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Development of Concept Note for Motor and Inverter Efficiency Program in Mongolia

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Motor and Inverter Efficiency Program

Prepared for

GLOBAL GREEN GROWTH INSTITUTE

By

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Leading the Transition to Clean Energy

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Acronyms and Abbreviations

AC	Alternative Current
ADB	Asian Development Bank
BAT	Best Available Technology
CBTL	CB Testing Laboratory
DE	Designated Entity
DB	Deutsche Bank
EBRD	European Bank for Reconstruction and Development
EE	Energy Efficiency
EPC	Energy Performance Contract
ERC	Energy Regulatory Commission
ESCO	Energy Service Company
GCF	Green Climate Fund
GEEF	Green Economy Financing Facility
GEF	Global Environment Facility
GGGI	Global Green Growth Institute
GMEE	Global Motor Energy Efficiency Programme
GOM	Government of Mongolia
GWh	GigaWatt Hour
HEPS	High Energy Performance Standards
HS	Hamonized System
IE	International Energy Efficiency Class
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IECEE	IEC System of Conformity Assessment Schemes for Electrotechical Equipment and Components
IIEC	International Institute for Energy Conservation
IIE-FTI	Institute of Industrial Energy – Federation of Thai Industries
ISO	International Organization for Standardization
kW	KiloWatt
MASM	Mongolian Agency for Standardization and Metrology
MEPS	Minimum Energy Performance Standard
MET	Ministry of Environment and Tourism

MGFC	Mongolian Green Finance Corporation
MIE	Motor and Inverter Efficiency Program
MonSEFF	Mongolian Sustainable Energy Financing Facility
MSME	micro-, small- and medium-sized enterprise
MVE	Monitoring, verification and enforcement
MWh	MegaWatt Hour
NAMA	Nationally Appropriate Mitigation Action
NCB	National Certification Body
NDC	Nationally Determined Contribution
NEEAP	National Energy Efficiency Action Program
NGDP	National Green Development Policy
NSP	NAMA Support Project
NVP	National Financing Vehicle
PFI	Participating Financial Institutions
PSC	Project Steering Committee
SME	Small Medium Enterprise
TDBM	Trade and Development Bank of Mongolia
TWG	Technical Working Group
UNDP	United Nations Development Programme
UN Environment	United Nations Environment Program
USD	United States Dollar
V	Volt
VSD	Variable Speed Drive
W	Watt

1 Introduction

1.1 Program rationale

According to the Nationally Determined Contribution (NDC) approved by the Government of Mongolia (GOM) in November 2019, Mongolia aims to contribute to the Paris Agreement through enhanced mitigation efforts with policies and measures in key economic and natural resource management sectors by 2030. The mitigation target of Mongolia's NDC will be a 22.7% reduction in total national greenhouse gas (GHG) emissions (about 16.9 million tCO2), from the projected emissions of 74.3 million tCO2 under a business as usual scenario in 2030 (with 2010 as the base year) to 57.4 million tCO2. The principle reduction targets shown in the NDC are in line with the relevant national policies and programs, including the National Energy Efficiency Action Program (NEEAP) of Mongolia for 2018 – 2022. Of the total 16.9 million tCO2 reduction target, contribution from energy saving measures in the industry is about 1 million tCO2.

NEEAP aims to reduce GHG emission and mitigate climate change through integrated management of conservation and efficient use of energy, and to introduce and promote use of advanced energy efficient techniques and technologies in the country. The Global Green Growth Institute (GGGI) in Mongolia promotes energy efficiency (EE) through policy advisory and technical assistance (TA) as part of the Memorandum of Understanding with the Energy Regulatory Commission (ERC) signed in March 2017. GGGI study (2017), carried out in support to the NEEAP Implementation, revealed that with introduction of Minimum Energy Performance Standards (MEPS) and mandatory energy labelling, Mongolia can save over 1,000 GWh of electricity annually by 2040 and reduce 1.3 million tCO2 of GHG emissions.

The 2017 GGGI study also identified the priority products for EE improvements in Mongolia as *refrigerators/freezers, 3-phase motors, distribution transformers, fluorescent lamps and washing machines*. In addition to that, an ADB market assessment in 2016 found that *distribution transformers, HOBs, induction motors, and variable speed drives (inverters)* are commonly used for heating, cooling, pumping and energy distribution applications. It stated that specifically, motor systems (electric motors coupled with pumps, fans and other machines) consume about 70% of industrial electricity in Mongolia – that are based on Eastern European less efficient technologies. One of main barriers to accelerating EE market development in Mongolia is size of the market and financing of EE, including initial cost barrier, high transaction costs, long payback time and other risks involved. Findings from the 2017 GGGI study affirm the importance of EE motor systems (EE motors and variable speed drives) which are included in the list of Nationally Appropriate. Mitigation Actions (NAMA) submitted in 2010 by GOM for the Copenhagen Accord. It was estimated that implementation of motor system efficiency improvement would result an annual emission reduction of about 240,000 tCO2.

Pursuant to the Energy Conservation Law (2015), the ERC is a government agency to ensure implementation of the energy conservation and is authorized to require designated entities (DEs) - large energy users in Mongolia - to undergo energy auditing and report on energy reduction measures implemented. The Government plans to provide incentives and penalties to ensure proper enforcement of the law. DEs are determined based on their electricity and heat consumption levels, and required to undergo an energy audit, submit regular reports on their consumption levels and indicate plans and project that it would implement to reduce energy consumption. Currently, there are 229 DEs that will be subject to the Energy Conservation Law – with the largest electric energy consumption in mining and manufacturing sectors and heat usage highest in manufacturing, public entities (buildings), and the services industry, and these include 89 buildings, 115 final energy users and 25 energy companies.

Motor systems are commonly used in DEs and improvement of the overall efficiency of the existing motor systems will greatly benefit the Mongolian energy sector, and the economy as the whole.

1.2 OBJECTIVES

The primary objectives of the Motor and Inverter Efficiency Program are to improve overall efficiency of electric motor systems in Mongolia, and to encourage energy efficiency and conservation in Mongolia through awareness, educational and incentive measures.

1.3 APPROACH

The Energy Regulatory Commission (ERC) of Mongolia will take the lead in implementation of the Motor and Inverter Efficiency Program, which involves a range of supporting mechanisms to create enabling environments for greater adoption of energy efficient motor systems in Mongolia. The supporting mechanisms include but not limited to financial incentives and rebate programs, and recommended capacity building in the banking sector and in overall institutional framework.

2 Context and baseline

An electric motor converts electrical energy into mechanical energy. Motors range from a few watts up to many hundreds of kilowatts in terms of power output, however almost all energy efficiency policies and programs have focused on medium-sized motors which consume the large amount of energy, and offer the greatest saving opportunity.

Box 1: Global Motor Stock Profile and Energy Consumption

Small motors with a power rating of 10 W to 750 W account for about 90% of all electric motors, but these motors use only about 9% of the total electricity consumed by electric motors. They are used in small appliances, to drive pumps and fans. These motors are often single-phase and are induction, shaded-pole, or shunt-wound motor types, which are typically custom made in large series to be integrated into specific machines or appliances. They often operate at, or at less than, mains voltage.

In contrast, medium motors in the power range 0.75 kW to 375 kW account for 68% of the electricity used by electric motors. For the most part, these are asynchronous AC induction motors of 2, 4, 6 or 8 poles, but some special motors (such as direct current, permanent magnet, switched reluctance, stepper and servo motors) are poly-phase motors operating at voltages of 200V to 1,000V. Medium-sized motors are manufactured in large series, usually with short delivery lead times and according to standard specifications that can be ordered from catalogues. These motors account for about 10% of all motors sold and are used with pumps, fans, compressors and conveyors, primarily for industrial handling and processing applications.

Large motors, defined as electric motors with a rated power of from 375kW up to 100MW, are poly-phase, high voltage motors operating in the 1kV to 20kV range. They are custom designed; some are of the synchronous type and are generally assembled on site and used in industrial and infrastructural applications. They account for only about 0.03% of the stock of all electric motors, but account for about 23% of the electricity used by electric motors.

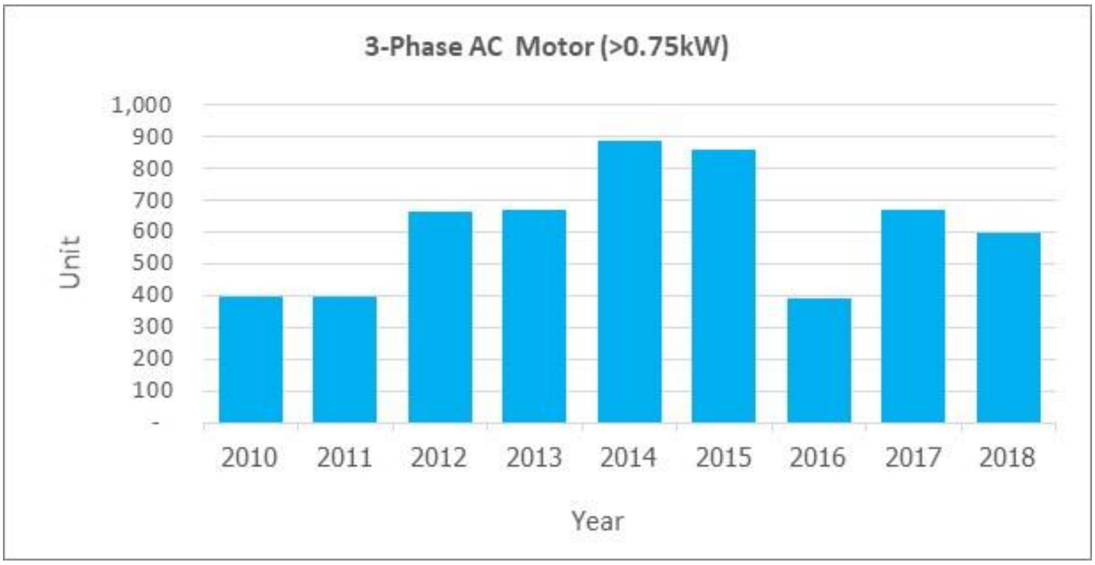
Source: Walking the Torque Information Paper, IEA, 2011

2.1 Motor and Inverter Market

In Mongolia, there is no data on detailed inventory and annual sales of 3-phase AC motors and inverters. The market and stock profiles for motors and inverters, subsequently discussed in this report, were developed based on three sets of secondary data, including: 1) motor import statistics from 2010 to 2018; 2) thirty one (31) energy audit reports conducted at selected designated entities (DEs); and 3) 2013-2016 motor and inverter sales reports compiled by ERC.

2.1.1 3-Phase Electric Motor

Based on import statistics, the demand of medium sized 3-phase AC motors (>0.75kW) in Mongolia was around 600 units per year from 2010 to 2018. The annual growth rate during the same period was around 5%.



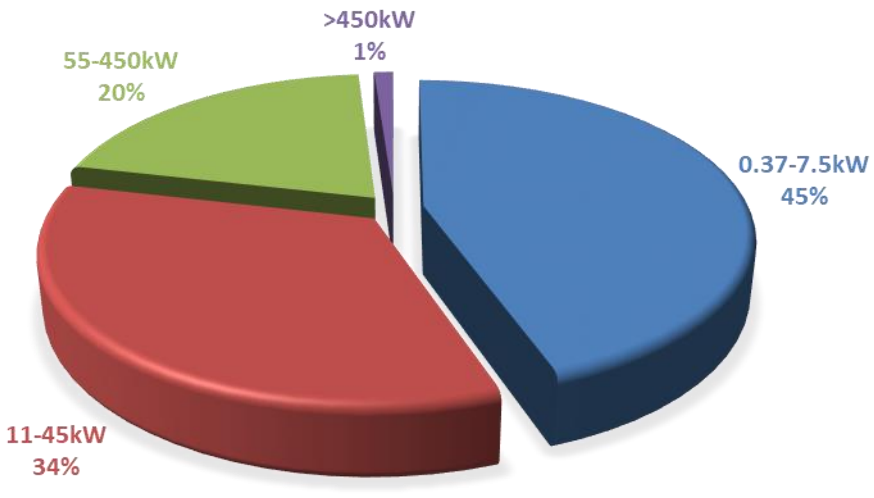
Source: Mongolian Customs General Administration

Figure 1: Annual Import of >0.75kW 3-Phase AC Motors in Mongolia (2010-2018)

This report categorizes 3-phase AC motors into four (4) categories as follows:

- Small Motor: 0.37-7.5kW
- Medium Motor: 11-45kW
- Large Motor: 55-450kW
- Extra Large Motor: >450kW

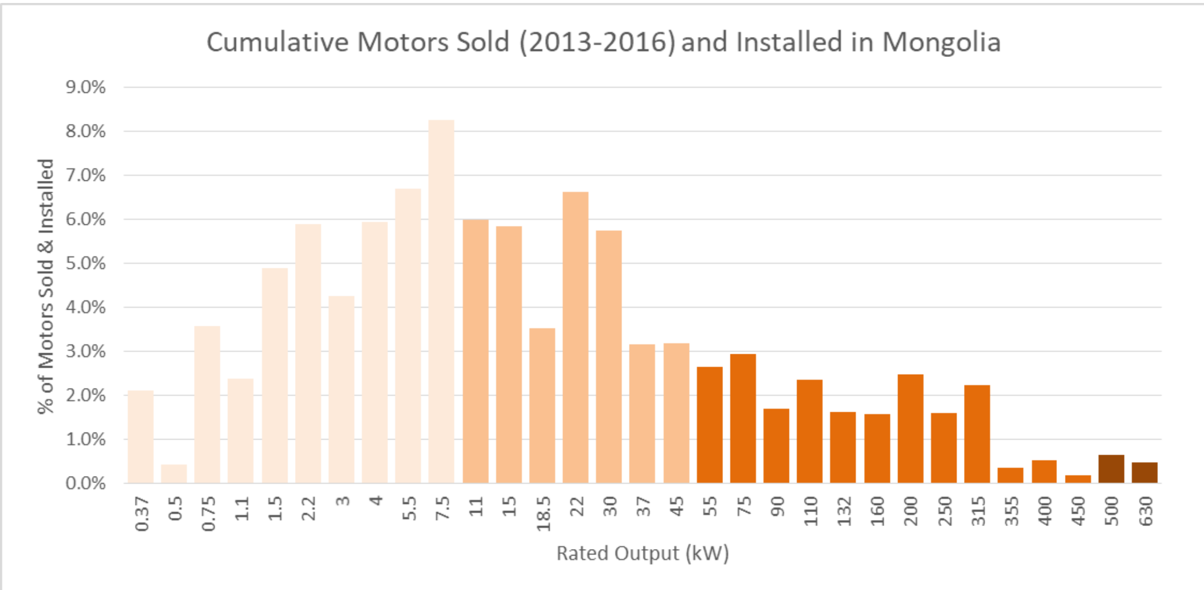
Analysis of energy audit reports for DEs and annual sale data of inverters and motors compiled by ERC, which include almost 6,000 3-phase AC motors, found that almost all of motors installed in DEs and sold in Mongolia from 2013 to 2016 have rated outputs between 0.37kW to 450kW (see Figure 2).



Source: Motor sales and energy audit reports provided by ERC and GGGI

Figure 2: Motor Stock Profile in Mongolia

Breakdowns of each category by motor rated outputs are shown in Figure 3. The most common rated outputs of 3-phase AC motors in Mongolia include 2.2kW, 4kw, 5.5kW, 7.5kW, 11kW, 15kW, 22kW and 30kW, and the average rated output of all the motors under the analysis is 49kW.



Source: Motor sales and energy audit reports provided by ERC and GGGI

Figure 3: Breakdown of Motors Sold (2013-2016) and Installed in Selected DEs by Rated Output

Analysis of the total cumulative kW of each category found that large motors with rated output between 55kW to 450kW account for 68% of the cumulative kW sold and installed. Medium sized motor (11kW to 45kW) came second with 16% of the cumulative kW, as shown in Table 1.

Table 1: Categories of Motor Rated Outputs in Mongolia

Motor size	Percentage of Units Sold & Installed	Percentage of Cumulative kW Sold & Installed	Average Rated Output (kW)	Nearest IEC Standard Rated Output (kW)
Small Motor (0.37-7.5kW)	45%	3%	4	4
Medium Motor (11-45kW)	34%	16%	24	22
Large Motor (55-450kW)	20%	68%	162	160
Extra Large Motor (>450kW)	1%	13%	554	500
Total	100%	100%	**49**	**45**

Source: Analysis by IIEC based on motor sales and energy audit reports provided by ERC and GGGI

This concept note report estimated the total running stock of 3-phase electric motors in Mongolia using a top-down approach based on the following assumptions:

- 46% of annual electricity consumption nationwide consumed by electric motors[1];
- The annual operating hours for medium sized motors are 3,000 hours[2];
- All 3-phase electric motors in Mongolia have IE1 efficiency levels (4-pole, according to IEC 60034-30-1);
- The average size of 3-phase electric motors in Mongolia is 49kW as shown in Table 1.

