Egyptian program for promoting Industrial Motor Efficiency

SAVE TODAY ... POWER TOMORROW

Roadmap and Action Plan to Support Motor Rewinding Shops

June 2022

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Abbreviations

EASA	Electrical Apparatus Service Association
EE	Energy Efficiency
EEHC	Egyptian Electricity Holding Company
ENCPC	Egyptian National Cleaner Production Center
ESCO	Energy Services Companies
GOEIC	General Organization For Export & Import Control
IDA	Industrial Development Authority
IMC	Industrial Modernization Centre
LV	Low Voltage
MCC	Motor Control Centers
MEPS	Minimum Energy Performance Standards
MHESR	Ministry of Higher Education and Scientific Research
MoETE	Ministry of Education and Technical Education
MoTI	Ministry of Trade and Industry
MSMEDA	Micro Small and Medium Enterprises Development Agency
MSO	Motor System Optimization
MV	Medium Voltage
PM	Permanent Magnet
PVTD	Productivity & Vocational Training Department
VSD	Variable Speed Drives

Acknowledgment

This document comes as part of the “Egyptian Programme for Promoting Industrial Motor Efficiency” by UNIDO focusing on improving the efficiency of Electric Motor Driven Systems (EMDS) and accelerating the market penetration of energy efficient motors in the industrial sector.

This document presents the proposed roadmap and policy actions to support the rewinding market to grow and the rewinding facilities to adapt to the changes in the industrial motors market place. The roadmap is developed by *Chemonics Egypt Consultants*, UNIDO’s consultant for the assignment of “Recommendation and development of operational policy tools, action plans and guidelines to promote the deployment of energy efficient motor driven systems in Egypt”.

The roadmap is based on the consultant’s experience, literature review, desk research and conducted on-site assessment and interviews with rewinding shops in the Egyptian market. The site visits to rewinding shops included diverse types of rewinding facilities to determine strengths and weaknesses, as well as good and bad practices from their point of view. The roadmap and proposed polices were presented in a workshop and discussed with relevant stakeholders for validation.

We would like to thank all the rewinding facilities participated in the survey for their valuable input, market data, as well as discussions.

I. Introduction

1. Background and Objectives of this Assignment

This report is one of the deliverables of Activity-3 of the project. It aims at supporting the motor rewinding shops to re-integrate and adapt to the changes in the industrial motors marketplace, particularly after the launch of the decree 463/2020 of Minimum Energy Performance Standards (MEPS). The awareness and move of industrial facilities towards energy efficient (EE) motors to save energy shall impact the business rewinding shops due to expected decreased motor rewinding and shifting towards rapid replacement of higher efficiency motors.

This report shall assess the market of rewinders by conducting rewinding market sizing and segmentation, presenting the feedback of the key stakeholders (rewinding shops) on the key barriers and business opportunities they face at the market, as well as developing a roadmap and action plan to support the rewinding workshops.

2. Work Methodology of this Assignment

This subsection describes the approach and methodology of the assignment, as well as key considerations during implementation of this methodology and activities.

Our approach is based on three basic pillars, as described below:

- ***Deep understand of the rewinding workshops business and market.*** Chemonics Egypt has good experience in the motors market in general and the rewinding workshops in particular. We have provided training on Motor System Optimization (MSO) and rewinding to several industrial facilities. We also developed guidelines for onsite facility rewinding shop of one of the largest carpets manufacturers to improve internal practices.
- ***Reliance on Existing Networks***. Leveraging existing networks of electric motor market players and stakeholders to provide access to data and knowledge as well as to map rewinding shops to participate in the development of the roadmap and workshops.
- ***Individual interviews and on-site assessment with rewinding shops.*** Our approach depends on individual interviews with rewinding shops, ensuring the diversity of shops based on type and size, to obtain detailed feedback on the market status, key barriers of the market, potential business opportunities and roadmap activities. This allows the room for capturing detailed data while ensuring confidentiality is protected, such as data of business plans, sales or marketing plans and values. Also, the site assessment aims at determining strengths and weaknesses, good and bad practices, assess identified business opportunities and determine possible interventions and actions that can lead to upgrading the quality of the rewinding services and allow them to expand to capture proposed opportunities in the future market trends.

3. Document Structure

The methodology, activities and results of this assignment are presented in this report which consists of four chapters. They are structured as the following:

I. ***Introduction:*** (this chapter) it provides the background of this assignment as part of activity-3 of the UNIDO project, and the objectives of this assignment. It also presents the approach and methodology used in this assignment.

II. ***Market Assessment of Motors Rewinding:*** It presents an overview of the rewinding market in Egypt, including market sizing and segmentation, market current status and demand, as well as mapping the rewinding shops with diverse size and type.

III. ***Barriers and Opportunities:*** it presents the key barries and weaknesses of the rewinding market. It also presents the potential businesses or employment loss as well as key opportunities and possible improvements to the market players to mitigate these possible business loss and expand the market.

IV. ***Roadmap to Support Rewinding Industry:*** presents the roadmap and action plans recommended to support the rewinders market based on the gap analysis and mapped barriers.

V. ***Conclusion:*** is the conclusion and summary of the report, highlighting the key findings and outcomes of this report.

II. Market Assessment of Motors Rewinding

1. Introduction to rewinding market

Rewinding market and EE motors - Motors are robust equipment with typically long life. Motors mainly fail due to deterioration in the insulating material surrounding the stator windings, and at less common occasions the insulation separating the lamination of the stator. This leads to a complete breakdown of the motor. It is typically a slow process driven by electrical and temperature stresses. At times, mechanical stresses could also accelerate such a breakdown. This typically takes 3 to 10 years before occurring with the time increasing when the motor is operated in design typical conditions. However, motor repairs are quite common and easy. Aside of replacement of coupling elements and bearing which could occur on shorter duration, the main repair action to bring the motor back to operation is motor rewinding. Rewinding refers to dismantling the motor, removing the stator windings (insulated wires) and rewinding new wires with insulation. The process requires considerable skills and know-how, and if done properly, can return the motor to close to original operating conditions. Industrial motors are typically rewound 2-3 times over the useful lifetime, and it can also be rewound 5-6 times till the stator lamination insulation fails. Hence, motors can operate for 30 years or even more despite having their first failure typically after 10 years or less.

Rewinding is either done by specialized service providers (rewinding shops) or on factory site rewinding workshops in large factories. Based on the surveys conducted in the Egyptian industry, larger factories tend to have their own motor rewinding workshop, while small and medium ones typically reach out to service providers. Service providers can be the original manufacturer of the motor and/or certified by the original manufacturer. In Egypt there are only two of such service providers, one through ABB and the other (Biraf) is certified by Siemens.

Rewinding business case - Rewinding business case is simple, while generating profits for the service provider, it saves the motor owner paying for the cost of a new motor. Rewinding typically costs 20-30% of the new motor cost. In Egypt, the cost of rewinding is on the lower side and can be at 20% or less of the cost of the motor (ibid). It increases as the motor rating increases as it varies between 9-10% for the 0.75 kW to 75 kW range and increases to 20% in the range of 75 kW to 375 kW. The rewinding cost can reach 30% at above 375 kW range. On the other hand, a motor rarely recovers its efficiency after rewinding. In Egypt, the efficiency typically drops by 2.5% to 5% points after each time the motor is rewound. Since motors in the range of 0.75 to 7.5 kW. Motors in the range of the 0.75 kW to 7.5 kW are typically rewound 1 time (with a drop of 5% points in efficiency) while those is 7.5 kW to 75 kW are rewound 2 times (with a drop of 5% points each rewinding time). Motors which are in the range of 75kW to 375 kW are rewound 3 times with an efficiency drop of 2.5% points each time they are rewound). Motors above 375 kW are rewound 4 times with also 2.5% points drop each time they are rewound. From the point of view of rewinding service provider, each time the motor is rewound, profits are generated, and hence early motor replacement can lead to limiting revenues. The motor rewinding market size can be assessed through using the number of rewinding times for each motor in each bracket of motor rating.

The average cost of rewinding in each bracket will hence provide the cost of each rewinding instant. Accordingly, the dollar value of rewinding services per year can be determined (ibid).

2. Market sizing of motors rewinding

The motor rewinding market size was estimated at 3.6 Million USD per year. Two approaches are considered in calculating the rewinding market size; bottom-up and top-down analysis. The bottom-up analysis is based on the distribution of motors in various rating ranges (in kW) and their relevant financial value (as illustrated in Annex 1 for motor market size and segmentation). This was combined with information on number of rewinding times and percentage cost of rewinding in each range as collected from interviews with key rewinding facilities[1] and literature (. The market size is estimated to be 3.6 Million USD. The top-down analysis on the other hand relies on the percentage of installed base of motors within life of 10 to 30 years (that are most likely applicable to rewinding process)[2]. In addition the average value of motor refurbishing cost is considered as 25% of the motor replacement value, with an average annual failure rate of 0.07[3]. This yields to an average estimated rewinding motor market size of 3.99 Million USD. The difference between the approaches is 10.8%. As a conservative estimation, the market size is considered to be the lower estimate of 3.6 Million USD in further analysis. Figure 1 shows the two used approaches for estimating the market size.

