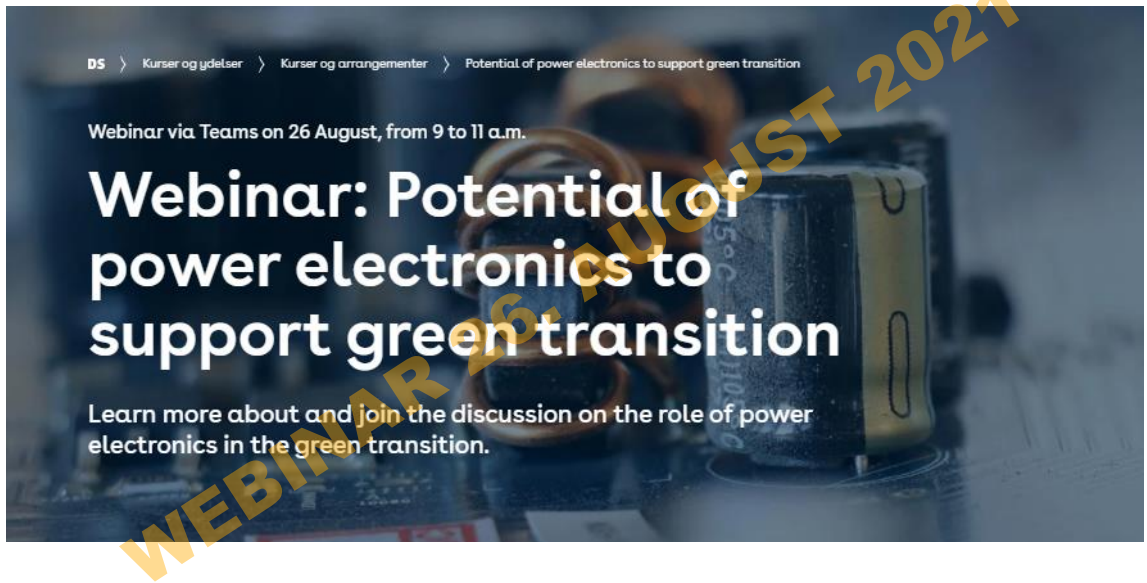

1

Potential of power electronics to support green transition

- **Preben Holm:** IEC 62477-1 and it's use in risk assessment
- **Norbert Hanigovszki:** Ecodesign and energy efficiency of variable speed drives
- **Jacob Lynge:** Testing of motors and associated frequency drives
- **Jakob Svendsen:** Implementation of standards and labelling schemes and their advantage on the world market
- Panel discussion and the opportunity to ask questions about the influence of standards and power electronics on the green transition

2

Potential of power electronics to support green transition

3

Potential of power electronics to support green transition

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Panel discussion and the opportunity to ask questions about the influence of standards and power electronics on the green transition

4

5

Preben Holm, personal profile

Lead standardization expert, Global standardization at Danfoss Drives in Gråsten, Denmark.

Working at Danfoss Drives since 1995

IEC standardization since 2004.

- Chair of IEC SC22G & IEC TC109.
- Chair of S522 & S609
- Convenor IEC 61800-5-1 & IEC 62477-1
- Safety expert in TC109 MT1-3 (IEC 60664-X)
- Former ACOS member (2011 – 2020)

Bachelor in Electronic engineering from Sønderborg teknikum in Denmark (1991)

Main interest is standardization related to electrical safety

6

Three **business segments** geared for growth

Danfoss Power Solutions

#2 Market position

- 7,826 employees
- 28 factories in 12 countries
- 2.2bn EUR annual sales

35% of Group sales

Danfoss Climate Solutions

#2 Market position

- 10,792 employees
- 32 factories in 15 countries
- 2.6bn EUR annual sales

42% of Group sales

Danfoss Drives

#2 Market position

- 4,504 employees
- 10 factories in 7 countries
- 1.5bn EUR annual sales

23% of Group sales

Breadth and depth in **expert products**

VLT®

- **AC drives** (0.18 – 1,400 kW)
- **Decentral drives**
- **Integrated servo drives**
- **Soft starters**
- **Power options** (filters)
- **Software tools**

VACON®

- **Air and liquid cooled drives** (0.25 – 6,000 kW)
- **Decentral drives**
- **Active Front-End drives**
- **Industrial system drives**
- **Grid converters**
- **DC/DC converters**
- **Hybrid and energy storage solutions**
- **Customer-specific solutions**
- **Software tools**


MARINE AND OFFSHORE
FOOD AND BEVERAGE
WATER AND WASTEWATER
HVAC/BUILDING AUTOMATION
REFRIGERATION
Examples
Application-optimized solutions and services for your industry
ELEVATORS AND ESCALATORS
CHEMICAL
MINING AND MINERALS
CRANES AND HOISTS
HEAVY INDUSTRY/ OIL AND GAS
WEBINAR 26. AUGUST 2021
Classified as Business
ENGINEERING TOMORROW

9


DIGITALIZATION
ELECTRIFICATION
URBANIZATION
GLOBAL MEGA-TRENDS
transforming our world
CLIMATE CHANGE
FOOD SUPPLY

10

Risk assessment – Why?

The method to ensure a sufficient safe product

11

Why should I make a risk assessment? (How it used to be !)

* E.g. European LVD 2014/35/EU Annex I

** E.g. Safety product standard

12

Why should I make a risk assessment? – Essential requirement

29.3.2014 EN Official Journal of the European Union L 96/357

DIRECTIVE 2014/35/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 26 February 2014
on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits

Article 3

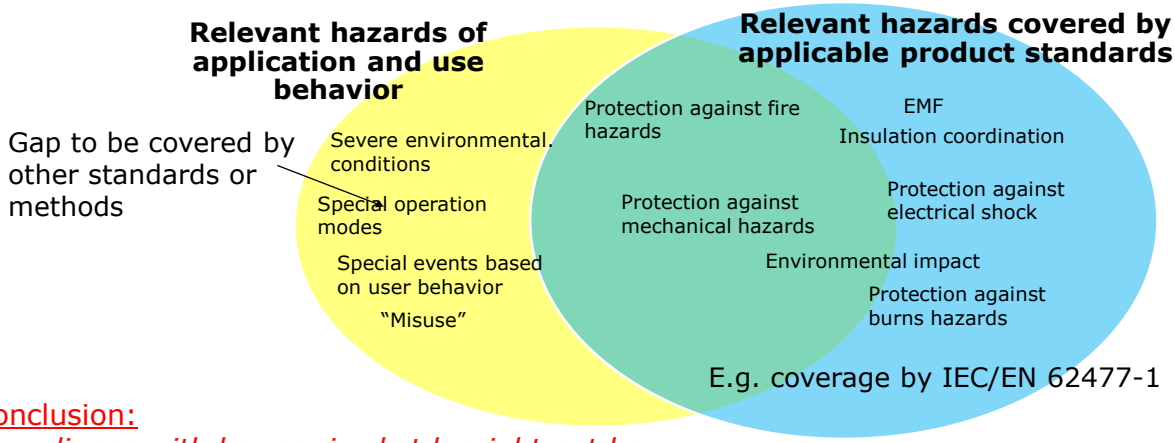
Making available on the market and safety objectives

Electrical equipment may be made available on the Union market only if, having been constructed in accordance with good engineering practice in safety matters in force in the Union, it does not endanger the health and safety of persons and domestic animals, or property, when properly installed and maintained and used in applications for which it was made.

