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AFRICA MEPS HANDBOOK SUITE

B PART B | PRODUCT HANDBOOK

Electric Motors

Practical guidance for developing, adopting and enforcing minimum energy performance standards and energy labels

To be used together with Part A: The MEPS Implementation Playbook



Efficiency First: Powering Africa's Sustainable Development

Implemented by the African Energy Commission (AFREC) with the support of the Government of Denmark

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Part B: Electric Motors

Practical guidance for developing, adopting and enforcing minimum energy performance standards and energy labels

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This handbook provides technical guidance. It does not prescribe minimum energy performance levels and does not replace national legal drafting, standards development or regulatory impact assessment. Numerical values drawn from regional, national and international instruments are given as benchmarks or illustrative examples; users should consult the latest edition of the original instruments. The designations employed and the presentation of material do not imply the expression of any opinion on the part of the African Union concerning the legal status of any country, territory or area or of its authorities. Mention of a commercial company or product does not imply endorsement. The views expressed do not necessarily reflect those of the Government of Denmark.

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AFREC African Energy Commission | African Union | Government of Denmark

About

About the Africa MEPS Handbook Suite

The Africa MEPS Handbook Suite gives African Union Member States, Regional Economic Communities and the Regional Centres for Renewable Energy and Energy Efficiency a common, practical method for developing, adopting and enforcing minimum energy performance standards (MEPS) and energy labels. It has two parts. **Part A**, The MEPS Implementation Playbook, sets out the common framework: the policy and institutional set-up, the eight-step method for setting national levels, product registration, monitoring, verification and enforcement, and a five-stage maturity model. **Part B** consists of product handbooks that apply this framework to individual product groups, each following the same structure so that readers can move easily between products. Part B will cover more than fifteen (15) appliances and equipment including lighting products; household refrigerators and room air conditioners; electric motors; distribution transformers; commercial refrigeration appliances; comfort fans; electric ovens; televisions; and washing machines.

The development was led by a consortium of HEAT and AESG with the guidance of the African Energy Commission.

About Efficiency First

The *Efficiency First: Powering Africa's Sustainable Development* project is a four-year programme (2024–2028) implemented by the African Energy Commission (AFREC), with support from the Government of the Kingdom of Denmark under the Africa Partnership for Peace and Sustainability. Its objective is to improve energy efficiency across Africa as a means of increasing access to affordable and reliable energy.

The programme focuses on three main outcomes: the development, adoption and enforcement of at least fifteen (15) Minimum Energy Performance Standards (MEPS) for electrical appliances and equipment; the reduction of technical losses in electricity distribution grids; and stronger monitoring and evaluation of energy efficiency policy instruments. Activities include developing continental handbooks and other knowledge products covering these outcomes, delivering training and supporting implementation at the country level.

The project contributes to the implementation of the African Energy Efficiency Strategy and Action Plan (AfEES), Agenda 2063 and the global commitment to double the rate of energy efficiency improvement by 2030.

About the African Energy Commission (AFREC)

The African Energy Commission (AFREC) is a specialised agency of the African Union mandated to coordinate, harmonise, protect, conserve, develop, rationally exploit, commercialise and integrate energy resources on the African continent. Created by decision of the Heads of State and Government in Lusaka in July 2001 and launched in Algiers in February 2008, AFREC is headquartered in Algiers, Algeria. It develops continental energy policies, strategies and plans, maintains the African Energy Information System, and supports Member States through technical assistance and capacity building. In energy efficiency, AFREC developed the AfEES, adopted by the AU Executive Council in February 2025, and led the launch of the African Energy Efficiency Alliance at COP29 in November 2024. More information is available at au-afrec.org.

About Denmark's Africa Partnership for Peace and Sustainability

The Africa Partnership for Peace and Sustainability (2024–2028) is Denmark's framework for partnership with the African Union. In support of Agenda 2063, it aims to contribute to the institution building of the AU and to their ability to deliver solutions, with engagements in peace and security, continental free trade, and climate and energy. Under its climate and energy engagement, Denmark supports AFREC's work to improve energy efficiency across the continent, in line with its commitment to Sustainable Development Goal 7.

Foreword

By the Ambassador of Denmark to Ethiopia and Permanent Representative to the African Union



At the outset, I wish to commend the African Energy Commission (AFREC) of the African Union for its excellent collaboration with Denmark and for developing this timely knowledge product. This publication addresses a pressing priority: making energy efficiency a driver of affordable electricity, economic opportunity and the African Union's vision of an integrated, prosperous and peaceful Africa.

Denmark and the African Union share a longstanding partnership grounded in a common commitment to peace, stability and sustainable development. Since 2004, Denmark has supported African efforts to strengthen peace, security and governance through the Africa Programme for Peace. Its evolution into the Africa Partnership for Peace and Sustainability reflects a shared conviction: lasting peace requires sustained investment in the institutions, services and opportunities that enable societies to thrive.

Energy efficiency has a strategic role in this endeavor. Making better use of existing resources and infrastructure can help countries expand access to modern energy services, strengthen industrial competitiveness, and improve essential public services. For Africa, where energy demand and development needs continue to grow, efficiency must be central to energy planning and investment.

Denmark's experience offers valuable lessons. The oil crises of the 1970s prompted a sustained national commitment to energy efficiency. Over subsequent decades, consistent policies, technological innovation and close cooperation with industry have helped Denmark achieve substantial economic growth while keeping energy consumption broadly stable. Danish enterprises have since provided global leadership in energy-efficient solutions, while Denmark has championed greater ambition on energy efficiency across Europe and internationally. This experience demonstrates that lasting progress requires sustained commitment. We bring that experience to our partnership with Africa in a spirit of mutual learning, supporting African leadership and priorities.

Through the Efficiency First: Powering Africa's Sustainable Development project, Denmark is supporting AFREC to translate continental ambitions into practical action. The project's knowledge products address three complementary priorities: Minimum Energy Performance Standards (MEPS), electricity distribution grid losses, and monitoring and evaluation of energy efficiency instruments. These knowledge products, such as this handbook, together with targeted capacity building and implementation support at the

country level, aim to advance the targets set out in the African Energy Efficiency Strategy and Action Plan (AfEES).

Effective standards can improve the efficiency of appliances and equipment, lower bills, and ease pressure on electricity systems. Reducing distribution losses can strengthen utilities and increase the electricity available to consumers. Robust monitoring and evaluation can show what works, strengthen accountability and guide better policy and investment decisions.

These benefits go beyond the energy sector. More reliable services and stronger enterprises can support jobs, livelihoods and public confidence, helping build the economic and institutional foundations of peaceful societies. Energy efficiency therefore contributes to both Africa's development ambitions and the broader purpose of our partnership.

I encourage policymakers, regulators, utilities, and industry to turn this knowledge into effective standards, targeted investments, and measurable improvements in energy services.

Denmark remains committed to working alongside the African Union to ensure that energy efficiency advances opportunity, resilience and lasting peace for Africa's people.

Sune Krogstrup

Ambassador of Denmark to Ethiopia and Permanent Representative to the African Union
Royal Danish Embassy, Addis Ababa

Preface

By the Executive Director, African Energy Commission



Current global geopolitical uncertainty has underscored the central role of energy in economic resilience, national security and human prosperity in developed and developing countries alike. For Africa, the urgency extends beyond present disruptions. Persistent gaps in access to affordable, reliable and sustainable energy continue to constrain economic transformation and human dignity. Nearly 600 million Africans lack electricity, while many more rely on polluting cooking fuels and technologies. These deficits limit educational opportunities, weaken healthcare delivery, restrict productive activity and undermine livelihoods. Closing Africa's energy gaps demands urgent investment in supply, matched by a sustained commitment to energy efficiency so that every unit of available energy delivers greater value.

Energy efficiency must therefore be Africa's first fuel and a central pillar of Agenda 2063. Every kilowatt-hour wasted through inefficient appliances and equipment adds to consumers' bills, places avoidable pressure on electricity systems and reduces the energy available for other essential needs. Appliance market transformation alone could deliver projected savings of more than 175 TWh across Africa by 2040.

The African Energy Efficiency Strategy and Action Plan (AfEES), adopted by Heads of State and Government in February 2025, provides a continental framework for this transformation, targeting improvements in energy productivity of 12% by 2030, 50% by 2050 and 70% by 2063. Standards and labels for appliances and equipment are essential instruments for translating these ambitions into results.

The appliances and equipment entering African markets today — from lamps, refrigerators and air conditioners to electric motors and distribution transformers — will shape electricity demand and consumer costs for years to come. Minimum Energy Performance Standards (MEPS) progressively remove the least efficient products from the market, while energy labels help consumers make informed choices. Clear performance requirements also give manufacturers and importers predictable rules that encourage investment in efficient products. Supported by robust testing, market surveillance and enforcement, these measures can lower electricity bills, ease pressure on power systems and improve energy services across the continent.

The Africa MEPS Handbook Suite is AFREC's contribution to this effort. Part A, The MEPS Implementation Playbook, sets out the common framework for establishing, strengthening

and sustaining MEPS and energy labelling programmes. The Part B handbooks apply this framework to individual product groups, each following the same structure. Together, they provide regulators, standards bodies, energy agencies and customs authorities with common methods and practical tools that Member States can adapt to their national circumstances.

This initiative also supports Africa's wider energy transformation. Regional harmonisation of requirements can facilitate trade in efficient products under the African Continental Free Trade Area (AfCFTA) and complement the African Single Electricity Market by strengthening demand-side efficiency. Wider adoption of efficient appliances and equipment also advances the objectives of the African Energy Transition Strategy and Action Plan, and helps Member States meet their commitments under international agreements such as the Minamata Convention on Mercury and the Kigali Amendment to the Montreal Protocol.

Developed in consultation with AU Member States, Regional Economic Communities and Regional Centres for Renewable Energy and Energy Efficiency, and reviewed by experts across the continent, the handbook suite reflects a shared commitment to practical implementation. I thank all institutions and experts whose contributions have strengthened its relevance and quality.

I wish to express my sincere appreciation to the Government of the Kingdom of Denmark for supporting this handbook suite and the wider set of knowledge products through the Efficiency First: Powering Africa's Sustainable Development project. This partnership is helping AFREC translate Africa's energy efficiency ambitions into practical tools, stronger institutional capacity and implementation support for Member States.

I call on Member States to use these handbooks to establish and enforce effective standards and labels, strengthen regional cooperation and share implementation experience.

AFREC stands ready to support these efforts through capacity building, regional harmonisation and mutual recognition arrangements. Together, we can make efficient appliances and equipment the standard across Africa — and ensure that expanding electricity access delivers lasting development benefits.

Rashid Ali Abdallah

Executive Director

African Energy Commission (AFREC)

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This handbook forms part of the Africa MEPS Handbook Suite, developed by the African Energy Commission (AFREC) under the programme Efficiency First: Powering Africa's Sustainable Development, with financial support from the Government of Denmark through the Africa Partnership for Peace and Sustainability.

The handbook was prepared under the leadership of Rashid Ali Abdallah, Executive Director of AFREC, and the general supervision of Yagouba Traore, Head of Policy, Planning and Strategy.

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AFREC thanks the Royal Danish Embassy in Addis Ababa for its support and guidance; the Regional Centres for Renewable Energy and Energy Efficiency (ECREEE, EACREEE, SACREEE, RCREEE and CEREEAC); and the energy ministries, energy agencies, regulators, standards bodies and testing laboratories of AU Member States whose experts reviewed the content of this handbook, including at the continental validation workshop held in Addis Ababa, Ethiopia, on 8–9 December 2025.

The handbook draws on the work of many organisations whose publications are cited throughout, in particular the United Nations Environment Programme's United for Efficiency initiative, the International Energy Agency, the International Electrotechnical Commission, and the regional harmonisation programmes of SADC, the EAC and ECOWAS.

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Abbreviations

ACRONYM	DESCRIPTION
AC	Alternating current
AFREC	African Energy Commission
AfCFTA	African Continental Free Trade Area
AFSEC	African Electrotechnical Standardization Commission
AMEE	Moroccan Agency for Energy Efficiency
ARSO	African Organisation for Standardisation
AU	African Union
CDM	Complete drive module (IEC 61800-9-2)
DOE	Department of Energy (United States)
EAC	East African Community
EACREEE	East African Centre of Excellence for Renewable Energy and Efficiency
EASA	Electrical Apparatus Service Association
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EMSA	Electric Motor Systems Platform (IEA 4E)
EOS	Egyptian Organization for Standardization and Quality
EPRA	Energy and Petroleum Regulatory Authority (Kenya)
EPREL	European Product Registry for Energy Labelling
EU	European Union
Ex eb	Increased-safety motor for explosive atmospheres
HS	Harmonized System (customs nomenclature)
IE	International efficiency class (IEC 60034-30-1)
IEA	International Energy Agency
IEA 4E	IEA Technology Collaboration Programme on Energy Efficient End-Use Equipment
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
kW	Kilowatt
LCCA	Life-cycle cost analysis

LoA	Letter of Authority (South Africa)
MEPS	Minimum energy performance standards
MVE	Monitoring, verification and enforcement
NEMA	National Electrical Manufacturers Association (United States)
NRCS	National Regulator for Compulsory Specifications (South Africa)
PDS	Power drive system
PM	Permanent magnet
PRS	Product registration system
RCREEE	Regional Center for Renewable Energy and Energy Efficiency
REC	Regional Economic Community
SACREEE	SADC Centre for Renewable Energy and Energy Efficiency
SADC	Southern African Development Community
SON	Standards Organisation of Nigeria
SynRM	Synchronous reluctance motor
U4E	United for Efficiency (UNEP)
UNEP	United Nations Environment Programme
VSD	Variable speed drive

Executive Summary

Why electric motors matter

Electric motor systems, meaning motors and the pumps, fans, compressors and machines they drive, use about 53% of global electricity. Energy accounts for more than 95% of a motor's life-cycle cost, so a modest gain in efficiency repays a higher purchase price quickly. Most motors in Africa are imported, many of them inside equipment, and many are repaired and rewound during their lives. Motor standards therefore matter most to industry, mining, agriculture and water supply, the productive sectors on which African economies depend.

What this handbook does

This handbook applies the common framework of Part A to general-purpose induction motors from 0.12 kW to 1,000 kW, classified under IEC 60034-30-1, with guidance on motors in imported equipment, variable speed drives, rewinding and second-hand motors. It does not prescribe MEPS levels: the choice of levels remains a national regulatory decision, and the numerical values in the handbook are drawn from published instruments and presented as benchmarks or illustrative examples.

