Consulting Report on Energy Efficiency Standards and Labeling for Electric Motor in Ethiopia

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KOREA ENERGY AGENCY

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Summary

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 ensure those developments, energy as one of the main resources of industries must be utilized efficiently. One of the mechanisms of saving energy is using energy efficient motors industries.

EE S&L of indigenous and some imported products, which is prioritized according to their energy consumption and lose has been started since 2015. Based on the strategy for household appliances the followings are prioritized: Injera mitad and cook stove, Electric ovens and cooking plates, Refrigerators, Air conditioning machines, and Clothes washing machines. From industrial equipment electric motor has been selected.

Ethiopia has been preparing the regulation and standard related to EE S&L since 2013 under Ethiopian Energy Authority. As shown in the Table below Ethiopia's MEPS is anticipated to be IE2 from 0.12kW to 1,000kW in the near future- Year 2021 and the motor efficiency test standard of single speed, three-phase squirrel cage induction motors IEC 60034-2-1 as more than 23 countries adopt

Item	Ethiopia
Regulation/Standard	Preparing
Organization	Ethiopian Energy Authority
Year first Introduced	2017
Latest Revision	2021
MEPS (IEC equivalent)	IE2 0,12kW-1000kW
Test Standard	IEC 60034-2-1
Common feature	single speed, three-Phase squirrel cage induction motors
Power Range	0,12KW to 1000kW
Speed	2,4,6 and 8 poles
Voltage	600V or less
Awareness Program	Eased on EEA's web-site's information
Incentive Scheme	Based on grant and technical support

In case of Ethiopia energy saving of 6127 GWh can be obtained from 2017 to 2024 by implementing of the EE standards and labeling of electric motors. A trial period could be utilized as a measure to

weaken a impact on the market and the industries of Ethiopia and voluntary agreement with them promoted before implementing EE S&L.

I. Background

1. The need for energy efficiency standards and labeling program of electric motor

Industries use electric motors for almost all processes, as they drive both core industrial processes, like presses or rolls, and auxiliary systems, like compressed air generation, ventilation or water pumping. With only some exceptions, electric motors are the main source for the provision of mechanical energy in industries. Those motors are the most prevalent and energy-intensive machines and 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. 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 more profitable and competitive.

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. Other electric energy customers like service and commercial sectors use electric motors especially for motor driven appliances.

Motors which exist 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), which are not yet introduced in Ethiopian industries.

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

As stated above clearly most of the problems mentioned above can be solved by implementing EE S&L (Energy Efficiency Standards & Labeling) program of electric motor in the country and also developing appropriate testing facility for those products. An energy efficiency standard is a regulation that prescribes minimum energy performance which is the maximum energy consumption that the energy-using products (i.e. household appliances, lighting products and other energy-consuming equipment) can consume to run

their main functions. Energy efficiency labels are information labels attached to manufactured products indicating the product's energy efficiency rating or estimated annual energy use in order to provide consumers with the data necessary to make an informed purchase. Consequently, EE S&L can prohibit the sale of products of which energy consumptions are higher than the minimum specified standards and create markets for energy-efficient goods and services by gradually eliminating low-cost, inefficient appliance models and by stimulating the development of more efficient technologies, labels and standards increase a country's overall energy efficiency, That is, EE S&L is the easiest one among various ways to save energy and reduce GHGs emission as well.

2. Global Electric Motor Market

In 2014, 45.8 million low voltage motors were sold globally. The volume is estimated to grow to 51.6 million by 2019 representing a 2.5% annual growth rate. In 2014 the shares of different efficiency classes in sales were: IE1 44% of unit sold, IE2 34%, IE3 14% and IE4 1%. Considerable transition towards more efficient motors is expected by 2019 partly driven by MEPS (see Figure 1). (Reine 2015)

In the case of low-voltage motors, the market was valued at $14.2 billion (€13.2 billion) in 2014. After accounting for 55% of the market's revenues in 2013, IE1 motors made up an estimated 51% of the market in 2014 and are expected to comprise less than 25% of market revenues by 2019. These IE1 products are sold mainly in the emerging markets that have not yet adopted any type of efficiency regulations; however, many leading suppliers are still successfully selling these motors in developed countries such as the United States and Germany. IE2 motors represented an estimated 19.5% of market revenues in 2014, but are expected to account for more than 45% of total market revenues by 2019. IE3 motors accounted for only 2% of global revenues in 2010, but made up 15% of market revenues in 2014. The world market for industrial IE4 low-voltage motors is estimated to have been worth $159.2 million in 2014 with nearly 300 000 units shipped. (Reine 2015)

Variable speed drives are a commonly used technology to improve the efficiency of electric motors. The drives market is expected to continue to be one of the fastest-growing industrial automation equipment markets in the future (Reine 2015).

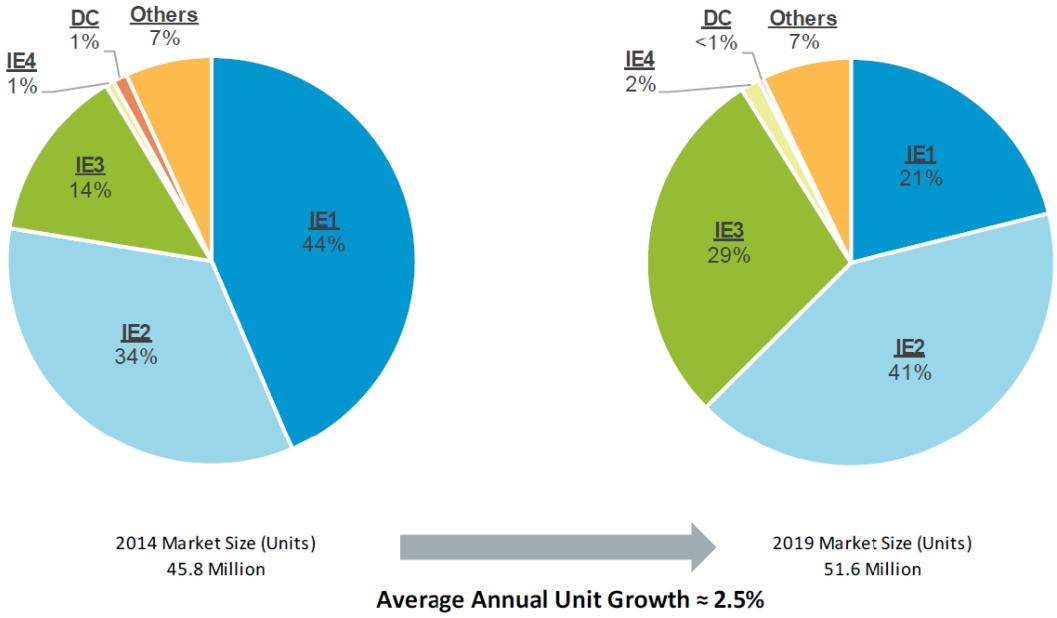

Figure 1. Efficiency class transition (units) globally (Source: Reine 2015)

3. Ethiopian Industrial Development Roadmap

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 ensure those developments, energy as one of the main resources of industries must be utilized efficiently. One of the mechanisms of saving energy is using energy efficient motors industries.

Therefore, improving the energy efficiency of electric motors by developing EE S&L program contributes to the Ethiopian Industry Development Roadmap by :

- Reducing demand on power, electric supply interruptions and outages, electrical infrastructure congestion, infrastructure, and capital investment in energy supply infrastructure,
- Saving energy to the industries and the nation, thereby enhancing national economic efficiency by reducing energy bills.
- Strengthen market competition among electric motor importers
- Improve the quality of electric motors used in the industries.
- Encourager research and innovation, and
- Assist the country in meeting climate change goals and averting regional pollution.

4. EE S&L in Ethiopia

As new electricity connections supported by the Government-sponsored rural electrification program increases, the end-user access to electricity is also increasing. As a result an increase in appliance usage is also expected to increase due to increased consumers connected to the grid combined with anticipated economic growth. Therefore implementing EE S &L program in Ethiopia has been considered as one of the best options to reduce growing loses.

Ethiopia, at the moment, cannot develop its own ee S &L because the capacity in Ethiopia for developing EE S &L from scratch is limited due to the characteristics of the import market. Therefore, products can be selected that are already subject to product policy in one of the major global trade blocks (EU, US, Asia). Slightly modified EU labels have been selected based on comments from various stakeholders and similar labels are already on the market. But product labels, which contain specific parameter will be developed when needed.

