



Energy Efficient End-use Equipment
International Energy Agency



Electric Motor Systems
EMSA

A background image showing a factory setting with several electric motor stators and rotors. A worker is visible on the left, working on a component. The image is overlaid with a semi-transparent orange banner containing the title text.

Supporting the energy transition in the electric motor sector through EMSA

the IEA 4E Electric Motor Systems Platform (EMSA)

Roland Brüniger – EMSA Electric Motor Systems Platform Chair

www.iea-4e.org/emsa

Content

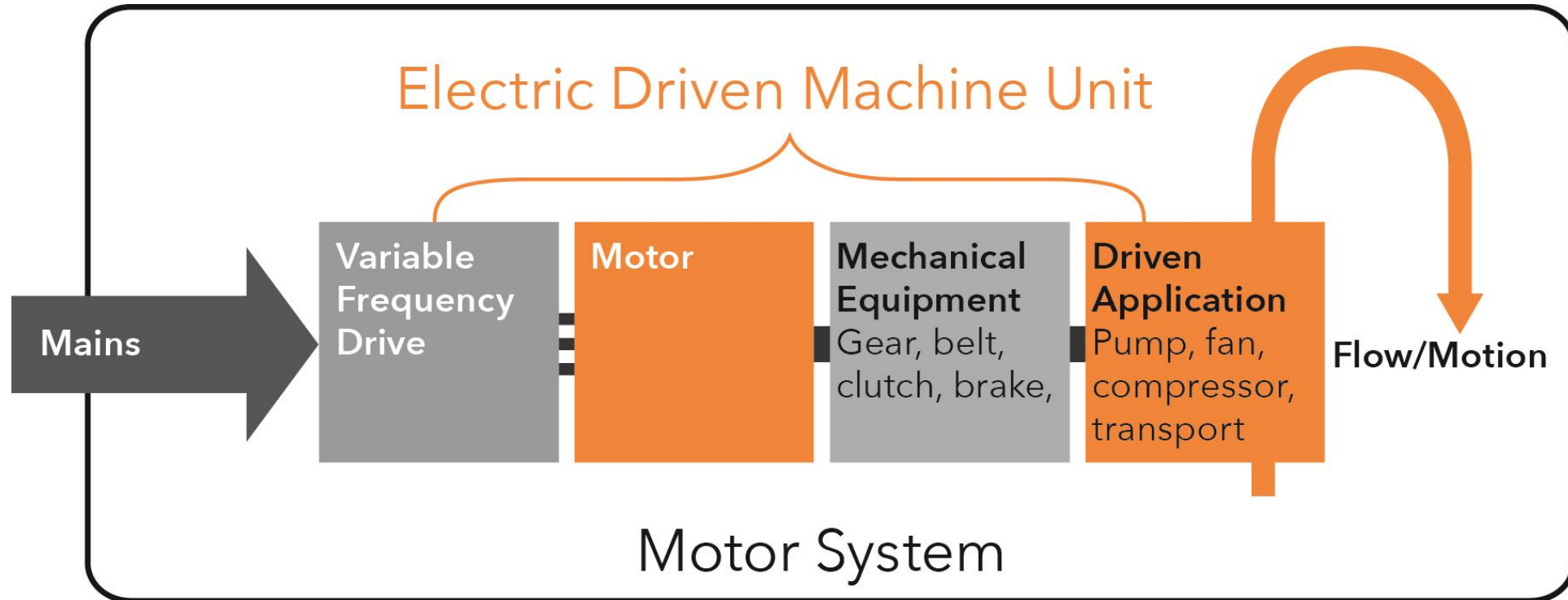
1. Introduction

2. Major EMSA work results 2019 – 2024

3. EMSA work 2024 - 2029

An electric motor system with different components is complex

Average savings potential on system level: 20 – 30%



$$\eta_{\text{System}} = \eta_{\text{VFD}} * \eta_{\text{Motor}} * \eta_{\text{Gear}} * \eta_{\text{Belt}} * \eta_{\text{Driven application}}$$

IEA TCP 4E Electric Motor Systems Platform (EMSA)

Technology Collaboration Programme
by IEA



IEA TCP 4E Energy Efficient End-Use Equipment

- Energy efficient equipment
- 15 members (EMSA + CA, CN, FR, JP, KR, UK)

Electric Motor Systems Platform (EMSA)

- Raise awareness, share information, initiate collaborative projects and transfer experience *to support effective policy development for energy efficient electric motor systems*
 - International standards, testing, coordination
 - Digitalisation and demand flexibility in motor systems
 - Motor Systems Tool, expert pool
- 9 members (AU, AT, DK, EC, NL, NZ, SE, CH, US)



www.iea-4e.org/emsa

IEA TCP 4E Electric Motor Systems Platform (EMSA)

EMSA liaises with...



EMSA levels of impact



EMSA: a source of reference for policy makers

EMSA facilitates that policy makers have:

- access to **relevant, reliable, independent, first-hand information** for their decisions
- access to **information on** expected **challenges** and gain **awareness on the most relevant issues** for successful policy implementation
- access to **best practices and tools** for their national policies to speed up the market transformation for motor systems
- a **forum for discussion through the EMSA meetings** of relevant issues for their national policy making, exchanging on differences and if deemed useful on any potentials for alignment
- the support of taking up **relevant standards** into national legislation, which are to be developed in a way that are suitable for this purpose.



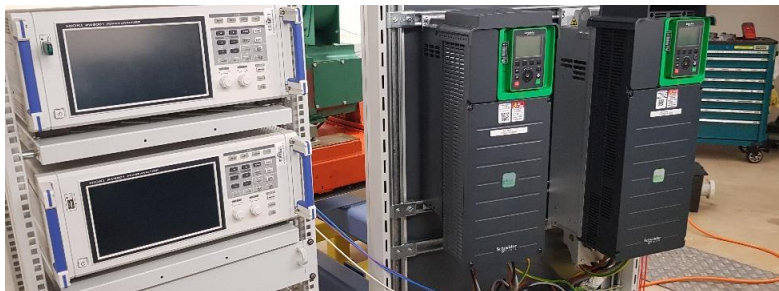


Major EMSA work results 2019 - 2024

International Round Robin for Variable Speed Drives (1/3)

Goal: determine whether

- **current energy efficiency test methods (IEC 61800-9-2) provide accurate /repeatable results**
- **level of reference losses** described in these provide a sufficient incentive to encourage greater levels of efficiency.
- **First publicly available independent study** that examined efficiency of Variable Speed Drives (VSDs)
- From **2017 to 2022** with **8 laboratories**
- **172 tests** on **52 different VSDs** of **0.12 kW to 55 kW**



