

Reducing Energy Consumption and CO₂ Emissions from Electric Motors in Pakistan Through Energy Efficiency Policy

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Prepared for NEECA by Amna Shahab, Salman Zaffar and Stuart Jeffcott



This report has been produced for CLASP by Amna Shahab and Salman Zaffar of HIMA^Verte and Stuart Jeffcott of Jeffcott Associates in October 2019, amended March 2020.

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Preface and Thanks

Energy use in Pakistan, and particularly the demand for electricity, has risen rapidly due to population expansion, rural electrification and general economic growth. However, over an extended period electricity demand has significantly outweighed supply, slowing economic growth and reducing the wellbeing of the population, particularly the less wealthy. Notable credit should be given to the Government of Pakistan for investing in the development of supply capacity to bridge the shortfall but, until recently, actions to ensure the efficient use of the electricity generated has been limited. However, there is now the beginning of a welcome transition in emphasis that recognises the importance of the role of energy efficiency in providing a reliable and sustainable energy supply solution.

To assist this transition in emphasis and begin the challenging road to widespread adoption of efficient products within the economy, CLASP has been supporting targeted policy development and implementation actions in Pakistan since 2016. This report has been prepared as a continuation of these actions, specifically to support the National Energy Efficiency and Conservation Authority (NEECA) with the development and introduction of Standards and Labels within Pakistan. In this case, specifically for the regulation of electric motors.

However, at the start of the study, almost no reliable data was available on which to undertake the analysis necessary to underpin a sustainable standards and labelling strategy for electric motors in Pakistan.

Fortunately, a wide variety of market stakeholders have participated in the development of these proposals and have provided encouragement at all stages of development, shared advice on appropriate actions, and extensive quantities of detailed data. While CLASP would like to extend our thanks to all stakeholders involved, we would like to specifically thank the following individuals and organisations without who's help the development of the proposals would not have been possible:

- Asad Mahmood and Muhammad Umar, NEECA
- Najam Rauf and members of the Pakistan Pump and Electric Motor Manufacturers' Association
- Participants in the Industry Forum and Stakeholder Workshops

Your assistance has been invaluable.



Eric Gibbs
Chief Program Officer, Climate
CLASP

Executive Summary

In early 2019, the National Energy Efficiency and Conservation Authority (NEECA) of Pakistan requested CLASP investigate the potential for the extension of the Pakistan standards and labelling program to include electric motors and, if appropriate, assist with the development of such a program. This report is the first step in that process, quantifying the current status of the motor market in Pakistan, the potential impact on introducing standards and labelling, and the practicality of doing so.

There are currently 14 million electric motors installed in Pakistan, a number projected to rise to 25 million by 2030. Collectively, these motors currently consume approximately 75TWh of electricity annually, costing industrial, commercial and domestic consumers PKR 1,520 billion (\$10bn). This places enormous stress on the economy, both in terms of direct costs to the motor user, and the indirect costs to the generation and distribution companies supporting the estimated 13GW of peak demand attributable to motors. There are also environmental costs associated with the 37 MTCO₂ annually emitted in the production of the electricity to service the motor demand. Further, without rapid and effective policy intervention, this economic and environmental stress is to become more acute with the electricity consumed by motors projected to increase by 60% to 120TWh by 2030, with a corresponding increase to PKR 2,400 billion (\$16bn) in costs to motor users, a new peak demand of 21GW, and associated CO₂ emissions of 60 MT.

However, given the current inefficiencies of the 1 million plus electric motors sold annually in Pakistan, there is huge potential to slow this increase in consumption and the associated economic and environmental costs. At the same time, management in motor energy consumption has the potential to support political actions expected of Pakistan under the Paris Climate Agreement and the attainment of the commitments made by Pakistan in their nationally defined contribution.

By adopting world's best practice in regulation of motor efficiency¹, Pakistan has the potential to cut almost 9TWh of annual electricity consumption by 2030, a reduction of 7.4% compared to leaving the market to evolve naturally (the business as usual scenario). In practice, adoption of world's best regulation is not currently viewed as realistic as no local manufacturers have the capacity to meet this performance requirement. Adoption would severely impact almost all of the 400 or so local producers, causing substantial financial and social stresses in the primary production hub of Gujranwala, and to a lesser extent Faisalabad. Further, implementation of regulation at this level would place significant strain on the institutional structures required for implementation, in particular the resources of NEECA and the almost non-existent motor testing infrastructure currently available in Pakistan.

However, it is larger motors (ie, those above 5kW) that use 70% of the total annual energy consumed by motors in Pakistan, yet these larger motors represent only 3% of local production. Thus, by initially focusing on these larger motors, a high proportion of the potential energy reductions can be captured while avoiding the majority of the negative societal impacts. Further, in terms of individual units sold, there are 25 times fewer sales in the segment above 5kW compared to those below 5kW, and the majority of these motors are imported. Therefore, regulation of this sector is more practical in the short term while local production, testing, and regulatory capacity is developed.

By adopting the internationally accepted International Electrotechnical Commission (IEC) testing protocols and performance ratings (adopted nationally as Pakistan Standard and Quality Control Authority standards), ongoing availability of motors in the market is assured. However, this does not mean regulation of motor efficiency will be easy. To achieve the desired levels of energy reductions, regulation of the refurbished motor market is necessary. Refurbished motors are particularly inefficient, and effective management of this market segment will be necessary to achieve 60% of the reduction potential. Regulation of this market will be a world-first and will require NEECA to implement a comprehensive communications and market surveillance program. Fortunately, this should be possible with funding generated on a self-sustaining basis—through nominal fees for motor registration and sales.

¹ This refers to world's best practice in regulation of the motor only. At this time, it is not recommended that Pakistan regulate variable speed drives either individually, or as a motor/variable speed drive system. However, such regulation is likely to be appropriate in the future in the light of additional information gained during the motor-only regulatory phase.

Hence, CLASP proposes NEECA's existing standards and labelling programme is extended to include mandatory regulation of electric motors. The national regulation should be based on the IEC testing and motor rating system. To enable suppliers to adjust to the new regulatory regime and allow time for NEECA to build capacity capable of managing the anticipated large number of covered electric motors, CLASP proposes that mandatory performance requirements are set in 2021 at IEC efficiency level IE1 for new motors above 5kW, increasing to level IE2 in 2023. Motor models must be registered with NEECA and comply with specific labelling and information requirements. In parallel, voluntary registration of refurbished second hand motors should begin in 2021 based on a practical "deemed efficiency" model, with this voluntary programme transitioning to compulsory registration and minimum performance requirements in 2023. During this period NEECA should direct a programme aimed at developing local production and testing capacity with the aim of expanding the scope of the regulation to include smaller three-phase and/or single-phase motors, and potentially increasing stringency of the regulations for larger motors to IE3. A market review should be undertaken in 2024 to determine market readiness for these regulatory revisions.

Even without further regulatory extensions, by 2030 implementation of the motor standards and labelling program as proposed would yield an annual electricity reduction of 4.5 TWh and corresponding consumer cost savings of PKR 89.3 billion (US\$600 million)—corresponding to a peak load reduction of 460MW, and a 2.2 MTCO₂ emissions reduction.² Cumulatively over the 2021-2030 period, reductions would be 37 TWh, PKR 740 billion (US\$5 billion) and 18.5 MTCO₂. While these projections assume 100% compliance, even with lower compliance levels, potentials are significant. The approach lays solid foundations for more stringent regulation to be introduced in the future, possibly as soon as 2025 following the proposed market review.

Important Addendum: Industry Consultation and Revised Policy Recommendations

Following completion of this report, but prior to publication, further industry consultation has not only endorsed the recommendations made above, but has pushed strongly for further stringency in requirements, and the extension of scope to include motors of all types down to 0.12kW. Importantly, this includes local suppliers immediately, initially under voluntary participation, and then with mandatory requirements from 2023. This industry push appears to be driven by a desire to develop the indigenous industry to a level that supports national goals (industry growth, retention of employment, efficiency improvements, etc) and potentially places the industry in a position to begin to develop export opportunities.

CLASP is highly supportive of this accelerated timetable for minimum energy performance standards (MEPS) and applaud the motor suppliers of Pakistan for lobbying for this acceleration. However, the authors wish to note that this accelerated timeframe places additional pressure on NEECA to:

- Ensure systems are fully operational to timescales (e.g. the registration system).
- Undertake extensive communication with, and training of, suppliers to ensure they are aware of their obligations, and that the suppliers have all the necessary tools to comply.
- Implement a very strong monitoring, verification and enforcement program, especially with respect to refurbished motors. The related compliance policy should be implemented in full.
- Facilitate appropriate supporting actions to enable smaller local manufacturers to comply with the regulations.
- Encourage development of appropriate testing facilities, and should they not reach international standards at the time of regulation, enable some form of modified testing regime that retains sufficient integrity for registration purposes, yet enables local manufacturers to comply with regulation.

² These savings estimates are larger than those produced by the United Nations' United for Efficiency (U4E) programme (U4E Country Assessments, Pakistan, September 2019). The reason for this is because the savings estimates produced by U4E are a top-down market projections based on regional data, while the projections used in this report are based on local market research, data collection and numerous interviews with experts from Pakistan's electric motors supply chain. Furthermore, the U4E projections apply *only* to new industrial motor system sales whereas the savings projections produced in this report include the refurbished motors, which are the major contributor to the estimated energy savings. Finally, under the more ambitious MEPS proposals selected by NEECA (presented under the Addendum), additional savings are secured from the inclusion of smaller three-phase and single-phase electric motors that were not included in the U4E savings calculation.

Should the full regulations be approved and rolled-out as currently planned, with high rates of compliance across all motors types, the 2030 energy, emission and consumer cost reductions are very impressive. As the Table and Figure below illustrate, rapidly implementing the revised regulatory approach bring Pakistan almost to the same levels of reductions possible from adoption of the world's best regulation.

While the reductions projections assume 100% compliance, even the realisation of only half of the reduction projections would yield exceptional value to the Government of Pakistan. This value would be in the form of reduced energy use and emissions, reduced required investment in generation and distribution infrastructure and electricity subsidies, and a reduced cost base to domestic, commercial and industrial users.

Potential annual and cumulative reductions in energy consumption, CO₂ emissions, peak load and consumer cost attributable to MEPS for electric motors in Pakistan with revised scope and schedule as proposed by NEECA

Year	2023	2024	2025	2026	2027	2028	2029	2030	Cumulative Total Saving by 2030
Total Reduction in Energy Consumption (GWh)	3,434	3,587	5,999	6,267	6,548	6,842	7,149	7,469	47,296 GWh
Peak Load Reduction (MW)	749	782	1,467	1,533	1,602	1,674	1,749	1,827	1,827 MW₃
Reduced Emissions CO₂ (MT)	1.7	1.8	3.0	3.1	3.3	3.4	3.6	3.7	23.6 MT
Reduced Operating Costs to Consumer (Billion PKR)	68.7	71.7	120.0	125.3	131.0	136.8	143.0	149.4	PKR 945.9 billion

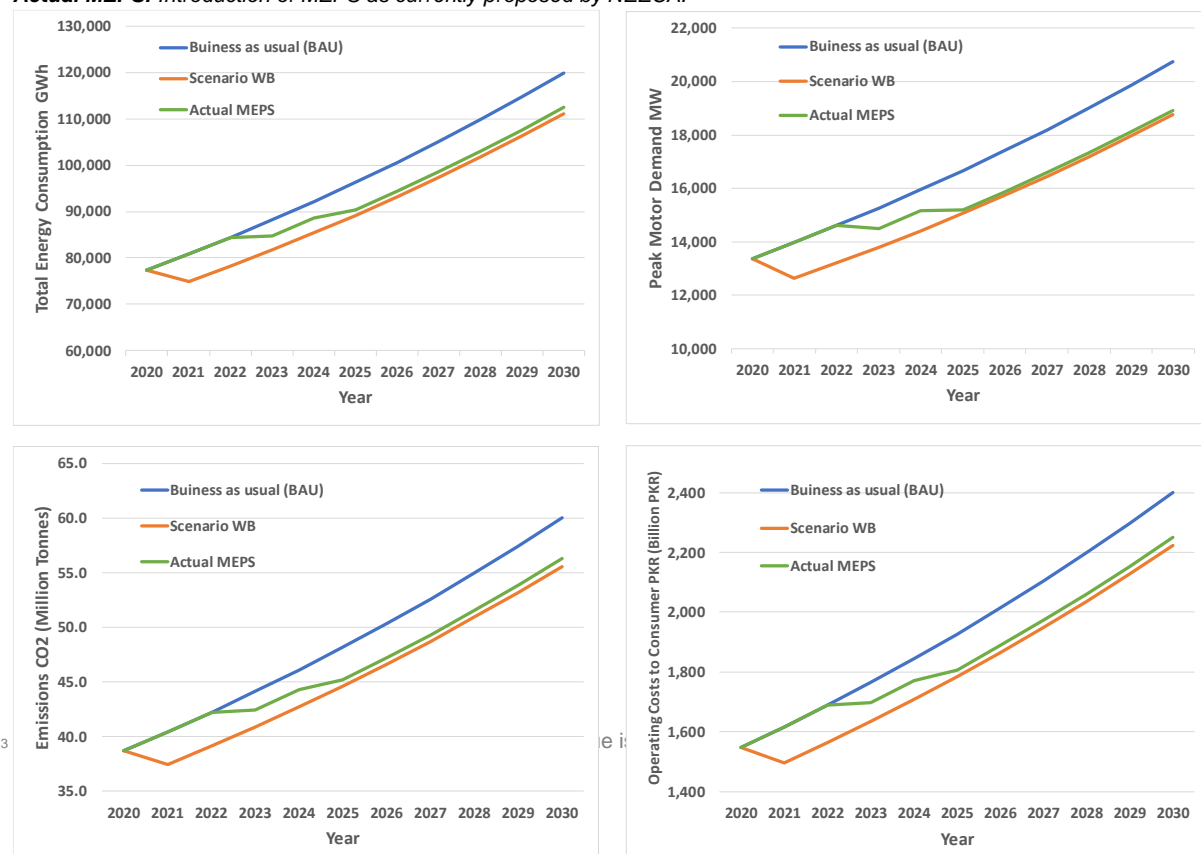
Potential reductions in energy consumption, CO₂ emissions, peak load and consumer cost attributable to electric motors in Pakistan from the implementation of the MEPS with revised scope and schedule currently proposed by NEECA in comparison with business as usual and regulating at the world's best levels

Key: Projected national motor energy consumption, supply capacity requirement, electricity costs to the consumer and resulting CO₂ emissions under the following conditions:

BAU = "Business as Usual" with market developing with no regulation by NEECA.

Scenario WB: Adoption of "World's Best" level regulation of IE3 for all new and second-hand motors.

Actual MEPS: Introduction of MEPS as currently proposed by NEECA.



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Acronyms and Abbreviations

ATP	All Three-Phase (motors)
ATP – NMO	All Three-Phase, New Motors Only
BAU	Business as Usual
BRESL	Barrier Removal to the Cost-Effective Development and Implementation of Energy Standards and Labeling Project
CO ₂	Carbon Dioxide
EFF	Ex European Motor Classification System
GEF	Global Environment Fund
GW	Gigawatt (10 ⁹ watts)
GWh	Gigawatt hour
IE	International Efficiency (rating system used by the IEC)
IEA	International Energy Agency
IEC	International Electrotechnical Commission
JICA	Japan International Cooperation Agency
kW	Kilowatt (10 ³ watts)
M	Million
MEPS	Minimum Energy Performance Standards
MW	Megawatt (10 ⁶)
NEECA	National Energy Efficiency and Conservation Authority
OEM	Original Equipment Manufacturer
PKR	Pakistani Rupee
PPEMMA	Pakistan Pump and Electric Motor Manufacturers' Association
PSQCA	Pakistan Standards and Quality Control Authority
SME	Small and Medium Sized Enterprises
TW	Terra Watt (10 ¹² Watts)
TWh	Terra Watt hour
UNDP	United Nations Development Program
U4E	United for Efficiency (a United National Environment Program)
VFD	Variable Frequency Drive
VSD	Variable Speed Drive
WB	World's Best
PSQCA	Pakistan Standards and Quality Control Authority

1 Introduction

CLASP has been supporting the National Energy Efficiency and Conservation Authority (NEECA) with the development and introduction of standards and labels within Pakistan since 2016. In early 2019, NEECA requested CLASP investigate the potential for the introduction of standards and labelling for electric motors within Pakistan and, if appropriate, assist with the development of such a program.

The International Energy Agency has estimated that 53% of all electrical energy, or 10,500 TWh per year, is consumed by electric motors globally, giving rise to around 6,800 million tonnes of carbon dioxide (CO₂) emissions⁴. There is uncertainty over whether motors in Pakistan consume more or less than this global average, however, given the historic inefficiency of energy use within Pakistani industry, the potential for reductions is very likely to be substantial. This hypothesis is supported by a limited number of studies into the use of energy by motors in Pakistan, for example, that Dr. Kumar produced in 2014⁵.

However, the studies undertaken to date are limited in number and typically based on sparse market and/or test data. Furthermore, the existing studies typically rely on extrapolation of international average motor use, which may not be wholly appropriate to Pakistan. Consequently, as a first step in the potential development of standards and labels for motors, NEECA sought CLASP's support in quantifying the current status of the motor market in Pakistan, the potential impact of introducing a standards and labelling program, and the practicality of doing so.

1.1 Report Content

This report seeks to fulfil NEECA's request to quantify the Pakistan motor market and assess the practical potential for the introduction of standards and labelling as follows:

Section 1: Introduction.

This introductory section of the report includes important notes on data sourcing and quality, areas excluded from the analysis, and a summary of the background to standards and labelling in Pakistan.

Section 2: Motor Supply, Use, Efficiency and Energy Consumption in Pakistan

Examining the complex supply chain of new and refurbished motors, producing estimates of the efficiency of new and the installed motors and, through the use of a stock model, estimating the current and projected energy consumption of motors throughout Pakistan.

The section also briefly investigates the current capacity for Pakistan to support regulation, for example, the availability of motor test laboratories.

Section 3: International Standards and Labelling of Motors

An examination of the current regulatory framework for motors globally and within the region to establish indications on the practicability of implementing standards and labelling within Pakistan, and the approach that is most likely to bring success.

⁴ World Energy Outlook 2016, IEA, 2016

⁵ Need of Escalating Energy Efficiency Standards of Motor in Industrial Sector of Pakistan, Kumar et al, Mehran University of Engineering Technology Jamshoro, 2014

Section 4: Reductions Potential from Standards and Labelling in Pakistan

Through use of the stock model, investigates the potential energy, cost and emissions reductions that may be possible through regulation of the various sectors of the Pakistan motor market.