EE S&L of indigenous and some imported products, which is prioritized according to their energy consumption and lose has been started since 2015. Based on the strategy for **household** appliances the followings are prioritized: Injera mitad and cook stove, Electric ovens and cooking plates, Refrigerators, Air conditioning machines, and Clothes washing machines. From **industrial equipment** electric motor has been selected.

Project document for green highlighted products was developed and implementation of electric injera mitad EE S & L has been started since 2015. Locally manufactured electric stove S & L will be done in 2017/2018 and electric motor labeling will be done in 2018/2019. All the above S & L programs will be implemented on voluntary basis.

For electric Injera Mitad product standard had been developed by ESA. Samples from 7 manufacturers were procured and tested. Their efficiencies are from 54% to 79% and MEPS for electric Injera Mitad was determined. Labeling Logo was developed and commented by stakeholders meetings. Other projects will follow based on the results and experiences obtained from those projects. In addition to the labeling program the EEA (Ethiopian Energy Authority) is also supporting development of energy efficiency products and research activities.

For the development of high efficiency injera mitad agreement has been signed with KEA. Proto type development has been completed. Energy efficiency testing for the prototype was done by MoWIE Alternative Energy Promotion Directorate testing lab and showed very encouraging result.

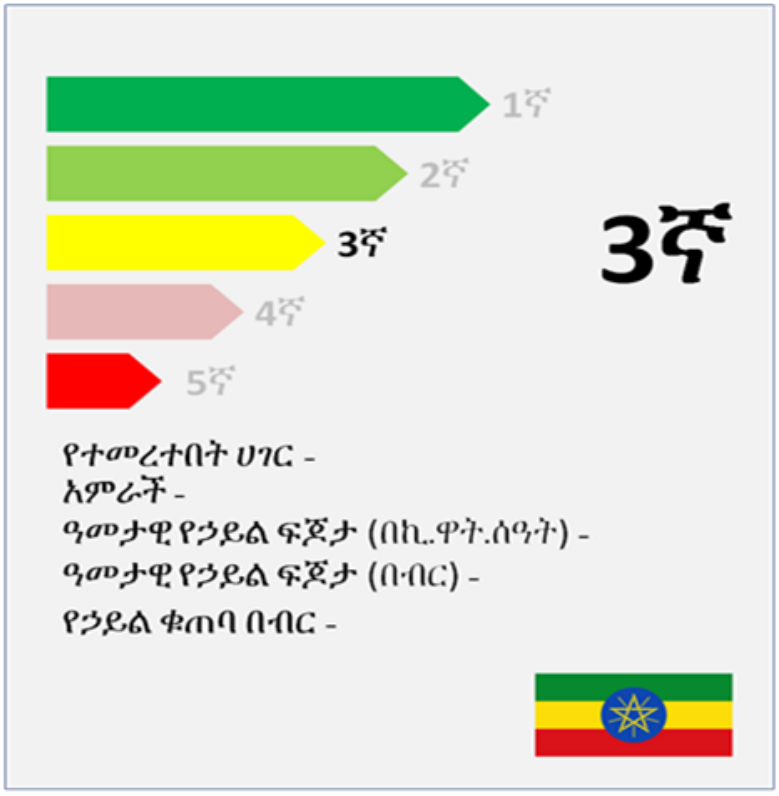

Figure 2. EE S&L logo of Ethiopia

II. Regulatory policy measures

For the development and implementation of effective EE S&L program for electric motors in Ethiopia it needs to review international best practices for regulatory policy measures and non- regulatory policy measures. Here regulatory policy measures include regulations, scope of regulatory electric motors, motor efficiency test standard and MEPS. Through reviewing such regulatory policy measures Ethiopia can have deep insight for implementing EE S&L successfully.

1. Laws and regulations

Globally, the regulations on electric motors were first introduced in all around North America. The United States implemented standards through the Energy Policy Act of 1992, but it was not until 2007 that the standards were applied. This so-called EPAct 92 standard was comparable to the IE2 class but the US has already initiated the IE3/NEMA Premium Motors shift in 2010. In Canada the first requirements came into force in 1997 and Mexico adopted the US EPAct standard in 1998. (IEA 2011, Unido 2011)

Brazil and China issued the first MEPS in 2002 but these concerned standard efficiency motors. MEPS for IE2 level took force in Brazil in 2009 and in China in 2011 and Brazil is considering shift to the IE3 level in 2017. Australia and New Zealand have set the MEPS at the IE2 level since 2006. Other countries with MEPS at the level of at least IE2 include Chile (2011-), Israel (2008-), South Korea (2013/IE2 level, 2015/partly IE3 level), Switzerland (2011/IE2, 2015/same level as Eco-design in Europe), Taiwan (2015-) and Turkey (2015-, same level as Eco-design in Europe). In addition, a number of countries have implemented requirements at IE1 level. (Almeida et. al. 2008, Siemens 2015, Unido 2011) In India a voluntary motor standard was first adopted in 2004 and revised in 2011 covering IE2 and IE3 motors. MEPS at the level of IE2 are under preparation and expected to be adopted during 2016. At present, IE1 motors or those with lower efficiency are imported to India from countries which themselves have issued MEPS and manufacturers take the opportunity to export lower efficiency motors to India as these products cannot be sold in the domestic market anymore. Indian manufacturers of efficient IE3 and IE4 motors usually export their products instead of selling them in the domestic market. (Kumar 2016)

In the EU, the first MEPS were issued in 2009 and by the implementation of the Eco-design Directive. From June 2011, IE2 level was required and further requirements took effect in. The relatively late introduction of the MEPS in Europe followed a period of Voluntary Agreement with the industry, which had had a limited impact on the market. Existing regulation only covers part of the electric motors placed on the market and the European Commission has initiated preparatory studies to evaluate the possibility of extending the scope to motors outside the current power range and to technologies other than three-phase induction motors. (Almeida et. al. 2015)

In 2015, Japan included electric motors into its Top-runner Programme. It is quite different in structure from traditional MEPS. The Top Runner Programme triggers race to the top among manufacturers because the product on the market with the highest energy efficiency (the Top Runner) sets the standard (energy efficiency improvement target) for others. In each product group the standard is revised every 3-4 years.

Figure 3 shows the annual realised and expected motor sales by efficiency class. It also relates the past and expected development to the introduction of progressive MEPA in some large market areas. Sales of IE1 motors are expected to somewhat decline by 2018 while the sales of IE2 and IE3 motors are expected to grow strongly. As the total volume of sales is growing, the proportion of more efficient motors in the totality is increasing.

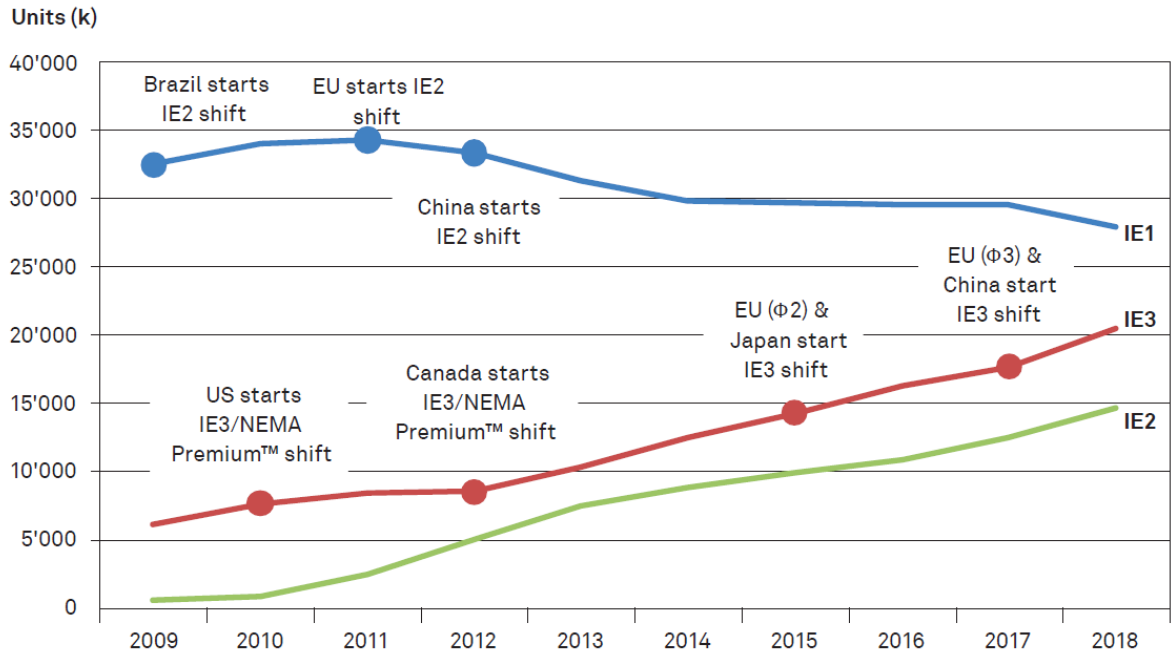

Figure 3. Policy impact on the sales of more efficient electric motors (Source: EMSA 2014)