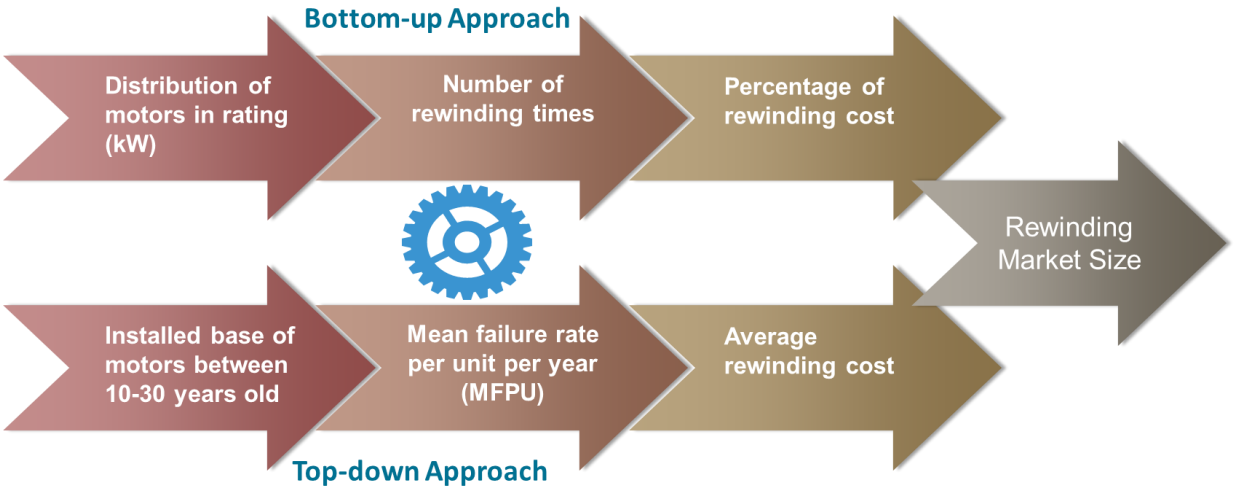


Figure 1: Bottom-up and Top-down approaches of estimating the market size

[1] *Validation of market data, barriers and opportunities, as well as roadmap actions was conducted through interviews with 17 rewinding facilities. The used template of the interview with rewinding facilities is presented in Annex 2. Also, a list of the contacted rewinding facilities is presented in Annex 3.*

[2] *Installed base of motors in Egypt are estimated to be 1.24 Million motors with and overall value of replacement of 570 Million USD. It is considered that motors older than 10 years are more applicable to rewinding. On the other hand motors older than 30 years are rarely rewound again and most likely would be replaced. Therefore, motors applicable for rewinding process (with age between 10 to 30 years) are estimated to be about 40% of the installed base, with a value of about 228 Million USD. Based on literature, the mean failure rate per unit per year (MFPU)is considered as 0.07. Also, an average rewinding cost of the motor is considered as 25% of the motor replacement value.*
*Rewinding market size = installed base of motors between 10-30 years*MFPU*average rewinding cost = 3.99 Million USD.*

[3] *Olav Vaag Thorsen and Magnus Dalva, "A survey of faults on induction motors in offshore oil industry, petrochemical industry, gas terminals and oil refineries", IEEE, 1994.*

In general, most of failures of motors are from mis-operation or mi-application. The failure modes of the motor represented as replaced/maintained components are basically failure of winding insulation, bearing issues, rotor shaft, rotor bar or end-ring failure, stator frame issues and loose cables. The cost breakdown of refurbishing process of the motor is shown in Figure 2, where winding copper is dominating by almost 50% followed by bearings (21%) and miscellaneous others of 11% (such as stator lamination, connectors and line cables, balance weights, etc.).

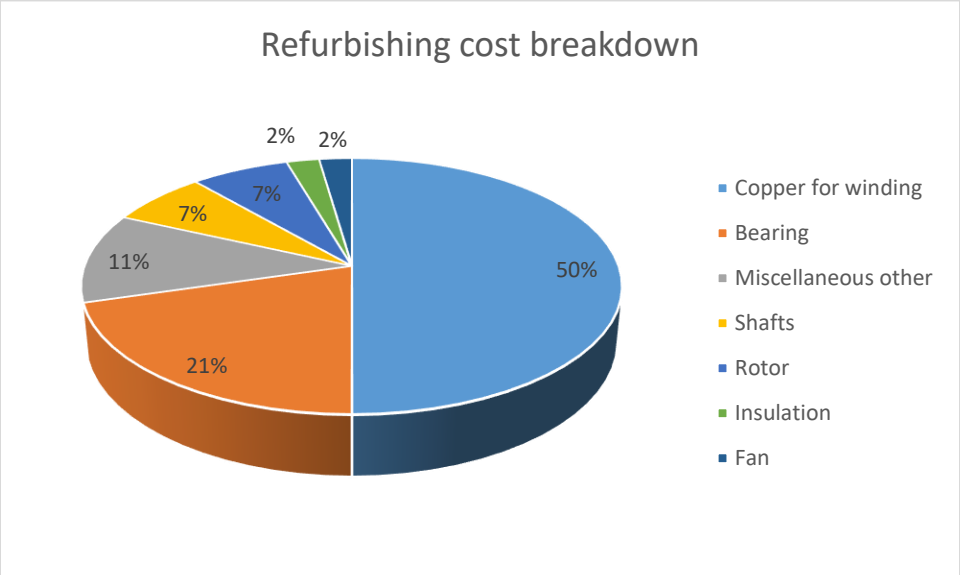


Figure 2: Cost of components for motor refurbishing market

3. Market current status and mapping of key rewinding facilities

Rewinding shops are classified into three broad classes:

- *Accredited facilities by main suppliers,* such as ABB own facility or Biraf which is an official rewinder for Siemens. They are large rewinding shops with specialized tools and equipment, with large number of employees (compared to this kind of business) and predefined operational procedures and standards.
- *Independent rewinding facilities*, which are generally not certified. They are usually located at the industrial zones to provide services to the factories and industrial facilities within the zone. These rewinding shops range from small size shops (1-2 technicians only, in form of family business and depending mainly on basic hand tools) to medium size shops (3-10 technicians with medium range

tools and measuring equipment). For the rewinding market, entrepreneurs mainly fall in this category of facilities[4].

- *Onsite rewinding shops in industrial facilities*. They usually focus only on the rewinding of the damaged motors of their own factory / industrial facility and do not provide services to other facilities.

Figure 3 presents the distribution of the mapped rewinding shops throughout the assignment's activities and interviews (17 interviews were conducted, as per Annex 3). It is dominated by the independent rewinding facilities followed by on-site shops in industrial facilities.

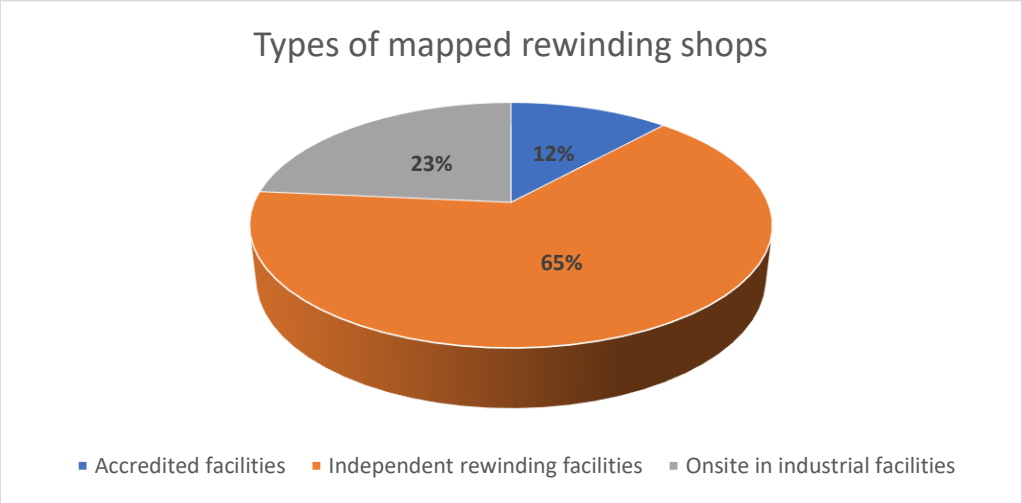


Figure 3: Classification of mapped rewinding shops (out of 17 mapped rewinding facilities)

Low awareness of importance of motor efficiency testing after rewinding. Most of the rewinding shops do not perform efficiency tests to the rewound motors as they are not required by the clients and also they are not part of the operation procedures of the workshop. For most of clients at the current status, the most important is the rewinding and refurbishment of the motor to be able to operate again and satisfy the load regardless its efficiency. Only large motors are tested (usually MV motors and motors greater than 130 kW), especially when they are rewound at one of the certified rewinding shops. Figure 4 shows that 85% of the interviewed rewinding shops (17 interviews were conducted, as per Annex 3). do not perform efficiency tests after the rewinding process.