The principal elements of the safety objectives are listed in Annex I.

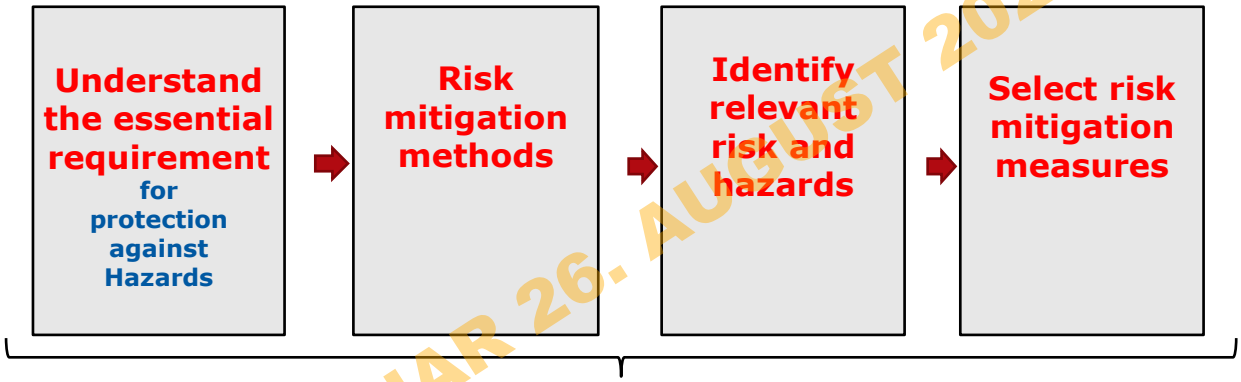
Short form:
LVD/35/EU require full coverage considering all relevant risks and hazards.

Why should I make a risk assessment?
(What is covered by my product standard?)

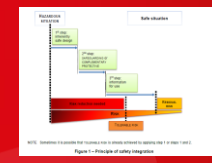


Conclusion:
Compliance with harmonized std. might not be sufficient to cover all essential requirements depending on the coverage and intended use.

Why should I make a risk assessment?
(The risk assessment approach)



The risk assessment will help you to *identify*, *evaluate* and find applicable *risk mitigation measures* for all relevant hazards to ensure a sufficient safe product in all phases during its life cycle.



Risk assessment – helpful tools

Cenelec guide 32 / IEC guide 116
- the 3 step risk mitigation method

IEC/EN 62477-1

Danfoss Drives - Risk assessment template

Cenelec guide 32 (IEC guide 116)

Cenelec guide 32 cl. 5 - Determination of the limits (abstract)

- RISK ASSESSMENT begins with the determination of the limits of the LV equipment. The limits of the LV EQUIPMENT are listed herein by grouping them in four categories (Use limits, Space limits, time limits, other limits).
- They serve the purpose to define the INTENDED USE and to consider REASONABLY FORESEEABLE MISUSE.

Cenelec guide 32 (IEC guide 116)

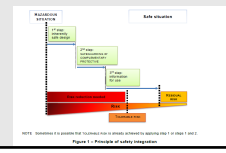
Essential requirement for protection against hazards

E.g.
European LVD 2014/35/EU Annex I

AS/NZS3820 (Essential safety requirements)

Risk mitigation principle
(Cenelec Guide 32)

4. Basic principles
5. Limits
   - Intended use
   - Reasonable foreseeable misuse.
   - Environment.
6. Hazard id.
7. Risk identification
8. Risk evaluation
9. Risk reduction

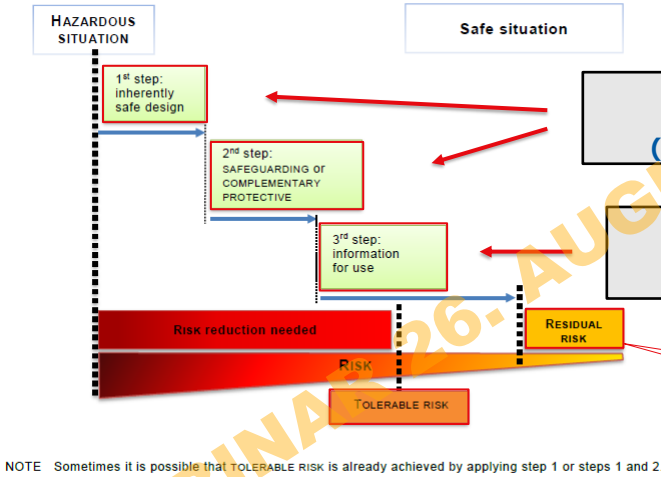


Identify relevant hazards
(Cenelec Guide - Annex D)

Relevant hazards e.g:

A.4	Electrical
A.5	Mechanical
A.6.3	EMF
A.6.6	Fire
A.6.7	Temperature
A.6.8	Acoustic Noise
A.6.11	Unattended operation
A.6.12	Connection to and interruption from power supply
A.9	Information

Cenelec guide 32 vs. IEC/EN 62477



NOTE Sometimes it is possible that TOLERABLE RISK is already achieved by applying step 1 or steps 1 and 2.

Figure 1 – Principle of safety integration

CLC Guide 32

(Safety related risk assessment and risk reduction)

- **Intended use**
- **Reasonable foreseeable misuse**
- **Limits**

Annex D

Relevant hazards E.g:

A.4 Electrical
A.5 Mechanical
A.6.3 EMF
A.6.6 Fire
A.6.7 Temperature
A.6.8 Acoustic Noise
A.6.11 Unattended operation
A.6.12 Connection to and interruption from power supply

A.9 Information

IEC/EN 62477-1

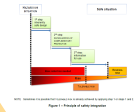
4. Protection against hazards
- 4.1 General
- 4.2 Fault and abnormal operating conditions
- 4.3 Short circuit and overload protection
- 4.4 Protection against electric shock
- 4.5 Protection against electrical energy hazards
- 4.6 Protection against fire and thermal hazards
- 4.7 Protection against mechanical hazards
- 4.8 Equipment with multiple sources of supply
- 4.9 Protection against environmental stresses
- 4.10 Protection against sonic pressure hazards
- 4.11 Wiring and connections
- 4.12 Enclosures
- 4.13 Components
- 4.14 Protection against electromagnetic fields