The following table shows the brief historical characteristics of the motor efficiency-related regulation of three countries- USA, EU and South Korea. In case of **USA** laws and regulations on electric motors are firstly introduced through Energy Policy Act of 1992. This act covered 1 to 200 HP electric motors. And it also was the first time in the world. This act was amended in 2005. At that time Premium Efficient motor was introduced. Energy Independence & Security Act of 2007 covered 1 to 500 HP and some of 1 to 200 HP were requested to be Premium efficient. Latest version of regulation was published in May 2014. In this almost all motors will be covered at **Premium Efficiency** levels.

EU introduced **ecodesign** requirements for electric motors in 2009. It was 17 year later than USA because EU is composed of 28 countries and it takes a lot period to determine some political issues, At that time **IE2 efficiency level** was adopted. In **Commission Regulation (EU) No 4/2014 mandatory minimum efficiency levels** for motors was set in the European market and IE3 level was adopted about 7.5 to 375kW.

In Korea Regulation on electric motor was introduced through **Rational Energy Utilization Act** in 2008 a year or faster than EU. It covered 0.75 to 385kW.

Table 1. The brief historical characteristics of the motor efficiency-related regulation of three countries - USA, EU and South Korea

Country	Regulations
USA	**Energy Policy Act of 1992** • Effective October 1997 • General Purpose 1-200 HP aMG1, table 12-11 Energy Efficient **Energy Policy Act of 2005** • Raised purchases for government to table 12-12 Premium Efficient(by executive order from president) **Energy Independence & Security Act of 2007** • Effective December 2010 • General Purpose 1-20 HP EPAct motor 12-12 Premium Efficient • Other 1-200 HP motor at table 12-11 Energy Efficient • 201-500 HP motors at 12-22 Energy Efficient **Amended Integral HP Rule** • Published May 29th 2014 DOE amends motor efficiency • Replaces Energy Independence & Security Act of 2007 • Take effect 24months after Finale Rule(June 1, 2016) • Almost all motors will be covered at Premium Efficiency levels NEMA MG 1, Table 12-12 or Part 20, Tabled B(IE3) • Improved definitions and testing guidelines
EU	**Commission Regulation (EC) No 640/2009** • implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors • motor″ means an electric single speed, three-phase 50 Hz or 50/60 Hz, squirrel cage induction motor • Effective from mid-2011 • IE2 efficiency level **Commission Regulation (EU) No 4/2014** • 6 January 2014 • amending Regulation (EC) No 640/2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors • These regulations set mandatory minimum efficiency levels for motors in the European market • covers 2-, 4- and 6-pole, single speed, three-Phase induction motors rated up to 1.000 V and on the basis of continuous duty operation. • Effective 1 January 2015 • IE3(7.5-375kW)
South Korea	**Rational Energy Utilization Act** • article 15 (Designation of machinery and materials subject to efficiency management, Effective February 2008) • article 16(Post management of machinery and materials subject to efficiency

	management, Effective February 2008) **<u>Operational Regulation on Machinery and Materials subject to Efficiency Management(Ministry of Trade, Industry and Energy notification)</u>** • Effective December 2009 • 3-phase induction motors with power consumption more than 0.75kW and less than 385kW are covered. • The measurement method is based on KS C IEC 60034-2-1 in order to determine loss and efficiency of the 3 phase electric motors

Technical definition of IE classes

The percentage of the input electrical energy converted into usable mechanical energy is defined as the energy efficiency of a motor. The International Electrotechnical Commission (IEC) is an international standards organisation that prepares and publishes standards for electrical equipment. IEC Standard 60034-30-1 categorises electric motors based on their energy efficiency, either as IE1 (lowest efficiency), IE2, IE3, IE4, or IE5 (highest efficiency). IE5 is not defined in detail yet, but it is envisaged for a future edition of the standard. It is the goal to reduce the losses of IE5 by some 20% relative to IE4. The level varies with the size of the motor, as can be seen in Figure below.

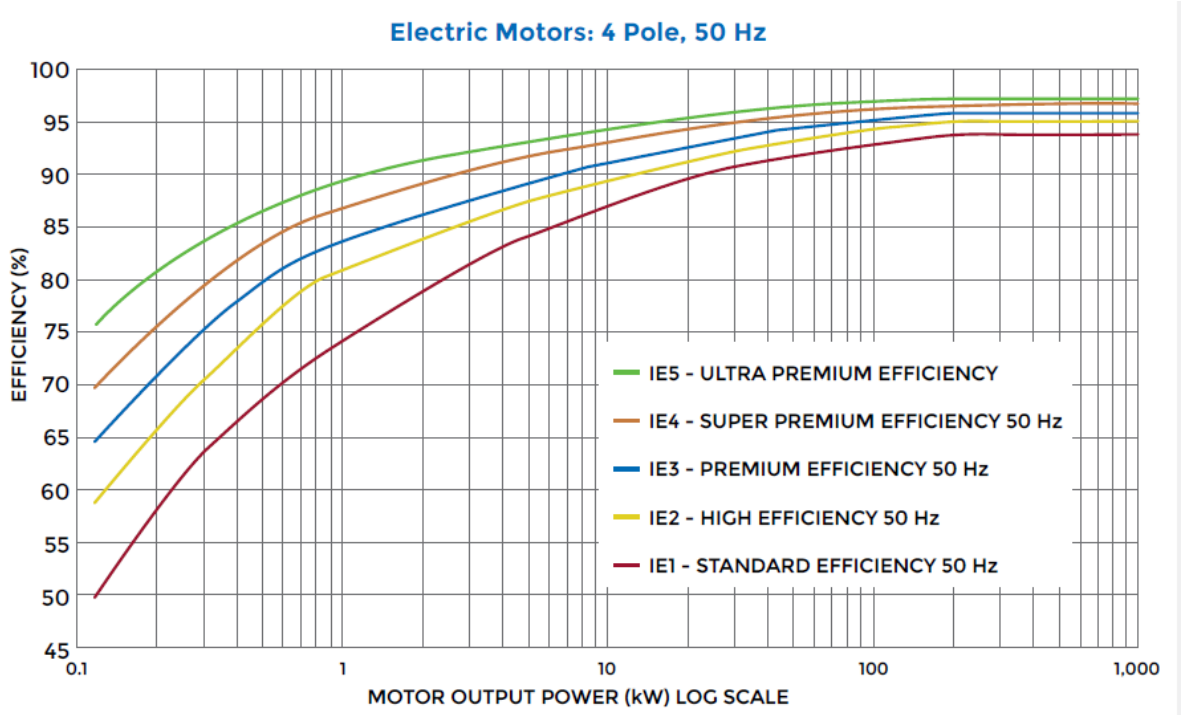

Figure 4. Example of IEC motor efficiency levels for a 4-pole motor operating at 50 H, similar curves exist for motors operating at 60 Hz17
(Source: Accelerating the Global Adoption of ENERGY-EFFICIENT ELECTRIC MOTORS AND MOTOR SYSTEMS, U4E POLICY GUIDE SERIES)

2. Scope of regulatory electric motors

As shown in Table 2 all of USA, EU and Korea regulated single speed, three-Phase induction motors. Power ranges are almost similar. Poles of electric motors regulated in EU are 2, 4 and 6 poles except 8 pole but voltage range is regulated up to 1000V. Main exclusions mainly apply to motors specifically designed in the three countries all.