[4] *Although entrepreneurs fall within this category, however, the rewinding market is considered as a well-settled market and no key innovations are presented from new start-ups. They are usually extended family business or employers of an existing rewinding facility who are leaving to start their own business. They usually follow the same procedures and techniques, so the proposed roadmap policies and actions are valid for both existing facilities and entrepreneurs.*

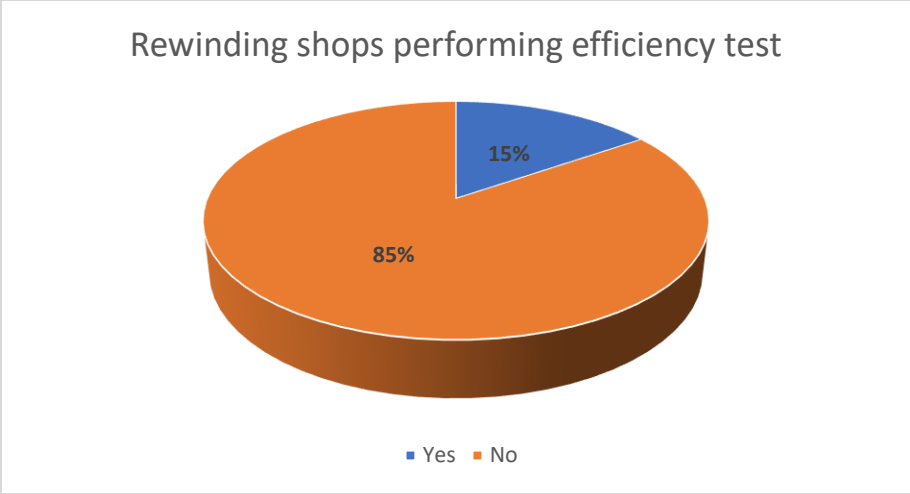


Figure 4: Rewinding shops performing efficiency tests to the rewound motors

Motors are rewound more than three times. Surveys showed that it is a common practice that motors in the Egyptian market are rewound more than three times. This is beyond the manufacturers' recommendations of having only two rewinding for the motor. The efficiency of the motors are affected by the excess rewinding, however as mentioned above, clients are not aware of the importance of the motor's efficiency and they consider only its operation not to stop the production.

No best practices are followed in the rewinding process. Using basic tools in the rewinding process is the most common practice, except for the large certified rewinding facilities which follow the standards of the rewinding process. Most of rewinding facilities depend on the basic hand tools and personal knowledge and experience of the technician to perform the motor rewinding. No special tools (such as oven, core-loss tester, mega-ohmmeter "megger", automatic winding machine, power analyzer, etc.) are used in most cases. Figure 5 shows the capacity of interviewed rewinding shops regarding the used tools and equipment in the rewinding process.

In addition, no certified designs or winding tables of the motors are used. Technicians usually use certain typical well-known designs and they use the closest one to the motors under rewound based on the preliminary reverse engineering they do during the disassembly of motor. Moreover, there is lack of trained and skilled technicians of motor rewinding. They are mainly general electrical technicians trained by the facility itself, or they gain the experience by practice.

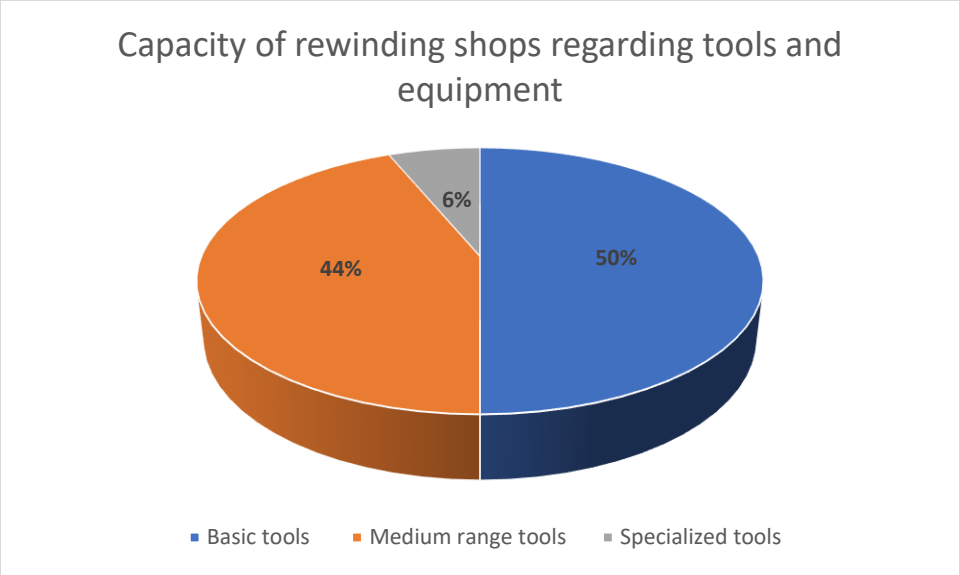


Figure 5: Rewinding shops capacity regarding the used tools and equipment (out of 17 mapped facilities)

4. Impact of the decree on the business of rewinding market

***Negative impact of the decree on rewinding shops*:** there are possible negative impacts of the decree #463/2020 on rewinding shops. Also increased awareness of EE motor practices can have negative impacts on rewinding service providers. The increased awareness of impact of high efficiency motors on energy saving for end-users as well as understanding the improvement in energy savings by moving to a new IE3 motor compared to repair could lead to a shift towards buying new motors rather than rewinding. Industrial motor users are faced by a critical decision when a motor fails; whether to rewind or replace the motor. Buying a new motor is typically more expensive than rewinding, however, the new motor provides higher efficiency leading to more savings to factory. Currently, industrial end-users are not aware of energy savings associated with higher efficiency motors and are more inclined to rewind the motor as much as possible. However, due to promotion of the decree and raising the awareness on savings in switching to higher efficiency motors, industrial users could choose to rewind less and move rapidly to procuring new EE motors. Assuming the promotion of IE3 will lead to early replacement of motors instead of rewinding, a business loss will take place for rewinders. A single-time decrease in rewinding incidences (factories rewinding one time instead of two, or two times instead of three) would lead to a business loss of 330,000 USD of annual business to SMEs[5]. No other business loss scenarios were identified associated with the decree or the switch to higher efficiency motors. However, it is possible that also the decree leads to positive impact.

***Positive impacts of the decree on rewinding shops*:** there are possible positive impacts of the decree on rewinding shops. Currently motors in the market are mainly IE2 or below. The decree would mean that

[5] *It is assumed that moving towards replacing old motors by EE motors will decrease the number of rewinds by one-time. The average cost of rewinding for the various ranges of motors are multiplied by the number of motors in each range, giving the estimated 330,000 USD of business loss.*

end-users will be expected to pay about 10-20% more in an IE3 motor, increasing expenses on factories. This could drive end-users to rewind their motors more, especially if the motor is less than 10 years and replacement is non-feasible, or for small factories and workshops where this increase in capital cost of motors is considerable compared to their expenses. Before the decree, the end-users could purchase an IE2 or IE1 motor to replace a motor that has failed. Since after applying the article of MEPS of the decree, end-users were obliged to purchase IE3 motors instead of the cheaper IE1 or IE2, so they might choose to rewind or repair the motor more times than before the decree. One-time increase in rewinding incidences than the current case will lead to a 600,000 USD of more business to rewinding service providers per year. Other positive impacts could stem from end-users demanding a better rewinding service with higher cost from rewinding service providers where efficiency of motor is improved or maintained by following the best practices in rewinding process. High efficiency rewinding will be a more expensive and profitable service to rewinders leading to extra business opportunities.

***Overall impact of increased EE motor awareness and the decree #463/2020*:** assuming an intermediary scenario between the negative impacts and positive impacts takes place, the net market impact of the decree and increased awareness of EE motors with industrial end-users will lead to a net positive impact of 270,000 USD (600,000 USD – 330,000 USD) of annual business for rewinding SMEs, as shown in Figure 6. Even more business could be generated if rewinding service provider offer higher value services in which efficiency of the motor is maintained. With increased awareness, end-users will be more inclined to pay rewinding service providers more for ensuring efficiency of rewound motor is maintained. New services can be offered by rewinding service providers including motor improved alignment and coupling or motor efficiency performance assessments through advanced measurement devices.