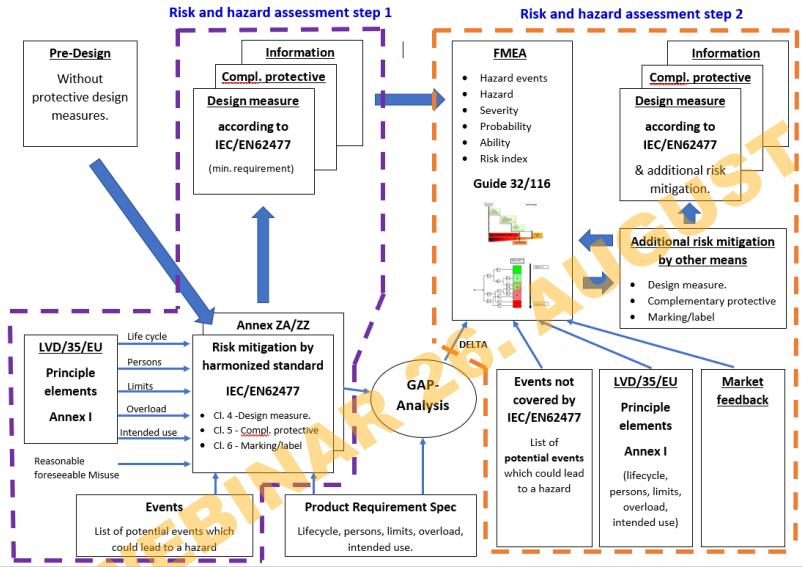
5. Test

6. Information and marking
- 6.2 Information for selection
- 6.3 Information for installation and commissioning
- 6.4 Information for use
- 6.5 Information for maintenance

Important: Be aware of type of hazard and risk

LVD/35/EU, Cenelec guide 32 vs. IEC/EN 62477





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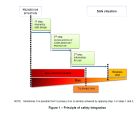
Risk assessment – (a useful template)

Hazard identification and risk estimation



Hazard identification
(Normal, abnormal and single fault condition)

Risk estimate
(before risk reduction)

Event/Cause | Operation mode | Product life cycle | Risk par. | Risk index

Risk assessment

Hazard identification							Relevant phases in product lifecycle						Risk estimation			
													Risk Parameters			
ID	Hazard category	Hazard	Possible hazard causes	Enclosure type (Open type, IP20, 21, 54)	Operation mode (Normal, Single fault, abnormal)	Risk	TRA	STO	INS	OP	MS	DIS	Severity of harm S1, S2, S3	Exposure and occurence F1, F2	Possibility of avoiding the hazard P1, P2	Risk index before reduction
1	Electrical hazard	Leakage current / touch current	**Leakage current / hazardous voltage:** Hazardous voltage on VSD chassis due to 1) capacitive currents orginated	IP20	Normal	Electric shock			x	x	x		3	2		5
2	Electrical hazard	Electric shock	**Electrical shock:** Break down of insulation system between coil and chassis (basic insulation) due to droplets in or without combination of dust between coil wires and chassis parts (chassis, iron core)	IP20	Normal	Electric shock							3	2		5
4	Electrical hazard	Leakage current / touch current	**Touch current /Disconnect of PE wire:** Hazardous touch current through human body, when PE wire is damaged or disconnected, due to high leakage current.	IP20	Single fault	Electric shock			x	x	x		3	1		4

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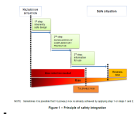
Risk assessment - (a useful template)

Hazard identification and risk estimation



Hazard identification & risk estimate (before risk reduction)

Coverage by Harm. standard

Risk reduction measures

Risk est. (after risk reduction)

Harm. std.

Alt. std.

Conclusion

Design (Step 1)

Comp. Prot. (Step 2)

Information (Step 3)

Risk assessment

	Hazard identification				Coverage			Risk evaluation	Risk mitigation			References
ID	Hazard category	Hazard	Possible hazard causes	Risk index before reduction	Covered by harmonized standard, EN61800-5-1 Ed. 2.1?	Covered by harmonized standard, CDV/EN61800-5-1 Ed. 3?	Coverage by harmonized standard EN 61800-5-1 ed. 2.1.? (Yes/No/partly)	Design measure	Complimentary protective measure	Information for user	Risk index after reduction
1	Electrical hazard	Leakage current / touch current	**Leakage current / hazardous voltage:** Hazardous voltage on VSD chassis due to 1) capacitive currents orginated	5	Normal operation not covered	Clause 4.4.4.3.4, 4.4.8, 6.3.9.5	No		Reinforced PE-wire Residual Current Device according to local regulations.	**Litterature:** Usage and dimension of PE connection & RCD. **Product:** Symbol - "Caution" **Packaging:** na	1
2	Electrical hazard	Electric shock	**Electrical shock:** Break down of insulation system between coil and chassis (basic insulation) due to droplets in or without combination of dust between coil wires and chassis parts (chassis, iron core)	5		Clause 4.4.7.1.3, 4.4.7.8.4.3, 4.4.7.8.5	Yes	VSD enclosures are designed according to IEC60529. For FA 6/7 frame sizes the environment for the DC coil is considered as PD3 or 4 and Type 1 or 2 protection on DC coil (Coating/potting) such that it can be placed in PD3/4 environment (IEC61800-5-1)	If design measures can't be provided: Install product in panel or similar to avoid dripping water in IP21	If complementary protective measure is used, then specify in litterature	1
4	Electrical hazard	Leakage current / touch current	**Touch current /Disconnect of PE-wire:** Hazardous touch current through human body, when PE wire is damaged or disconnected, due to high leakage current.	4	Clause 4.3.5.5.2, 5.2.3.5, 6.3.6.7	Clause 4.4.4.3.3, 6.3.9.5	Yes	Touch current exceeds 3.5mA and therefore the drive is design for reinforced PE wire (2 x nom. or 10mm2) required to prevent a hazardous current in case the PE-conductor is interruted. Designed to be compatible to RCD type B	Reinforced Protective earthing (PE) conductor. RCD type B	**Literature:** Installation manual: usage and dimension of reinforced PE-conductor and RCD **Product:** Symbol - "Caution marking" **Packaging:** na	1

Residual risk reduced to an acceptable level

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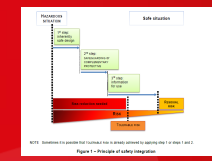
Risk assessment



The overall use of IEC/EN 62477-1

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IEC 62477-1 cl. 4 - Protection against hazards

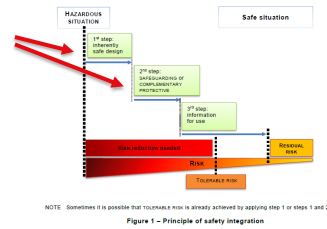
Overall purpose of clause 4:

Cl. 4.1: Definition of the fundamental frame of the hazard evaluation and risk mitigation.	Frame of the fundamental concept of hazard evaluation. (Normal use, abnormal use, single fault, reasonable forseeable misuse)
Cl. 4.2: Risk evaluation considering single fault / abnormal conditions.	Fundamental concept of hazard evaluation under single fault condition
Cl. 4.3-4.14: Design requirement, mainly deterministic considering horizontal and group safety publication for risk mitigation.	Deterministic design methods to support cl. 4.1 and 4.2. (Design measures for risk reduction (step 1))

Clause 5 - Test

Overall purpose of clause 5:

Cl. 5.1: Definition of the fundamental conditions for testing.



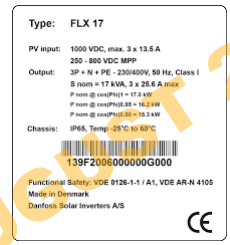
NOTE Sometimes it is possible that TOLERABLE RISK is already achieved by applying step 1 or steps 1 and 2.

Figure 1 – Principle of safety integration

Cl. 5.2: Compliance test to verify whether
- the risk mitigation by clause 4 (by design) is sufficient.
- additional design measures or supplementary protective measures are required for sufficient risk mitigation.
- additional information or marking shall be specified.

