		Mr Aklilu Denbi
49	Dashen Brewery Share Company	Amhara	Gonder	+251 581140414		Mr Mekebeb Alemu / Mr Dereje
50	Harar Brewery Share Company	Oromia	Harar	+251 256660267		Mr Abebe Ergicho
51	Bedele Brewery					
52	Castel Brewery					
53	Awash Winery Share company	Addis Ababa	Torehayelo ch	+251 113717050		Ms. Elsa Admassu
54	Ambo Mineral Water Share Company	Oromia	Ambo	+251 911511939		Mr Girma Tadesse
55	Meskerem Alcohol and Soft Drink Factory	Addis Ababa	Kality	+251 911226782		Mr. Yohnas H/Mariam
56	National Alcohol and Liquor Factory	Addis Ababa	Mexico	+251 115516999		Mr Haylemariyam
57	Balezaf Alcohol and Liquors Factory Plc	Oromia	Sebeta	+251 11200979		Mr Belay Tekle
58	Hen Sea Land Business PLC	Addis Ababa		+251 116628161		
59	Desta Alcohol & Liquor	TIGRAY		+251 344410410		Mr Desta

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
	Factory Plc					
60	Victoria Alcohol Liquor Factory	Addis Ababa		+251 911644247		Ms. Seble
61	Rorrank Business Alcohol and Liquors	Amhara				
62	Ponumonu Supplies P.L.C	Addis Ababa		+251 116293434		
63	Afman Holdings PLc			251-111560550		
64	Alaje Mercy Natural spring water	Tigrai		251-34440507		
65	Ambo mineral water factory			251-115516252		
66	Asharaf Agricultural &Industry PLC			251-1141 66691		
67	Babile mineral water and soft drink factory			251-116662278		
68	Belay Industrial PLC			251-112755974		
69	Burayu spring water PLC			251-112841494		
70	Debre Birhan Natural spring water PLC			251-1151512203		
71	Derry Kebede Business PLC			251-114169425		
72	Electro commercial S.C			251-113871279		
73	Maiaynee Business PLC			251-0344452886		
74	East Africa Bottling S.C			251-112756114		
75	Erigb International PLC			251-116293463		
76	Ethiopian ventures LTD/Appex bottling Co.plc			251-114421800		
77	Great Abyssinia PLC			251-111141414		
78	Maiaynee Business private limited company			251-114169421		
79	Meskerem liquor & soft drink factory			251-114163795		
80	Midroc Ethiopia PLC			251-113711277		
81	Moha soft Drink Industry S.C			251-116614655		
82	Origin purified mineral water			251-113871279		
83	Papisco International			251-114669999		
84	Tsege Siyum Reta			251-114161852		
85	T.G.M.D Trade Works PLC			251-112841721		

7. Plastic Factories

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
1	AB plastic PLC			251-116293494		

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
2	Addis Ababa Foam & plastic			251-114391570	911201940	
3	Ethiopia plastic S.C			251-115512666		
4	Excel plastic PLC			251-116292196		
5	Fuad Abdulrahman bajiba			251-114391188		
6	G.M. plastic shoe &sole factory PLC			251-114196337		
7	Goesynthetics Industrial works PLC			251-114395282		
8	Ethiopia Tyre & Rubber Economy plant PLC			251-115516431		
9	Ethiopolymers PLC			251-114340974		
10	Eco Plastic PLC			251-111560544		
11	Desta PLC			251-116299951		
12	Des General Trading PLC			251-111116022		
13	Sirak & Family PLc			251-115155191		
14	Summit Engineering plastic PLc			251-116604878		
15	Tamra Techno packaging PLC			251-114407391		
16	Unique plastic industry			251-115154124		
17	Unique plastic industry			251-112767510		
18	Universal plastic factory PLC			251-116293416		
19	Zamu PLC			251-115527890		
20	Midroc Ethiopia technology Group	A.A.		251-113718900		
21	National plastic industry PLC			251-114431699		
22	Ok plastic PLC			251-114392548		
23	Oxford Polyethylene Industries PLC			251-116636521		
24	Rainbow plastic & Foam industry PLC			251-114665755		
25	Roha pack PLC			251-114195142		
26	Roto PLC			251-116186130		
27	Ruskuo shoe &plastic factory PLC			251-114390520		
28	Kangaroo plastic PLC			251-116631533		
29	Lema plastics PLC			251-115158197		
30	Mekab Engineering PLC			251-116182874		
31	Jelaram PLC			251-115519185		
32	Adiss gas and plastics Factory PLC			251-115519899		
33	Adnan mohamed aly plc			251-114196268		
34	Afatcop trading plc			251-112761895		
35	Alemayehu Nigussie Tefera			251-113728000		
36	Amaya PLC			251-112136670		
37	ANGEL Industries plc			251-116475887		
38	Aqua pure General trading PLC			251-114407377		
39	Avon industries plc			251-114432292		

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
40	Besrat plc			251-113483896		
41	Blacky shoe and sole plc			251-114390269		
42	Classic packaging			251-114196262		
43	Damena shewane plastic production inteprise			251-111553851		
44	Damot industrial & commercial PLC			251-111564646		
45	Dashen plastic plc			251-115159075		
46	Gindo industrial and trading plc			251-114421835		
47	HF- tafo plastic plc			251-1165144121		
48	Inova packaging plc			251-115538060		
49	Inova POLY BAG plc			251-115538060		

8. Tire Industry

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
1	Horizon Addis Tire Factory	A.A.	Sairs	115545696		

9. Sugar Industries

No	Factory Name	Address	Location	Address		
				Office Tel	Phone no	Contact Person
1	Metehara sugar factory	Oromia	Metehara	251-221110600	251-911209358	
2	Tendaho sugar factory			251-116182370	251-116183593	
3	Wonji Shoa sugar factory	Oromia	Wonji	251-222200002	251-222200023	
4	Ficha sugar factory	Oromia				
5	Kesem sugar factory	Afar	Awash Arba			
6	Arjo Dedessa	Oromia				

Annex 5.

Electric motors main parameters Identification and test methods

1. Purpose

This document sets forth the information required by Inspection, Verification, and Test Laboratories for inspection and test of Electrical Motors sample, including the testing stages in accordance with the procedure and standards recommended by recognized technical adviser.

2. Scope

The Scope of this document is to state and define the principal performance characteristics of electric Electrical Motors and to describe the methods for measuring their characteristics and give guidelines for the evaluation of test results.

The test may be applied more reliably for comparative testing of Electrical Motors at approximately the same time, in the same laboratory, by the same operator and with the same power supply source, rather than testing the samples in various laboratories.

Currently, it is not possible to devise a single test method which will measure the characteristic of Electrical Motors in a consistently reproducible way, due to the difference of Motors coming from various manufacturers, its form, shape and dimensional variation in varying environment, as all have significant effect on the test results obtained. Due to basic characteristics similarity of motors, the following standards have been referred for the test.

3. Reference Standards

IEC 60034-1	Rotating Electrical Machines Part 1: Ratings and Performance
IEC 60034-2	Rotating Electrical Machines Part 2: Methods for Determining Losses and Efficiency of Rotating Electrical Machinery from Tests
IEEE 112	Standard Test Procedures for Poly phase Induction Motors and Generators
IEEE 739	Recommended Practices for Energy Conservation and cost-Effective Planning in Industrial Facilities

EN 60034-5	Rotating electrical machines: degrees of protection by the integral design of rotation electrical machine
EN 60034-6	Rotating electrical machines: methods of cooling
EN 60034-7	Rotating electrical machines: classifications of types of constructions and Mounting arrangements
EN 60034-8	Rotating electrical machines: terminal markings and direction of rotation
EN 60034-9	Rotating electrical machines: noise limits
EN 60034-12	Rotating electrical machines: starting performance of single-speed three- Phase cage induction motors

IEC 60068-2-2,	Environmental testing procedures
IEC 60085,	Thermal evaluation and classification of electrical insulation
IEC 60529,	Degrees of protection provided by enclosures (IP Code)
IEC 60990	Methods of measuring touch-current and protective conductor Current
IEC 61010	Safety requirements for electrical equipment for Measurement, control, and laboratory us
ISO/IEC 17025	General requirements for the competence of testing and calibration Laboratories

4. Definitions

4.1 Rated voltage: voltage assigned to Electrical Motors by the manufacturer

4.2 Working voltage : maximum voltage to which the part under consideration is subjected when Electrical Motors is supplied at its rated voltage and operating under normal operation

4.3 Rated power input : power input assigned to Electrical Motors by the producer

4.4 Rated current : current assigned to Electrical Motors by the Manufacturer

4.5 Rated frequency : frequency assigned to the Electrical Motors by the producer

4.6 Normal operation : conditions under which Electrical Motors is operated in normal use when it is connected to the supply mains

4.7 Basic insulation : insulation applied to live parts to provide basic protection against electric shock

4.8 Functional insulation :insulation between conductive parts of different potential which is necessary only for the proper functioning of the appliance

4.9 Protective device: device, the operation of which prevents a hazardous Situation under abnormal operation conditions

4.10 Parameter and units Value; Nominal power (VA), Voltage line-line (V), Frequency (Hz), Stator resistance (ohm), Stator inductance (H), Rotor resistance referred to stator (ohm), Rotor inductance referred to stator (H), Mutual inductance (H), Inertia (kg-m2), Friction factor (N-m-s) Pole pairs 1

5. General Test conditions for measurements

Electrical Motors shall be constructed so that in normal use they function safely so as to cause no danger to persons or surroundings, even in the event of carelessness that may occur during its operation.