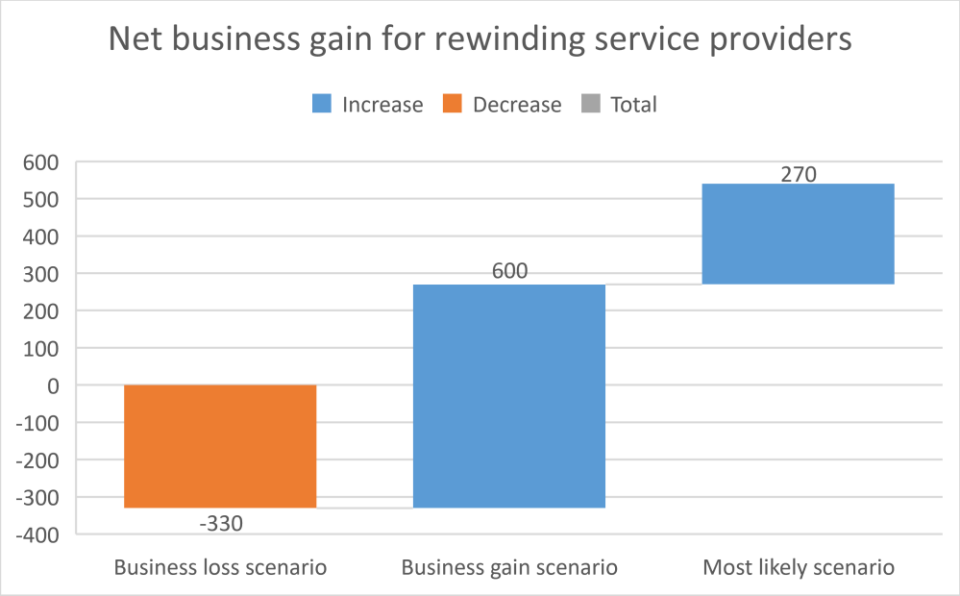


Figure 6: Business loss and gain scenario with net gain for rewinding service providers

III. Barriers and Opportunities

1. Key market barriers

This subsection presents the feedback of the 17 interviewed stakeholders/rewinding shops (Contact list Annex 3) , and workshop (Annex 4) regarding the barriers against providing EE rewinding of motors and the expansion of their market.

Lack of talented labor and technicians, access to EE materials and components for EE rewinding, access to finance as well as low end-user awareness are the top barriers against the process of EE rewinding and expansion of the rewinders market. Figure 7 presents the intensity of the captured barriers according to the interviewed shops.

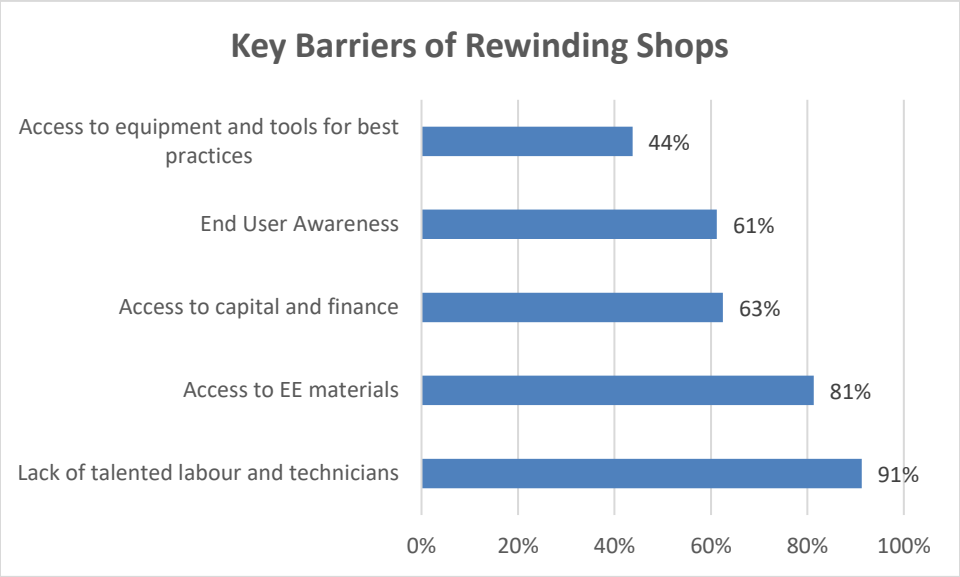


Figure 7: Barriers of rewinding shops (against EE rewinding)

Lack of talented labor and technicians – rewinding shops claim that it is difficult to get trained and qualified technicians for the rewinding of motors. There is a shortage in the qualified technicians from the technical schools and colleges, specialized in motor maintenance and rewinding. They usually train their technicians internally and depend on the gained knowledge and experience during their work at the rewinding facility itself.

Access to EE materials and components – Some rewinding shops find difficulty to access to the required material and components for rewinding EE motors to maintain their efficiency. This includes high grades of copper for windings, high grades of insulating material, efficient bearing, stainless steel shafts, etc. They replace the damaged components with the available ones, even if with less quality, which affects the overall efficiency of the rewound motor.

In addition, some rewinding shops claim that they failed in obtaining importer license to import the required components and material, so they had to use the available at the market. Moreover, they

claimed that there is no regulations or monitoring for the quality of motor refurbishment material in the market, as some rewinders use the components of imported used motors (usually integrated with imported used production line).

Access to capital and finance – most of independent rewinding facilities are small to medium scale. They are dealt as "craftsmen", and their legal and financial status are considered as risky for banks and financial institutions. Also, they have issues with their taxes, invoices and documentation in general. These lead to having difficulties in getting loans or financial support to expand their activities or upgrade the workshop with the expensive specialized tools and equipment.

Low end user awareness – some rewinding shops claimed that even if they abide to the rewinding best practices and high-quality material, some end users are not aware of the importance of the efficiency of the rewound motor and they consider only the cost of rewinding. Some end users prefer the lowest price offer regardless the quality of the rewinding process or the used material. This affects the quality of the market and opens the door to the bad practices and the unlicensed shops.

Access to special tools and equipment – special tools and equipment for rewinding (such as oven, power analyzer, automatic rewinding machines, etc.) are expensive for small independent rewinding facilities. In addition, some rewinding shops are not aware of the best practices of EE rewinding, and they follow the traditional processes captured from the more experienced technicians within the facility. Therefore, they use only basic hand tools, and they are not aware of the required special tools and equipment to achieve the EE rewinding process.

An additional mapped barrier that was mentioned by two of the interviewed rewinding facilities is that they face lack of trust from the tax authority, and taxes are estimated based on the law between 35% - 40% of the profit assuming five capital cycles per year, regardless the submitted invoices.

Two more barriers were observed by the consultant team during the market analysis and interviews with rewinding facilities. They are:

- Absence of advanced business and marketing model that can provide advanced services
- Limited capacity to assess savings

These two barriers exist mainly at independent rewinding facility which are considered as small (or family) business, with poor marketing, business development or business management capabilities. This affects their business growth.

2. Key market business opportunities

This subsection explores the proposed business opportunities that can support the rewinding facilities to develop their businesses and/or expand their market. The opportunities were illustrated and scores were given by the interviewed rewinding facilities.

Manufacturing of small motors, upgrading to high efficiency rewinding, maintenance and services of variable speed drives (VSDs) and motor related ESCO services are the top four proposed opportunities. Scores of the proposed opportunities are presented in Figure 8[6].

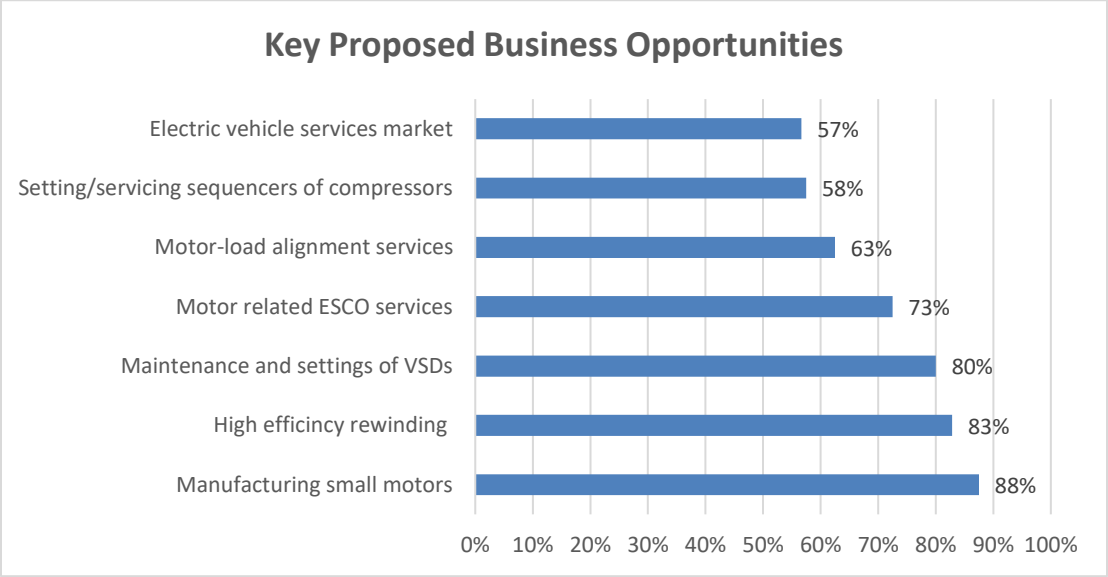


Figure 8: Key proposed business opportunities

Manufacturing of small motors – rewinding facilities have good experience in motor rewinding and assembly. They can shift smoothly to (or add to their business model) the business opportunity of manufacturing of motors, especially small (fractional) motors, either by integrating with an existing motors manufacturer or by establishing a new manufacturing facility. They can supply small motors to the home appliances manufacturers.