Section 5: Recommendations related to the introduction of Standards and Labels for Electric Motors in Pakistan

Based on the preceding analysis, this section makes recommendations on potentially appropriate standards and labelling for application to electric motors within Pakistan, the time frames in which it may be practical to introduce such a program, and support measures that are likely to be necessary to make the program successful.

1.2 Important note on data sources and quality

As noted above, information on the supply and use of electric motors in Pakistan is very limited. To gain a truly accurate picture of motor supply and usage patterns across the whole of Pakistan industry, commerce and the domestic sectors would require a multi-million-dollar investment in research, resource which is not currently available to either the Pakistan Government through NEECA, or any supporting organisation. However, in developing this report CLASP have taken a pragmatic approach of using:

- Existing studies following critical review of the data sources used and the analysis performed.
- Targeted primary research into local manufacture; supply chains for locally produced and imported motors; the distribution mechanisms used to supply motors within Pakistan; and motor deployment in some of the larger industrial sectors and within households.
- Extensive interactions with local motor producers and importers of all sizes, motor distributors, end users, etc. These interactions have occurred in one to one meetings, small industry forums and large workshops.
- Interviews with, and data supplied from, a number of relevant government agencies, e.g. the Pakistan Customs.

In a number of cases, the information gained has been made available, primarily in the following publications:

- Summary Analysis of PPEMMA Production Survey⁶.
- Monitoring, Verification and Enforcement Regime for the Pakistan Energy Label⁷.
- Market Research for Energy Efficiency and Conservation Program for Punjab⁸.
- Three-phase motor labelling strategy⁹:
- Status of Motor Laboratories in Pakistan¹⁰.
- Notification of Minimum Energy Performance Standards and Labelling Regulation for Electric Motors¹¹.

However, in a large number of cases, the information gathered was provided on a confidential basis to be used by the CLASP in the development of material to support NEECA and/or to be shared with NEECA

⁶ An analysis of data received following a survey of members production undertaken by the Pakistan Pump and Electric Motor Manufacturers' Association. Report in draft form at time of preparation of this report. Publication anticipated in April 2020.

⁷ Monitoring, Verification and Enforcement Regime for the Pakistan Energy Label, CLASP, 2017.

⁸ Market Research for Energy Efficiency and Conservation Program for Punjab, InConsult for the World Bank Group, June 2010.

⁹ Three-phase motor labelling strategy: discussion paper, Stuart Jeffcott (on behalf of CLASP) for NEECA, 2019 – confidential and not published.

¹⁰ Status of Motor Laboratories in Pakistan, Mark Ellis (on behalf of CLASP) for NEECA, (2019)

¹¹ Notification of Minimum Energy Performance Standards and Labeling Regulation for Electric Motors", prepared for NEECA by CLASP, January 2021.

only. While all this information has been documented, not all is referenced directly within the report but has been used to develop and validate much of the material presented.

Ultimately, while accepting the material included does not provide a 100% accurate representation of motor supply and use within Pakistan, CLASP is confident that the information presented is the most accurate representation of the market currently available.

Further, by providing a fully transparent, bottom-up model of installed stock, estimated motor efficiency, energy consumption and resulting emissions (refer to Annex 1), this presents NEECA with a framework to further develop the accuracy of projections as more data becomes available, for example, through motor performance data and/or sales volumes that may be gained through any future regulatory requirement to disclose data. Such developments will assist NEECA in evaluation of any policy adopted in the near term, and improve their ability to project the impact of any future proposed regulatory revisions.

1.3 Exclusions from the Analysis

Exclusion of consideration of Variable Speed Drives from the scenario analysis.

Variable Speed or Frequency Drives (VSDs or VFDs) provide excellent energy saving opportunities in a number of applications irrespective of the efficiency of the motor. As such their application is heavily promoted in many jurisdictions, and actively regulated as motor/VSD combinations in Europe and elsewhere. However, at this early stage in NEECA's regulatory development, and the current state of the motor market, the addition of VSDs to motor regulation seems optimistic. This is particularly true given the current limitation in testing facilities within Pakistan for "standalone motors", let alone the more sophisticated requirements of testing motor/VSD combinations.

Therefore, it is strongly recommended that NEECA do not attempt to regulate VSDs at this stage, either as a stand-alone product or as part of a motor/VSD system, but focus on effective implementation of motor only regulation. Evaluation of potential regulation of VSDs and VSD/motor systems may then take place in the light of additional information gained during the motor-only phase, and appropriate regulatory actions taken thereafter. On this basis, the inclusion of VSDs has been excluded from the scenario analysis.

However, this *does not* mean NEECA should exclude VSDs from their general activities and application should be encouraged wherever possible, particularly in applications where there is a variable load on a fan or pump where energy and costs savings for users can be substantial.

Rewind and repair

As extensive research in the USA, Europe and beyond demonstrates, if following good practice, motor rewinds have little to no impact on efficiency of a motor. However, if performed badly, the performance of the motor can be significantly impaired, often with efficiencies falling 5-10% with each poor rewind. Within Pakistan motor repair and rewinding is common and relatively cheap (significantly cheaper than all alternatives), but typically skill levels and equipment are lacking. Hence, it is assumed this is continually degrading the overall efficiency of motors installed in Pakistan. However, due to lack of any reliable data on the frequency of rewind through motor life, the true reduction of efficiency with each rewind, and how these vary by motor type and size, their impact has been excluded from the analysis. The consequential assumption that motors will retain the efficiency at point of purchase will have the effect of underestimating lifetime energy consumption (and/or the ability of the motor to carry out its rated performance). However, as a number of assumptions have the opposite effect, (for example the assumption that most motors are operating on full load), it is believed that the underestimation of motor consumption due to the exclusion of rewind considerations is more than offset by the overestimate caused by some of the other necessary assumptions.

Nevertheless, the potential exists for NEECA and/or their partner organisations to develop rewind (and other repair) training and certification programs for the industry that are likely to result in substantive energy and cost savings as motors move through their lives. Investigation of the potential in this area lies beyond the scope of this study, but it is recommended this area be investigated in the future.

1.4 Summary Background to Standards and Labelling in Pakistan

During much of the twenty-first century, Pakistan faced a severe energy crisis with routine load shedding of 4 -12 hours/day across much of the country. These power shortages cost the country up to 2-4% of GDP/year affecting industrial competitiveness and the wellbeing of the population. While much of the power shortage has now been alleviated with the rapid expansion of supply capacity, slowing the growth in energy demand remains a key plank of the Pakistan Government's multifaceted response to the crisis.

As part of this response, the National Energy Efficiency and Conservation (EE&C) Act (2016) created NEECA. The Act placed NEECA as the sole Federal authority to administer, implement and enforce the provisions of the Act, including implementation of energy efficiency standards and labelling.

A fuller history of the development of the standards and labelling program in Pakistan, along with the legal and institutional framework of the program can be found in the CLASP report *"Monitoring, Verification and Enforcement Regime for the Pakistan Energy Label"*¹². However, to briefly summarise the current situation, the first product to be labelled in Pakistan was domestic cooling fans. Given previous unsuccessful attempts (in particular, extensive efforts to introduce standards and labels for a range of products including motors under the UNDP/GEF BRESL Project), CLASP supported NEECA with the 2016 labelling of fans to demonstrate the practicality of introducing such programs within Pakistan. While currently voluntary, the label has indeed proved successful with 15 manufacturers participating, and over half a million high efficiency labelled fans sold.

The success of the fan label enabled NEECA to push further and begin the development of mandatory minimum performance standards (MEPS) and labelling for a range of products. Currently under development are MEPS and labelling for some of highest energy using products in Pakistan, i.e.:

- Electric Motors (with the assistance of CLASP and the subject of this report)
- Lighting products (with the assistance of the United Nations Environment U4E program)
- Domestic refrigerators and air conditioners (with assistance from the Japan International Cooperation Agency (JICA))

It is anticipated that MEPS and Labelling regulations for Electric Motors and Lighting will be approved in 2020 and come into force in 2021. It is also expected the current cooling fan labelling program will become mandatory at the same time. Refrigerator and Air Conditioner regulations are expected to be approved in 2021 and come into force in 2022. Other products will follow but are yet to be prioritised.

¹² Monitoring, Verification and Enforcement Regime for the Pakistan Energy Label, CLASP, 2017. For the Standards and Label history and associated institutional structures, refer to section 3.

2 Assessment of Motor Supply, Use, Energy Consumption and Supporting Infrastructure in Pakistan

This section examines the motor supply chain within Pakistan. The aim is to develop a transparent understanding of:

- The quantity, types and sizes of motors sold, and their sources. This information enables estimation of the current installed stock of motors within Pakistan, their current and projected levels of efficiency, energy consumption and associated greenhouse gas emissions. These values give policy makers an understanding of the magnitude of electricity consumed by motors within Pakistan against which the impact of potential standards and labelling options can be measured.
- The routes motors take to market and ultimately the consumer which allows for evaluation of how a full standards and labelling compliance regime may be successfully introduced.

Observations are also made on the current and potential institutional capacity of Pakistan to support motor regulation.

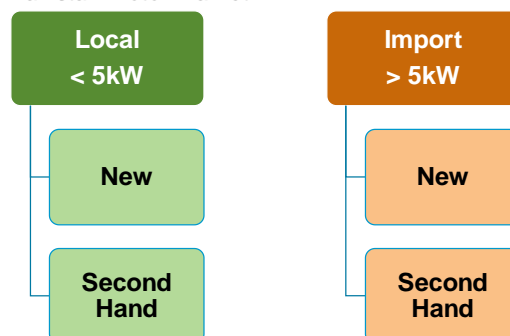
2.1 The Motor Supply Chain within Pakistan.

In conceptual terms, the supply of AC motors can be split into those below 5kW which are predominantly produced by local suppliers, and those above 5kW which, with the exception of those just above the 5kW boundary, are almost wholly imported. In both cases the markets are further divided into new and refurbished motors.

Single and three-phase motors of 5kW and below

Locally produced (and second-hand) motors below 5kW

Figure 1: Simple conceptual breakdown of the Pakistan motor market



There are approximately 400 motor and pump manufacturers within Pakistan (motors and pumps are included as one group as the majority of pump producers actually manufacture the motor/drive section and assemble, with the pump casing and pump impeller typically purchased from a third-party supplier). Producers are located throughout Pakistan, but the vast majority are located in the town of Gujranwala (approximately 80%) with a smaller hub in Faisalabad. Of these, 150 producers are members of the Pakistan Pumps and Electric Motor Manufacturers Association (PPEMMA)¹³.

Of the 400 suppliers, approximately 20-25 may be considered “medium” in size employing 20-30 employees, of which three employ around 50 people. This group of medium sized suppliers are *relatively* sophisticated producers, often using higher quality materials, employing semi-automated winding techniques and producing products of a consistent quality. The group have the potential, and apparent enthusiasm, to improve quality further, and produce motors of international quality. However, at present, their ability to produce better quality products is limited by:

- Lack of quality, affordable, testing facilities that will allow them to effectively evaluate their current production and identify areas for improvement.
- Design skills that can optimise, for example, motor aerodynamics and winding geometry.
- To a lesser degree, tariffs and other taxes on premium quality raw materials.

¹³ <http://ppemma.org>

While servicing a significant element of the domestic and agricultural single phase-pump market, medium sized producers are also the primary producers of three-phase motors (usually) below 5kW. As such, they are the major suppliers of smaller motors to the commercial sector and to small and medium sized manufacturing industry, with some also supplying to well-known multinationals for example Honda. In many cases these producers also supplement their range (in both size and/or quality) though acting as importers/distributors for, primarily, Chinese suppliers.

Other local manufacturers of motors and pumps range downward in size all the way to only two or three employees. These manufacturers use very basic production techniques with hand winding, rotors often retrieved and reworked from scrapped American style “through the window” air-conditioners, and stator laminations made of steel stamped from old oil drums.

While the refurbished market for motors below 5kW appears limited, this may not be the case with the smaller manufacturers often reworking older motors and, through repainting etc, presenting them as new. However, the magnitude of this market is unknown as their production appears as “new” in the market.

Distribution to market and the ultimate consumers can either be direct or via local markets. As might be expected, the smaller producers tend to supply to a very small number of

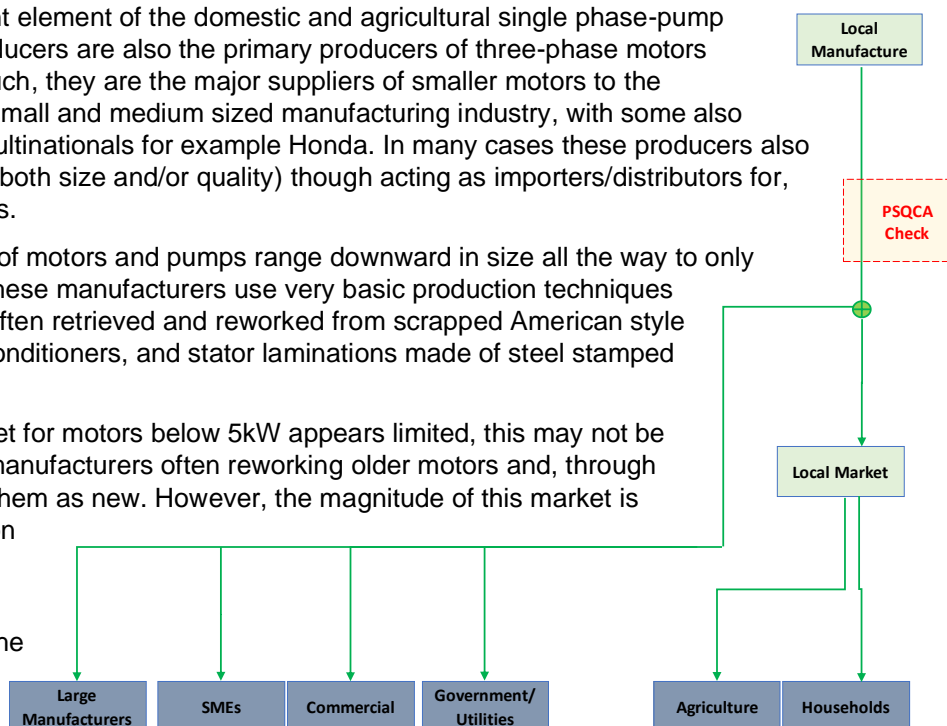


Figure 2: Schematic of the distribution routes for locally produced single and three-phase motors below 5kW

outlets (often only one) which then onward sell to local domestic and agricultural users. The larger suppliers have a variety of distribution approaches varying from direct to user groups and/or through distributors/markets. In all cases, manufacturers are required to gain certification of product quality through the Pakistan Standards and Quality Control Authority (PSQCA) and pay a charge for each product sold (see Figure 2). However, the degree to which PSQCA exerts any control over the market in terms of quality is questionable.

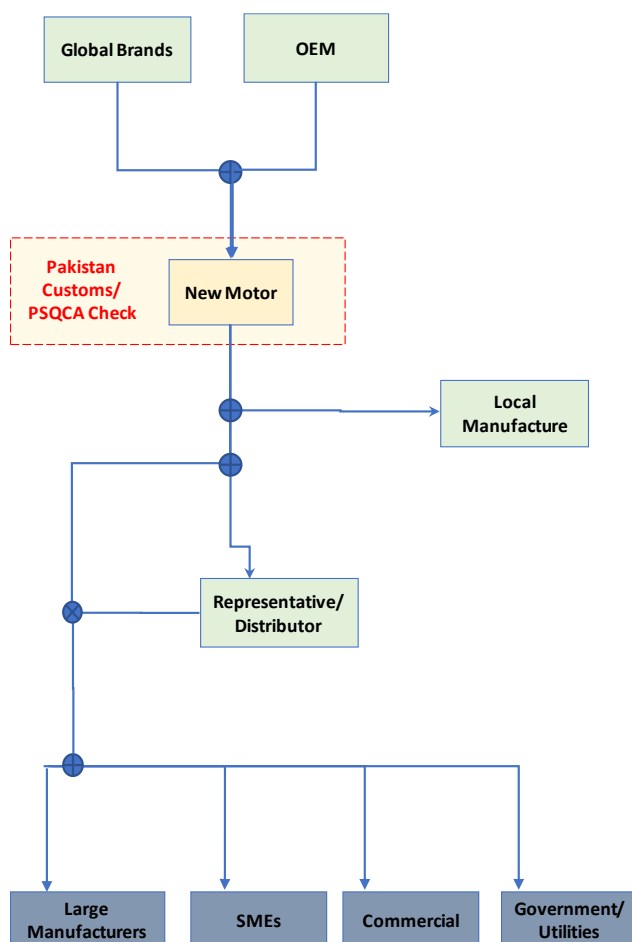
Imported three-phase motors below 5kW

A proportion of three-phase motors below the 5kW threshold are imported for use in more advanced industry sectors (typically multinational or those supplying multinationals for the export market, e.g. textiles), often to pumping or spinning/weaving applications. Imports constitute approximately 45% compared to the 55% locally produced units. The suppliers and routes to market mirror that of the larger motor imports detailed below, and are often supplied by the same distributors as part of full-service contracts with their customer groups.

Three-phase motors above 5kW

Prior to the 1970's, Pakistani based manufacturers supplied much of the market above 5kW with production ranging up to 60kW. Siemens was also producing motors within Pakistan. However, as a result of regulatory changes (primarily to import duties) in the 1970's, a market for cheaper imported refurbished motors developed. Through first cost pressure, this brought about a retreat in the local production to mainly the “below 5kW” range where the cost of import generally outweighs local manufacturing costs. Siemens also closed their production facility in this period (although they do retain a substantive service/rewind centre). Consequently, the supply of three-phase motors above 5kW is now serviced catered for almost entirely by imports, split roughly equally between new and refurbished motors (53% and 47% respectively). These motors are imported either directly or, in the case of refurbished motors, often indirectly as “scrap” (due to the recent devaluation in the Pakistani currency, and the consequential increase in import costs, a market for refurbished motors sourced within Pakistan has begun to develop, but it is very small).

Figure 3: Schematic of the source and distribution routes for global brands and OEM imported new three-phase motors.