Key messages

- **Use the IEC framework.** The IE classes of IEC 60034-30-1 and the test methods of IEC 60034-2-1 (Method 2-1-1B, or the equivalent IEEE 112 Method B and CSA C390) are the common basis of all major programmes (Chapter 5).
- **Build on international and African practice.** Fifty-six countries have motor MEPS, and most apply IE3 to 0.75–375 kW. Egypt, Morocco and South Africa apply IE3; Ghana and Ethiopia apply IE2. The U4E model regulation (2025) offers an advanced option (IE2 for 0.12–0.75 kW, IE3 for 0.75–1,000 kW and IE4 for 75–200 kW) and bridging options at IE3 or IE2 (Chapter 4).
- **A label alone is not enough.** A mandatory label that accepts IE1, as in Kenya, informs buyers but does not remove the least efficient motors from the market (Chapter 4).
- **The economics are clear.** In the illustrative 15 kW case, an IE3 motor repays its price premium in about a year (Chapter 6).
- **Mark the rating plate.** Rating-plate marking of the IE class is the core information requirement; labels, where used, should use the IE classes (Chapter 8).
- **Reach motors in equipment and in workshops.** Registration with family dossiers and mutual recognition, rating-plate checks, verification testing (one unit, then three, with a

tolerance on losses) and explicit procedures for motors in imported equipment and repair workshops keep the burden low and enforcement credible (Chapters 9 and 10).

- **Look beyond the motor.** Good-practice rewinding preserves efficiency; poor practice erodes it. Drives, right-sizing and system design offer further savings of 15–25% beyond motor MEPS (Chapter 7).
- **A good early product.** Motors are well suited to an early stage of a national MEPS programme (Chapter 11).

How to use this handbook

Policy makers can start with Chapters 1 to 3 and 11; regulators and standards bodies with Chapters 4 to 8; and energy agencies, customs authorities and testing laboratories with Chapters 9 and 10. Chapters 12 to 15 cover supportive measures, case studies, tools and references, and Chapter 14 maps each chapter to Part A.

CHAPTER

01

Introduction

B

IN THIS CHAPTER

1.1 Scope and purpose
1.2 Topics covered
1.3 Policy and regulatory linkages
1.4 Intended users
1.5 Relationship with Part A
1.6 How to use this handbook with Part A
1.7 Scope limitations

This handbook provides practical guidance for the development, implementation and enforcement of Minimum Energy Performance Standards (MEPS) and energy labelling for **electric motors** in African Union (AU) Member States. It forms part of the Africa MEPS Handbook Suite and should be read together with Part A: The MEPS Implementation Playbook, which provides the common framework for MEPS and energy labelling across product categories [1].

1.1 Scope and purpose

This handbook is the electric motors handbook of the Africa MEPS Handbook Suite. It is organised to the standard Part B structure, so that a reader who has used any other product handbook in the suite finds the same material in the same place.

Electric motors differ from the other products in the suite in three ways that shape the whole handbook. First, they are **capital equipment bought by businesses and public utilities**, not consumer goods: the buyer is an engineer, a procurement officer or an equipment manufacturer, and the relevant information is technical. Second, most motors are **sold inside other equipment** — pumps, fans, compressors, conveyors, machine tools — so regulation must reach motors that never appear on a shop shelf. Third, a motor is only one part of a **motor system**: the largest savings often come from matching the motor, drive and driven machine to the real load, which MEPS alone cannot achieve [2].

The purpose of this handbook is to help AU Member States and their partners to:

- Define the scope of motors covered by regulation and map it to customs codes.
- Use the international efficiency classes (IE codes) and test methods on which all major motor regulations are based.
- Benchmark against the UNEP United for Efficiency (U4E) model regulation and African and international programmes.
- Design registration, nameplate marking, labelling and conformity assessment for motors.
- Design practical systems for border control, market surveillance and check-testing.
- Address the issues specific to motors: motors in imported equipment, rewinding, power quality and motor-system efficiency.

This handbook does not prescribe MEPS levels for AU Member States. The choice of levels remains a sovereign national regulatory decision. Where numerical levels appear, they are drawn from published international and regional instruments and are presented as reference points, consistent with Part A [1]. The method for reaching a national decision is set out in Chapter 6 and in Part A, Chapter 6: MEPS Development Methodology.

1.2 Topics covered

- **Product scope and classification.** Which motors are covered, how they are classified by power, poles and phases, and how they map to customs codes.
- **Performance metrics and test methods.** Rated efficiency, the IE classes of IEC 60034-30-1 and the test methods of IEC 60034-2-1.
- **MEPS and labelling design.** Using benchmarks and life-cycle cost analysis to set levels, and designing nameplate marking and labels for professional buyers.
- **Registration, verification and enforcement.** Registration-before-placement, border checks, check-testing and the treatment of motors inside equipment.
- **Technology and policy considerations.** Motor systems and variable speed drives, power quality, rewinding and the market for repaired and second-hand motors.

1.3 Policy and regulatory linkages

Motor MEPS depend on, and support, several other policy frameworks:

- **MEPS and labelling regulation.** Requirements must be anchored in a legal instrument that defines scope, test methods, performance thresholds, marking, registration and penalties (Part A, Chapter 5).

- **Industrial energy efficiency policy.** Energy audits, energy management standards and industrial efficiency programmes are the main route to motor-system savings beyond the motor itself.
- **Customs and trade.** Most motors used in Africa are imported, alone or inside equipment, so customs classification and border control are central (Part A, Chapter 8).
- **Regional harmonisation and trade.** Harmonised motor requirements within Regional Economic Communities, and mutual recognition of test results under the African Continental Free Trade Area, reduce costs for suppliers and regulators (Part A, Chapter 12).
- **Technical and vocational training.** Motor repair and rewinding workshops are part of the installed-base efficiency picture and depend on technician skills (Chapter 7.4).

1.4 Intended users

This handbook is intended for the institutions and stakeholders listed in Table 1.

TABLE 1 Intended users of this handbook.

USER GROUP	MAIN USE OF THIS HANDBOOK
Energy ministries and energy agencies	Setting policy objectives for motor efficiency and linking MEPS with industrial efficiency programmes.
MEPS lead agencies and energy regulators	Designing motor MEPS, marking and labelling requirements, registration and enforcement arrangements.
National standards bodies and electrotechnical committees	Adopting IEC 60034 standards as national standards and maintaining alignment with regional instruments.
Customs authorities	Classifying motors and motor-driven equipment, applying risk profiles and verifying registration at the border.
Market surveillance authorities	Inspecting distributors and equipment suppliers, sampling motors and handling non-compliance.
Testing laboratories and certification bodies	Applying IEC 60034-2-1 test methods and accreditation requirements.
Motor manufacturers, assemblers, importers and distributors	Understanding obligations on efficiency, marking, registration and documentation.
Original equipment manufacturers (pumps, fans, compressors)	Understanding how requirements apply to motors integrated in their products.
Industrial users, utilities and public procurement agencies	Using registered data in procurement, replacement and repair-or-replace decisions.
Motor repair and rewinding workshops	Applying good-practice repair procedures that preserve efficiency.
Regional economic communities and regional centres	Supporting harmonised requirements, mutual recognition and regional capacity.

1.5 Relationship with Part A

Part A is the common, product-neutral framework for establishing, strengthening and sustaining MEPS programmes. This handbook is a Part B product handbook that applies that framework to electric motors. The suite comprises ten product classes: lighting, household refrigerators, non-ducted air conditioners, industrial electric motors, distribution transformers, commercial refrigeration, comfort fans, electric ovens, televisions and washing machines.

TABLE 2 Relationship between Part A and this handbook.

DOCUMENT	PRIMARY ROLE	MAIN CONTENT
Part A: The MEPS Implementation Playbook	Provides the common, product-neutral framework for MEPS and energy labelling programmes.	Maturity model, policy and regulatory context, MEPS development methodology, implementation pathway, MVE, stakeholder engagement, financing, capacity building, regional coordination and tools.
Part B: Electric motors (this handbook)	Applies the Part A framework to electric motors and provides product-specific technical and implementation guidance.	Scope and HS mapping, IE classes and test methods, benchmark landscape, motor systems, rewinding and power quality, marking and labelling, registration fields, check-testing protocols, case studies, tools and references.

Part A should be treated as the primary source for general programme architecture and institutional guidance. This handbook should be treated as the primary source for motor-specific technical choices.

1.6 How to use this handbook with Part A

a) Refer to Part A for general programme guidance

- Assessing national MEPS maturity and readiness (Part A, Chapter 1).
- Establishing a lead agency, enabling legislation and inter-agency governance (Part A, Chapter 5).
- Applying the eight-step MEPS development methodology (Part A, Chapter 6).
- Designing a minimum viable MEPS programme and its implementation phases (Part A, Chapter 7).
- Establishing general MVE procedures and graduated penalties (Part A, Chapter 8).
- Engaging stakeholders, financing the programme and building capacity (Part A, Chapters 9–11).
- Coordinating with regional and continental initiatives (Part A, Chapter 12).

b) Refer to this handbook for motor-specific guidance

- Defining the motor scope and its customs mapping.
- Choosing IE classes, test methods and verification tolerances.
- Comparing candidate levels with African and international benchmarks.
- Designing registration, marking and labelling for motors, including motors in equipment.

- Designing border, distributor and workshop inspections and check-testing.
- Addressing motor systems, rewinding and power quality.

1.7 Scope limitations

This handbook is a technical and implementation reference. It is not a model regulation and does not replace national legal drafting, standards development, regulatory impact assessment or stakeholder consultation. It does not:

- Set mandatory MEPS levels for any Member State.
- Replace national or regional legislation or the harmonised standards adopted by RECs.
- Replace IEC or national test and safety standards.
- Certify individual models or replace laboratory accreditation and conformity assessment.
- Cover the design of complete motor systems in individual facilities, which belongs to energy audits and industrial efficiency programmes.

CHAPTER

02

Product Scope and Definitions

B

IN THIS CHAPTER

2.1 Product primer: how motors use and lose energy

2.2 Purpose of the product scope

2.3 Products covered

2.4 Products excluded

2.5 HS code mapping

2.6 Market segmentation and product classification

2.7 Key definitions

2.8 Use of the scope and definitions in enforcement

This chapter explains how electric motors work and where their losses arise, defines the products covered by regulation, maps them to customs codes, and sets out the definitions on which registration and enforcement depend.

2.1 Product primer: how motors use and lose energy

An electric motor converts electrical energy into mechanical work. The motors covered by this handbook are **induction motors**: alternating current in the stator windings creates a rotating magnetic field that induces current in the rotor and drives it round. They are robust, inexpensive and simple to start directly from the mains, which is why they power most pumps, fans, compressors and conveyors in industry, water supply, mining, agriculture and buildings.

The difference between electrical input and mechanical output is lost as heat. Table 3 shows the main loss components and how higher-efficiency designs reduce them. Because the losses of a large motor are a small share of its input, small gains in efficiency are large reductions in losses: raising efficiency from 92% to 94% cuts losses by about 25% [3].

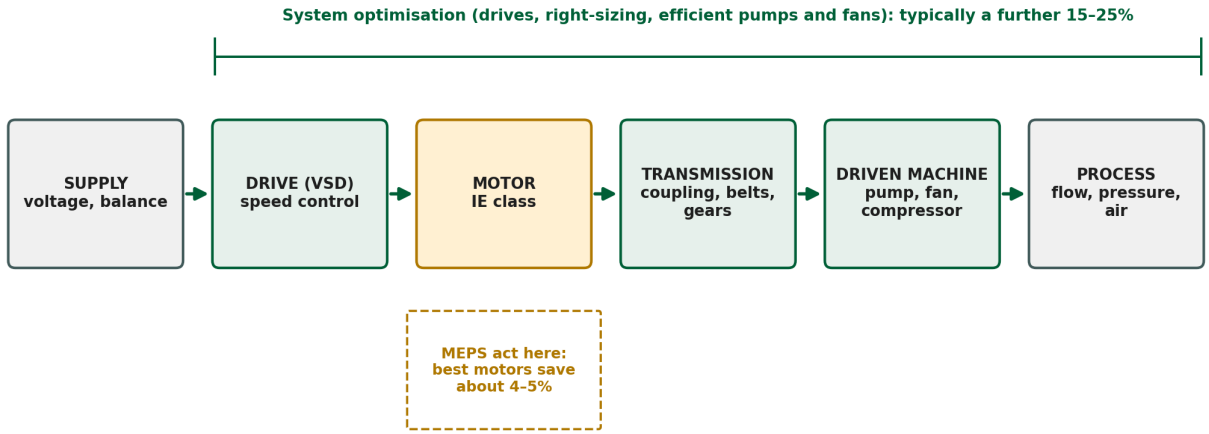
TABLE 3 Loss components in an induction motor and how higher-efficiency designs reduce them.

LOSS COMPONENT	TYPICAL SHARE OF TOTAL LOSSES	WHAT DRIVES IT	HOW IE3 AND IE4 DESIGNS REDUCE IT
Stator copper (I^2R) losses	25–40%	Conductor size	More copper in the stator windings
Rotor losses	15–25%	Rotor conductor size and material	Larger rotor bars and end rings; copper rotors in some designs
Core (iron) losses	15–25%	Type and quantity of magnetic steel	Better electrical steel and thinner laminations
Stray load losses	10–20%	Manufacturing and design methods	Optimised air gap and slot design
Friction and windage	5–15%	Fans, bearings and seals	Smaller, more efficient cooling fan

Source: U.S. DOE, Premium Efficiency Motor Selection and Application Guide, shares for standard-efficiency induction motors [3].

A motor rarely works alone. It is part of a **motor system**: the electricity supply, any variable speed drive (VSD), the motor, the mechanical transmission, the driven machine (pump, fan, compressor) and the process it serves (Figure 1). The International Energy Agency estimates that moving from standard to the best available motors typically saves about 4–5% of motor electricity, while optimising the whole system — matching speed to load with drives, right-sizing and efficient pumps and fans — typically saves another 15–25% [2]. MEPS secure the first of these savings across the whole market; the second depends on the supportive measures of Chapter 12.

FIGURE 1 The motor system: where losses arise and where MEPS act.



Losses arise at every stage: supply imbalance, drive losses, motor losses, transmission losses, throttling and oversizing in the driven machine. Savings ranges: IEA (2011).