Table 2. Scope of regulatory electric motors: USA, EU and Korea

Item	USA	EU	Korea
Regulation/Standard	EISA 2007	Regulation 640/2009 Regulation 04/2014 (Amendment)	Operational Regulation on Machinery and Materials subject to Efficiency Management
Year first Introduced	1997	20011(to 2017 in stages)	2008
Latest Revision	2014	2014	2017
Common feature	single speed, three-Phase induction motors		
Power Range	0,75KW to 370kW (1 – 500 HP)	0,75 kW to 375 kW	0,75 kW to 385 kW
Speed	2, 4, 6 and 8 poles	2, 4 and 6 poles	2, 4, 6 and 8 poles
Voltage	600V or less	1000V or less	600V or less
Main Exclusions	• Single phase ODP motors • Single phase Enclosed motors • C motors • Multi-speed motors • Submersible motors • Water-cooled motors	• Motors designed to operate wholly immersed in a liquid; • Motors completely integrated into a product • Motors specifically designed • Brake motors	• Motors specifically designed • TENA • Multi-speed motors

3. Motor efficiency test standard

The motor efficiency test standard of USA and Canada is based on **IEEE 112.** On the other hand EU, Australia and Korea accept IEC 50034-2-1 as the test standard. Most Countries adopt this standard as their standards because of its relative lower costs to test. To test the large number of motor models already in the market, motor manufacturers see it as a cost-effective alternative test of those motors as shown in Table 3. But the IEEE standard is much stricter than IEC Standard.

Table 3. Motor efficiency test standard: USA, EU and Korea

Country	Test standard	Purpose/scope	Remarks
USA	IEEE 112(2004)	To determine efficiency, to investigate performance of induction motors and generators	
	IEEE 113(1985)	To determine the performance of single-phase induction motors	Withdrawn
	IEEE 114(2002)	To investigate the performance of single-phase induction motors	
	IEEE 115(1955)	To investigate the performance of synchronous machines	
	ANSI/NEMA MG1	To select and apply proper motors and generators	
Canada	C390-98 (2005)	To measure the energy efficiency of three-phase induction motors rated 0.746kW at 1800 rpm (or equivalent) and greater.	Very similar to IEEE 112-B
	CAN/CSA C22.2 No. 100-04	To investigate performance of motors and generators.	This is the Canadian equivalent to ANSI/NEMA MG1
EU	IEC 60034-2 (1962)	To establish method of determining efficiencies from test, and also specifies method of specific losses	It applies to DC machines and to AC synchronous and induction machine of all sizes
	IEC 61972(2002)	This test standard, developed as a possible replacement of IEC 60034-2 in what concerns three-phase induction motors, allows two methods to determine their efficiency and losses.	Method 1 – Input-output method (Similar to IEEE 112-B) Stray load losses determined from measurements. Method 2 – Indirect method(assigned variable allowance)
	IEC 60034-2-1	This new version of IEC 60034-2 was approved by 23 countries in favor, 5 abstentions and no disapprovals. It introduces the Eh-Star test as a recognized method to determine additional load losses of induction machines	Because of its relative lower costs to test the large number of motor models already in the market, motor manufacturers see this method as a cost-effective alternative tests of those motors
Australia	AS 1359.102	This standard establishes methods of determining efficiencies from tests, and also specifies methods of obtaining particular losses when these are required for other purposes. It applies to DC machines and to AC synchronous and induction machines of	It is expected that the Australian Standard will shortly collapse to follow the revised international standard IEC 60034-2

		all sizes within the scope of IEC 60034-1.	
Korea	KS C IEC 60034-2-1	This determines loss and efficiency of the 3 phase electric motors.	Korean version of IEC 60034-2-1

Source: Renewable and Sustainable Energy Reviews 14 (2010) 877–898

The table below shows the minimum accuracy requirements of the instruments used to test the motor efficiency. It can be seen that the requirements for IEEE 112-B are significantly stricter than for IEC 34-2. For this reason and taking into account the revision of IEC standard, the minimum accuracy requirements for new laboratories should be based on the requirements of IEEE 112-B.

Table 4. Instrumentation accuracy of efficiency testing standards

Unit	IEC 34-2	IEEE 112 (Method 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% f_N
Speed(RPM)	±2	±1
Torque(N·m)	---	±0.2%
Ohms	±0.5%	±0.2%
Temperature(°C)	±2	±1

(Source: Efficiency Testing of Electric Induction Motors, Anibal T. De Almeida and Fernando Ferreira, ISR, Dep. Eng. Electrotecnica, University of Coimbra)

4. MEPS (Minimum Energy Performance Standards)

The minimum efficiency value that a motor must meet in order to qualify for registration and importation in USA, EU, China and Japan is at the moment IE3(Premium Efficient) and IE3 will be MEPS in Korea since 2018 as shown in Table below. So manufacturers in such countries are prohibited from branding or marketing motors as high efficiency unless they qualify.

Table 5.MEPS for main countries
(Source: MEPS regulations worldwide, www.siemens.de/international-efficiency)

	Australia	China	Japan	Korea	EU	USA
Voltage/ Frequency	Voltage up to 1100 V, Frequency: 50 Hz	Voltage up to 1000 V, Frequency: 50 Hz	Voltage up to 1000 V, Frequency: 50/60 Hz	Voltage up to 600 V, Frequency: 60 Hz	Voltage up to 1000 V, Frequency: 50 Hz	Voltage up to 600 V, Frequency: 60 Hz
Regulation/ Directive/ Standard	AS/NZS 1359.5:2004 (MEPS)	GB18613-2012		MKE-2015-28 KS C IEC60034	EU regulation 640/2009 EU regulation 04/2014 IEC 60034-30-1	Energy Conservation Standards for Commercial and Industrial Motors, Final

						rule: 2014 EPAct; EISA 2007; NEMA MG-1 Table 12-12 und Table 12-11;
Year	2016	2017	2016	2018	2017	2016
Power range [kW]	0.75 – 185	0.75 kW – 375 kW	0.75 kW - 375 kW	0.75 kW - 200 kW(1 HP - 275 HP, 2, 4, 6, 8 pole): IE3 mandatory from 01.10.2018 225 kW - 375 kW(275 HP - 500 HP, 2, 8 pole): IE2 mandatory from 01.10.2016 225 kW - 375 kW(275 HP - 500 HP, 4, 6 pole): IE3 mandatory from 01.10.2016	0.75 kW - 375 kW	0.75 kW - 150 kW(1 HP – 200 HP, 4,6,8 pole): NEMA Premium Efficient mandatory from 01.06.2016 on for NEMA Design C 0,75 kW - 375 kW(1 HP – 500 HP, 2,4,6,8 pole): NEMA Premium Efficient mandatory from 01.06.2016 on for NEMA Design A & B and fire pumps
Power range [HP]	1 HP – 250 HP	1 HP – 500 HP	1 HP – 500 HP		1 HP – 500 HP	
Poles	2, 4, 6, 8	2, 4, 6	2, 4, 6		2, 4, 6	
Minimum efficiency	IE2 mandatory since 31.03.2006	IE3 mandatory from 01.09.2017	IE3 mandatory since 01.04.2015		IE3 or IE2 with variable speed drive mandatory from 01.01.2017 on	

Exception:

1. Australia

1) Motors designed to operate wholly immersed in a liquid;
2) Motors completely integrated into a product (for example gear, pump, fan or compressor) of which the energy performance cannot be tested independently from the product;
3) Pole-changing motors;
4) Duty type S2;
5) Torque motors;
6) Re-export motors (from Australia/ New Zealand).

2. China

1) Motors completely integrated into a machine (for example pump, fan and compressor) that cannot be tested separately from the machine;
2) Special design motors for special application environment such as application in high altitudes exceeding 1.000 m above sea level;
3) Special design motors for special application such as smoke-extraction motors, textile industry specified motors and etc. ;
4) Motors designed for variable conditions, such as inverter duty motor;
5) Motors with integrating brake inside;
6) Motor working duty with non S1 or S3 with a rated cyclic duration factor of 80 % or higher;
7) Dual-windings and/or multi-windings motors;
8) 60Hz motors (only 60Hz data on rating plate);
9) IC 416 motor for DOL and VSD use.

3. Japan

1) Explosion proof motors;
2) Special insulation (Temp class H, N, R, 250);
3) Delta-star starting;
4) Marine motors;
5) Motors designed to operate wholly immersed in a liquid;
6) High-slip motors;
7) Gate motors;
8) Canned motors;
9) Used in very low temperature (designed for lower than -20 degree C);
10) Motors, designed only for inverter duty and with forced ventilation.