Imported new motors above 5kW

The market for new motors splits almost equally between large global brands and OEM suppliers, typically of Chinese origin. The global brands supplying are ABB, Siemens and WEG, with ABB and Siemens operating their own offices locally and WEG operating through three distributors (although most sales are through one distributor called Avanceon). There are estimated to be 30 OEM suppliers, typically operating through a single, or less often multiple, local distributor(s). While there is sometimes a degree of variation in quality between the various suppliers, in practice the global brands and OEMs (with a small number of exceptions) have a range of products that cover almost every application and all efficiencies in the IE ratings scale and it is the purchaser (distributor or ultimate customer) that chooses the quality/efficiency combination to meet their needs.

As would be expected, the markets for these larger motors is more restrictive but still expansive. The market covers users such as large manufactures, the commercial sector, larger SMEs, the Government related sector (e.g. water and power companies) and, as noted above, to local suppliers as addition to their own ranges. While there is clearly overlap between the two, the global brands tend to predominate in sales to multinational or those supplying multinationals or the export market (often driven by internal or imposed corporate purchasing policies), while the OEM have a greater share of the other sectors.

Typically motors arrive by road from China, or by sea through ports such as Karachi, where they are subject to a PSQCA check and normal customs procedures, followed by onward transportation to the distributor or final consumer (see Figure 3). A per product payment is required by PSQCA, and duties and fees totalling approximately 40% of invoice value are also payable (the latter variable based on declared product quality). However, it is worth noting that “normal” customs procedures require extensive supporting paperwork that, for a consignment of 100 motors, may extend to 200+ pages. The clearance procedure varies in length depending on a number of factors, but for frequent importers is typically completed within a week, but can sometimes extend to several weeks or even months. As it is impossible for suppliers to hold inventories covering all product ranges, and hence some products are imported to order, this delay can be problematic for motor suppliers as late delivery may cause extensive problems for customers whose production may be disrupted if motor supply is late.

Refurbished motors above 5kW

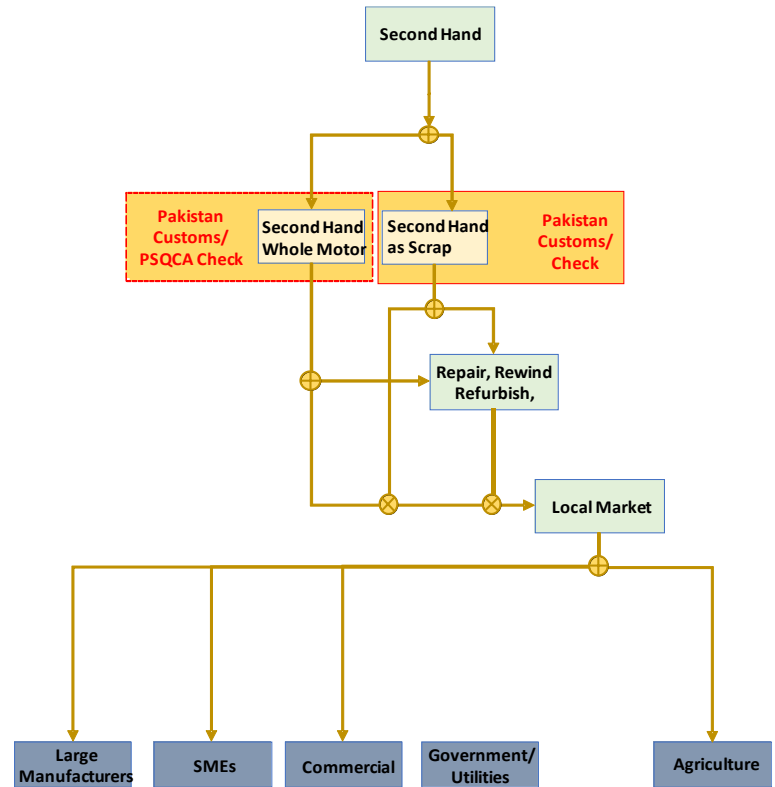
As indicated above, while there is a recent minor trend to use refurbished motors sourced within Pakistan, the vast majority of refurbished motors are still sourced from outside Pakistan and this group is the focus of attention of the report.

During the 1980-90's, refurbished motors were primarily sourced from Europe due to the perception European sourced motors were of high quality, and motor availability was high due to the European de-industrialisation occurring during the period. As the rate of European de-industrialization slowed in the early 2000's, refurbished importers looked to other markets, for example, Korea, Japan and

Iraq/Afghanistan (the latter as a result of western military units vacating the countries but leaving non-critical infrastructure such as motors). More recently China has begun to be a source.

Refurbished motors follow two routes of entry to the Pakistan market (see Figure 4). The first mirrors that of new motor imports where the refurbished motor is imported as a complete unit and declared to customs/PSQCA as such, thus becoming liable to the same processes and duties/fees as new motors. Once imported these motors either go directly to market or through a rework facility where minor flaws in the units are repaired. However, as these motors follow the same route and are subject to the same processes and costs as new motors, this erodes the potential importer value added/competitive advantage of supplying refurbished motors. Hence, this route to market is typically only used for very large motors where the price differential remains sufficiently high, or where the refurbished motors are considered by the importer to be of particularly high quality, e.g. a set of identical motors that had recently been installed in a plant that was subsequently closed.

Figure 4: Schematic of the source and distribution routes for second-hand imported three-phase motors



Much more frequently, refurbished motors are imported as “scrap”, frequently deliberately mixed with other metal waste within a container (often labelled for recycling). This is legal, and in many ways legitimate. Motors contain large amounts of copper, steel and other high value components that are in short supply in Pakistan. Hence recovery from waste products is both profitable and economically advantageous to the country. As such they are imported with minimum duty and are not subject to PSQCA checks. However, following import, whole motors are removed from the waste stream and are reworked by importers; for example, painting, sometimes replacement of bearings, fans or rewinding, etc. as necessary (where units are irretrievably damaged they are returned to the waste stream and recycled as normal with no net loss of value to the importer). The reworked motors are then placed on the market. Such markets are widespread throughout Pakistan, but the key “wholesale” markets are located in Faisalabad, two in Lahore, Karachi and Gujranwala. Many hundreds or thousands of motors may be on sale in these markets with ratings up to 250kW or sometimes beyond.

Refurbished motors are often considered exceedingly good value by buyers. Their

Figure 5: Typical second-hand motor outlet in Pakistan



price is typically around half of the cheapest new motor option (refer to motor pricing, section 2.2). Despite the difficulty in identifying the better performing units, and the consequential potential for these second-hands motors to have very poor efficiencies (refer to motor efficiencies in section 2.4), a number of buyers pride themselves in identifying what they perceive to be higher efficiency refurbished motors. Further, these purchases are not limited to smaller, less sophisticated buyers, but many relatively advanced manufacturing units employing highly qualified staff continue to source refurbished products in this way.

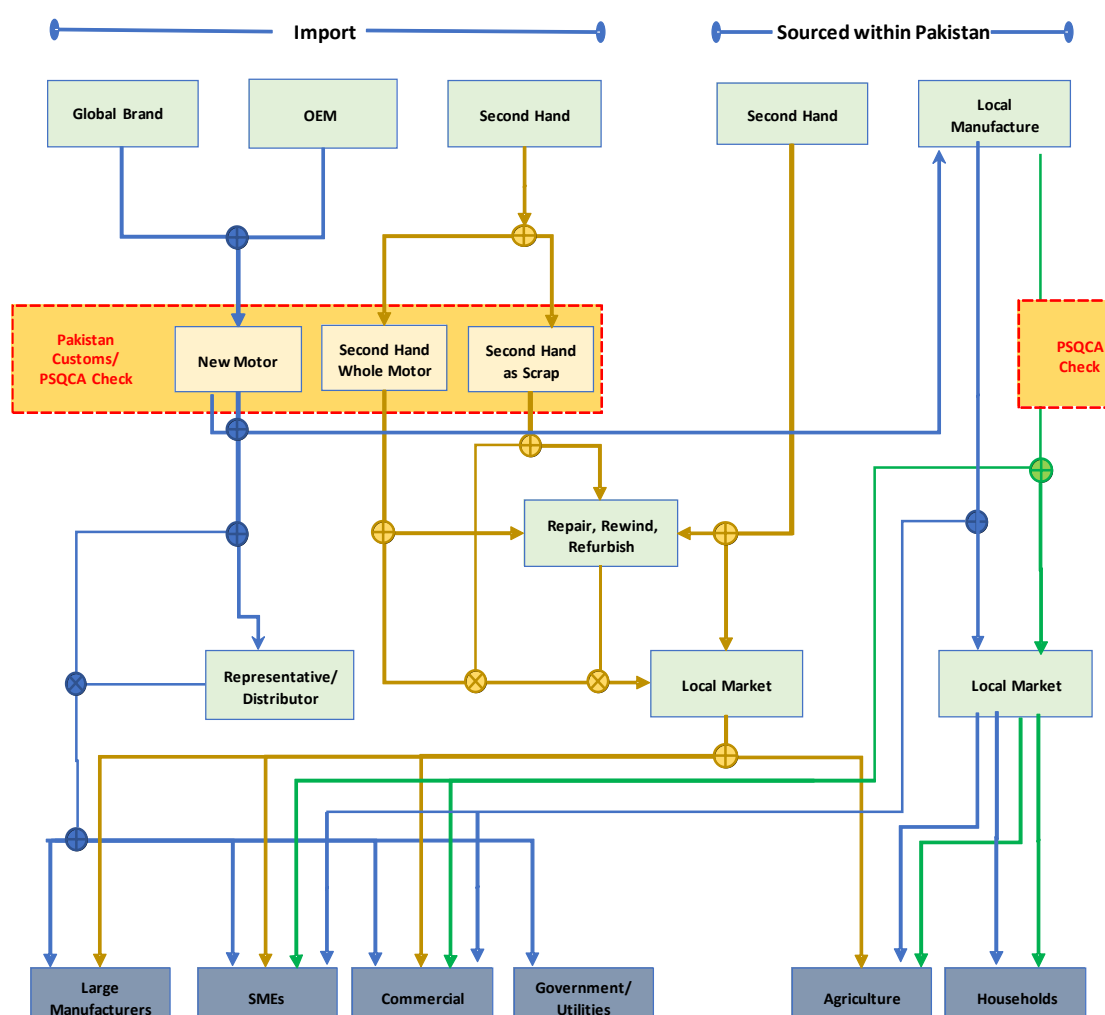
From a supplier perspective, margins on refurbished motors are very high given the differential between “scrap” values and the potential refurbished market price, even where this market price is significantly below that of new motors. The extent of the differential is shown by a number of refurbished dealers being able to support quite profitable businesses through sale of 2-3 motors per month.

Hence, the profit potential to suppliers, and the purchasers' perceived excellent value route to obtaining motors with high efficiencies explains the extensive market penetration of refurbished motors.

Full market supply chain

The schematic diagram shown in Figure 6 brings all the elements of the supply chain together and demonstrates the complexity of the market faced by a regulator wishing to address motor efficiency in Pakistan.

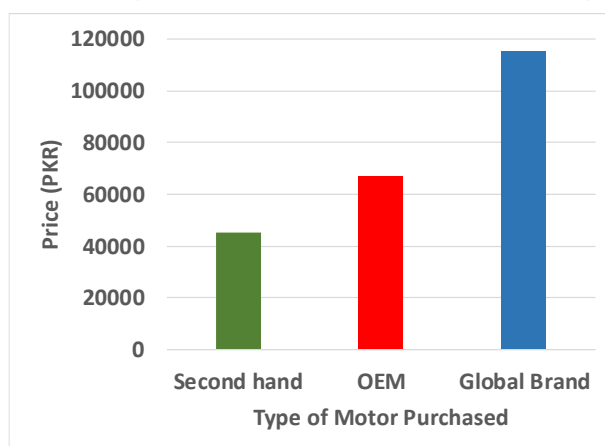
Figure 6: Schematic of full motor supply chain in Pakistan



2.2 Motor pricing

It is very difficult to be specific about motor pricing in most countries as the actual price of a motor relates to brand, inherent quality and performance, quantities purchased (at one time and/or over extended periods), existing relationships between the buyer and seller (formal and informal), corporate purchasing policies, etc. This situation is compounded in Pakistan where personal, family and business relationships are often heavily intertwined. However, CLASP's investigations suggest, for a motor of any given duty and rating (greater than 5kW), and *perceived* by the market to be of comparable efficiency, then for a nominal refurbished motor price of x , comparative costs of new (typically Chinese) OEM and global brand motors are $1.5x$ and $2.5x$ respectively. Figure 7 provides a real-life example of this price differential in motors available in the Lahore marketplace for a new global brand, OEM and refurbished 11kW (S1 duty) motor, all perceived by purchasers to be of comparable efficiency.

Figure 7: Comparative market prices for a new Global Brand, OEM and second-hand 11kW (S1 duty) motor perceived by purchasers to be of comparable efficiency



2.3 Estimated motor sales and historic, current and projected installed motor stock

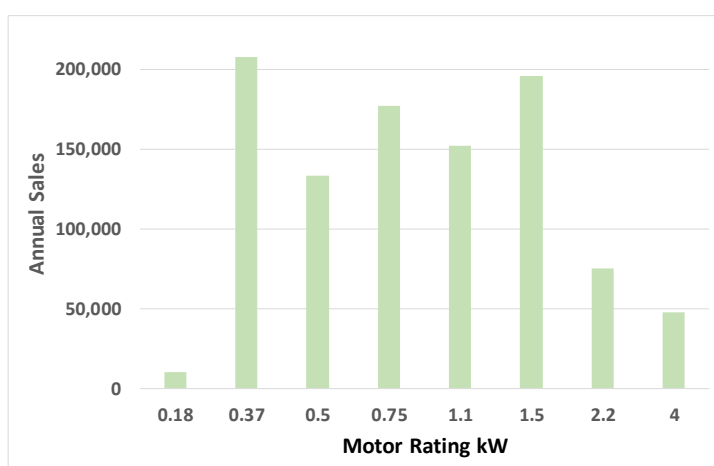
While no contemporary and reliable estimates of motor sales or bottom-up estimates of installed motor (stock) numbers have been found, through a combination of direct supplier survey, face-to-face interviews and wider consultation, a significant amount of base data has been accumulated. This data, along with a number of considered assumptions have been used to establish the estimated 2018 sales of motors in Pakistan by both source and rating. Further, building on this sales data it has been possible to develop a stock model which gives an estimate of the number and capacity of operational motors in the Pakistan economy from 1990 to the present day, and further projects the likely growth of this stock to 2030. More details of original data sources, assumptions, calculation methodologies and data tables can be found in Annex 1.

Motor Sales

Total sales of locally produced single-phase motors in 2018 are estimated at 990,000. As expected, distribution of single-phase sales (Figure 8) is centred around the 0.37-1.5kW range given the primary demand stems from domestic and small agricultural pumps.

Total sales of three-phase motors below 5kW are almost an order of magnitude smaller at approximately 140,000 units per annum. As would be expected, the majority of sales are from 0.75kW upwards where the performance characteristics of single-phase motors begin to be insufficient for most industrial and commercial applications. Local manufacturers supply approximately 55%

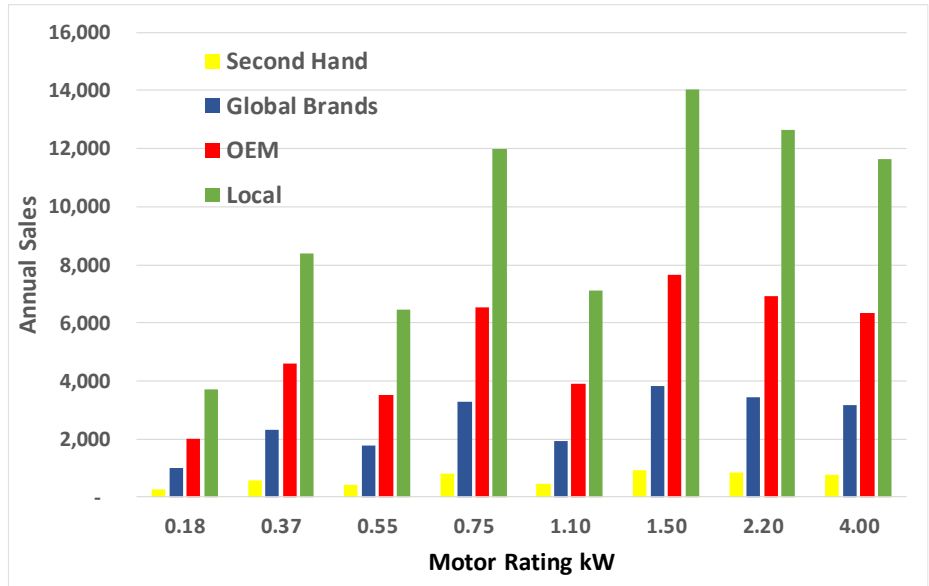
Figure 8: Distribution by rating of sales of locally produced single-phase motors



of this market (see Figure 9). The dominance of local suppliers is to be expected due to the physically small nature of the motors (and hence ease of production) and much of the demand coming from small scale companies where local relationships are likely to be important to sales. The remaining supply is split on approximately 2:1 basis between OEMs and global brands respectively.

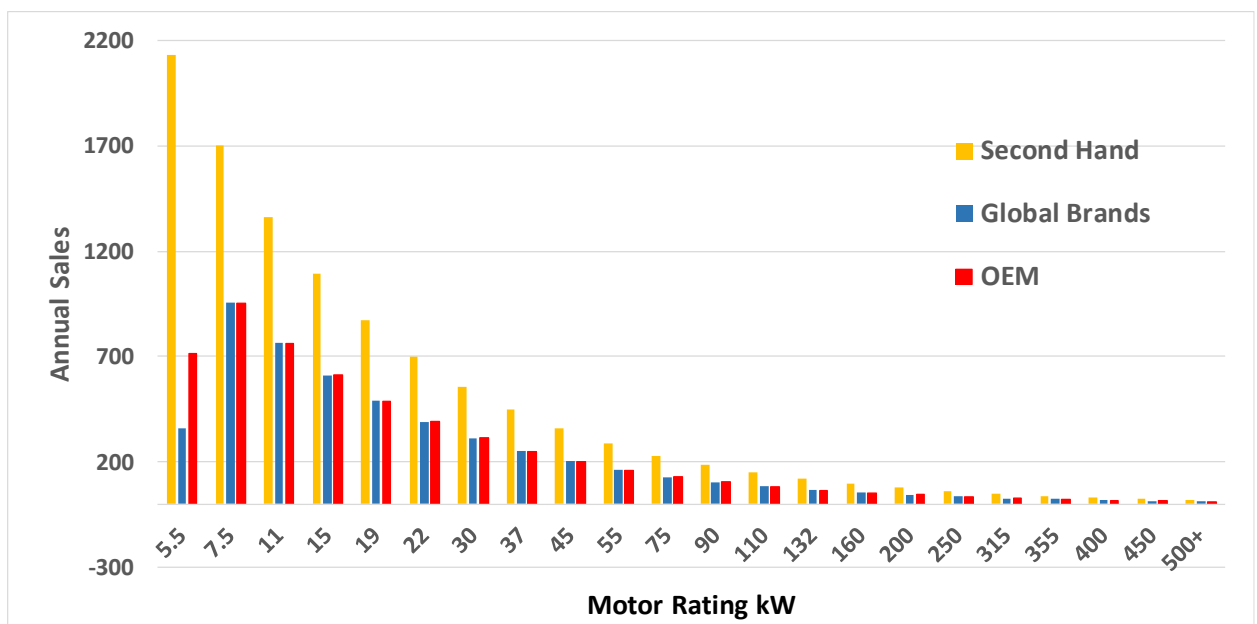
For three-phase motors above 5kW, total sales are much lower at just over 41,000 (of which approximately 20,000 are from local manufacturers but restricted to the 5-12kW range). This much smaller demand is due to primarily applications in the industrial and larger commercial sector. Again, as would be expected for the range of possible applications, overall more than 70% of sales fall within the 5.5-15 kW range, after which sales fall exponentially to around 150 motors a year above 400kW (see Figure 10).