According to the latest annual electricity consumption data published by ERC, Mongolia consumed 5,259 GWh in 2018. Based on the above assumptions, the total electricity consumed by electric motors in 2018 was 2,419 GWh, and each 49kW 3-phase motor consumes about 160 MWh per year. This top-down estimation translates to about 15,090 running electric motors in Mongolia in 2018.

There is no data on the expected life time of electric motors in Mongolia. However this concept note report references the approach used by the U4E Country Assessment, and an average life time of 15 years is used for electric motors. With these operating parameters, each unit of electric motors in Mongolia consumes 2,405 MWh throughout its life time, which is equivalent to an emission of about 2,551 tons of CO_2.

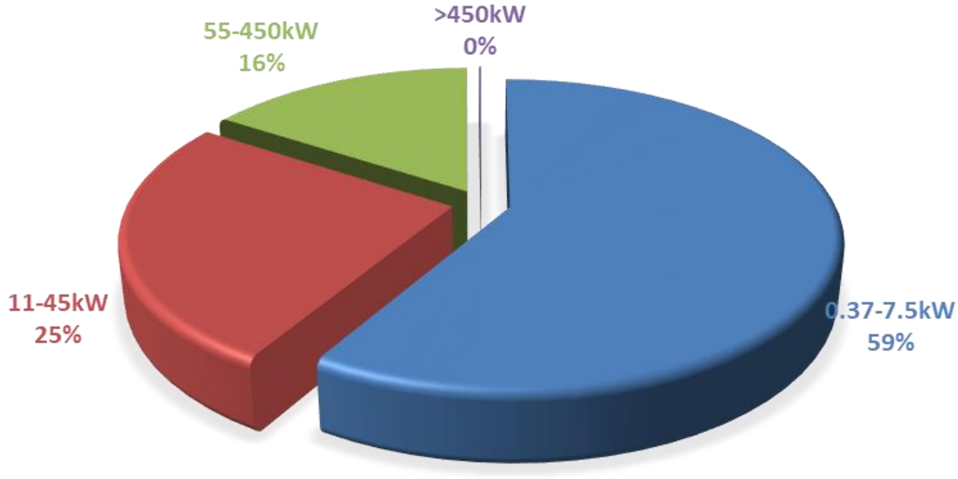
2.1.2 Inverter

Similar to 3-phase electric motors, there is no data on detailed inventory of inverters for 3-phase electric motors in Mongolia. Import/export statistics are not a reliable source for market information of inverters for electric motors in Mongolia as there is no specific Harmonized System (HS) Code for import/export tariff for motor inverters. As a result, the import statistics of motor inverters have been mixed with other products, such as voltage regulators and frequency converters for telecommunication applications.

[1] Source: Walking the Torque Information Paper, IEA, 2011

[2] Source: Table 6: Estimated electricity demand for EMDS, by type of electric motor, Walking the Torque Information Paper, IEA, 2011

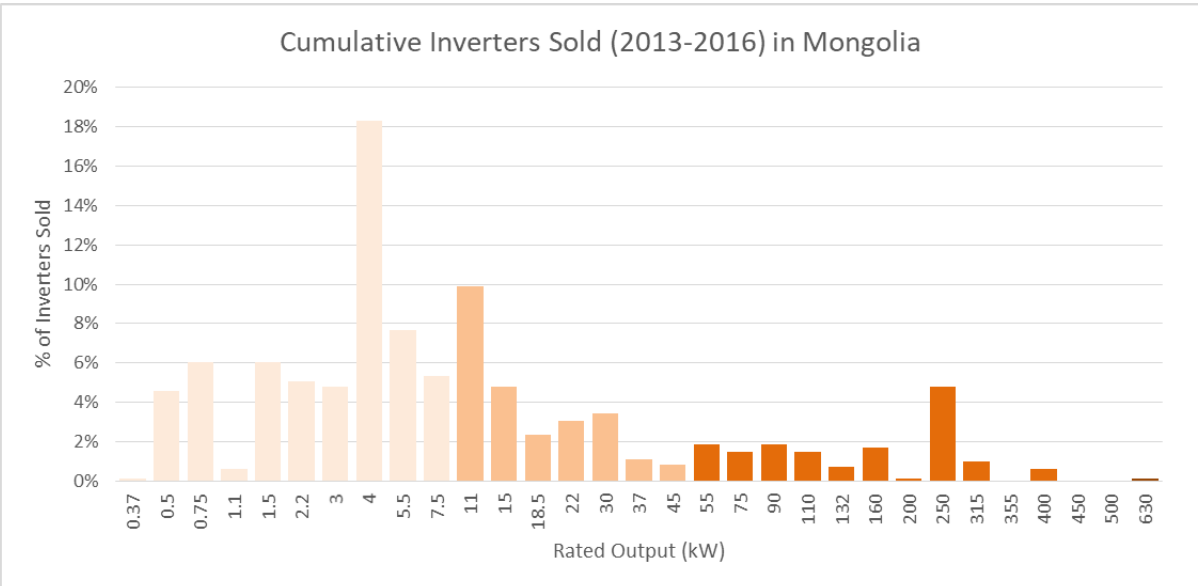
The best available data for analysis of inverter is the 2013-2016 sale report compiled by ERC, and about 800 units of low-voltage (<660 volts) frequency inverters for 3-phase electric motors were imported and sold in Mongolia from 2013 to 2016. Similar to the electric motor profile, virtually all of inverters sold in Mongolia from 2013 to 2016 have rated outputs between 0.37kW to 450kW (see Figure 4).



Source: Inverter sales and energy audit reports provided by ERC and GGGI

Figure 4: 2013-2016 Inverter Sale Profile in Mongolia

Breakdowns of each category by inverter rated outputs are shown in Figure 5, and the most popular rated outputs of inverters sold in Mongolia from 2013 to 2016 are 4kw and 11kW. Comparison of motor and inverter units sold during 2013-2016 found that the number of inverters accounted for about 30% of the total number of motors sold for the same rated output.



Source: Inverter sales and energy audit reports provided by ERC and GGGI

Figure 5: Breakdown of Inverters Sold (2013-2016) by Rated Output

Box 2: Installation of Inverters (Variable Speed Drives) for Electric Motors in Mongolia

Applying inverters or variable frequency drives (also called variable speed drives) to adjust speed of 3-phase induction motors for better process control and energy savings is not new in Mongolia. Review of more than 30 energy audit activities conducted over the past 5 years found that inverters have already been integrated with various motor sizes (up to 630kW) for pump, fan, compressor and conveyor applications. These energy audits also recommend additional installation of inverters which would deliver further energy savings, and summarized below are the main characteristics of the proposed energy savings measures using inverters:

Typical Sizes of 3-Phase Electric Motors	7.5kW to 75kW
Applications	Pump, Fan, Conveyor Feeder
Estimated Annual Energy Savings	20% to 25%
Estimated Simple Payback Period	20 months

ERC reported that installations of inverters for pumps in mining and hotel facilities have delivered more than 30% energy savings. One example is the installation of 200 kW inverter to control speed of three pumps at Bor-Undur Mine and Ore Dressing Plant (ODP) of Mongolrostsvetmet LLC in November 2018. As a result on this inverter installation, the Bor-Undur mine and ore dressing plant saved about 2.3 GWh in 2019 which is equivalent to MNT 443.5 million of electricity cost.

Another example is the installation of inverter to control speed of circulating pumps in heat supply pipelines in Chingis Khan hotel which is one of the largest hotel in Ulaanbaatar, the capital city of Mongolia. The hotel is connected with the centralized district heating through heat supply pipelines, with two circulating 22 kW circulating pumps. With support from the ERC and GIZ energy efficiency project, the hotel installed two inverters for the circulating pumps to control speed and reduce electricity consumptions.

Chingis Khan Hotel and Two Inverters for Circulating Pumps

Measurements of electricity consumption by inverters were undertaken from 26 January 2019 to 1 May 2020, and it is found that the circulating pumps were required to run at 70% of the rated speed (i.e., at 35 Hz) to meet the flow demand. As a result, the power consumption of each circulating pump was reduced to 8.35 kW, or only 38% of the rated motor output (22 kW). Considering that the operation pattern of the two circulating pumps remains unchanged after the inverter installation, Chingis Khan hotel would save about 42,260 kWh of electricity consumption annually, or about 62% savings (see the measurement and computation details in the table below). The electricity savings were also reflected in the hotel's total electricity consumption. In 2018, The total electricity consumption of Chingis khan hotel was about 2.4 million kWh. In 2019 the total electricity consumption was reduced to about 2.1 kWh, or about 13% reduction. Heat consumption was also reduced from 3,770 Gcal to 2,425 Gcal.

Pumps	Circulating pumps without inverter		Circulating pumps with inverter	
	CP1	CP2	CP1	CP2
Working period	26 Jan 2019-1 May 2020	26 Jan 2019-1 March 2020	26 Jan 2019-1 May 2020	26 Jan 2019-1 March 2020
Power consumption, kW	22	22	8.35	8.35
Motor frequency/speed	50Hz/2900rpm		35Hz/2030rpm	
Estimated Annual Operating hours	2280	816	2280	816
Electricity consumption, kWh	50,160	17,952	19,038	6,814
Electricity tariff, MNT/kWh	128.5	128.5	128.5	128.5
Cost of electricity, MNT	6,445,560	2,306,832	2,446,383	875,548
	8,752,392		3,321,931	
Cost savings, MNT	5,430,461			

Source: Energy Statistics 2019 and energy audit reports provided by ERC and GGGI

2.2 Estimated Energy Consumption and Energy Efficiency Potential

Estimation of energy consumption and energy efficiency potential from adoption of energy efficient 3-phase electric motors and inverters in Mongolia was carried out through a bottom-up approach which utilizes the total stock of 15,090 running motors in 2018, as identified in Section 2.1.1, to estimate the population of running motors in Mongolia from 2020 to 2040. The bottom-up approach was recommended to enable integration of the retirement probability function for projection of end-of-life motors to be replaced annually. Annual sales throughout the projection period are then computed from the sum of new motors purchased for new installations, and new motors purchased for replacement of end-of-life motors. More details of the proposed bottom-up approach are given in Annex I.

The key parameters used for projections of the 3-phase electric motor population in Mongolia from 2020 to 2040, and the analysis of energy consumption, energy efficiency potential and associated CO_2 emission reductions are shown in Table 2 and Table 3. In addition to the impact analysis of energy efficient motors, this report assumes that installation of inverters would conservatively yield an annual energy savings of 20%, and a maximum of 30% of new and replacement motors installed annually would be equipped with inverters.

Table 2: Key Parameters for 3-Phase AC Motor Stock Projection and Impact Analysis

Parameter	Value	Note
Installed stock 2018	15,090 unit	Top-down estimation in Section 2.1.1
Annual market growth	5.1% (2019) -2.6% (2020) 5.1% (2021) 5% (2022-2040)	Source: ADB (for 2019-2021), and assumption for 2022 on ward
Average lifetime	15 years	U4E Country Assessment, UN Environment, 2019
Annual operating hours for motors	3,000 hours	Walking the Toque Information Paper, IEA, 2011
Electricity Emission Factor	1.06 tCO_2/MWh	Source: IGES

Table 3: Assumptions on Rated Outputs and Efficiency Values for Electric Motors

Motor size	Average Size (kW)	Full Load Efficiency (%)		
		Baseline (Business-As-Usual, IE1 Efficiency Level)	Energy Efficiency Scenario (IE3 Efficiency Level)	BAT Scenario* (IE4 Efficiency Level)
Small Motor (0.37-7.5kW)	4	83.1%	86.0%	91.1%
Medium Motor (11-45kW)	22	89.9%	93.0%	94.5%
Large Motor (55-450kW)	160	93.8%	95.8%	96.6%
Extra Large Motor (>450kW)	500	94.0%	96.0%	96.7%

Source: Analysis by IIEC; *BAT: Best Available Technology

With the estimated annual growth rate of 5%, number of 3-phase electric motors (>0.37kW) in Mongolia will rise from about 15,500 units in 2020 to about 41,000 units in 2040. All 3-phase electric motor purchased before 2020 will reach their end-of-life and will be replaced by new motors by 2040. The annual replacement of 3-phase electric motors is computed by a retirement probability function[3] with 15 years lifetime.

[3] The retirement probability function is a mathematical model for estimation of a number of annual end-of-life products, used by the Policy Analysis Modelling System (PAMS) developed by Lawrence Berkeley National Laboratory (LBNL), https://ies.lbl.gov/project/policy-analysis-modeling-system. See Annex I for more information.

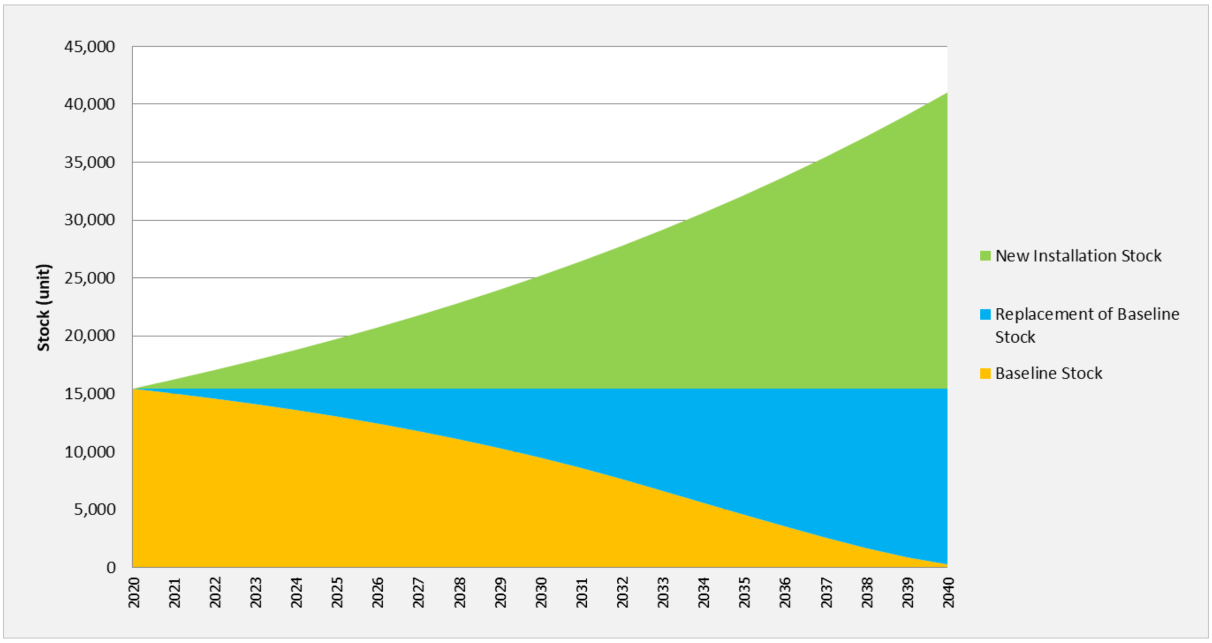


Figure 6: 3-Phase Electric Motor Stock in Mongolia (2020-2040)

Shown in Figure 7 are trends of annual energy consumption by 3-phase electric motors in Mongolia under different scenarios. Without aggressive adoption of energy efficient motors and utilization of inverter, annual electricity consumption by 3-phase electric motors in Mongolia is estimated to be about 6,281 GWh in 2040. Impacts on energy savings from adoption of energy efficient motors and inverter under different scenarios are described below:

1. **Scenario 1 – IE3 Energy Efficiency:** All 3-phase AC motors for new installation and replacement purchases will meet the IE3 efficiency levels as specified in IEC 60034-30-1. The annual energy consumption in 2040 is estimated at about 6,124 GWh, or an annual saving of 158 GWh (2.5%) in 2040.

2. **Scenario 2 – IE4 Best Available Technology (BAT):** All 3-phase AC motors for new installation and replacement purchases will meet the IE4 efficiency levels as specified in IEC 60034-30-1. The annual energy consumption in 2040 is estimated at about 6,060 GWh, or an annual saving of 221 GWh (3.5%) in 2040.

3. **Scenario 3 – IE3 Energy Efficiency with Inverter:** 20% of 3-phase AC motors for new installation and replacement purchases will be integrated inverters, and additional annual energy savings of about 20% will be realized through speed control. The annual energy consumption in 2040 is estimated at about 5,984 GWh, or an annual saving of 281 GWh (4.5%) in 2040.