High efficiency rewinding – as end users get aware of the importance of the motor's efficiency and energy savings, it becomes important to the rewinding shops to follow the best practices in rewinding process to maintain the efficiency of the motors after the rewinding process, and provide test report including the measurement of the motor's efficiency. In addition, refurbishing high-efficiency motors requires using similar material and components to the original ones used in the motor's manufacturing. Rewinding shops should upgrade their process, rewinding practices and their supply chain to coop with the new market dynamics.

Maintenance and services of variable speed drives (VSDs) – rewinders are familiar with motors' applications and operating conditions, including variable speed applications. In addition, many applications and new technologies of motors include integrated VSDs with the motor, which require good knowledge of the VSD operation to completely test the motor operation. It is important to rewinding shops to be able to operate VSDs, especially when integrated with PM motors and servo-motors. This give

[6] *Some of the on-site rewinding shops within industrial facilities did not give scores for the business opportunities as they claimed that they are not applied to their role within the facility. They are dedicated only for the maintenance of motors within the facility and not expected to expand their activities or shift to other markets.*

the opportunity to provide the service of setting and maintenance of VSDs in addition to the motors with some additional trainings and certifications from the VSDs manufacturers.

Motor related ESCO service – it is a common and essential practice by the rewinding shop to test the operation of the motor before its refurbishing. The aim is to explore its status and observe any abnormal operating condition, such as vibration, noise at bearing, spark, etc. In addition, testing the motor efficiency after rewinding is also an essential practice. Therefore, it is applicable to the rewinding shops to upgrade to the business of energy services companies (ESCO) and provide energy services related to motor applications. This can include testing motor efficiency on-load, monitoring its condition and recording operating history, as well as providing motor system optimization (MSO) activities to the industrial facilities.

Motor-load alignment and coupling services – this is also one of the easy services that rewinding shops can expand their business e to it. After rewinding of a motor, they can provide the service of re-installing the motor to its load (compressor, pump, fan, etc.) and perform the accurate alignment and coupling services with most technological tools to ensure the best operation of the motors and support the industrial facility in avoiding additional fractional losses or the coupling of motor-load got damaged. This service may require additional investments to purchase the shaft alignment tools and training on how to use it.

Setting of compressors sequencer – rewinding shops can also expand their services to include the services and optimization of motor related applications, such as settings of compressors sequencers and pumps controllers. Additional trainings and certificates are required to expand to this market.

Electrical vehicles services market – one of the potential markets to the rewinding shops is providing maintenance services to the electrical vehicles, especially that this market is growing. This requires trainings and certificates from the vehicles manufacturers. Also, most of the electric vehicles depend on new and special motors, such as PM motors, which the rewinders are not familiar to their maintenance and operation. This makes it difficult to join this market without the integration with the original manufacturers of the vehicles and/or their representatives in the local market. Although this business opportunities had the lowest score by the interviewed facilities, however the consultant team considers it as a promising opportunity.

IV. Roadmap to Support Rewinding Industry

This section presents the key actions, proposed polices and interventions to formulate a roadmap of developing the market of rewinding facilities. These key actions is validated by key stakeholders in a workshop (Annex 4)

The Proposed actions can be divided into groups according to their target. They can be grouped as:

Group A: Technical knowledge and capacity building

- Technical training on the new technologies and services (MSO, measurements, efficiency assessment)
- Technical schools and trained technicians

Group B: Market quality monitoring and control

- Provide certification to the rewinding shops
- Raise awareness of end-users
- Develop and promote for best practices guidelines and rewinding manuals

Group C: Financial support

- Proper taxes evaluation in coordination with MoTI as manufacturers
- Access to finance (loans) as manufacturers for equipment and worker capital
- Raising bank awareness on equipment needed
- Support rewinding facilities in importing EE materials (importer license) as manufacturers

Group D: Market expansion and business opportunities

- Linkages with end-users and EV firms and with large producers
- Linking with VSD producers to provide service
- Upgrading to EE rewinding services and efficiency assessment
- MSO services training and coupling elements trading

Figure 9 presents an overview of the roadmap and proposed actions on the short, medium and long term. The following sections describe the interventions and actions of each group, presenting the description of each action, responsible stakeholders, lead stakeholders and expected duration of each action.

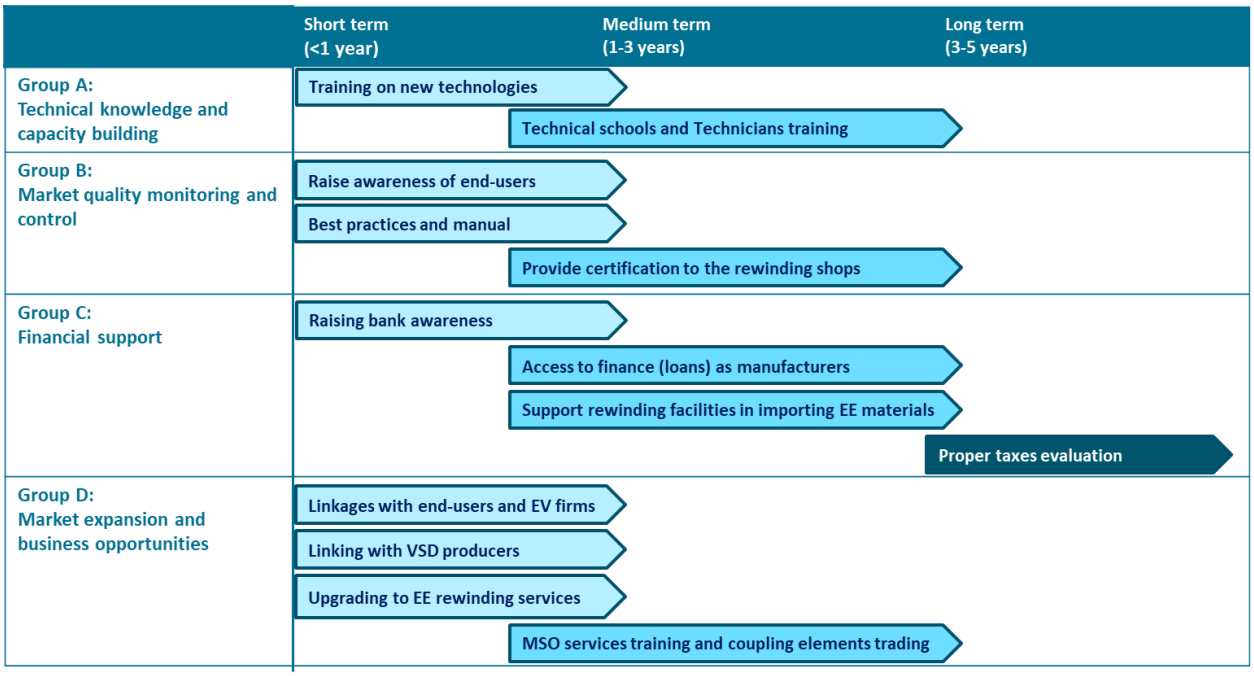


Figure 9: Overview of the roadmap actions on the short, medium and long term

1. Group A - Technical knowledge and capacity building

This group addresses the issues of low availability of talented and well trained labor, as well as the absence of a technical best practice guideline.

Table 1: Interventions of technical knowledge and capacity building

Intervention	Duration	Responsible	Lead
Technical training on the new technologies and services (MSO, measurements, efficiency assessment)	<1 Y	IMC, UNIDO, ENCPC	UNIDO
Technical schools and trained technicians	1-3 Y	MoETE, MHESR, PVTD	IMC, UNIDO

Technical training on the new technologies and services **-** beside the training and capacity building for the rewinding of traditional motors (three phase induction motors), rewinding shops need to upgrade their knowledge and skills to coop with the new technologies. Permanent Magnet (PM) motors, reluctance motors and servo motors are samples of motors with new technologies, and most of rewinding shops are not capable of refurbishing them. Besides, technical training on the measurements and efficiency assessment of motors using the right tools is crucial to determine motors efficiency after rewinding process to ensure that best practices are followed. Training on motor system optimization (MSO), dealing with VSDs and motor control centers (MCCs) is also important and requires additional knowledge.

Technical schools and trained technicians – this intervention address the shortage of talented labor and technicians. Motor rewinding, and motor related services in general, should be included in the curriculum of the technical schools and training centers. Knowledge transfer also can be provided by the cooperation with foreign experienced institutions, such as the Electrical Apparatus Service Association (EASA) to guarantee certified centers. In addition, providing support to keep the well trained technicians within the field is important, by establishing union for them, providing medical insurance, etc.

2. Group B: Market quality monitoring and control

This group addresses the issues of low market quality and absence of rewinding market monitoring and control. This can be achieved through certification of rewinding shops, raising awareness of end-users, promoting and enhancing the quality of material and components in the market.

Table 2: Interventions of market quality monitoring and control

Intervention	Duration	Responsible	Lead
Provide certification to the rewinding shops	1-3 Y	MoTI	IMC
Raise awareness of end-users	<1 Y	ENCPC, IMC	UNIDO, IMC
Develop and promote for best practices guidelines and rewinding manuals	<1 Y	IMC, UNIDO	IMC

Provide certification to the rewinding shops – There should be a governmental certification to the rewinding shops (or profession practice license) to guarantee the minimum level of knowledge and quality control in the facility's process. Also, dissemination of this certificate is important. It is also suggested to provide this certificate in two tiers. Tier 1 can be provided to rewinding shops that can rewind motors with ratings up to 100 kW. Tier 2 can be given to rewinding shops for rewinding motors more than 100 kW, including MV motors.