Sample tests are carried out in a draught-free location, at an ambient temperature of 20 °C ± 5 °C. The electrical measurements shall be made at rated voltage which is within ±10 % and rated frequency. The voltage used for the tests should conform to the nominal supply voltage shown on the name plate of the motor. Unless otherwise an alternative option is specified, the tests are carried out in accordance with the test procedure attached herewith.

6. Parameters having adverse effect on Electrical Motors performance

a) **Power Supply Quality:** induction motors are designed to operate with symmetrical 3-phase sinusoidal waveforms with the nominal voltage value. Deviations from these ideal conditions may cause significant deterioration of the motor efficiency and lifetime.

b) **Voltage Unbalance:** leads to high current unbalance which in turn leads to high losses; long operation under unbalanced voltage can damage or destroy a motor; and negative consequence of unbalance is the reduction of the motor torque.

c) **Under voltage or Overvoltage:** motors running at full load, voltage fluctuations exceeding 10% can decrease motor efficiency, power factor and lifetime.

d) **Harmonics:** loads, namely VSDs, power electronic devices, arc furnaces, saturated magnetic cores, TVs, computers that cause distorted waveform contains a series of sine waves with frequencies, so-called harmonics increase the motor losses and noise, reduce torque, and cause torque pulsation and overheating. Vibration and heat can shorten the motor life, by damaging bearings and insulation.

e) **System Over sizing:** Oversized motors will allow high starting torque loads, will be able to accommodate load fluctuations, and operate under adverse conditions, such as voltage unbalance. If the motor is significantly oversized and operates at partial load, its efficiency may be reduced, energy consumption is increased, create poor power factor and additional losses.

f) **Motor Losses:**

- **Electrical losses** of the type I^2R,
- **Magnetic losses** in the steel laminations of the stator and rotor due to hysteresis and eddy currents, and vary with the flux-density and the frequency.
- **Mechanical losses** due to friction in the bearings, ventilation and
  windage losses.
- **Stray load losses** due to leakage flux, non-uniform current distribution;

c) Conditions for Electrical parameters monitoring means

Electrical Requirements

- The supply voltage should have the voltages with an unbalance less than 0.5% and the voltage magnitude should also be within 1 % of the nominal value. Harmonic distortion can increase the losses of electrical motors and therefore decrease the efficiency values of the motors being tested. In this case, there may be a need to install harmonic filters to reduce harmonic distortion to under 1%.

Instrumentation Accuracy Requirements

- The minimum accuracy requirements of the instruments used to test the motor efficiency. The minimum accuracy requirements for new laboratories should be based on the requirements of IEC 60034-2 and IEEE 112-B

Instrumentation accuracy of efficiency testing standards	Instrumentation accuracy of efficiency testing standards (IEC 60034-2)	Instrumentation accuracy of efficiency testing standards (IEEE 112-B)
Power,W	±1,0%	±0,2%
Current, I	±0,5%	±0,2%
Voltage, V	±0,5%	±0,2%
Frequency, Hz	±0,5%	±0,1% fN
Speed, RPM	±2	±1
Torque, N m	---	±0,2%
Ohms	±0,5%	±0,2%
Temperature, ºC	±2	±1

d) Data Acquisition and Control System requirement

- Data acquisition and control system for motor testing, which is able to perform in an automated mode the efficiency and power factor test from no-load (or near condition due to minimum residual torque given by the dynamometer) to full-load. Inputs to the data acquisition system will include speed and torque (both usually provided by the dynamometer), operating temperatures (provided at least by 4 temperature sensors), currents, voltages, power factor, active power and reactive power (provided by a three-phase power analyzer).
- Measurement of voltage & current;
- Measurement of power;
- Measurement of energy consumption;

e) Field Tests for Determining Efficiency measurement ;

- Power input (kW);
- Stator winding **(I^2R)** loss (kW) at test temperature;
- Core loss (kW);
- Winding-friction loss (kW)
- Rotor winding **(I^2R)** loss (kW) at test temperature

- Stray-load loss (kW)
- Temperature corrected stator winding (I2R) loss (kW)
- Temperature corrected power output (kW)

(f) Losses and Efficiency: Efficiency is the ratio of mechanical energy output divided by the electrical energy input. *Motor* Energy *Losses* are the determining factor in motor efficiency. These losses can be divided in five classes:

Name	Percent of Total Losses	Description	Fixed or Variable	How to reduce
Core Losses	15-15%	Energy required to magnetize core.	Fixed	Improved permeability steel, lengthening core, using thinner laminations in the core
Windage and friction	5-15%	Losses due to bearing friction and Air resistance, which is primarily caused by the cooling fan.	Fixed	Lower friction bearings, improve fan design and air flow.
Stator Losses	25-40%	Heating due to current flow through the resistance of the stator winding.	Variable	Increasing the volume of copper wire in the stator, through improved stator slot designs, and by using thinner insulation.
Rotor Losses	15-25%	Heating due to I2R losses in the Rotor conductive bars.	Variable	Increasing the size of rotor conductive bars and end rings to reduce resistance.
Additional Load Losses	10-20%	Leakage fluxes induced by load currents and various other minor losses.	Variable	

The main difference between the standards emerges from the way in which the additional load losses, is treated.

The IEC 34.2 standard assumes a standard value for the additional load losses at rated load of 0.5% of the input power, these are :

$$P_{addt} = [P_{in} - P_{out}] - [P_{Fe} + P_{Stator} + P_{Rotor} + P_{fr.w}]$$

Types of Electrical Motor losses

— Stator **(I^2R)** loss,

— Rotor **(I^2R)** loss,

— Friction and windage loss,

— Core loss,

— Stray-load loss,

— Brush-contact loss;

$$P_{Tloss} = P_{strloss} + P_{rotloss} + P_{adtloss}$$

$$\eta_M = Pout/Pin \quad \text{or} \quad \eta = 1 - P_{Tlosses} / P_{in}$$

Note: The voltage applied to Electrical Motors under test is rated under steady state conditions, marked on the Electrical Motors Nameplate, from regulated and stabilized a.c. power source.

6.1 Electrical Motors test data acquisition steps

Electrical Motors samples are collected for performance or safety test, that are made according the technical specification set by the consultant to make sure that it is working efficiently. To check the Electrical Motors, the following steps are followed

Step 1 – Preparation

To prevent laboratory technician from danger, the Electrical Motors should be kept disconnected or turned off from power supply source, until the test setup is completed.

Step 2 – Resistance readings

- Place relevant probe on each terminal and take the winding resistance value of the Electrical Motors, and have the record for further evaluation, the best place to test the motor is in the connection box with the leads disconnected. If that's not possible, test as close to the motor as possible.

- The resistance readings should be between 1-2% of each other - in other words, BALANCED! There is no way to tell how much resistance you should get, but it is typically low.

- Realize that you are testing with a DC battery. Therefore, you are reading the resistance of the copper wire. In many cases, this will look like a short circuit. It's when it doesn't look like a short circuit that you have problems. As long as the readings are low and balanced, you're ready to go to the next step.