- Strong link between clause 4 design requirement and clause 5 test requirement.

Clause 6 – Information and marking



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Clause 6 – Information and marking

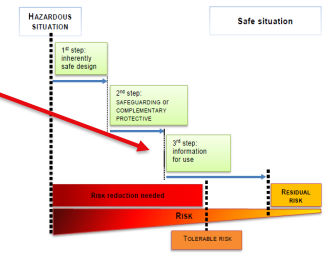
Overall purpose of clause 6:

Cl. 6.1: General

Cl. 6.2–6.5: Information required for safety

- selection (6.2)
- installation (6.3)
- commissioning (6.3)
- operation / use (6.4)
- maintenance (6.5).

of the PECS.



NOTE Sometimes it is possible that TOLERABLE RISK is already achieved by applying step 1 or steps 1 and 2.

Figure 1 – Principle of safety integration

This includes information about:

- Intended use and limits (e.g. environmental conditions)
- specified additional protective measures.
- needed information and marking for additional risk mitigation.

- Strong link between clause 4 design requirement and clause 6 "information and marking" requirement.

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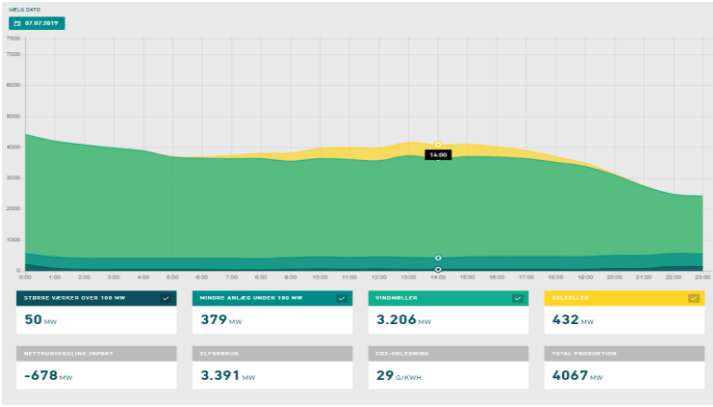
Potential applications for use of EN/IEC 62477-1

Renewable energy sources
Electrification (Energy storage, transportation)
Drives, UPS, SMPS

30

The potential use of IEC 62477-1/2 in miscellaneous (future) power conversion applications.

Energy generation of renewable energy sources:



Source: Energinet.dk (Link)

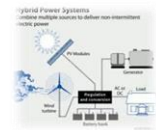
Solar

Wind

Tidal

Hydro

Hybrid power

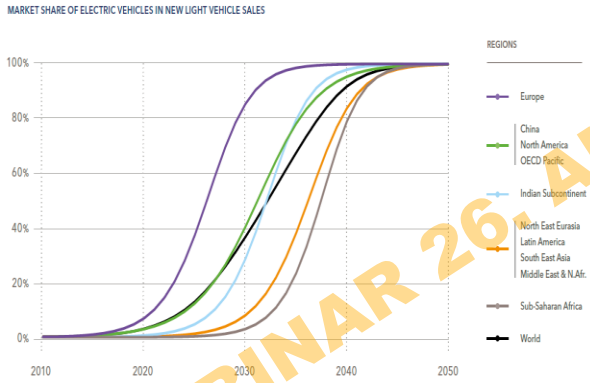


Wave energy

31

The potential use of IEC 62477-1/2 in miscellaneous (future) power conversion applications.

Transportation and energy storage:



Source: 2017 DNV GL energy transition outlook – renewables, power, and energy use

Marine

Car charging

Energy storage

Public transportation

The potential use of IEC 62477-1/2 in miscellaneous (future) power conversion applications.

Traditional power electronic applications:

Motion/process control by Drives:

SMPS

UPS / Datacentre:

The global use of IEC 62477-1

Europe
Japan
China
Australia
North America

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Global harmonization

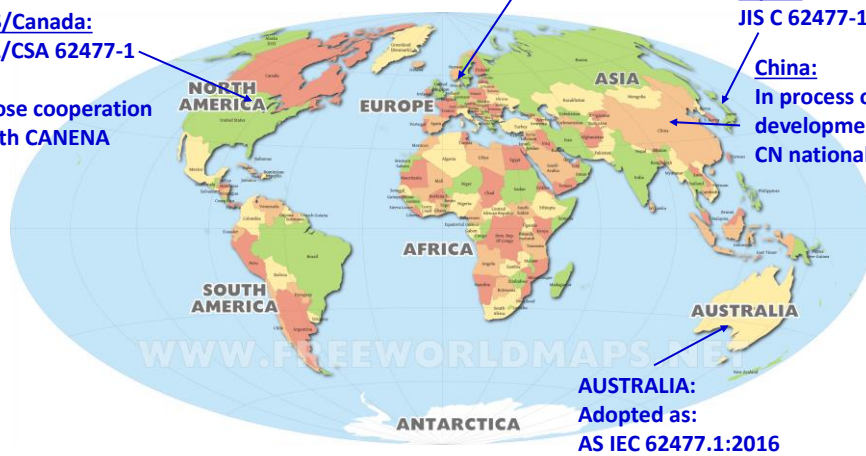
Europe:
EN 62477-1+A1 (2016)
In the process of being listed under the LVD directive (LVD/35/EU).

US/Canada:
UL/CSA 62477-1

Close cooperation with CANENA

Japan:
JIS C 62477-1

China:
In process of development as CN national std.



AUSTRALIA:
Adopted as:
AS IEC 62477.1:2016

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Q & A Session

Please use the chat

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A better tomorrow is **driven by drives**

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Potential of power electronics to support green transition
DS/S-522 Related products

- Power electronics products standards:
  - Power supplies (IEC SC22E)
  - Electrical transmission and distribution (IEC SC22F)
  - Power drive systems (IEC SC22G)
  - Uninterruptible power systems (IEC SC22H)

- Related product fields:
  - LVDC
  - HVDC
  - Wind turbines
  - Solar power
  - Rechargeable batteries
  - Electrical vehicles

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Potential of power electronics to support green transition

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- **Jacob Lynge:** Testing of motors and associated frequency drives
- **Jakob Svendsen:** Implementation of standards and labelling schemes and their advantage on the world market

Panel discussion and the opportunity to ask questions about the influence of standards and power electronics on the green transition

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For a **better tomorrow**

20%
of the world's energy consumption is **electrical energy**

50%
of electrical energy is used by **electrical motors**

Variable speed drives control power supply to electric motors and typically save **15-40%** of energy consumed

TODAY:
75%
of variable speed drives are used on pumps, fans and compressors

TOMORROW:
Variable speed drives have the potential to save
8%
of global electricity consumption by 2040

Source: IEA World Energy Outlook 2016

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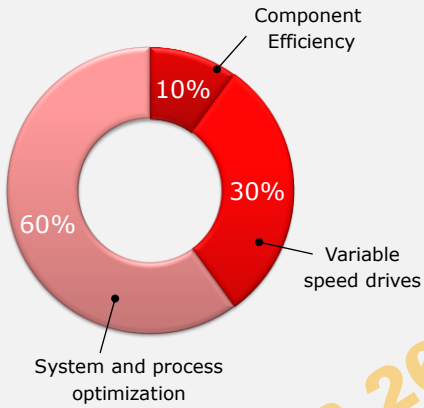