©Photograph: Berne University of Applied Sciences

Results:

- The **uniform testing** protocol assured highly **repeatable** and accurate results and **helped IEC eliminate ambiguities in the second revision of IEC 61800-9-2.**
- The losses of all VSDs are below the threshold for IE2 → complying to most efficient level
- Possible and beneficial **policy options** are:
 - Introducing **global (not only EU) Minimum Energy Performance Standards (MEPS) for VSDs**
 - Introducing **information requirements for additional part load duty points**
 - Inputs for other policies that stimulate **improving efficiency at a system level.**

International Round Robin for Variable Speed Drives (RR'C) (2/3)

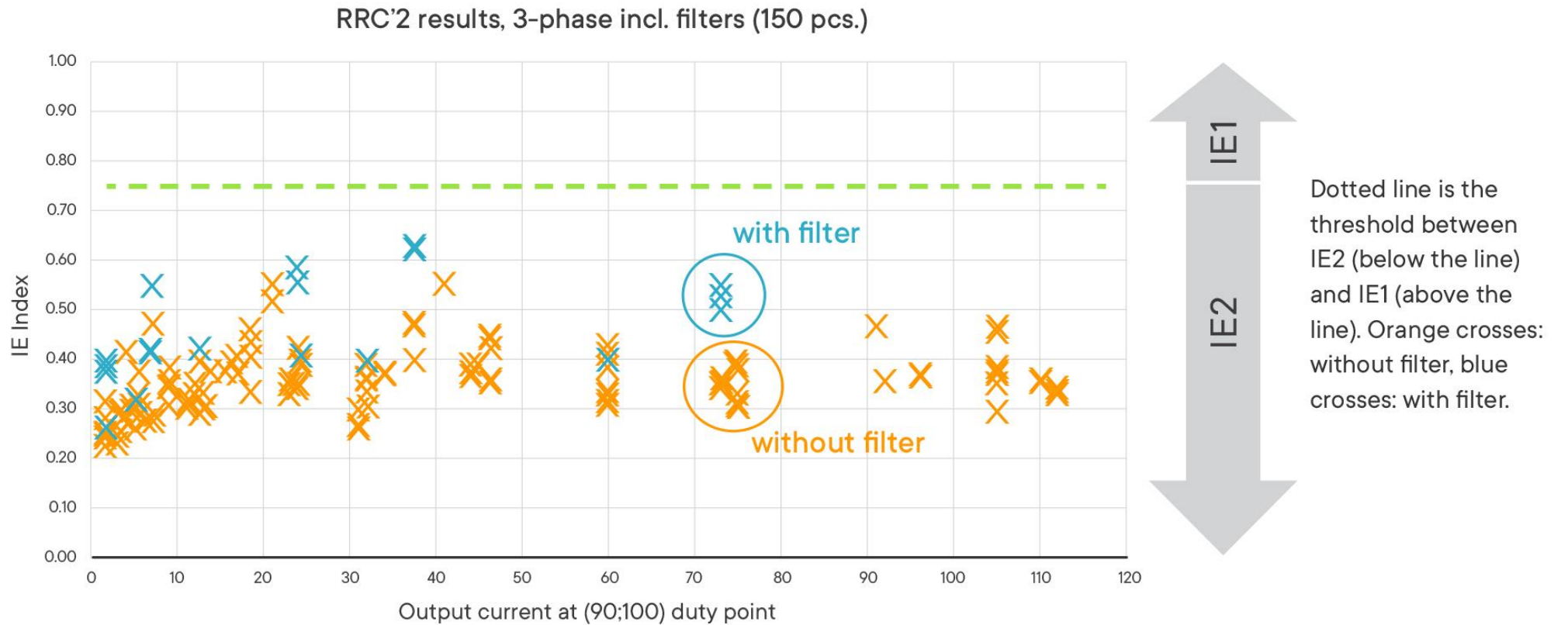


Figure 3: IE-index for 3-phase Basic Drive Modules over nominal output current at (90:100) duty point.

EMSA's input helped to eliminate ambiguities in the second revision of IEC 61800-9-2.

More on the Round Robin for Variable Speed Drives (3/3)

[Full report](#)



4E Electric Motor Systems
EMSA

Photo: BFH

Report on Round Robin of Converter Losses
Final Report of Results

Elaborated by: DTI, Denmark and BFH, Switzerland

November 2022

Technology Collaboration Programme
by IEA

Summary of key findings: [EMSA Policy Brief #6](#)



4E Electric Motor Systems
EMSA

Round Robin for Variable Speed Drives

EMSA6
UPDATED

Energy Efficient End-use Equipment
International Energy Agency

ENERGY EFFICIENCY POLICY BRIEF

The 4E Electric Motor Systems Annex (EMSA) promotes the opportunities for energy efficiency in motor systems by disseminating best practice information worldwide. It supports the development of internationally aligned test standards and policies to improve the energy performance of new and existing motor systems with the aim of achieving 20% to 30% energy savings.

Variable speed drives (VSD) attached to motors adjust the power output to meet the requirements of the end-use application and this can lead to large energy savings. However, there are energy losses associated with VSDs which affect their overall energy efficiency.

EMSA in cooperation with the International Electrotechnical Commission (IEC) launched the project to determine whether the current energy efficiency test methods provide accurate and repeatable results and if the level of reference losses described in these provide a sufficient incentive to encourage greater levels of efficiency. The test method to determine the losses in variable speed drives (and hence their efficiency) is described in two IEC standards¹.

In this EMSA organised international Round Robin, independent testing laboratories in Australia, Denmark, Switzerland and the USA were funded by EMSA members.

This Policy Brief summarises the key findings of the Round Robin for converter losses.

Observations for Policy Makers

- This Round Robin ran from 2017 to 2022 and is the first publicly available independent study that has systematically examined the efficiency of VSDs.
- During the Round Robin, 8 laboratories performed a total of 172 tests on 52 different converters in the range of 0.12 kW to 55 kW according to the uniform testing protocol devised for this project.
- This protocol has proven itself by returning highly repeatable and accurate results from a broad range of VSDs on the market and helped the IEC to eliminate ambiguities in the second revision of IEC 61800-9-2.
- The participation of independent test laboratories and the cooperation with IEC were crucial to the success of this project.
- The European Union, Switzerland and the UK were the first economies to adopt Minimum Energy Performance Standards (MEPS) for VSDs in July 2021.
- MEPS in these economies are set at the IEC level, which is currently the highest (most efficient) class for VSDs specified in the relevant standards.
- The Round Robin has shown that the introduction of additional IE classes could enable further differentiation of VSDs, however, may not bring substantial added value in terms of energy savings. For many applications, energy can be saved effectively through variable speed control, reducing the losses in part load operation.