Step 3 – Speed mode testing

- To measure a specific Load Point, the dynamometer is set to control in either speed mode or torque mode, depending on customer preference.
- If the dynamometer is under speed control mode (speed mode testing), then a speed is established by the dynamometer and torque is produced based on the capabilities of the motor.
- If the dynamometer is under torque control mode (torque mode testing), then a load is established by the dynamometer and speed is produced based on the capabilities of the motor. In either case, once the desired point is established, the tester can measure speed, torque, voltage and current (amps) depending on how the individual tester is configured.

Step 4 – Full load point application

- The most commonly used single load point is the full load point. This means that the speed selected is the motor’s rated speed (if speed mode testing is used) or the load selected is the motor’s rated torque (if torque mode testing is used). Then any data gathered is full load data. As many load points as desired can be gathered. (i.e. Voltage, Current, Power, Power Factor, Speed, Torque, Mechanical Power and Efficiency

6.2 . Temperature measurement

The temperature of Electrical Motors is measured with fine-thermocouple wire embedded to a particular measuring point, or use infra red remote sensing temperature measuring instrument, with an accuracy class I measuring instruments as stated in IEC 60051-1.

The temperature sensing probe is embedded in the stator winding by applying a force of at least I Newton in order to improve the heat transfer between the probe and the winding.

7. Measurement of power & Energy

7.1 Power measurement and Efficiency Evaluation

The efficiency of a Electrical Motors is simply the utilized energy divided by the total energy input (or the energy utilized during a driving session divided by total energy consumed the Electrical Motors).

When direct power measurements are available, use them to estimate motor load. With measured parameters taken from hand-held instruments, you can use the equations stated below to calculate the three-phase input power and efficiency to the *loaded motor. You can then quantify the motor's load by comparing the measured* input power under load to the power required when the motor operates at rated capacity.

$$P_i = \frac{V \times I \times PF \times \sqrt{3}}{1000} \qquad (1)$$

Where:

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

$$P_{ir} = hp \times \frac{0.7457}{\eta_{fl}} \qquad (2)$$

Where:

P_{ir} = Input power at full-rated load in kW
hp = Nameplate rated horsepower
η_{fl} = Efficiency at full-rated load

$$Load = \frac{P_i}{P_{ir}} \times 100\% \qquad (3)$$

Where:

Load = Output power as a % of rated power
P_i = Measured three-phase power in kW
P_{ir} = Input power at full-rated load in kW

$$Load = \frac{I}{I_r} \times \frac{V}{V_r} \times 100\% \qquad (4)$$

Where:
Load = Output power as a % of rated power
I = RMS current, mean of 3 phases
I_r = Nameplate rated current
V = RMS voltage, mean line-to-line of 3 phases
V_r = Nameplate rated voltage

$$Load = \frac{Slip}{S_s - S_r} \times 100\% \qquad (5)$$

Where:
Load = Output power as a % of rated power
Slip = Synchronous speed - Measured speed in rpm
S_s = Synchronous speed in rpm
S_r = Nameplate full-load speed

$$Load = \frac{Slip}{(S_s - S_r) \times (V_r / V)2} \times 100\% \qquad (6)$$

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

Efficiency % = Temperature Corrected Power Output X 100 / [Power Input]

$$\eta = \frac{0.7457 \times P_{hp} \times Load}{P_i} \qquad (7)$$

Where:
η = Efficiency as operated in %
P_{hp} = Nameplate rated horsepower
Load = Output power as a % of rated power
P_i = Three-phase power in kW

$$Load = \frac{P_i \times \eta}{hp \times 0.7457} \qquad (8)$$

Where:
Load = Output power as a % of rated power
P_i = Three-phase power in kW
η = Efficiency as operated in %
hp = Nameplate rated horsepower

8 . Electrical Motors Name Plate Data & Marking

- Manufacturer or trade mark;
- supplier's model identifier;
- rated voltage (V);
- rated current (I);
- Frequency (Hz);
- Rated power (kW);
- Efficiency (**%)**
- Speed (rpm);
- Connection (Star/Delta);
- Insulation class (F);
- Frame (LD 200 L)

Annex 6.

Electric motors testing procedure

	Description	page	Remark
1	Purpose		
2	Scope		
3	Reference Standards		
4	Terms & Definitions		
5	Testing procedure and Methods		
5.1	Testing procedure		
5.2	Test Methods		
5.3	Application of the Test methods		
6	General requirements		
6.1	Power requirements for tests		
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7	Test facility and Measuring equipment		
7.1	General requirements		
7.2	Preliminary Checking Procedure for Test facility or devices		
7.3	Safety criteria for test device selection		
7.4	Instrument Selection and calibration		
8	Procedures for testing, including particular conditions		

1. Purpose

Electric motors are most wide spread and convenient means for electromechanical power conversion in industrial environment, and approximately 60-65% of the total industrial electric energy is consumed by electric motors.

This document includes instructions for conducting and reporting the more general applicable and acceptable tests to determine the performance characteristics of polyphase induction motors. The main focus of this document is evaluation of electrical motors efficiency, and the use of efficient motor technologies.

2. Scope

This document specifies the test methods to be used in measuring the energy efficiency of three-phase induction motors in support of a *consumer and user to provide standard* information and determining the nominal efficiency values specified by accredited motor manufacturers.

It also covers instructions for conducting general and acceptable test methods for polyphase induction motors. Since polyphase power systems are almost universally used in the industrial and commercial sectors.

3. References:

[1] IEC 60034-2-1, Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles), Ed.1.0, 2007-09

[2] IEC 60034-2-3, Rotating electrical machines – Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motors, draft edition, is intended to describe test methods and required instrumentation specifications while measuring efficiency of VSD fed motors.

[3] IEC 60034-30, Rotating electrical machines – Part 30: Efficiency classes of single-speed, three phases, cage-induction motors, Edition 1, 2008

[4] IEC 60034-31 Rotating electrical machines – Part 31: Selection of energy-efficient motors including variable speed applications – Application guide, Edition 1.0, 2010-04

[5] IEEE 739 Recommended Practice for Energy Conservation and Cost-Effective Planning in industrial Facilities.

[6] EN 60034-5 Rotating electrical machines: degrees of protection by the integral design of rotation electrical machine.

[7] EN 60034-6 Rotating electrical machines: methods of cooling

[8] EN 60034-7 Rotating electrical machines: classifications of types of constructions and mounting arrangements

[9] EN 60034-8 Rotating electrical machines: terminal markings and direction of rotation

[10] EN 60034-9 Rotating electrical machines: noise limits

[11] EN 6034-12 Rotating electrical machines: starting performance of single-speed three-phase cage induction motors

[12] IEC 60068-2 Environmental testing procedures

[13] IEC 60085, Thermal evaluation and classification of electrical insulation

[14] IEC 60529, Degrees of protection provided by enclosures (IP Code)

[15] IEC 60990 Methods of measuring touch-current and protective conductor current

[16]IEC 61010 Safety requirements for electrical equipment for Measurement, control, and laboratory use

[17]ISO/IEC 17025 General requirements for the competence of testing and

4. Terms & Definitions:

4.1 Rated voltage- voltage assigned to Electrical Motors by the manufacturer

4.2 Rated frequency : frequency assigned to the Electrical Motors by the producer

4.3 Normal operation : conditions under which Electrical Motor is operated in normaluse when it is connected to the supply mains.

4.4 Functional insulation :insulation between conductive parts of different potential which is necessary only for the proper functioning of the appliance

4.5 Protective device: device, the operation of which prevents a hazardous situation under abnormal operation conditions

4,6 Motor current interface: Insertion of current sensing element directly into current path contributes to least uncertainties in measurement.

4.7 Estimation of measurement uncertainties: This section describes the procedure followed to estimate measurement uncertainty for the measurement setup used in this study.

4.8 Energy efficiency*:* is the ratio of mechanical energy output divided by the electrical energy input.

4.9 Idle running tests: Running tests without load are made for the determination of core loss and windage and friction losses. Some other tests such as shaft voltage may also be performed under these conditions.

4.10 Motor Efficiency Testing Standards: testing standards which prescribe specific procedures, such as what test equipment may be used, how long the motor is to run prior to testing, how loads are to be applied, what data are to be collected, and how various losses are to be measured.

4.11 Tests with load: are made for the determination of efficiency, power factor, speed, current, and temperature rise.

4.12 Waveform: The power supply shall provide balanced voltages closely approaching a sinusoidal waveform. The harmonic distortion coefficient, THD, shall not exceed 0.05.