Raise awareness of end-users to the importance of testing the efficacy of motors after rewinding. This will lead to the shift to certified facilities and encourage them to upgrade and improve their services and tools. It is also proposed to have central testing laboratory at each industrial zone, to facilitate testing of rewound motors and examine their efficiency after the rewinding process. This should help both the rewinding facilities (reduce the cost of getting testing equipment for each rewinding facility) and the end-users (validate the rewinding efficiency by a third party), and hence improve the quality of the market.

Develop and promote for best practices guidelines and rewinding manuals – Rewinding facilities should follow the best practices in the rewinding process to maintain the motor efficiency. The guidelines according to the international best practices and rewinding manuals should be disseminated widely to ensure its effectiveness to the market.

3. Group C – Financial support

This group addresses providing financial support to the rewinding facilities, either by supporting them in having proper taxes evaluation as manufacturers, getting access to finance, raising awareness of banks

regarding equipment needed and their business model, and support them in importing required materials.

Table 3: Interventions of financial support

Intervention	Duration	Responsible	Lead
Proper taxes evaluation in coordination with MoTI as manufacturers	3-5 Y	MoTI, MSMEDA, IMC	IMC
Access to finance (loans) as manufacturers for equipment and worker capital	<1 Y	MoTI, MSMEDA, IDA, IMC	IMC
Raising bank awareness on equipment needed	<1 Y	IMC, UNIDO	UNIDO
Support rewinding facilities in importing EE materials (importer license) as manufacturers	1-3 Y	MoTI, MSMEDA, IMC, GOEIC	IMC

Proper taxes evaluation in coordination with MoTI – Several rewinding shops claimed that the taxes evaluation is not done properly considering their type of business and cost of materials, components and services. Taxes are estimated based on the general guide of law (35%-40% as profit margin and assuming five capital cycles per year). It is recommended that the business model shall be evaluated by experts from MoTI to be as a guide for the tax authority in the estimation of tax.

Access to finance (loans) as manufacturers – Rewinding shops require access to finance to upgrade assets and working capitals such as special tools and equipment, enhance the quality control of rewinding process, and expand their business. However, most of independent rewinding facilities are small scale business, owned and moderated by technicians. They usually fail to get loans or support from banks, either because they are considered risky to the credit team of the bank, or they fail to provide enough documents required for the loan (such as feasibility studies of the investment, good financial statements, etc.). MoTI shall support these rewinding shops by raising their awareness and providing guidance and feasibility studies to support their status for the bank evaluation. In addition, rewinding facilities should be considered as manufacturers to benefit from the low interest rates and initiatives dedicated to SMEs.

Raising bank awareness on equipment needed – it is important to raise the awareness of bank regarding the business model and feasibility of rewinding facilities, as well as their need to the measurement tools and equipment for best rewinding practices. This will help in improving the communication between banks and rewinding facilities, and increase the possibility of developing special financing products to suit their business model, when needed.

Support rewinding facilities in importing EE materials (importer license) as manufacturers – Rewinding facilities can be considered as manufacturers due to the value added they provide. They should have the proper support in importing the required materials for the rewinding process as manufacturers and benefit from the low customs on components and materials as part of manufacturing process.

4. Group D – Market expansion and business opportunities

This groups addresses supporting the rewinding shops to expand their market through new business opportunities, such as local manufacturing of motors, know-how of rewinding of special motors (including PM motors and drives) as well as providing ESCO services for motor-related activities (MSO).

Table 4: Interventions of market expansion and business opportunities

Intervention	Duration	Responsible	Lead
Linkages with end-users and EV firms and with large producers	<1 Y	IMC	IMC
Linking with VSD producers to provide service	<1 Y	IMC	IMC
Upgrading to EE rewinding services and efficiency assessment	<1 Y	ENCPC, IMC	IMC
MSO services training and coupling elements trading	1-3 Y	IMC	IMC

Linkages with end-users and EV firms and with large producers – rewinding facilities can act a feeding industries to large produces and end-users by integrating with them as local manufacturers of motors to provide motors required for their applications and equipment. Also, they can be inked to electric vehicle (EV) firms to provide the maintenance services of electric motors in the vehicles.

Linking with VSD producers to provide service – Several industrial applications are recently using variable speed drives (VSDs) with the motor. Therefore, extending the provided services by the rewinding facilities to include services, maintenance and adjustment of VSDs is a good opportunity and provides good added value to the rewinding facility.

Upgrading to EE rewinding services and efficiency assessment – The basic and essential practice of rewinding shops to expand (or at least maintain) their market is to upgrade their services to be energy efficient (EE) rewinding services, including the efficiency assessment of motors both after rewinding and during motor operation on-load. This is strongly related to the raised awareness of end users to the importance of EE rewinding.

MSO services training and coupling elements trading - rewinding facilities can expand their services not only to refurbishing/maintaining the motors, but also they can include services to the motor system (including the load and coupling), and provide motor-related energy services. This requires training and capacity building of the MSO techniques and introducing to them the various financial models of ESCO companies.

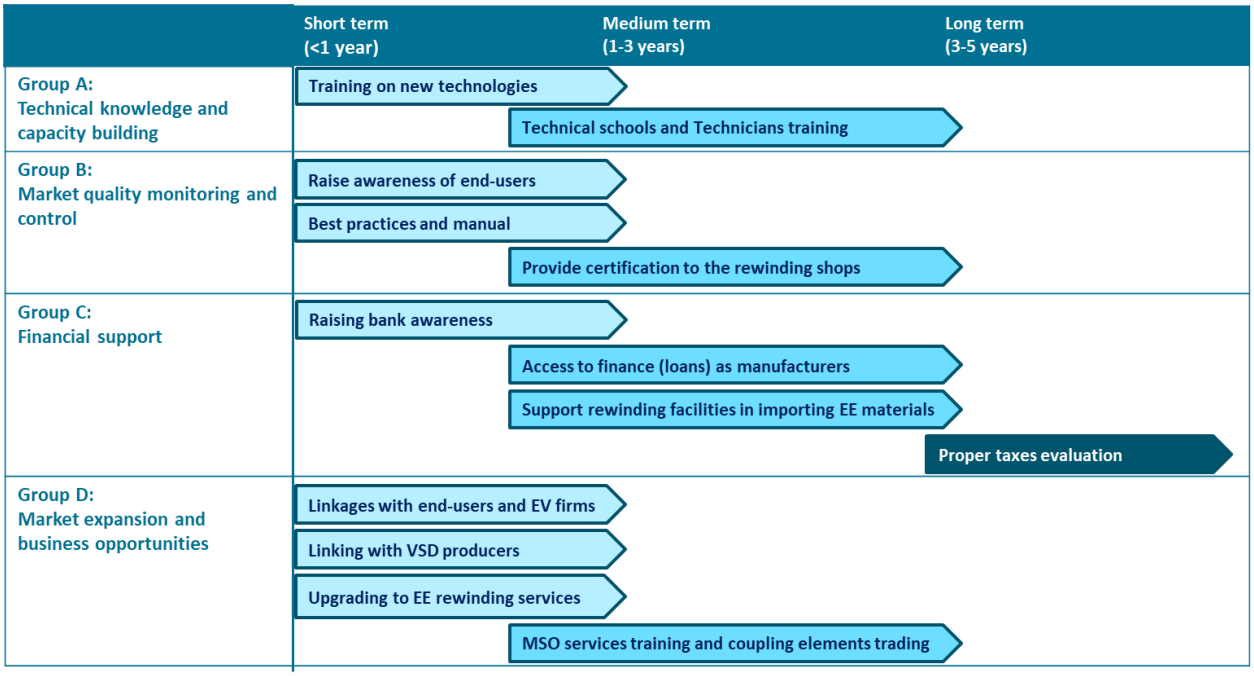
V. Conclusion

This document targeted supporting the market of motors rewinding and the rewinding facilities.

A detailed market assessment is developed, by defining the market, the key stakeholders and the current status of the market. Also, market sizing is developed with estimated annual market size of 3.6 Million USD, with the breakdown of components contribution in the rewinding process. In addition, the impact of the decree 463/2020 on the rewinding market was assessed, represented as possible business loss and gain. The assessment showed an expected business loss of about 330,000 USD, versus expected business gain of about 600,000 USD. Therefore, the net expected impact is a business gain (or increased market size) of about 270,000 USD. Accordingly, it is concluded that no specific measures are required to mitigate the negative impact of the decree on the Egyptian motor rewinding market.

Moreover, the key barriers of the market are mapped and validated with the interviewed stakeholders. Also, possible business opportunities of the market are presented and discussed.

Finally, a roadmap with the proposed actions and polices to support the rewinding market is developed. The roadmap actions were divided into four main categories and mapped to short, medium and long term as the following figure.



Key responsible entities and leaders of the roadmap were also proposed to make the roadmap achievable and can be implemented.

