Advisory Committee on Energy Efficiency

Case study on low-voltage electrical installations

Case study on electric motors

September 22nd, 2020

Maarten van Werkhoven, Franco Bua, Jacques Peronnet & Philippe Vollet

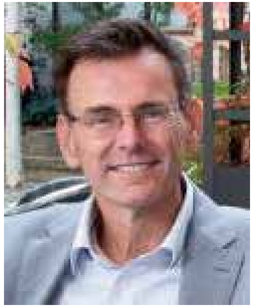
IEC Academy Webinar on Energy Efficiency

IEC INTERNATIONAL ELECTROTECHNICAL COMMISSION ®

Speakers

Franco Bua

Electrical engineer, since 2007 he has been active in standardisation activities in the field of energy efficiency and energy management at national and international level as member of IEC ACEE, CEN-CENELEC Sector Forum on Energy Management and secretary of CEI CT315 “Energy efficiency”.



Maarten van Werkhoven

Maarten van Werkhoven works as consultant on energy efficiency research, technology and policy in industry and commerce. He works as Operating Agent of the IEA TCP 4E Electric Motor Systems Annex EMSA. Maarten is working for the IEC ACEE as co-convenor of Task Group 6 that deals with the CAISEMS project: Coordination and Alignment of IEC and ISO Standards for Energy Efficient Electric Motor Driven Systems.

Jacques Peronnet

IEC TC64 Chairman

He has been working since more than 30 years in the Energy Sector and has built a comprehensive experience from energy generation up to end use thanks to various positions in Schneider Electric.

He is very active in standardization at IEC level: chairman of IEC TC64 covering LV electrical installations and protection against electric shock, active member of the IEC ACEE, expert in the IEC SyC LVDC (System committee on LVDC current).

Philippe Vollet

IEC ACEE Chairman – IEC SC23K Secretary

He has been working for Schneider Electric since 1989, at several positions from Engineering , Business Development, Offer management and Strategy for both Low and Medium Voltage departments.

He has been involved in standards work since 2013, mainly in Energy Efficiency and Smart Building topics.

Content

ü Introduction

ü IEC ACEE Takeaways from Webinar on June 23

ü IEC ACEE 03 Case Study: LV Electrical installation

ü IEC ACEE 02 Case Study: Electric Motors

ü Conclusion

IEC ACEE
Take aways from Webinar on June 23

Presentation

Philippe Vollet

ACEE Terms of References

- ü To coordinate activities related to energy efficiency.
- ü To be responsible for the assignment of horizontal energy efficiency aspects and requirements.
- ü To deal with energy efficiency matters which are not specific to one single technical committee of the IEC.
- ü To provide guidance for implementation in a general perspective and for specific sectors.
- ü To encourage a systems perspective for the development of standards for energy efficiency and provides support for system considerations.

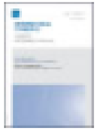
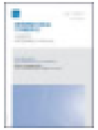
ACEE has published 2 Guides:

ACEE Advisory Committee on Energy Efficiency

Scope | Structure | Documents | Guides/Projects | Meetings / Workshops

Guides | Project files

Guides ACEE

Preview	Reference, Edition, Date, Title	Guide Download
	IEC GUIDE 118:2017 Edition 1.0 (2017-03-28) Inclusion of energy efficiency aspects in electrotechnical publications	EN
	IEC GUIDE 119:2017 Edition 1.0 (2017-03-28) Preparation of energy efficiency publications and the use of basic energy efficiency publications and group energy efficiency publications	EN

ACEE expectations

IEC TCs, after reading the two guides, are invited:

- to assess which EE aspects are relevant to their standardisation activities;
- to include EE aspects in their SBP (Strategic Business Plan) in case of positive answer to the previous question;
- to assess the applicability and, possibly, to apply ACEE guides to the preparation of new standards and to the revision of existing ones.

ACEE Webinars on Energy efficiency

General considerations on Energy Efficiency
Guides presentations

- ü **Webinar 1: June 23, 2020**

  ACEE - Energy Efficiency
  Key Principles, terminology and good practice for use in electrotechnical publications

Case Studies presentations

- ü **Webinar 2: September 22, 2020**

  ACEE - Energy Efficiency
  Case study on low-voltage electrical installations
  Case study on electric motors

IEC ACEE 03
Case Study:
LV Electrical installation

Presentation

Jacques Peronnet

Case Study:
Low Voltage Electrical Installation

- This case study is provided to illustrate a practical example
  - on how IEC Guide 118 concepts can be applied:
    - in low-voltage electrical installations; and
    - in product standards; and,
  - on how International Standards can support the energy efficiency market and national energy efficiency policies
- It is based on IEC 60364-8-1


IEC ACEE 03

Edition 1.0 2020-01

ACEE PUBLICATION

IEC Advisory Committee on energy efficiency (ACEE)

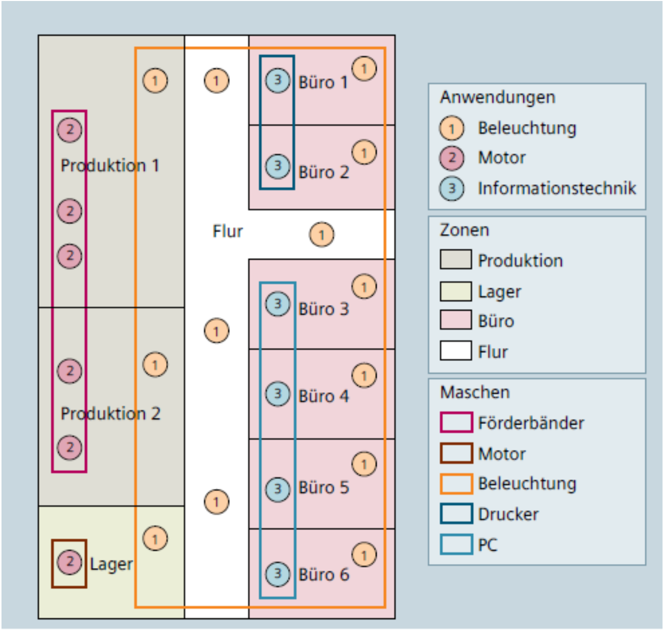
Case study: low-voltage electrical installations