Source: AFREC, prepared for this handbook; savings ranges from IEA (2011) [2].

2.2 Purpose of the product scope

The scope tells manufacturers, importers, equipment makers, customs and inspectors which motors must comply. For motors it must be defined by **technical characteristics** — type, rated power, number of poles, voltage, frequency and duty — because the same motor may be imported alone, as a spare, or inside a pump or compressor. A scope based on these characteristics also allows a country to use the IEC classification and the international test reports already produced for the global market.

2.3 Products covered

The U4E model regulation (2025) and the EU Ecodesign regulation define a common scope that most new regulations follow [4, 5]:

- Induction motors with squirrel-cage or wound rotors, rated for direct-on-line operation on a three-phase or single-phase sinusoidal supply.
- Rated output from 0.12 kW to 1,000 kW, with 2, 4, 6 or 8 poles.
- Rated voltage above 50 V up to and including 1,000 V, at 50 Hz (and 60 Hz where relevant).
- Continuous duty at rated power (duty types S1, S3 ≥ 80% or S6 ≥ 80%) [4].

- Motors sold on their own or as a component of a motor-driven product such as a pump, fan or compressor.

Countries commonly start with a narrower range — three-phase motors of 0.75–375 kW, which use about two-thirds of motor electricity — and extend it later [2, 6]. South Africa's VC 9113, for example, covers 0.75–375 kW [7]. The U4E guidelines cover small three-phase motors (0.12–0.75 kW) at IE2 under their advanced option and allow single-phase and Ex eb motors to be added in a second stage [4].

2.4 Products excluded

- Motors other than induction motors, such as permanent-magnet or reluctance motors designed only for converter supply, which are classified separately under IEC TS 60034-30-2 [8].
- Motors fully integrated into a product so that they cannot be tested separately.
- Motors designed to operate wholly immersed in a liquid (submersible pump motors).
- Multi-speed motors, torque motors and brake motors whose brake is integral to the motor construction.
- Motors for special duty or special supply conditions beyond the IEC 60034 series, and motors rated for temperatures or altitudes outside the regulated range [4].
- Motors placed on the market as spare parts for identical motors in products placed on the market before the regulation applied, where the regulation allows it and the marking says so [5].

2.5 HS code mapping

HS codes allow customs to identify motors and motor-driven equipment at the border (Table 4). HS codes are necessary but not sufficient: a six-digit code does not distinguish induction motors from other AC motors, so customs procedures must check the declared motor type and the registration number.

TABLE 4 HS code mapping for electric motors and related products (six-digit, HS 2022).

HS CODE	DESCRIPTION (ABBREVIATED)	REGULATORY RELEVANCE
8501.40	Other AC motors, single-phase	In scope (single-phase motors) where regulated
8501.51	Other AC motors, multi-phase, output ≤ 750 W	In scope (small three-phase motors, 0.12–0.75 kW)
8501.52	Other AC motors, multi-phase, output > 750 W but ≤ 75 kW	In scope (core range)
8501.53	Other AC motors, multi-phase, output > 75 kW	In scope (large motors)
8504.40	Static converters	Variable speed drives (where regulated)
8413, 8414	Pumps; fans and compressors	Motor-driven products containing in-scope motors

Source: WCO HS 2022 [9]; U4E [4].

Two practical points matter at the border. Motors in equipment are declared under the equipment heading, so customs risk profiles for pumps, fans and compressors should include a check of the integrated motor. And motors are sometimes declared as parts or as "generators" to avoid controls; risk profiles should flag unusual descriptions within heading 85.01.

2.6 Market segmentation and product classification

- **Rated output (kW)**: efficiency requirements are tabulated by rated output; motors of 0.75–375 kW use about two-thirds of motor electricity [2].
- **Number of poles (2, 4, 6, 8)**: determines synchronous speed (3,000, 1,500, 1,000 or 750 rpm at 50 Hz); 4-pole motors are the most common.
- **Phases**: three-phase motors dominate industrial use; single-phase motors are common in small workshops, agriculture and buildings.
- **Supply frequency**: African public grids operate at 50 Hz, but 60 Hz motors arrive in equipment built for other markets; requirements and test reports must state the frequency.
- **Protection and duty**: explosion-protected (Ex eb) motors, brake motors and special-duty motors may have different requirements or exemptions.
- **Sales channel**: standalone motors through distributors; motors inside imported equipment; and repaired or second-hand motors.

2.7 Key definitions

TABLE 5 Key definitions for motor MEPS regulation.

TERM	DEFINITION FOR REGULATORY USE
Induction motor	An AC motor without brushes, commutators, slip rings or electrical connections to the rotor (squirrel-cage), or with a wound rotor, in which rotor current is induced by the stator field; the U4E scope covers both rotor types [4].
Rated output (P_N)	The mechanical power at the shaft for which the motor is designed, as marked on the rating plate (kW).
Rated efficiency	The efficiency at rated output, voltage and frequency, determined by the test method of IEC 60034-2-1 [10].
Nominal efficiency	The representative efficiency declared for a motor design, less than or equal to the average full-load efficiency of a population of motors of that design [4].
IE class (IE code)	The international efficiency class of a line-operated motor (IE1 to IE5) defined in IEC 60034-30-1 [11].
Motor-driven product	A product in which a motor is integrated, such as a pump, fan or compressor.
Variable speed drive (VSD)	An electronic power converter that continuously adapts the electrical power supplied to the motor to control its speed and torque.
Model (design)	A version of a motor with the same rated output, poles, voltage, frequency and construction; different ratings are different models for registration.
Rewinding	Replacement of a motor's stator winding during repair, covered by IEC 60034-23 [12].
Registration-before-placement	The rule that a motor model must be registered before it may be imported, offered for sale or put into service.

2.8 Use of the scope and definitions in enforcement

Scope and definitions must be written so that a customs officer or inspector can apply them from the rating plate, without laboratory equipment. In practice this means using characteristics printed on every motor — rated output, poles or speed, voltage, frequency, phase and IE class — and requiring the IE class and nominal efficiency to be marked on the rating plate [4, 5]. Exemptions should be narrow and verifiable from the marking or documentation, so that they cannot be used as a loophole.

CHAPTER

03

Why Motors Matter for Africa

B

IN THIS CHAPTER

3.1	Motors in electricity use	3.5	Power quality and operating conditions
3.2	Motors in productive sectors	3.6	Distributional impacts
3.3	Market dynamics: imports, equipment and repair	3.7	Strategic fit with energy and climate policies in Africa
3.4	Life-cycle cost and the first-cost barrier	3.8	Implications for MEPS and labelling design

This chapter explains why motors deserve priority in African MEPS programmes: their share of electricity use, their concentration in productive sectors, the structure of the market, and the gap between their purchase price and their lifetime energy cost.

3.1 Motors in electricity use

Electric motor systems are the largest single end use of electricity in the world. The IEA 4E Electric Motor Systems Platform estimates that they consumed about 53% of global electricity — some 13,460 TWh — in 2023 [13]. Fifty-six countries, covering about 80% of the electricity used by motor systems worldwide, have adopted motor MEPS, most of them at the IE3 level for 0.75–375 kW [6].

National data for Africa are limited, but the available studies show the same pattern: in Egypt, industrial motor systems used an estimated 23.5 TWh in 2015, around 60% of manufacturing electricity use [14]. For SADC, the U4E regional assessment estimated that a minimum-ambition motor MEPS at IE2 would save about 4,450 GWh a year by 2030, worth about USD 417 million a year to users and avoiding about 4.1 million tonnes of CO_2 a year [15].

3.2 Motors in productive sectors

Motors drive the sectors on which African growth depends: mining and minerals processing, manufacturing, municipal water supply and wastewater treatment, irrigation, cold chains and commercial buildings. In water utilities, pumping is often the largest operating cost after staff. Efficient motors therefore lower the cost of production and of public services, and the benefit falls mainly on businesses and utilities rather than on households.

3.3 Market dynamics: imports, equipment and repair

Most motors used in Africa are imported, either alone or inside pumps, fans, compressors and machinery. The U4E guidance recommends IE3 as a starting point for countries that import all their motors and IE2 for countries that produce motors domestically [16]. The main exporting countries already require IE3 at home (Chapter 4), so compliant motors are widely available.

Two features of African markets weaken the effect of efficiency requirements if they are not addressed. Motors are commonly **repaired and rewound** many times over their life, and the quality of repair determines whether efficiency is maintained (Section 7.4). And **second-hand motors and equipment** are imported from markets that have tightened their own requirements. A regulation that covers only new standalone motors misses a large part of the installed base.

3.4 Life-cycle cost and the first-cost barrier

Over its life, a motor uses electricity worth many times its purchase price. The IEA estimates that energy typically accounts for more than 95% of a motor's life-cycle cost [2], and U4E puts the purchase price at generally less than 2% [6]. Yet motors are often bought on first cost: an equipment manufacturer who pays for the motor does not pay the electricity bill, and a maintenance department under pressure to restore production quickly will rewind or buy the cheapest replacement. This split between purchaser and user is the main reason why MEPS are needed for motors even though efficient motors pay back quickly (Section 6.3).

3.5 Power quality and operating conditions

Motor efficiency is rated at nameplate voltage and a balanced supply. Many African networks operate with voltage variations and unbalance between phases, which raise motor losses and temperatures (Section 7.3). These conditions do not change the case for efficient motors, but they make correct installation, protection and maintenance part of any motor programme.

3.6 Distributional impacts

Small and medium-sized enterprises, farmers using electric pumps and municipal utilities are the users most exposed to inefficient and poorly repaired motors, and the least able to absorb high energy costs. MEPS protect them by removing the least efficient products from the market and by creating a reference — the IE class on the rating plate — that a non-specialist buyer can use. Programmes should pair MEPS with access to finance and repair-or-replace advice for these users (Chapter 12).

3.7 Strategic fit with energy and climate policies in Africa

Motor MEPS contribute to the African Energy Efficiency Strategy and Roadmap (AfEES), adopted by the AU Executive Council in February 2025 [17], to industrial energy efficiency measures in many Nationally Determined Contributions, and to industrial competitiveness. Several African countries already regulate motors (Chapter 4); none of the regional harmonised MEPS adopted so far covers motors — the ECOWAS (2017), SADC (2023) and EAC (2025) instruments cover air conditioners and refrigerators [18, 19] — which leaves room for regional cooperation on motors.

3.8 Implications for MEPS and labelling design

- Base requirements on the IE classes and test methods of IEC 60034, so that existing international test reports can be accepted.
- Make the IE class and nominal efficiency on the rating plate the central compliance information, because the buyers are professionals.
- Reach motors inside imported equipment through scope, registration and customs procedures.
- Address rewinding and second-hand motors, which determine the efficiency of the installed base.
- Combine MEPS with motor-system programmes, where the larger savings lie.

KEY TAKEAWAYS — CHAPTERS 1 TO 3

- Motor systems use about 53% of global electricity [13]; energy accounts for more than 95% of a motor's life-cycle cost [2].
- Most motors in Africa are imported, often inside equipment, so scope, registration and customs procedures must reach integrated motors.
- Requirements should be based on IEC 60034-30-1 IE classes and IEC 60034-2-1 test methods.
- Rewinding and second-hand imports decide whether the installed base stays efficient.
- Motor MEPS secure product savings; system optimisation offers further savings of 15–25% [2].

CHAPTER

04

International Benchmarks Landscape

IN THIS CHAPTER

4.1 Purpose of international benchmarking
4.2 African national instruments
4.3 U4E model regulation guidelines
4.4 European Union
4.5 United States
4.6 China and India
4.7 Other references
4.8 Comparative benchmark table
4.9 Methodology for selecting national motor MEPS levels

This chapter sets out motor MEPS in African national instruments and in the main international reference programmes. It is reference information to inform national decisions, not a recommendation. AFREC does not prescribe efficiency levels; Member States set their own through the process in Chapter 6 and Part A, Chapter 6 [1].

4.1 Purpose of international benchmarking

Motor requirements are more comparable across countries than those of almost any other product, because nearly all programmes use the IE classes of IEC 60034-30-1, or equivalent NEMA levels, and equivalent test methods [6, 20]. Benchmarking therefore answers practical questions directly: which IE class the global supply chain delivers as standard; which scope and staging other countries have used; and how quickly a country can move from one class to the next. Differences between programmes lie mainly in scope (power range, phases, poles), in the timing of each step, and in enforcement.

4.2 African national instruments

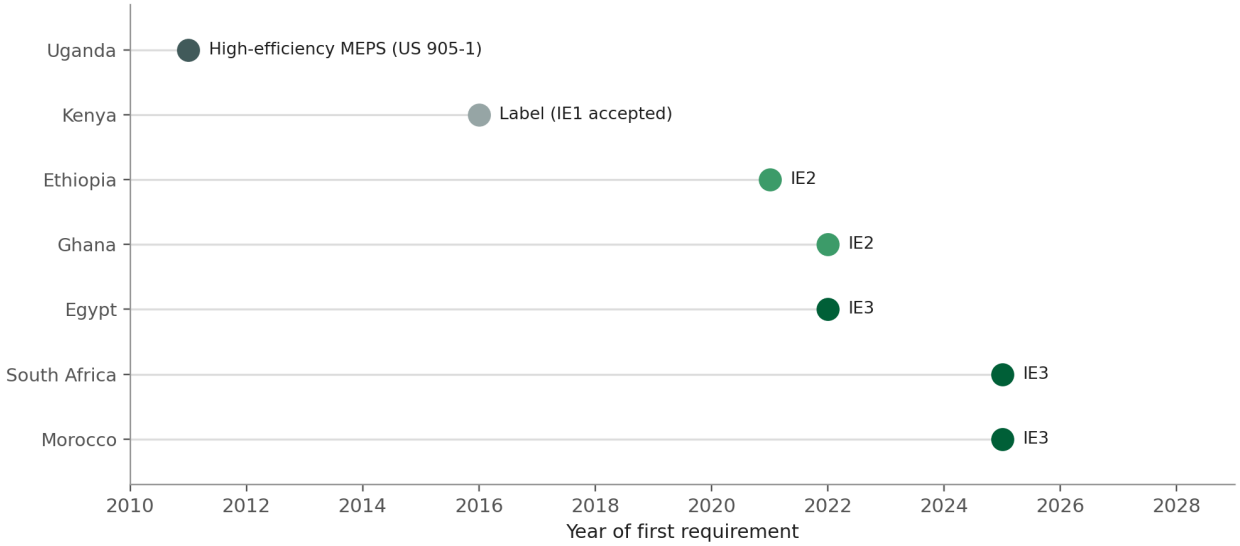
Several African countries already regulate motors, and others are developing requirements (Table 6, Figure 2). No regional harmonised motor MEPS has yet been adopted by a Regional Economic Community.