4.13 Voltage unbalance: shall not exceed 0.5%. The percent voltage unbalance equals 100 times the maximum voltage deviation from the average voltage divided by the average voltage.

4.14 Frequency: the frequency shall be within ±0.5% of the value required for the test being conducted, unless otherwise specified.

4.15 No-load current: average of the line currents at rated voltage is the no-load current.

4.16 No-load losses: measured input power is the total of the losses in the motor at no-load. These losses consist of the stator I^2R, friction (including brush-friction loss on wound-rotor motors), windage, and core losses.

4.17 Stray-load losses- the additional fundamental and high-frequency losses in the iron; strand and circulating-current losses in the stator winding; and harmonic losses in the rotor conductors under load. These losses are assumed to be proportional to the rotor current squared.

4.18 Friction and windage: Windage-friction loss- the mechanical losses due to Bearing friction and windage. To determine the friction and windage loss, subtract the stator *I*2*R* loss (at the temperature of the test) from the total losses

4.19 Dynamometer test- a test in which the mechanical power output of a machine acting as a motor is determined by the shaft torque, by means of a dynamometer, together with the rotational speed.

5. Testing procedure and Methods

5.1 Testing procedure

Technical requirements and test methods are interrelated elements of product standards and should always be considered together. Wherever possible, the standards should contain test specifications for complete and clearly checking compliance with the technical requirements. It should be easy to recognize which test methods apply to each technical requirement. The tests should be performed at the ambient temperature, humidity and atmospheric pressure described in the technical description.

In some cases, a compliance statement such as 'visual inspection', 'manual testing' or similar is adequate for this purpose if such a method gives an accurate assessment.

Appropriate headings should designate the appropriate test and a reference should be made to the clause containing the requirement. This also applies for references which are made to other relevant test standards.

When testing the sample, relevant information provided in the instruction for use should be taken into account. Before commencing the test, the sample under test should be disconnected from the Supply mains. If not possible, special precautions should be taken to prevent HARM to the personnel performing the tests and/or other individuals who might be involving in the test process.

5.1.1 General conditions

The following general conditions should be respected:

a) After the sample to be tested has been set up for normal use, tests are carried out within the range of environmental conditions specified in the technical description.

c) In cases where ambient temperatures cannot be maintained, the test conditions are to be consequently modified and results adjusted accordingly.

d) The tests should be performed with qualified personnel, who have the knowledge, experience, and acquaintance with the relevant technologies and regulations. The personnel should be able to assess safety and be able to recognize possible consequences and hazards arising from non-conforming samples.

f) All tests are to be performed in such a manner that no unacceptable risk arises for testing personnel, or other individuals.

g) If not otherwise stated, all values for current and voltage are effective values (r.m.s.) values as appropriate.

h) All tests performed should be comprehensively documented. The documentation should contain as a minimum the following data:

- identification of the testing laboratory (e. g. company, department);
- names of the persons, who performed the testing and the evaluation(s);
- identification of the sample (e. g. type, serial number, inventory number);
- measurements (measured values, measuring method, measuring equipment);
- date and signature of the individual, who performed the evaluation;
- if applicable, the sample tested should be marked / identified accordingly.

5.1.2 Sequence of tests

Unless stated otherwise, the tests are to be sequenced in such a way so that the results of any test do not influence the results of other tests. Tests should, if applicable, be performed in the sequence, unless otherwise stated by particular standards.

-Stator winding resistance measurement at ambient tempeature
-Remove accessible drive-end seals (but without dismantling)
-Rated load temperature test
-Load curve test with torque measurement,
-Stator winding resistance measurement
-Stator winding resistance measurement
-No-load test

Determination of loss components

-Constant losses (Friction and windage losses); (Iron losses)
-Load losses (Stator and rotor winding losses, including temp. correction)
-Additional losses (Residual losses)
-Calculate total losses
-Calculate efficiency

5.2 Test Methods: This document deals with most common test methods for evaluation of electrical motor efficiency, according National Standards adopted from International standards, in particular by losses determination methods. The methods are distinguished in to **Direct** (i.e. the input - output power measurement), and indirect (i.e. measuring losses) methods for the evaluation of motor efficiency.

a) Simple Input-Output: This method is used to load the motor while the torque and speed are measured to calculate load parameters necessary for the evaluation of the efficiency.

b) Input-Output with loss segregation (or separation): This method uses a dynamometer, an instrument that maintains a constant torque resistance, allowing motor load to be calculated. This method lets the measurement the mechanical losses, core losses and short-circuit losses.

c) Back to back machine test with separation of losses: One machine is operated as a motor while the other becomes a generator, returning power back to the electrical grid. The efficiency is measured by dividing the total losses by two. It can be applied when two equal machines are available. One of them operates as a motor and the other one, as a generator.

d) Equivalent circuit calculation: This is usually the least accurate way to calculated motor efficiency because such a large portion of losses are not directly measured. The document estimates the efficiency by the direct method;

Note: *The electric input power is measured using a high accuracy wattmeter and the output power is measured using a speed sensor and a torque sensor. This is an accurate method, if the instrumentation has the desired accuracy and the test procedure is followed rigorously.*

5.3 Application of Test methods

5.3.1 Input-Output Method with Indirect Measurement of the Stray-Load Loss and Direct Measurement of the Stator Winding (**I^2R**), Rotor Winding (**I^2R**), Core and Windage-Friction Losses

5.3.2 Install thermocouples or other temperature-measuring devices in the motor in or on the winding-end heads or in the slots out of the cooling air circulation path, and measure and record the following:

(a) The motor stator line resistance; and

(b) The winding temperature.

5.3.3 Apply rated voltage, frequency, and full load to the motor until thermal equilibrium *is* reached. When constant winding temperature is reached under full load conditions, shut off the power supply, and within the time interval indicated in the following table disconnect the motor leads, and measure and record the following:

(a) The stator line resistance;
(b) The winding temperature; and
(c) The ambient temperature:

5.3.4 Apply rated voltage and frequency to the motor, and load the motor to four load points approximately equally spaced between not less than 25% load and up to and including 100% load, and two load points suitably chosen above 100% load but not exceeding 150% load. When loading the motor, start at the highest load value and move in descending order to the lowest.

At each of the six points, measure and record the

(a) Torque output corrected;*
(b) Observed power input;
(c) average line current (A);
(d) speed *(r/min);*
(e) average winding temperature at that point;
(f) ambient temperature; and
(g) Average motor terminal voltage.

5.3.5 Disconnect the motor from the load and apply rated voltage and frequency to the motor until the no-load loss is stabilized. The no-load loss is stabilized when the no-load power input varies by 3% or less, when measured at two successive 30 min intervals.

5.3.6 When the motor has been disconnected from the load, apply power at rated frequency to the motor, at three or more values of voltage approximately equally spaced between 125% and 60% of rated voltage and three or more values of voltage approximately equally spaced between 50% of rated voltage down to approximately 20% of rated voltage, or to a point where the line current reaches a minimum value or becomes unstable. At each of the voltage values, measure and record the

(a) Average applied voltage;
(b) Average line current;
(c) No-load power input; and
(d) Average winding temperature at that point.

5.3.7 Calculate the stator winding (I^2R) loss at each of the six load points measured in Clause 5.3.4, using the equation

Stator winding (I^2R) loss = 0.0015 I^2Rs (kW)

I = average line current as measured in Clause 5.3.4(c)

Rs = average line resistance as measured in Clause 5.3.2, corrected to winding temperature in Clause 5.3.4 (e) as follows:

$$R = R_t \times [t_s + K] / [t_T + K]$$

R_t = test value of winding resistance
t_s =winding temperature (0C) (see Clause *5.2.4(e))*
t_T = temperature of winding when resistance was measured (^0C)
K = 234.5 for pure copper
K = 225 for aluminum based on a volume conductivity of 62%

5.3.8 Calculate the core loss and the windage-friction loss from no-load tests prescribed in Clause 5.3.6 as detailed below:

(a) The core loss and the windage-friction loss are considered to be independent of load for Methods (1) and (2), and the values calculated at no load can be used at each of the six load points in Clause 5.3.4;

(b) For each of the values of voltage given in Clause 5.3.6, subtract from the no-load power input readings (see Clause 5.3.6)(c)

The no-load stator winding **(I^2R)**loss calculated as follows:

No-load stator winding (fA) loss = 0.0015 **(I^2Rs)** (kW)

Where

I = no-load line current (see Clause 5.3.6(b))