IEC 60364-8-1: a Group Energy Efficiency Publication

- Buildings represent 40 % of the global energy demand. A significant part of this energy is supplied by electricity. Therefore, the overall efficiency of the low-voltage electrical installation is key.
- IEC 60364-8-1 *Low-voltage electrical installations – Part 8-1: Functional aspects – Energy efficiency* is based on the concepts of IEC Guide 118
- IEC 60364-8-1 is also a group energy efficiency publication (GEEP) according to IEC Guide 119. Therefore, it can be used by other IEC Technical Committees in order to design the functions to be implemented in their product to contribute to the implementation of energy efficiency measures in low-voltage electrical installations

Energy efficiency of Low Voltage Electrical Installation: boundaries

- Boundaries are key elements to define in order to make the relevant optimization of the usage of energy
- Circuits designed for optimizing the use of electrical energy are called meshes, usually referring to a zone (e.g. a room, a floor) and a usage (e.g. lighting, HVAC)
- Meshes are used to get the lowest electrical energy consumption and/or cost with regards to a solution for a service which is, and can be, compared to another solution



IEC Guide 118 > Energy efficiency aspects

This Guide:

- helps in harmonizing the approach to energy efficiency by promoting a system approach
- helps technical committees to identify energy efficiency aspects that contribute to energy efficiency improvement of the product itself and of the entire application;

5 EEAs to be considered when developing a standard

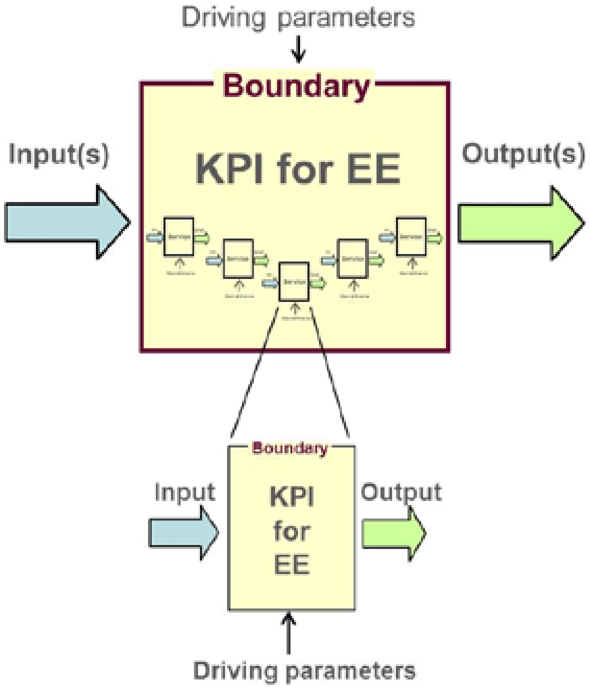
Energy efficiency aspect	Examples of inclusion in standards
Define energy efficiency	▪ Define system boundaries ▪ Define (establish) KPIs (energy efficiency indicators) ▪ Define (establish) energy baseline ▪ Define (establish) driving parameters (adjustment factors, static factors) ▪ Define (establish) reference applications ▪ [...]
Measure energy efficiency	▪ Define test methods ▪ Define measurements methods ▪ Define measurements plans ▪ [...]
Assess energy efficiency	▪ Energy audits ▪ Benchmarking methods ▪ Energy efficiency investment evaluation
Improve energy efficiency	▪ Energy management system ▪ Design criteria guidelines ▪ Application guidelines ▪ [...]
Enable energy efficiency	▪ Interoperability ▪ Communication ▪ [...]

IEC 60364-8-1 applies Guide 118 concept to:
- improve by design the efficiency of the installation;
– control the usage of equipment;
– benefit from the tariff of the supplied electricity;
– measure the consumption of relevant loads;
– maintain the energy performance of the installation;
– assess the efficiency of the installation.

Energy efficiency of Low Voltage Electrical Installation: design principles

- The design principles take into account the following aspects:
    - load energy profile;
    - availability of local generation (PV, wind turbine, generator, etc.) and storage;
    - reduction of energy losses in the electrical installation;
    - the arrangement of the circuits with regard to energy efficiency (meshes);
    - the customer's power use distribution over time;
    - the tariff structure offered by the supplier of the electrical energy;
    - maintaining the quality of service and the performance of the electrical installation.
- In order to verify the achievement of electrical energy efficiency measures, an overall energy efficiency assessment should be made