Figure 9: Distribution of second-hand and new local, global brand and OEM sales of three-phase electric motors below 5kW production by rating



However, as emphasized in the preceding sections, the attractiveness of refurbished motors is clearly evident with refurbished motors accounting for sales of approximately 10,500 of the 21,000 non-locally produced motors. The remaining sales are split evenly between global brand and OEM importers.

Figure 10: Distribution of second-hand and new local, global brand and OEM sales of three-phase electric motors above 5kW production by rating



Note: Sales of approximately 20,000 units in the local production in the 5-12 kW range that are not displayed,

Installed motor stock

Figure 11, Figure 12 and Figure 13 show estimates of the Pakistani stock of single- and three-phase motors below and above 5kW from 2000 to the present day, and an onward projection of growth through to 2030. In all cases, the Figures show a remarkable rise in the motor stock, broadly doubling between 2000-2015, and then doubling again by 2030 (projections are based on an average annualised growth rate of 4%).

It is recognised this smooth growth in stock is a function of the modelling methodology and may distort certain areas. For example, the ratio of installed refurbished to new three-phase motors remains constant across the period when the proportion of refurbished motors is likely to be increased given their main arrival in the market in the 1970-90's. Nevertheless, it is believed the Figures do give a reasonably accurate guide to the average change in stock over the period, and in the case of refurbished motors, give a reasonable representation of their significant penetration in the market; a point that is of importance for regulators to be aware.

The Figures also illustrate growth across all motor types, sizes and sources. By 2030 there are predicted to be over 20 million single-phase motors installed in the domestic and agricultural sector, and over 3 million three-phase motors in the commercial, industrial and agricultural sectors, more than 400,000 of which are above 5kW.

Figure 11: Growth of single-phase motors installed in 2000-2030

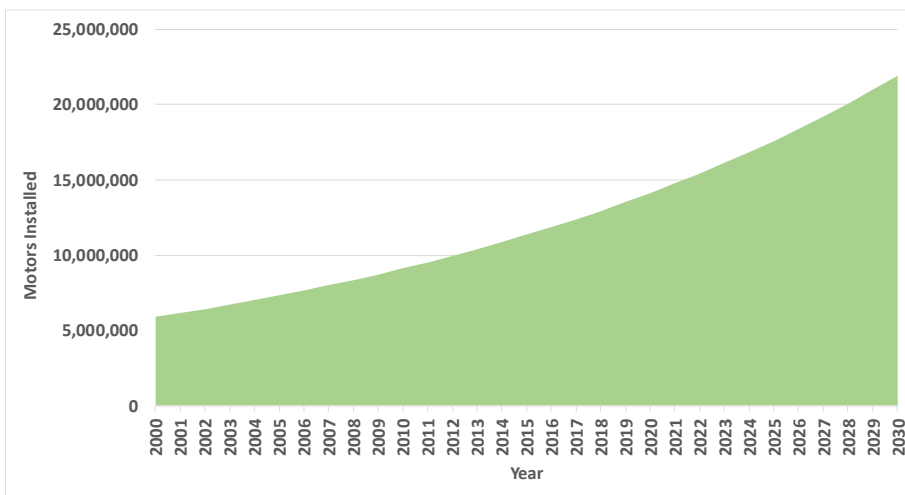


Figure 12: Growth of new and second-hand three-phase motors below 5kW installed in 2000-2030

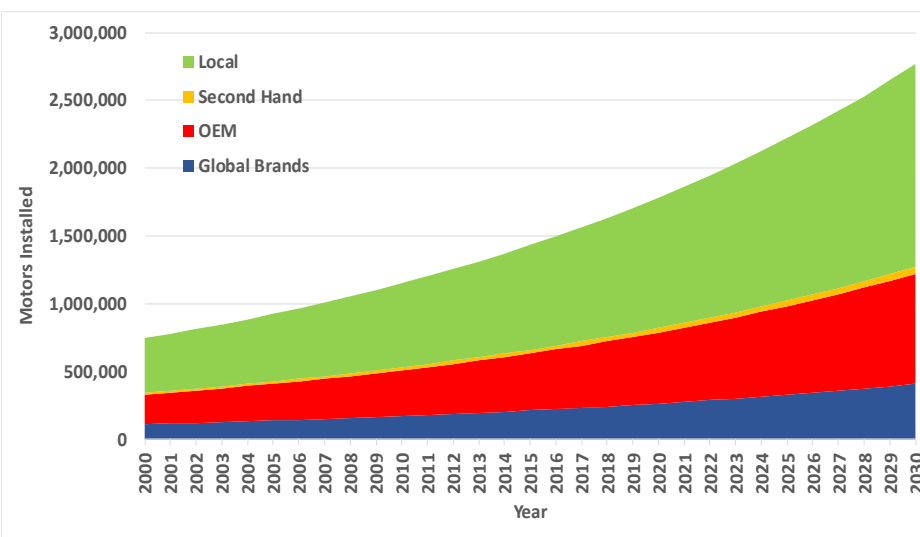


Figure 13: Growth of new and second-hand three-phase motors above 5kW installed in 2000-2030

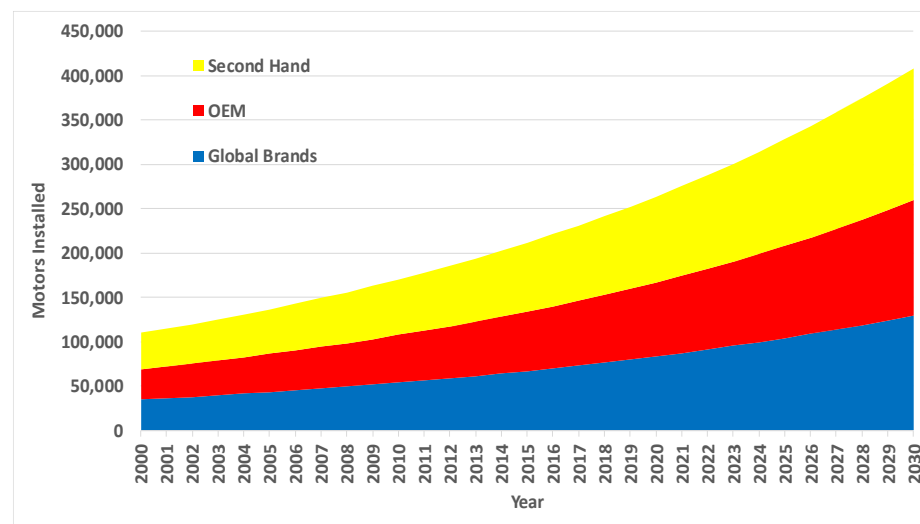
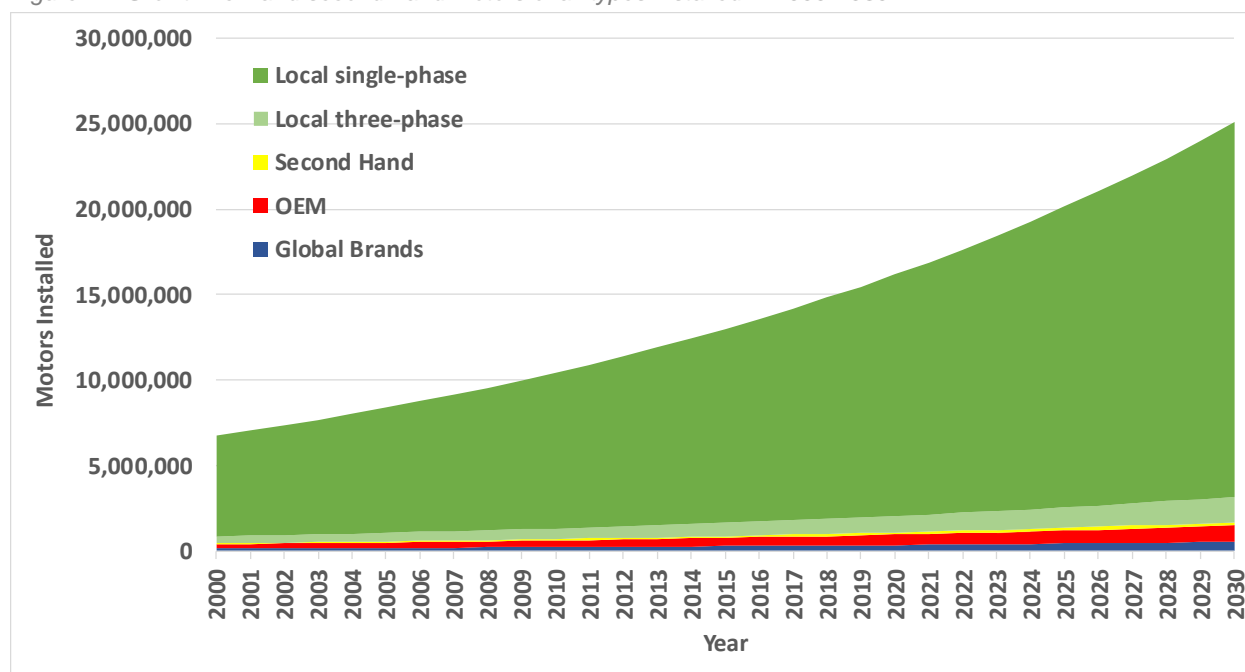


Figure 15 brings all sizes, types and sources of motors on to one graphic. The two striking features of this graphic are the sheer number of motors installed, currently around 14 million but rising to around 25 million by 2030, and the predominance of small single-phase motors (three-phase motors accounting for only around 10% of installations). This prominence of single-phase motors, particularly their visibility in many homes is likely to be the cause of the call for regulation of this motor type. However, the sheer volume of motor installations is only part of a larger picture of motor impact on the Pakistan economy, a picture which is further developed in the coming sections.

Figure 14: Growth new and second-hand motors of all types installed in 2000-2030



2.4 Historic, current and projected efficiency, installed capacity, energy consumption and CO₂ emissions of motors in Pakistan

While the number of motors installed is clearly important, from a regulatory perspective, it is the size, efficiency and periods of operation that ultimately define how much electricity these motors consume, and how beneficial any regulatory intervention might be.

Efficiency of current and projected motor sales – new motors

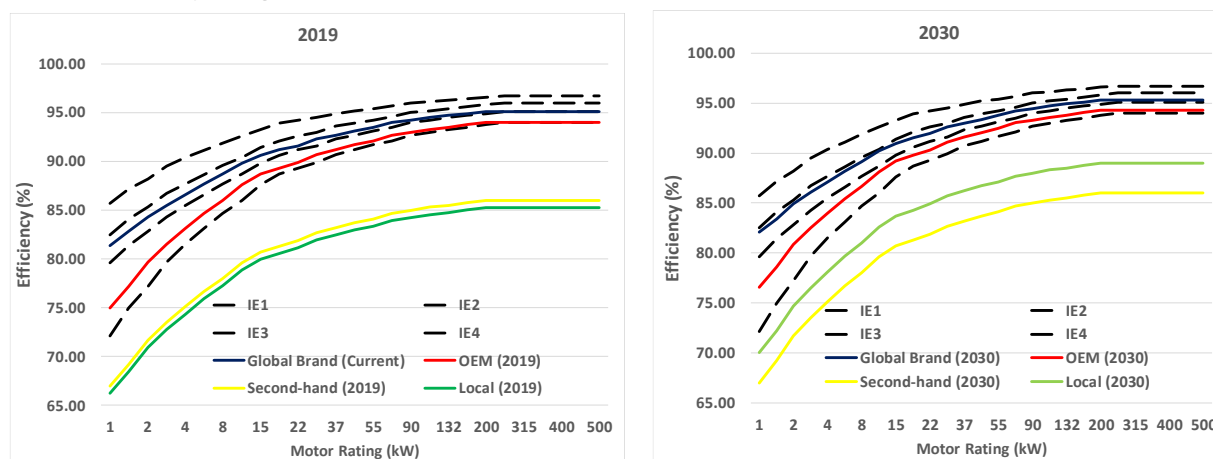
While almost no reliable test information exists for motors of any kind installed in the Pakistani market (with the exception of type test reports for most global brand and OEM suppliers), given the lack of a driver to improve efficiency, there are indications that historically locally manufactured motors below 5kW were of very low efficiencies. These efficiencies are estimated to have been, on average, approximately 10% below the current IEC IE1 motor classification. However, over the last 10-20 years, an increasing awareness of motor efficiency issue have driven the medium sized producers to improve efficiency and CLASP's discussions with these suppliers indication that at least a proportion of the production of the medium sized producers is now within a few percentage points of the IEC IE1 efficiency class. However, suppliers producing these "better" motors do not necessarily do so across the entire range and, when including the very high number motors of poorer quality supplied by the small producers, efficiencies tail off very rapidly. Hence, it is estimated current average efficiencies of new locally produced motors under 5kW is around 8% below the current IE1 standard, but is projected to improve slightly to 5% below IE1 by 2030. However, the improvement is mostly going to be made by the medium sized producers, with an increasing differential in efficiency compared with the smaller producers who lack the skills to develop further (see Figure 16).

As noted earlier, the global branded and OEM suppliers have access to motors across the efficiency and performance spectrum and hence the efficiency of supply is (mainly) driven by consumer preference. However, both ABB and WEG are now only supplying motors of IE2 efficiencies or better having withdrawn their IE1 offerings. At least one OEM supplier is following a similar route with others considering the option. With no external intervention it is expected this gradual rise in the average efficiency of sales will continue, driven by rising consumer awareness, the supplier response to regulation in other jurisdictions, and their own corporate responsibility agendas. Therefore, estimates of *average* current efficiency of global branded motors and OEMs are just below the IE2 and just above the IE1 threshold respectively, and are expected to rise to close to the IE3 and IE2 thresholds respectively before 2030 (see Figure 16).

Efficiency of current and projected motor sales – refurbished motors

The efficiency of refurbished motors is perhaps the most challenging issue in evaluating the overall efficiency of sales and installed stock. For example, two identical motors may come from the same location conducting the same function (e.g. pumping in a chemical plant). However, one motor may have been the prime-mover, with the second acting as a standby. Over a 10-year period of installation, the prime-mover may have operated for 70-80,000 hours and have been rewound several times, while the standby motor may have only operated 500-1,000 hours when undergoing annual standby testing, and during periods when the prime-mover was being rewound. Yet after a “rework”, both motors will appear very similar even with internal inspection. Without testing, the efficiency and “remaining life” relative to the nameplate data will be very difficult to ascertain. Despite this, a number of buyers pride themselves in identifying higher efficiency motors even when their observations occur in the less than ideal environment offered by typical refurbished markets.

Figure 15: Estimated efficiency of current new and second-hand motors, and projected efficiency in 2030 relative to the IE efficiency ratings



Hence without a major testing program it is impossible to ascertain a true picture of the average efficiency of imported refurbished motors, particularly those that have arrived through the scrap route. However, given the likelihood of at least one rewind at some point in their lifetime, and the detrimental effect of various renovations during installed life and pre-sale rework, it is estimated that refurbished motors are, on average 8% less efficient than their nameplate rating. Given the market conditions where suppliers already claim the motors are of high efficiency and with no way for buyers to prove otherwise, without some kind of external driver (e.g. regulation), it is not foreseen this level of efficiency will change in the future (see Figure 16).

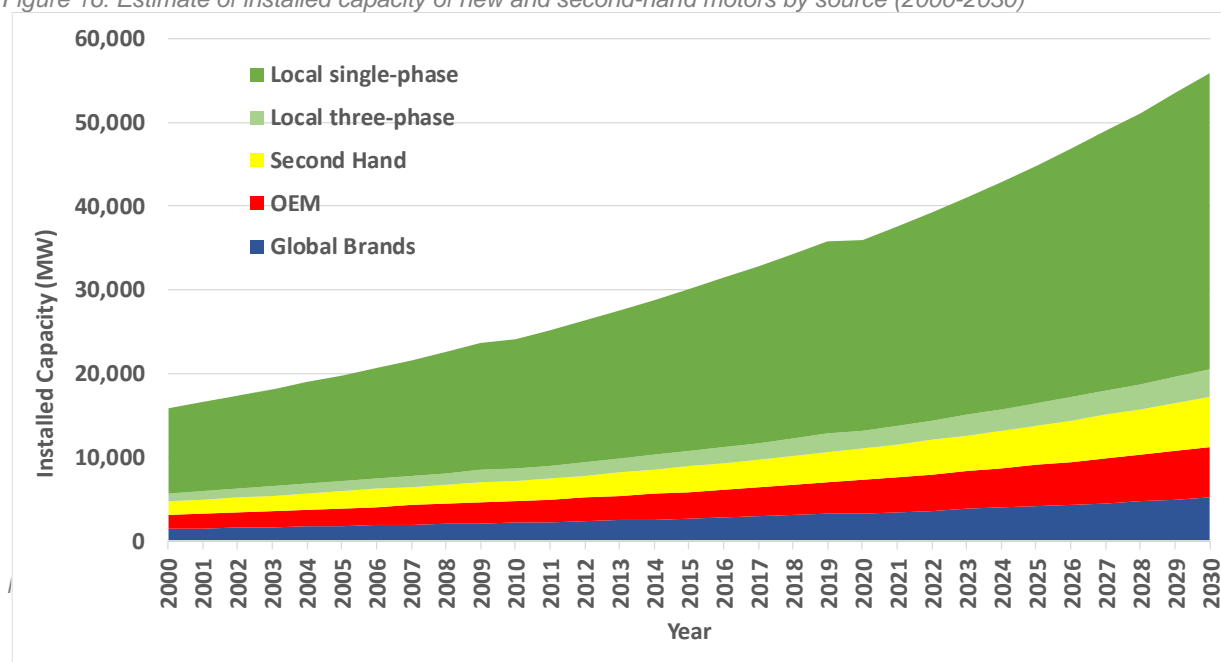
Installed Capacity

The installed capacity of motors is the total maximum electricity that can be drawn by the installed stock of motors. While in itself, knowing the total installed capacity is not entirely useful as impact clearly depends on whether the motor is operating at any given time and under what loading conditions. Indeed, theoretically, if all installed motors operated at one time on full load, then the current supply and distribution

system would likely collapse. However, it is valuable to the regulator in offering an indication of how motors can impact on overall demand for supply capacity, and how that may change into the future. Clearly, given the historical shortages of electricity within Pakistan, this is a critical measure and, as evidenced by Figure 17, installed motor capacity is set to increase by over 60% in this next decade (to over 50,000MW).