Source: SAVE Report of EU & ZVEI

- 7 TWh can be saved by using more efficient motors
- 23 TWh can be saved by using variable speed

Savings potential

- 10% - Increase component efficiency
- 30% - Use variable speed drives
- 60% - System and process optimization
- Recent years' political initiatives to improve the efficiency of motor systems focused mainly on component level efficiency

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ENGINEERING TOMORROW

The drive system
A standard for efficiency of motor drive systems

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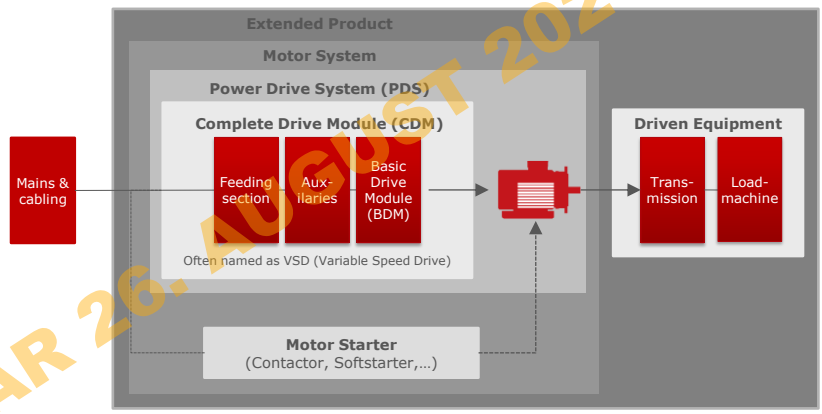
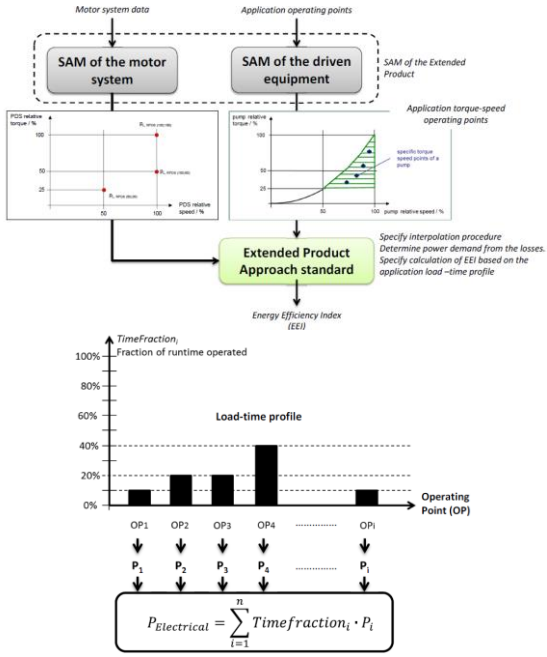
Ecodesign of power drive systems **IEC 61800-9**

- IEC 61800-9 has been published in March 2017 and is harmonized in Europe as EN61800-9
- Part I (IEC61800-9-1) deals with *Extended Product Approach*
- … and is designated at *Group Energy Efficiency Publication*
- Part II (IEC61800-9-2) deals with efficiency determination and classification of drives and power drive sytems
- It also deals with determination of partial-load efficiency

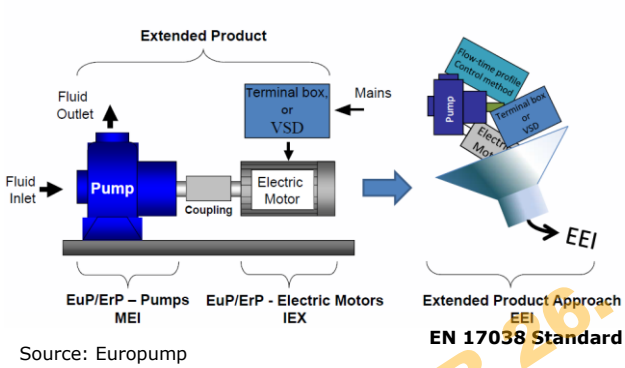




Extended **product approach**

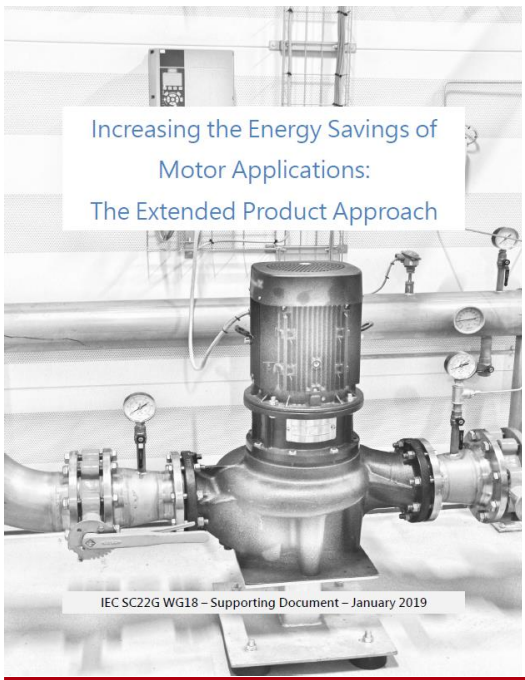
- The extended product approach combines the losses or efficiency of the motor system with the losses/efficiency of the driven system (pump, fan, conveyor, etc.)
- Based on the losses or efficiency of the extended product, the **energy efficiency index (EEI)** can be calculated for a given load-time duty profile
- Knowing the part load losses for the motor-drive system is essential for calculating the EEI, which is the ultimate purpose of the ecodesign standard
- EPA can be used to determine if, for a specific application, variable speed operation is beneficial or fixed speed shall be used

Extended product approach example



Source: Europump

- EEI is the relation between average power input and the reference power input of an extended product when operated according to a specified flow-time profile
- Low EEI= high efficiency



EPA supporting document

- IEC has published a supporting document that is available for free download and explains the Extended Product Approach

https://www.iec.ch/public/sc22g/IEC%20SC22G%20WG18%20Energy%20Savings%20Motor%20Applications%20EPA%20v1.pdf

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Efficiency classification and **part load losses**

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Classification of **motors and drives**

Motor

IEC/EN 60034-30-1

- Fixed speed motors (DOL)
- Classes IE1 – IE4

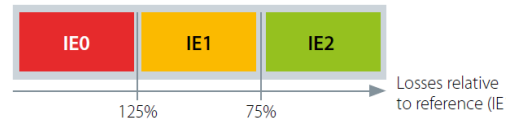
IEC/EN 60034-30-2

- Variable speed operation
- Classes IE1 – IE5

Drive

IEC/EN 61800-9-2

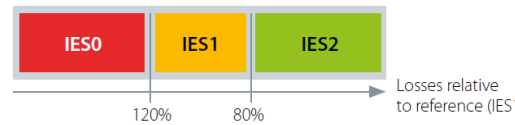
- Complete Drive Module (CDM)
- Classes IE0 – IE2