Energy efficiency of Low Voltage Electrical Installation: Driving parameters



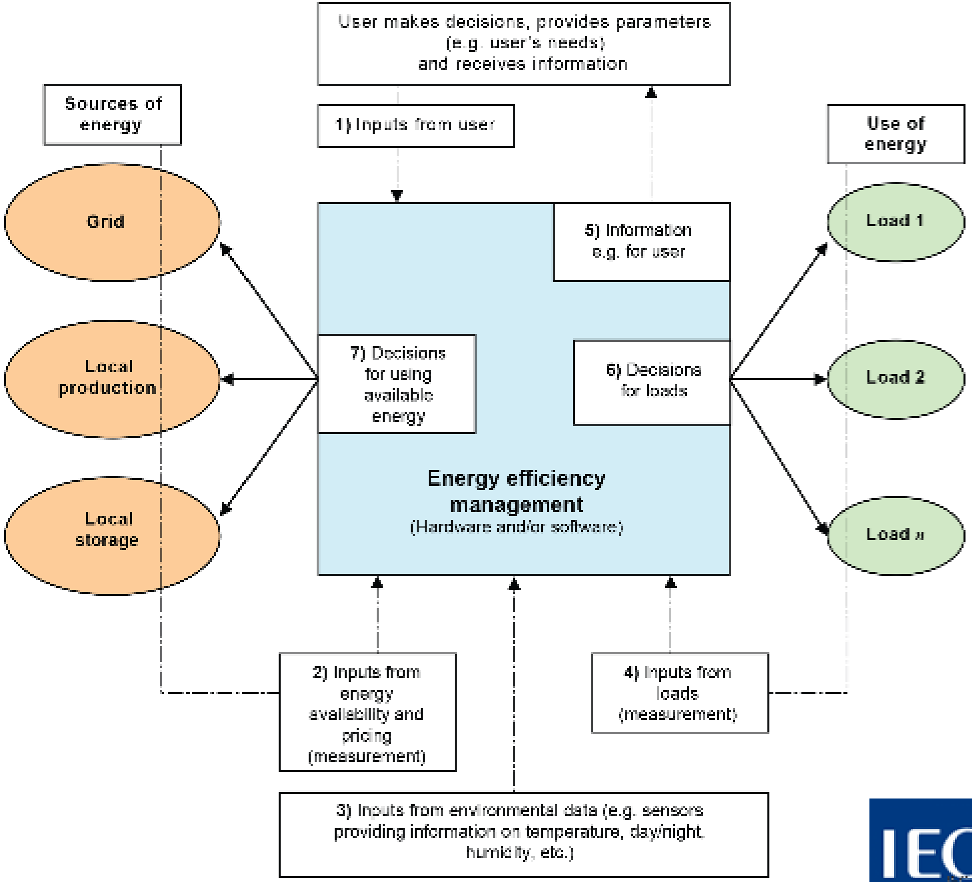
- Driving parameters having the most influence on energy efficiency shall be identified.
- Driving parameters should be assessed to evaluate their relative influence on the overall consumption of the installation.
- Usually, at least the following driving parameters are considered:
  - occupancy;
  - operating time;
  - environmental conditions;
  - cost of the electricity.

Energy efficiency and load Management System

- An energy efficiency and load management system provides guidance on how to optimize the usage of the energy consumed, taking into account the loads, local production and storage and user requirements.

- Building Automation Control System or House Energy Management System can lead to savings from 20% to 47%*