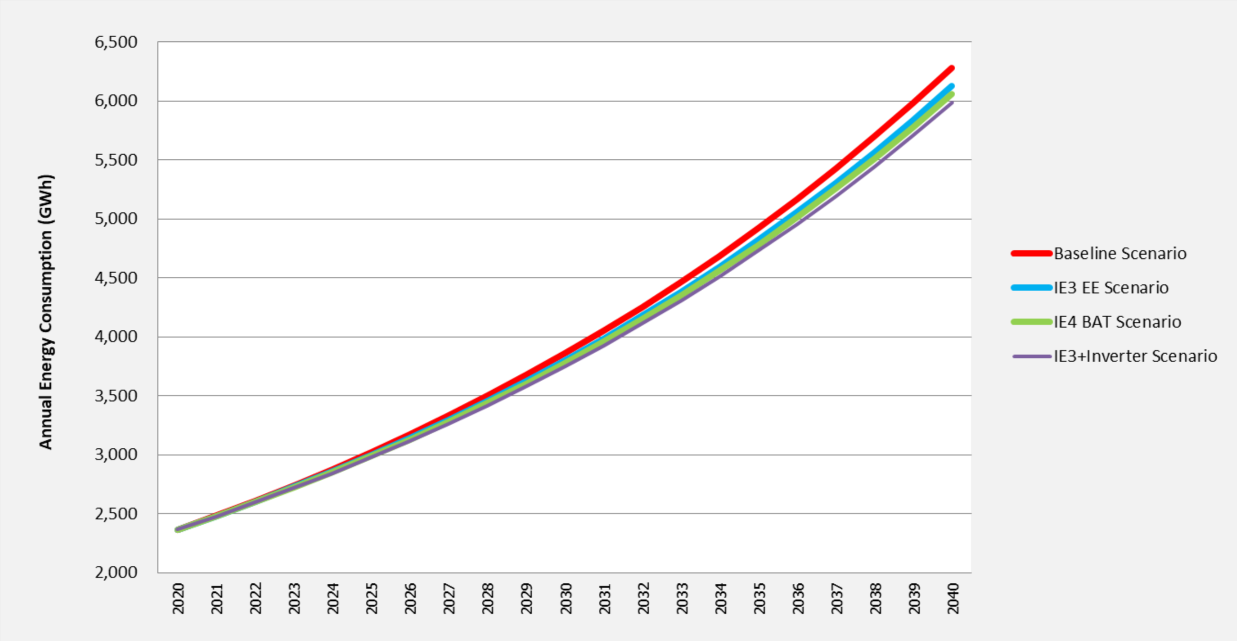


Figure 7: Trends of Annual Energy Consumption by 3-Phase Electric Motor Stock in Mongolia (2020-2040)

Annual and cumulative savings from 2021 to 2040 for the abovementioned scenarios are summarized in the table below. Depending on the chosen scenario, the estimated annual GHG emission reductions account for about 6% to 10% of the NDC's target from energy saving measures in the industry in 2030 (about 1 million tCO2). Note that the estimated energy savings and GHG emission reduction potential shown below are the overall potential at the national level. The previous energy audit exercises supported by GGGI/ERC reveal that installation of inverters for pump and fan application in twelve (12) large designated entities (see Annex V) would result the total annual energy savings of about 9 GWh, accouting for about 20% of the potential savings under Scenario 3. More details on projection of motor stock and annual savings are given in Annex II.

Table 4: Annual and Cumulative Energy Savings and GHG Emission Reduction from Energy Efficient Motors and Inverters

Item	**Annual (2025)**	**Annual (2030)**	**Annual (2040)**	**Cumulative (2021-2040)**
Scenario 1 – IE3 Energy Efficiency				
Electricity Savings (GWh)	24.5	57.5	157.6	1,375.1
GHG Emissions Reduction (tCO_2)	26,048	61,043	167,219	1,458,973
Scenario 2 – IE4 Best Available Technology (BAT)				
Electricity Savings (GWh)	34.4	80.7	221	1,928.2
GHG Emissions Reduction (tCO_2)	36,526	85,598	234,482	2,045,843
Scenario 3 – IE3 Energy Efficiency with Inverters				
Electricity Savings (GWh)	43.8	102.6	281.1	2,452.7
GHG Emissions Reduction (tCO_2)	46,460	108,880	289,259	2,602,292

2.3 Current Practices in Implementing EE Motor Systems

During preparation of the concept note document, data on awareness and knowledge of EE potential and technical and financial capacity in adopting EE motor systems (inverter and energy efficient motors) among DEs was collected through questionnaires distribution supported by ERC. Considering the limited timeframe of the assignment and various restrictions during the COVID-19 pandemic, ERC distributed the questionnaires to the following sub-sectors:

- Public services (electric, heating and water utilities);
- Manufacturing Industry (mining, food and beverage, textile);
- Building (commercial, office, hospital).

Thirteen DEs responded to the questionnaires, and the overall findings from the DE surveys correspond with the inverter market data discussed in Section 2.1, showing that DEs in Mongolia are aware of EE in general, and energy savings potential from inverter utilization in motor systems. More than 90% of the DE respondents have experience in installation of inverters with motor systems for pump and fan applications. However only around 60% of the DE respondents have adequate budget for EE investments. Details of the DE survey findings are discussed below.

2.3.1 Energy Audits and Recommended EE Measures

85% of the DE respondents reported that energy audits have been conducted in their facilities over the last four (4) years (2017-2020). The most recent energy audits conducted in 2020 were reported by three (3) DEs. Key findings on experience in energy audits and awareness of EE measures are summarized in Figure 8. In summary, majority of the DE respondents, even those without energy audits, are aware of potential energy savings from EE measures, and all claimed to be aware of EE potential in motor systems.

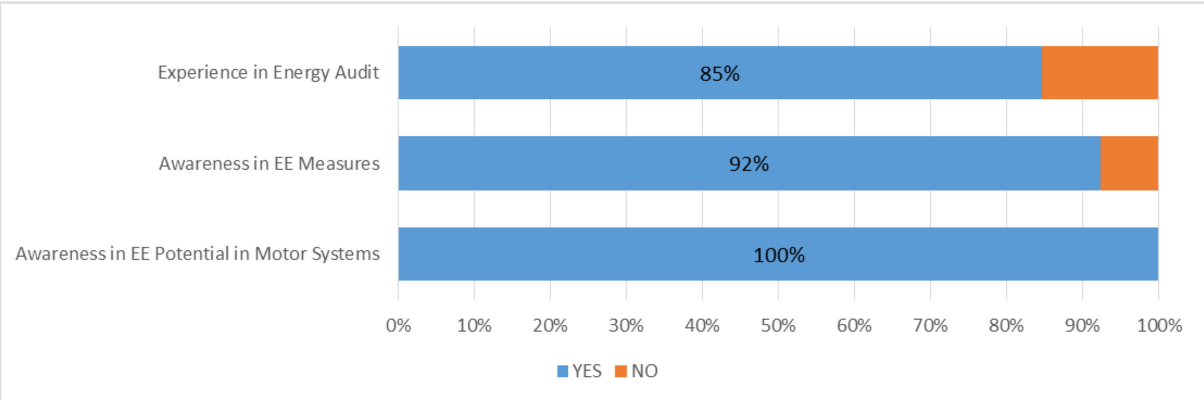


Figure 8: DEs' Responses on Experience in Energy Audits and Awareness of EE Measures

The most common EE measures reported by the DE respondents include inverter, EE lighting, insulation, and EE cooling, as shown in Figure 9.

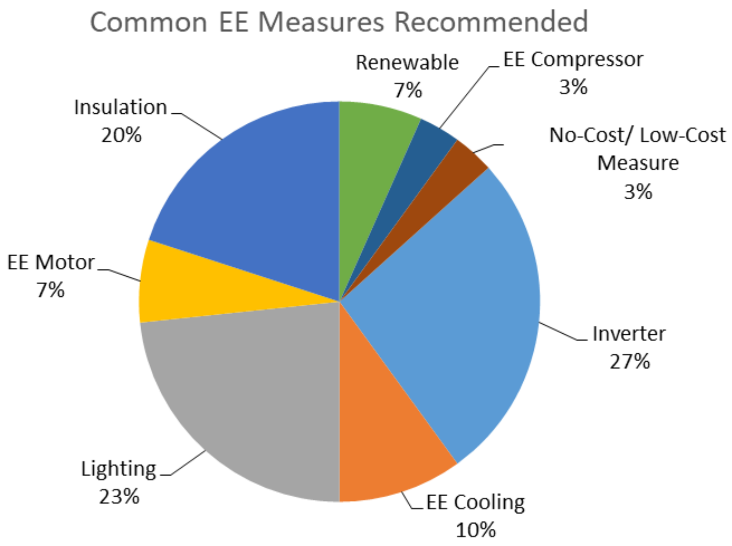


Figure 9: Common EE Measures reported by DE Respondents

2.3.2 Implementation of EE Motor Systems

92% the DE respondents have experience in applying inverters in motor systems for energy savings, and most of these inverter investments are financed by equity . 85% of the DE respondents said they have had investments planned for EE motor systems, however only about half of the DE respondents indicated the budget level committed. 85% of DE respondents said they have sufficient technical capacity in EE motor system, but only about 60% of the DE respondents said they have adequate financial capacity to support investment in EE motor systems, without indications whether the available funds would come from debt or equity financing. Most of the DE respondents, including those who have experience in EE motor systems, said they are not aware of any fiscal incentive and financial support programs for EE motor systems implemented by GOM.

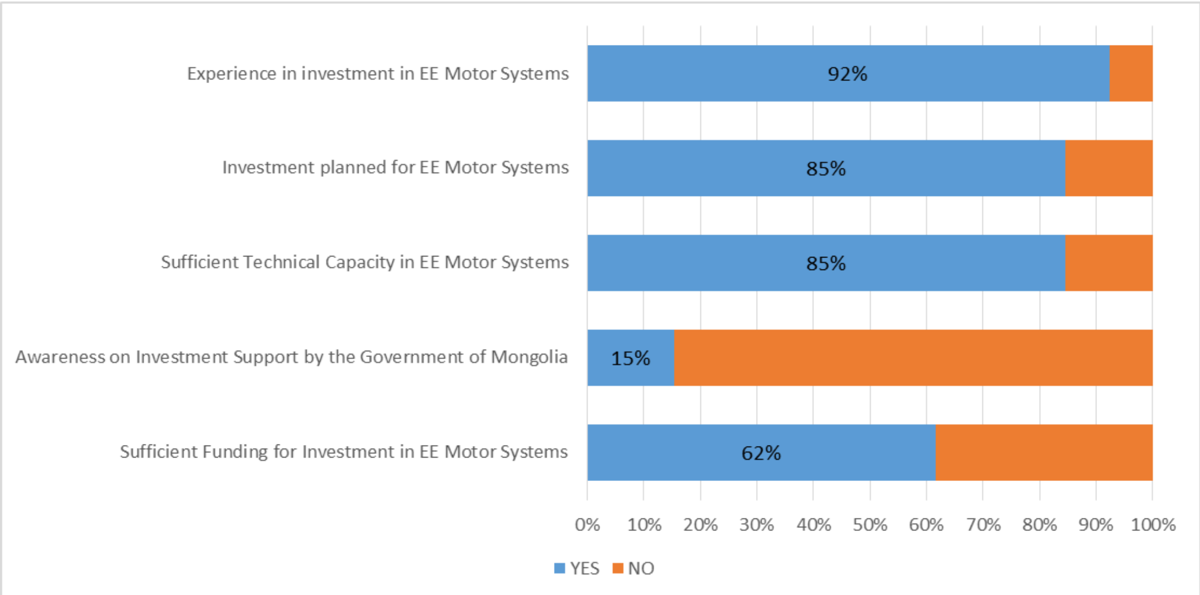


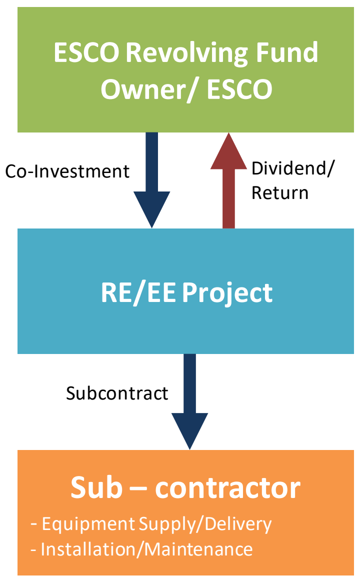
Figure 10: DEs' Responses on Experience and Capacity in EE Motor Systems

Box 3: ESCO Mechanism to Support EE Motor System Investments in Thailand

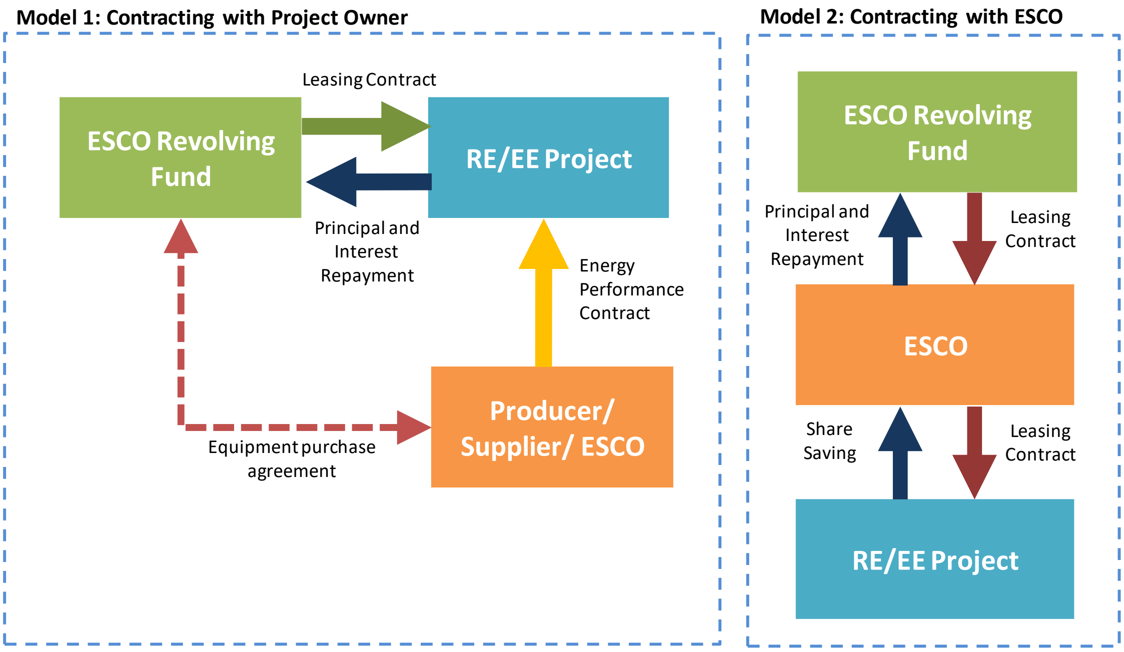
The Energy Service Company (ESCO) mechanism in Thailand was probably triggered by the Thailand ESCO pilot project funded by the World Bank in 1999. Following an initial challenging period, the ESCO market in Thailand has grown gradually, with the exception for a significant drop in 2007 due to the global economic crisis. The ESCO financing in Thailand has gradually grown over the past decade. According to the Thai ESCO Information Center (www.thaiesco.org) managed by the Institute of Industrial Energy – Federation of Thai Industries (IIE-FTI) with support from the Thai Ministry of Energy, there were almost 1,000 Contracts signed between ESCOs and factories/commercial buildings in Thailand from 2009 to 2017. The four most common EE measures implemented by ESCOs in commercial and industrial facilities in Thailand are EE chillers, EE lighting, EE air compressors and inverters (variable speed drives – VSD).

One of the key factors driving the ESCO mechanism in Thailand is the ESCO Revolving Fund started by the Thai government in 2008 with financial support from the Thai Energy Conservation and Promotion Fund. The ESCO Revolving Fund has been able to stimulate the total investment of around THB 5 billion (about US$165 million) to date, mostly through Equipment Leasing and Equity Investment. The business models for equipment leasing and equity investment under the ESCO Revolving Fund are described below.

Equity Investment. The ESCO Revolving Fund will make equity investments in EE or RE projects. Investment criteria applied are: i) size of equity investment: 10-50 percent of total investment cost but limited to THB 50 million (about US$1.7 million) per project; ii) investment period of 5-7 years; and iii) exit method of selling back the shares to the entrepreneur, or find new strategic partners.



Equipment Leasing. The leasing criteria include: i) 100 percent of equipment cost but not exceeding THB 25 million (about US$800,000) per project; ii) repayment duration of 5 years; and iii) interest rate of 3.5% per annum[4]. Project owners have options to either directly sign contract with the Fund and manage the leasing contracts on their own, or enter into Energy Performance Contracts (EPCs) with ESCO for equipment leasing, as shown below.



Source: IIEC

Most of the DE respondents indicated that they would consider investments in inverters and EE motors when equipment has reached their end-of-life, and/or repairing does not make economic sense. The factors which the DE respondents highlighted as the keys when purchasing products and equipment are 1) energy efficiency performance; 2) product quality; and 3) price, while brand name, warranty and after-sale services are considered less importance. Note that, fiscal and financial instruments to support purchasing of products and equipment are less important compared with other factors.

[44] During the initial phases of the ESCO Revolving Fund, the maximum budget for equipment leasing was THB 10 million with 4% interest.