TABLE 6 Motor MEPS and labelling instruments in Africa (selected).

COUNTRY AND INSTRUMENT	SCOPE	REQUIREMENT	MARKING, LABELLING AND ENFORCEMENT
Egypt — Ministerial Decrees 463/2020 and 474/2020; Decree 499/2023	Three-phase cage induction motors, 0.75–375 kW, locally made or imported [21]	IE3 after an 18-month transition from the 2020 decrees; standard ES 2623-3, revised in 2023 [21]	IE code marked on the rating plate; conformity testing to ES 2623 or an accredited test certificate [21]
Ghana — L.I. 2456 (2022)	Single- and three-phase induction motors, 0.12–1,000 kW, 2/4/6/8 poles, 50 Hz, direct-on-line, continuous duty [22]	IE2 [6]	Mandatory 1–5 star label [6]; Energy Commission; in force 2 November 2022 with a one-year transition [23]
Kenya — Energy (Appliances' Energy Performance and Labelling) Regulations, 2016	Three-phase cage induction motors [24]	Labelling requirement; motors rated IE1 have been approved [25]	Mandatory star label (IE1 = 1 star, IE2 = 2 stars, IE3 = 3 stars); registration with EPRA [24, 25]
Morocco — Décret 2-20-716 and Arrêté 1530-24	Electric motors under the national MEPS framework	IE3, or IE2 combined with a variable speed drive [26]	Entered into force in 2025 [26]
South Africa — Compulsory specification VC 9113 (2024)	0.75–375 kW, 2/4/6/8 poles, above 50 V to 1,000 V [7]	IE3, effective June 2025 [7]	Letter of Authority from the NRCS before sale; no energy label [7]
Uganda — US 905-1:2011	Three-phase cage induction motors, 0.73 kW to below 185 kW, up to 1,100 V [27]	High-efficiency MEPS requirements [27]	Mandatory standard; Uganda National Bureau of Standards [27]
Ethiopia — ES 6892:2021	Three-phase 50 Hz cage induction motors, 0.75–375 kW, 2/4/6 poles [28]	IE2, to be maintained during maintenance and replacement [28]	Efficiency class declared on the rating plate [28]
Nigeria	Electric motors	MEPS under development by the Standards Organisation of Nigeria [29]	Inception and validation workshop on technical findings held in Lagos, April 2026 [29]

Source: Compiled by AFREC from the instruments cited.

FIGURE 2 Adoption of motor MEPS in Africa: year of first requirement and minimum IE class.



Source: Instruments cited in Table 6. Kenya's requirement is a mandatory label under which IE1 motors are accepted [24, 25].

Two lessons stand out. First, the newest instruments — South Africa (2025), Morocco (2025) and Egypt (2022) — went directly to IE3 (Morocco also accepts IE2 with a variable speed drive), the level most of the world now uses [6, 7, 21, 26]. Second, Kenya's experience shows the difference between a label and a MEPS: a mandatory label that includes IE1 informs buyers but does not remove the least efficient motors from the market [24, 25].

4.3 U4E model regulation guidelines

The UNEP United for Efficiency (U4E) model regulation for general purpose electric motors (2025) is the reference most directly designed for countries developing their first motor regulation [4]. It defines the scope described in Section 2.3, the IE2, IE3 and IE4 efficiency tables, the test method (IEC 60034-2-1:2024, Method 2-1-1B), information and marking requirements, verification procedures and a stock sell-through period. It presents three options (Table 7).

TABLE 7 Options in the U4E model regulation for electric motors (2025).

OPTION	REQUIREMENT	INTENDED USE
A — Advanced	IE3 for three-phase motors 0.75–1,000 kW; IE4 for three-phase motors 75–200 kW (excluding brake and explosion-protected motors); IE2 for three-phase motors 0.12–0.75 kW, single-phase motors and Ex eb motors	Alignment with the most advanced programmes
B — Bridging	IE3 for three-phase motors 0.75–375 kW, 2/4/6/8 poles	The level most countries with motor MEPS apply
C — Bridging	IE2, as a temporary step towards IE3	Countries with domestic production that needs time to adapt

Source: U4E (2025) [4].

The guidelines allow implementation in up to three stages: IE3 for three-phase motors first; then single-phase and Ex eb motors; then IE4 for 75–200 kW. They also provide a module for variable speed drives, with a minimum of class IE2 under IEC 61800-9-2 [4]. A companion policy guide sets out the supporting measures for motor systems [6].

4.4 European Union

The EU regulates motors under Regulation (EU) 2019/1781, as amended by Regulation (EU) 2021/341 [5]. From 1 July 2021 it requires IE3 for three-phase motors of 0.75–1,000 kW and IE2 for motors of 0.12–0.75 kW; from 1 July 2023 it requires IE4 for three-phase motors of 75–200 kW with 2, 4 or 6 poles, and IE2 for single-phase and Ex eb motors. Variable speed drives must meet IE2 from 1 July 2021 [5]. The regulation replaced Regulation (EC) No 640/2009, which introduced IE2 in 2011 and IE3 (or IE2 with a drive) in 2015–2017 [30]. The EU does not use a consumer-style energy label for motors; instead the IE class, nominal efficiency and year of manufacture must be marked on the rating plate, and thirteen items of product information must be published [5]. The Commission estimates that the EU motor and drive regulations together will save about 106 TWh of electricity a year by 2030, about 14 TWh of it from the 2019 revision, noting some double counting with other ecodesign products [31].

4.5 United States

The U.S. Department of Energy has required NEMA Premium efficiency — broadly equivalent to IE3 — for general purpose motors of 1–500 hp since 1 June 2016 [32]. A 2023 rule extends scope to 750 hp and to air-over motors and raises some ranges to IE4-equivalent levels, with compliance from 1 June 2027 [33]. In June 2026 DOE delayed, to October 2029, enforcement of test-procedure requirements for inverter-only, synchronous and other expanded-scope motors that are not yet subject to standards [34]. Nominal efficiency and a DOE compliance certification number must appear on the nameplate [20].

4.6 China and India

- **China**: GB 18613-2020, in force from 1 June 2021, sets IE3 as the minimum for motors of 0.12–1,000 kW, with three energy efficiency grades and the China Energy Label [35].
- **India**: compulsory certification to IS 12615:2018, whose lowest class is IE2, has applied since 1 October 2017 under a Quality Control Order, making IE2 the effective minimum [6, 36]; the Bureau of Energy Efficiency star label for general purpose industrial motors is voluntary [37].

4.7 Other references

TABLE 8 Selected other national motor MEPS.

COUNTRY	MINIMUM LEVEL AND SCOPE	YEAR
Brazil	Premium-equivalent minimum efficiencies for three-phase induction motors, 0.12–370 kW [38]	Manufacture and import from 2019
Mexico	NOM-016-ENER (equivalent to IE3), 0.746–373 kW; replaced by NOM-016-ENER-2025 [39]	2016; revised 2025
Saudi Arabia	IE3 for three-phase induction motors under SASO 2893/2018 [40]	2018
Japan	Top Runner target at IE3, 0.75–375 kW [41]	FY2015
Canada	NEMA Premium (about IE3), 0.75–375 kW [42]	2016
United Kingdom	Same requirements and dates as EU Regulation 2019/1781 [43]	2021 and 2023
Australia and New Zealand	About IE2 for 0.73 kW to below 185 kW; in May 2026 Australian ministers approved extending scope to 0.12–375 kW at IE2 (small) and IE3 (medium and large), with a later IE4 stage; New Zealand has yet to decide [44]	2001; revised 2006 and 2019

4.8 Comparative benchmark table

TABLE 9 Selected reference requirements for three-phase induction motors.

PROGRAMME	CORE REQUIREMENT	HIGHER REQUIREMENT	INFORMATION
U4E model regulation (2025)	IE3, 0.75–375 kW (Option B) or 0.75–1,000 kW (Option A)	IE4 for 75–200 kW (Option A)	IE class and efficiency on rating plate; registration [4]
EU 2019/1781	IE3, 0.75–1,000 kW (2021)	IE4 for 75–200 kW (2023)	Rating plate and published information [5]
United States	NEMA Premium (≈ IE3), 1–500 hp (2016)	IE4-equivalent ranges from 2027	Nameplate efficiency and certification number [32, 33]
China GB 18613-2020	IE3, 0.12–1,000 kW (2021)	Grades 1 and 2	China Energy Label [35]
South Africa VC 9113	IE3, 0.75–375 kW (2025)	—	Letter of Authority [7]
Egypt	IE3, 0.75–375 kW (2022)	—	IE code on rating plate [21]
Ghana L.I. 2456	IE2, 0.12–1,000 kW (2022)	—	1–5 star label [6]
India	IE2 (three-phase)	—	Voluntary star label [37]

Source: Instruments cited in Sections 4.2 to 4.7.

4.9 Methodology for selecting national motor MEPS levels

1. **Identify regional and trading-partner requirements** — neighbouring countries, the main supplier countries and any REC instrument — and use them as the starting reference.
2. **Establish whether motors are produced or assembled nationally.** Importing countries can generally adopt the class the global supply chain already produces; producing countries may need a transition period [16].
3. **Map the national market** against the IE classes using customs data, distributor surveys and registration data (Section 6.2).
4. **Decide the scope and staging:** three-phase 0.75–375 kW first, then smaller, single-phase and larger motors.
5. **Test candidate levels** with life-cycle cost analysis (Section 6.3) and set a staged pathway with announced dates.

CHAPTER

05

Performance Metrics and Test Standards

IN THIS CHAPTER

5.1 Purpose of performance metrics

5.2 Main metrics

5.3 IE efficiency classes

5.4 Reference test and classification standards

5.5 Test methods and measurement principles

5.6 Test conditions

5.7 Verification tolerances and compliance criteria

5.8 Illustrative framework for adoption by AU Member States

This chapter explains the efficiency metric and classes used for motors, the international standards behind them, the test conditions, and how compliance is verified.

5.1 Purpose of performance metrics

A motor regulation needs one metric that is measured the same way everywhere and that a customs officer can read from the rating plate. Rated efficiency, expressed as an IE class, meets both needs. Unlike appliance metrics, it does not depend on a usage pattern or climate assumption, so the same test report is valid in every country with the same supply frequency.

5.2 Main metrics

TABLE 10 Motor performance metrics and information.

METRIC OR INFORMATION	DEFINITION	WHY IT IS REGULATED
Rated (nominal) efficiency at full load	Mechanical output divided by electrical input at rated output, voltage and frequency (%)	Primary compliance metric; compared with the IE class table
IE class	Efficiency class (IE1–IE5) defined by minimum efficiency values for each rated output and number of poles	Basis of MEPS and of marking and labelling
Efficiency at 75% and 50% load	Efficiency at part load	Most motors operate below full load; required product information in the EU and U4E texts [4, 5]
Losses at defined speed–torque points	Losses at operating points used to calculate system efficiency with drives	Information for motor-system and drive selection [5]
Rated output, poles, voltage, frequency	Rating-plate characteristics	Define the applicable requirement and allow inspection

5.3 IE efficiency classes

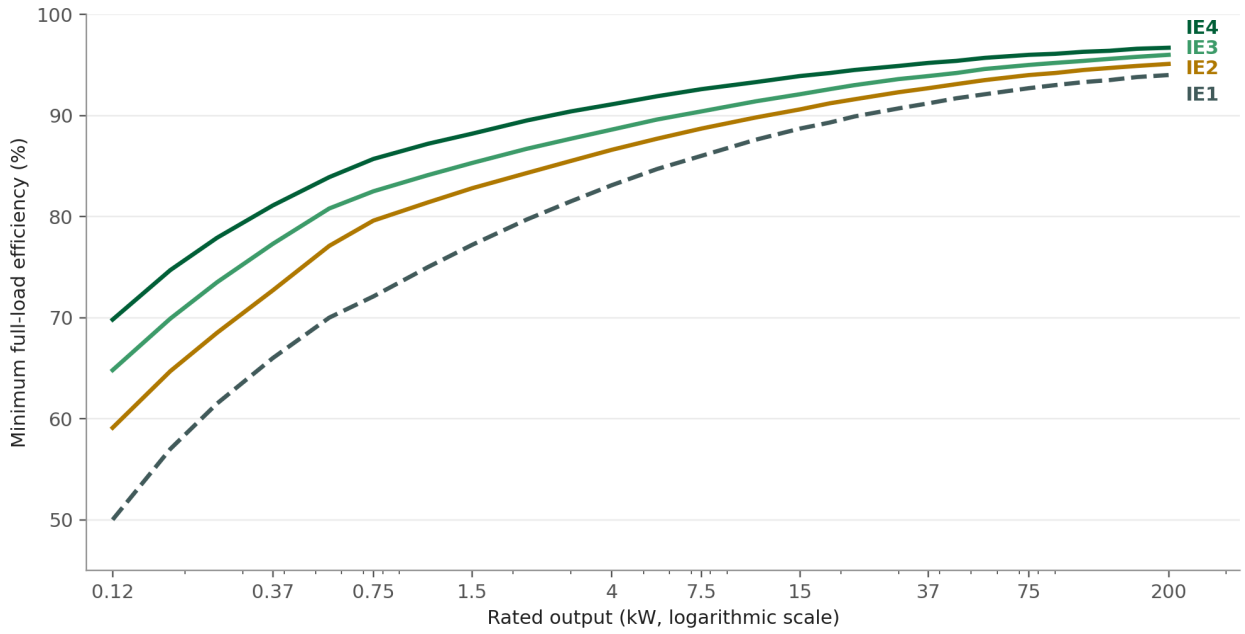
IEC 60034-30-1 defines the efficiency classes of line-operated AC motors: IE1 (standard), IE2 (high), IE3 (premium) and IE4 (super premium). The 2025 edition adds IE5 [11]. Classes are defined by minimum efficiency values for each rated output and number of poles at 50 Hz and 60 Hz, with interpolation formulas for intermediate ratings. Variable-speed motors that cannot run directly on line, such as permanent-magnet and synchronous reluctance motors, are classified separately under IEC TS 60034-30-2 [8], and drives under IEC 61800-9-2 [45]. Table 11 and Figure 3 show the IE1, IE2, IE3 and IE4 requirements for 4-pole motors at 50 Hz at selected ratings.