*according to European Standard EN 15232

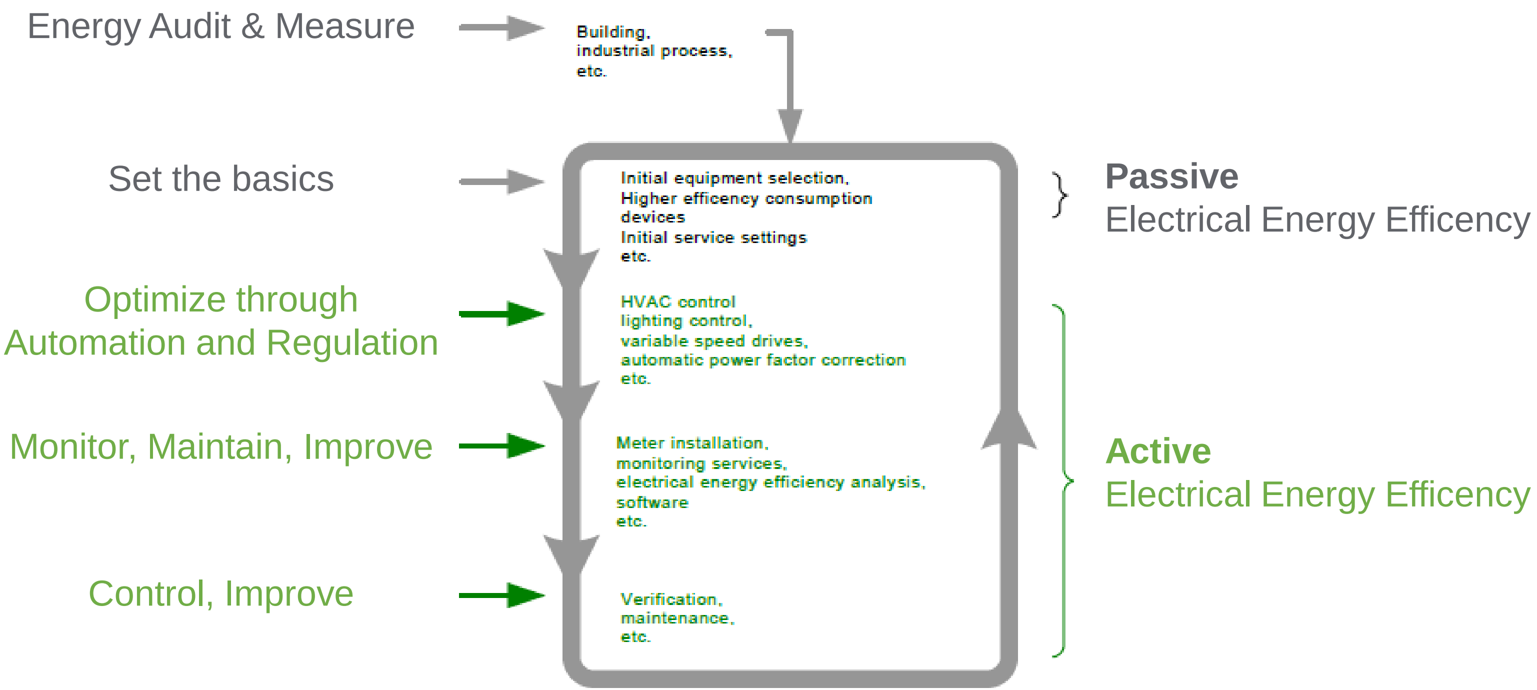


Energy efficiency of Low Voltage Electrical Installation: measurement

- Making measurements is key to determine and assess the efficiency of a building.
- The measurement of electrical parameters is required in determining the electrical consumption and needs to be supplemented by the measurement of relevant driving parameters such as the presence of people, temperature, quality of air, daylight, operating time, cost of energy.

- Measurement applications are:
  - Billing
  - Energy usage analysis
  - Power monitoring
  - Energy estimation

Energy Efficiency Life cycle method in order to maintain the building performance:

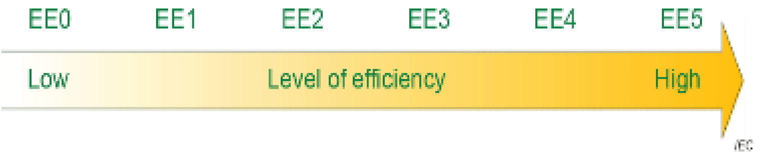


Energy Efficiency Assessment method

IEC 60364-8-1 provides a **method to assess** the EE of an electrical installation based on the level of implmentation of the energy efficiency measures describes in the standard for:

- Initial installation
- Energy management
- Performance maintenance
- Power monitoring
- Bonus

For each parameter, some points are given depending on the level of implementation



Case Study:
LV electrical installation

- Is an example on how to apply the principles of IEC Guide 118 and Guide 119
- Introduce how the GEEP IEC 60364-8-1 helps TCs to understand how their products are used in a system within some boundaries and therefore develop:
    - Products
    - Features in their products
- Enable and/or contribute to the efficient use of energy in the electrical installation

IEC ACEE 02
Case Study: Electric Motors

Presentation

Franco Bua
Maarten van Werkhoven

IEC Guide 118: Setting the context

Barriers to energy efficiency

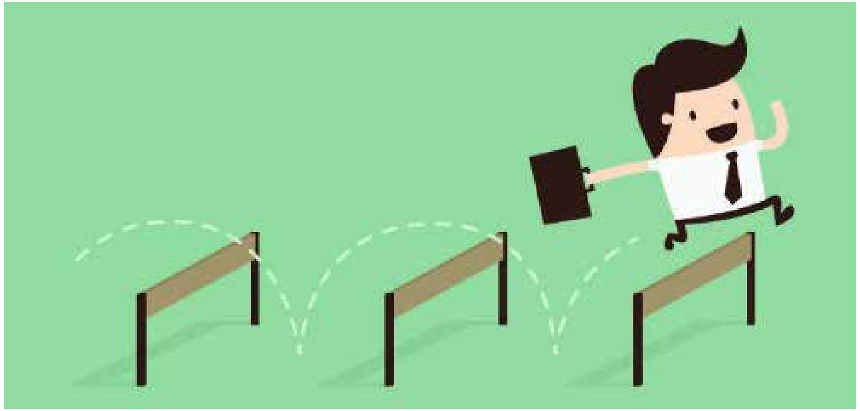
- Lack of awareness of savings potential
- Focus on:
  - devices instead of systems = lower ROI
  - Low initial cost vs. life-cycle gains
-

IEC Guide 118: Setting the context

Barriers to energy efficiency

… one possible solution?

Technical standards!



Document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context

NOTE Standards should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits.

(Art. 3.2 ISO/IEC Guide 2: 2004 – Standardization and related activities – General vocabulary)

IEC Guide 118

Energy efficiency aspects inclusion in electrotechnical standards

This Guide:

- helps in **harmonizing the approach to energy efficiency**;
- **raises awareness** that provisions in IEC publications can affect the energy performance of the product itself (taken individually) and of the entire application (embedding the product), in both negative and positive ways;
- **helps technical committees** to identify energy efficiency aspects that contribute to energy efficiency improvement of the product itself and of the entire application;
- **promotes the use of a systematic approach** when addressing energy efficiency in the context of standardization;
- **promotes the use of a systems approach** when addressing energy efficiency aspects in the context of standardization.