4. Korea

1) Motors specifically designed to operate:
i) at altitudes exceeding 1 000 meters above sea-level;
ii) where ambient air temperatures exceed 40 °C;
2) Duty type different to S1;
3) Motors specially designed for inverter duty;
4) Motors designed to operate wholly immersed in a liquid;
5) TENV and TEAO enclosure (totally enclosed non-ventilated, totally enclosed air over);
6) Pole changing motors;
7) Torque curve: Design C and D;
8) Water cooled motor as similar to TEAO.

5. EU

1) Motors designed to operate wholly immersed in a liquid;
2) Motors completely integrated into a product (for example gear, pump, fan or compressor) of which the energy performance cannot be tested independently from the product;
3) Motors specifically designed to operate:
i) at altitudes exceeding 4.000 meters above sea-level;
ii) where ambient air temperatures exceed 60 °C;
iii) in maximum operating temperature above 400 °C;
iv) where ambient air temperatures are less than – 30 °C for any motor or less than 0 °C for a motor with air cooling;
v) where the water coolant temperature at the inlet to a product is less than 0 °C or exceeding 30 °C;
vi) in potentially explosive atmospheres as defined in Directive 94/9/EC of the European Parliament and of the Council;
4) Brake motors;
5) Duty type different to S1 or S6;
6) Motors specially designed for inverter duty;
7) Pole changing motors.

5. Organizations for Implementing EESL

General agency of managing EESL in USA is US DOE(Department of Energy). Its r**elated agencies, institutions & coalition are:**

- US Environmental Protection Agency,
- Lawrence Berkeley National Laboratory
- NEMA(National Electrical Manufactures Association),
- American Council for an Energy-Efficient Economy, Alliance to Save Energy,
- Appliance Standards Awareness Project,
- Natural Resource Defense Council,
- Earhjustice,
- Northeast Energy Efficiency Partnership,
- Northwest Energy Efficiency Alliance,
- Pacific Gas and Electric, etc.

Testing of motors has to be conducted under US DOE. Each manufacturer has to request a Compliance Certification (CC) number from the Department of Energy (DOE) and motors have to be pre-validated before they can be introduced into the market.

General agency of managing EESL in EU is European Commission. Their **Related agencies , institutions & Coalition are:**

- ESOs (European Standardization Organization)
- CEN (European Committee for Standardization),
- CELELEC(European Committee for Electrotechnical Standardization)
- CEMEP(European Committee of Manufacturers of Electrical Machines and Power Electronics), etc

Testing of motors is based on Self-declaration process. Manufacturers can declare that their product is compliant to EC Directives by placing the CE mark on the motor(There is no requirement for advance registration or qualification process).

General agency of managing EESL in Korea is **Korea Energy Agency. There are two types of testing laboratories: Testing Laboratories under Korean government** and **Private Testing Laboratories. Both of them** have to get accreditation from the Ministry of Trade, Industry and Energy to measure the efficiency of electric motors.

III. Non-regulatory policy measures

Non-regulatory policy measures can be considered to be a kind of key motivation to accelerate the penetration of efficient electric motors in the industries of Ethiopia. It includes awareness raising, training program (capacity building and tool), subsidies, tax rebates and incentives, etc. Such measures may be available for procurement of efficient motors and in developing countries and investments may be financed by government and international financing institutions. Financing can also be enabled by soft loans with low interest rates and interest-free grace period particularly among small and medium sized enterprises while third party financing by energy service companies (ESCOs) may be an option for larger industries. Here non-regulatory policy measures which can be applied to Ethiopia will be reviewed through studying best practices of main countries.

1. Awareness Program

The awareness program of USA is **Appliance Standards Awareness Project (ASAP)** under US DOE which was founded in 1999 and dedicated to increasing awareness of, and support for, appliance and equipment efficiency standards at the federal and state levels. It leads a coalition of energy efficiency advocates that participate in DOE rulemakings on appliance efficiency standards and test methods and negotiate consensus standards with manufacturer organizations and provides advice and technical support to states interested in advancing their standards. Between 2007 and 2011, ASAP and allies led the pro-efficiency advocacy effort in every active **DOE standards-setting process**. These covered more than **30 products** and resulted in **new or updated standards for more than 15 products(Source:** https://appliance-standards.org)

EU′s awareness program is **4EM-MCP(Motor Challenge Programmem, under SAVE group developed by European Commission** which was launched in Brussels on 24-25 January 2006. It created a European framework to encourage top level decision makers to adopt energy savings measures as management priority. raised awareness of the potential for energy and money saving measures and made a wide range of information tools available. Public recognition of the efforts was made by companies that have committed to energy saving "Action Plans" through the use of the MCP logo, catalogues, etc. The 4EM-MCP was undertaken by the Consortium consisting of 9 Project partners from 6 countries: Bulgaria, Romania, Hungary, Italy, Portugal and Poland(Source: https://ec.europa.eu/energy/intelligent/projects/en/projects/4em-mcp**)**

Korea's awareness program is **Energy Efficiency Management System under KEA(Korea Energy Agency)** founded in 2010. It helps customers to buy high efficiency products, urges the industries to develop energy efficiency technologies and makes transition into high efficiency equipment market possible and gives to customers the following information (Source: KEA homepage):

- Regulation explanations
- High efficiency product search
- Supporting/Incentive scheme
- Calculation of payback-period

- Saving know-how.
- Events notification,
- Testing Laboratories. etc

2. Financial scheme

(1) Subsidies

It is quite usual that subsidies are given to promote energy efficiency. Energy efficient motors and VSD(Variable Speed Drive)s are among the commonly supported technologies. Subsidized energy audits promote a bit more indirectly the shift to better efficiency. In developing countries investments may be financed by international financing institutions instead of government policies and programmes.

Eskom in South Africa launched an **Energy Efficient Motors Programme** in mid-2007. The programme promotes the replacement of old, inefficient motors with new, highly-efficient motors, through subsidizing the purchase cost. Efficient motor suppliers registered with Eskom are directly paid the subsidy, resulting in an immediate discount off the purchase price for the consumer. For motors to be subsidized, the suppliers must be accredited by Eskom, for the company's financial status and the motors technical specifications to be verified and approved. The purchaser must trade in their old motor, along with all components, for scrapping. Subsidies ranging from ZAR 400 to ZAR 3,500 (27-233 Euros) are offered for premium efficiency motors. Eskom regularly performs random process compliance audits, while an independent measurement and verification body will verify the megawatt savings achieved by the programme (Source: IEA Energy Efficiency Policies and Measures Database).

Determining the subsidy amount

The subsidy amount is calculated to cover most of the cost of the difference between the average motor supplier′s catalogue price of Eff1(High Efficiency) and Eff2(Standard Efficiency) motors, thus incentivizing the purchase of Eff1 motors over Eff2 motors. Shown in table below are the 100% load efficiency values of 2- and 4-pole Eff1 motors with the respective subsidies which, depending on the size of the motor, range from R400 to R3,500.

Table 6. Eskom subsidy table (to be revised Sept 09 www.eskom.co.za/dsm)

kW Rating	4-pole Eff1	2-pole Eff1	DSM Subsidy
	Eff(%)		
1.1	≥83.8	≥83.8	R 400
1.5	≥85	≥84.1	R 400
2.2	≥86.4	≥85.6	R 500
3	≥87.4	≥86.7	R 500

4	≥88.3	≥87.6	R 500
5.5	≥89.2	≥88.5	R 700
7.5	≥90.1	≥89.3	R 700
11	≥91	≥90.6	R 700
15	≥91.8	≥91.3	R 700
18.5	≥92.2	≥91.8	R 1,000
22	≥92.6	≥92.2	R 1,300
30	≥93.2	≥92.9	R 1,400
37	≥93.6	≥93.3	R 1,700
45	≥94.9	≥93.7	R 2,200
55	≥94.2	≥94	R 2,600
75	≥94.7	≥94.6	R 3,000
90	≥95	≥94.6	R 3,500

Energy efficient motor savings calculation

When replacing a standard 22kW (Eff3) motor with a premium efficiency 22kW (Eff1) motor as part of the Eskom energy efficient motor programme the benefits will include a once-off rebate of R1 300 on the catalogue price; an energy saving of 9,05kWh/year or R5 071 and the payback period reduced by 4 months as illustrated in table 2 opposite.