TABLE 11 Minimum full-load efficiency for 4-pole motors at 50 Hz, selected ratings (%).

RATED OUTPUT (KW)	IE1	IE2	IE3	IE4
0.12	50.0	59.1	64.8	69.8
0.37	66.0	72.7	77.3	81.1
0.75	72.1	79.6	82.5	85.7
1.5	77.2	82.8	85.3	88.2
4	83.1	86.6	88.6	91.1
7.5	86.0	88.7	90.4	92.6
15	88.7	90.6	92.1	93.9
37	91.2	92.7	93.9	95.2
75	92.7	94.0	95.0	96.0
110	93.3	94.5	95.4	96.3
200 and above	94.0	95.1	96.0	96.7

Source: IE1 values from IEC 60034-30-1:2014, Table 1, as reproduced in ABB (2018) and Topmotors (2014) [11, 46, 47]; IE2 to IE4 values from the efficiency tables of Regulation (EU) 2019/1781 and the U4E model regulation [4, 5]. Full tables for 2, 4, 6 and 8 poles and interpolation formulas are given in those instruments.

FIGURE 3 Minimum efficiency of 4-pole, 50 Hz motors by IE class and rated output.



Source: Plotted from IEC 60034-30-1:2014, Table 1 (IE1) [46], and the efficiency tables of Regulation (EU) 2019/1781 and the U4E model regulation (IE2 to IE4) [4, 5].

Each step up in class reduces losses substantially. At 15 kW, an IE2 motor has about 19% lower losses than an IE1 motor, an IE3 motor about 17% lower losses than an IE2 motor, and an IE4 motor about 24% lower losses than an IE3 motor (calculated from Table 11). For small motors the first step is larger: at 0.75 kW, IE2 cuts the losses of an IE1 motor by about a third. The gap in percentage points of efficiency is largest for small motors, but most of the absolute energy savings come from medium and large motors that run for long hours. IE1 is no longer accepted as a minimum level in the major programmes reviewed in Chapter 4, but IE1 motors are still registered for sale in some African markets, for example under Kenya's labelling scheme [24, 25], which makes the IE1 column a useful reference when establishing a national market baseline.

5.4 Reference test and classification standards

TABLE 12 Reference standards for motor MEPS.

STANDARD	SCOPE	ROLE
IEC 60034-1:2026	Rating and performance of rotating electrical machines	Rating conditions, duty types and tolerances [48]
IEC 60034-2-1:2024	Methods for determining losses and efficiency from tests	Test method; Method 2-1-1B (summation of losses with residual-loss determination) for three-phase motors [10]
IEC 60034-30-1:2025	Efficiency classes of line-operated AC motors (IE code)	IE1–IE5 class tables [11]
IEC TS 60034-30-2:2016	Efficiency classes of variable-speed AC motors	Classes for motors designed for converter supply [8]
IEC 61800-9-1 and -9-2	Ecodesign for power drive systems	IE classes for drives and IES classes for drive systems [45]
IEC 60034-23:2019	Repair, overhaul and reclamation	Repair practice that preserves efficiency [12]
IEC TS 60034-31:2021	Selection of energy-efficient motors including variable-speed applications	Application guidance for users [49]
IEEE 112 Method B; CSA C390	North American test methods	Accepted by the U.S. DOE alongside IEC 60034-2-1 [20, 50]
ISO/IEC 17025:2017	Competence of testing laboratories	Accreditation basis for accepting test reports [51]

5.5 Test methods and measurement principles

For three-phase motors, IEC 60034-2-1 specifies a preferred method in which the individual losses — stator and rotor winding losses, iron losses, friction and windage, and additional load losses — are determined and summed, with the additional load losses found from the residual losses of a load test (Method 2-1-1B) [10]. This method has low uncertainty and is the one referenced by the U4E model regulation and the EU regulation [4, 5]. Single-phase motors are tested by direct measurement of input and output power. The test requires a load machine or dynamometer, precision power analysers and temperature measurement, and takes about a day per motor; it is more demanding than lamp testing, so most countries rely on accredited laboratories abroad or in the region for full verification (Section 10.2).

5.6 Test conditions

Efficiency classes are based on operation at rated voltage and frequency, an ambient (coolant) temperature of 25 °C and an altitude up to 1,000 m [11]. Motors designed for operation in ambient temperatures from −30 °C to +60 °C and altitudes up to 4,000 m remain in scope, but their rated efficiency is still determined at the reference conditions [4, 5]. Hot climates and high altitude therefore do not require different test conditions; they are addressed through correct motor selection and derating at installation.

5.7 Verification tolerances and compliance criteria

Because efficiency varies between motors of the same design, regulations verify compliance against the declared nominal efficiency using a tolerance on losses (Table 13).

TABLE 13 Verification procedure and tolerances in reference instruments.

ELEMENT	U4E MODEL REGULATION (2025)	EU REGULATION 2019/1781
First test	One motor taken from the market	One unit
If the first unit fails	Three further motors of the same design; their average must comply (not required for designs produced at fewer than five units a year)	Three further units; their average must comply (models produced at five or more units a year)
Tolerance on total losses	+15% (IEC 60034-1)	+15% for 0.12–150 kW; +10% above 150 kW
Drives	Tolerance on losses +10%	Tolerance on losses +10%

Source: U4E (2025) [4]; Regulation (EU) 2019/1781, Annex III [5].

Tolerances apply only to verification by the authority. A supplier may not use them to declare a better efficiency than its own tests support.

5.8 Illustrative framework for adoption by AU Member States

- **Adopt IEC 60034-1, IEC 60034-2-1 and IEC 60034-30-1 as national standards**, coordinated through the national electrotechnical committees and the African Electrotechnical Standardization Commission (AFSEC), so that Member States cite identical methods.
- **Accept test reports from any ISO/IEC 17025 laboratory accredited for IEC 60034-2-1**, regardless of country, at registration.
- **Plan check-testing capacity regionally**: a motor test bench serving several countries is more economical than national laboratories in every country.
- **Reference the standard edition in force at adoption** in the regulation, and update references at each review.
- **Use mutual recognition** within RECs and, for trade, AfCFTA provisions on technical barriers (Part A, Chapter 12).

KEY TAKEAWAYS — CHAPTERS 4 AND 5

- Fifty-six countries have motor MEPS; most apply IE3 to 0.75–375 kW [6]. Egypt, Morocco and South Africa apply IE3 [7, 21, 26]; Ghana and Ethiopia apply IE2 [6, 28].
- The U4E model regulation offers an advanced option (IE2 for 0.12–0.75 kW, IE3 for 0.75–1,000 kW and IE4 for 75–200 kW) and bridging options at IE3 or IE2 [4].
- A mandatory label that accepts IE1, as in Kenya, informs buyers but does not remove the least efficient motors [24, 25].
- IEC 60034-2-1 Method 2-1-1B (or the equivalent IEEE 112 Method B and CSA C390) and the IE tables of IEC 60034-30-1 are the common basis of all major programmes [10, 20, 50].
- Verification uses one unit, then three, with a tolerance on losses.

CHAPTER

06

Setting National MEPS Levels in Country Context

IN THIS CHAPTER

6.1 Applying the eight-step methodology to motors

6.2 Data needs for motors

6.3 LCCA considerations specific to motors

6.4 Setting national MEPS levels for motors

6.5 Transition timelines for motors

6.6 Summary of country-level motor MEPS design

This chapter applies the eight-step MEPS development methodology of Part A, Chapter 6 to electric motors [1]. It does not recommend levels. It explains what data a country needs, how to test candidate levels with life-cycle cost analysis (LCCA), and how to stage requirements so that suppliers, equipment manufacturers and repair workshops can adapt.

6.1 Applying the eight-step methodology to motors

TABLE 14 The Part A eight-step methodology applied to electric motors.

PART A STEP	MOTOR-SPECIFIC APPLICATION
1. Scope definition	Define the motors covered by type, rated output, poles, phases, voltage and frequency (Chapter 2); decide how motors in imported equipment and spare motors are treated.
2. Market characterisation	Estimate annual imports and local assembly by power range from customs data (HS 8501) and distributor surveys; identify the share of IE1, IE2 and IE3 motors on sale and of motors arriving inside equipment.
3. Benchmark review	Compare candidate requirements with trading partners, neighbouring countries and the U4E model regulation (Chapter 4).
4. Technical analysis	Confirm availability of compliant motors in each power range from the main suppliers; check physical size and starting-current implications for retrofit.
5. Economic analysis (LCCA)	Compare life-cycle costs for representative motors and operating hours (Section 6.3).
6. Stakeholder consultation	Importers and distributors, equipment manufacturers and assemblers, large users (mining, water, manufacturing), utilities, repair workshops, customs and standards bodies.
7. Regulation drafting and adoption	Use the U4E model regulation or a trading-partner regulation as the template; include marking, information, registration, verification and sell-through provisions.
8. Implementation planning	Announce dates for each stage; prepare registration and customs procedures; arrange access to accredited test laboratories; plan support for repair workshops.

Source: Part A, Chapter 6 [1], applied by AFREC.

6.2 Data needs for motors

TABLE 15 Data needs for setting motor MEPS.

DATA ITEM	WHAT IS NEEDED	TYPICAL SOURCES
Import volumes and values	Annual units and values by HS line (8501.40, 8501.51–53) and origin	Customs; importer declarations
Efficiency distribution	Share of motors on sale by IE class and power range	Distributor catalogues and rating plates; registries of trading partners
Motors in equipment	Imports of pumps, fans and compressors and their motor sizes	Customs (HS 8413, 8414); equipment suppliers
Prices	Price premium of IE3 and IE4 motors over the classes they would replace	Distributor price lists; procurement records
Operating hours and loading	Typical annual hours and load factor by sector	Energy audits; utility and industry surveys
Installed base and repair	Size of the installed base, rewinding volumes and practices	Industry surveys; repair workshop surveys
Tariffs	Industrial and commercial electricity tariffs	Regulator tariff schedules

Source: AFREC, drawing on U4E guidance [4, 6].

6.3 LCCA considerations specific to motors

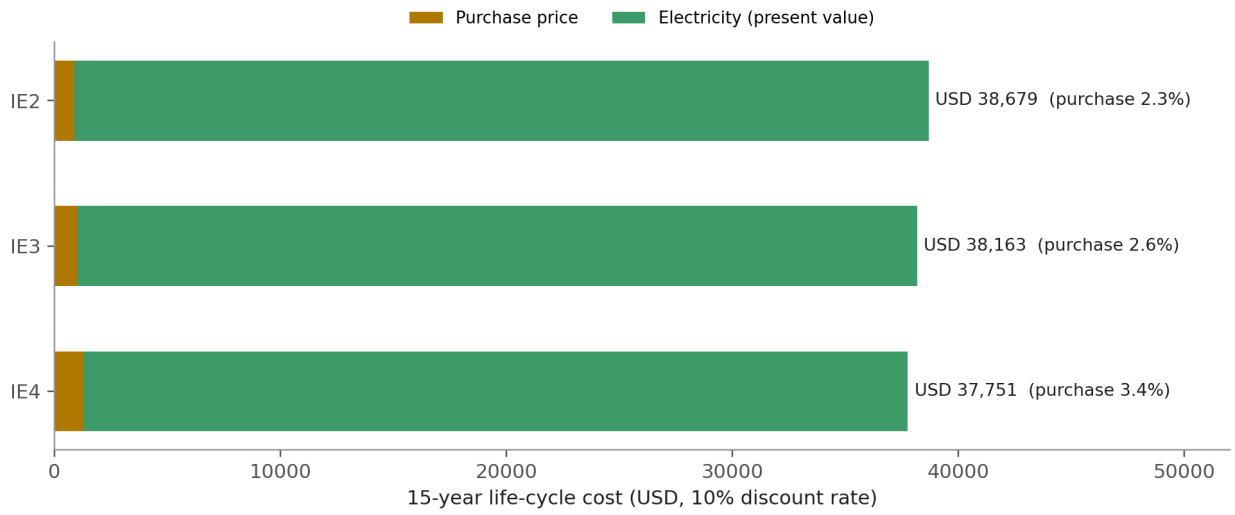
For motors, LCCA nearly always favours higher efficiency, because energy accounts for more than 95% of life-cycle cost [2]. The analysis is used mainly to choose between classes for each power range, to set the timing of a step to IE4, and to show users the case for replacement rather than repeated rewinding. Table 16 gives an illustrative comparison for a common motor.

TABLE 16 Illustrative life-cycle cost of a 15 kW, 4-pole motor over 15 years.

PARAMETER	IE2 (90.6%)	IE3 (92.1%)	IE4 (93.9%)
Shaft load (75% of rated output)	11.25 kW	11.25 kW	11.25 kW
Electrical input	12.42 kW	12.21 kW	11.98 kW
Annual energy (4,000 hours)	49,670 kWh	48,860 kWh	47,920 kWh
Annual electricity cost (USD 0.10/kWh)	USD 4,967	USD 4,886	USD 4,792
Assumed purchase price	USD 900	USD 1,000	USD 1,300
Life-cycle cost, 15 years, 10% discount rate	about USD 38,680	about USD 38,160	about USD 37,750
Simple payback against IE2	—	about 1.2 years	about 2.3 years

Source: AFREC calculation for illustration only. Full-load efficiencies from Table 11; prices, tariff, hours and loading are assumptions and must be replaced with national data.

FIGURE 4 Composition of the 15-year life-cycle cost of the illustrative 15 kW motor.



Source: AFREC calculation for the example in Table 16.

Three points follow. First, the purchase price is only about 2–3.5% of life-cycle cost in this example, so even a large price premium is repaid quickly. Second, the result is sensitive to operating hours: at 1,000 hours a year the IE4 payback lengthens to about nine years (AFREC calculation). This is consistent with IE4 being required only for 75–200 kW in the EU and in the U4E advanced option [4, 5]. Third, the benefit of the efficient motor is lost if it is later rewound badly (Section 7.4).