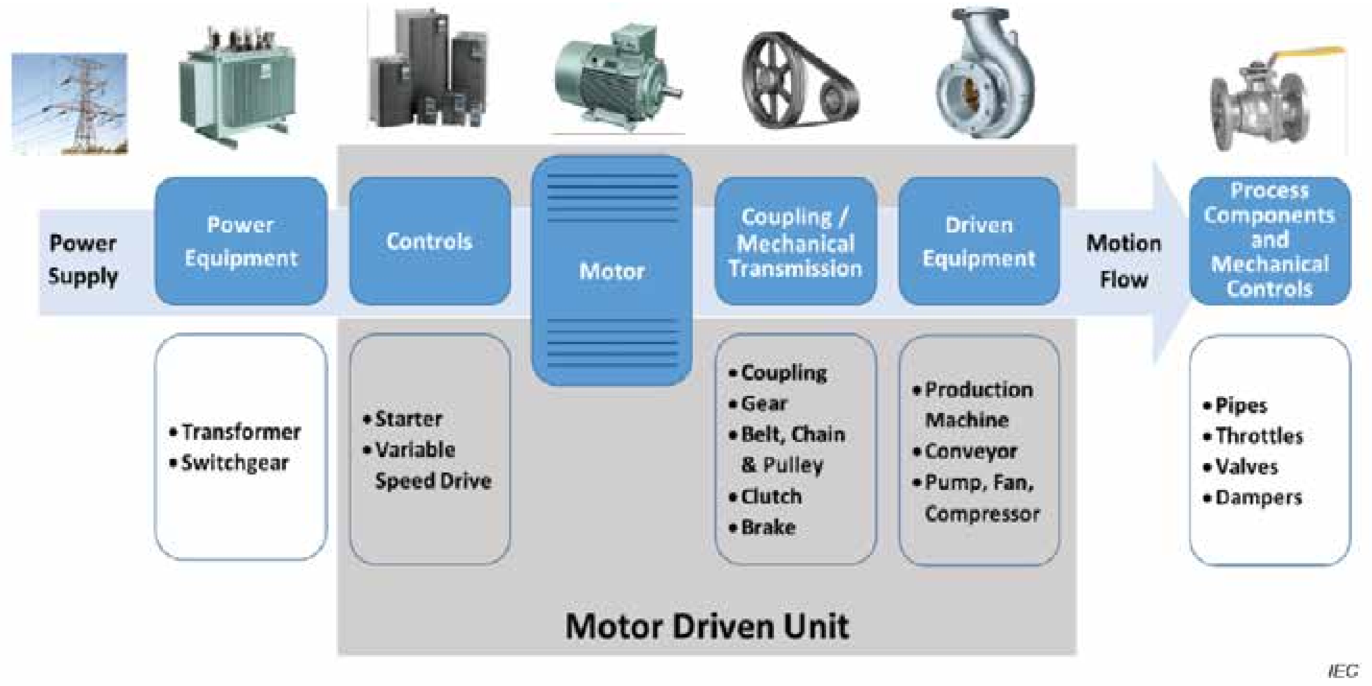
IEC Guide 118 Energy efficiency aspects

The use cases for energy efficiency

Energy efficiency aspect	Examples of inclusion in standards
Define energy efficiency	▪ Define system boundaries ▪ Define (establish) KPIs (energy efficiency indicators) ▪ Define (establish) energy baseline ▪ Define (establish) driving parameters (adjustment factors, static factors) ▪ Define (establish) reference applications ▪ [...]
Measure energy efficiency	▪ Define test methods ▪ Define measurements methods ▪ Define measurements plans ▪ [...]
Assess energy efficiency	▪ Energy audits ▪ Benchmarking methods ▪ Energy efficiency investment evaluation
Improve energy efficiency	▪ Energy management system ▪ Design criteria guidelines ▪ Application guidelines ▪ [...]
Enable energy efficiency	▪ Interoperability ▪ Communication ▪ [...]