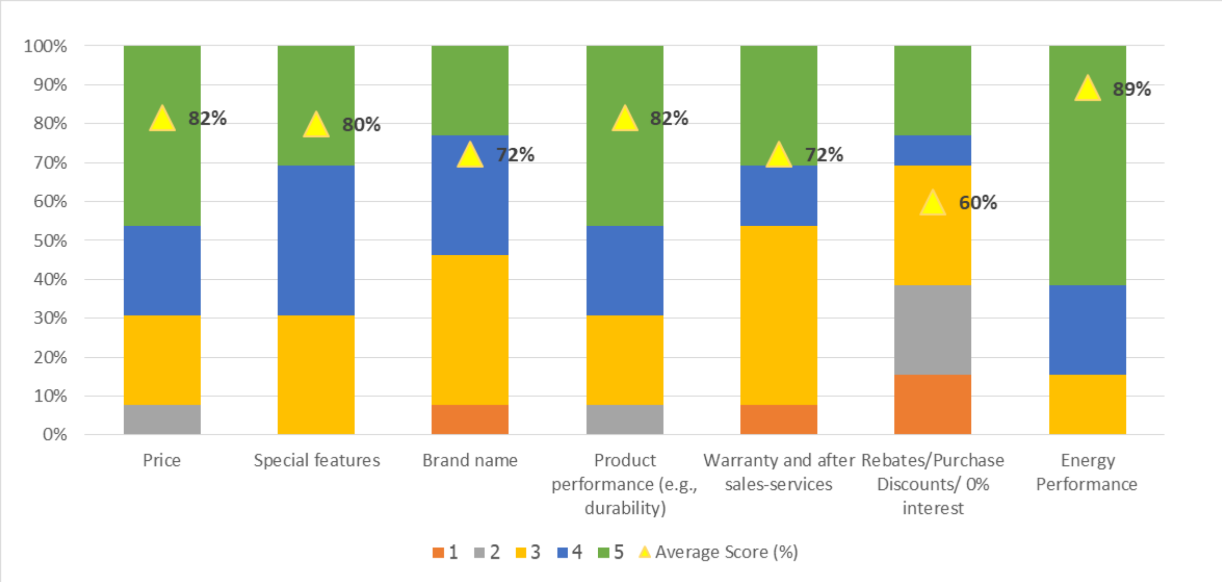


Figure 11: Factors influencing Purchasing Decision of Products/Equipment by DE Respondents

The DE respondents generally procured inverters and EE motors from local suppliers in Mongolia, including but not limited to Bodit Chadal LLC, Monhorus LLC and Prestige Electric LLC[5]. This has indicated that local inverter and motor suppliers have already coordinated with large commercial, industrial and public end-users in Mongolia to market inverter and EE motor technologies, and engineering works related to investments in inverters and EE motors are usually provided by the suppliers.

Although 85% of DE respondents said they have sufficient technical capacity in EE motor system (see Figure 10), they highlighted importance of technical training on inverters and motors, technical assistance in evaluation of potential energy and cost savings from EE motor systems, and provision of evaluation software and manuals. Similar cases studies in implementation of inverters and EE motor systems are less important compared with specific technical assistance which are directly relevant to the DEs' facilities.

[5] A list of main importers and distributors of motors and inverters is given in Annex II.

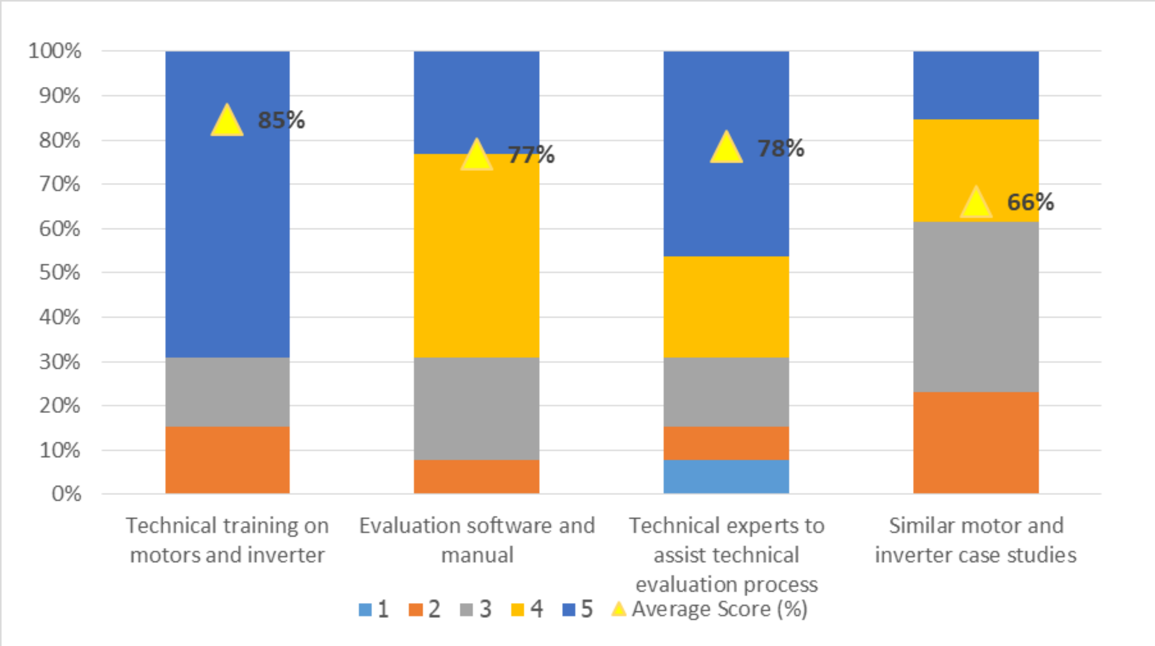


Figure 12: Technical Assistance and Supports for Identification and Evaluation of EE Potential in Motor Systems

3 PROGRAM DESCRIPTION

3.1 GOAL AND OBJECTIVES

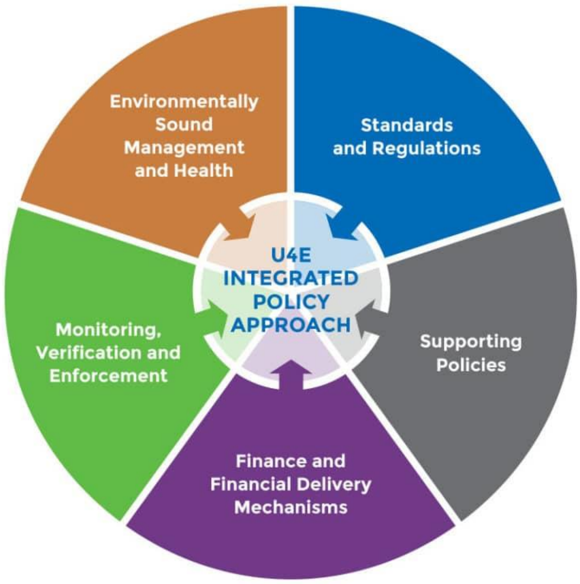
The Motor and Inverter Efficiency (MIE) Program will be implemented by the Government of Mongolia (GOM) through the Energy Regulatory Commission (ERC). The initial phase outlined in this design will run for a minimum of three (3) years.

The longer term Goal of the MIE program is to ensure that commercial and industrial end-users in Mongolia benefit from increased efficiency of motor systems through adoption of energy efficient 3-phase electric motors and application of inverters (variable frequency drives) to control motor speed to match the process requirements leading to sustainable energy savings in a long term.

The purpose of the MIE program over the next three years will be to enhance capacity of relevant local authorities in Mongolia to adopt international standards necessary for certification of energy efficiency performance of motor system equipment sold in Mongolia, and to strengthen technical and financial capacity of local vendors, local ESCOs and commercial and industrial end-users in identifying, designing, planning, installation and commissioning, and conducting measurement and verification (M&V) of associated benefits (energy savings and GHG emission reduction) of energy efficient motor systems.

3.2 PROGRAM CONCEPTUAL DESIGN

To achieve the abovementioned objectives, the MIE program will reference the Integrated Policy Approach promoted by the United for Efficiency (U4E), a global initiative led by UN Environment. The Integrated Policy Approach comprises the five core elements as shown in the figure below.



Source: United for Efficiency

***Figure 13**: U4E Integrated Policy Approach*

The MIE program will specifically focus on the following four elements of the above Integrated Policy Approach: 1) standards and regulations; 2) supporting policies; 3) finance and financial delivery mechanisms; and 4) monitoring, verification and enforcement (MV&E), and program activities and outputs will be delivered through the following three program components:

- Component 1 - Motor Efficiency Standards and Certification: Participatory establishment and implementation of standards and certifications for 3-phase electric motors and inverters.
- Component 2 – Energy Efficiency Funding Mechanisms: Appropriate EE Funding Mechanisms to support implementation of MEPS, HEPS and energy efficient motor systems developed, approved and operational.
- Component 3 - Awareness Raising and Capacity Building: Enhancement of awareness and core skills through training programs and strategic partnerships with technology suppliers, and promotional campaigns for public, civil and commercial and industrial end-users of motor systems.

3.2.1 Component 1 – Motor Efficiency Standards and Certification

3.2.1.1 Motor Efficiency Standards

Under this component, international standards for electric motors and inverters developed by the International Electrotechnical Commission (IEC) will be adopted by Mongolia for relevant conformity assessment and certification schemes. The relevant standards would include the IEC 60034 standard series for rotating electrical machines (electric motors), and the IEC 61800 standard series for adjustable speed electrical power drive systems (inverters). One of the key standards in the IEC 60034 standard series is IEC 60034-30-1 which provides agreed matrices of energy performance for electric motors, and this standard specifies four levels of motor efficiency ("IE-code"):

- IE1 Standard Efficiency
- IE2 High Efficiency
- IE3 Premium Efficiency
- IE4 Super premium Efficiency

Different economies across the globe chose different IE codes for their minimum energy performance standard (MEPS) and high energy performance standard (HEPS) programs. Most large economies, such as China, US, Canada, Japan and Korea chose IE3 as mandatory MEPS for all motors sold in their economies. Some smaller economies, such as Thailand and Vietnam, chose IE1 as mandatory MEPS, but introduced special labels or markings for IE3 motors as high efficiency products.

Most of mandatory MEPS for 3-phase electric motors worldwide cover rated output powers from 0.73 kW to 375 kW (i.e., around 1hp to 500hp). All economies cover 2, 4, or 6 poles, while some economies extend the scope to cover 8 poles motors. Some economies cover dual frequencies (50/60Hz), while some not. In terms of rated input voltages, a maximum input voltage of 600 volts is a common requirement for both 50Hz and 60Hz economies. Some 50Hz economies which reference IEC standards specify a rated voltage of electric motors up to 1,000 volts. All economies have opted for not including 3-phase induction motors which are not designed for general applications, such as multispeed motors, submersible motors, etc.

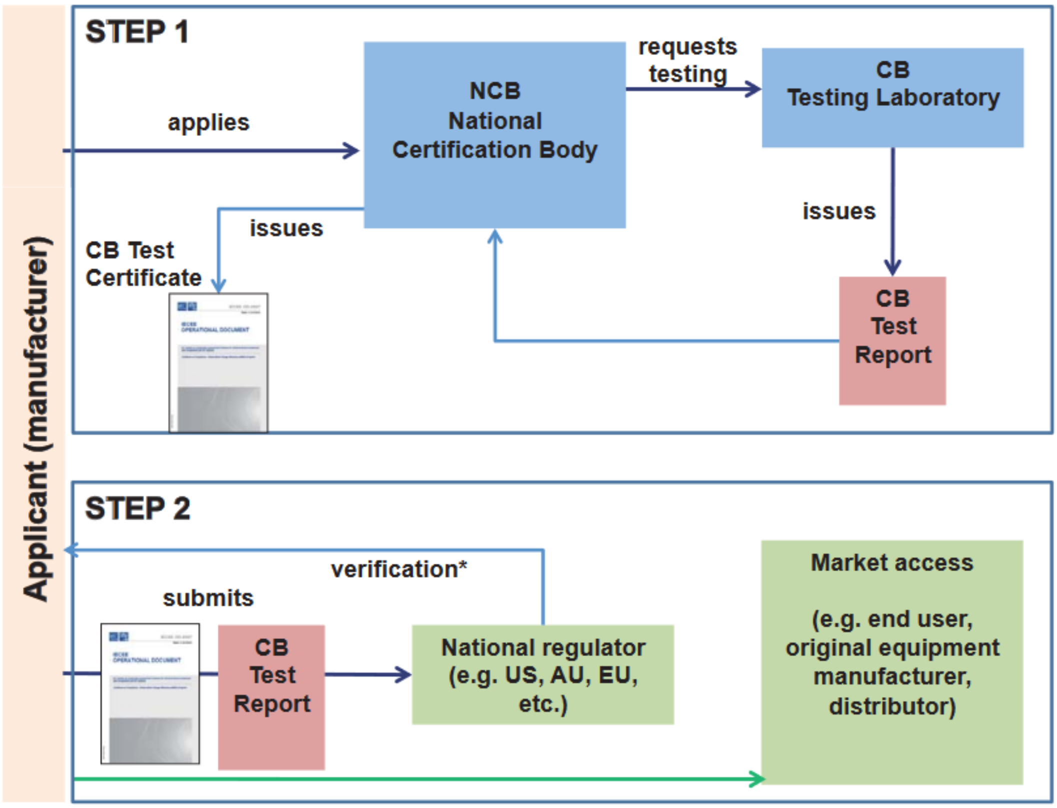
Based on the energy audit and sale reports, more than 80% of 3-phase electric motors in Mongolia are medium- and large-size motors. Considering this, Mongolia should consider adopting 0.75kW to 375kW as the scope of motor efficiency standards and certification for 3-phase electric motors.

3.2.1.2 Conformity Assessment and Certification

Once standards are in place, demonstration of compliance with the standards are required at the market entry points. Quality motors and inverters are tested by manufacturers, and usually equipped with test certificates, therefore monitoring for compliance at the entry points can be easily carried out through submission and inspection of test reports. Motor manufacturers have initiated the IECEE Global Motor Energy Efficiency Programme (GMEE): www.iecee.org/about/gmee/. The goal of the programme is to have one recognized test method (IEC 60034-2-1), one test report format, one efficiency classification (IEC 60034-30-1), one certification process and one label for electric motors in all participating economies. GMEE certifications can also be adopted for conformity assessment and certification purposes in Mongolia. The compliance process at the entry points can also be strengthened through a prerequisite product registration requirement before importation and/or distribution.

Box 4: IECEE Global Motor Energy Efficiency Programme (GMEE)

Major motor manufacturers produce and sell electric motors across many economies. Many economies around the world have adopted IEC standards or equivalent testing methods as the test standards for three-phase induction motors. However, efficiency levels and certification schemes still vary from economy to economy. GMEE is based on the IECEE Certification Body (CB) Scheme which follows IEC International Standards. The main objective of the Scheme is to realize the concept of “one product, one test, one certificate” through promoting the harmonization of national standards with International Standards. Shown in the figure below is the process for obtaining GMEE certifications for market entry verification.



Source: IECEE Global Motor Energy Efficiency Programme Brochure, 2016

***Figure 14**: Process for Obtaining GMEE National Certification under the IECEE CB Scheme*

Under GMEE, the applicant (which is usually a motor manufacturer) applies for a CB certificate for a specific motor model with any participating National Certification Body (NCB). The IECEE has more than 50 Member economies, nearly 80 participating NCBs and close to 500 CB Testing Laboratories (CBTLs). NCBs are assessed on site to verify their compliance against ISO/IEC 17065 and the IECEE Basic Rules, Rules of Procedures and Operational Documents, and the applicant is free to choose any NCB in any countries.

Once the CB certificate is obtained, motor manufacturers or importers can submit the same CB certificate and test report to any national regulator which participates in GMEE for verification. Upon approval of the national regulator, a motor model with a verified CB certificate can be imported and sold in a regulated market.

3.2.1.3 Expected Outputs

The following outputs are envisaged under Component 1:

- Relevant IEC standards for 3-phase electric motors and inverters adopted, and enable certification and promotion of products which are compliant with MEPS and HEPS.
- Certification process for motors and inverters streamlined to support inspection and compliance monitoring process at the entry points if necessary.

3.2.2 Component 2 – Energy Efficiency Funding Mechanisms

3.2.2.1 Investments Required for Energy Efficient Motor Systems

Analysis of cost per rated output (in kW) of motors and inverters, as shown in Annex IV, found that cost per kW of small motors and inverters varies significantly, and the ratios get stabilized once the rated outputs exceed 7.5kW for motors, and 11kW for inverter. Based on these findings, average investment costs per kW for different sizes of motors and inverters are estimated as shown in the figure below. The analysis also found that the incremental cost that end-users have to pay when purchasing high efficiency motors instead of standard efficiency motors is about 15% for small and medium motors (0.37kW to 45kW), and about 10% for large to extra large motors.