¹ IEC 61800-9-2:2017 Adjustable speed electrical power drive systems - Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their drive applications - Energy efficiency indicators for power drive systems and motor starters, IEC TS 60034-2-3:2013 Rotating electrical machines - Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motors. Replaced by IEC 60034-2-3:2020 during the Round Robin Converters (RRC).

MORE INFORMATION Further information is available here on the EMSA website: www.iea-4e.org/emsa and by contacting andrea.vezzini@bfh.ch and sbn@teknologisk.dk.

Published May 2023

Technology Collaboration Programme
by IEA

EMSA: a catalyst for ISO/IEC Joint Advisory Group JAG22

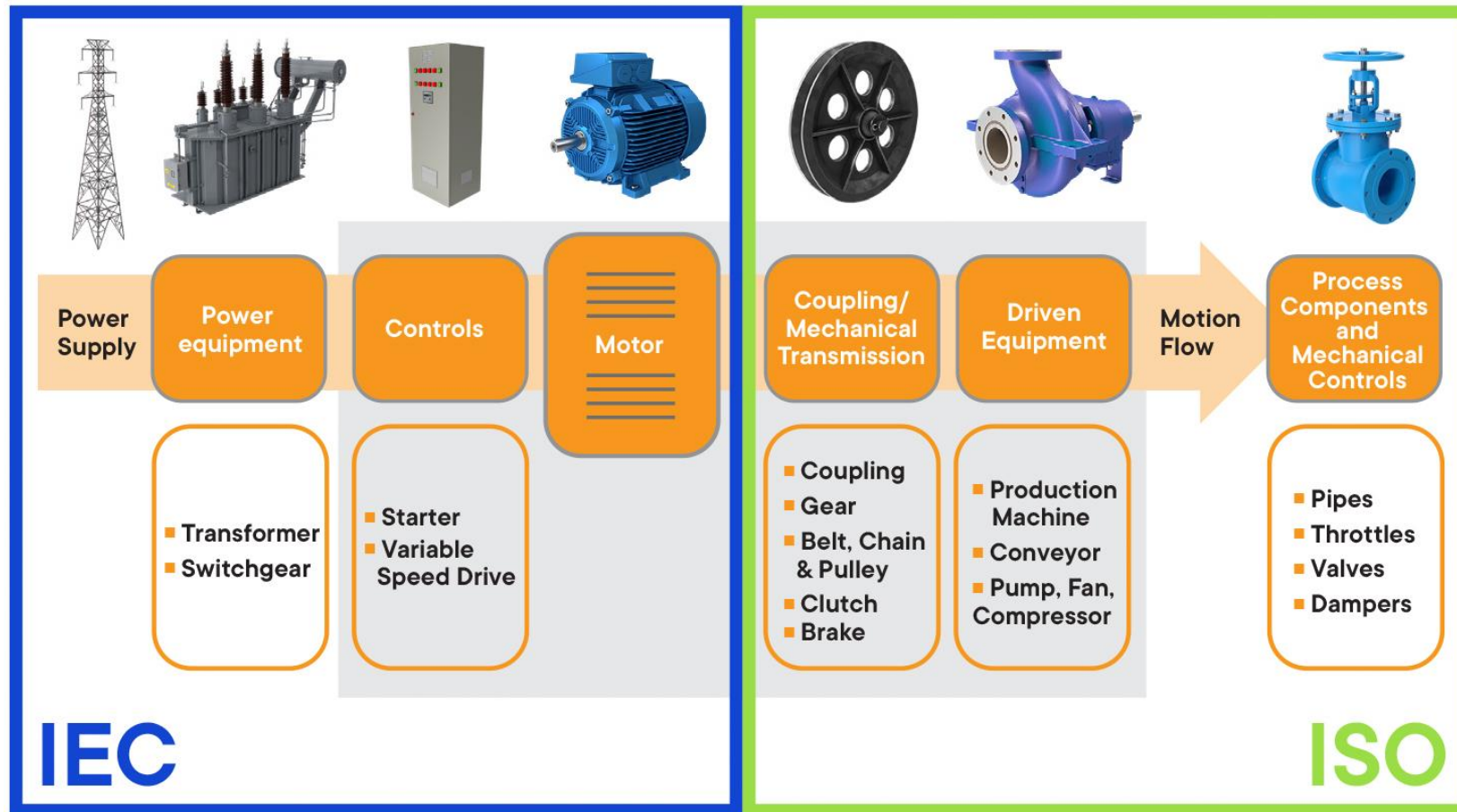


Figure 1: Scope of IEC and ISO for motor systems

More information: [EMSA Policy Brief #5](#)

EEMODS Wed 14:00 Policies IV: Conrad U. Brunner & Maarten van Werkhoven

How ISO and IEC work together to design Energy Efficient Electric Motor Driven Systems

- Elements of a motor system are covered by around **10 different IEC and ISO committees.**
- EMSA initiated a project to **increase the coordination and alignment of energy efficiency standards for motor driven systems.**
- Within two years (2023) the **ISO/IEC Joint Advisory Group JAG22** started.
- Concrete work is focusing on the **systems of fans, motors and converters.**

Digitalisation of motor systems (1/3)

Findings:

- Digitalisation aimed at achieving more efficient processes **requires collecting data** and information.
- Digitalisation creates therefore **transparency**: when and how is energy being used?
- The potential **savings can be significant and vary greatly**, depending on how data is used and to what extent systems are already optimised.
- Energy savings are not always the primary driver for digitalisation, **non-energy benefits** play a more decisive role.