- Energy price (R/kWh) = 0.56 (Megaflex, peak, high-demand season)
- Power factor = 88%
- Purchasing price (Eff1) = R16 100
- Subsidy contribution = R1300 (Eff1, 22kW; 4-pole)

Table 7. Energy efficient motor savings calculation

(Source: http://re.jrc.ec.europa.eu/energyefficiency/eurodeem/index.htm)

Motor Characteristics	Old motor (Eff3: Low Efficiency)	Replacement motor (Eff1)	Saving
Type	22kW 4-pole	22kW 4-pole	
Efficiency	86.6%(Original)	93.1%	
Efficiency loss operating life	-2%(due to repair)		
Differential Cost(R)		14,700	
Energy use(kWh/yr)	129,524	120,468	9,056
Energy cost(R/yr)	72,533	67,462	5,071
Payback(yrs)	2.89		

(Source: Eskom Holdings Limited Reg No 2002/015527/06, Issued by Eskom Demand Side Management October 2009)

In **Turkey**, Several financial incentive programs are offered to industries for realizing energy-efficiency improvements. In case of **YEGM Productivity Enhancement Project (EIP)** Energy-saving measures identified through energy audits can benefit from grants up to 30% of the cost of the investment required, with an upper limit of 300,000 TL (about 52 200 Euros).. The payback period should be 5 years or less (www.eie.gov.tr). For **KOSGEB(Small**

and Medium Enterprises Development Organization) SMEs(Small and Medium Enterprises) with an annual energy consumption higher than 200 TOE can receive 50% to 60%, support depending on the region. The upper limit of energy-efficiency support is 30,000 TL(about 9500 Euros) (www.kosgeb.gov.tr).

In **Switzerland**, the **Competitive Tender Programme** which was launched in 2010 supports financially the implementation of the federal Energy Strategy 2050. Funding is granted on the basis of an auction process for projects and programs with the lowest cost efficiency per saved kWh i.e. project which would not have been implemented without the subsidy (principle of additionality). Subsidies vary from 20% (payback time at least 2 years) to 40% (payback time at least 6 years) of creditable costs. The tenders are funded by a surcharge on transmission cost in the high voltage electricity grid(Funding stemming from levy on the electricity transmission grid; up to 0.1cts./kWh). In **New Zealand**, subsidies are given for businesses that invest in energy-saving technology, in the case of motor replacement up to NZ$ 2,000 (about 1,200 Euros).

Table 8. Competitive Tenders Impacts

Competitive tenders	Projects(25%)			Programs(75%)			Total Savings (Gwh)
	Number	GWh	Euro cents per kWh (average)	Number	GWh	Euro cents per kWh (average)	
1st round (2010)	18	113	2.3	8	457	1.5	570
2nd round (2011)	32	99	4.5	13	548	1.7	647
3rd round (2012)	67	242	3.2	9	276	2.4	518
4th round (2013)	35	167	4.1	23	421	2.9	588
5th round (2014)	61	191	3.7	21	509	3.2	700
Total							3,023
Switzerland's annual electricity consumption in 2013							59,323
Proportion of Swiss Consumption							5.1%

(Source: EEMODS'15, 16 September 2015, Dr. R. Philips)

The **Chinese** "**Ten Key Projects**" Programme which is a key element of China's Medium and Long-Term Plan for Energy Conservation launched in 2004 to support the national binding goal of reducing energy intensity (energy consumption per unit of GDP) and carbon intensity (carbon dioxide emissions per unit of GDP) and it has been included both in the 11th Five Year Plan(2006-2010) and 12th Five Year Plan(2011-2015). Motor system energy conservation is among the Ten Key Projects and the objective was to improve energy efficiency by 2-3% by 2015. **Financial rewards** were given for realized energy-savings. During the 12th FYP the rate of rewards was 250 RMB (about 36 Euros) per tce (tonnes of coal equivalent) saved in East China and 300 RMB per tce saved in Central and West China. The threshold of minimum energy savings to qualify for the rewards was 5,000 tce.

Table 9. Ten Key Projects for Energy Savings

No.	Key projects	11st FYP Started Energy-Saving Goals	11st FYP Energy Saving (Mtce)	11st FYP CO2 Emission Reductions (MtCO2)
1	Renovation of coal-fired industrial boilers	35 Mt coal during 11th FYP	25	69
2	District level combined heat and power projects	35 Mtce/yr in 2010	85	244
3	Waste heat and pressure utilization	7 Mtce/yr in 2010	21	60
4	Oil conservation and substitution	38Mt of oil	8	16
5	**Motor system energy efficiency**	**20 TWh/yr in 2010**	**17**	**4**
6	Energy system optimization	Not started		
7	Energy efficiency and conservation in buildings	108 Mtce	100	323
8	Energy-efficient lighting saving	29 TWh	12	25
9	Government procurement energy efficient products	Not started		
10	Monitoring and evaluation systems	Not started		
Total			268	743

(Source: LBNL estimates and calculations based on National Development and Reform Commission (NRDC), 2006. Implementation Suggestions of Ten Key Energy-Conservation Projects during the Eleventh Five-Year Plan, NDRC Department of Resource Conservation and Environmental Protection Document #: [2006] 1457.)

The **Clean Technology Innovation Program** of **Australia** is a $200 million competitive, merit-based grant program. This Program will offer grants from $50,000 to $5 million and will fund up to 50 per cent of eligible expenditure on a 1:1 funding basis. For the purpose of the Clean Technology Innovation Program, clean technology is defined as the development and/or adaptation of an economically competitive and productive technology and/or associated services designed to deliver greater energy efficiency and/or greater reduction in greenhouse gas emissions than its alternatives(Source: AusIndustry)

Table 10. Clean technology of Clean Technology Innovation Program

Type of Technology	Examples
Technologies to generate energy from renewable and low emissions sources	Wind, Solar, Wave, Tidal, Hydro, Geothermal, Low emission coal, Bio-fuels, Cogeneration
Methods, equipment, technology and associated services to reduce energy demand or increase energy efficiency	**More energy efficient industrial equipment,** Energy efficient water treatment technologies, Waste management technologies that reduce energy demand
A component that will reduce greenhouse gas emissions via the product in which it is used	New gearing in a wind turbine to improve the efficiency of energy generation

In Europe financing is available also from the EU through structural and investment funds, particularly the **European Regional Development Fund** which supports e.g. energy efficiency in SMEs and the Cohesion Fund which supports new EU Member Countries. (EU

2015).

In Korea Motor Challenge Program was run from Jan 2012 to Dec 2014 for grant and technical development support to promote production and sale for the Premium electric motors.

(2) Soft Loans and Incentives

In **Turkey**, some preferential credit lines are supported for energy and energy-efficiency investments. TTGV offers credit for energy-efficiency investments in the range of USD 100,000-1,000,000 with no repayment needed during the first year followed by repayment over a period of four years with no interest (http://www.ttgv.org.tr/en).
Turkey development bank offers financial support for private-sector investments in renewable energy and energy-efficiency investments in the production of goods, services, construction expenses, as well as related consulting services. Support is limited to USD 50,000,000. Repayment Periods are long term (2-5 years grace period, 10-15 years at total) (www.kalkinma.com.tr).
The Turkey Private Sector Sustainable Energy Finance Facility (TURSEFF) is a framework operation with up to USD 265 million under which credit lines are provided by the European Bank for Reconstruction and Development Bank to eligible commercial banks for on-lending to private sector borrowers to support energy-efficiency and small-scale renewable energy investments. Projects funded under TURSEFF must meet certain performance criteria. Industrial and commercial energy-efficiency projects must save more than 20% in energy usage (www.turseff.org). The World Bank and French Development Agency (AFD) also provide credit lines to Turkish banks for energy efficiency financing.

A World Bank report published in March 2015 identified the following gaps:

1. SMEs have moderate access to financing. There is a lack of incentive programs specifically targeting new financing mechanisms such as energy service companies or vendor leasing.
2. Although there are a number of technical assistance programs funded by donors, they tend to be intermittent and dispersed. There is a lack of a centralized information center that provides comprehensive technical, financial, and implementation information to end users. YEGM EIP: - In the years 2012 and 2013, implementation of 67 projects was approved by the decision of the Energy-Efficiency Coordination Board for financing. - Only 3 applications for voluntary agreements were received by 2013.