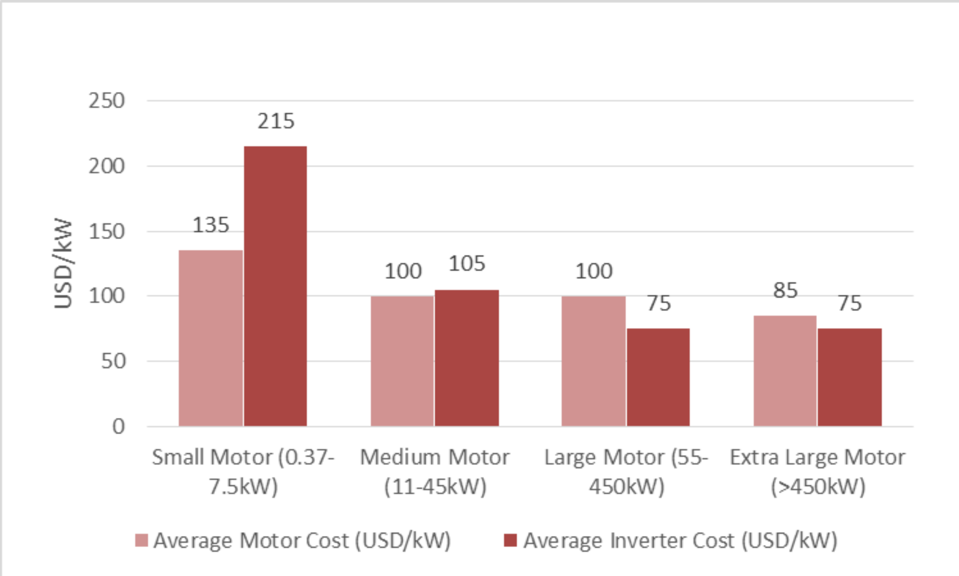


***Figure 15**: Cost per kW Rated Output of Motors and Inverters*

Projection of motor stock in Section 2.2 estimated that about 60 MW of 3-phase electric motors will be purchased and installed annually from 2021 to 2025. Majority of these electric motors are large size motors with rated outputs from 55kW to 450kW.

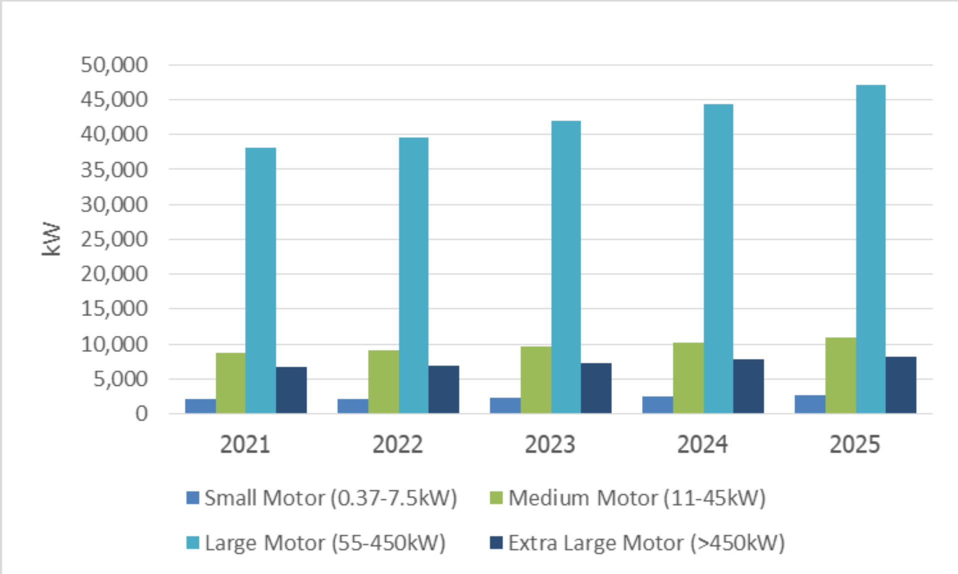


Figure 16: Projected Motor kW installed in Mongolia (2021-2025)

Assuming that all 3-phase electric motors sold in Mongolia in 2021 to 2025 are at the IE2 efficiency levels, the incremental cost to improve efficiency levels of these IE2 motors to IE3 motors during the same period will be close to USD 700,000 annually. Using a conservative estimation that 20% of 3-phase electric motors installed annually are integrated with inverters, the average annual investment cost for inverters will be around USD1 million. Breakdowns of projected annual investments are summarized in Table 5.

Table 5: Annual Investments Required for Energy Efficiency Motor Systems in Mongolia, 2021-2025

Budget Item	2021	2022	2023	2024	2025
Annual New and Replacement Motors (Unit)	1,174	1,223	1,292	1,368	1,451
Annual Inverter Installed (Unit)	235	245	258	274	290
Average Incremental Cost per Unit of Motor (USD)*	520				
Average Investment per Unit of Inverter (USD)	4,024				
Total Incremental Cost for High Efficiency Motors (USD)	611,025	636,596	672,671	712,101	755,417
Total Investment Cost for Inverters (USD)**	944,742	984,278	1,040,056	1,101,020	1,167,994
Total Investment Cost for Motors and Inverters (USD)	**1,556,523**	**1,621,639**	**1,713,505**	**1,813,915**	**1,924,221**

Note: * Cost difference between standard and high efficiency motors
** Assuming 20% of annual new and replacement motor installations come with inverters.

The financial analysis shows that investments in inverters and incremental cost of high efficiency motors are attractive with simple payback periods of less than 3 years, except small sizes inverters (<7.5kW), as shown in Figure 17. The results of this financial analysis are in line with the recommendations by the energy audit project funded by GGGI in 2017 which estimate the simple payback period of about 2 years for installation of inverters for pump and fan applications in twelve DEs. A summary of inverter measures in these DEs is given in Annex V.

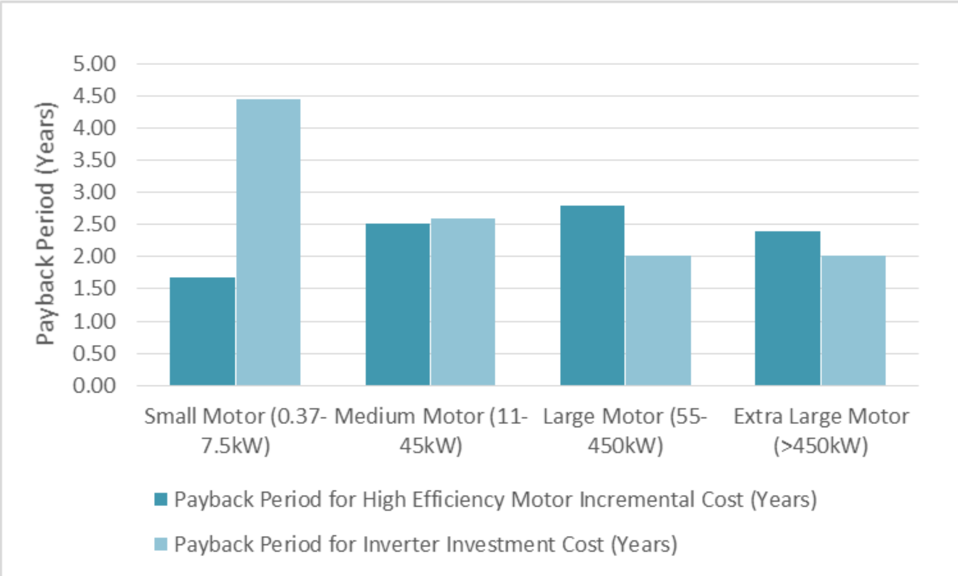


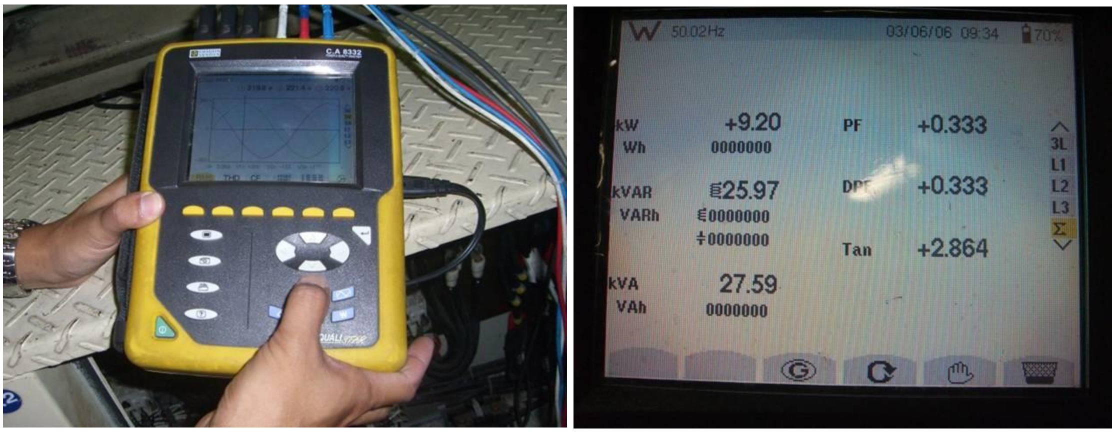
***Figure 17**: Payback Periods of High Efficiency Motors and Inverters In Mongolia*

Box 5: Inverters to Control Hydraulic Pumps in Plastic Injection Molding Machines

A factory producing plastic parts and components for home appliances in Thailand consumes about 21 GWh of electricity per year. The factory has twelve (12) plastic injection molding machines with constant speed hydraulic pumps, and electricity consumptions by these injection molding machines account for about 6% to 7% of the annual electricity consumption. The factory decided to install an inverter with a closed-loop hydraulic pressure sensor to control speed of the hydraulic pump and hydraulic pressure in each injection machine.

Plastic Injection Molding Machine and Inverter for Hydraulic Pump

Measurement and verification (M&V) of energy savings was conducted before and after the installation of inverters using data loggers. The M&V activities reveal that the variable speed hydraulic pumps deliver energy savings of about 600 MWh or about USD 60,000 per year (an average electricity tariff in Thailand was about USD 0.10/kWh). The total investment for inverters and closed-loop hydraulic pressure sensors was about USD 135,000, and the simple payback for these inverter investments was slightly over 2 years.



Measurement and Verification of Energy Savings using Data Logger

Source: IIEC

3.2.2.2 Financial Mechanisms for Energy Efficient Motor Systems in Mongolia

Financial delivery mechanisms help facilitating the adoption of higher efficiency motors and inverters by commercial and industrial end-users in Mongolia. Note that financing energy efficiency (EE) investment is not new in Mongolia. Financial resources provided by international funders such as European Bank for Reconstruction and Development (EBRD), the Global Climate Partnership Fund managed by Deutsche Bank (DB), and the Green Climate (GCF) have been channeled to Small Medium Enterprises (SMEs) and individuals through local intermediary financial institutions (FIs), for example XacBank and Khan Bank[6]. Brief summary of the past and ongoing EE financing programs in Mongolia is discussed below.

The EBRD Energy Efficiency Financing Program titled Mongolian Sustainable Energy Financing Facility (MonSEFF) was introduced in 2015 while the DB funded program was launched in 2013. These EE financing programs promote demand side energy projects in SMEs in the commercial sector, and eligible projects include building retrofit for lighting and structural projects, heating and cooling, equipment replacement and waste to energy projects. The total EBRD MonSEFF loan to Khan Bank is worth USD 60 million. The XacBank EE lending program can fund solar retrofit projects in commercial buildings and mining sector diesel hybridization and replacement by solar as well as retrofitting of existing plants, equipment and production process, modification and expansion of production capacity, as well as energy efficiency investment in efficient refrigeration systems, efficient electric motors, efficient electric transformers, compressed air systems, efficient electricity systems, thermal insulation of premises, boilers, variable speed drive controls, heat recovery systems, micro CHP generation systems.

[6] TA-8483 REG: Asia Energy Efficiency Accelerator- Assessing Energy Efficiency Potential in Mongolia (46241 – 001), Final Report, IIEC, October 2016

With funding from GCF, XacBank is currently implementing the EE Consumption Loan Program. This program provides loans to EE heating appliances and housing products, with heating appliances certified to achieve at least a 20 percent reduction in energy usage. XacBank plans to blend GCF funding with the XacBank commercial fund to achieve lower loan interest rates and lengthened loan terms. This program is expected to complete in 2029. Another ongoing EE financing program in Mongolia is the Green Economy Financing Facility (GEFF) funded by EBRD and Green Climate Fund (GCF). GEFF is currently offering leases, through XacLeasing, to micro-, small- and medium-sized enterprises (MSMEs) for investments in high-performing technologies that improve the use of energy and water resources[7]. Climate-friendly technologies can be identified through the Green Technology Selector[8], and EE variable speed motor and pump are listed as eligible technologies.

In November 2020, GCF approved a funding proposal submitted by XacBank to support the Mongolian Green Finance Corporation (MGFC)[9]. MGFC is a joint public-private sector effort to create a national financing vehicle (NFV) to overcome the existing challenges and constraints of climate change mitigation in Mongolia. MGFC aims to become a major institution for effective and strategic financing of climate change mitigation policies and measures, thus supporting the GOM to achieve its GHG emissions reduction targets stated in its NDC and the National Green Development Policy (NGDP) of Mongolia. MGFC will mainstream green finance for low-carbon, climate-resilient development through dedicated financing to energy intensive users and households in partnership with local participating financial institutions (PFIs). MGFC will provide wholesale financing to PFIs for EE in industry, thermal insulation and green affordable housing.

In its first stage, MGFC's financial products will target households living in peri-urban (Ger) areas of Ulaanbaatar (~216,000 households) as well as in rural areas throughout Mongolia, and transitioning to low-carbon and energy efficient practices in designated entities and energy intensive end-users. After initial operations, MGFC aims to attract new capital and target other sectors with potentially direct investment. In the future, MGFC will have the capacity to target additional markets in relationship with Mongolia's climate change and green development commitments.

The existing EE financial mechanisms in Mongolia can benefit investments in energy efficient motor systems, however, with a relatively small budget required for each energy efficient motor system (about USD 4,500), the existing EE loans are unlikely to be effective for support investments in energy efficient motor systems, as the FI intermediaries would opt for larger EE investments to cover their costs.

With attractive payback periods but small investments, the MIE program should collaborate with the GEEF Mongolia and MGFC to strengthen the implementation of the leasing scheme for EE motor system, and establish specific financial delivery mechanisms aiming at directly supporting greater adoption of energy efficient motor systems in Mongolia.

1. Direct or indirect subsidy mechanisms to offset incremental cost of high efficiency motors for end-users or suppliers. These can be in a form of financial rebates or tax incentives.

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[7] https://www.ebrd.com/news/2020/ebrd-and-gcf-boost-climate-financing-for-mongolian-enterprises.html

[8] https://techselector.com/mongolia-en/

[9] Total investment of MGFC is USD 49.7 million, where GCF is providing 53.7% of the total investment (USD 15.0 million loan and USD 4.7 million equity). Also, MGFC is leveraging the GCF financing through investments from Government of Mongolia (USD 5 million equity, USD 13 million debt) and local commercial banks (USD 5 million equity).

2. Special financing facility for demand aggregators or market facilitators (such as local suppliers or ESCOs) to enable these actors to offer longer repayment schemes for their customers. Establishment of a revolving fund to support operation of this special financing facility can also be considered.

3.2.2.3 Expected Outputs

The following outputs are expected under Component 2:

- Financial delivery mechanism for high efficiency motors established and operationalized.
- Special financing facility for energy efficient motor system demand aggregators designed, developed and operationalized.

3.2.3 Component 3 – Awareness Raising and Capacity Building

This component aims to raise awareness and strengthen capacity among key players in the motor and inverter industry in Mongolia which include the key players in the supply side, demand side, financiers, facilitators (ESCOs) and regulators (ERC, MASM). The program activities should capture both non-technical and technical aspects of energy efficient motor system (motor, inverter, load) designs, benefits of energy efficient motor systems, and choices of equipment. Training and capacity building for key project stakeholders, consumer awareness and communication campaigns, and direct communication with policy makers and regulators will collectively deliver the expected outputs.

Under this component, a comprehensive training and capacity building program will be developed to address needs of different groups of stakeholders. The training and capacity building program will be designed based on results and outputs from Component 1 and 2, and implemented in collaboration with local institutions and agencies.

The communication and awareness campaigns will aim at persuading commercial and industrial end-users and relevant stakeholders in the motor and inverter industry in Mongolia to change or modify their behaviors by providing information about energy efficient motor systems and their benefits. The communication and awareness campaigns will be tailored for each group of target audience, addressing the economic implications of certified energy efficient motor systems (with IE3/IE4 motors or inverters) versus standard designs, and the environmental and social benefits. Implementation of the campaign will be carried out in partnership with the motor and inverter industry stakeholders, and communication and awareness activities implemented by the private sector stakeholders will be considered as co-financing to the MIE program.

3.2.3.1 Expected Outputs

The following outputs are envisaged under Component 3:

- Comprehensive training and capacity building program on energy efficient motor system designs developed and implemented.

- Strategy and communication campaigns for creating public awareness designed and implemented.

3.2.4 Expected Program Benefits

The MIE program is expected to contribute to both global environmental and national benefits, and the cumulative energy savings and emission reduction of about 198 GWh and 210,000 tCO2 respectively are estimated from adoption of high efficiency motors and inverters from 2021 to 2025. Summarized in the table below are the annual and cumulative program benefits over the next five (5) years.