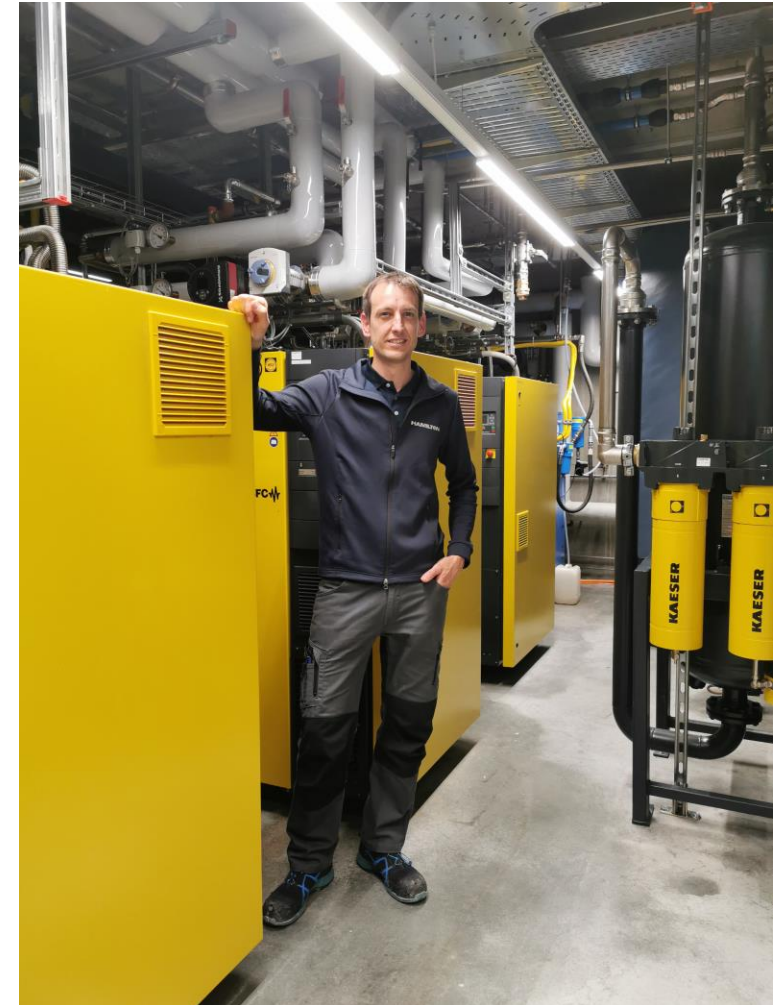
Digitalisation of motor systems (2/3)

Case study: Hamilton Bonaduz, Switzerland

- Produces medical devices and laboratory equipment
- Measures: adaptive air pressure management system, retrofit of compressors (2 out of 5 with a VSD)
- Result: compressors are run more efficiently by an optimised control, allowing a lower total system pressure
- 16% of electric energy saved, assuming the same amount of air volume produced

Before optimisation	After optimisation
Digital technology applied	
–	Intelligent control, real-time monitoring and digital twin
Air volume produced	
3'874'262 m ³	5'117'319 m ³ *)
Operating hours	
ca. 8'736 h/a	8'396 h/a
Electric energy consumption	
487'654 kWh/a	544'156 kWh/a *)
Energy per m³ compressed air	
126 Wh/m ³	106 Wh/m ³ *)
Specific power	
7.55 kW/(m ³ *min)	6.38 kW/(m ³ *min)
Cost of electric energy	
58'518.44 EUR (@0.12 EUR/kWh)	81'623 EUR (@0.15 EUR/kWh)

More information: [Catalogue of case studies](#)



®Photograph by Pascal Kienast

Digitalisation of motor systems (3/3)

Publications (2024)

- [Part I: Findings for policy makers \(includes a summary of Parts II – III - IV\)](#)
- [Part II: Technical recommendations for industrial end-users](#)
- [Part III: Catalogue of case studies](#)
- [Part IV: Energy consumption due to the digitalisation of electric motor systems](#)
- [Webinar: how can digitalisation enable savings in motor systems? \(recording, slides\)](#)

More information: EMSA Policy Brief #7 coming up and www.iea-4e.org/emsa/our-work/digitalisation

EEMODS Wed 16:00 Digitalisation I: Konstantin Kulterer
Barriers and Solutions to increase Energy Efficiency of Electric Motor Systems by Digitalisation

EEMODS Wed 16:30 Digitalisation III: Rita Werle
Energy consumption of digitalisation in motor systems

Roland Brüniger, EMSA, 3 Sep 2024

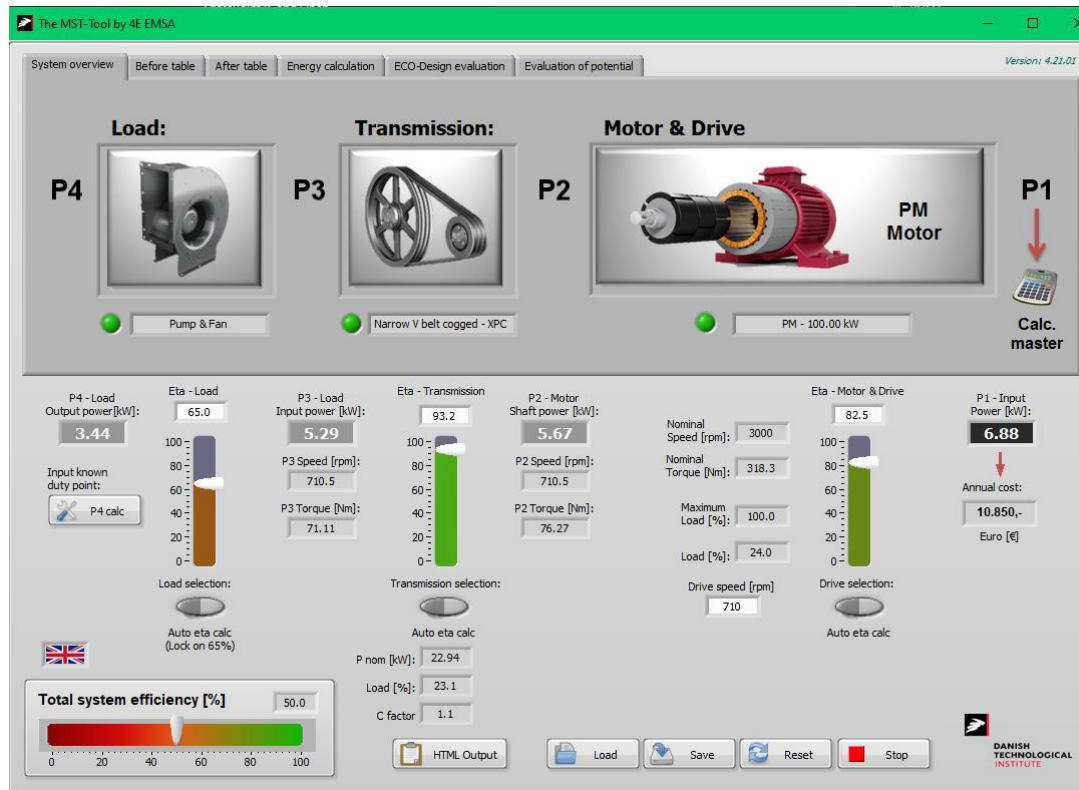
Case studies of digitalisation

Case studies of digitalisation of Electric Motor Driven Systems (EMDS)