6.4 Setting national MEPS levels for motors

A national decision usually answers four questions:

1. **Level for the core range.** Which IE class to require for three-phase motors of 0.75–375 kW, the range that uses most energy. Most countries with motor MEPS apply IE3 [6].
2. **Scope extension.** Whether and when to cover small three-phase motors (0.12–0.75 kW), single-phase motors, motors above 375 kW and Ex eb motors, typically at IE2 for the small and special motors [4].
3. **Higher step.** Whether to announce a later step to IE4 for 75–200 kW, as the EU and the U4E advanced option do [4, 5].
4. **Drives.** Whether to regulate variable speed drives, for which the U4E guidelines set a minimum of IE2 under IEC 61800-9-2 [4].

Whatever the national choice, it should be expressed in IE classes and the IEC test method, so that the same test reports and registrations can be used across the region and a later regional instrument can be adopted without changing the national metric.

6.5 Transition timelines for motors

- An effective date for imports and local production **12 to 24 months** after publication; Egypt allowed 18 months for its move to IE3 [21].
- A sell-through period for stock already in the distribution chain, which the U4E model regulation limits to two years or until stocks are exhausted, whichever is earlier [4].
- A later date, announced at adoption, for each scope extension or higher step.
- A provision for motors integrated in equipment, which may need a longer period because equipment manufacturers must redesign mounting and wiring.
- A review within five years of entry into force [4].

6.6 Summary of country-level motor MEPS design

TABLE 17 Summary of national design choices for motor MEPS.

DESIGN ELEMENT	COMMON STARTING POINT	VARIATION TO CONSIDER
Reference instrument	U4E model regulation or a main trading partner's regulation	Align with a neighbouring country's requirements
Metric	IE class under IEC 60034-30-1; test to IEC 60034-2-1	—
Core level	IE3 for three-phase 0.75–375 kW	IE2 as a bridging step where motors are produced nationally
Scope extension	Small, single-phase and Ex eb motors at IE2 in a second stage	Larger motors up to 1,000 kW
Higher step	IE4 for 75–200 kW announced at adoption	Later timing where long-hour use is rare
Drives	IE2 under IEC 61800-9-2	Second stage

CHAPTER

07

Technology and Policy Considerations

B

IN THIS CHAPTER

7.1 Technology trends

7.2 Motor systems and variable speed drives

7.3 Power quality and operating conditions

7.4 Rewinding and repair

7.5 Second-hand motors and motors in imported equipment

7.6 End of life

7.7 Interaction with other policy frameworks

7.8 Implications for future MEPS revisions

This chapter covers technology and policy issues that bear on motor MEPS in Africa: new motor technologies, motor systems and drives, power quality, rewinding, second-hand motors and motors inside equipment.

7.1 Technology trends

- **IE3 is the most common MEPS level** for new three-phase motors, and IE4 is required for 75–200 kW in the EU, Norway, Switzerland, Türkiye and the United Kingdom [5, 6].
- **IE5 has been defined** for line-operated motors in the 2025 edition of IEC 60034-30-1 [11].
- **New motor technologies** — permanent-magnet and synchronous reluctance motors — reach IE4 and IE5 but generally require a variable speed drive; they are classified under IEC TS 60034-30-2 [8].
- **Drives and system classes**: IEC 61800-9-2 defines efficiency classes for drives and for complete drive systems, which allows regulation to move from the motor alone towards the system [45].

7.2 Motor systems and variable speed drives

Most motors drive pumps, fans and compressors whose output is regulated by throttling or by switching on and off. Matching motor speed to the actual demand with a variable speed drive can improve the energy performance of such systems by up to 40% where they run below rated speed [6]. Oversizing is also common: a large U.S. assessment found that over 40% of motors operated at less than 40% of rated load, where efficiency and power factor fall [52]. MEPS cannot address these system losses, which is why the U4E guidance pairs motor regulation with drive requirements and with audit and system-optimisation programmes [4, 6] (Chapter 12).

7.3 Power quality and operating conditions

Under IEC 60034-1, motors must deliver rated output within ±5% of rated voltage and be able to operate within ±10%, with a higher temperature rise [48]. At 90% of rated voltage, full-load efficiency typically falls by 1–3% and current rises by 5–10% [53]. Voltage unbalance between phases is more damaging: NEMA MG 1 calls for derating above 1% unbalance — to about 75% of rated output at 5% — and does not recommend operation above 5% [54]. Higher operating temperatures shorten insulation life, which roughly halves for every 10 °C rise [55]. For African utilities and industrial users this means that:

- motor programmes should be coordinated with utility efforts to reduce voltage unbalance and improve supply quality;
- installers should verify supply voltage and balance and apply derating where needed;
- regulation should not modify the rated test conditions to reflect local supply, since this would prevent use of international test reports — supply quality is an installation and network issue.

7.4 Rewinding and repair

In many African countries motors are rewound several times during their life, and repair is often cheaper and quicker than replacement. Good repair practice maintains efficiency: in the EASA/AEMT studies, motors rewound under controlled procedures stayed within the ±0.2-point accuracy of the test — the 2019 study of ten IE3 motors found an average change of −0.1 points — whereas motors rewound without stripping and rewinding controls in the 2003 study lost 0.3–0.5 points [56, 57]. The critical factors are the temperature used to burn out the old winding (the good-practice guide warns that burnout above 400 °C risks damaging the core insulation), preserving or improving the winding design and conductor size, and avoiding damage to the core and bearings [58]. IEC 60034-23 sets procedures for repair, overhaul and reclamation, including general principles for maintaining efficiency [12].

Regulators can protect the efficiency of the installed base by:

- adopting IEC 60034-23 as a national standard and promoting recognised good-practice guidance;
- registering or accrediting repair workshops that commit to good practice, and requiring them in public procurement;
- requiring, as Ethiopia does, that the minimum efficiency class be maintained during maintenance and replacement [28];
- giving users simple repair-or-replace guidance based on life-cycle cost, particularly for small motors and motors with damaged cores;
- training technicians and giving workshops access to basic test equipment (Chapter 12).

7.5 Second-hand motors and motors in imported equipment

Second-hand motors and equipment are imported from markets that have moved to higher efficiency classes. A regulation should state whether used motors are covered on import; where they are, the rating plate allows customs to check the IE class. Motors integrated in imported pumps, fans and compressors are covered by the U4E and EU scope when they can be tested separately [4, 5]. Equipment suppliers should be required to declare the integrated motor's IE class in registration and documentation, and customs risk profiles for HS 8413 and 8414 should include this check.

7.6 End of life

Motors contain copper, steel and aluminium with high scrap value, so they are usually recovered. The main end-of-life concern is that motors removed under replacement programmes are sold back into the market. Programmes that fund replacement should require the old motor to be scrapped and documented.

7.7 Interaction with other policy frameworks

TABLE 18 Interaction of motor MEPS with other policy frameworks.

FRAMEWORK	INTERACTION	COORDINATION NEEDED
Industrial energy efficiency programmes	Audits and system optimisation deliver savings beyond MEPS	Use registered motor data in audits; promote replacement of failed motors with registered efficient models
Energy management standards and large-user obligations	Require monitoring and improvement of energy use	Include motor systems and repair practice
Public procurement	Water utilities and public works buy large numbers of motors and pumps	Specify registered motors at or above MEPS and accredited repair
Utility network codes	Supply quality affects motor efficiency and life	Coordinate on voltage unbalance and power factor
Vocational training	Technicians determine repair quality	Include efficiency-preserving rewinding in curricula
Climate commitments (NDCs)	Industrial motor efficiency is a low-cost mitigation option	Report savings in NDC tracking

7.8 Implications for future MEPS revisions

- Review requirements within five years of entry into force [4].
- Plan the extension of scope to small, single-phase and large motors and to drives.
- Consider IE4 for ranges with long operating hours as prices fall.
- Follow international work on system-level requirements under IEC 61800-9-2 [45].
- Coordinate revisions with trading partners and neighbouring countries.

CHAPTER

08

Label Design Considerations

IN THIS CHAPTER

8.1 Rating-plate marking and the common label frame

8.2 Information requirements for motors

8.3 User comprehension

8.4 Design of efficiency classes and class boundaries

8.5 Practical design and implementation guidance

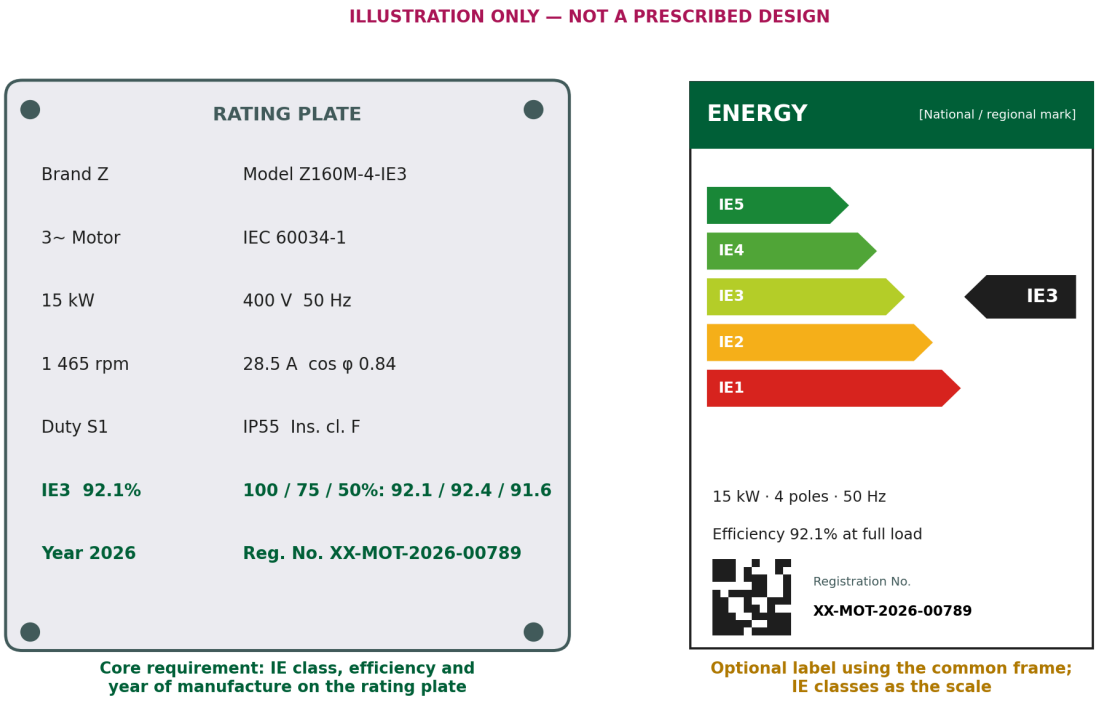
Motors are bought by professionals, usually from catalogues, specifications and rating plates rather than from a shop display. Most programmes therefore rely on information marked on the motor and published in documentation rather than a consumer-style label. This chapter sets out how marking and, where used, labels should fit the common continental label frame.

8.1 Rating-plate marking and the common label frame

The EU, the United States and South Africa do not require a comparative energy label for motors. The EU and the United States require the efficiency class or nominal efficiency to be marked on the rating plate and published in documentation [5, 20]; South Africa's specification references IEC 60034-30-1, under which the class is marked on the rating plate [7, 11]. Ghana and Kenya use a star label linked to the IE classes [6, 24], and China uses its energy label [35].

Where a Member State uses a label, it should follow the common label frame of the suite: the class indicator, the registration number and QR code, and the national or regional mark in standard positions. For motors the comparative scale can simply be the IE classes, which are already understood by buyers worldwide (Figure 5).

FIGURE 5 Illustrative rating-plate marking and label for a motor using the common frame (not a prescribed design).



Source: AFREC, prepared for this handbook. Illustration only; values are placeholders.

8.2 Information requirements for motors

TABLE 19 Information requirements for motors.

ELEMENT	RATING PLATE	DOCUMENTATION AND WEBSITE	LABEL (WHERE USED)
IE class	Yes	Yes	Yes (class indicator)
Nominal efficiency at full load	Yes	Yes	Yes
Efficiency at 75% and 50% load	Where space allows	Yes	Optional
Year of manufacture	Yes	—	—
Rated output, poles, voltage, frequency, speed	Yes	Yes	Yes
Registration number and QR code	Recommended	Yes	Yes
Operating conditions (altitude, ambient temperature, explosive atmosphere)	—	Yes	—
Losses at speed–torque operating points	—	Yes	—
Reason for exemption (if claimed)	Spare-part marking	Yes	—

Source: Based on Regulation (EU) 2019/1781 and the U4E model regulation [4, 5].

8.3 User comprehension

The users of motor information are engineers, procurement officers, equipment manufacturers and maintenance staff. Comprehension testing should check whether these users can find the IE class and efficiency on the rating plate and in catalogues, understand that a higher class means lower operating cost, and use the registry to check a motor. Where star labels are used, testing should confirm that users understand the link between stars and IE classes.

8.4 Design of efficiency classes and class boundaries

For motors, the IE classes provide internationally defined boundaries. A national label or rating should use them directly rather than creating new boundaries: this keeps the label consistent with catalogues and test reports from every supplier. Where stars are used, each star should correspond to one IE class, and the classes below the national MEPS should not be displayed as compliant ratings, otherwise the label signals that non-compliant motors are acceptable.

8.5 Practical design and implementation guidance

- **Rating plate first**: require the IE class, nominal efficiency and year of manufacture on the rating plate, as the EU and U4E texts do [4, 5].
- **Catalogues and quotations**: require IE class and efficiency in all catalogues, price lists and tenders.
- **Registry and QR code**: link the motor to its registration record so customs and inspectors can verify it.
- **Equipment**: require pumps, fans and compressors to state the IE class of the integrated motor in their documentation.
- **Spare parts**: require exempt spare motors to be marked as such.

KEY TAKEAWAYS — CHAPTERS 6 TO 8

- Energy is more than 95% of a motor's life-cycle cost [2]; the illustrative IE3 motor repays its premium in about a year.
- Most countries apply IE3 to the core range [6] and extend scope in stages; IE4 is applied to 75–200 kW in the most advanced programmes [5].
- Drives, right-sizing and system design offer larger savings than motor efficiency alone.
- Good-practice rewinding preserves efficiency; poor practice erodes it.
- Rating-plate marking of the IE class is the core information requirement; labels, where used, should use the IE classes.