Drive + motor

IEC/EN 61800-9-2

- Power Drive System (PDS)
- Classes IES0 – IES2



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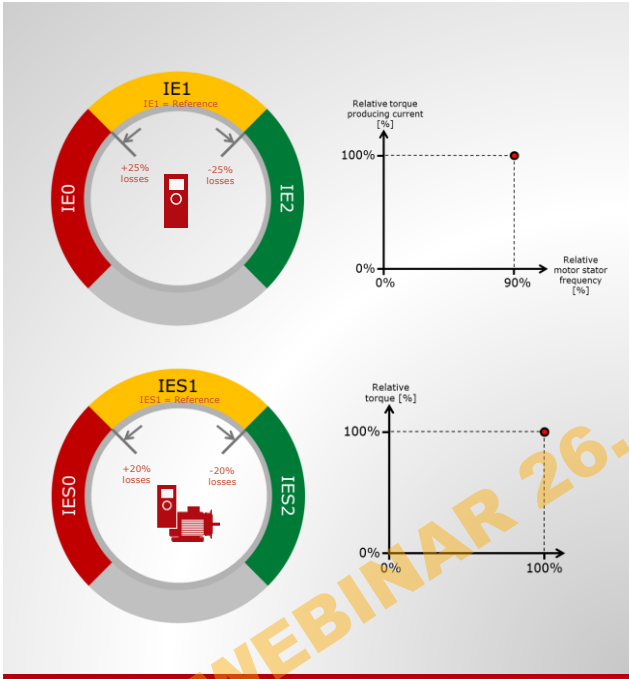

Definition of
IE and IES classes

- IE classed for drives (CDM) are defined at 90% frequency and 100% torque-producing current
- IES classes for motor + drive systems (PDS) are defined at 100% speed and 100% torque

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Determining IES classes
drive + motor

- It is not possible to calculate the IES class directly out of the IE classes for drive and motor: $IE2_{motor} + IE2_{VSD} \neq IES2$
- The IES class can be calculated using motor and drive losses and comparing the sum with the IES reference value
- For determining the IES class of a system consisting of a Danfoss drive and any induction motor, it is possible to use the ecoSmart tool

Losses $_{Motor}$

\+

Losses $_{VSD}$

Losses $_{VSD+Motor}$ → **IES**

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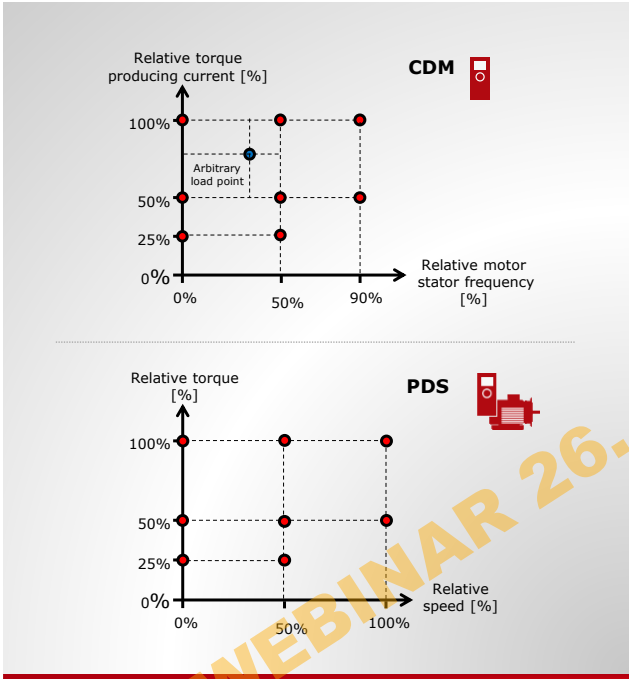

Part load losses

- Part load losses are defined in the nominal point and in 7 additional part load points for:
  - CDM (drive)
  - PDS (drive + motor)
- Note that the nominal point for drives is 90% of nominal load and 100% for systems
- Part load losses can be determined in any point by interpolating between the 8 standardized points

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Ecodesign
Regulation for motors and drives

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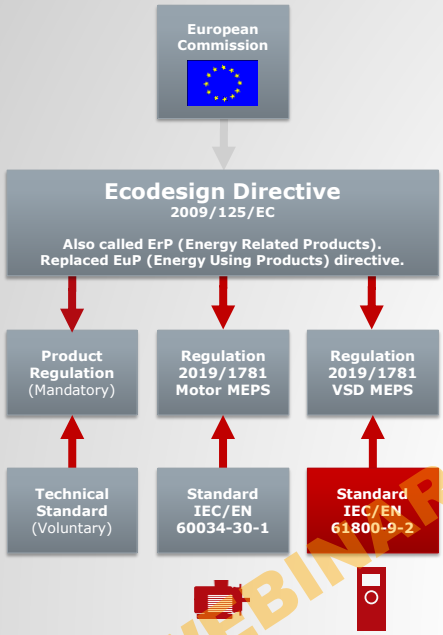

Ecodesign in Europe

- Ecodesign Directive is the legislative framework in the EU for reducing energy consumption of products.
- Concrete legislative measures for products come into force via regulations
- Technical aspects of regulations are often based on technical standards
- Regulations set **M**inimum **E**fficiency **P**erformance **S**tandards (**MEPS**) for eliminating "bad products"

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MEPS Timeline Europe

European Regulation (EG) No. 640/2009 defines which **induction motors** must fulfill **M**inimum **E**fficiency **P**erformance **S**tandards (MEPS), and when.

Valid	Power	MEPS	MEPS alternative
01.01.2017	0,75 – 375 kW	IE3	IE2 + VSD

A new regulation (EU) 2019/1781 is in force since 1st of October 2019

Valid	Motor (2,4,6,8 pole)*			VSD / Drive		MEPS alternative
	Power		MEPS	Power	MEPS	
01.07.2021	3~	0,12 – 0,75 kW	IE2	3~ 0,12 – 1000 kW	IE2	omitted
	3~	0,75 – 1000 kW	IE3			
01.07.2023	1~	≥0,12 kW	IE2			omitted
	2,4,6 pole					
	3~	75 – 200 kW	IE4			
	Ex eb - 2,4,6,8 pole					
	3~	0,12 - 1000 kW	IE2			

*Starting 01.07.2022 motor part load losses for operation at VSD must be provided

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Conclusion

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Future trends

- Increased focus on **total cost of ownership** and other similar indicators (lifecycle cost) requires system level approach and ability of predicting system efficiency in a standardized manner

- **Digitalization** leads to major opportunities
- For example, pumps loose efficiency during their lifetime because of factors such as wear-out, fouling, sanding, etc.
- **Condition monitoring** enables continuously monitoring the efficiency of the pump and triggering maintenance when the efficiency falls below prescribed parameters

- **Second edition of IEC61800-9** – expected 2022

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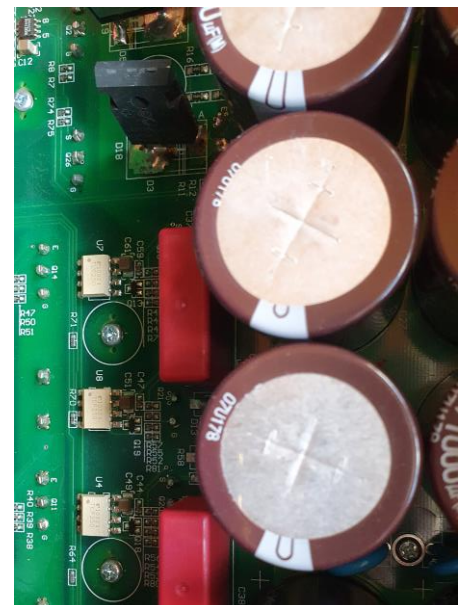
Potential of power electronics to support green transition
Product standards