Company	Role of digitalisation	Power equipment	Controls		Motor	Transmission	Application (PFCO)	Piping, other	Heat exchanger, other
			VSD	Control, sensor, gateway					
Yorkshire Water	P		S	X					
PRiOT	P			X				S	
IKEA	A			X					
Hamilton Bonaduz	A		X	X			X	S	S
BMW	P	S						S	
Innio Jenbacher	A	S						S	
Coca Cola HBC Austria	A		X						S
Smurfit Kappa	P								

EMDS = Electric Motor Driven System; VSD = Variable Speed Drive; PFCO = pump/fan/compressor
 ■ cases including hardware upgrades
 A = active role: digitalisation has a direct influence on the energy consumption of an EMDS
 P = passive role: digitalisation is an enabler for identifying savings (delivers information)
 X = components added to the EMDS
 S = sensor(s) added to the EMDS

EMSA Motor Systems Tool



- Independent calculator for complete motor systems, from power supply to application.
- Uses neutral models of standardised components to determine the efficiency at any given duty point and the total system efficiency.
- Recognised as a **unique, impartial tool** for standard makers, engineers, policy makers.
- Developed continuously, includes:
 - calculation model methods from **AMCA standards**
 - detailed **application calculator** for pumps, fans, compressors and hydraulic machines
 - **Ecodesign evaluator**.

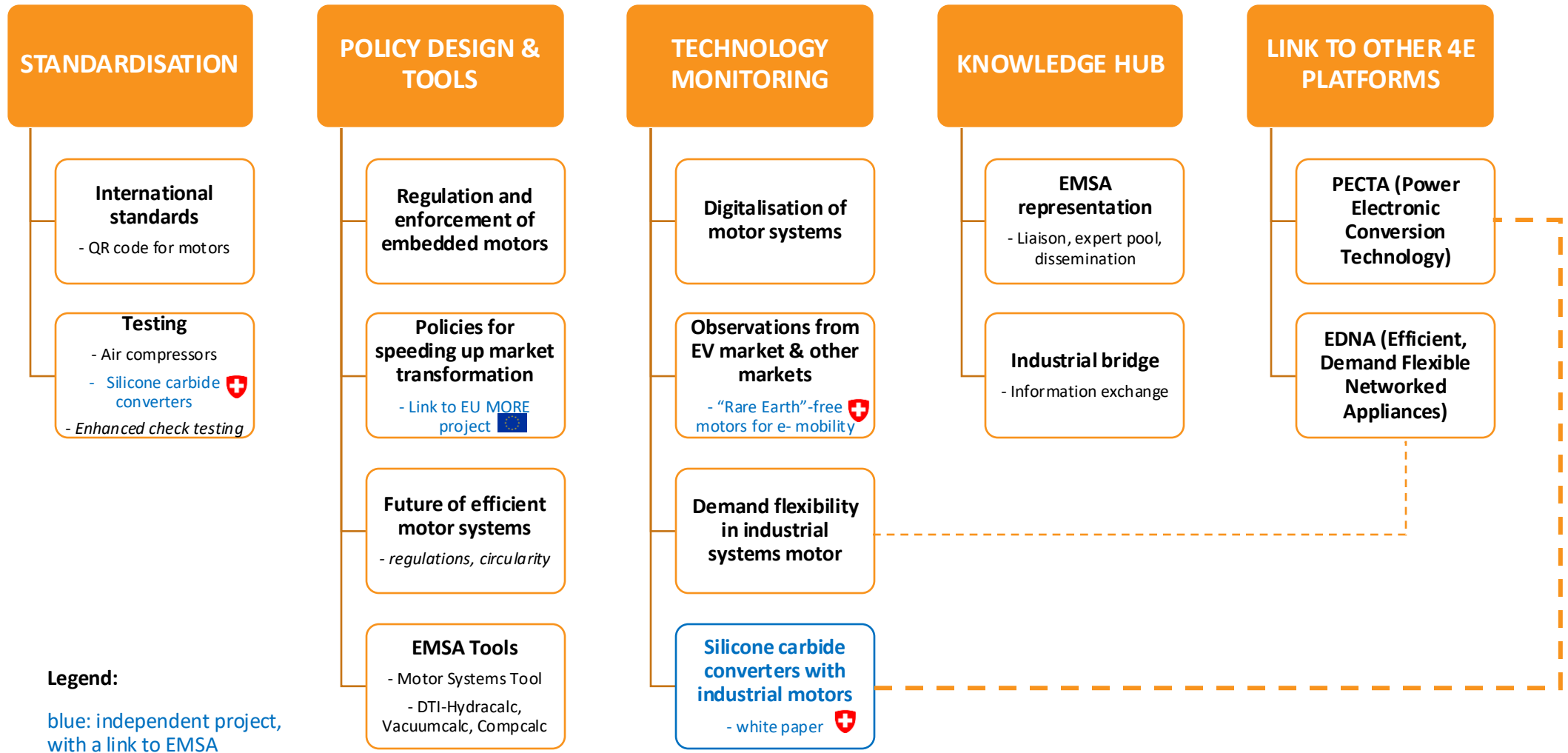
Download: www.iea-4e.org/emsa/our-work/emsa-tools/