(Source: World Bank ESMAP. 2015. Republic of Turkey Institutional Review of Energy Efficiency in Turkey. http://documents.worldbank.org/curated/en/2015/03/24337799/institutional-review-energy-efficiency-turkey)

In **UK** the **ECA(Enhanced Capital Allowance)** scheme provides businesses with a first year 100% tax allowance on designated energy efficient equipment investments, including energy efficient motors and VDSs(Variable Drive Systems) under Department of Energy & Climate Change. The list of eligible products (the Energy Technology Product List, ETPL) is updated monthly.

If your business pays corporation or income tax at 20%, every £10,000 spent on qualifying equipment would reduce its tax bill in the year of purchase by £2,000. In contrast, for every £10,000 spent, the generally available capital allowance for spending on plant and machinery* would reduce your business's tax bill in the year of purchase by £360. In other words, an ECA can provide a cash flow boost of £1,640 for every £10,000 it spends in the year of purchase**.

Loss-making companies can now also realize the tax benefit of their investment in ETL qualifying technologies with Payable ECAs by surrendering losses attributable to ECAs in return for a cash payment from the Government.
The amount payable to any company claiming payable ECAs will be expressed as 19% of the loss that is surrendered. So if a company surrenders a loss of £100,000, the Payable ECA it will receive is £19,000. Payable ECAs will, however, be capped. The maximum credit claimable is limited by the total of the company's PAYE and National Insurance payments for the year in which the claim is made or, if greater, £250,000

*Assuming all available Annual Investment Allowances (AIA) have been taken and standard capital allowances are being claimed, the standard rate is 18% on a reducing balances scale. A company can claim ECAs in addition to AIAs, thereby increasing total available accelerated tax allowance.
**ECAs provide 100% tax relief, so there is no further tax relief in later years. The general rate of capital allowances does not provide 100% tax relief so there is a balance of spending to carry forward on the reducing balance basis for relief in later years

(Source: A guide to equipment eligible for Enhanced Capital Allowances, Carbon Trust)

In the **Netherlands**, an asset is eligible for 41.5% deduction from the taxable profit when it is more energy efficient than standard equipment used; this means a net discount of approximately 10% of the investment costs given the 25% taxation level for Dutch businesses (Source: Policies and Measures for Promoting Efficient Electric Motors in Industry, FINAL REPORT 18 APRIL 2016).

In **France** the **Eco-Energy Loan Programme**, running since March 2012, is designed for SMEs to finance certain particularly energy-intensive technologies including electric motors(2% interest rate and range from 10 000 to 50 000 Euros for a period of five years)

In **France** "**Eco-Energy loans**" have been implemented by BPI-France since March 2012 thanks to state funding of EUR 33 million that must allow to distribute and guarantee loans of up to 100 m€. Destined to the TPE and SME, this system allows to be funded for the installation and work necessary to upgrade certain premises that consume a lot of energy.

Four categories of equipment are involved: lighting, heating, air-conditioning and electric motorization. The total amount of loans ranges between EUR 10 000 and EUR 50 000for a duration of 5 years, of which a 1-year grace period in capital. Its fixed low interest rate is of 2%. Moreover, no guarantee or individual caution may be requested to the bank manager (Source: Energy efficiency action plan for France – 2014, Ministry of Ecology, Sustainable Development and Energy).

In **Korea Soft Loan for Energy Saving Facilities & Tax Incentives** was launched in 1980 under KEA. This offers long-term and low-interest rate loans to cover part of the investments in energy saving facilities. Its interest rate is quarterly adjustable rate linked to average rate of return of 3 year negotiable Korean treasury bond(Payment terms: Payable in installments in 5 years with a three-year grace period or Payable in installments in 7 years with a three-year grace period for ESCO). Maximum 15 billion Korean Won is allowed for an entity (Maximum 30 billion Korean Won for ESCO)(Source: http://www.kemco.or.kr/web/kem_home_new/new_main.asp)

USA′s incentive program is the **Energy Incentive Program of Federal Energy Management Program under Office of Energy Efficiency and Renewable Energy**. It helps federal agencies take advantage of these incentives by providing information about the funding-program opportunities available in each state, provides information about the availability of **energy-efficiency and renewable-energy project funding** for Public purpose programs, Utility programs, Demand-response and load-management programs, Programs sponsored by state agencies designed to promote energy efficiency and renewable energy and typically funded out of general tax revenues. In 2014, over **$1.7 billion** was budgeted for energy efficiency programs in case of **California**. PG&E, SCE, SDG&E, SoCal Gas, and SWG offer **financial incentives for efficiency upgrades** that may include lighting, air conditioning, refrigeration**, motors, variable speed drives,** etc.(Source: https://energy.gov/eere/femp/energy-incentive-programs)

3. Capacity building

Training courses organized by various bodies (e.g. **the educational system, adult training organizations and motor manufacturers**) are typically quite well available for acquiring or updating skills. However, the barrier is their cost including both work time and tuition. To lower costs, on-line training modules have been developed. In addition, e.g. many energy efficiency agencies publish handbooks and brochures for information dissemination. Also motor manufacturers publish technical information and tools e.g. to help in correct specifications.

USA - The long-running tool **MotorMaster+** enables the companies to evaluate the energy efficiency opportunities of their motor-driven systems using an unbiased approach.

Motor Systems Tool developed under Electric Motor Systems Annex (EMSA) program in 2011 is intended to assist engineers, machine builders, machine component suppliers, energy consultants and others working on optimizing machine systems to benefit from reduced electricity consumption. EMAS exists since 2008 and is a cooperation of Australia, Austria, Denmark, the Netherlands, Switzerland and USA

Key objectives of the **Green Deal Programme in the Netherlands** are to encourage a wider application of efficient electric motor systems in industry by exploring and communicating the potential of motor systems in example projects, and strengthening the competitiveness of the partners by developing innovative products and services for motor systems. One of the three key elements of the Programme is knowledge transfer and communication to end users. Another one is developing a standard approach or working method for analyzing and optimizing a specific motor system. Data from practical case examples has been collected through piloting the approach. Savings range from 4-10% in cases were only older motors were replaced by premium motors up to 40% as a result of improving a total motor system. (van Werkhoven et al. 2015*)*

Representatives of the Dutch supply chain of motor systems and the government have joined forces in starting a Green Deal Program on efficient motor systems in Dutch Industry. Key aspects of this program are three fold. 1) Developing a standard method for the analysis of opportunities for efficiency improvements in motor systems. 2) Developing sound business cases on efficient motor systems, delivering concrete energy savings. 3) Knowledge transfer and communication to end users and the supply chain to create leverage in terms of working methods, capacities and energy savings.
The initiators of this specific Green Deal project the Green Deal Efficient Motor Systems are the FEDA and the Uneto-VNI. FEDA is the Federation of suppliers of Electric Motors, Drives and Automation Engineering, and Uneto-VNI is the trade association of installation and electromechanical maintenance companies.
FEDA and Uneto-VNI and twenty-eight companies from FEDA and Uneto-VNI have joined the Green Deal and are participant in the project as well as two main pump and compressor suppliers. The project has been carried out by the 30 participants, see Figure 5. The program management is done by TPA consultants in cooperation with FEDA and Uneto-VNI. The government is involved via the Netherlands Enterprise Agency as secretary of the project group and directly via the Ministry of Economic Affairs in a steering committee.

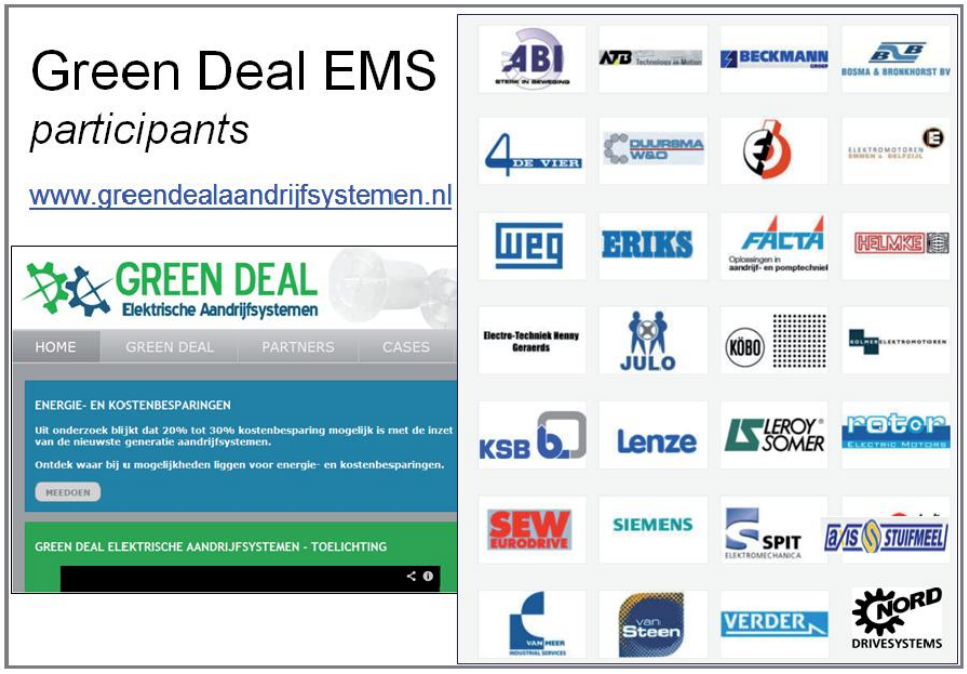

Figure 5. Partners of Green Deal electric motor systems.