DS DANSK STANDARD

- Wind turbines
  DS/EN IEC 61400-series
  - S-588
    IEC TC 88, CLC TC 88
- Photovoltaic (PV)
  DS/EN IEC 61853-series
  - S-582
    IEC TC 82, CLC TC 82
- Battery systems
  DS/EN IEC 62485-series
  - S454
    IEC TC 21, IEC SC21A,
- Electrical vehicles (EV)
  DS/ISO 6469-series (CD 5474-s)
  - S454
    ISO TC22 SC37
- EV Charging systems
  DS/EN IEC 61851-series
  - S454
    IEC TC 69
- Power electronic systems
  DS/EN IEC 62477-1
  DS/EN IEC 62909-series
  - S-522
    IEC TC 22
    IEC SC 22E
- Energy storage
  DS/EN IEC 62933-series
  - S-508
    IEC TC 120



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Potential of power electronics to support green transition

- **Preben Holm:** IEC 62477-1 and it's use in risk assessment
- **Norbert Hanigovszki:** Ecodesign and energy efficiency of variable speed drives
- **Jacob Lynge:** Testing of motors and associated frequency drives
- **Jakob Svendsen:** Implementation of standards and labelling schemes and their advantage on the world market
- Panel discussion and the opportunity to ask questions about the influence of standards and power electronics on the green transition

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Testing of motors and associated frequency drives

A short presentation of my work with the MGE motors, and my journey towards standards.

be think innovate

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Agenda

1 About Me

2 My journey towards standards

3 Grundfos E-pumps with MGE

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General Info

- Name: Jacob Lynge
- Education:
  - Bachelor of Engineering within Electronics and Computer Engineering, AAU Esbjerg. January, 2017.
- Works @Grundfos
  - Engineer

&

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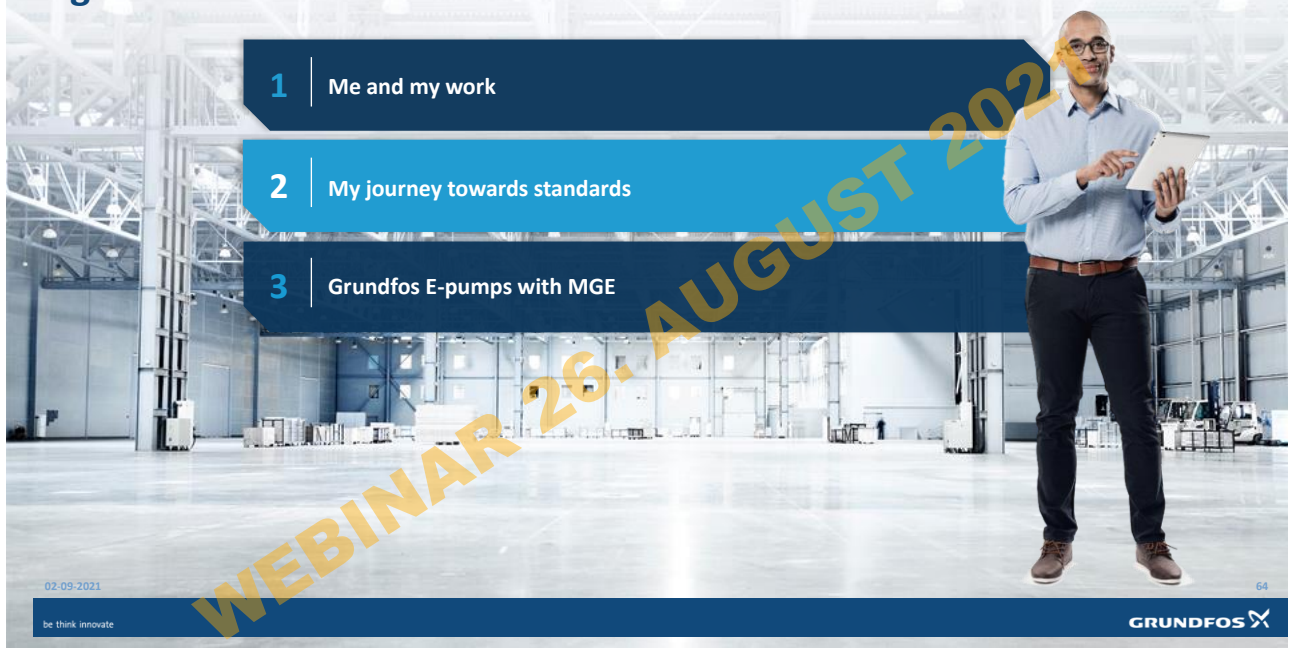
Agenda



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My journey towards standards

- Hired @ Grundfos.
- Started EMC Testing
  - Drives
    - Cispr 11 B
    - EN61800-3
- DS Workshop
- IEC YPP General Assembly Shanghai 2019

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My journey towards standards

- Committee Work S-522
  - Power Electronics
    - Commenting on drafts (IEC 61800-9-1: Adjustable speed electrical power drive systems…)
    - Committee meeting
    - Insight into upcoming standards.
- Materials in Components
- Even more testing

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Agenda

1 About Me

2 My journey towards standards

3 Grundfos MGE and Standards/Tests

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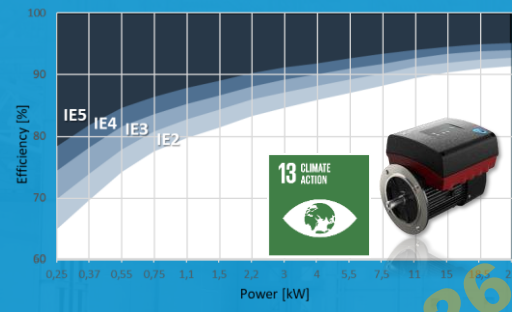
MGEs and Standards/Tests



IEC 60034-30-2 for variable speed (only) AC motors – Grundfos motors among the first IE5 motors

Grundfos MGE motors (0.75 to 11 kW) have attained IE5 status

Developed to use less Energy:
The MGE I5 motor was developed, so it could fulfil the requirements of IEC60034-30-2 Efficiency class IE5. The Following table 6, is from the previousiy mentioned standard.