Electric motors and energy efficiency

Boundaries

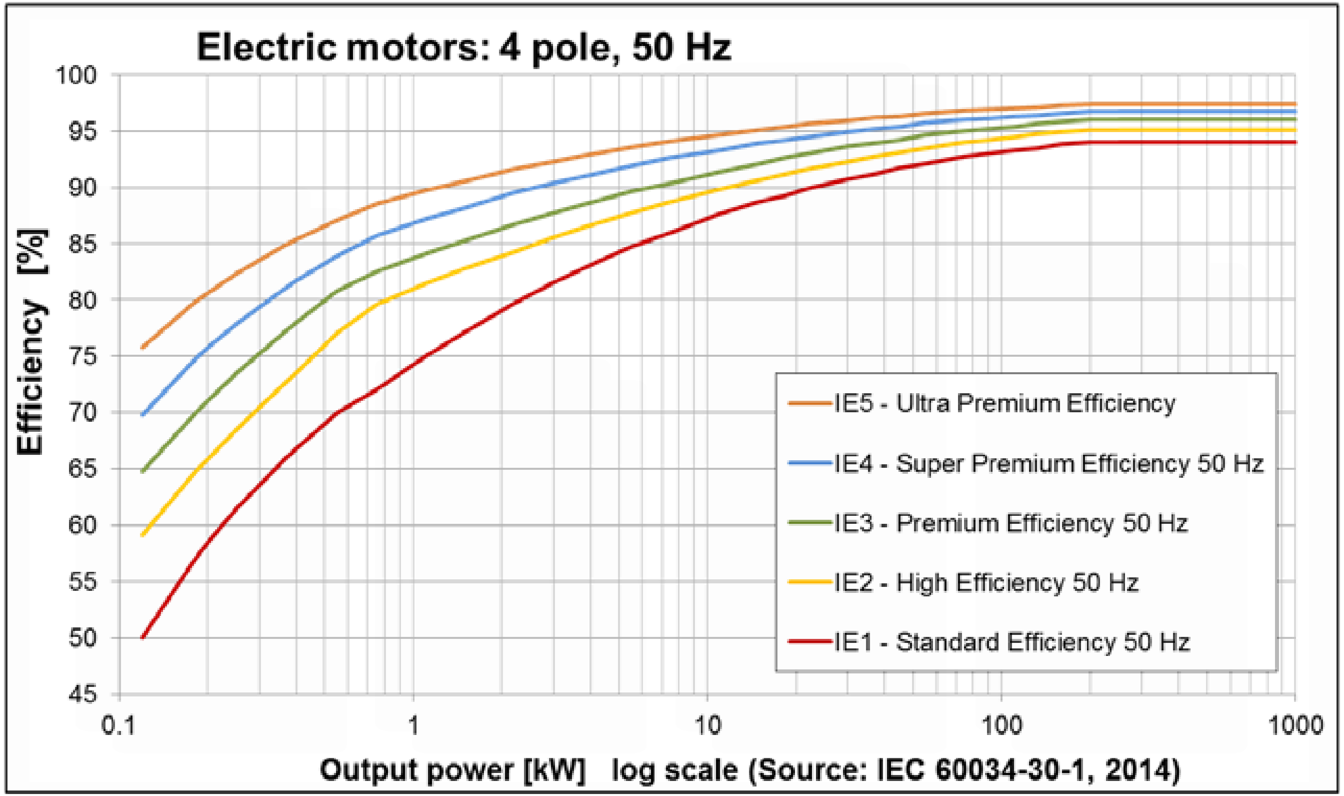


Electric motors and energy efficiency
Energy efficiency aspects

Energy efficiency aspect category	Energy efficiency aspect	Example of inclusion in publication
Define energy efficiency of a motor	Define system boundaries (including the scope for energy efficiency)	IEC 60034-1:2017, Rotating electrical machines – Part 1: Rating and performance
Define energy efficiency of a motor	Define EE KPIs (energy efficiency key performance indicators)	IEC 60034-30-1:2014, Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)
Measure energy efficiency of a motor	Define test methods	IEC 60034-2-1:2014, Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)
Improve energy efficiency of motor and converter	Application guidelines	IEC TS 60034-31:2010, Rotating electrical machines – Part 31: Selection of energy-efficient motors including variable speed applications – Application guide

Electric motors and energy efficiency

Define energy efficiency > Efficiency classes



IEC 60034-30-1

Rotating electrical machines

Part 30-1: Efficiency classes of line operated AC motors (IE code)

Electric motors and energy efficiency

Measure energy efficiency > Test methods

Table 2 – Induction machines: preferred testing methods

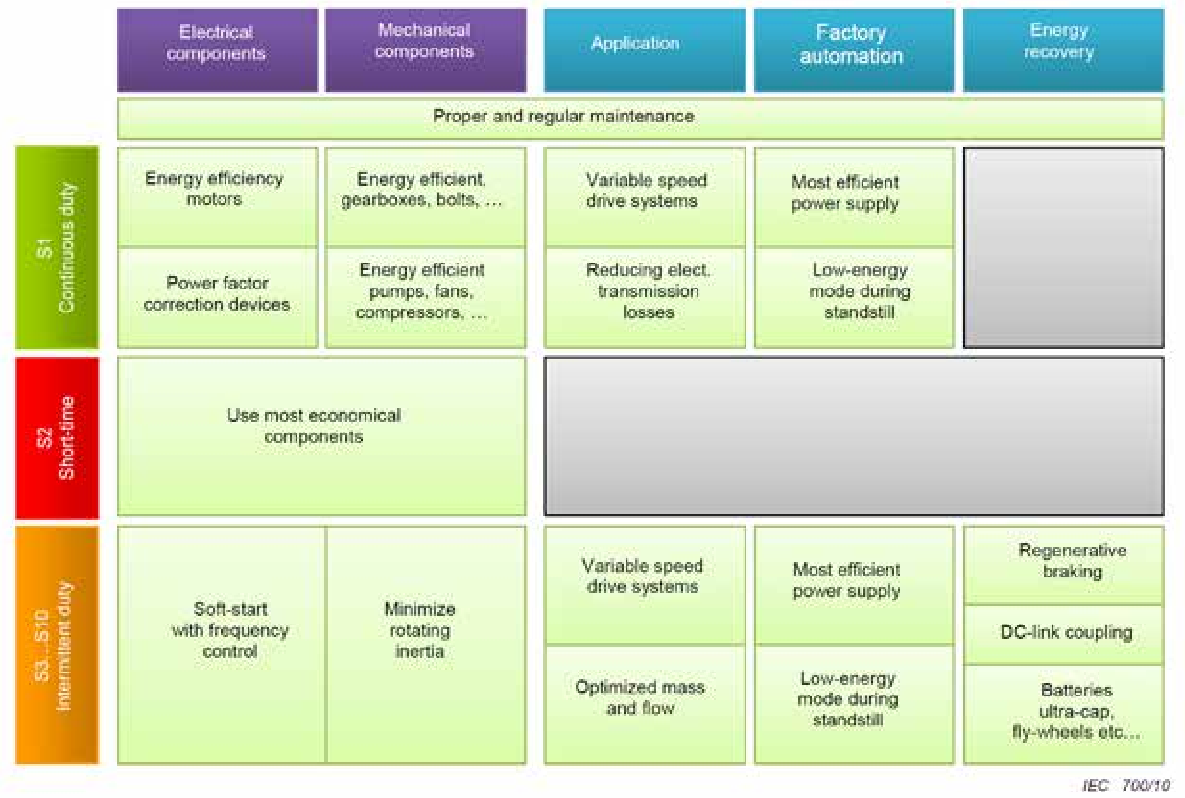
Ref	Method	Description	Clause	Application	Required facility
2-1-1A	**Direct measurement:** **Input-output**	Torque measurement	6.1.2	All single phase machines	Dynamometer for full-load
2-1-1B	**Summation of losses:** **Residual losses**	P_{LL} determined from residual loss	6.1.3	Three phase machines with rated output power up to 2 MW	Dynamometer for 1,25 × full-load, or load machine for 1,25 × full-load with torque meter
2-1-1C	**Summation of losses:** **Assigned value**	P_{LL} from assigned value	6.1.4	Three phase machines with rated output power greater 2 MW.	