Rs = average line resistance as measured in Clause 5.3.2 (a) corrected to winding temperature in Clause 5.3.6(d) as follows:

where

A_t = test value of winding resistance (0) (see Clause 5.3.2 (a)

t_S = winding temperature (^{0}C) (see Clause 5.3.6

t_T = temperature of winding when resistance was measured (^{0}C)

K = 234.5 for pure copper

K = 225 for aluminum based on a volume conductivity of 62%

5.3.9 Calculate the rotor winding **(I^2R)** loss at each of the six load points measured in Clause 5.3.4 using the equation:

Rotor winding **(I^2R)** loss = (measured power input)

(See Clause 5.3.4(b))-stator winding (I^2R) loss

(See Clause 5.3.7)-core loss

(See Clause 5.3.8 (a) x slip Where slip is per unit of synchronous speed:

$$\text{Slip} = \frac{\text{synchronous speed - measured speed}}{\text{Synchronous speed}}$$

5.3.10 Calculate the stray-load loss at each of the six load points measured in Clause 5.3.4 by first calculating the residual kilowatts as follows:

Residual kilowatts = power input (see Clause 5.3.4(b)) - power output (as calculated from torque (see Clause 5.3.4(a) and speed (see Clause 5.3.4(d) - stator winding **(I^2R)** loss (see Clause 5.3.7) - core loss (see Clause 5.3.8(a)) - windage-friction loss (see Clause 5.3.8(a)) - rotor winding **(I^2R)** loss (see Clause 5.3.9)

$$\text{Power output (kilowatts)} = \frac{\text{torque (N-m)} \times \text{r/min}}{9549}$$

Smooth the residual power output (kW) data by using a linear regression analysis:

Residual power output (kW) = A T2 + B

where

T = torque output (see Clause 5.3.4(a))
A = slope
B = intercept
If correlation coefficient q is less than 0.9, delete the worst point and recalculate A and B. If this increases, ie, $q > 0.9$, use the second calculation; if not, the test is unsatisfactory. Errors in the instrumentation or test readings, or both, are indicated. The source of the error should be investigated and corrected, and the test repeated.

When the A (slope constant) is established from the above, stray-load loss for each of the six points in Clause 5.3.4 can be calculated by using the equation

Stray-load loss = AT

Where

T = torque output (from Clause 5.3.4(a)
A =slope (from Clause 5.3.10)

5.3.11 Calculate stator winding **(I^2R)** loss corrected to the temperature as measured in Clause 5.3.3 and to 25°C ambient temperature for each of the six load points measured in Clause 5.2.4 using the equation Temperature corrected stator winding **(I^2R)** loss = 0.0015 **(I^2Rs)** (kW)

$Rs = Rt \times [ts + K] / [t_T + K]$

where

I =average line current as measured in Clause 5.3.4(c)

Rs = average stator line resistance as measured in Clause 5.3.2(a) corrected to an ambient temperature of 25°C as follows

where

R_t = average stator line resistance as measured in Clause 5.3.2(a) ~

t_S = winding temperature (0C) (see Clause 5.3.5

t_T = temperature of winding when resistance was measured (^{0}C)

K = 234.5 for pure copper

K = 225 for aluminum based on a volume conductivity of 62%

5.3.12 Calculate the rotor winding **(I^2R)** loss corrected to the temperature as measured in Clause 5.3.3 and to 25°C ambient temperature for each of the six load points in Clause 5.3.4 using the equation Temperature corrected rotor winding **(I^2R)** loss = (measured power input (see Clause 5.3.4(b) - temperature corrected stator winding **(I^2R)** loss (see Clause 5.3.11) - core loss (see Clause *5.3.8(a))* x slip (corrected)

where

Slip(corrected) - $S \times [ts + K] / [t_T + K]$

Where

slip (corrected) = slip per unit of synchronous speed corrected to the stator winding temperature in Clause 5.2.3(b) corrected to 25°C ambient temperature

S = slip per unit of synchronous speed from the speed as measured in Clause 5.3.4(d) and previously calculated in Clause 5.3.9

ts = stator winding temperature as measured in Clause 5.2.3(b) corrected to 25°C ambient temperature (~ = 5.3.3(b) + 25°C - 5.3.3

t_T =	observed stator winding temperature as measured in Clause 5.1.3(e)
K =	234.5 for pure copper
K =	225 for aluminum based on a volume conductivity of 62%

5.3.13 Calculate the power output temperature corrected at each of the six load points in Clause 5.2,4 using the equation

Power output (temperature corrected) = power input (at test point) - losses (corrected)

Where;

power input (at test point) = as measured in Clause 5.3.4(b} losses (corrected) = core loss (Clause 5.3.8(a) + windage-friction loss (Clause 5.3.8(a) + stray-load loss (Clause 5.3.10) + temperature corrected stator winding (I^2R) loss(Clause 5.3.11) + temperature corrected rotor winding (I^2R) loss (Clause 5.3.12)

5.3.14 Calculate the efficiency at each of the six load points in Clause 5.3.13 using the equation

$$\text{Efficiency} = \frac{\text{power output (temperature corrected)}}{\text{power input (at test point)}}$$

Where power output (temperature' corrected) is as calculated in Clause 5.3.13 and power input (at test point) is as measured in Clause 5.3.13.

5.3.15 Determine the efficiency at precise load points by plotting efficiency using values calculated in Clause 5.3.14 against the power output (temperature corrected) calculated in Clause 5.3.13.

6. General requirements

6.1 Power requirements for tests

Unless otherwise specified by an alternative, sample is tested at favorable rated voltage within the predetermined voltage range. For the laboratory test purpose stabilized and uninterruptible power supply unit must be used. It may be necessary to perform some of the tests more than once in order to establish confidence with the result obtained during previous tests.

6.2 Supply Mains

The source of supply should closely approach sine waveform and should provide balanced phase voltages. The voltage waveform deviation factor should not exceed 10%. The frequency shall be maintained within ±0.5% of the value required for the test being conducted, unless otherwise specified

SUPPLY MAINS used for testing the sample should be assumed to have the following characteristics:

- voltage dips, short interruptions and voltage variations on the Supply mains as described in the general test condition
- no voltage application in excess of 110 % or lower than 90 % of the Nominal value(i.e according to the Ethiopian National standard the nominal voltage value is 400V/230V ±10%) between any of the conductors of the system or between any of these conductors and earth.
- voltages that are practically sinusoidal and forming a practically symmetrical supply.
- protective measures as described in relevant standards

7. Test and Measurement equipment Selection

The indicating instruments used in measurements shall be selected to give indications well up on the scale, that is, where a fraction of a division is easily estimated and where such a fraction is a small percentage of the value read. The indicating instrument shall be calibrated to limit errors to no greater than ±0.5% of full scale deflection traceable to national standards.

7.1 General requirements

- The measurement and test equipment should comply with requirements of the IEC 61010 series of standards.
- In NORMAL USE the measuring equipment should not expose the person doing the testing or other individuals to unacceptable RISKS.
- The accuracy of the measuring functions within the range marked or declared by the measuring equipment manufacturer should be specified in test data sheet.
- The measuring equipment used for the tests should be tested and calibrated at regular intervals according to the information given by its manufacturer and should be traceable to national or international standards.
- For the tests, protective earth connections may be interrupted in the measuring devices, if protection against electric shock is guaranteed by another means of IEC 61010-1.
- It is recommended to use dedicated test equipment (e.g. dielectric withstand tester, ground bonding and continuity tester, etc.).
- The test equipment should be capable of providing all voltages and currents needed

7.2 Preliminary Checking Procedure for Test facility or devices

The users of the laboratory equipment must understand how important laboratory personnel checks are. Some equipment and environments may demand special needs, thus the following checklist should be respected.

1. Check the overall condition of the equipment,

2. Check the supply cable, connection devices, etc.

3. Check if they have valid label indicating it has been formally inspected and calibrated

4. Check the facility is suitable for the environment.

5. Check the plug and make sure the cable is securely gripped and there is no mechanical damage.

6. Check that the ground connecters have not been removed.

7. Check the socket outlet to make sure there are no signs of damage or overheating.

8. Check that the facility is working correctly as expected.

If the Lab technician is not happy with any of the above, then the following test steps, should not be continued to make the test, then

1. Switch off the power and disconnect the sample from the supply.
2. Clearly label to identify that it must not be used.
3. Report to the appropriate responsible person.