Annex 1 – Motors Market Size and Segmentation

The installed motor base in the industrial sector is estimated to be at 1.24 million motors with a total value of 570 M USD. This estimate can be reached through two methods; bottom up and top-down analysis.

The bottom-up analysis relies on assess the number of motors in each industrial subsector and aggregating the numbers to create all the motor installed base. The process relies on benchmarks which correlates the yearly electricity consumption in each industrial subsector distributed by each motor rating bracket[7]. Coupling this with estimates of number of operating hours can lead to number of motors in each rating bracket. This leads to aggregated number of motors in industrial sector in Egypt of 1.24 million motors. The data for energy consumption was mainly managed through Egyptian Electricity Holding Company (EEHC) official report of 2018/2019. It was considered that data from 2018/2019 is more representative of than that of 2019/2020. The number of motors estimated of 1.24 million represents that in stock in 2019. The number could have increased in 2020 but no attempts were made to estimate this value. This is due to difficulties in estimation due to market disturbance associated with COVID-19. The top-down analysis on the other hand relies on aggregating motors entering the Egyptian market as recorded in CAPMAS data which provides information on motors imported/exported by rating bracket[8]. This assessment leads to an estimated 1.15 million motors in Egypt industry. This number doesn't account for motor integrated in production machinery. The difference between the two methods is 7%. The total values were validated with sales data from key manufacturers.

Based on the above analysis, the highest number of motors being installed in Metals and Machinery sector (48%) followed by Chemicals (16%) and Food and Beverage (13%) – see Figure 10.

[7] Percentages by subsector of energy consumption in motors can be found in "Energy Efficiency and CO2 Emissions Reduction Potential in Industrial Motor Systems in Egypt", 2015, UNIDO and Global Efficiency Intelligence.

[8] CAPMAS data are also till the year 2019 as well and they can be searched by motors HS code and are mainly of the family 8508 and 8509

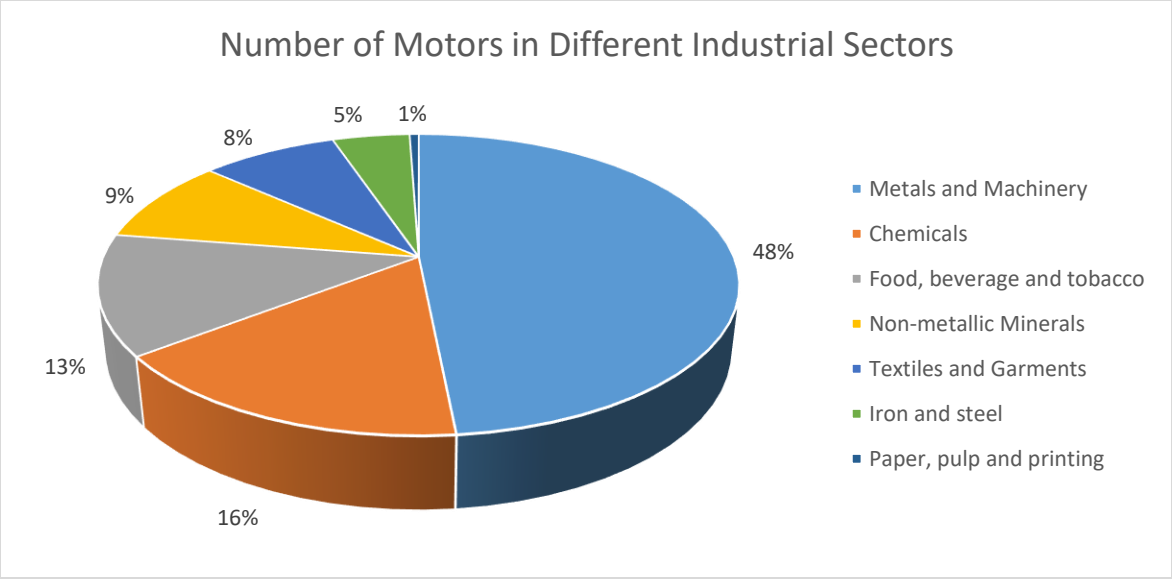


Figure 10: Percentage of motors installed base in Egyptian industry by subsector as of 2019

Another view of the distribution of motors is that of the kW range. In terms of numbers, the fractional HP motors represent 27% of the installed base. The range of 0.75 kW to 10 kW includes the highest percentage of the installed base at about 62% of the market. The range of 10 kW to 70 kW captures 10% of the installed base. The range above 70 kW only represents 1% of the installed base. Figure 11 presents the percentage of motors distribution by kW range.

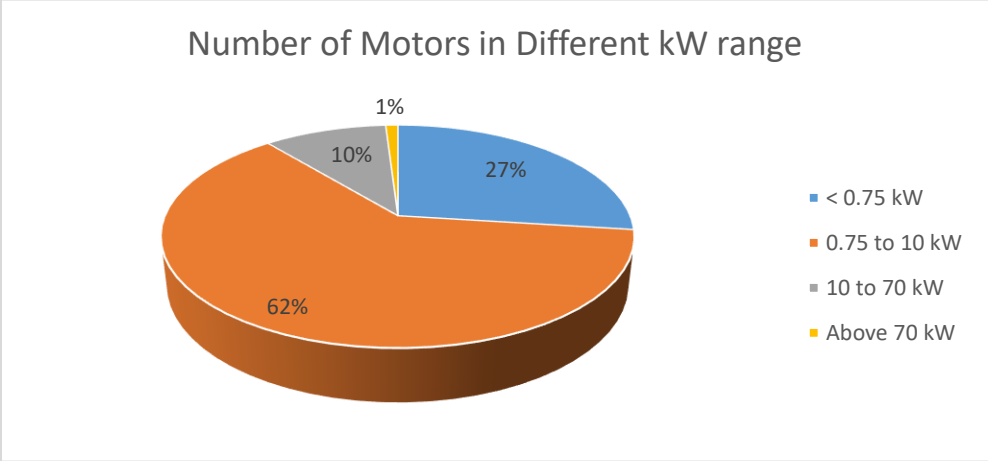


Figure 11: Percentage of motors installed base in Egyptian industry by kW range as of 2019'

However, this should not be confused with amount of energy consumption or dollar value of each bracket. Fractional motors tend to work for less number of hours per day and also represents a lower dollar value. As presented in Figure 12, the percentage of installed base by financial value is higher above 10 kW. This means that while the number of motors above 10 kW is smaller (only 11% of number of installed motors) than below 10 kW, they represent 48% of the financial value in the market. The range of 0.75 kW to 10

kW includes 62% of the installed motors and only 46% of the financial value. The market above 70 kW includes a limited number of motors of about 9,300 motors however captures 8% of the financial value[9].

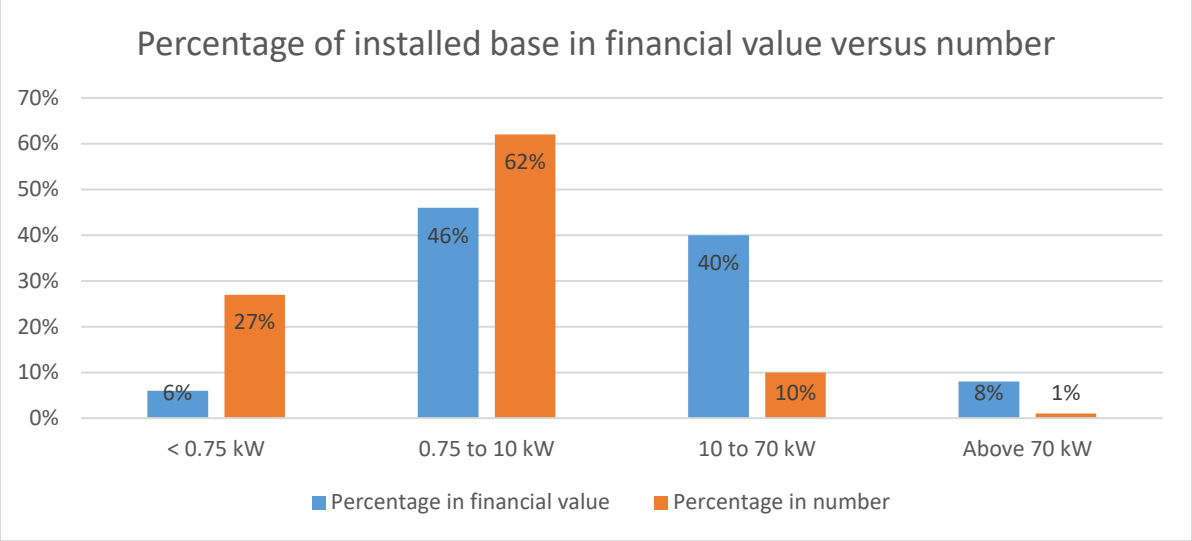


Figure 12: Percentage of motors installed base in Egyptian industry by financial value and number as of 2019

Tracking the electricity consumption in the industrial sector through EEHC reports can provide an estimate of how the motor in Egyptian industry grow as can be seen in Figure 13. Assuming a stock model with 15 years lifetime will lead to 45% of the motors in the Egyptian industry older than 10 years old[10].