CHAPTER

09

Product Registration

IN THIS CHAPTER

9.1 Purpose and role of product registration

9.2 Registration data fields for motors

9.3 Product registration process for motors

9.4 Registration requirements specific to motors

9.5 Relationship to conformity assessment, labelling and enforcement

9.6 Practical implementation of a PRS for motors

9.7 Sample PRS data template for motors

Product registration links each motor model to its declared efficiency, its test evidence and its marking. For motors it also provides the reference that customs need to check motors arriving alone or inside equipment.

9.1 Purpose and role of product registration

This handbook recommends the **registration-before-placement** principle: no motor model within scope may be imported, placed on the market or put into service until it is registered with the designated authority. The U4E model regulation provides for registration of motor designs with the national authority on the basis of product information and test reports [4], and South Africa requires a Letter of Authority before a motor may be sold [7]. Registration gives the authority a complete list of motors on the market, is the gate at which declared efficiency is checked against the requirement, and gives customs and inspectors a reference list.

9.2 Registration data fields for motors

TABLE 20 Registration data fields for electric motors.

FIELD GROUP	CONTENT
Supplier	Legal name, address, tax and customs identifiers; local representative
Product identification	Brand; model identifier; frame size; mounting; enclosure and cooling method
Customs	HS line; country of manufacture
Rating	Rated output (kW); number of poles; rated voltage(s) and frequency; rated speed; single- or three-phase; duty type
Efficiency	IE class; nominal efficiency at 100%, 75% and 50% load; losses at specified speed–torque points where required
Operating conditions	Ambient temperature range; altitude; explosive-atmosphere classification (e.g. Ex eb)
Test evidence	Laboratory, accreditation number, report number and date; IEC 60034-2-1 method applied
Exemption claimed	Reason, where the model is claimed to be outside scope or exempt
Attachments	Test report; rating-plate drawing or photograph; product information sheet

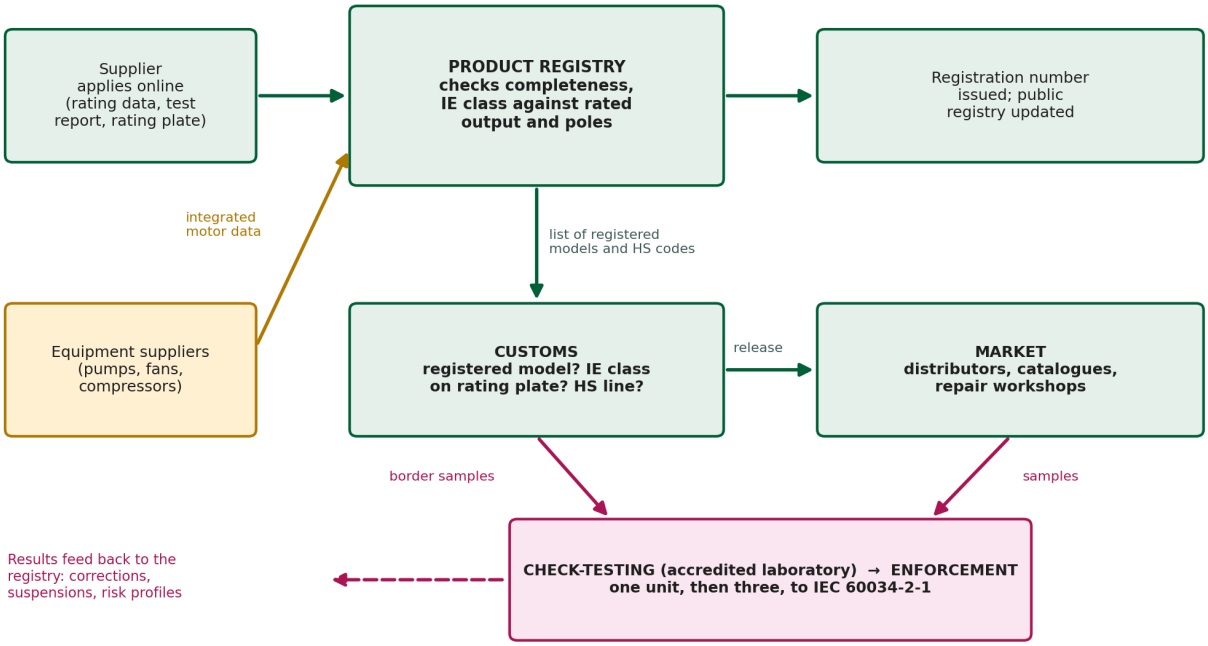
Source: Based on the U4E model regulation and Regulation (EU) 2019/1781 [4, 5].

9.3 Product registration process for motors

A typical process, illustrated in Figure 6, runs as follows:

1. The supplier submits the application online with the data fields and attachments.
2. The registry checks completeness and compares the declared nominal efficiency with the requirement for the rated output and number of poles.
3. Staff review the test report: accreditation scope, test method and consistency with the rating plate.
4. The registry issues a registration number; the record appears in the public registry.
5. Customs systems receive the list of registered models and their HS codes.
6. The supplier notifies changes; registration is renewed on a fixed cycle — South Africa's Letter of Authority, for example, is valid for three years [7].

FIGURE 6 Registration-before-placement and the motor compliance information flow.



Source: AFREC, prepared for this handbook.

9.4 Registration requirements specific to motors

- **Model families.** A manufacturer's range covers many ratings on common frames. Each rating is a separate model, but a family dossier with test reports for representative ratings and calculated values for others, as allowed by IEC methods, reduces burden.
- **Motors in equipment.** Suppliers of pumps, fans and compressors should register, or reference the registration of, the integrated motor model.
- **Mutual recognition.** The U4E model regulation allows registration on the basis of a registration certificate from a country in a recognised regional mutual-recognition arrangement [4].
- **Spare-part exemptions.** Where the regulation allows spare motors for existing equipment, the supplier should declare the equipment for which they are intended.

9.5 Relationship to conformity assessment, labelling and enforcement

Registration is a supplier declaration supported by test evidence; it is not certification. Credibility comes from combining registration with check-testing (Chapter 10): a supplier who knows that a motor may be taken from the market and tested has no incentive to over-declare. The registration number links the rating plate and documentation to the registry record.

9.6 Practical implementation of a PRS for motors

- **Use catalogue data.** Most suppliers publish IE class and efficiency for every rating; registration can import these data in bulk with supporting test reports.
- **Use other registries.** Registries and approvals in trading-partner countries can help verify claims for the same models.
- **Charge a modest fee**, per family where possible.
- **Plan for a regional registry** where countries in a REC adopt common motor requirements.

9.7 Sample PRS data template for motors

TABLE 21 Sample registration data template for a three-phase motor (illustrative).

FIELD	FORMAT	EXAMPLE ENTRY	MANDATORY
Registration number	System-generated	XX-MOT-2026-00789	Yes
Brand / model identifier	Text	Brand Z / Z160M-4-IE3	Yes
HS code	6-digit or national line	8501.52	Yes
Rated output	kW	15	Yes
Poles / rated speed	Number / rpm	4 / 1,465	Yes
Rated voltage / frequency	V / Hz	400 / 50	Yes
Phases	List	Three-phase	Yes
IE class	List	IE3	Yes
Nominal efficiency 100% / 75% / 50% load	%	92.1 / 92.4 / 91.6	Yes
Ambient temperature range / altitude	°C / m	–20 to +40 / 1,000	Yes
Test method	Standard and method	IEC 60034-2-1:2024, Method 2-1-1B	Yes
Test laboratory and accreditation	Text	Laboratory Y, ISO/IEC 17025, accreditation no. …	Yes

Source: Illustrative entries only.

CHAPTER

10

Product-Specific MVE Protocols

IN THIS CHAPTER

10.1 Objectives and scope of motor MVE

10.2 Check-testing procedures for motors

10.3 Sample selection methodology

10.4 Border verification checklist for imported motors

10.5 Distributor and workshop inspection checklist

10.6 Non-compliance handling and enforcement actions

10.7 Key risk indicators for motors

10.8 Summary of motor MVE protocol elements

This chapter sets out monitoring, verification and enforcement (MVE) protocols for motors, building on the general procedures of Part A, Chapter 8 [1].

10.1 Objectives and scope of motor MVE

Motor MVE aims to keep motors below the required class out of the market, to verify that declared efficiencies are true, and to reach motors that arrive inside equipment. Because motors are marked with their IE class, much of the enforcement can be done by inspection of rating plates and documentation; laboratory testing is reserved for verifying declared values.

10.2 Check-testing procedures for motors

The U4E model regulation and the EU regulation use the same sequence [4, 5]:

1. One motor of the design is taken from the market and tested to IEC 60034-2-1.

2. It complies if its measured efficiency is not less than the declared nominal efficiency after allowing the tolerance on losses (Table 13).
3. If it fails, three further motors of the same design are tested, and the design complies if their average meets the requirement (except for designs produced in very small numbers).

Motor testing requires a load test bench and takes about a day per motor. For most Member States, the practical arrangement is to contract accredited laboratories in the region or abroad and to share testing programmes within the REC. Testing costs for full verification should be borne by the supplier when a design fails.

10.3 Sample selection methodology

- **Risk-based selection**: prioritise high-volume ratings (typically 4-pole motors of 1.5–37 kW), unknown brands, low prices, declared efficiencies just above the requirement, and suppliers with past failures.
- **Where to sample**: from distributors and equipment suppliers, not from the manufacturer.
- **Motors in equipment**: include pumps and fans whose integrated motors can be tested separately.
- **Annual target**: a stated number of designs each year, with priority to the core power range.

10.4 Border verification checklist for imported motors

TABLE 22 Border verification checklist for motors.

CHECK	WHAT CUSTOMS OR THE INSPECTOR VERIFIES
Registration	Model on the rating plate and documentation matches a registered model
Rating plate	IE class, nominal efficiency and year of manufacture marked; rated output and poles consistent with the declared HS line
Class	IE class at or above the requirement for the rated output
Equipment	Integrated motor in pumps, fans and compressors identified and compliant
Exemptions	Exemption claims (spare parts, special motors) supported by marking and documentation
Used motors	Treatment according to the regulation's provisions on second-hand motors

Source: AFREC, drawing on the U4E model regulation [4].

10.5 Distributor and workshop inspection checklist

- Motors in stock and in catalogues carry the IE class and registration number.
- No motors below the required class on sale after the sell-through period.
- Catalogues, quotations and tenders state the IE class and efficiency.
- Repair workshops follow the registered good-practice procedures where such a scheme exists (Section 7.4).

10.6 Non-compliance handling and enforcement actions

Part A, Chapter 8 sets out graduated penalties [1]. For motors, typical responses are: correction of missing marking or documentation; deregistration and stop-sale for a design that fails verification; withdrawal of non-compliant stock; and penalties for repeated or fraudulent non-compliance. The U4E model regulation provides for effective, proportionate and dissuasive sanctions, including publication of test results and of non-compliant suppliers [4]. Authorities should share non-compliance decisions with neighbouring countries so that the same design is not sold elsewhere in the region.

10.7 Key risk indicators for motors

TABLE 23 Key risk indicators for motors.

INDICATOR	WHY IT SIGNALS RISK
Price well below the market for the class	Possible overstatement of efficiency or false marking
Declared efficiency exactly at the requirement for many ratings	Possible declaration of class values rather than tested values
Missing or inconsistent rating-plate data	Possible non-compliant or relabelled motors
Motors declared as parts or under unusual descriptions	Possible evasion of border controls
Equipment with integrated motors from unknown sources	Motors reaching the market without registration
Complaints of overheating or failure	Poor design or poor repair

10.8 Summary of motor MVE protocol elements

TABLE 24 Summary of motor MVE protocol elements.

ELEMENT	MOTOR APPROACH
Registration	Registration-before-placement; family dossiers; mutual recognition
Border	Rating-plate and registration check; equipment with integrated motors
Market	Distributor and catalogue checks; repair workshop scheme
Testing	One unit, then three, to IEC 60034-2-1 with a tolerance on losses [4, 5]
Enforcement	Deregistration, stop-sale, publication; regional information sharing

CHAPTER

11

MEPS Implementation by Maturity Stage

IN THIS CHAPTER

11.1 Using the Africa MEPS Maturity Model for motors

11.2 Stage 0 – No motor MEPS programme

11.3 Stage 1 – Exploratory work for motors

11.4 Stage 2 – Minimum Viable motor MEPS programme

11.5 Stage 3 – Established motor MEPS programme

11.6 Stage 4 – Mature motor programme with continuous improvement

11.7 Summary: motor MEPS by maturity stage and regional support

This chapter applies the Africa MEPS Maturity Model of Part A, Chapter 1 to electric motors. The model has five stages; Table 25 reproduces Part A's definitions [1].

11.1 Using the Africa MEPS Maturity Model for motors

TABLE 25 The five stages of the Africa MEPS Maturity Model (Part A, Chapter 1).

STAGE	NAME	DEFINITION IN PART A
0	No programme	No functioning MEPS programme for any product category; no enabling legislation, lead agency, registration database or MEPS-specific surveillance.
1	Exploratory	Deliberate work begun but no mandatory standards adopted; lead agency designated, draft regulation under preparation, voluntary or pilot programmes may exist.
2	Minimum Viable	Mandatory MEPS launched for at least one product category, with functioning registration, basic surveillance and customs integration, operating with limited resources.
3	Established	A functioning programme across multiple product categories with the supporting institutional machinery in place.
4	Mature with continuous improvement	A mature programme engaged in continuous improvement, technology adaptation and continental coordination.

Source: Part A, Chapter 1 [1].

Motors are well suited to an early stage of a national programme: the metric is international, requirements can be checked from the rating plate, and the number of suppliers is smaller than for consumer products.

11.2 Stage 0 – No motor MEPS programme

- Review motor requirements in trading partners and neighbouring countries.
- Map motor imports using customs data for HS 8501 and motor-driven equipment.
- Survey distributors to estimate the share of IE1, IE2 and IE3 motors on sale.
- Engage large users — water utilities, mining, manufacturing — whose motors use most energy.

11.3 Stage 1 – Exploratory work for motors

- Adopt IEC 60034-1, IEC 60034-2-1 and IEC 60034-30-1 as national standards.
- Draft the regulation from the U4E model regulation or a trading-partner regulation.
- Carry out LCCA for representative motors (Chapter 6).
- Agree access to accredited test laboratories for check-testing.
- Survey repair workshops and their practices.

11.4 Stage 2 – Minimum Viable motor MEPS programme

- Make registration and rating-plate marking mandatory; apply the requirement to three-phase motors in the core range.
- Check rating plates at the border and at distributors.
- Run a first check-testing round through a regional or foreign laboratory and publish results.
- Launch repair good-practice guidance.