As noted, caution needs to be exercised in interpreting this megawatt value as all motors *will not* be operational at one time, nor on those operating doing so at full-load or the same mix of ratings. Yet it seems reasonable to expect the proportion of operational motors and their loading to remain broadly unchanged over the next decade. In which case, the increase in system load caused by motors might still be expected to rise by 60% and appropriate supply needs to be planned to avoid further shortage situations.

Figure 16: Estimate of installed capacity of new and second-hand motors by source (2000-2030)



The efficiency of the motors installed will have an impact on peak demand, and any action taken by the regulator to improve efficiency (in this case the potential introduction of MEPS) is beneficial. However, it should be recognised that this will have a relatively marginal effect on peak demand. But other opportunities potentially remain open to the regulator. As illustrated in Figure 17, when motor capacity is taken into account, the dominance of the number of single-phase motors reduces dramatically, from 87% of all installed motors, to 64% of installed capacity. Nevertheless, from a regulator's perspective, the prevalence of single-phase motors in the overall capacity picture remains high. Given their typical use in non-time critical applications, e.g. domestic water pumping and agriculture, this predominance of capacity in non-critical applications raises the potential for the application of remote demand response actions that can potential offset periods of peak electricity demand¹⁴.

Current and projected annual energy consumption and running cost of electric motors

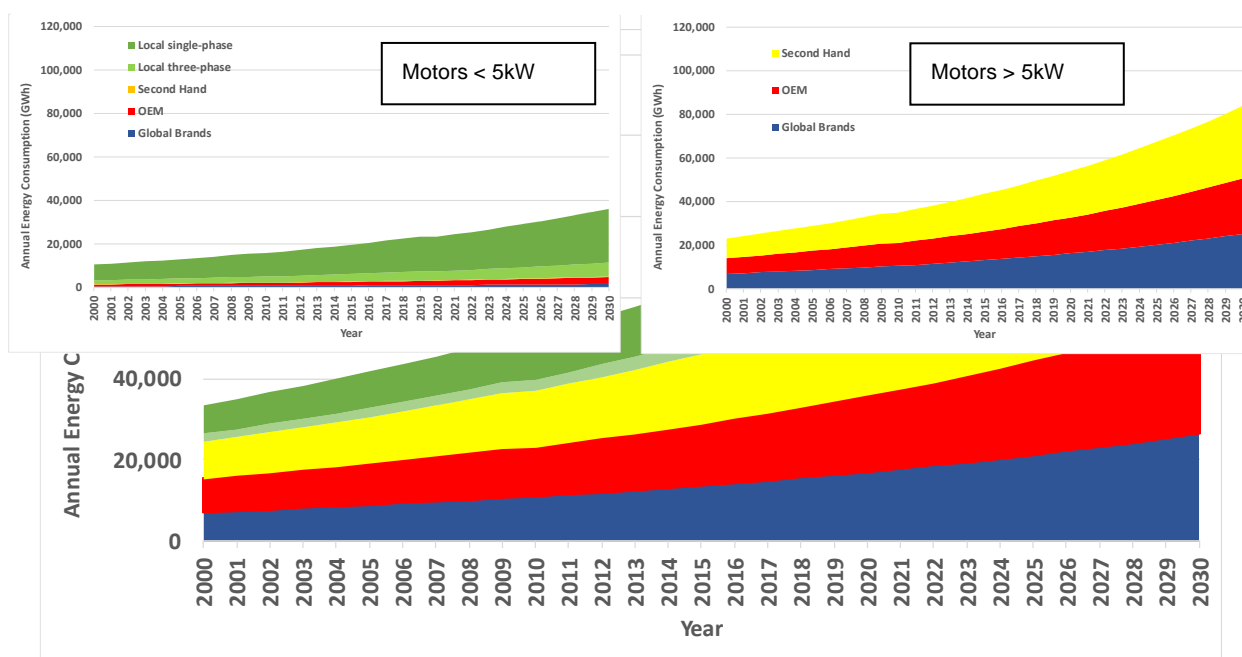
The total annual energy consumption of the motor is a function of the size of a motor (its rated capacity); the load applied to the motor when in use (e.g. whether working at full-load, no-load, or somewhere in-between); the efficiency of the motor; and the period of time the motor operates over a year. As Figure 18 demonstrates, this dramatically changes the picture. Despite their dominance in terms of numbers, single-

¹⁴ In this context, including a demand response device in the motor would enable a remote operator (e.g. the electricity supply company or government regulator) to turn off the device during periods of peak load and then restart the device when lower demand occurs. Ideal such pumps would operate in the low demand overnight period but this is obviously impractical due to noise considerations. However, even moving the demand by a few hours may prove significantly beneficial. While such actions may sound impractical, Australia has already mandated the inclusion of demand response capability in a number of devices and is currently considering implementing demand response on non-time critical applications, e.g. swimming pool pumps and commercial air conditioning systems.

phase motors are taking only 21% (16TWh¹⁵) of total annual motor energy consumption (this nevertheless costs domestic and small motor users over 320 billion PKR per year in running costs). While 16TWh is large representing 15% of total national electricity consumption in 2018¹⁶, three-phase motors dominate annual electricity consumption consuming a massive 59TWh (55% of national electricity consumption and at a motor user cost of 1,200 billion PKR per year), which is predicted to further rise to 95TWh by 2030 (120TWh when including single phase units). This migration of focus from small (primarily) single-phase to larger three-phase motors is a function of the single-phase motors typically being very low rated capacity and, in the case of household pumps, operating for less than two hours a day¹⁷. Conversely, typically larger rated motors have extended run times, with applications in heavy industry (chemicals, steel, cement, etc) running 24 hours per day.

This differential in motor size and run time, and the resultant impact on total annual energy consumption by motors is further emphasised when the energy consumption is split between installed motors above and below 5kW. The axis scales in Figure 19 have been kept the same as those in Figure 18 to visibly highlight motors above 5kW consume 70% of the total annual motor electricity use. Hence, due to this proportionately high energy consumption, and significantly smaller quantity of sales, it is motors above 5kW that may be the area to initial target for regulators wishing to reduce the growth in motor energy consumption.

Figure 18: Total energy consumption of electric motors in Pakistan by type and source above and below 5kW rating



¹⁵ As noted several times previously, given the paucity of data currently available within Pakistan, a number of reasonable assumptions have been used in developing the projections used in this document. However, in a similar way to not all motors being operative at the same time meaning the installed capacity noted in the previous section is an overestimate, the total energy consumption of motors presented here is similarly overestimated as, for practical reasons, it is assumed the motors are running at full load for all the periods they are operational. Nevertheless, while the total consumption may be 10-15% less than indicated in these projections, the proportions of consumption by the differing motor types and sizes may be considered indicative of the actual situation and, as such, the uncertainty in the true quantum of energy consumption should not impact the rationale for regulation, merely add a small degree of uncertainty to the total energy savings attainable.

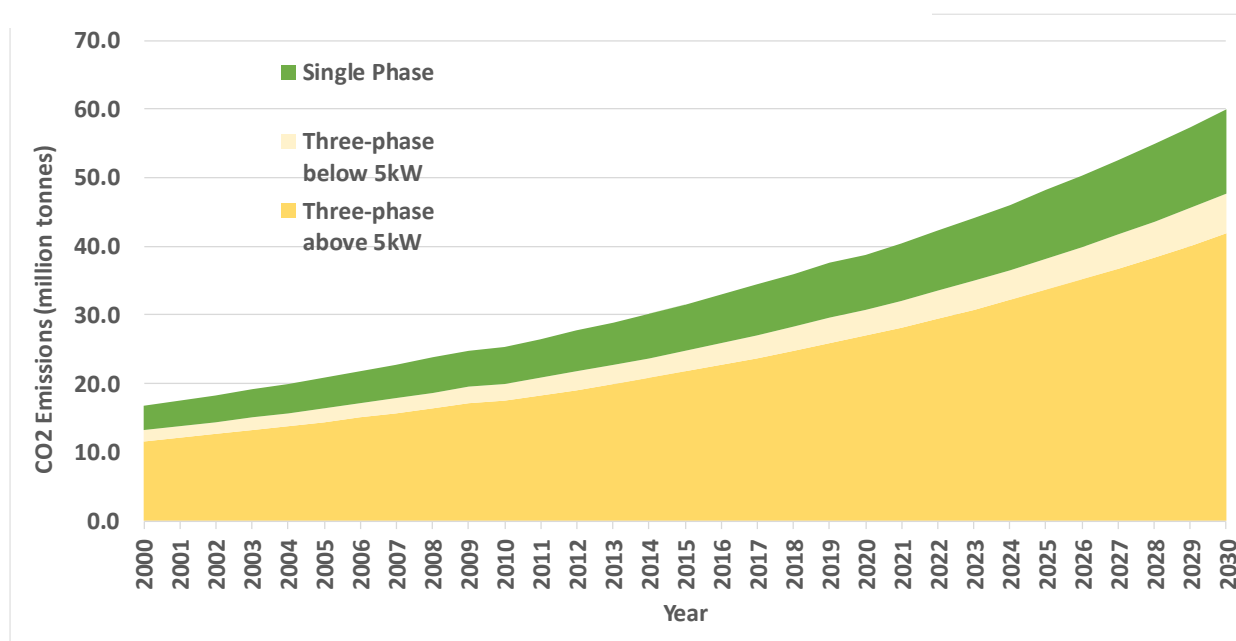
¹⁶ National Energy Consumption is assumed to be 107TWh. Value is given for 2017 in Preface to "Electric Vehicles in Pakistan, Volume 1", LUMS Energy Institute and USPCAS-E, 2019.

¹⁷ Refer to section 4.3 of "Market Research for Energy Efficiency and Conservation Program for Punjab", InConsult for the World Bank Group, 2017.

Annual CO₂ emissions related to current and projected energy consumption of motors

The comparative energy consumptions by motor size and type are, not surprisingly, repeated in terms of CO₂ emissions with three-phase motors above 5kW accounting for 26 million tonnes of CO₂ out of a total 37.5 million tonnes produced annually by all motors. This is expected to rise to 42 and 60 million tonnes respectively by 2030.

Figure 19: Total annual CO₂ emissions from motors from 2000-2030 by type and size



2.5 Supporting institutional capacity

In order for any standards and labelling program to be implemented, an extensive framework of institutional support is required. At present there are a number of areas of weakness in the institutional framework, the addressing of which would enhance the likelihood of successful implementation of MEPS and labelling for electric motors.

These have been extensively investigated and appropriate recommendations made in two CLASP reports¹⁸. However, to briefly summarise the outcomes:

- Some capacity building is required within NEECA. In particular:
 - Additional human resource is likely to be necessary to cope with the increased workload due to the implementation of motor regulations. For example, the additional human resources required for registrations, management of the monitoring, verification and enforcement regime, etc. This is particularly true should the introduction of any motor standards and labelling program coincide with the introduction of similar programs for other products.
 - Development of a full automated on-line product registration system is necessary to move from the few tens of registrations per year for the existing voluntary fan labelling program, to a mandatory approach that, should other products also be included, will involve the registration of several thousand products per year.
 - A mechanism for sustainably funding the above, plus an effective monitoring, verification and enforcements regime, most likely through registration fees or similar.

¹⁸ Compliance Framework for Pakistan Product Energy Efficiency Regulations, Mark Ellis (on behalf of CLASP) for NEECA, 2019, and Status of Motor Laboratories in Pakistan, Mark Ellis (on behalf of CLASP) for NEECA, (2019) – confidential and not published.

- Development of close ties with potential implementation partners, for example Customs should it prove appropriate for the compliance regime to be partially implemented at the border.
- Development of testing capacity. To support the introduction of Standards and Labelling program, laboratories with the capacity to test motors to the IEC standard are required to enable suppliers to justify performance claims made during registration of their products; enable NEECA and other entities to undertake product tests to verify that they meet the regulations; and support manufacturers to optimize the performance of their new motors. This is not a problem if regulation is restricted to motors above 5kW as almost all motors are imported and testing can occur at (or close to) the point of supply. Similarly, NEECA and other regulatory agencies can commission testing outside of Pakistan for verification purposes. However, should motors below 5kW be included in any regulation, then it will be necessary to nurture appropriate testing capacity within Pakistan to enable local manufacturers' to further develop their products to meet the required performance levels, and to enable testing for registration and verification.
- Should any potential regulation include local manufactures, substantive efforts may be necessary to support them with compliance. While the small number of medium sized suppliers may well be able to develop the necessary skills to produce compliant motors with focused assistance (e.g. development of design skills), more extensive interventions may be needed to support the smaller, less skilled suppliers to either improve their skills, or transition to supply of other products.

Additionally, the Punjab Energy Efficiency and Conservation Agency (PEECA) will need assistance to convert public procurement to energy efficient motors. PEECA is the only provincial designated agency based upon the federal Act and is keen to adopt any new energy label notified by NEECA. Considering 50% of Pakistan's population is within the province of Punjab, strategic technical and financial assistance to PEECA will be a key factor in the success of any energy label scheme. As more provincial agencies are formed, they may need similar assistance.

3 International Actions to Manage Motor Efficiency

This section provides a summary review of the current regulatory framework for motors globally and within the region. The aim is to provide NEECA and related policy makers with:

- An understanding of the internationally recognised testing method and motor performance rating system that is increasingly being adopted around the world, and how adoption of this system will increase the likelihood of higher efficiency motors being supplied to Pakistan while simultaneously creating the foundations for future export opportunities for local motor producers.
- A summary review of the standards and labelling requirements for motors globally and regionally to learn from experiences elsewhere, and to identify key issues that may be of value to the development of the regulatory program for motors within Pakistan.

3.1 Test methods and international performance rating of motors

International harmonisation of testing and performance rating of motors

Until relatively recently, countries or other bodies wishing to test motors performance often followed to locally developed standards. This did not cause significant problems as, historically, motor production was within a country or local region. However, from the early 1990's onwards, the global trade in motors expanded rapidly. At this point the differing test methodologies began to place burdens on suppliers as the same motor may have had to be tested using a number of slightly different method depending on the ultimate end user. This was compounded as various jurisdictions began developing their minimum performance standards and labelling programs, consequentially requiring each motor to be tested for varying levels of performance using differing test methodologies even though, ultimately, the resulting differences in *apparent* motor performance were typically very small (and the motor itself was the same).

Fortunately, in the late 1990's and 2000's a group including major manufacturers, international standards bodies, testing laboratories and other stakeholders began working together to produce a unified approach to motor testing and performance rating; the IEC 60034 series of standards.

The IEC 60034 series of standards and motor ratings

The IEC 60034 series of motor standards were first introduced (in their current form) in 2008, revised in 2014, and have recently been revised again. The series of standards provide a framework for the identification, measurement, performance rating and marking of a wide range of motors, other rotating machinery, and their ancillary products (for example variable speed drives). However, from the perspective of motor-only regulation, three parts of the series are of primary importance. Summary explanations of these standards are given in Table 1.

The IEC 60034 series apply to almost all motor types, connected phases, poles, supply frequencies, etc. Importantly, the IE efficiency classifications also effectively provide equivalence tables for the efficiency of 50Hz and 60Hz motors (typically it is easier for a 60Hz motor to achieve any given level of efficiency).

Fortunately, as Table 1 illustrates, each of these standards have been, or are in the process of being, adopted by PSQCA as Pakistan national standards. This provides NEECA with all the tools to measure the performance of motors, and to categorise them using an internationally accepted methodology.

Obviously, as highlighted in sections 2.1 and 2.4, currently domestic motor manufacturers are unable to produce motors to the lowest IEC motor rating (IE1). However, as noted in the same sections, with appropriate support and development of local testing facilities, it is anticipated at least a proportion of local suppliers will be able to manufacture to this level in the medium term and comply with any proposed regulation. This will not only yield energy savings at the national level, but will also open export opportunities to these suppliers.

Table 1: IEC 60034 key standards for regulating motors in Pakistan

IEC Standard Number (and Pakistan equivalent)	Name and function of Standard
IEC 60034-1 (PS:186/2012 Part 5)	Rotating electrical machines: Part 1: Rating and performance Creates the framework for motor testing including specifying how to define motor operating conditions, application (duty), how motors should be marked (nameplate), etc.
IEC-60034-2-1 PS-IEC-60034-2-1/2012	Rotating Electrical Machines: Standard Method for determining losses and efficiency from Tests Defines how various motor losses (resistive, mechanical, etc) can be established from testing, and from those how to calculate the ultimate efficiency of the motor ¹⁹ .
IEC 60034-30-1 PS-TBA²⁰	Rotating Electrical Machines: Efficiency classes of line operated AC motors (IE code) Provides the system which defines classes for the efficiency of motors, IE1 (Standard Efficiency), IE2 (High Efficiency), IE3 (Premium Efficiency) and IE4 (Super premium Efficiency). An IE5 classification is currently under development.