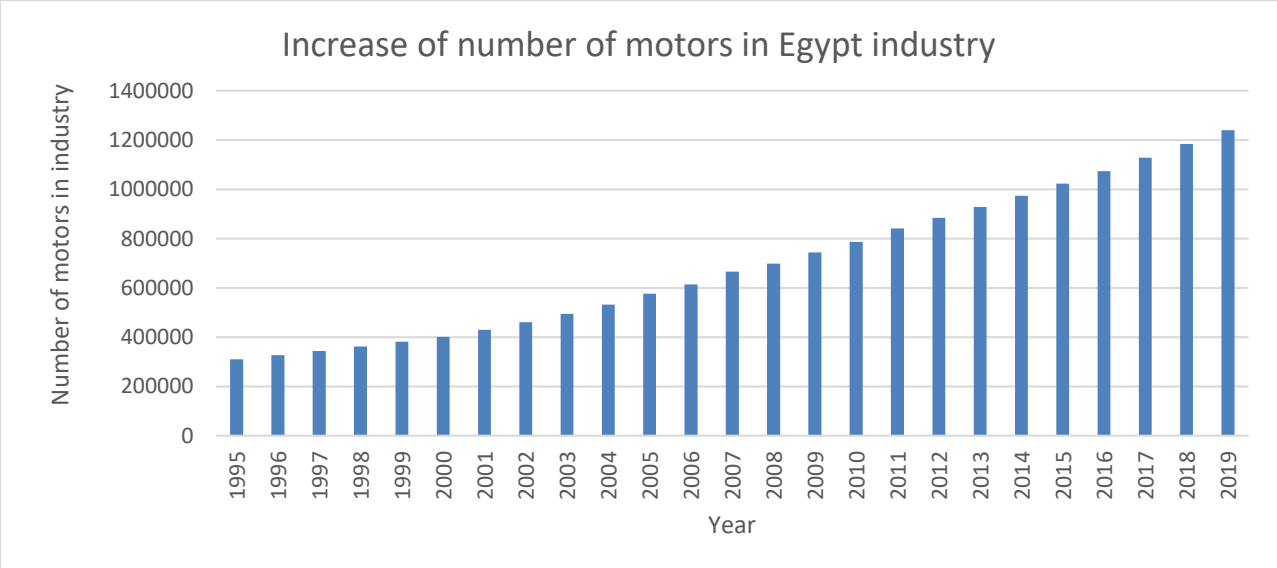


Figure 13 Increase of number of motors in Egyptian industry

[9] *Pricing data collected from key suppliers*

[10] *In agreement with IFC presentation in STEP project with 50% of motors in 2017 – MEPs design for Egypt*

Annex 2 – Rewinding Facilities Interview Template

This interview should be conducted with Rewinders (certified, independent, on-site) - to assess their market size, perception of the decree, readiness to participate in the roadmap								Notes
Basic Information of Entity								
Entity Name								
Address								
Provided Services								
Contact Person	Name							
	Title							
	Phone							
	Email							
Cuurent market distribution of rewound motors	**Motor Rating Range**	**Number of rewindings**	**Avergae cost of one motor rewinding**	**Marekt size (Units/percentage)**	**Efficiency tests are done (Y/N)**			
	0 - 0.75 kW							
	0.75 - 4 kW							
	4 - 10 kW							
	10 - 30 kW							
	30 - 70 kW							
	70 - 130 kW							
	> 130 kW							
What are the bad practices of motor rewinding in market?								
What are the key equipment/tools you have at the workshop for the rewinding process? (such as oven, insulation tetser, etc.)								
Number of employees/technicians in the rewinding workshop								
Do you have issues with the talented and trained technicians? How do you overcome that in general?								
What are the proposed actions to overcome the lack of trained labour (training, technical schools, etc.)								
Perception of decree 463/2020								
Are you aware of the decree 463/2020 regarding EE								
Are you aware of the benefits to the private sector and								
What are the disadvantages of this decree?								
What are the challenges to have the EE motors rewinding process (i.e. keep the same efficincy after rewinding) (score 1-5, 1= low challenge)			**1**	**2**	**3**	**4**	**5**	
	Client/End User Awareness							
	Access and availability of talented labour and technicians							
	Access to equipment and tools for best practices							
	Access to capital and finance							
	Access to EE materials							
	Others							
How do you think can the market trend threaten the rewinders market? (score 1-5)	**Moving to the EE motors**							
	Increased use of VSDs							
	Increased use of PM and BLDC motors							
	Energy management systems with preventive maintenance							
Policies development								
What kind of policies shall support the implementation of the decree (score 1-5, where 1 is low support and 5 is high)			**1**	**2**	**3**	**4**	**5**	suppoting institutions
	MEPS and regulations							
	Labelling of products							
	Finacial programs - governmnetal tax support							
	Finacial programs - loans and credit							
	Knowledge and communication							
	Energy audit and management programs (for ESCO)							
	Company management program for motors							
	Improve motor repair practicies and quality standards							
	Others?							
What are the business opportunities you think they can be suitable to you? (score 1-5, 1 = lowest opportunity)	**Maintenance and settings of VSDs**							
	Setting/servicing sequencers of compressors							
	Motor-load alignment services							
	Manufacturing small motors							
	EV services market							
	High efficincy rewinding							
	Motor related ESCO services							
	Others							
Would you like to participate in developing policies?								
Which policies?								

Annex 3 – List of Contacted Rewinding Facilities

#	Entity Name	Location	Contact Person
1	Oriental Weavers	10th Ramadan	Maintenance Team
2	Mac Carpet	10th Ramadan	Mahmoud
3	El-Habak	10th Ramadan	Magdy Elhabak
4	El-Sewedy-ECMEI	10th Ramadan	Khaled Abdelazim
5	El-Sewedy-Arab Cables	10th Ramadan	Mohamed Hamid
6	El-Mostaqable	6th October	Ahmed Ali
7	El-Amier	6th October	Emad Nassef
8	El-Waseet	6th October	Mohamed
9	El-Taqwa	6th October	Adel
10	El-Handaseia	6th October	Essam
11	Mo'atemed	6th October	Mohamed Mo'atemed
12	Soyria	6th October	Ahmed
13	Biraf Egypt	6th october	George Ibrahim Saad
14	Masria motors	6th october	Tarek Shebl
15	Murad Anis	Helwan	Murad Anis
16	Arafa	Maadi	Sayed Arafa
17	ABB	Obour City	Amr El-Sayed

Annex 4 – Rewinding Market Roadmap Workshop

A workshop was held on ***Wednesday 9th March 2022***, to present the market assessment and developed roadmap of motor rewinding market in Egypt. The discussed topics during the workshop included:

- The objectives of the workshop and work approach
- The current status and market assessment of the motor rewinding market in Egypt
- Barriers and proposed opportunities of the rewinding market
- The proposed roadmap actions and polices

The proposed roadmap actions were discussed and the feedback of the attended stakeholders was considered in developing the roadmap. A separate detailed report describing the key discussions and activities of the workshop is attached with this document. (Attached the meeting minutes of the workshop as Supplementary document_1)

Table 5 presents the list of attendees of the workshop.

Table 5: List of attendees of rewinding market roadmap workshop

#	Organization	Full Name
Private Sector		
1	ABB	Mohamed Reyad
2	Al-Araby	Mahmoud Khairy Abdelazim
3	Arab Cables	Mohamed Hamid
4	ARAB COMMERCIAL GROUP S.A.E - ACG	Sameh Attia
5	ARAB COMMERCIAL GROUP S.A.E - ACG	Essam Attia
6	Daoud	Emad Halawa
7	El Abd Group	Sameh Saad Abd El-Hameed
8	El Araby Group	Abdelnaser Tahoun
9	El Sewedy cables	Khalil Elnoury
10	El Sewedy cables	Ahmed Halaby
11	EL Sweedy	Yasser Saleh
12	Elmarwa Group	Amr Fathy
13	Elmarwa Group	Raghda Saeed
14	Elnasera group	Osama Ishak Fawzy
15	Elsewedy	Khaled Abdelazim
16	Elsweedy	Amr Abdelkader
17	Fresh Electric Co.	John Safwat
18	Mac Carpet	Mohamed Nouh
19	Tanta Motors Co.	Ahmed Sharawy
Governmental		
20	ECO-FEI	Hassan Mohamed Aboelatta

21	EGAC	Ayman Fathy Farag
22	ENCPC	Mohamed Sabry
23	Engineering Export Council	Mohamed Samy
24	EOS	Seham Tawfik
25	EOS	Marwa Ibrahim
26	EOS	Salama Shahat
27	ERI	Sherine Abdelkader
28	GOEIC	Wael El Nagomi
29	ICA	Azza Hassan
30	IDA	Noha Amin
31	IDA	Mohamed Eissa
32	IDA	Mohamed Hesham Ahmed
33	IMC	Akram Samy
34	NREA	Mohamed Zeinhom Abdelmawgood Elgarery
35	NREA	Kareem Abdelaaty Abdelsalam
36	NREA	Mahmoud Abdelaal