Table 6: Estimated Annual and Cumulative Program Benefits for 2021 to 2025

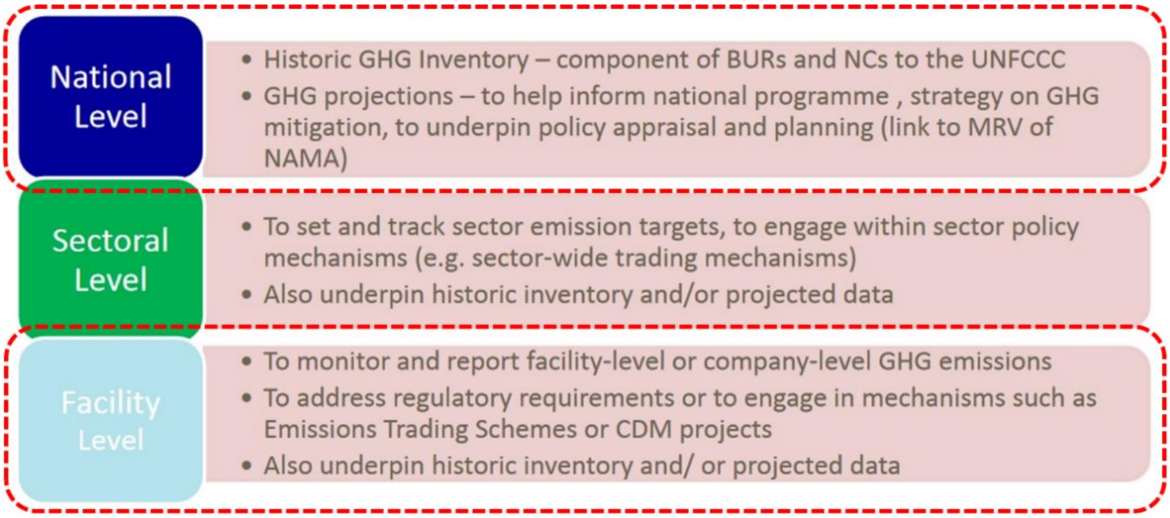
Program Benefits	2021	2022	2023	2024	2025	Cumulative Energy Savings (2021-2025)
High Efficiency Motor						
Energy Savings (GWh)	4.4	9.0	13.9	19.1	24.6	71.0
GHG Emission Reduction (‘000 tCO2)	4.7	9.6	14.8	20.2	26.0	75.3
Inverter						
Energy Savings (GWh)	7.9	16.1	24.8	34.0	43.8	126.7
GHG Emission Reduction (‘000 tCO2)	8.4	17.1	26.3	36.1	46.5	134.4

It is envisaged that the existing in-country technical resources would be adequate to support transition to high efficiency motors as electrical, mechanical and civil works required for design, installation and commissioning of standard efficiency and high efficiency motors would be more or less the same. However additional technical resources will be required to support greater adoption of inverters for 3-phase electric motors, and it is estimated that at least 10 green jobs to support design, installation and commissioning works should be recruited by the motor and inverter industry in Mongolia during the implementation of the MIE program and beyond.

Unlike distribution transformers and cooling equipment, electric motors and inverters do not contain highly toxic or ozone depleting substances. Moreover, most parts of discarded and end-of-life motors and inverters can be recycled. However, inverters have printed circuit boards and other electronic components, which are considered as electronic waste at their end-of-life. Therefore, it is important that electronic waste management schemes are in place to ensure safe disposal of discarded and end-of-life inverters in a long-term.

3.2.5 Measurement, Reporting and Verification of Emissions

The proposed measurement, reporting and verification (MRV) for emissions savings under the MIE program will primarily focus on estimation of emissions the national and facility levels as illustrated in the figure below.



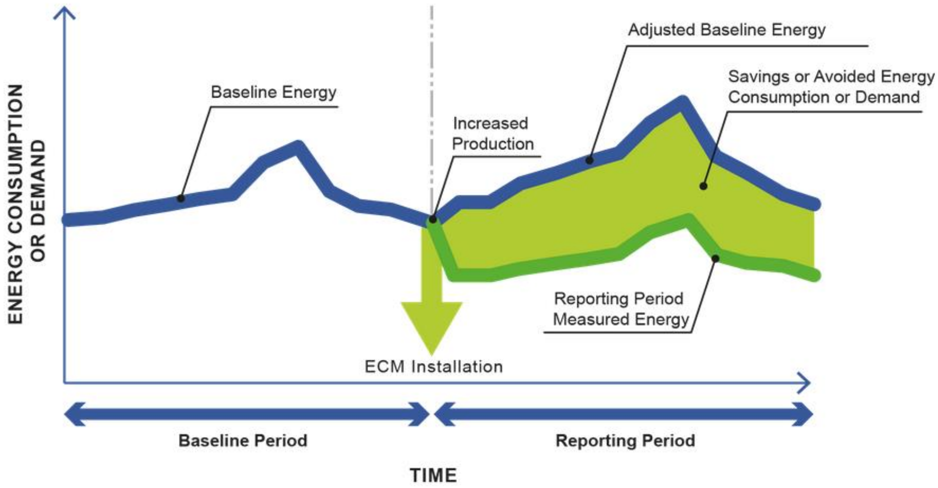
Source: How to Set up National MRV Systems, GIZ

***Figure 18**: Layers of MRV of Emissions*

The proposed MRV aims to measure, report and verify the impacts of the mitigation actions proposed under the MIE program to demonstrate to funders the energy savings and emission reduction. At the national level, a decision to employ relevant top-down, bottom-up or a combination of both should be reviewed and finalized during the preparation of the detailed design of the MIE program. The decision of the MRV approach should be based on a good balance between accuracy and costs involved in data collection, management and analysis. Relevant outputs of the Development of GHG MRV project, funded by GGGI in 2018, should also be taken into consideration when developing the national MRV framework for the MIE program.

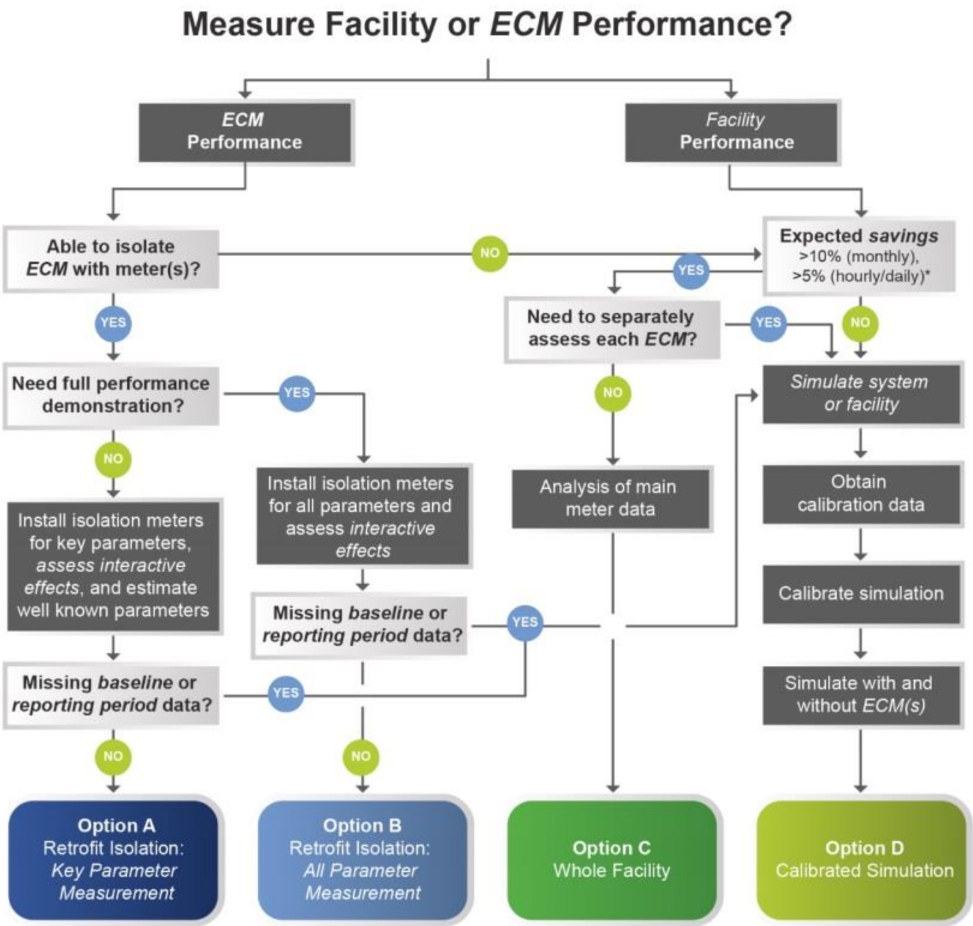
For the facility level MRV, there is no relevant CDM mechanism appropriate for installation of EE motors and inverters. Considering this, the International Performance Measurement and Verification Protocol (IPMVP) published by the Efficiency Valuation Organization (EVO)[10] is recommended for MRV of energy savings and corresponding GHG emission reduction of EE motors and inverters at the facility level. The overall IPMVP framework is illustrated in Figure 19. The IPMVP documents provide detailed guidelines and examples on to apply different IPMVP options for Energy Conservation Measures (ECMs), as shown in Figure 20. The proposed cost effective MRVs for the MIE program at the facility level include Option A for EE motors (without inverters), and Option B for EE motors integrated with inverters.

[10] www.evo-world.org



Source: www.evo-world.org

***Figure 19**: IPMVP Framework*



Source: Measurement & Verification – Issues and Examples, IPMVP, EVO 10300-1:2019, February 2019

Figure 20: IPMVP Options

3.2.6 Budget

The budget estimates show a total cost of about USD3.8 million for the MIE program over a five-year period (see Table 7). Within the total budget, technical assistance and develop of a product registration system under Component 1 would require approximately USD 300,000. The intensity of Component 1 activities will be during the first two years of the program to support adoption of standards and strengthen product certification works. Component 2 will be the largest component with the budget of about USD 3 million to support development financial delivery mechanisms for greater adoption of high efficiency motors and inverters in Mongolia. The budget for Component 3 is to cover technical assistance to carry out design and implementation of awareness raising and capacity building activities.

Table 7: Estimated MIE program Budget 2021-2025

Component	Budget (USD)	Type of Financial Support
1. Motor Efficiency Standards and Certification	300,000	Grant/in-kind
2. Energy Efficiency Funding Mechanisms	3,000,000	Loan/Grant
3. Awareness Raising and Capacity Building	500,000	Grant/in-kind
Total	**3,800,000**	

3.2.7 Potential Donor Agencies

The potential donor agencies for the MIE program would include but not necessarily limited to Global Environment Agency (GEF), Green Climate Fund (GCF), and NAMA Facility. Mongolia has past and ongoing experience with these information donor agencies, and applying financial supports from these international funders requires development of a more detailed project proposal which can be developed based on this conceptual design document. The potential funding cycles for the MIE program are briefly described below:

- **7th GEF Replenishment Period (GEF-7)** – A total budget of USD 2.35 million was initially allocated for climate change activities in Mongolia for the period of July 1st, 2018 to Jun 30th, 2022[11]. It is recommended for ERC to discuss with the GEF Operational Focal Point in Mongolia, the Ministry of Environment and Tourism (MET), to understand how the allocated fund has been distributed among in-country agencies. ERC should also coordinate with GEF implementing agencies, such as Asian Development Bank (ADB), United Nations Development Programme (UNDP), United Nations Environment Program (UN Environment), and the World Bank, to explore other potential funding avenues under GEF.

[11] https://www.thegef.org/sites/default/files/council-meeting-documents/GEF-C.55-Inf.03-GEF-7-STAR.pdf

- **Green Climate Fund (GCF)** – GOM signed an agreement with GCF in November 2019 exempting GCF resources from national taxation, the agreement ensures that more resources will be channelled directly to project beneficiaries. The agreement is part of the Government's support towards the implementation of the Paris Agreement, as specified in the updated Nationally Determined Contribution (NDC), and GOM sees GCF as a key partner in helping achieve the ambitious new goals. Mongolia has implemented four national projects totalling USD 183.65 million in GCF financing, and three multi-country projects. In addition, GCF approved seven readiness activities totalling USD 5 million to build capacities of national stakeholders. GCF financing is available as grant and loan, and shall be applied through an accredited entity with approval from the National Designated Authority (NDA), MET. In Mongolia, Trade and Development Bank of Mongolia (TDBM) and XacBank LLC are the two national accredited entities. In addition, most international development banks (e.g., ADB, EBRD, the World Bank) and UN agencies (e.g., UNDP and UN Environment) are also accredited entities and can serve as the vehicles to access GCF financing.

- **NAMA Facility** – The NAMA Facility's 7th Call for NAMA Support Projects (NSPs) was closed in September 2020. While the new funding commitment and timeline of the next call has not yet been published, the NAMA Facility can be considered as the potential donor for the MIE program as the NAMA Facility aims at financing innovative projects that tackle specific local challenges for reducing emissions in sectors and countries with strong potential for up-scaling, replication and the ability to influence wider sectoral changes; and unlocking investment opportunities by providing tailor-made climate finance to fund projects. Selection of NSPs from across all sectors and developing countries and emerging economies will be processed through open competitive calls, and national ministries and eligible legal entities are eligible for submission of NSPs.

In addition to the abovementioned international funding agencies, the Environment and Climate Fund chaired by MET should be explored if the MIE program can access to support implementation of specific program activities, such as communication and awareness activities.

3.2.8 Program Management

3.2.8.1 Implementation Arrangement

The proposed program management and implementation are illustrated in Figure 21. It is proposed that a Project Steering Committee (PSC) is established to provide overall guidance and oversee the progress and performance of the MIE program as well as to enhance and optimize the coordination and contribution with various project partners. The PSC will be chaired by a high level official nominated by ERC. Technical Working Groups (TWGs) should be established to provide guidance in specific technical related issues, such as EE standards and certifications, and MRV.

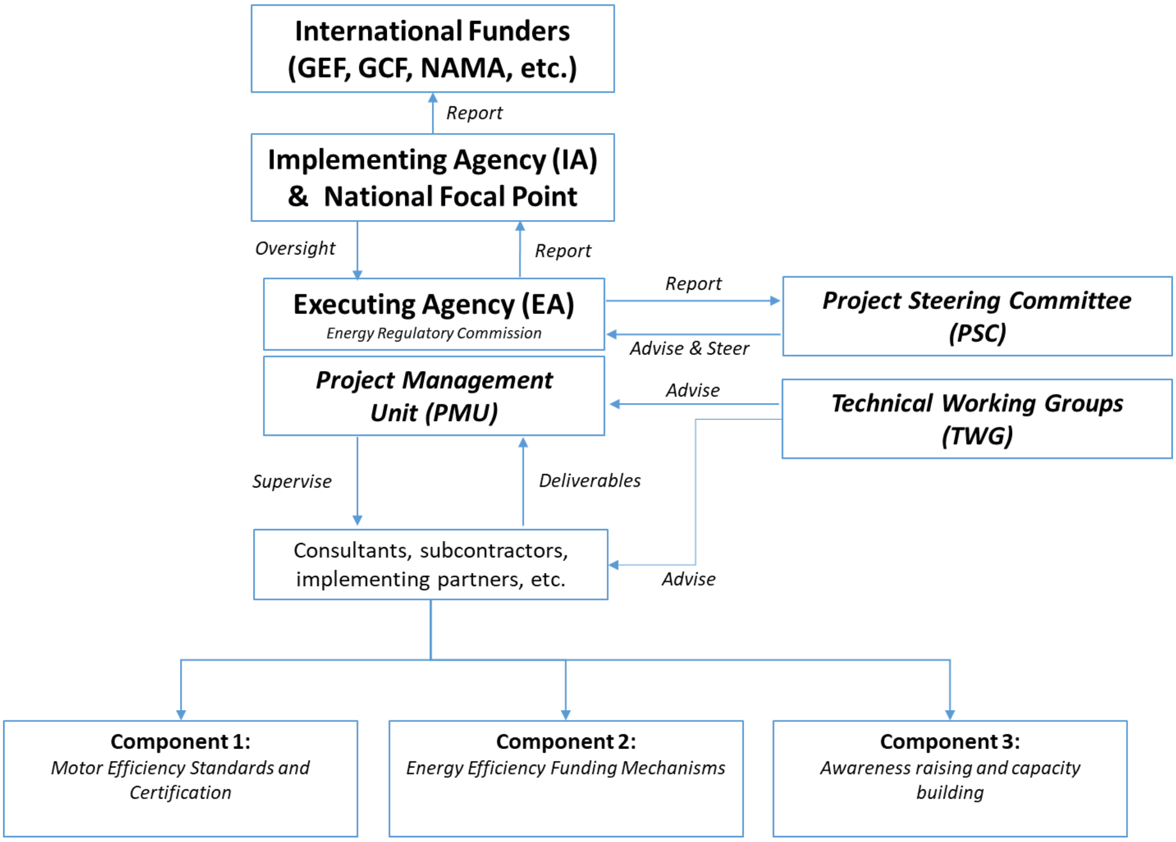


***Figure 21**: Program Management and Implementation Structure*

Brief description on roles and responsibilities of organizations and bodies involved in the project implementation are described below.