This type of inspection should only be carried out by a competent person as defined by the laboratory instruction manual before starting active tests.

7.3. Safety criteria for test device selection

The measurement and test equipment should be selected so that the test operator cannot be accidentally subjected to hazardous voltages and currents such as those used for a dielectric strength test, and protective earthing connection continuity test.

It is recommended to use measurement and test equipment which includes safety interlocks which provide protection by automatically shutting down the VOLTAGE output whenever a safety switch on the device is switched ON.

7.4 Instrument Selection and Calibration

7.4.1 Instrument Selection

Several iterations were required to arrive at an instrumentation set that would reliably measure the output. Four different voltage probes were used and two current monitors were evaluated.

The probes are designed for single-ended compensation, but it can be seen from various differential measurements to monitor the line to line voltage.

Subsequently, voltages were measured using a voltage divider that had been used on high voltage measurement methods for years.

The final probe used was a Test Precision Instruments battery operated unit specifically designed for measuring the output of the drives.

This instrument was found to work well. A similar evaluation was performed for the current measurement.

The testing commenced using current transformers, but they did not provide noise immunity in the motor testing environment.

7.4.2 Instrument Selection and Calibration

The reference standards (e.g. voltage, current, impedance, temperature, speed, torque, etc.) used by the equipment supplier for calibrating measurement and test equipment should be certified to traceable national standards. This ensures the integrity of calibration accuracy and compliance with IEC/ISO 17025

8. Procedures for testing, including particular conditions

The following subclasses describe the framework for performing tests that are required by relevant sample test procedure written as a sheet format:

a) Equipment requested by the test;
b) Safety precautions during the test;
c) Test sample preparation;
d) Test conditions;
e) Test set-up procedure; and
f) Presentation of the test results.

Note: *Normal laboratory safety procedures are to be used during this test.*

8.1 Power consumption of the Motor

a) Equipment requested for the testing:

1) Adjustable regulated a.c. power supply 1 – 500 V, 50 Hz,
2) Suitable true r.m.s. or average responding, true r.m.s. calibrated voltmeters, ammeters
3) Professional digital VOLT meter
4) Power measuring instrument
5) Assorted interconnection cables
6) Torque measuring instruments

b) Safety precautions during the test:

1) It is important to determine the correct type of power input circuit to use for the sample under test.
2) Normal laboratory safety procedures are to be used during this test.

c) Test sample preparation:

One representative sample loaded with all optional ACCESSORIES

d) Test conditions:

NORMAL CONDITION

e) Test set-up and PROCEDURE:

1) Connect normal load to the SAMPLE and operate under the most severe conditions until the input has reached a stable value.

2) Measure and record the input current for 90 % of the lowest RATED voltage, the highest RATED voltage of 110 % of the highest RATED voltage at the frequencies specified by the PRODUCER.

3) The steady state or average current is measured with a true r.m.s. reading instrument.

4) RATED input power, if expressed in volt-amperes, is either measured with a volt-meter or determined as the product of the steady state current (measured as described above) and the supply voltage.

f) Presentation of the test results:

A table is provided for the test results

8.2 Determination of voltage, current or energy

a) Equipment requested by the test:

1) Digital storage scope
2) Voltmeter
3) Ampere meter
4) Ohmmeter
5) Temperature sensor
6) Watt meter
7) Var meter
8) Torque measuring devices

b) Safety precautions during the test:

Normal laboratory safety procedures are to be used during this test.

c) Test sample preparation:

One representative test sample.

d) Test conditions:

The relevant supply circuit should be made available

This test applies intended to be connected to a power source by a plug

e) Test set-up and PROCEDURE:

1) The SAMPLE is operated at RATED voltage or at the upper limit of the RATED voltage range.

2) The SAMPLE is disconnected from the power source with any relevant switch in the “On” and “Off” positions.

3) Either the SAMPLE is disconnected from the power source by means of compatible ACB, in which case the test is performed as many times as necessary to allow the worst case to be measured, at the peak of the supply voltage waveform.

4) The voltage between the pins of the plug and between any pin and the ENCLOSURE is measured

f) Presentation of the test results:

A table is provided for the test results

8. 3 Working Voltage Measurement

a) Equipment requested by the test:

1) Digital storage scope

2) True r.m.s voltmeter

b) Safety precautions during the test:

Normal laboratory safety procedures are to be used during this test.

c) Test sample preparation:

One representative test sample.

The relevant supply circuit should be made available

d) Test conditions:

1) Unearthed accessible conductive parts should be assumed to be earthed. It should be assumed to be earthed at the point by which the highest **Working Voltage**

2) For insulation between any two points of the winding should be used, taking into account external voltages to which the motor will be connected.

e) Test set-up and Procedure:

1) The sample is operated at Rated voltage or at the upper limit of the Rated voltage range.

2) A voltmeter is connected at each location indicated and the maximum voltage in the circuit is measured and recorded.

f) Presentation of the test results:

A table is provided for the test results

Annex 7.

Testing facility and existing relevant standards

1. Purpose

This document sets forth the information required by Inspection, Verification, and Test Laboratories, the availability of **testing facility** for inspection and test of sample Electrical Motors by using existing **relevant standards** including the testing stages in accordance with the procedure and standards recommended by a recognized consulting firm.

2. Scope

This document deals with standards prepared by regional and international standard institutions for the performance and safety tests of electrical appliances similar to Electrical Motors for household and commercial services, their rated voltage being not more than 400V±10% for three phase and 230 V ± 10% for single-phase 50Hz electrical supply lines.

The purpose of this document is to state and define the principal performance characteristics of electric measuring devices and facilities to monitor the performance parameters of heating appliances and give guidelines for the evaluation of test results.

This document defines main devices and facilities required to check the passive and active performance characteristics of Electrical Motors which are of interest to the user and specifies relevant standards to set testing methods and procedures to carry out tests within locally set-up testing facility or under Ethiopian conformity assessment laboratory

Relevant Reference Standards

[1] IEC 60034-2-1, Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles), Ed.1.0, 2007-09

[2] IEC 60034-2-3, Rotating electrical machines – Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motors, draft edition, is intended to describe test methods and required instrumentation specifications while measuring efficiency of VSD fed motors.

[3] IEC 60034-30, Rotating electrical machines – Part 30: Efficiency classes of single-speed, three phase, cage-induction motors, Edition 1, 2008

[4] IEC 60034-31, Rotating electrical machines – Part 31: Selection of energy-efficient motors including variable speed applications – Application guide, Edition 1.0, 2010-04

[4] IEEE 739 Recommended Practice for Energy Conservation and Cost-Effective Planning in industrial Facilities.

[5] EN 60034-5 Rotating electrical machines: degrees of protection by the integral design of Rotating electrical machine.

[6] EN 60034-6 Rotating electrical machines: methods of cooling

[7] EN 60034-7 Rotating electrical machines: classifications of types of constrctions and mounting arrangements

[8] EN 60034-8 Rotating electrical machines: terminal markings and direction of rotation

[9] EN 60034-9 Rotating electrical machines: noise limits

[10] EN 60034-12 Rotating electrical machines: starting performance of single-speed three- phase cage induction motors

[11] IEC 60068-2 Environmental testing procedures

[12] IEC 60085, Thermal evaluation and classification of electrical insulation

[12] IEC 60529, Degrees of protection provided by enclosures (IP Code)

[13] IEC 60990 Methods of measuring touch-current and protective conductor current

[14]IEC 61010 Safety requirements for electrical equipment for Measurement, control, and laboratory use

[15]ISO/IEC 17025, General requirements for the competence of testing and calibration Laboratories

[16]AS1359: Rotating electrical machines – General Requirements Part 101: Rating and Performance

[17]AS1359: Rotating electrical machines – General Requirements Part 102.1: Methods for determining losses and efficiency – General

[18]AS/NZS1359: Rotating electrical machines – General Requirements Part 102.3: Methods for determining losses and efficiency – Three phase cage induction motors

[19]AS/NZS1359: Rotating electrical machines – General Requirements Part 5: Three phase cage induction motors – High efficiency and minimum energy performance standards (MEPS) requirements

[20] Aldo Boglietti, Andrea Cavagnino, Marco Cossale, Alberto Tenconi, and Silvio Vaschetto, "Efficiency determination of converter-fed Induction Motors: Denver, CO, USA, 15- 19 September 2013

[21] *Rahul S. Kanchan1, Rathna Chitroju2, Freddy Gyllensten2 1ABB AB Corporate Research,* Evaluation of efficiency measurement methods for sinusoidal and converter fed induction motors

4. Testing facility and devices requirement

It is often possible to build performance checks – system suitability checks – into test methods (e.g., based on the levels of expected detector or sensor response to calibration standards, the resolution of calibration standards in separating systems, the spectral characteristics of calibration standards, etc). These checks are completed before the equipment is used.