In cooperation with the partners of the Green Deal Efficient Motor Systems and the (some of the) end-users of motor systems a standard approach or working method is developed for analyzing and optimizing a specific motor system. The five basic steps are shown in Figure 6

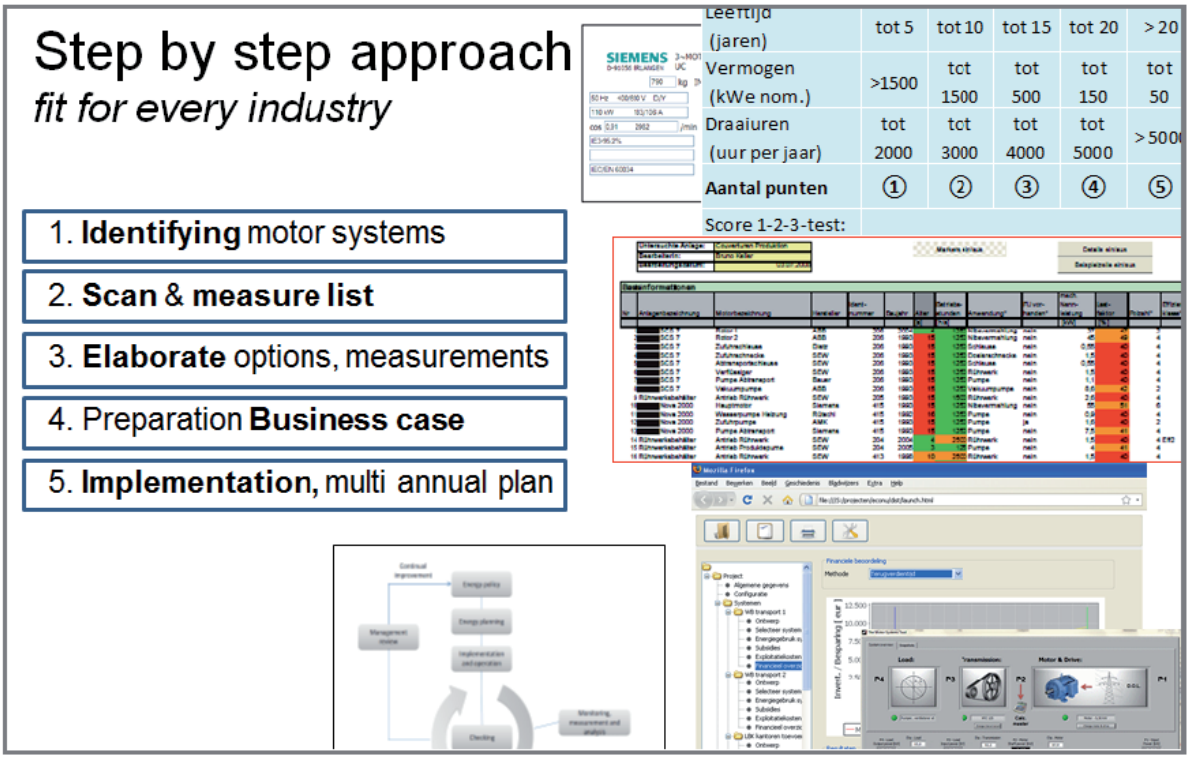

Figure 6. Step by step approach

(Source: Engaging Dutch industry in implementing efficient motor systems with the Green Deal Program, ECEEE 2014 INDUSTRIAL SUMMER STUDY)

V. Summary and Lessons learned

1. Summary and suggestion

Ethiopia has been preparing the regulation and standard related to EE S&L since 2013 under Ethiopian Energy Authority. As shown in the Table below Ethiopia's MEPS is anticipated to be IE2 from 0.12kW to 1,000kW in the near future- Year 2021 and the motor efficiency test standard of single speed, three-phase squirrel cage induction motors IEC 60034-2-1 as more than 23 countries adopt.

Table 11. Main characteristics of Ethiopia EE S&L for electric motors in comparison with USA, EU and Korea

Item	USA	EU	Korea	Ethiopia
Regulation/ Standard	EISA 2007	Regulation 640/2009 Regulation 04/2014 (Amendment)	Operational Regulation on Machinery and Materials subject to Efficiency Management	Preparing
Organization	US Department of Energy	European Commission	Korea Energy Agency	Ethiopian Energy Authority
Year first Introduced	1997	20011(to 2017 in stages)	2008	2017
Latest Revision	2014	2014	2017	2021
MEPS (IEC equivalent)	0,75 kW - 200 kW(1 HP - 275 HP, 2, 4, 6, 8 pole): IE3 mandatory from 01.10.2018 225 kW - 375 kW(275 HP - 500 HP, 2, 8 pole): IE2 mandatory from 01.10.2016 225 kW - 375 kW(275 HP - 500 HP, 4, 6 pole): IE3 mandatory from 01.10.2016	IE3 or IE2 with variable speed drive mandatory from 01.01.2017 on	0.75 kW - 200 kW(1 HP - 275 HP, 2, 4, 6, 8 pole): IE3 mandatory from 01.10.2018 225 kW - 375 kW(275 HP - 500 HP, 2, 8 pole): IE2 mandatory from 01.10.2016 225 kW - 375 kW(275 HP - 500 HP, 4, 6 pole): IE3 mandatory from 01.10.2016	IE2 0,12kW-1000kW
Test Standard	IEEE 112	IEC 60034-2-1	KS C IEC 60034-2-1	IEC 60034-2-1
Common feature	single speed, three-Phase induction motors			single speed, three-Phase squirrel cage induction motors

Power Range	0,75KW to 370kW (1 – 500 HP)	0,75 kW to 375 kW	0,75 kW to 385 kW	0,12KW to 1000kW
Speed	2,4,6 and 8 poles	2,4 and 6 poles	2,4,6 and 8 poles	2,4,6 and 8 poles
Voltage	600V or less	1000V or less	600V or less	600V or less
Awareness Program	Appliance Standards Awareness Project (ASAP)	4EM-MCP(Motor Challenge Programme)	Energy Efficiency Management System	Eased on EEA's web-site's information
Incentive Scheme	Energy Incentive Program	European Regional Development Fund, etc.	Soft Loan for Energy Saving Facilities & Tax Incentives	Based on grant and technical support

2. Lessons learned

If all countries adopted best practice **MEPS for industrial electric motors**, approximately **322 TWh/year would be saved by 2030** with corresponding emission reductions of 206 Mt of CO2 (IEA 2011). For example, the savings estimate by 2020 by the MEPS established through the Eco-Design Directive in Europe is **135 TWh/year by 2020**, equivalent to the output of **22 nuclear reactors.**

In case of Ethiopia energy saving of 6127 GWh can be obtained from 2017 to 2024 by implementing of the EE standards and labeling of electric motors(Source: project document on Electric Motors Energy Efficiency Standards and labeling by DANAS Electrical Engineering).

In the EU, the first MEPS were issued in 2009. By the implementation of the Eco-design Directive from June 2011, IE2 level was required and further requirements took effect. The relatively late introduction of the MEPS in Europe followed a period of **Voluntary Agreement with the industry, which had had a limited impact on the market**.(Almeida et. al. 2015)

A trial period could be utilized as a measure to weaken a impact on the market and the industries of Ethiopia and voluntary agreement with them promoted before implementing EE S&L.

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