For assistance and questions, contact the expert pool:
mst@iea-4e.org

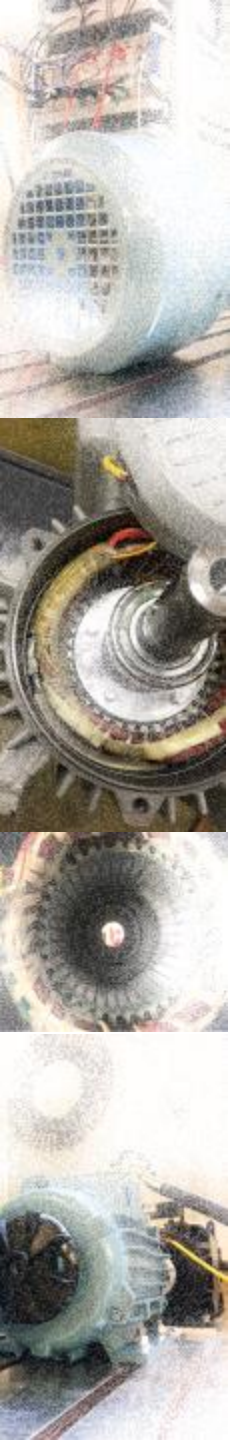


EMSA work 2024 - 2029

EMSA activities (2024 - 2029); Overview



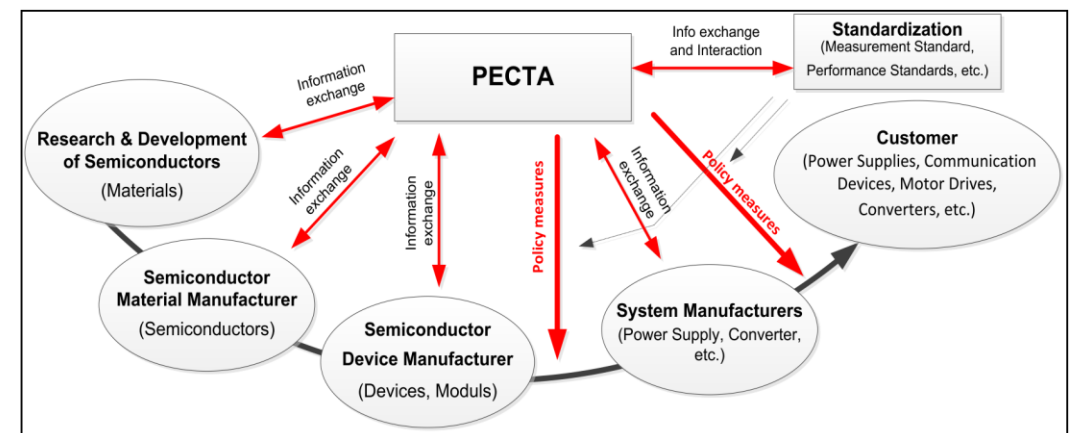
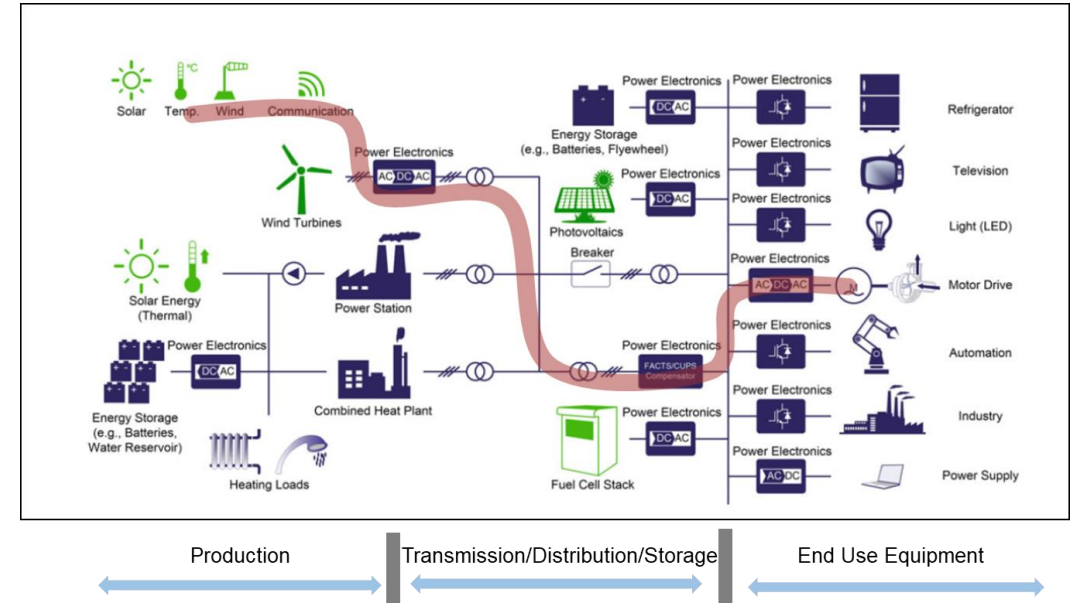
EMSA activities (2024 - 2029) → PECTA as cooperation partner



PECTA (Power Electronic Conversion Technology)


Goals of PECTA:

- **Generates broad knowledge** about wide bandgap (WBG).
- Engages a **unique network** of experts from academia and industry and **links with government officials**.
- **Develops** the ground for new and **innovative testing methods** to support standardization efforts (efficiency).
- Investigates topics of WBG technologies: **energy efficiency, reliability, market readiness and environmental impacts**.
- Enables **governmental approaches** for promoting WBG-based power electronics.



EMSA activities (2024 - 2029) in conjunction with PECTA

Wide Bandgap Industrial Inverter Research Roadmap 2024-2027

Silicone carbide converters with industrial motors
- white paper 

Research Topics

Aspects to consider

RT1: Application Readiness

- Cost comparison on component level
- Cost comparison on system level
- Cost comparison on holistic level
- Production capacity and availability
- Supply chain challenges

RT2: Design an Implementation

- Comparison of WBG multilevel topologies
- Potential of alternative topologies
- Requirements and design of input and output filter design and topologies
- Operational parameter optimization for optimal efficiency

RT3: Reliability and Durability

- State of the art prediction of MTBF
- Methods for WBG Reliability and Duration Testing
- Advances in modelling of WBG power semiconductor
- Standard and advanced thermal optimization technologies for WBG power semiconductors