The standardization of instruments is performed using reference standards when these are available, or against certified standard instruments when not available. This is done before the instrument is used.

Calibrations are conducted under the same instrumental conditions as those that will exist during the measurement process. The frequency of calibration depends on the accuracy requirements of the investigation and the stability of the instruments. Calibration checks are performed immediately prior to a series of measurements at other times. For unstable instruments, the calibration is checked prior to each series of measurements, in between measurements, and after the last measurement.

The calibration process is vital to all measurement programs and is governed by a calibration plan. The calibration plan provides for:

- calibration procedures and record forms
- stated calibration frequencies
- appropriate sources for obtaining certified and high quality standards,
- a list of all calibration standards
- specifications of environmental conditions
- range of validity Calibration procedures include information on the following:
- groups of equipment to which the procedure is applicable
- a brief description of the scope, the calibration method (an example and a reference may also be included)
- calibration specifications, such as the number of calibration points, environmental requirements, and precision and accuracy requirements
- a list of the calibration standards and accessory equipment needed to perform an effective calibration, manufacturer's name, and instrument model number
- a complete, clear, concise, step-by-step written calibration procedure
- specifications for calibration facilities, equipment, temperature, and humidity, and physical protection for calibration standards
- specific instructions for obtaining and recording the test data (includes data collection forms)

Motor Test Bench integrated instrumentation

Instrument	**Model**	**Discussion**	
VOLTAGE			
North Star 500:1 voltage divider	PVM-10	Not designed to be compensated as differential pair	
LEM voltage sensor	#LV100- 2000	Not enough bandwidth	
Tektronix 1000X high voltage prove	P6015A	Not designed to be compensated as differential pair	
UT-CEM voltage divider		Difficult to size power resistor for continuous operation	

Test Precision Instruments voltage probe	ADF25A	Performed well, battery maintenance an issue	
CURRENT			
Pearson Electronics wide band current	301X	Noise susceptibility in PWM environment	
LEM current sensors	#HAX- 2500S	Performed well	

Item	Item Description	Price(USD)	Price(Birr)
1	Constant Temperature & Humidity Climatic chamber	19,342.94	
2	Digital Millimeter	810.38	
3	Current clamp meter	764.05	
4	Portable Insulation tester	1,731.19	
5	Resistance measuring device	3,868.59	
6	Integrated Appliance Tester	9,091.18	
7	Power measuring meter	23,395.29	
8	Energy Analyzer	5,232.27	
9	Digital timer	193.43	
10	Infrared Temperature measuring facility	4,835.74	
11	Calibrated Linear meter	290.14	
12	Calibrated caliper	336.57	
13	Calibrated Micrometer	352.04	
14	Stabilized power source with appropriate setting devices and setting facility	10,896.77	
15	Primary Current injection facility	7,089.19	
16	Sampling tools	7,231.28	
17	Dymo meter	96,714.71	
18	Custom made Laboratory Motor Test bench with complete accessories	112,172.06	
	Total	**304,347.83**	**7,000,000.00**

The bench-top Motor tester for testing the safety of electrical heating appliances by performing a ground bond test, an insulation test, specific ground leakage tests and operational VA tests according international standards. Among the issues that can arise during this process are safety precautions to be taken by the lab technicians like:

- Exposure to live, conductive parts due to damage to the outer casing of the equipment.
- Worn and/or frayed power cord.
- Defective, loose or missing earth/ground connections.
- Failure to identify and correct problems such as those listed above can result in the electrical equipment becoming a shock hazard or a fire risk.

Many of these problems can be identified visually, but still often go unreported. Internal faults often go undetected. Appliance testing involves performing a series of tests identify faults or product defects that would otherwise not be detected.

In addition to protecting personnel, regular safety checks of electrical equipment tend to increase the operational life of that equipment. An appliance tester allows the lab technician to make a number of safety tests with a single instrument, including:

5. Testing facility and devices application

5.1 Earth Bond and Continuity Tests device

To verify the integrity of exposed metalwork on grounded appliances.

5.2 Insulation Test device

To check that equipment conductors are isolated from earth.

5.3 Touch Current Test device

To check that the equipment case and all exposed metal parts are isolated from earth/ground.

5.4 Differential Leakage Test device

To measure the difference in current between live and neutral conductor during operation.

5.6 Alternative Leakage Test device

To check that the equipment case and all exposed metal parts are isolated from earth/ground, by use of a safe test voltages as an added protection against seriously faulted test items.

5.7 Functional Load Test device

An operational test to ensure the asset works as it should without drawing excessive current from the supply.

5.8 Power Cord Tests device

To check cords and line cords for safe operation. In addition to these standard tests, some instruments will perform a flash test (hipot or dielectric strength test) to test breakdown voltage levels. This test is normally done on new equipment, articles that have had a major overhaul, or equipment in the rental industry.

5.9 Earth resistance test device

This test shows the resistance offered by the earthing rods with the connection leads. Various testing instruments are available for earthing resistance tests. The earthing resistance should be less than 1Ω.

5.10 Earth continuity test device

The equipment shall have a measured resistance of the protective earth circuit, or the earthing conductor of the appliance cord set, which does not exceed 1Ω.

5.11 Current injection test facility

This test requires specialized test equipment, knowledge and training;

- A current, equal to the rated tripping current, shall be "suddenly" applied between active and protective earth and the operating time measured with maximum trip time 40ms for Type I and 300ms for Type II.

6. Testing facility and devices performance examination

Visual examination is vital and always precedes electrical testing. It often reveals major defects that would not be revealed by testing alone. Categories of in-service visual examination and electrical testing are divided into three types:

- Lab technician checks (no records if equipment is OK).
- Formal visual examination (recorded).
- Combined visual examination and electrical testing (recorded).

Intended use: some equipment is just more likely to sustain damage than others. Handheld types are handled and moved more than other types and this can lead to rough handling, which often results in damage and early life failure. For example the continual flexing of a steam-iron cable will subject it to more risk of early failure than that of a microwave oven.

Design: The safety of Class I instrument relies on a low resistance path to the supply earthing/grounding system for safety protection. If the earth conductor within the power cable is damaged, the hazard rises and will, therefore, require electrical testing on a more regular basis.

6.1 Isolation of equipment: in normal circumstances, lab technician must be able to reach the plug/socket without difficulty and disconnect/ isolate. Isolation is simplest when the equipment is connected via a plug and socket. Not all equipment will be connected in this way and isolation may be achieved via a main switch or removal of a fuse.

Caution must be exercised when inspecting equipment without the usual plug/socket arrangement. When inspecting equipment, permission from the equipment operator should be gained before disconnecting from the supply. Failure to do this could result in serious loss of data. It should also be noted that equipment might need to be powered down in the correct manner before isolation.

6.2 **Equipment condition:** before beginning any equipment inspection, lab-technician or the client should be asked if they are aware of any faults and whether the equipment is functioning as expected.

The formal visual examination should involve similar checks to those undertaken by the operator. The following items need to be inspected:

6.3 The power supply system

Is the facility containing appropriate regulated and stabilized power supply system?
Is the facility in good condition?
Is it free from physical damage, wear and tear?
Is it in a position or suitable where it could be used for the intended testing process?
Does it have adequate self protection and is insulated from external hazard?

6.6 Environment

- Is the equipment suitable for the environment in which it is being used?
- Is the equipment being used for the correct purpose?
- Is the lab technician satisfied with the equipment?

Annex 8

Electrical Test Laboratory House Keeping Standards Operating Procedure

Contents

1. PURPOSE

The purpose of this work instruction is to ensure that house keeping activities are undertaken as per the documented procedures detailed herein.

2. SCOPE

The house keeping activities given in this work instruction are to be adhered to by laboratory personnel while working in the electrical testing laboratory.