IEC 60034-2-1, Rotating electrical machines

Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)

Electric motors and energy efficiency

Improve energy efficiency



IEC 60034-31

Rotating electrical machines

Part 31: Selection of energy-efficient motors including variable speed applications – Application guide

Electric motors and energy efficiency

Conformity assessment

1	2	3	4	5
SCOPE	TESTING	EFFICIENCY CLASSES	GUIDE	CERTIFICATION
IEC 60034-1	IEC 60034-2-1	IEC 60034-30-1 IEC 60034-30-2*	IEC/TS 60034-31	IECEE OD-2057 GMEE
standard conditions & technologies, tolerances	one preferred test method	IE1, IE2, IE3, IE4. *Advanced technology IE5 not yet published	system integration, life cycle cost	conformity assessment, lab accreditation

IECEE: System of Conformity Assessment Schemes for Electrotechnical Equipment and Components
GMEE: Global Motor Energy Efficiency Program

Motor MEPS* worldwide

Efficiency Levels 3-phase induction motors (Low Voltage < 1000 V)	Efficiency Classes IEC 60034-30-1, 2014 Global classes IE-Code I	Testing Standard IEC 60034-2-1, 2014 incl. stray load losses	Performance Standard Mandatory MEPS III National Policy Requirement	
Super Premium Efficiency	IE4	Preferred Method II	EU 28 **	75 - 200 kW
Premium Efficiency	IE3		Canada	0.75 - 375 kW
			Mexico	0.75 - 375 kW
			USA	0.75 - 375 kW
			USA, Canada *	0.18 - 2.2 kW
			South Korea	0.75 - 375 kW
			EU 28 **	0.75 - 1.000 kW
			Switzerland **	0.75 - 375 kW
			Turkey	0.75 - 375 kW
			Japan	0.75 - 375 kW
			Israel	7.5 - 375 kW
			Singapore	0.75 - 375 kW
			Taiwan	0.75 - 375 kW
		Summation of losses with load test:	Brazil	0.12 - 370 kW
			Ukraine ***	0.75 - 375 kW
			Saudi Arabia	0.75 - 375 kW
High Efficiency	IE2	Additional losses P_{LL} determined from residual loss	Australia	0.73 - 185 kW
			Chile	0.75 - 7.5 kW
			China	0.75 - 375 kW
			Peru	0.75 - 375 kW
			Colombia ** **	7.5 - 375 kW
			Iran	(7.5 - 375 kW)
			EU 28 **	0.12 - 0.75 kW
			Israel	0.75 - 5.5 kW
			India	0.12 - 1000 kW
			Ecuador	0.746 to 373 kW
			New Zealand	0.73 - 185 kW
Standard Efficiency	IE1		Peru	0.75 - 375 kW

15 09 2020
Impact Energy Inc. & TPA advisors
© EMSA 2020

I) Output power: 0.12 kW - 1000 kW, 50 and 60 Hz, line operated, 2-, 4-, 6- and 8-poles.
II) for 3-phase machines direct online < 1 kV rated output power < 1000 kW.

III) Minimum Energy Performance Standard (set as requirement by regulators)
*) Polyphase: broadly equivalent to IE3; single phase: IE2 levels or above.

**) Tier1: per 15/7/21; Option IE2+VSD removed (0.75-375 kW)
Tier2: 1/7/2023, 1-phase >0.12 kW IE2, 0.75-75 / 200-1.000 kW IE3.
***) IE3 or IE2+VSD, per 1-9-2019 + 2 years for implentation.
** **) Per 09/2021 >= 0.75 kW. Per 09/20 motor operated with VFD: IE2.