Stakeholders	Roles
Energy Regulatory Commission (ERC)	ERC will serve as implementing entity for the MIE program. It will also responsible for the overall management of the project including day-to-day project implementation, communication and coordination with key partners, providing staff and administrative support, liaison with local governments, monitoring and project financial management.
Ministry of Environment and Tourism (MET)	MET is the focal government body for climate change mitigation activities. MET acts as the Operation Focal Point for GEF, and the National Designated Authority (NDA) for GCF. MET also has the mandate to promote NAMA development and implementation in Mongolia. MET will be the agency in
Mongolian Agency for Standardization and Metrology (MASM)	MASM is responsible for research, development and update of national standards. MASM will be the key national stakeholder in implementation of Component 1 (motor efficiency standards and certification).

Stakeholders	Roles
Ministry of Energy (MOE)	MOE is responsible for energy and energy efficiency policy development and implementation. It will assist in energy related data collection for establishing the baseline energy consumption for motor systems.
Importers/Distributors of Motor System Equipment	Importers and distributors of motor system equipment (i.e., motors, inverters, pumps, fans, conveyors, etc.) are the main private sector stakeholders driving successes of the MIE program. The ESCO industry in Mongolia is nascent stage, and importers of EE motor systems can also act as vendor ESCOs providing technical assistance and finance for potential EE motor system projects.
Local Financial Institutions	Local financial institutions will participate in the Project to support the formulation and implementation of financial strategies and barrier removal activities to increase investment in EE motors and inverters.
Academia and Civil Society	Academia and civil society will be involved in the development of capacity building for organizations and individuals involved in design, development and implementation of EE motor systems. Professional and industry will play an active role in disseminating information and raising the awareness of different stakeholders on EE motor systems by using their current networks, and participate in EE motor and inverter implementation.
International Development Agencies and Development Banks	Various international development agencies and development banks, including but not limited to, ADB, EBRD, GGGI, UN agencies, the World Bank, will play an important role in supporting ERC and MET in accessing international funding for implementation of the MIE program.

3.2.8.2 Monitoring and Evaluation

The proposed monitoring and evaluation (M&E) plan for the outputs and impacts expected to be delivered by the MIE program shall be consistent with the monitoring and evaluation policy of the Government of Mongolia (GOM) and/or donor agencies. Indicators for each expected output along with the key deliverables and benchmarks will be the main tools for assessing project implementation progress, and whether project results are being achieved. Development of quality indicators shall follow the SMART (Specific, Measurable, Achievable, Relevant and Time-bound) framework and shall be identified during the detailed design phase of the MIE program.

The M&E plan should be reviewed and revised as necessary during the project inception phase to ensure project stakeholders understand their roles and responsibilities vis-à-vis project M&E requirements. Indicators and their means of verification may also be fine-tuned at the inception phase. It is envisioned that the key indicators will be reviewed and reported annually. General project monitoring is the responsibility of ERC but other project partners could have responsibilities in collecting specific information to track the indicators. In general, both primary and secondary data sources will be used to evaluate the program's impacts. M&E of the program's impacts linked to gender equity, will separately track program impacts for men and women. The baseline study required for M&E will collect gender segregated data, and subsequent evaluations will capture separate indicators for the different groups.

3.2.8.3 Gender

It is proposed that relevant gender specific issues are incorporated into the detailed design of the MIE program. In principle, the MIE program should mainstream a gender perspective, specifically targeting women to not only participate in and benefit from activities, but to implement and manage the activities. The specific activities to be considered by the MIE program to address gender related issues may include but not limited to:

- The specific targeting of women to assume management responsibility for the RLSS and the PIES systems, and to advocate for responsible use;
- The specific targeting of women to assume management responsibility for vendors or distributors for motor and inverter technologies;
- The encouragement of vendors/distributors to employ female technical staff, wherever possible;
- A requirement for participating in training and capacity building activities to ensure that 1 in 5 maintenance trainees are female;

3.2.8.4 Risks involved in Program Implementation

The MIE program is subject to possible risks that can be managed and mitigated to ensure successful program development and implementation. The possible risks and mitigation measures during the MIE program development and implementation are summarized in the table below.

Risk description	Risk Mitigation Measures
Changes priority and commitments of the Government of Mongolia in promoting energy efficiency in commercial, industrial and public sector.	ERC should maintain regular dialogues with key project proponents and partners, and convey the importance of EE motor systems in Mongolia to high-level policy makers to secure commitments in development and implementation of the MIE program.

Risk description	Risk Mitigation Measures
The COVID-19 pandemic in Mongolia and continued throughout the project period, and all project partners and stakeholders are in a wait-and-see situation, causing delay in overall project implementation that affect to the project outputs.	As of October 2020, the COVID-19 pandemic situation in Mongolia is entirely under control. It is very likely that the government will continue with cautious control of country opening up for official and business travels. With COVID-19 vaccines expected to be available early next year, it is expected that the MIE program will be implemented with limited COVID-19 impact. However, delays in COVID-19 vaccine trial and approval and uncontrollable infection rates could affect the MIE program development and implementation. Potential measures to mitigate impacts of COVID-19 during the MIE program development and implementation would include: 1) Periodically review of the situation as needed. 2) Utilization of appropriate communication channels or IT online platforms to support regular dialogues and meetings with all project partners and stakeholders during the MIE program development phase. 3) Creation of matrix of outputs and measures to adjust project implementation timeline and budget to reflect the situations and mitigate delays as needed.
Limited choices of EE motors and inverters in Mongolia, imported EE motor system components are not cost effective and suitable with the Mongolian context (local knowledge, technical capacities, and climatic conditions)	ERC should collaborate and consult with the industry partners and designated entities to review existing potential EE motor system projects identified by energy audits, and create a pipeline of EE motor system projects to stimulate competition among local suppliers to serve the existing market demand.
Local importers/ distributors of EE motor systems are not interested to participate in the MIE program.	Local importers/ distributors are the key partners driving successes of the MIE program, and it is crucial to ensure their support and participation during the program development and implementation phases. The potential risk mitigation measures would include: 1) Identify needs and demands through continuous dialogue to scoping out and design of the capacity building for local manufacturers/ suppliers. 2) Implement the capacity building programs for local importers/ distributors of EE motor system components and utilize past and ongoing implementation of EE motor systems to showcase and create demand of EE motor systems in Mongolia.

Risk description	Risk Mitigation Measures
High incremental cost of EE motor system components (IE3/IE4 motors and inverters) compared with the basic design (standard motor systems without inverters) may prevent greater adoption of EE motor systems.	Utilize the financial mechanism and revolving fund established under the MIE program to offset the higher upfront investment cost for demonstrate the reasonable payback of EE motor systems through lower operating expenses.

4 ANNEXES

Annex I	Annual Motor Sales and Replacements
Annex II	Motor Stock Projection and Impact Analysis
Annex III	Importers and Distributors of Motors and Invertors in Mongolia
Annex IV	Analysis of Motor and Inverter Cost
Annex V	Inverter Installation Recommendations for Designated Entities
Annex VI	References

4.1 ANNEX I: ANNUAL MOTOR SALES AND REPLACEMENT MODELLING

Calculations of annual motor sales volume or shipments are important, since the proposed conceptual design primarily focuses on improving efficiencies of new motors and motors systems purchased annually. Changes in motor sales volume are typically driven by the economic expansion, increase of services and productions in commercial and industrial sectors, or by the replacement of failed/end-of-life motors. The mathematical models used to quantify the motor sales volumes are credited to the Policy Analysis Modelling System (PAMS), developed by LBNL. PAMS utilizes the cumulative retirement probability function, as given below, to predict number of motors which would reach their end-of-life and be replaced by new ones annually.

$$\Pr(age) = \frac{1}{1+e^{-(age-age_0)/\Delta age}} \;;$$

Where: age is the given equipment/appliance age

P_r *(age)* is the probability of retirement after a given number of years of use,

age_0 is the average lifetime of motors, and

Δ_{age} is the mean deviation of replacement ages, which vary by country.

Replacements in each year are given by the relationship

$$\text{REP}(y) = \sum_{age=1}^{L} stock(y-1, age) \times \Pr(\text{age}) \times L_{inc} \;;$$

Stock(y,age) is the number of products of vintage age remaining in each year. While, L_{inc} is the incremental of lifetime factor that affects the motor replacement, assumed to be 97% annually. The increment of lifetime will reduce the motor replacement overtime after the analysis year (2018).

In developing countries, the first purchase or new installation of motors could be the dominant driver of sales, while this figure could be marginal (based on new commercial and industrial facilities only) in developed countries.

The function for the first purchase ($FP_{(y)}$) is given by:

$$FP_{(y)} = Shipment_{(y,\ specified\ by\ users)} - replacement_{(y)}$$

The projection of annual sales towards 2040 assumes the economic growth rate (conservative rate) and the number of shipments in the baseline year, where data were collected from the import statistics. The total shipment or annual sales volume for any given year is computed by:

$$Shipment_{(y)} = FP_{(y)} + \text{REP}(y)$$

4.2 Annex II: Motor Stock Projection and Impact Analysis

Basic Parameter	2015	
Emission Factor (tCO_2/MWh)	1.06	IGES
Annual Growth (2019)	5.1%	
Annual Growth (2020)	-2.6%	
Annual Growth (2021)	5.1%	
Annual Growth (2032-2040)	5.0%	
Lifetime (years)	15.0	

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Installed Stock (unit)	12,165	12,937	13,741	15,091	15,860	15,448	16,236	17,048	17,900	18,795	19,735	20,722	21,758	22,846	23,988	25,187	26,447	27,769	29,157	30,615	32,146	33,753	35,441	37,213	39,074	41,027
Annual New Installation	0	772	804	1,350	770	0	788	812	852	895	940	987	1,036	1,088	1,142	1,199	1,259	1,322	1,388	1,458	1,531	1,607	1,688	1,772	1,861	1,954
Annual Installation	252	1,051	1,105	1,671	1,112	363	1,174	1,223	1,292	1,368	1,451	1,543	1,641	1,746	1,853	1,963	2,081	2,215	2,359	2,490	2,594	2,684	2,792	2,934	3,101	3,282
Annual Replacement (2020 Stock)	0	0	0	0	0	0	411	440	473	512	556	605	657	710	762	819	889	963	1,018	1,035	1,023	1,003	975	913	791	615

Stock Profile 2015 - 2040	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
New Installation Stock							788	1,600	2,452	3,347	4,287	5,274	6,310	7,398	8,540	9,739	10,999	12,321	13,709	15,167	16,698	18,305	19,993	21,765	23,626	25,579
Replacement of Baseline Stock	0	0	0	0	0	0	411	851	1,325	1,836	2,392	2,997	3,655	4,365	5,127	5,946	6,835	7,798	8,817	9,852	10,874	11,877	12,852	13,765	14,556	15,170
Baseline Stock						15,448	15,037	14,597	14,124	13,612	13,056	12,451	11,794	11,083	10,321	9,502	8,613	7,650	6,632	5,596	4,574	3,571	2,596	1,683	892	278

Stock by Motor Category	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Small Motor						6,893	7,245	7,607	7,987	8,387	8,806	9,246	9,709	10,194	10,704	11,239	11,801	12,391	13,011	13,661	14,344	15,061	15,815	16,605	17,436	18,307
Medium Motor						5,250	5,518	5,794	6,084	6,388	6,707	7,043	7,395	7,765	8,153	8,561	8,989	9,438	9,910	10,405	10,926	11,472	12,046	12,648	13,280	13,944
Large Motor						3,130	3,290	3,454	3,627	3,808	3,998	4,198	4,408	4,629	4,860	5,103	5,358	5,626	5,907	6,203	6,513	6,839	7,181	7,540	7,917	8,312
Extra Large Motor						174	183	193	202	212	223	234	246	258	271	284	299	314	329	346	363	381	400	420	441	463

New Installation & Replacement by Motor Category	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Small Motor							524	546	577	611	648	688	732	779	827	876	928	988	1,053	1,111	1,157	1,198	1,246	1,309	1,384	1,465
Medium Motor							399	416	439	465	493	524	558	593	630	667	707	753	802	846	882	912	949	997	1,054	1,116
Large Motor							238	248	262	277	294	313	333	354	375	398	422	449	478	505	526	544	566	594	628	665
Extra Large Motor							13	14	15	15	16	17	19	20	21	22	24	25	27	28	29	30	32	33	35	37

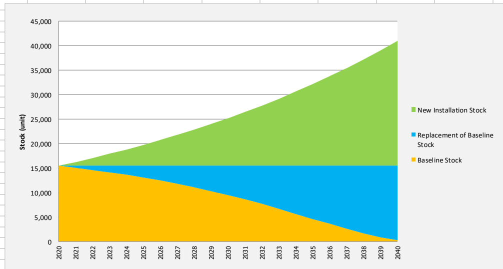
Baseline Annual Energy Consumption (MWh)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Small Motor (4kW)						99,542	104,618	109,849	115,342	121,109	127,164	133,522	140,198	147,208	154,569	162,297	170,412	178,933	187,879	197,273	207,137	217,494	228,368	239,787	251,776	264,365
Medium Motor (22kW)						385,463	405,121	425,377	446,646	468,979	492,428	517,049	542,901	570,046	598,549	628,476	659,900	692,895	727,540	763,917	802,113	842,218	884,329	928,546	974,973	1,023,722
Large Motor (160kW)						1,601,645	1,683,329	1,767,495	1,855,870	1,948,664	2,046,097	2,148,402	2,255,822	2,368,613	2,487,044	2,611,396	2,741,966	2,879,064	3,023,017	3,174,168	3,332,876	3,499,520	3,674,496	3,858,221	4,051,132	4,253,689
Extra Large Motor (500kW)						278,424	292,623	307,254	322,617	338,748	355,685	373,470	392,143	411,750	432,338	453,955	476,652	500,485	525,509	551,785	579,374	608,343	638,760	670,698	704,233	739,444
Total (MWh)						2,365,073	2,485,692	2,609,976	2,740,475	2,877,499	3,021,374	3,172,443	3,331,065	3,497,618	3,672,499	3,856,124	4,048,930	4,251,377	4,463,945	4,687,143	4,921,500	5,167,575	5,425,954	5,697,251	5,982,114	6,281,220

IE3 Annual Energy Saving (MWh)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Small Motor (4kW)							470	959	1,476	2,023	2,604	3,221	3,877	4,575	5,317	6,102	6,934	7,820	8,764	9,760	10,797	11,871	12,988	14,161	15,401	16,714
Medium Motor (22kW)							976	1,994	3,069	4,207	5,414	6,697	8,062	9,514	11,055	12,687	14,418	16,260	18,223	20,294	22,451	24,684	27,006	29,446	32,025	34,755
Large Motor (160kW)							2,541	5,188	7,986	10,947	14,089	17,428	20,980	24,759	28,769	33,017	37,521	42,315	47,422	52,813	58,427	64,236	70,279	76,628	83,341	90,446
Extra Large Motor (500kW)							441	900	1,385	1,899	2,444	3,023	3,640	4,295	4,991	5,728	6,509	7,341	8,226	9,162	10,136	11,143	12,191	13,293	14,457	15,690
Total (MWh)						0	4,428	9,041	13,916	19,076	24,550	30,369	36,559	43,143	50,132	57,534	65,382	73,736	82,635	92,028	101,811	111,933	122,463	133,528	145,225	157,605
Total (tCO2)						0	4,698	9,593	14,765	20,240	26,048	32,221	38,789	45,775	53,190	61,043	69,370	78,234	87,675	97,642	108,022	118,761	129,933	141,673	154,084	167,219

IE4 Annual Energy Saving (MWh)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Small Motor (4kW)							664	1,356	2,088	2,862	3,683	4,556	5,485	6,473	7,521	8,632	9,809	11,062	12,397	13,806	15,274	16,793	18,373	20,032	21,787	23,645
Medium Motor (22kW)							1,426	2,911	4,481	6,143	7,906	9,780	11,773	13,893	16,144	18,528	21,055	23,745	26,611	29,636	32,786	36,046	39,437	43,000	46,767	50,753
Large Motor (160kW)							3,528	7,204	11,088	15,199	19,561	24,197	29,129	34,375	39,943	45,841	52,094	58,751	65,841	73,325	81,120	89,185	97,575	106,391	115,711	125,575
Extra Large Motor (500kW)							591	1,206	1,857	2,545	3,276	4,052	4,878	5,756	6,689	7,676	8,723	9,838	11,025	12,279	13,584	14,934	16,339	17,816	19,376	21,028
Total (MWh)						0	6,209	12,678	19,513	26,749	34,426	42,584	51,265	60,497	70,297	80,677	91,681	103,396	115,874	129,046	142,765	156,958	171,724	187,239	203,642	221,001
Total (tCO2)						0	6,588	13,451	20,704	28,381	36,526	45,182	54,392	64,187	74,585	85,598	97,274	109,704	122,942	136,918	151,473	166,533	182,199	198,661	216,064	234,482