3. TERMINOLOGY / REFERENCES

a. The definitions ISO/IEC/17025 and ISO 1400 P APPLY

3.1 Test Laboratory Quality Manual

4. PRINCIPAL RESPONSIBILITIES

a. It is the responsiblity of the Laboratory to ensure that this work instruction is adhered to. Personnel working in the Laboratory shall ensure that the defined house keeping activities are followed.

5. PROCEDURE

Safety Precautions: Cleaning activities shall only be done at the time when test sample is not on test and taking care of any warning signs placed at designated locations.

The working environment plays a major part in the selection of appropriate testing equipment. Selecting the wrong equipment can have a detrimental effect on the test result obtained from the test.

Special consideration should be given to equipment for use where it will be exposed to natural hazards, extreme temperatures, high or low pressure, wet, dirty , mechanical or physical damage.. Thus the following checks should be checked before starting the test:

- Set room temperature and humidity monitoring devices at appropriate positions and keep the record.

- Easily accessible means of disconnection/isolation from the supply.
- The equipment is operated with all protective covers
- There are no unprotected cable runs.

6. Flow Chart

6.1 House keeping activities shall be carried out in accordance with the testing laboratory procedure for security, and confidentiality.

6.2 Cleaning of testing facility shall be done once a week according to the duty roster shown in Appedix A,and B. Mantenance of test facility shall be done periodically prior to calibration with maintenance activities

6.3 The Laboratory technician is responsible with the assistance of the cleaner carrying out the dusting and arrangement of test facility before starting the testing process.

6.4 Laboratory technicians and helpers shall ensure that they keep their working area clean and tidy at all times. Measuring instruments, tools and other equipment shall be kept in an orderly manner during use and returned to their respective locations immediately after use.

6.5 If the floor becomes dirty or wet as a result of any testing activity, the testing technican informs the cleaner and ensures that cleaning is done to his satisfaction.

6.6 Equipment manuals and standards are kept in appropriate files that are kept in the laboratory closed shelfs. Any rettrieved mannual or standar for use shall be returned by the user to the approprate file.

6.7 Every laboratory personnel shall remove from the working tables any files, books, and equipment mannuals which they have finished using and return them to their respctive lications in the cabinet.

6.8 Custody of laboratory keys shall be kept according to the roster shown in appendix C, D and E

6.9 Only authorized personnel shall be allowed to enter to the laboratory.

6.10 The lab-personnel in custody shall be responsible for opening and locking the laboratory at the beginning and the end of working hours.

6.11 At no one time shall the laboratory be left open and unattended by at least one of the laboratory personnel. No visitors shall be left in the laboratory alone.

7.0 APPENDICES

7.1 Appendix a = Duty Roster for cleaning of test equipment

7.2 Appendix b= Duty Roster for arrangement of working documents

7.3 Appendix c= Duty Roster for custody of keys

7.4 Appendix d = Personnel authorized to operate test equipment

8.0 ASSOCIATED DOCUMENTS

Appendix A = Duty Roster for cleaning of test equipment. A duly filled and up to dated duty roster in the format shown below shall be dispelayed on the laborartory notice board.

Month	Name of Responsible Technician	
	Testing Laboratory I	Testing Laboratoryu II
Hamle		
Nahase		
Meskeram		
Tikmet		
Hidar		
Tahisas		
Tir		
Yekatit		
Miazia		
Ginbot		
Sene		

Not : Wehn a technician is on leave, the technician responsible the following month takes over.

Signed:______________________ Date:________________________

Appendix B: Duty Roster for arrangement of working documents

A duly filled and up to date duty roster in the format shown shall be displayed on the laboratory notice baord.

Month	**Responsible Technician**
Hamle	
Nahase	
Meskeram	
Tikmet	
Hidar	
Tahisas	
Tir	
Yekatit	
Megabit	
Miazia	
Ginbot	
Sene	

Note: When a technician is on leave the technician responsible the following month takes over.

Signed:______________________

Date________________________

Appendix C : Duty Roster for custody of keys

Aduly filled and up to date duty roster in the format shown below shall be displayed on the laboratory notice board.

LABORATORY	RESPONSIBLE TECHNCIAN		
	Responsible	Alternative I	Alternative II
Laboratory I			
Laboratory II			

Signed:_________________________

Date:__________________________

Appendix D : Personnel Authorized to operate Test equipment

The following laboratory personnel are authrised to use to Test equipment

1. ___________________________________
2. ___________________________________

Other laboratory staff may operate to said equipment ONLY under supervsion of any of the above listed personnel.

Appendix E = Test Method /Procedure and Document Control
Test Method /Procedure

SOP TITLE	Doc. No.
House Keeping in the Laboratory	ETS/_________________
	Issue: / Rev
	Date:
	SOFT Copy Ref.___________
Issued by:	
Signed:	Date:
Audited by:	Date:
Signed:	
Authorized by	
Signed	Date

Document Control

Copy No:	
Issued to:	
Issued Date:	
Controlled/Uncontrolled	
Location of Copy	

Note: Controlled copies of this standard operating procedure may not be copied.

Annex 9.

Standardized Electric Motors Sampling Procedure

Purpose

To outline the sampling plan and procedures for sampling of Electrical Motor or products for subsequent testing. This procedure shall be adapted for Electrical Motor efficiency evaluation of industrial electrical motors.

Scope or Field of Application

This procedure covers all industrial induction electrical Motor***s***, while the item covers 70% of the industrial application. Due to dimensional, capacity, performance and other physical features electrical Motors, there is no sampling exclusion. Sampling will be taken from all manufacturers or maintenance shops in agreement that will be set between the regulatory body and motor manufacturers.

Sub-sampling performed in the test laboratory is carried out according the tests in standard operating procedure or test method set for the sample Electrical Motor;

Representative Sample

There must be a minimum of 2- samples in each sampling steps that is taken from the whole product, or production batch. For the characteristics identification of the Electrical Motor, one pair of new Electrical Motor will be taken with the main sample.

Responsibilities

The individual authorized by the regulatory body or the laboratory taking samples is responsible for:

- sample contents and history
- taking a representative sample from product
- integrity of the sample

Materials Required

Sampling equipment and ambient conditions (proper tools, transport handling frame).

Sampling containers and packing (essential to prevent damage during transport or storage).

- ✓ Tamper proof seals (for legal samples)
- ✓ Support letter and Sample submission form
- ✓ Chain of custody form (for legal samples)

Procedure

Sampling Plans:- Each sampling plan must fulfill the following criteria:

Administrative arrangements

- sampling personnel: EEA representative or delegated authority
- representation of stakeholders concerned: EEP, electrical motor producers, assembly plants, repair workshops, and industrial sector representative etc.
- safety, and security precautions: As per the safety precaution stated in the product standard document
- Identification and inspection of the lot prior to sampling (important in survey sampling for identification, condition of the lot, and selection of the method of sampling).
- Sampling procedures (as agreed by the regulatory body and the laboratory performing the test)
- sample size: Minimum of 2 –samples
- Samples will be collected by the EEA or an organ delegated by EEA
- As per the agreement reached between EEA and the producer, samples are selected
- Packing, and marking of samples and sample containers (identification of units)
- sealing of sample containers
- marking
- packing samples for storage or transportation, type of container used

- Precautions during storage and transportation of samples, expected danger on the collected samples, (fragile, transport handling position)
- Sampling report

- administrative details
- details of unit packs or enclosure containing the samples
- marking and sealing of samples

Key Activities for Sampling: *Sample Contents and History*

1. Thoroughly complete the sample submission form.
2. Record visible signs of potential alteration.
3. Record identity of product, lot # / code dates, time of sampling, and any other information as necessary.
4. Label sample with indelible marking pens.

Representative Sample

1. Obtain clear guidelines for the sampling to be done.
2. Choose proper units to be sampled, suitable number of samples (may be based on agreement between the producer and the regulatory, if it is on purchase based sampling, there must be at least three randomly selected samples from the periodical lot), and choose the right area to sample.

Sample Integrity

1. Consider the necessary handling, storage, and transportation arrangements involved after sampling.
2. Ensure samples are transferred to the appropriately labeled sample storage area.
3. Pack samples to prevent breakage.
4. Transport to the test laboratory by the most rapid method so samples can be examined as soon as possible to minimize rescue. .

Documentation

Completed sample submission forms are received at sample reception and forwarded to the laboratory.

Reference Procedures

Specifications set out in individual sample plans

Code # – Handling of Test Items

References

"Household Electrical Appliance Standard Method of Sampling from a Lot," ISO Catalog, International Organization for Standardization,