RT4: Risks to Equipment

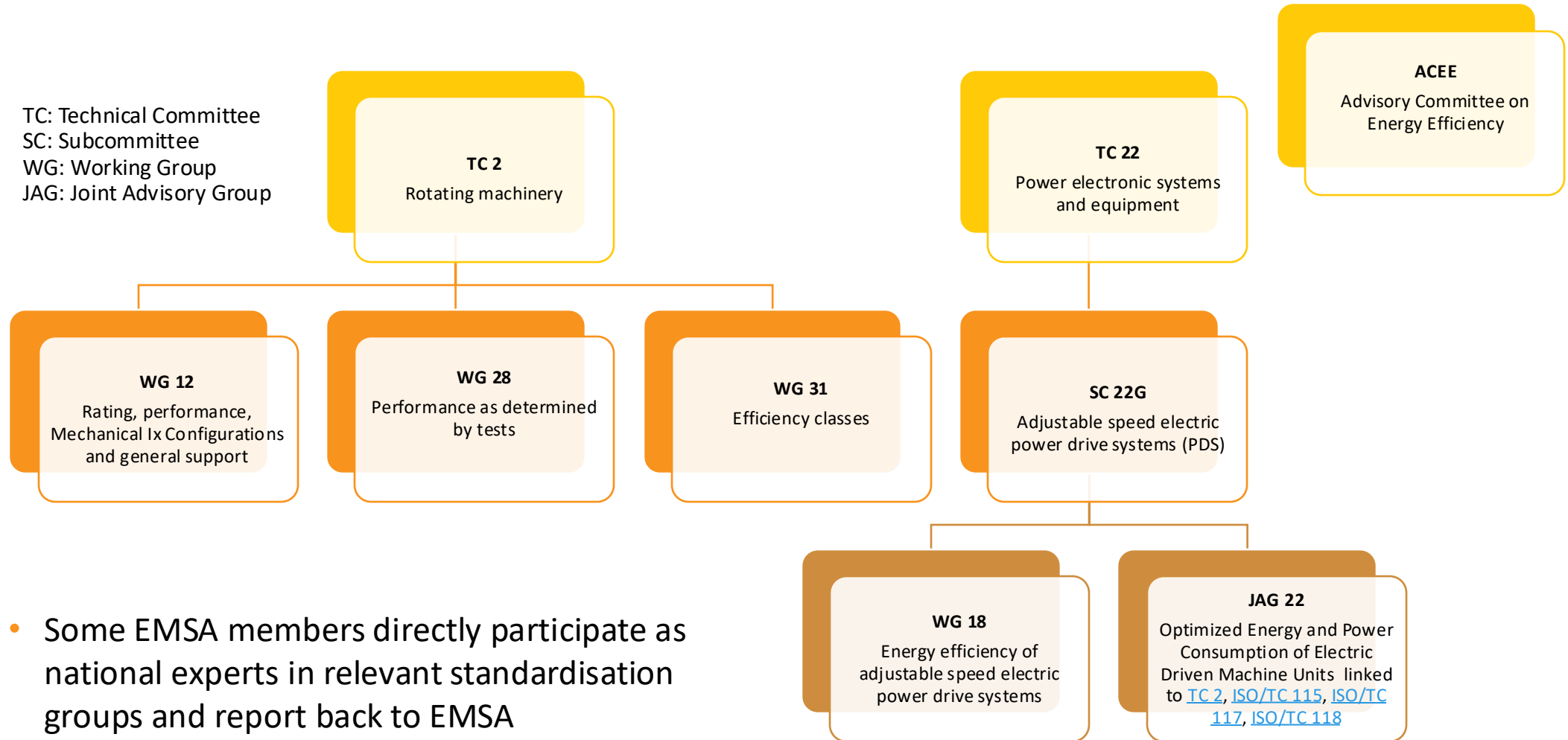
- Impact on bearings and insulation aging
- Impact on EMC Testing and EMC measures
- Increased measurement equipment accuracy for WBG inverter testing



→ Inputs for relevant topics are welcome

EMSA members in international standardisation

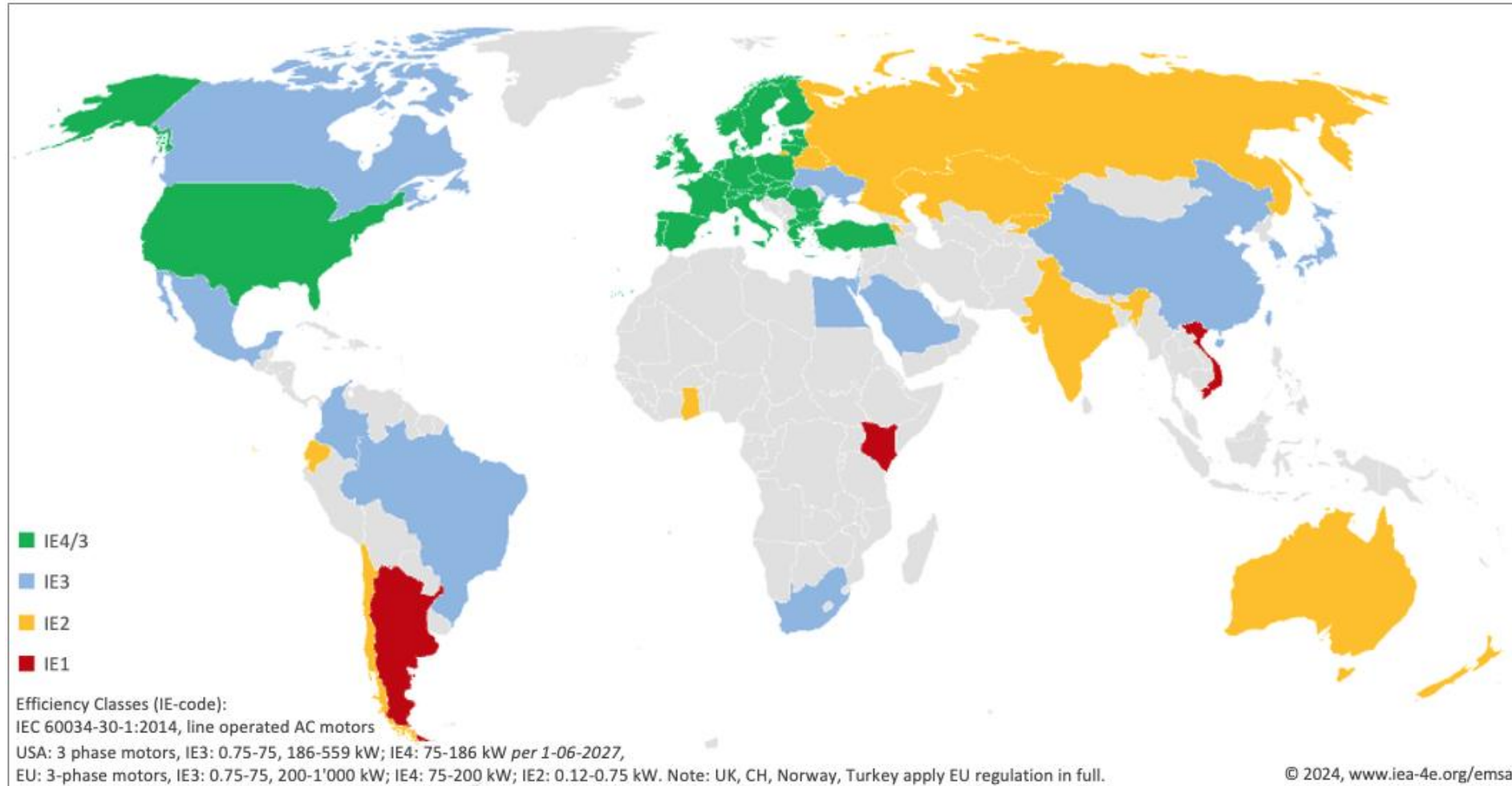
TC: Technical Committee
SC: Subcommittee
WG: Working Group
JAG: Joint Advisory Group



- Some EMSA members directly participate as national experts in relevant standardisation groups and report back to EMSA








Global overview of Minimum Energy Performance Standards (MEPS)

MEPS for motors



Coming up on www.iea-4e.org/emsa:
Additionally, MEPS for Variable Speed Drives, pumps, fans, compressors