11.5 Stage 3 – Established motor MEPS programme

- Extend scope to small, single-phase and Ex eb motors and to motors in equipment.
- Introduce requirements for variable speed drives.
- Establish a registration or accreditation scheme for repair workshops.
- Link registry data to public procurement and industrial efficiency programmes.

11.6 Stage 4 – Mature motor programme with continuous improvement

- Review requirements and consider IE4 for long-hour ranges.
- Move towards system-level requirements and incentives.
- Offer testing and training services to neighbouring countries.
- Contribute to continental coordination through AFREC and to standards work through ARSO and AFSEC.

11.7 Summary: motor MEPS by maturity stage and regional support

TABLE 26 Stage-specific priorities for motor MEPS and the support available from regional centres.

STAGE	MOTOR PRIORITY	SUPPORT FROM REGIONAL CENTRES AND CONTINENTAL BODIES
0	Benchmark trading partners; customs mapping; distributor survey	Regional market assessments; policy briefs; peer exchange
1	Adopt IEC standards; draft regulation; LCCA; laboratory access	Template regulations; LCCA tools; training of officials
2	Registration and marking; border and distributor checks; first test round	Shared access to motor test laboratories; customs and inspector training
3	Scope extension; drives; repair workshop scheme	Regional registry interoperability; mutual recognition; technician training
4	Review; IE4; system measures; regional services	Continental coordination through AFREC; standards through ARSO and AFSEC

Source: Regional centres: ECREEE (ECOWAS), EACREEE (EAC), SACREEE (SADC), RCREEE (Arab region, including North Africa) and CEREEAC (ECCAS) — Part A, Chapter 12.

KEY TAKEAWAYS — CHAPTERS 9 TO 11

- Registration-before-placement, with family dossiers and mutual recognition, keeps the burden on suppliers low.
- Rating-plate checks do most of the enforcement work; laboratory tests verify declared values one unit, then three.
- Motors in imported equipment and repair workshops need explicit procedures.
- Motors are well suited to an early stage of a national MEPS programme.

CHAPTER

12

Supportive Measures

IN THIS CHAPTER

12.1 Role of supportive measures in motor programmes

12.2 Financial and fiscal incentives

12.3 Awareness and information

12.4 Capacity building for motor programmes

12.5 Green public procurement

12.6 Industrial and utility programmes

12.7 Summary of supportive measures for motors

MEPS remove the least efficient motors from the market. Supportive measures extend the savings to the installed base and to motor systems, where most of the remaining potential lies.

12.1 Role of supportive measures in motor programmes

Motors last for decades and are repaired many times, so a regulation on new motors changes the installed base only slowly. And because the largest savings come from system optimisation — drives, right-sizing, efficient pumps and fans — a programme that stops at MEPS captures only part of the potential [2, 6]. Supportive measures address both gaps.

12.2 Financial and fiscal incentives

- **Replacement incentives** for old, oversized or repeatedly rewound motors, tied to registered motors at or above the national requirement and to scrapping of the old motor.
- **Credit lines and energy service contracts** for industrial and municipal motor-system projects, where savings repay the investment.
- **Utility programmes** that fund drives and efficient motors in water pumping and industry where they reduce peak demand.
- **Import duty or tax relief** on efficient motors and drives, targeted at the classes above the MEPS.

12.3 Awareness and information

- Publish the registry with IE class and efficiency for every registered motor.
- Provide repair-or-replace guidance based on life-cycle cost for maintenance managers.
- Train procurement officers to specify IE class, efficiency and registration in tenders.
- Work through industry associations and equipment suppliers, who are the main source of advice.

12.4 Capacity building for motor programmes

- **Testing laboratories.** A regional motor test facility, accredited to ISO/IEC 17025 for IEC 60034-2-1, serving several Member States.
- **Customs and inspectors.** Training on rating plates, IE classes, HS classification and motors in equipment.
- **Repair workshops.** Training in efficiency-preserving rewinding to IEC 60034-23 and recognised good-practice guidance, with access to basic test equipment [12, 58].
- **Energy auditors and engineers.** Training in motor-system assessment and drive application, using IEC TS 60034-31 [49].

12.5 Green public procurement

Water utilities, public works and state-owned industries are among the largest buyers of motors and pumps. Requiring registered motors at or above the national requirement — or at a higher class such as IE4 for long-hour applications — and repair by registered workshops creates a stable market for efficient products and demonstrates the regulation's credibility.

12.6 Industrial and utility programmes

Energy audits, energy management systems and motor-system optimisation programmes deliver the system savings that MEPS cannot. Variable speed drives can improve the energy performance of systems that run below rated speed by up to 40% [6]. National programmes can link these activities to the registry, for example by requiring that motors replaced after an audit be registered efficient models.

12.7 Summary of supportive measures for motors

TABLE 27 Summary of supportive measures for motors.

MEASURE	PURPOSE	EXAMPLE
Replacement incentives	Accelerate turnover of the installed base	Grants or loans tied to registered motors and scrapping
System programmes	Capture savings beyond MEPS	Audits, drives, pump and fan optimisation
Repair workshop scheme	Preserve efficiency of repaired motors	Registered workshops following IEC 60034-23
Awareness	Inform professional buyers	Registry; repair-or-replace guidance; tender specifications
Capacity building	Testing, inspection and repair skills	Regional test laboratory; technician training
Public procurement	Create demand above MEPS	Specifications for water utilities and public works

CHAPTER

13

Case Studies and Lessons Learned

IN THIS CHAPTER

13.1 European Union: staged progression from IE2 to IE4

13.2 China: moving the world's largest producer to IE3

13.3 United States: nameplate marking and certification

13.4 South Africa: a compulsory specification at IE3

13.5 Egypt: IE3 with a transition period

13.6 Ghana: broad scope with a mandatory label

13.7 Kenya: a label without a minimum

13.8 Cross-cutting lessons and recommendations

This chapter presents motor programmes from Africa and elsewhere, drawn from the countries for which public information is available.

13.1 European Union: staged progression from IE2 to IE4

The EU introduced motor MEPS in 2011 at IE2, moved to IE3 (or IE2 with a drive) in 2015–2017, and under Regulation (EU) 2019/1781 extended scope to 0.12–1,000 kW and required IE4 for 75–200 kW from July 2023 [5, 30]. It also regulated variable speed drives. The Commission expects the motor and drive regulations together to save about 106 TWh a year by 2030 [31].

- **Lesson**: a pathway announced in advance, with each step dated, lets manufacturers plan and lets regulators raise requirements without disruption.
- **Lesson**: regulating drives alongside motors begins to address system efficiency.

13.2 China: moving the world's largest producer to IE3

China, the world's largest motor producer, made IE3 the minimum for motors of 0.12–1,000 kW from 1 June 2021 under GB 18613-2020, with higher grades shown on the China Energy Label [35].

- **Lesson**: because China, the world's largest motor producer, requires IE3 at home, IE3 motors are widely available from Chinese suppliers to African importers [35].

13.3 United States: nameplate marking and certification

The United States has required NEMA Premium efficiency for general purpose motors of 1–500 hp since 2016, enforced through manufacturer certification and nameplate marking of nominal efficiency and a certification number [20, 32]. Its 2023 rule extends scope and raises some ranges to IE4-equivalent levels from June 2027 [33].

- **Lesson**: for professional buyers, a nameplate efficiency and certification number can do the work of a consumer label.

13.4 South Africa: a compulsory specification at IE3

South Africa's compulsory specification VC 9113 requires IE3 for motors of 0.75–375 kW with 2, 4, 6 or 8 poles, effective from 3 June 2025 [7]. Motors must receive a Letter of Authority from the National Regulator for Compulsory Specifications before sale [7].

- **Lesson**: an existing pre-market approval system for other products can be extended to motors.
- **Lesson**: moving directly to IE3 aligned South Africa with its main trading partners.

13.5 Egypt: IE3 with a transition period

Egypt's Ministerial Decrees 463/2020 and 474/2020 required IE3 for three-phase cage induction motors of 0.75–375 kW, locally made or imported, after an 18-month transition, with the IE code marked on the rating plate within six months [21]; the national standard ES 2623-3 was revised in 2023 [21]. Industrial motor systems used an estimated 60% of Egypt's manufacturing electricity in 2015 [14].

- **Lesson**: a defined transition — shorter for marking, longer for the efficiency class — gives suppliers and local producers time to adapt while making the class visible early.

13.6 Ghana: broad scope with a mandatory label

Ghana's L.I. 2456 of 2022 covers single- and three-phase induction motors of 0.12–1,000 kW [22] at IE2, with a mandatory 1–5 star label [6]; it is administered by the Energy Commission and entered into force on 2 November 2022 with a one-year transition [23].

- **Lesson:** an established appliance labelling programme can be extended to motors with a wide scope from the start.

13.7 Kenya: a label without a minimum

Kenya's 2016 regulations require three-phase cage induction motors to be registered and labelled with a star rating linked to the IE classes (IE1 = 1 star, IE2 = 2 stars, IE3 = 3 stars) [24]. Motors rated IE1 have been approved for sale [25].

- **Lesson:** a mandatory label informs buyers, but without a minimum class the least efficient motors remain on the market.

13.8 Cross-cutting lessons and recommendations

TABLE 28 Cross-cutting lessons from motor programmes.

LESSON	EVIDENCE	RECOMMENDATION
Use international classes and tests	All programmes reviewed use IEC 60034-30-1 and IEC 60034-2-1, or equivalent North American methods [20, 50]	Adopt the IEC standards and accept accredited test reports
Stage and date the pathway	EU 2011–2023; Egypt transition	Announce each step and its date at adoption
Combine a minimum with information	Kenya (label only) compared with Ghana and Egypt	Pair marking or labelling with a minimum class
Reach motors in equipment	EU and U4E scope	Cover integrated motors in scope, registration and customs checks
Protect the installed base	Rewinding studies; Ethiopia requirement	Promote good-practice repair and replacement
Look beyond the motor	EU drive requirements; system savings	Regulate drives and support system programmes

CHAPTER

14

Tools, Resources, and Cross-References to Part A Handbook Suite

IN THIS CHAPTER

14.1 Tools and resources for motor MEPS

14.2 Cross-references to Part A

14.1 Tools and resources for motor MEPS

TABLE 29 Tools and resources for motor MEPS and labelling.

RESOURCE	PROVIDER	USE
Model regulation guidelines for general purpose electric motors (2025)	UNEP U4E	Template regulatory text, efficiency tables, verification and drive module [4]
Policy guide for energy-efficient motor systems (2025)	UNEP U4E	Supporting policies for motor systems [6]
Regional savings assessments	UNEP U4E and AFREC	Estimated savings from motor MEPS in African regions [15]
Electric Motor Systems Platform (EMSA)	IEA 4E	Policy briefs, MEPS map and technical guidance [13, 59]
IEC TS 60034-31	IEC	Selection of efficient motors and variable-speed applications [49]
Good practice guide to maintain motor efficiency	EASA and AEMT	Efficiency-preserving repair [58]
Premium efficiency motor selection and application guide	U.S. DOE	Motor selection, losses and system practice [3]
Part A companion deliverables and self-assessment framework	AFREC	Country self-assessment, inter-agency MOU templates and implementation tools (Part A, Chapter 15)

14.2 Cross-references to Part A

Table 30 lists the Part A chapters, using the numbering established in Part A, and the sections of this handbook that apply them to motors.

TABLE 30 Cross-references to Part A.

PART A CHAPTER	PART A TITLE	WHERE APPLIED IN THIS HANDBOOK
1	The Africa MEPS Maturity Model	Chapter 11
2	Why MEPS Matters for Africa	Chapter 3
3	MEPS and Energy Labelling Fundamentals	Chapters 5 and 8
4	Global and Regional Practice	Chapter 4
5	Policy and Regulatory Context for Africa	Sections 1.3 and 7.7

6	MEPS Development Methodology	Chapter 6
7	Implementation and the Minimum Viable MEPS Pathway	Sections 6.5 and 11.4
8	Monitoring, Verification and Enforcement (MVE)	Chapters 9 and 10
9	Stakeholder Engagement and Change Management	Section 6.1 (Step 6)
10	Financing and Sustainability	Section 12.2
11	Capacity Building, Awareness, and Social Inclusion	Sections 12.3 and 12.4
12	Continental Coordination and Regional Harmonization	Sections 5.8 and 4.2
13	Cross-Cutting Themes	Sections 7.3, 7.4 and 7.5
14	Case Studies: Successes, Struggles, and Cross-Cutting Lessons	Chapter 13
15	Tools, Resources, and the Country Self-Assessment Framework	Section 14.1

Source: Chapter numbering as in Part A [1].

CHAPTER

15

Product-Specific Glossary and References

B

IN THIS CHAPTER

15.1 Motor-specific glossary of key terms

15.2 References for motor MEPS and energy labelling

15.1 Motor-specific glossary of key terms

TABLE 31 Motor-specific glossary of key terms.

TERM	DEFINITION
Additional (stray) load losses	Losses in a loaded motor not accounted for by winding, iron, friction and windage losses [10].
Direct-on-line operation	Operation of a motor connected directly to the supply without a converter.
Duty type (S1, S3, S6)	Classification of a motor's load cycle in IEC 60034-1; S1 is continuous running duty [48].
Ex eb motor	An increased-safety motor for use in explosive atmospheres.
IE class	International efficiency class (IE1 to IE5) for line-operated AC motors under IEC 60034-30-1 [11].
Induction motor	An AC motor in which the rotor current is induced by the rotating field of the stator.
Method 2-1-1B	The IEC 60034-2-1 test method in which losses are summed and additional load losses are determined from residual losses [10].
Motor system	The supply, drive, motor, transmission and driven machine that together deliver a mechanical service.
Nominal efficiency	The representative full-load efficiency declared for a motor design [4].

Poles	The number of magnetic poles of the stator winding, which sets synchronous speed (3,000 rpm for 2 poles at 50 Hz).
Rated output	The mechanical power a motor delivers at its shaft under rated conditions (kW).
Rewinding	Replacement of a motor's stator winding during repair [12].
Variable speed drive (VSD)	A power electronic converter that controls motor speed and torque by varying the supply frequency and voltage.
Voltage unbalance	The maximum deviation of any line voltage from the average of the three line voltages, expressed as a percentage of that average [54].

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