3.2 Current global and regional standards and labelling of motors

Three-phase motors

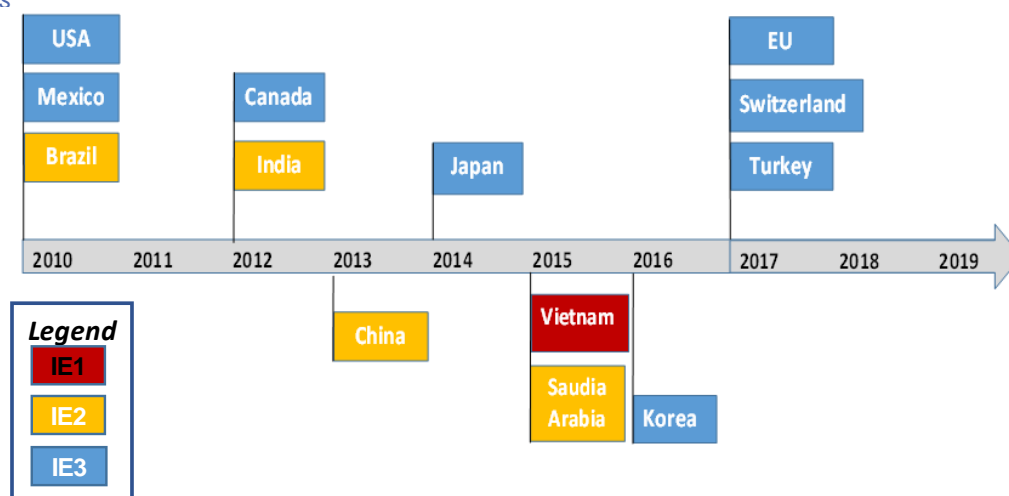
The USA was the first country to introduce minimum performance standards for electric motors in 1997. Initially MEPS were set at a level equivalent to IE2, later revising to IE3 in 2007. Other countries quickly followed with the EU establishing a voluntary motor classification in 1997 (the EFF scale) and moving to mandatory use of the IEC 60034 test and classification from 2011. This 2011 revision set a MEPS level of IE2, strengthening to IE3 in 2015 (2017 below 7.5kW). IE4 performance is now planned for some motors from 2023. However, it was not simply developed economies that began establishing MEPS. China, at the time a much less developed economy than it is today, introduced their first minimum performance requirement for motors in 2002 at the equivalent of IE1, and now have MEPS at IE2. Similarly, Vietnam has recently (2015) introduced their first MEPS at the IE1 level with aspirations to increase this MEPS as market conditions allow. Such is the importance of effectively managing electric motor consumption that, at the time of report preparation, MEPS in place for motors in over 40 countries ranging from Turkey and Canada through to Australia and Vietnam, although it should be noted in a small number these are voluntary, e.g. India (Figure 21 gives a timeline of recently introduced or strengthened MEPS for a selection of countries). It was estimated that in 2019, more than 72 per cent of motors sold globally had have efficiency levels higher than IE2, including 29 per cent at IE3 and 2 per cent at IE4²¹.

¹⁹ It should be noted that IEC 60034-2-1 offers more than one route to measure motor losses and determine overall efficiencies. The standards defines a preferred method, i.e. "Summation of losses method". However, from the current level of development of motor regulation within Pakistan, the differences in the test methods and calculation of efficiency are insignificant and all approaches can be considered equivalent.

²⁰ IEC 60034-30-1 has been adopted by PSQCA but no PS number is yet issued.

²¹ Motor market update presentation to the Motor Summit 2014, Chausovsky, A. 2014

Figure 20: Timeline and performance level of minimum performance standards adopted by a selection of countries



The scope of the regulation in these economies typically focuses on “general purpose, medium sized three-phase motors”. This is simply because this motor range comprises 10 per cent of the global stock, but accounts for 68 per cent of energy used by motors²² (as is broadly the case in Pakistan). Hence, regulators initially target this group of motors as it captures much of the energy saving potential while allowing the development of local capacity to manage wider regulation. Over time, other motor types and sizes are included and (typically) the minimum performance requirements strengthened.

Many countries first adopted MEPS after the IEC 60034 standards were initially introduced. At the time the scope of the IEC standards was 0.75 – 375kW and so many regulators simply mirrored this range²³. However, given specific local conditions, other established more limited scopes, for example the lower limit of MEPS in Israel is 7.5kW. Further, the regulation can differ across the full range of motor sizes. For example, as noted above, the EU is applying an IE3 minimum performance requirement for all motors within the 0.18 – 1,000 kW range, and is scheduled to introduce the minimum IE4 requirement in 2023. However, this more stringent requirement is initially limited to the 75 - 200kW range as it is only this range where market conditions make strengthened regulation appropriate.

Single-phase motors

Identification of countries which regulate single-phase motors has been more challenging as the focus of literature is on the three-phase market. However, it appears this is simply due to a smaller number of jurisdictions addressing single-phase motors directly. In at least some cases, this is because local markets do not have many applications for single-phase motors that are not captured in other regulation. For example, in the majority of developed countries, the primary application of smaller single-phase motors is in domestic appliances and, rather than attempt to regulate the motor separately, regulation is sensibly applied to the efficiency of the whole appliance. Elsewhere, although evidence is limited, it may be due to the administrative effort and market disruption of regulating a very large number of smaller motors outweighs the benefit of the limited potentially energy savings. However, there are at least 10 countries that have MEPS for single-phase motors including Columbia, Canada, Ecuador, the EU, Ghana, Iran and the USA.

Within the regulated markets, the scope and stringency of the regulation varies significantly. For example, the EU regulates all single-phase motors above 0.12kW at the IE2 level, and Ecuador at the lower IE1 level and just within the 0.18-1.5kW range. However, there is one additional important observation. No country regulates single-phase motors above the IE2 level. This is a practical consideration as, while technically the IEC 63004 series of standards would cover single-phase motor efficiency to IE4, manufacturing a single-phase motor with efficiencies beyond IE2 is economically impractical.

²² Energy Efficiency Policy Opportunities for Electric Motor-Driven Systems, IEA, 2011.

²³ The more recent edition of IEC 60034 extends the scope to 0.14 – 1,000kW. The EU is already moving their regulations to align with this expanded scope.

Registration, Information and labelling

The requirements for information and labelling of motors are very diverse. There are at least 6 jurisdictions using comparative labels or similar (e.g. Peru, China, Vietnam and Korea) and at least 5 using a variety of endorsement label (e.g. Brazil and the Ukraine). Other mandatory requirements include compulsory use of bar codes (China, Chile and Saudi Arabia). At least 10 jurisdictions require mandatory registration for all motors, and others that require registration on a voluntary basis (e.g. India if participating in the MEPS program). In almost all cases there are also additional requirements for specified information to be included on nameplates, technical documentation and/or promotional literature.

Within any individual jurisdiction, motor registration requirements are typically in line with other products in terms of required declarations and costs. To some extent this is also true of the comparative labelling requirements as they often mirror those for other products within a national program. For example, the three tier China Energy Label for motors follows the same format as those for air conditioners, refrigerators and many other products in China. However, unlike other products motors, are rarely seen by the customer prior to purchase, and almost never in the comparative environment that may exist in a retail outlet stocking many sizes, shapes and brands of a particular appliance. Hence the primary function of the label is somewhat weakened. Further, the physical shape of motors makes attaching a label very difficult unless it is specially designed for the purpose, as is the case for the voluntary Indian label, although this rather undermines the rationale of continuity with labelling with other products in a national program. The compromise reached in most programs is that, while labelling may be mandatory, it does not have to be attached to the motor itself, but included in promotional and/or supporting technical information (paper or web based). This provides the programmatic continuity with other products while recognising the differing motor situation. Typically, there is a similar requirement for endorsement labels, although sometimes this is mandated for inclusion on the motor nameplate.

3.3 Motor regulation in the Region

While globally the picture is relatively clear that motor regulation is practical and desirable, with energy and cost saving benefits accruing with minimal market disruption, there is value in briefly reviewing motor regulation in the region to establish if any regulation in Pakistan is likely to align with neighbours and current (and potentially future) major trading partners. In summary

- China was one of the earliest countries to implement motor MEPS in 2002. Initially the MEPS were set at IE1 equivalent, which was increased to IE2 in 2013. Testing aligns with IEC 60034 series, as does the China Energy Label grading which matches tiers to IE classes. Registration is mandatory for all motors prior to sale.
- India has had a comparative efficiency label for induction motors since 2009, and a voluntary standard on IE2 level since 2012. India's standards are aligned with the IEC series for testing and efficiency where India's star rating has been aligned with IE levels (although intermediate steps have been added between IEC thresholds). Registration is mandatory prior to sale.
- Thailand's motor regulations started under the Thai Green Label scheme in 1998. Voluntary MEPS for three-phase motors were introduced in 2010, along with a definition of "High Energy Performance Standards" aligned with IE3. The Thailand government is currently working towards making the motor MEPS mandatory. Thailand's standards are also aligned with IEC standards for energy classification and testing.
- Turkey has adopted the same regulations as the European Union. It has therefore the same technical and regulatory requirements for performance, information, etc, and totally aligns with IEC 60034 series of standards.
- Voluntary labelling for electric motor with capacity lower than 20 kW were introduced in Vietnam in 2011. This was upgraded to mandatory labelling in 2013 and then converted to mandatory MEPS in 2015. The minimum efficiency level is IE1 in Vietnam. Both testing and efficiency ratings are aligned with the IEC. Registration of motors is required prior to sale.

3.4 Lessons from global and regional regulation of electric motors

From NEECA's standpoint, the review of international regulation of motors offers the following perspectives:

- A very large number of regulators, globally and regionally, and in both developed and developing markets, are specifying minimum levels of performance from three-phase motors. These requirements are often initially set to apply to a limited range of motors and then, as market conditions evolve, expanded to cover wider motor ranges and/or at increased levels of stringency. As evidenced by the regular upward revisions in MEPS stringency in many markets, there is no indication that such regulation has any impact on the availability motor supply, nor causes significant negative impact on the demand side in either developed or developing markets. Therefore, there are no international indicators that suggest limits to where NEECA might set any regulatory performance requirements for three-phase motors and, therefore, levels can be set as appropriate to the local market and supporting regulatory infrastructure.
- Regulation of single-phase motors is less prevalent, but is in place in a number of economies. While evidence is limited, it appears many jurisdictions choose not to regulate single-phase motors as they have few applications beyond appliances (which are separately regulated) and/or the complication of regulating very large numbers of small motors that often have small energy/cost saving potential. However, given the extensive use of single-phase motors in domestic and agricultural pump applications in Pakistan, it is likely to be appropriate to regulate this group when market conditions and regulatory infrastructure are conducive (primarily when local manufacturers have gained the ability to supply at proposed efficiency levels, and NEECA has the administrative capability to manage regulation of 1 million+ motors per year).
- Regulations in almost all jurisdictions are now based on the IEC series of standards (or the locally adopted equivalent), and Pakistan has adopted these standards through PSQCA. This foundation enables accelerated implementation of regulations as:
 - Appropriate test methods exist for measurement of performance requirements at any level of regulation that may be required.
 - While existing national laboratory capacity is developed to reliably test to the requirements of the IEC 60034 series, a very large number of international laboratories already have the ability to do so, thus enabling NEECA to contract these laboratories for any verification testing that may be necessary. Further, given the widespread adoption of the same test method and performance classification, NEECA will be able to seek cross border cooperation on compliance, potentially with China, Vietnam or other regional neighbours with active regulatory programs based on the IEC approach.
- Registration and labelling requirements are common in many markets. However, in many cases the labelling requirements are primarily to maintain programmatic alignment with other national regulated products. Thus, in practice, most jurisdiction do not require the label to be attached to the product, but rather to appear in supporting technical and/or promotional material.

4 Options for Regulation of Motors in Pakistan

This section examines potential options for effective implementation of standard and labelling for electric motors in Pakistan. In particular, the section aims to:

- Present a series of scenarios that demonstrate the potential energy and emissions reductions through application of varying stringencies of minimum performance requirements targeting specific segments of the electric motor market.
- Investigate the practicality of implementation of the various scenarios, or a hybrid of those scenarios, to assist policy makers in identifying the most appropriate future regulations that yield best energy and emission reductions while being practicable, sustainable and acceptable to the wider community.
- Make observations on additional policy measures that may be necessary to support the most appropriate policy approach, including the potential application of the Pakistan Energy Label and the NEECA security sticker.

4.1 Scenarios analysis of potential energy and emissions saving through a standards and labelling program

Defining the four comparative regulatory scenarios

In order for policy makers within Pakistan to have a clear understanding of the potential energy and emissions savings that may be available from an extension of the standards and labelling program to include motors, projections have been made using three scenarios. These scenarios are broadly based around the range of performance requirements currently in force in the various jurisdictions presented in section 3, although slight modifications have been made to provide maximum transparency of options. A fourth scenario is “business as usual” where the market evolves without regulatory intervention. This business as usual scenario is the situation presented in section 2 which is the likely market outcome if no policy interventions are made, and is used as the “base case” against which the other scenarios can be compared.

To maintain clarity and enable direct comparison between scenarios, all policy interventions are assumed to take effect from January 2021. However, in practice, it may not be possible to implement some elements of the scenarios in this timeframe. Thus, where a particular scenario appears most appropriate for implementation, alternative practical timelines are presented with their associated impact.

As section 3 indicates the majority of jurisdictions currently focus on minimum energy performance standards as their main regulatory tool for electric motors. This is reflected in the scenarios presented. However, this does not pre-empt the use of labelling in Pakistan, and that is investigated later in this section.

The four scenarios used are described in Table 2.

Table 2: Scenarios used for evaluating comparative energy and emissions savings.

Scenario Name (and Acronym)	Scenario Description
World's Best (WB)	This scenario broadly replicates the up-coming EU regulations that require all three-phase motors to be IE3 level. In line with the EU, the scenario also sets a threshold of IE2 for single-phase motors, although this is optimistic in the Pakistan circumstance.

Scenario Name (and Acronym)	Scenario Description
All Three-Phase (ATP)	This scenario is the same as the WB scenario except that, like the majority of jurisdictions, removes requirements for single-phase motors. Further, three-phase motors below 5kW are excluded from regulation (exclusion of smaller motors is typical in the first round of regulation as institutional structures are developed with larger motors prior to expansion to the broader market. The 5kW threshold is used here as the majority of motors above this level are imported in Pakistan and is thus a natural break point, although higher than limits that have typically been used elsewhere).
Three-Phase, Motors Only (ATP – NMO)	New This scenario repeats the ATP scenario, but in line with all known regulations, excludes the regulation of refurbished motors. This scenario represents the typical first stage of regulation in most jurisdictions, although such first stage regulation is usually slightly less stringent than the IE3 levels used in the scenario.
Business as Usual (BAU)	This is the current situation where no regulation exists and the market evolves naturally as presented in section 2.

4.2 Potential savings in energy, capacity, CO₂ and costs to the consumer from regulatory scenarios

As illustrated in Table 3 to Table 6, (and graphically in Figure 22), in comparison with the BAU scenario, the potential savings in energy, peak load demand CO₂ emissions and costs to the consumer from the three regulatory scenarios are all significant, although of markedly differing scale.

As would be expected due to the widest market coverage, the WB regulatory scenario has the best potential savings, yielding a projected annual electricity saving of just below 9TWh in 2030, a saving of 7.4% in comparison to the BAU scenario. This equates to annual savings of 4.4 million tonnes of CO₂, PKR 177 billion (\$1.18 billion) annual cost savings to the consumer, and a peak load reduction of almost 2,000MW. Quite astonishingly, the projected cumulative energy savings for the period 2021-2030 are 73TWh which is over 90% of the total projected motor electricity consumption in 2020, with equivalent savings in CO₂ emissions (36.7 million tonnes) and cost to the consumer (PKR 1,470 billion or \$9.8 billion).

The ATP scenario yields annual energy, CO₂ and consumer cost savings of almost exactly two thirds of those under the WB scenario, equal to 5.7TWh, 2.8 million tonnes and PKR 113 billion (\$760 million) respectively. This two-thirds ratio is reflected in all years of the scenario projection and therefore the cumulative potential savings over the 2021-2030 period are also two thirds of that for the WB scenario. This reduction in potential savings results from the exclusion of single-phase motors from the ATP scenario. However, given the ubiquity of such motors, and the annual sales of over 1 million per year, the *relatively* small reductions in potential savings does demonstrate that they are small consumers of electricity in comparison to the three-phase motors. Given the challenges in effectively regulating this sector in the near future (see below), it may be sensible to exclude this group from early MEPS application. One caveat to this conclusion is that, if reduction in peak load is one of the key considerations of NEECA, then exclusion of the single-phase motors may be more problematic. At only a third of the reduction that occurs under the WB scenario, the peak load saving of 650MW in the ATP scenario suggests single-phase motors are responsible for almost two thirds of the peak load reduction available through motor regulation (noting that only 20% of single-phase motors are assumed to be in operation during peak periods and, if this percentage is actually higher in practice, the peak load reduction available through regulation of single-phase motors would be higher still). Hence, inclusion of single-phase motors should be seriously considered if practical, and reduction in peak load remains a high priority issue.

The ATP-NMO scenario that excludes refurbished motors results in a very significant drop in energy savings, equal to just 22% of the WB scenario, and only 34% of the ATP scenario (energy, CO₂ and cost

savings to the consumer of 2TWh, 1 million tonnes and PKR 39 billion (\$260 million) respectively). This huge drop in savings potential demonstrates how refurbished motors are the primary source of energy loss in motors due to inefficiency in Pakistan. Hence failure to adequately address the refurbished market results in excluding the biggest opportunity for savings potential available to NEECA.