Overview of relevant international standards

	Scope	Testing	Efficiency classification	Guidance
	motor	IEC 60034-2-1* standard motors IEC 60034-2-2 large machines	IEC 60034-30-1 fixed speed motors IEC 60034-30-3 high voltage motors	IEC 60034-31 IEC TS 60034-30-2 IEC 61800-9-1 IEC 61800-9-2
 	motor driven by a VFD	IEC 60034-2-3**	IEC TS 60034-30-2	
 	VFD			
 	motor+VFD		IEC 61800-9-2	IEC Guide 118

- Coming up on www.iea-4e.org/emsa
- Motors & VSDs
- Pumps
- Fans
- Compressors

preliminary

VFD: Variable Frequency Drive

*asynchronous fixed speed single & poly-phase and synchronous fixed speed poly-phase motors

**asynchronous variable speed single & poly-phase, permanent magnet, synchronous

Round Robin for air compressors

Goal:

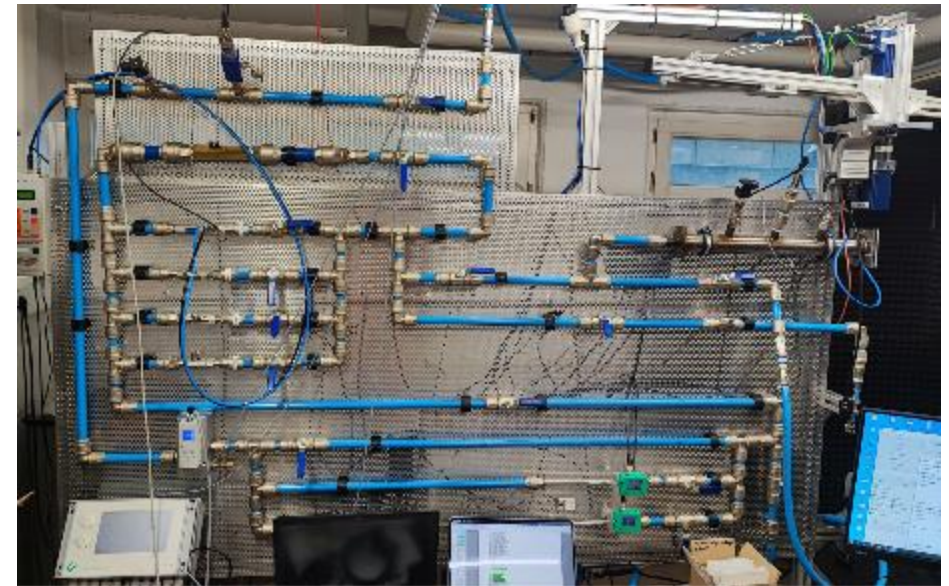
- Perform a round robin test exercise with two standard air compressor units
- Publish a guide to ISO 1217 and offer a calculator for isentropic efficiency by end of 2024

Labs involved:

- Australia: CalTest
- Denmark: Danish Technological Institute
- Germany: University of Stuttgart

More: download [project brief](#)

EEMODS Wed 16:00 Compressors III: Peter Radgen & al.
Round Robin for the Development of a Guide to the Measurement of Packaged Air Compressor Efficiency



®Photo of test rig layout, IER, University of Stuttgart, Germany

Coming up: Leonardo webinars with EMSA members

1. Sandie B. Nielsen (10 September 2024): [Registration](#)
The 4E EMSA Motor Systems Tool



2. Maarten van Werkhoven & Rita Werle (5 November): [Registration](#)
**Minimum Energy Performance Standards for motor systems:
Global overview**



3. Andrea Vezzini (21 November 2024): [Registration](#)
**Advancing industrial inverters:
The research roadmap for Wide Bandgap Power Semiconductors**



An initiative by



Coming up: IEC webinar with EMSA member

Maarten van Werkhoven &
Philippe Vollet & Andreas Schneider (12 September): [Registration](#)
**Addressing energy efficiency in standardization:
Learn about the new Guide 118**



This Webinar gives the unique opportunity to learn from energy efficiency experts about:

- Guide 118 Edition 2 and how it can support you in addressing energy efficiency in your publications.
- Case studies from two IEC committees about how they have incorporated energy efficient guidelines into their work.

These include IEC TC 100, who developed a standardized way of measuring networked power consumption, and IEC SC 22G and their contributions to energy savings policies for electric motor system



EEMODS and EMSA

EMSA members in the Organizing Committee



Prof. Dr. Andrea Vezzini

Professor for Industrial Electronics

Co-host:

Berne University of Applied Sciences



Rita Werle

Energy efficiency consultant

Co-organizer:

Impact Energy

EMSA contributions

- Speakers
- EEMODS'24 International Program Committee members
- Sponsoring



Looking forward to an interesting conference!

Keep in touch!

Subscribe to [EMSA newsletter \(EN/CN/JP/ES\)](#)

News

IE4: a minimum requirement for electric motors in the European Union and the USA

Motors with a rated output between 75 kW and 200 kW must meet the IE4 efficiency class in the European Union since 1 July 2023. From 1 June 2027, motors in the USA between 100 HP (75 kW) and 250 HP (186 kW) are required to meet IE4 as well. With these regulatory requirements the EU and the USA are the first jurisdictions in the world to require IE4 for certain electric motors, in a similar size range.



See the sections below with more details on the EU and US regulations concerning motor systems.

European Commission regulatory update

- **Motors & Variable Speed Drives** (EC 2019/1781): from 1 July 2023, **motors** with a rated output **between 75 kW and 200 kW must meet** the requirements of efficiency class **IE4** (or better). A review of the regulation was due in 2023 but delayed in view of competing priorities. It is expected to kick off in the course of 2024.
- **Circulators** (EC 641/2009): Impact Assessment paused due to competing priorities, to be resumed in due time with a view to a possible adoption by the end of 2026.
- **Pumps** (EC 547/2012): Impact Assessment received positive opinion and will be revised with a view to address the comments received. Further steps expected in 2024 with possible adoption in 2025.
- **Fans** (EC 327/2011): The final text of the review has been approved by the Regulatory committee in January 2024. Adoption and publication are expected by mid-2024, after scrutiny by EU Parliament and Council.
- **Air Compressors**: no new requirements are foreseen in near future.



[More information](#)

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4E Electric Motor Systems
EMSA

IEA 4E Electric Motor Systems

The 4E Electric Motor Systems Platform promotes opportunities for energy efficiency in electric motor systems worldwide.

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About

The 4E Electric Motor Systems Platform promotes the opportunities for energy efficiency in electric motor systems by disseminating best practice information worldwide. It supports governments in the design and implementation of policies for efficient motor systems. Furthermore, it supports the developme ... see more

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