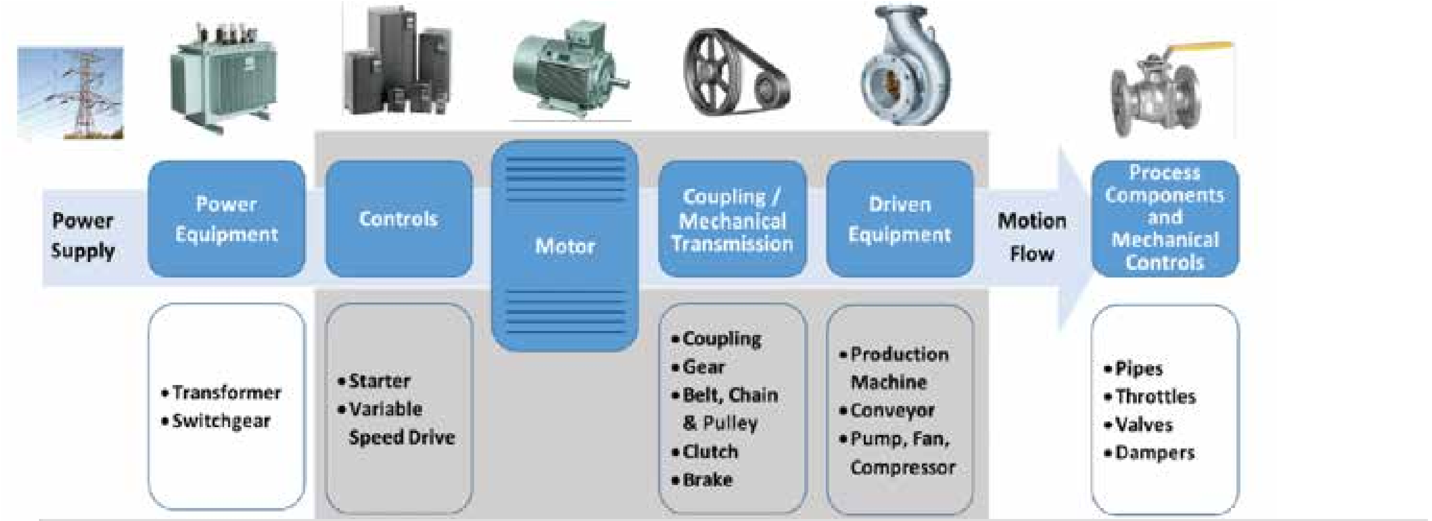
EU - revised motor MEPS

more ambition in scope and efficiency levels

Scope		2017	2018...2020	2021	2022	2023 →
AC induction motors <= 1000 V						
0.75-375 kW	3 phase, 2/4/6 poles	IE2+VSD/IE3 →	→	→		
0,75-1000 kW	3 phase, 2->8 poles			IE3 →	→	→
↳ 75-200 kW	2/4/6 poles, excl. ATEX, non-integr. brake and Ex eb					IE4 →
0.12-0.75 kW	3 phase 2->8 poles			IE2 →	→	→
>= 0.12 kW	1 phase					IE2 →
0.12-1000 kW	Incr. safety Ex eb 2->8 poles					IE2 →
ATEX and non-integr. brake motors				**No more exempt**		
Variable speed drives						
0.12-1000 kW	3-phase			**IE2** →	→	→

Colour legend

From Motor to System



	power input	VSD	Motor	Mechanical	Application	Throttles, valves	*power output*	Efficiency
Standard	100		95%	92%	77%	49%	33	**33%**
Optimised	47	96%	96%	97%	88%	89%	33	**70%**

MEPS Electric Motor Driven Systems

EMDS	Product type	China	EU	USA
Pump *)	Clean water	**Pump only**	**Pump only**	**MDU**
	MEPS status	In effect	In effect (under revision)	Published, in effect per 2020
	Nr.	(GB 19762-2007)	(547/2012)	(10 CFR Parts 429 and 431)
Fan **)	Industrial fans	**Fan only**	**MDU**	**MDU**
	MEPS status	In effect	In effect (under revision)	Under development
	Nr.	(GB 19761-2009)	(327/2011)	
Compressor ***)	Standard Air	**Compressor package**	**Compressor package**	**Compressor package**
	MEPS status	In effect	Under development	Published, in effect per 2025
	Nr.	(GB 19153-2009)		(10 CFR Parts 429 and 431)

Notes: 1) Darker color = more comprehensive MEPS with a metric that includes more aspects of the MDU. The evalua- tion of the status of MEPS in the different regions is based on the regulations that are currently (2017) in effect. In the USA there is currently no regulation for fans, whilst regulation for compressors in the EU is in draft stage, therefore both not marked with color in the table. In the USA regulation for compressors has been published per 10-01-2020.
2) MDU – Motor Driven Unit is synonym for EMDS.
*) Clean water pumps. Circulators: in the EU under revision (641/2009); in the USA under consideration.
**) Industrial fans (CN, USA), Fans driven by motors (0.125–500 kW) (EU). In USA and China also MEPS in effect for residential fans: ceiling fan, cooktop, duct fan; and in EU for ventilation units (buildings). There is no draft regu- lation for fans in the USA.
***) Air compressors. There is currently no regulation for compressors in the USA.

Conclusion

Take Aways

Franco Bua
Maarten van Werkhoven
Jacques Peronnet
Philippe Vollet

Take aways

- Energy efficiency aspects: understand TC's role in promoting energy efficient technologies
- Importance of holistic approach: from component to system
- Sets of standards help regulators for energy efficiency regulation

ACEE expectations

IEC TCs, after reading the two guides & use cases, are invited:

- ü to assess which EE aspects are relevant to their standardisation activities;
- ü to include EE aspects in their SBP (Strategic Business Plan) in case of positive answer to the previous question;
- ü to assess the applicability and, possibly, to apply ACEE guides to the preparation of new standards and to the revision of existing ones.

Please visit our IEC ACEE WebSite @ www.iec.ch/acee

ACEE Advisory Committee on Energy Efficiency

Scope | Structure | Documents | Guides/Projects | Meetings / Workshops

Working Documents | Supporting Documents

Log in | En | Fr

Documents available in this area are supporting documents uploaded by the committee. The IEC is not liable for the content of these documents.

ACEE Supporting Documents

Table search:

Title, description	Downloads	Created	Publication reference
Case study: low-voltage electrical installations This case study is provided to illustrate a practical example (in practice) on how IEC Guide 118 concepts can be applied/found in low-voltage electrical installations and in product standards and, more generally, on how International Standards can support the energy efficiency market and national energy efficiency policies.	906 kB	2020-01-20	IEC GUIDE 118:2017
Introduction to ACEE work This document provides an introduction to ACEE work.	1369 kB	2019-10-01	IEC GUIDE 118:2017
Case study: electric motors This case study is provided to illustrate a practical example (in practice) on how IEC Guide 118 concepts can be applied/found in electric motors standards and, more generally, on how International Standards can support the energy efficiency market and national energy efficiency policies.	1412 kB	2019-10-01	IEC GUIDE 118:2017

Thank you for your attention !

Any Questions and/or Remarks ?

Thank you!

Franco Bua, Maarten van Werkhoven
Jacques Peronnet, Philippe Vollet
IEC ACEE

ACEE Webinar
22 September 2020

International
Electrotechnical
Commission