Table 3: Potential annual and cumulative energy consumption savings from implementation of the various regulatory scenarios (GWh)

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Cumulative Total Saving by 2030
Scenario WB	5,985	6,253	6,533	6,826	7,132	7,452	7,786	8,135	8,500	8,881	73,483
Scenario ATP	3,821	3,992	4,170	4,357	4,552	4,756	4,969	5,191	5,424	5,667	46,900
Scenario ATP-NMO	1,313	1,372	1,434	1,498	1,566	1,636	1,709	1,786	1,867	1,950	16,132

Table 4: Potential annual peak load savings from implementation of the various regulatory scenarios (MW)/

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Cumulative Total Saving by 2030
Scenario WB	1,338.0	1,397.9	1,460.6	1,526.1	1,594.6	1,666.1	1,740.9	1,819.0	1,900.7	1,986.0	Not Applicable
Scenario ATP	435.6	455.1	475.4	496.7	518.9	542.2	566.5	591.8	618.4	646.1	Not Applicable
Scenario ATP-NMO	175.8	183.7	191.9	200.5	209.5	219.0	228.8	239.1	249.8	261.1	Not Applicable

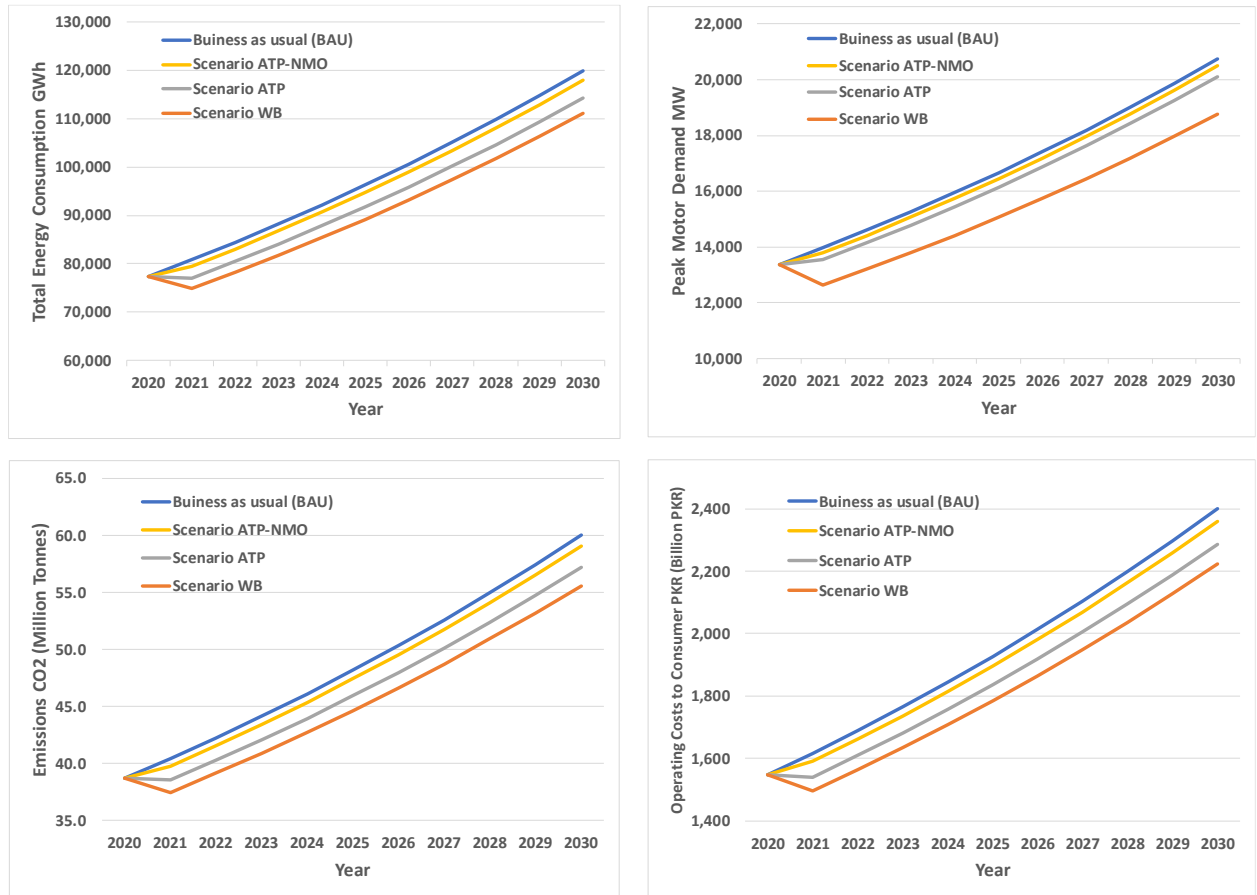
Table 5: Potential annual and cumulative CO2 savings from implementation of the various regulatory scenarios (million tonnes)

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Cumulative Total Saving by 2030
Scenario WB	3.0	3.1	3.3	3.4	3.6	3.7	3.9	4.1	4.2	4.4	36.7
Scenario ATP	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	23.5
Scenario ATP-NMO	0.7	0.7	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0	8.1

Table 6: Potential annual and cumulative cost savings from implementation of the various regulatory scenarios (Billion PKR)

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Cumulative Total Saving by 2030
Scenario WB	119.7	125.1	130.7	136.5	142.6	149.0	155.7	162.7	170.0	177.6	1,469.7
Scenario ATP	76.4	79.8	83.4	87.1	91.0	95.1	99.4	103.8	108.5	113.3	938.0
Scenario ATP-NMO	26.3	27.4	28.7	30.0	31.3	32.7	34.2	35.7	37.3	39.0	322.6

Figure 21: Potential savings in energy, capacity, CO₂ and costs to the consumer from regulatory scenarios



4.3 Feasibility of regulating motor market sectors

The scenarios presented in the previous section demonstrate the magnitude of potential savings available by regulation of the various segments of Pakistan's motor market, i.e. savings are maximised through the regulation of refurbished motors, followed by new three-phase motors, and lastly smaller motors (although regulation of the latter maximises peak load reduction). However, it does not address the practicality of regulating these sectors and hence whether the potential saving can actually be realised.

Practicality of regulation of new three-phase motors

As section 3 illustrates, regulation of three-phase new motors is the starting point for most major economies. This is a very practical approach as larger motors are almost always the biggest energy consumers, yet in terms of numbers of products requiring regulation they are the smallest, thus making effective compliance activities a more manageable task (particularly market surveillance). Further, it was many of the suppliers of this group of motors that were the first to adopt the international testing and performance rating protocols under the IEC 60034 series and hence there is widespread availability of products demonstrably meeting these requirements.

From a Pakistani perspective, all these arguments hold, with this sector having the largest energy consumption, the smallest number of annual sales, and products already available in the market that could comply with any performance level set (or at the very least, suppliers that have easy access to such products even if they are not currently on the Pakistan market). Hence, while regulation of this sector does yield the lowest savings potential (essentially the ATP-NMO scenario if MEPS were set at IE3), it would be by far the easiest for NEECA to manage. This provides the opportunity and time for NEECA to develop their internal capacities and skills to offset the institutional barriers highlighted in section 2.5 prior to moving

to regulate some of the more challenging sectors. This becomes even easier should the lower threshold limit for regulation be set at 5kW. Above this threshold almost all motors are imported meaning potential problems with capacity of local suppliers to meet new regulations and the current lack of test laboratories are also offset, and compliance requirements are likely to be easier for all stakeholders to fulfil.

However, unlike many countries, initiating regulation *only* in this sector does have problems. Regulating three-phase motors at anything below IE2 will yield almost no energy savings (as demonstrated in section 2.4, three-phase above 5kW already *average* well above IE1 and by 2030 will move to well above IE2 with no regulatory intervention). Thus, to generate any significant savings, regulation would need to be at the IE3 threshold in line with the ATP-NMO scenario. However, this would likely result in significant increases in the price of the majority of new motors given the step up from current IE1 and IE2 supply. Such price increases will likely push marginal purchasers of new motors²⁴ back to the purchase of the (currently) significantly less efficient refurbished motors. This will have the effect of off-setting much of the potential energy saving from regulation, potentially actually increasing consumption if sufficient numbers of current new motor purchasers transition from the new market back to purchase of refurbished units.

Thus, while regulation of this sector has many positive benefits, doing so without taking at least some action to manage the efficiency of motors in the refurbished market would at the very least lead to marginal energy savings, and potential increases in consumption.

Practicality of regulation of refurbished motors

Regulation of the refurbished motor market is beset by problems. The disaggregated nature of the market makes it difficult to access and inform suppliers of any regulation and, it is anticipated, there may be resistance from suppliers for any kind of market control. Further, ensuring effective compliance becomes a problem as supplier testing of what are effectively bespoke products is impractical, even if there were sufficient test laboratories to undertake the thousands of tests required yearly.

Nevertheless, failure to address this market will miss the largest energy saving potential available to NEECA, and may undermine regulation of other market sectors (as is the case for new three-phase motors as noted above). Obviously, the simple solution would be to ban the sale of refurbished motors. While on the surface this is very appealing, in reality it is far less practical. Given the large number of individual suppliers, from a logistical standpoint it is difficult to envisage a situation where NEECA or its partners would be able to enforce such a ban, particularly if the market moves underground as a result of the attempt to regulate. Further, an outright ban risks significant political opposition driven by the loss of jobs in the refurbished supply chain, and the probable backlash from the customer groups that currently purchase from this market. In reality, this would be a cost-effective switch for almost all users as the reductions in energy costs would more than offset the additional first cost, but this is not apparent to many less sophisticated purchasers and/or they may not have the capital required to cover the additional first cost premium.

A potential solution would be to remove the requirements for testing of refurbished motors prior to registration and replace by some less onerous requirement. This may be achieved by setting some kind of minimum qualification level, for example requiring an original nameplate to present and then defining some level of registered performance based on that declaration. To maintain market integrity, the registered performance level could not be that declared on the nameplate as this would mislead potential purchases given the very likely degradation of performance of the majority of refurbished motors prior to entering the market, and would undermine those offering new motors that were truly at the level declared. However, it may be appropriate to use a related alternative, for example, if the motor has a nameplate declaring IEx or the efficiency equivalent, it may be registered and marketed as “deemed rating” of IEx-1. This removes the option of regulating at IE3 as that would require IE4 motors to be available to the refurbished suppliers which is not the case. In fact, in practice, IE2 nameplate motors are likely to be highest efficiency refurbished motors generally available in the near term, which may rise to IE3 as more of these motors enter the global refurbished market later in the decade. Nevertheless, bringing any requirement to this market sector that is widely adopted would yield the significant energy savings given the current estimated average efficiencies of 5-10% below the IE1 threshold.

²⁴ The “marginal new motor purchaser” is a purchaser that currently buys new motors but, due to extreme first costs sensitivity, will switch to the purchase of second-hand motors when only very small increases in first cost of new motors occurs.

In order for such a “deemed rating” approach to work in practice, it will require a very significant communications program by NEECA to engage suppliers and make them aware of the new regulatory requirements, and a heavy market monitoring program to try and ensure compliance following introduction of the regulation. This will not be easy, and appears to be the first time regulation of this market sector has been attempted anywhere in the world. However, given the necessity of regulating this sector, the “deemed rating” approach seems a practical (or the least impractical) route to do so.

Practicality of regulation of single-phase and three-phase motors below 5kW

As in section 2, grouping single-phase and three-phase motors below 5kW together is sensible as the majority of both markets are serviced by local producers and consequently face the same barriers to regulation.

A regulatory option exists for this group to face the same requirement as other new motors as indicated in the WB scenario, and this would lead to significant energy savings. However, two key barriers to this approach exist. The local producers servicing this sector do not currently have the ability to produce motors that meet any of the IE performance ratings, and the partially linked lack of testing facilities that is hampering the development of performance of locally produced motors. Hence, any strict requirement will effectively ban local supply. While it is anticipated actual motor availability in the market could be maintained through import of new motors, the significant impact on local suppliers and resultant balance of payment impact and unemployment issues in towns such as Gujranwala make this approach politically unacceptable.

While routes around the testing capacity issue may be found. For example, requiring a test based on the IEC 60034 series, but modified to requiring less rigour enabling the use of existing Pakistani laboratories. Such an approach would also allow development testing by manufacturers. However, perhaps the more pragmatic route would be for NEECA and their partners to delay the introduction of regulation for this sector while appropriate testing capacity is developed, and investment is made in the design and build capabilities of the local suppliers (ideally with support from NEECA and their partners) increasing the likelihood of their compliance with any future regulation and potentially increasing their opportunities to export motors to the international market.

Recommended route to motor regulation.

In the light of the analysis undertaken above, it is recommended that NEECA:

- Introduce minimum performance regulation for new motors above 5kW beginning immediately (2021) at the IE1 level. In parallel, voluntary registration of refurbished motors should be opened. While such an approach will lead to almost no energy savings, it will allow NEECA time to develop their internal and external capacity to regulate motors.
- In 2023, the minimum performance threshold for new motors above 5kW can be raised to IE2 and a new mandatory threshold requirement for refurbished motors introduced based on the “deemed rating” concept.

In parallel, support should be given for the development of national motor testing capacity and the development of design and production capability within local motor producers.

No later than the end of 2024, a review should be completed which evaluates the evolved state of the motor market with a view to the practicality of strengthening the existing requirements on new and refurbished motors above 5kW (potentially to IE3 for new motors), and extending the scope to include three-phase and/or single-phase motors below this threshold.

While such an approach does not maximise energy savings in the short term, it is a practical and achievable approach which will significantly increase the likelihood of actually realising real market change, and putting in place the foundations for more stringent regulation in the future.

4.4 Inclusion of Pakistan Energy Label and Security Stickers on regulated motors

NEECA, understandably, wishes to increase the visibility and subsequent consumer awareness of the Pakistan Energy Label on products. Such increased awareness leads to preferential purchase of more efficient products by some consumers, which in turn leads suppliers to deliver more efficient products to market to satisfy this growing consumer demand. This virtuous circle is the key goal of any energy labelling. However, unlike the typical consumer product on which labels are normally displayed, with the exclusion of small domestic and agricultural pumps, motors are typically not on display with the purchase happening through a detailed specification, often with the consumer not having seen the product prior to its delivery. Consequently, required application of the label may have little impact on purchaser behaviour. Further, there are logistical and cost difficulties for suppliers in applying the label, and potential challenges for NEECA in enforcement. Similar issues are experienced internationally which, as section 3 illustrates, have led the majority of countries to not require a label to be displayed on the motor but (typically) place extensive nameplate requirements and/or mandated information requirements on supporting information and/or promotional material. India is the most notable exception where the addition of a label to motors is mandatory, although only where the motor is registered under the *voluntary* program.

Similarly, application of the NEECA security sticker to consumer products is an excellent route to providing consumers with confidence they have purchased a legitimate, regulated appliance. Further the security sticker has a key role in assisting NEECA's monitoring, verification and enforcement activities (and tracking total sales of efficient appliances). However, application of the security sticker to motors may be less appropriate for NEECA's needs, and challenging for suppliers to undertake.

These issues are investigated in some detail in a confidential consultative document produced for NEECA²⁵, and have been discussed extensively with other stakeholders in a number of forums. The recommended compromise solution is:

- Should new motors below 5kW be regulated, whether imported or made locally:
 - The appropriate Pakistan Energy Label for motors should be printed on the motor packing where it exists. If the motor is marketed to the consumer without packaging, no label will be required.
 - The NEECA security sticker should be included on all motors.
 - Specific information on motor performance and operational limitations should be included on the nameplate and in all supporting technical and promotional documentation. The Pakistan Energy Label should also be included within all supporting information and promotional material.
- Should new motors above 5kW be regulated, whether imported or made locally:
 - Neither the Pakistan Energy Label nor the NEECA security sticker should be included on any motor (although some specific declaration(s) to NEECA, e.g. that of serial numbers may be required).
 - Specific information on motor performance and operational limitations should be included on the nameplate and in all supporting technical and promotional documentation. The Pakistan Energy Label should also be included within all supporting information and promotional material.
- Should refurbished motors of any size or source be regulated:
 - The Pakistan Energy Label should not be included on any motor.
 - The NEECA security sticker should be displayed on all products.
 - The original nameplate must be attached to the motor irrespective of content. No other information requirement shall apply

²⁵ Three-phase motor labelling strategy: discussion paper, Stuart Jeffcott (on behalf of CLASP) for NEECA, 2019 – confidential and not published

5 Recommendation for MEPS and Labelling of Electric Motors in Pakistan

This section presents the recommendations for regulation of single and three-phase electric motors in Pakistan, including:

- The specific types, sizes and sources of motors to be regulated.
- Proposed performance thresholds and timelines for implementation.
- The approach to labelling of motors.
- Additional policy measures that may be necessary to support the recommended policy approach.

5.1 Recommended standards and labelling approach for electric motors in Pakistan

Based on the analysis conducted in section 4, the following recommendations are made for the adoption of standards and labelling for electric motors in Pakistan.

Phase 1: To come into force in 2021

Implement mandatory minimum energy performance standards for new 3-phase motors above 5kW and no larger than 1,000kW, and a voluntary program for refurbished motors of the same range.

- For new motors above 5kW a threshold of IE1 on the IEC rating scale should be set. A test report based on IEC 60034-2-1 or equivalent should be required to support registration with NEECA. Information on efficiency, operating conditions and performance should be required on the nameplate and supporting information. The Pakistan Energy Labelling should not be required on the motor, but should be included in supporting information (specific alignment of label thresholds with IEC IE ratings to be decided by NEECA). No security sticker will be required.

This should:

- Cause no disruption in supply as the vast majority of the market to be covered by this regulation is already delivering motors of this efficiency or higher and have access to international test facilities (most already having tested to the required standard to comply with regulation in other jurisdictions).
- Have positive cost/benefit to consumers that are currently buying new motors without IE certification as the marginal additional first cost will be more than outweighed by significant lifetime savings.
- Result in a small reduction in energy and emissions. Although at this stage these savings will be marginal as most motors in this grouping are already of IE1 or better, it will set the essential foundations for substantive savings in Phase 2 (2023 onward).
- Most importantly, allow NEECA to become experienced in implementing motor regulations on a sector that is relatively easy to manage (e.g. developing and operating the product registration system, cooperation with Custom for verification checks during import, etc). This experience can then be applied to subsequent phases which address more complex sectors.

- b) For refurbished motors supported by test report based on IEC 60034-2-1 or equivalent, and the test certificate is less than 2 years old, voluntary registration should be allowed at the reported IE rating.

For motors not supported by test reports, voluntary registration should be based on the nameplate rating, with the IE rating registered as 1 below that shown on the nameplate (or efficiency equivalent).

In neither case will any additional information be required in supporting or promotional material. NEECA security stickers should be attached to all voluntarily registered motors at point of sale.

While it is expected that a few refurbished motor suppliers will register their products, the number is very unlikely to be high. However, by making this phase voluntary, it gives the opportunity for NEECA to engage with the refurbished motor community and raise their awareness of the program, and prepare them for the mandatory requirements in Phase 2

Key policy support measures for Phase 1 and preparing for Phase 2

A number of supporting policy measures are necessary to increase the likelihood of success of Phase 1. Of particular importance are:

- Additional human resource within NEECA to cope with the enlarged workload associated with the implementation of motor regulations. This is particularly true should the introduction of standards and labelling for other products coincide with the introduction of motor regulations.
- Development, testing (both internally and with potential registrants) and introduction of a fully automated registration system for MEPS products.
- Liaison and formal agreements with partners that may be necessary for successful implementation of regulations. For example, customs who may be able to support verification as almost all motors falling under mandatory requirements in this phase are imported.
- Immediately after the mandatory element of the scheme comes into effect, initiate a widespread check of information and promotional material for compliance. Also undertake verification testing of 5-10 registered products. Where non-compliance is found, initiate the enforcement protocols under the NEECA compliance policy²⁶. Irrespective of whether products pass or fail on any count, widely publicise the results (or at the very least that monitoring and verification action has been initiated) to prove NEECA is serious in implementation. If possible, repeat after 6 months of implementation.
- Development of a sustainable funding mechanism for the above, most probably through a registration and per product fee.
- Public procurement initiatives facilitated by provincial bodies such as PEECA.