Inverter Penetration Rate	20%																									
IE3+Inverter Annual Energy Saving (MWh)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Small Motor (4kW)							378	771	1,187	1,627	2,094	2,591	3,119	3,680	4,276	4,908	5,577	6,290	7,049	7,850	8,685	9,548	10,447	11,391	12,388	13,444
Medium Motor (22kW)							1,328	2,711	4,173	5,721	7,363	9,108	10,964	12,939	15,035	17,255	19,608	22,114	24,783	27,600	30,534	33,570	36,728	40,046	43,554	47,267
Large Motor (160kW)							5,275	10,771	16,579	22,727	29,248	36,180	43,555	51,399	59,725	68,544	77,893	87,847	98,448	109,639	121,294	133,354	145,898	159,080	173,016	187,765
Extra Large Motor (500kW)							917	1,872	2,882	3,950	5,084	6,288	7,570	8,934	10,381	11,913	13,539	15,268	17,111	19,056	21,082	23,178	25,358	27,649	30,072	32,635
Total (MWh)						0	7,898	16,126	24,821	34,025	43,789	54,167	65,208	76,952	89,417	102,620	116,618	131,519	147,391	164,145	181,595	199,649	218,431	238,166	259,030	281,111
Total (tCO2)						0	8,380	17,110	26,335	36,100	46,460	57,471	69,186	81,646	94,871	108,880	123,731	139,542	156,382	174,158	192,672	211,828	231,755	252,694	274,831	298,259

Annual Energy Consumption (GWh)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Baseline Scenario						2,365	2,486	2,610	2,740	2,877	3,021	3,172	3,331	3,498	3,672	3,856	4,049	4,251	4,464	4,687	4,921	5,168	5,426	5,697	5,982	6,281
IE3 EE Scenario						2,365	2,481	2,601	2,727	2,858	2,997	3,142	3,295	3,454	3,622	3,799	3,984	4,178	4,381	4,595	4,820	5,056	5,303	5,564	5,837	6,124
IE4 BAT Scenario						2,365	2,479	2,597	2,721	2,851	2,987	3,130	3,280	3,437	3,602	3,775	3,957	4,148	4,348	4,558	4,779	5,011	5,254	5,510	5,778	6,060
IE3+Inverter Scenario						2,365	2,477	2,593	2,714	2,842	2,975	3,115	3,262	3,416	3,578	3,748	3,926	4,113	4,308	4,514	4,730	4,957	5,195	5,446	5,709	5,984



4.3 Annex III: Importers and Distributors of Motors and Inverters in Mongolia

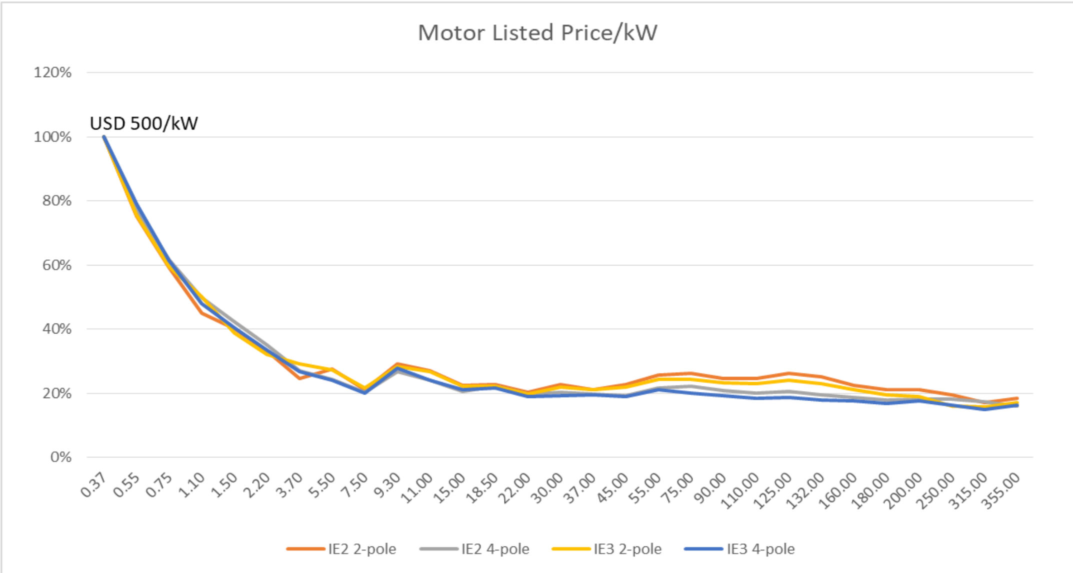
Main importers and distributors of motors and inverters in Mongolia are summarized below.

Company name	Brand of product	Address	Contact
MonHorus International LLC	Different type of motors and Invertors of ABB brand	Narnii Zam 15, 2nd Khoroo, Sukhbaatar District, Ulaanbaatar	Batsaikhan. N Tel: +976 7732 0700 Cell: +976 9400 0114 E-mail: batsaikhan@monhorus.mn
Erchim Concern LLC	Different type of motors and Invertors of ABB brand	Erchim Concern building, Bayangol district, 20th ward, Ulaanbaatar, Mongolia	Bayarmagnai. E Tel: +976 7018 2626 Cell: +976 8811 5280 E-mail: bayarmagnai.e@monnis.com
Hahn Electrical Mongolia	Hahn Electrical Mongolia offers Variable Speed Drives in 415 Volt, 690 Volt, 1000 Volt, and 3.3 KV in KW ratings up 700 KW.	Level 5, New Millenium Building, 15th Khoroo, Khan-Uul District, Ulaanbaatar, 17011 Mongolia	+976 7000 4585 info@hahnmongolia.com sales@hahnmongolia.com
Amper House LLC	Different type of motors and Invertors of ABB brand	Amper House building, 100 ail, Ikh Toiruu, Sukhbaatar District, Ulaanbaatar, Mongolia	Chimegsuren. B Tel: +976 7012 8498 Cell: +976 9903 5125 E-mail: chimegsuren@monhorus.mn
Schneider Electric Mongolia LLC	Discover a wide range of variable speed drives and soft starters offering a powerful and reliable combination for your motor control solutions up to 20 MW.	LS plaza, Level 9, #903, Bogd Javzandamda St, 15th region, Khan-Uul District Ulaanbaatar 17011, Mongolia	Telephone: +976-70009961, +976-70009963 E-Mail: zaw-zaw.aung@se.com Website: http://www.schneider-electric.com/mn, https://www.se.com/ww/en/
MyMonSource LLC Munkh-Erdene. E	Different type of motors and Invertors of ABB brand	Union Business Center, A-block, A-1, Sunroad 62, Sukhbaatar district, Ulaanbaatar, Mongolia	Munkh-Erdene. E Tel: +976 7711 1999 Cell: +976 8811 5929 E-mail: munkherdene@source.mn
Prestige Electric LLC	Different type of motors and Invertors of ABB brand	Prestige Electric LLC office, Building 10/1, Apt #25, Sukhbaatar district, Ulaanbaatar, Mongolia	Baljinnyam. G Tel: +976 9901 0082 Cell: +976 9904 0265 Email: baljinnyam@p-el.mn

Company name	Brand of product	Address	Contact
Bodit Chadal LLC	Different type of motors and Invertors of ABB brand	Bodit Chadal LLC office River stone villa, 26A bldg, Apt. #108 Khan-Uul district Ulaanbaatar, Mongolia	Batkhurel. S Tel: +976 7601 5492 Cell: +976 8807 5492 Email: s_batkhurel@yahoo.com
IM Trading LLC	Different type of motors and Invertors of ABB brand	Union building A-403-1, Sunstreet, Sukhbaatar district, Ulaanbaatar, Mongolia	Ochirbat. B Tel: +976 7710 9997 Cell: +976 9907 0395 Email: ochirbat@imt.mn
SmartCraft LLC	Different type of motors and Invertors of ABB brand	SmartCraft LLC building, Khan-Uul district, Ulaanbaatar, Mongolia	B.Ochkhuu Tel: +976 7575 1860 Cell: +976 9910 4738 Email: ochkhuu@smart-craft.mn
Business Council of Mongolia	Industrial automation, low and medium voltage, power generation, transmission	Bodi Tower 1001, Sukhbaatar Square, 15160, Ulaanbaatar, Mongolia	Telephone: 976-11-31600; 976-11-312575 Website: http://www.siemens.com
Energy Tech Progress LLC	Energy Tech Progress LLC become official distributor of Schneider Electric in 2014. Therefore, within framework of 0.4kV-35kV, Energy Tech Progress LLC will be supplying all electric devices	Energy Tech Progress Co., LTD Building, 20th khoroo, Peace Avenue, Bayangol district, Ulaanbaatar city, Mongolia	+976-70008383 +976-77078383 9666-9420, 9666-9400, 9865-9400 info@energytech.mn

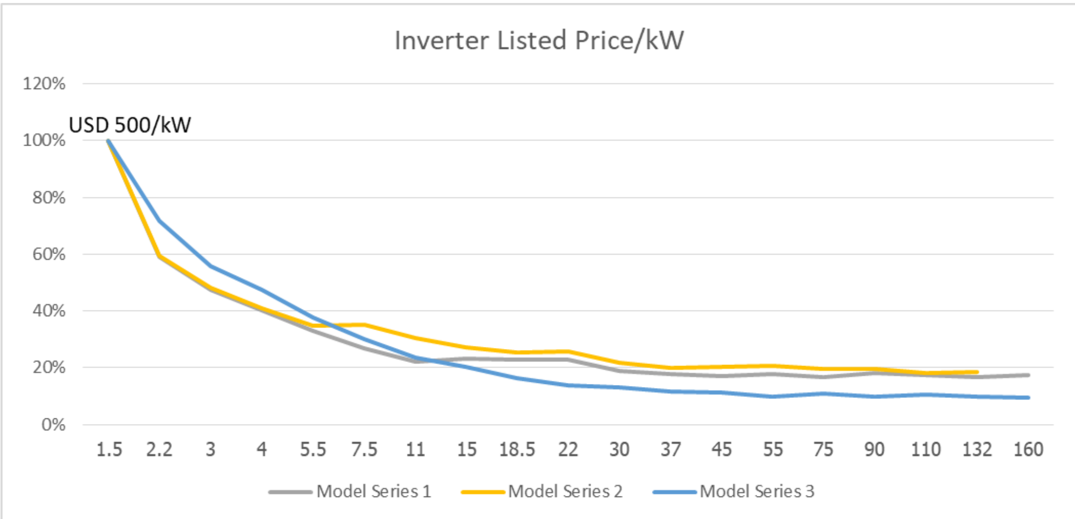
4.4 Annex IV: Analysis of Motor and Inverter Cost

Analysis of cost per rated output (in kW) of motors and inverters was based on the best available secondary resources[12] during the preparation of the concept note report. The analysis found that the maximum cost per kW of motors and inverters is about USD 500 per kW at the smallest rated output. When rated output increases, cost/kW decreases, and cost/kW ratios get stabilized once the rated outputs exceed 7.5kW for motors, and 11kW for inverter, as shown in Figure 22 and Figure 23.



Source: Analysis by IIEC

***Figure 22**: Motor Listed Prices per Rated Outputs in kW*



Source: Analysis by IIEC

***Figure 23**: Inverter Listed Prices per Rated Outputs in kW*

[12] The available secondary resources include low-voltage motor catalogs published by ABB and Siemens, and inverter price lists published by ABB.

The analysis also found that the incremental cost for standard efficiency motors to high efficiency motors is about 15% for small and medium motors (0.37kW to 45kW), and about 10% for large to extra large motors. Summarized in Table 8 are average costs per kW rated output of motors and inverters based on suppliers' catalogs.

Table 8: Average Cost per kW Rated Output of Motors and Inverters

Motor size	Average Size (kW)	Average Motor Cost (USD/kW)*	Average Inverter Cost (USD/kW)*
Small Motor (0.37-7.5kW)	4	135	215
Medium Motor (11-45kW)	22	100	105
Large Motor (55-450kW)	160	100	75
Extra Large Motor (>450kW)	500	85	75

*Note: Computed based on the maximum cost per kW of USD 500 and % shown in Figure 22 and Figure 23

4.5 Annex V: Inverter Installation Recommendations for Designated Entities

No.	Designated Entity	Energy Conservation Measures	Annual energy savings (kWh)	Annual Savings (million MNT)	Estimated Investment (million MNT)	Payback period (year)	CO_2 saving, tonnes/ year
1	Erdenet Carpet factory	Install VFD to all ventilation funs to vary air flow rate as per process load and ambient temperature	186,754	44.2	42	0.95	198
2	Vitafit Soft drink factory	Install VFD with header pressure feedback control system to RO (juice plant and water plant) HP pumps	41,360	6.4	18	2.81	44
		Install VFD with header pressure feedback control system to Ice water and Brine water supply pumps in refrigeration system	42,530	6.58	6.5	0.99	
3	Achit Ikht Copper plant	Install VFD to rectifier cooling water pumps to improve CW delta T to 4-5°C	72,468	12.4	6.5	0.52	77
		Install VFD to refine pumps to avoid recirculation	638,852	109.3	124	1.13	678
		Install VFD to RO plant HP pumps to avoid throttling	22,080	3.78	5.25	1.39	23
		Install VFD to boiler ID and FD fans to avoid throttling	71,280	12.2	21	1.72	76
		Install VFD to air compressor to avoid recirculation	50,530	8.6	20	2.33	54
4	Suu Joint Stock company (dairy product)	Install VFD to ice water supply pumps with temperature and pressure feedback control system	33,858	5.2	10.5	2.02	36
5	Third State Central Hospital	Install VFD to district heating and hot water system supply pumps	32,040	5.82	7.83	1.35	34

No.	Designated Entity	Energy Conservation Measures	Annual energy savings (kWh)	Annual Savings (million MNT)	Estimated Investment (million MNT)	Payback period (year)	CO_2 saving, tonnes/ year
		Install VFD and increase temperature setting of cardio section air washer from 21°C to 23°C	12,434	2.26	5.5	2.43	13
6	Chinggis khan hotel	Install VFD with header pressure feedback control system to district heating hot water supply pumps to save pump power consumption	41,472	6.42	8.8	1.37	44
		Install VFD to all the AHU with fan motor capacity 5.5 kW and above to save AHU fan motor consumption	446,130	69.8	198	2.84	473
7	Baganuur JSC (Coal mining)	Install VFD to conveyor motors to increase motor loading to reduce losses	151,441	25.84	65	2.52	161
		Reduce pressure drop across the bag filters and install VFD to dedusting fan motors in loading pointe -1&2.	24,499	4	10.4	2.60	26
		Install VFD to crusher to match the motor speed to mechanical load (coal)	74,527	12.71	36	2.83	79
8	Makh impex LSC (meat processing factory)	Install VFD to district heating hot water supply pump to very water flow as per ambient temperature and process heat load	21,946	3.13	4.4	1.41	20
9	Nalaikh Thermal Power Plant	Installation of VFD to the boiler feed water pump to reduce the discharge pressure	155,200	22.06	64	2.90	
10	The Ulaanbaatar 3rd Power Plant Co., Ltd	Install VFD to secondary FD fan to reduce excess air in boiler and to avoid throttling loss	338,217	43.46	64	1.47	359
		Install VFD to the condensate extraction pumps in medium pressure power plant to avoid throttling at the discharge side	62,222	8	14.8	1.85	66
		Install VFD to primary FD fan to reduce excess air in boiler and to avoid throttling loss	238,266	30.62	80	2.61	253
		Install VFD to ID fan to reduce excess air in boiler and to avoid throttling loss	387,763	49.83	140	2.81	70240

No.	Designated Entity	Energy Conservation Measures	Annual energy savings (kWh)	Annual Savings (million MNT)	Estimated Investment (million MNT)	Payback period (year)	CO_2 saving, tonnes/ year
		Install VFD to the condensate extraction pumps in medium pressure power plant to avoid throttling at the discharge side	722,964	92.9	148	1.59	2544
		Install VFD to secondary FD fan to reduce excess air in boiler and to avoid throttling loss	2,037,632	261.84	480	1.83	350
		Install VFD to ID fan to reduce excess air in boiler and to avoid throttling loss	2,398,137	308.91	600	1.94	
		Install VFD to the Auxiliary cooling water pump in high pressure power plant to avoid throttling	66,528	8.55	14	1.64	2544
11	Mongolian University of Life Sciences	Install VFD with header pressure feedback control system to OHT water pumps	44,550	6.77	4	0.59	
12	Gobi corporation (Cashmere processing factory)	Install VFD to hot water supply pumps with temperature and pressure feedback control system	10,627	1.37	1.3	0.95	11
		Install VFD with return air temperature feedback control to humidifier supply fans and spray pumps	517,889	66.5	133	2.00	550
		Reduce pressure drop across the bag filters and install VFD to all combing machine fans	275,616	35.4	77.7	2.19	292

4.6 Annex VI: References

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