When resources become available, it would be helpful to begin actions in support of the implementation of Phase 2. In particular:

- No more than 6 months prior to Phase 2 coming into effect, initiate a major communication program targeting refurbished suppliers. Given the nature of these suppliers, it is probable the most effective route will be through face-to-face communication (similar to sales calls operated by commercial companies) promoting the up-coming mandatory requirement on refurbished motor suppliers. To heighten the likelihood of success, this communication should be repeated *at least twice*.
- While not absolutely necessary at this stage, it is likely to be useful for NEECA to engage with stakeholders that may be able to support laboratory development. In the longer term, enhanced laboratory capacity is essential to support expansion of the program to include locally manufactured smaller three-phase and/or single-phase motors (both for product development by manufacturers, and to enable registration of their products).

²⁶ CLASP is supporting the development of this policy at the time of preparation of this report.

Phase 2: To come into force in 2023

Strengthen mandatory minimum energy performance standards for new 3-phase motors above 5kW and no larger than 1,000kW, and move to mandatory minimum performance standards for refurbished motors of any size.

- a) For new motors above 5kW, raise the minimum performance threshold to IE2. All other requirements for this group to remain the same.

This should:

- Cause no disruption in supply as the global brands and OEM suppliers that dominate this group can simply migrate to their higher efficiency ranges where they have not already done so.
- Have positive cost/benefit to consumers as the marginal additional first cost of those currently purchasing IE1 motors will be more than outweighed by significant lifetime savings.

- b) For refurbished motors, registration and minimum performance standards become mandatory.

For motors supported by test report based on IEC 60034-2-1 or equivalent, and the test certificate is less than 2 years old, registration should be allowed at the reported IE rating. However, the minimum performance of these motors should be IE1 or equivalent.

For motors not supported by test reports, registration should be based on the nameplate rating with IE rating registered as 1 below that shown on the nameplate (or efficiency equivalent). However, the minimum performance of these motors should be IE1 or equivalent, i.e. the nameplate value should be *at least* IE2 or equivalent.

In neither case will any additional information be required in supporting or promotional material. However, NEECA security stickers should be attached to all motors at point of sale.

This is a truly critical phase of implementation. Setting a mandatory base for the efficiency of refurbished motors should begin to result in significant energy savings through the removal of the very worst products from the market. However, heavy policing of the regulation will initially be required to ensure compliance (and to educate those who are not complying). Failing to do so risks not just missed energy savings from those refurbished suppliers not complying, but may result in an increase in energy consumption as some purchasers switch from the new motors to refurbished motors due to the increasing price differential.

Key policy support measures for Phase 2

- As noted above, ensuring compliance of suppliers of refurbished motors is critical to achieving the desired energy savings. As regulation to this group of suppliers is completely new and is likely to receive adverse reaction, effective monitoring, verification, enforcement, and ongoing communication is critical.

While seemingly resource intensive, this may actually be easier than it initially appears. As nameplate data is the basis for the regulation of the majority of refurbished motors, no testing is required for compliance. Therefore, simple observation of motors in the market can establish compliance. Additionally, the requirement for application of the security sticker will further assist with identification of non-compliant units. Thus, to ensure success, surveys of all markets should be undertaken at least quarterly for the first year.

Such surveys will not only increase the likelihood of energy savings being realised, but will also ensure ongoing income for NEECA as a result of the registration and security sticker fees. Hence, it is likely these compliance checks will be self-funded.

- Ongoing monitoring, verification and enforcement (and publication of these actions) should also continue for new motors.

- When resources become available continued engagement with stakeholders to support laboratory development.

Review of progress and consideration of strengthening existing MEPS and expanding scope

Following the implementation of Phases 1 and 2 of the program, a review should be undertaken no later than the end of 2024 to establish the degree of success of implementation on the market transformation and consumer/environment impact to date, and the potential for further program expansion. In particular, the review should examine:

- The potential to increase stringency of regulation for new motors to IE3, and refurbished motors to IE2 equivalence (IE3 nameplate rating).
- The state of local manufacturing capability to achieve IE1 standard of production for either single and/or three-phase motors below the 5kW threshold.
- The condition of the local testing facilities and their ability to support regulation of smaller single and/or three-phase motors, be that under the existing IEC 60034 series of tests, or through a suitably modified version.

Potential annual and cumulative savings from the implementation of the recommended motor regulation

The annual and cumulative energy, emissions, peak load and consumer cost reductions from the implementation of regulation of the motor market as proposed above is shown in Table 7 and graphically in Figure 23. While these projected savings assume 100% compliance, even with lower compliance levels, potential savings are significant, and the approach lays solid foundations for more stringent regulation to be introduced in the future.

Table 7: Potential reductions in energy consumption, CO₂ emissions, peak load and consumer costs attributable to electric motors in Pakistan from the implementation of MEPS as provisionally proposed by CLASP

Year	2023	2024	2025	2026	2027	2028	2029	2030	Cumulative Total Saving by 2030
Total Reduction in Energy Consumption (GWh)	3,320	3,469	3,624	3,786	3,955	4,132	4,317	4,510	37,334 GWh
Peak Load Reduction (MW)	338.8	354.0	369.8	386.3	403.6	421.7	440.6	460.3	460.3 MW²⁷
Reduced Emissions CO₂ (Million Tonnes)	1.6	1.7	1.8	1.9	2.0	2.0	2.1	2.2	18.5 MTonnes
Reduced Operating Costs to Consumer (Billion PKR)	65.7	68.7	71.7	75.0	78.3	81.8	85.5	89.3	PKR 739.2 Billion

²⁷ The Peak Load Reduction is not cumulative but the 2030 value is reproduced.

Figure 22: Potential reductions in energy consumption, CO₂ emissions, peak load and consumer costs attributable to electric motors in Pakistan from the implementation of the MEPS as provisionally proposed by CLASP in comparison with business as usual and regulating at the world's best levels

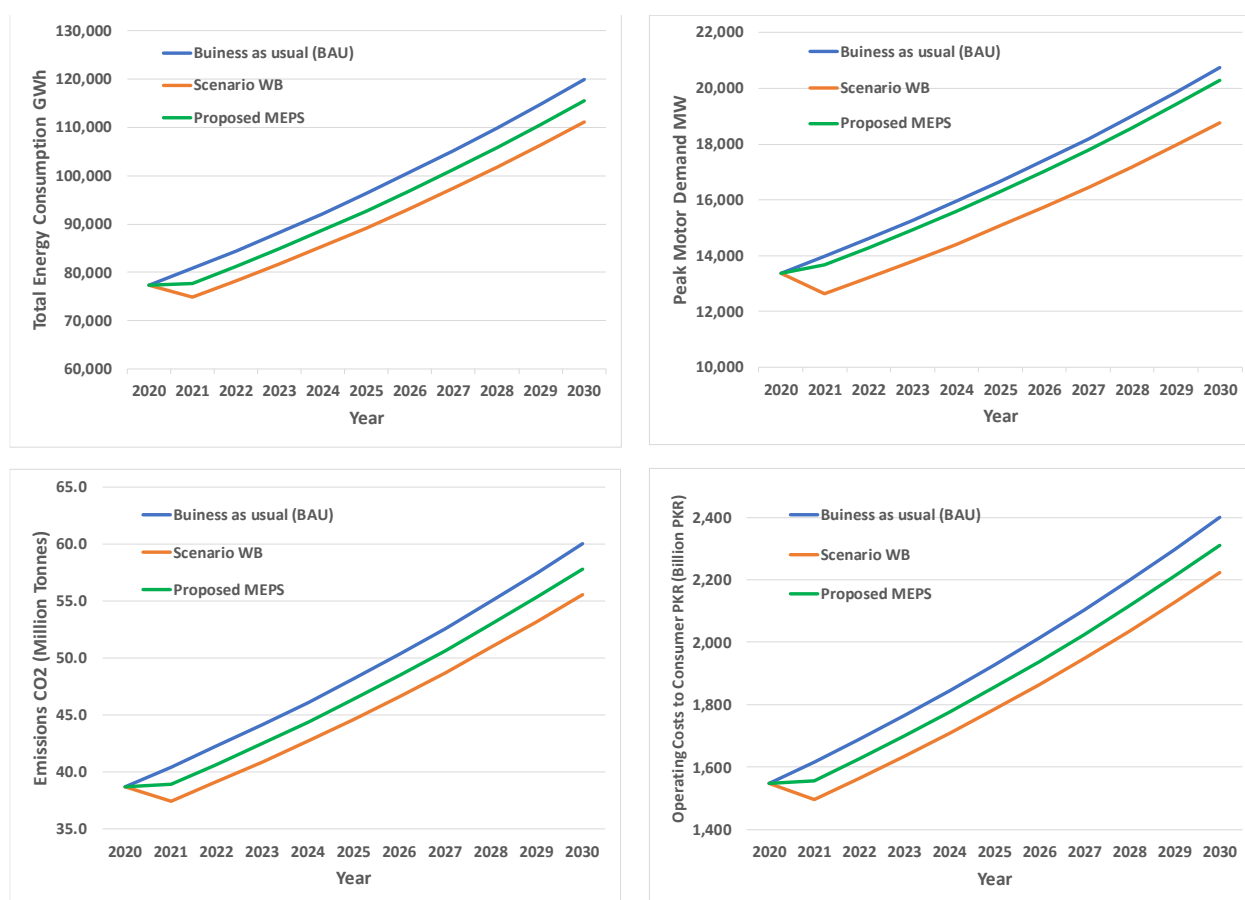
Key.

Projected national motor energy consumption, supply capacity requirement, electricity costs to the consumer and resulting CO₂ emissions under the following conditions:

BAU = "Business as Usual" with market developing with no regulation by NEECA.

Scenario WB: Adoption of "World's Best" level regulation of IE3 for all new and second-hand motors.

Actual MEPS: Introduction of MEPS as provisionally proposed by CLASP.



5.2 Important Addendum: Industry Consultation Revised Policy Recommendations

Following completion of this report, but prior to publication, further industry consultation has not only endorsed the recommendations made above, but has pushed strongly for further stringency in requirements, and the extension of scope to include motors of all types down to 0.12kW. Importantly, this includes local suppliers immediately, initially under voluntary participation, and then as a mandatory requirement from 2023. In summary, the revised proposals are:

- New three-phase motors from 5kW to 1,000kW:
 - 2021: Mandatory registration and minimum performance standards of IE1.
 - 2023: Mandatory registration and minimum performance standards of IE2.
- New three-phase motors from 0.12kW to 5kW:
 - 2021: Voluntary registration.
 - 2023: Mandatory registration and minimum performance standards of IE1.

- 2025: Mandatory registration and minimum performance standards of IE2.
- Refurbished motors of all sizes between 0.12kW and 1,000kW:
 - 2021: Voluntary registration.
 - 2023: Mandatory registration and minimum performance standards of IE1 for motor registrations supported by test certificate or nameplate rating or IE2 for non-tested motors registered under the “deemed rating” approach.
 - 2025: Mandatory registration and minimum performance standards of IE2 for motor registrations supported by test certificate or nameplate rating of IE3 for non-tested motors registered under the “deemed rating” approach.
- A New single-phase motor above 0.12kW:
 - 2021: Voluntary registration.
 - 2023: Mandatory registration and minimum performance standards of IE1.
 - 2025: Mandatory registration and minimum performance standards of IE2.

There are also a number of additional requirements on labelling, use of the NEECA security sticker, public information, etc. These are fully detailed in the draft regulations which, at the time of report revision, are awaiting approval at NEECA²⁸.

CLASP are highly supportive of this accelerated timetable for MEPS introduction and applaud the motor suppliers of Pakistan for lobbying for this acceleration. However, CLASP wish to note that this accelerated timeframe places additional pressure on NEECA to:

- Ensure systems are fully operational to timescales (e.g. the registration system).
- Undertake extensive communication with, and training of, suppliers to ensure they are aware of their obligations, and that the suppliers have all the necessary tools to comply.
- Implement a very strong monitoring, verification and enforcement program, especially with respect to refurbished motors. The related compliance policy should be implemented in full.
- Facilitate appropriate supporting actions to enable smaller local manufacturers to comply with the regulations.
- Encourage development of appropriate testing facilities, and should they not reach international standards at the time of regulation, enable some form of modified testing regime that retains sufficient integrity for registration purposes, yet enables local manufactures to comply with regulation.

Should the full regulations be approved and roll-out as currently planned, and compliance rates are high across all motors types, the energy, emission and consumer cost savings by 2030 that will be realised are very impressive (Table 8) and as Figure 24 illustrates, very rapidly approach those achievable under the World’s Best efficiency scenario presented in section 4.

Again, while the projections in savings assume 100% compliance (Table 8 and Figure 24), even with lower compliance levels and potential slippage in the implementation of later phases of the regulation resulting in realisation of only half of these potential energy savings, this still would yield exceptional value to the Government of Pakistan in terms of energy and emissions reduction (plus reduced required investment in generation and distribution infrastructure and electricity subsidies), and a reduction in the cost base to domestic, commercial and industrial users.

Year	2023	2024	2025	2026	2027	2028	2029	2030	Cumulative Total Saving by 2030
Total Reduction in Energy Consumption (GWh)	3,434	3,587	5,999	6,267	6,548	6,842	7,149	7,469	47,296 GWh

²⁸ Final Draft Content for “Notification of Minimum Energy Performance Standards and Labeling Regulation for Electric Motors”, prepared for NEECA by CLASP, January 2021.

Peak Load Reduction (MW)	749	782	1,467	1,533	1,602	1,674	1,749	1,827	1,827 MW
Reduced Emissions CO₂ (Million Tonnes)	1.7	1.8	3.0	3.1	3.3	3.4	3.6	3.7	23.6 MTonnes
Reduced Operating Costs to Consumer (Billion PKR)	68.7	71.7	120.0	125.3	131.0	136.8	143.0	149.4	PKR 945.9 billion

Table 8: Potential annual and cumulative reductions in energy consumption, CO₂ emissions, peak load and consumer costs reductions from the implementation of MEPS as currently proposed by NEECA

Figure 23: Potential reductions in energy consumption, CO₂ emissions, peak load and consumer costs attributable to electric motors in Pakistan from the implementation of the MEPS as currently proposed by NEECA in comparison with business as usual and regulating at the world's best levels

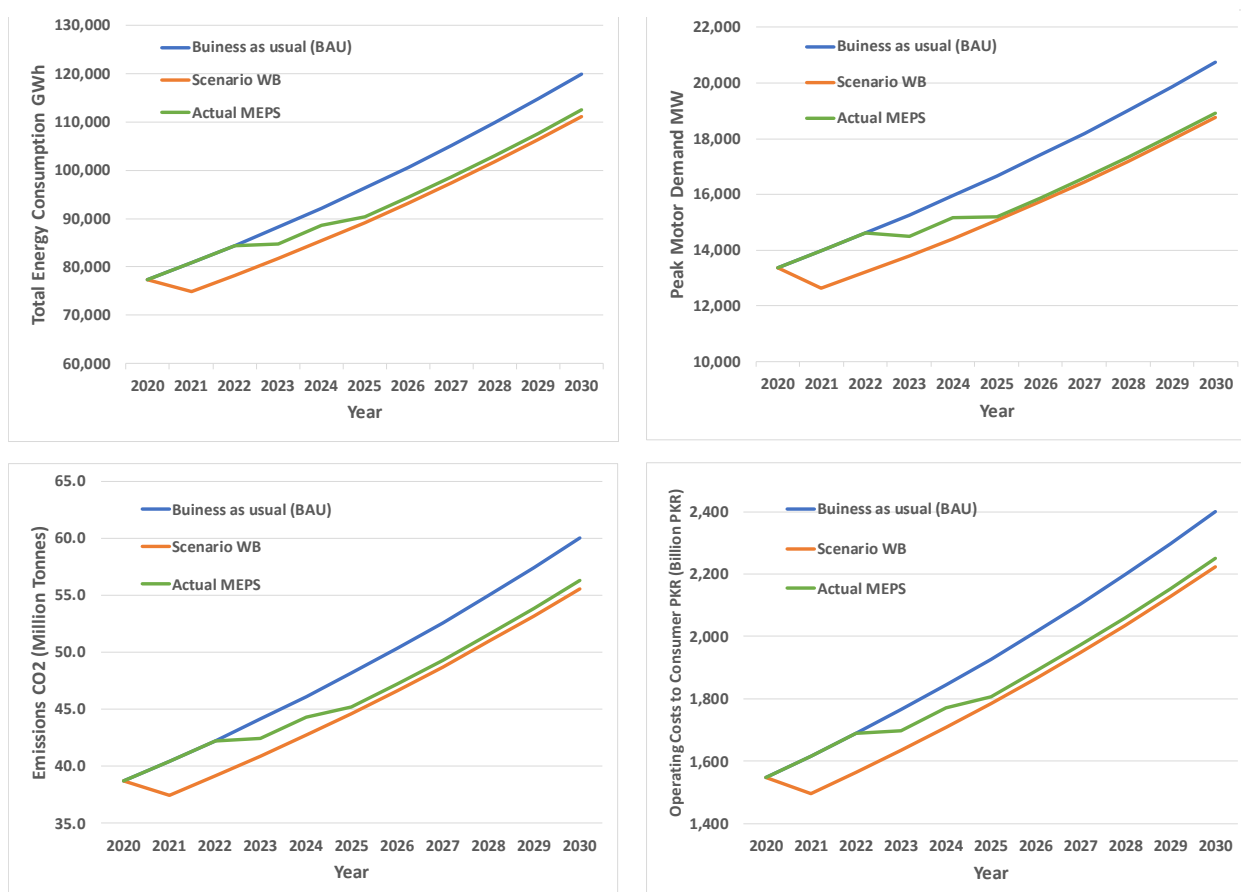
Key.

Projected national motor energy consumption, supply capacity requirement, electricity costs to the consumer and resulting CO₂ emissions under the following conditions:

BAU = "Business as Usual" with market developing with no regulation by NEECA.

Scenario WB: Adoption of "World's Best" level regulation of IE3 for all new and second-hand motors.

Actual MEPS: Introduction of MEPS as provisionally proposed by CLASP.



Annex 1: Modelling of Current and Projected Motor Supply, Installation and Use within Pakistan

This Annex is extensive in content and consists of both written commentary and excel spreadsheets. Therefore, it has been published as a separate dossier under the title of this Annex.