Table 6 – Reference values (%) for the calculation of IE5 nominal efficiency limits

Rated output power P_N [kW] at rated speed and full-load torque	Rated speed within 600 to 900 /min	Rated speed within 901 to 1 200 /min	Rated speed within 1 201 to 1 800 /min	Rated speed within 1 801 to 6 000 /min
0,12	67,4	69,8	74,3	71,4
0,18	71,9	74,6	78,7	75,2
0,20	73,0	75,7	79,6	76,2
0,25	75,2	78,1	81,5	78,3
0,37	78,4	81,6	84,3	81,7
0,40	78,9	82,2	84,8	82,3
0,55	80,6	84,2	86,7	84,6
0,75	82,0	85,7	88,2	86,3
1,1	84,0	87,2	89,5	87,8
1,5	85,5	88,4	90,4	88,9
2,2	87,2	89,7	91,4	90,2
3	88,4	90,6	92,1	91,1
4	89,4	91,4	92,8	91,8
5,5	90,4	92,2	93,4	92,6
7,5	91,3	92,9	94,0	93,3
11	92,2	93,7	94,6	94,0

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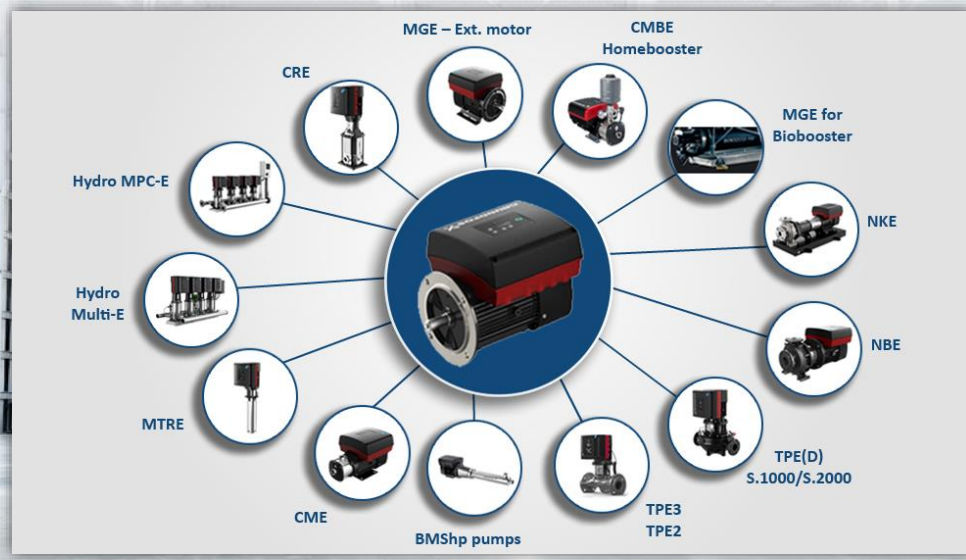
Look for MGE on these Grundfos products



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MGEs and Standards/Tests

IEC 61800 Series “Adjustable speed electrical power drive systems”
- 61800-3 “EMC Requirements and Specific Test Methods”
- 61800-5-1 “Safety Requirements – Electrical, Thermal and Energy
- 61800-9-2

- Why do we EMC test?
  - To fulfill the essential demands of the EMC directive
- What do we EMC test?
  - Emission
  - Immunity
- How do we evaluate?
  - Logging
  - Visual/Audio-able inspection
  - Function Test

Table 2 – Criteria to prove the acceptance of a PDS against electromagnetic disturbances

Item	Acceptance (performance) criterion [a]		
	A	B	C
General system performance	No noticeable changes of the operating characteristic Operating as intended, within specified tolerance	Noticeable changes (visible or audible) of the operating characteristic Self-recoverable	Shutdown, changes in operating characteristics Triggering of protective devices [b] Not self-recoverable
Special system performance Torque generating behaviour	Torque deviation within specified tolerances	Temporary torque deviation outside specified tolerances Self-recoverable	Loss of torque Not self-recoverable
Sub-component performance Operation of power electronics and driving circuits	No malfunction of a power semiconductor	Temporary malfunction which cannot cause unintended shut-down of the PDS	Shut-down, triggering of protective devices [b] No loss of stored program No loss of user program No loss of settings Not self-recoverable
Sub-component performance Information processing and sensing functions	Undisturbed communication and data exchange to external devices	Temporarily disturbed communication, but no error reports of the internal or external devices which could cause shut-down	Errors in communication, loss of data and information No loss of stored program, no loss of user program No loss of settings. Not self-recoverable
Sub-component performance Operation of displays and control panels	No changes of visible display information, only slight light intensity fluctuation of LEDs, or slight movement of characters	Visible temporary changes of information, undesired LED illumination	Shut down, permanent loss of information, or unpermitted operating mode, obviously wrong display information No loss of stored program, no loss of user program No loss of settings

[a] Acceptance criteria A, B, C – False starts are not acceptable. A false start is an unintended change from the logical state "STOPPED" which can make the motor run.

[b] Acceptance criterion C – The function can be restored by operator intervention (manual reset). Opening of fuses is allowed for line-commutated converters operating in inverting mode.

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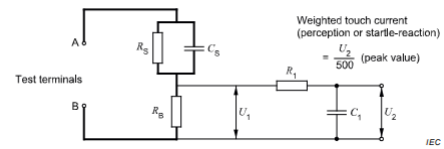
MGEs and Standards/Tests

- Ensuring safety through standards.
  EN61800-5-1 specifies safety requirements.
- Protection against electric shock
  “Protection against Direct contact is employed to prevent requirements of section 4.3.4.”
  - IPXXB Requirement according to 15.1 of IEC 60529.
- Product is safe to touch
  “ 4.3.5.5.2 Touch current in case of failure of protective ea
  - Test measurement to verify compliance of 3,5mA a.c. or
  - Done via following test method of 5.2.3.5
- Wire Bending Space Check.
- But there is so much more testing in 61800-5-1



Size of wire mm²	Minimum bending space, terminal to enclosure mm		
	Wires per terminal		
	1	2	3
10 – 16	40	–	–
25	50	–	–
35	65	–	–
50	125	125	180
70	150	150	190
95	180	180	205
120	205	205	230
150	255	255	280
185	305	305	330
240	305	305	380
300	355	405	455
350	355	405	510
400	455	485	560
450	455	485	610

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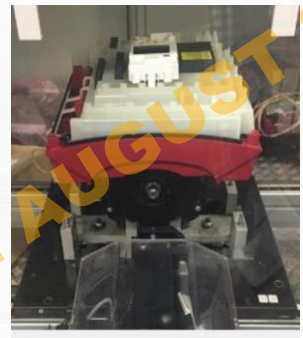
MGEs and Standards/Tests

- From Lwp cpl. -> MGE -> Pump/system, we are running test in production.
  - HV test relevant to the operating voltages
  - Function test
  - Final test



- These test ensures we eliminate Non-compliant product and Ensure we fulfill the marks we put onto the MGE.
  - These approval marking are based on requirements and standards.

E-pumps with MGE makes export to another part of the world easy

BENEFITS

✓ **Global Market Access:**
Through keeping an eye on standards in development Grundfos MGE has obtained all required markings for global distribution, incl. CE, CCC, RCM, and cURus

✓ **Independent of network:**
This process also had an impact on the decision to make the MGE ready for operation in all 200-240 and 380-500V as well as both 50/60Hz areas.

Why standards are awesome to comply with.

- Grants easier access to market.
- Highlights more robust design.
- Higher Safety.
- Energy Savings.
- All in all making a difference.

BENEFITS

be think innovate

GRUNDFOS

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DS
DANSK STANDARD

Potential of power electronics to support green transition

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Potential of power electronics to support green transition

- **Preben Holm:** IEC 62477-1 and it's use in risk assessment
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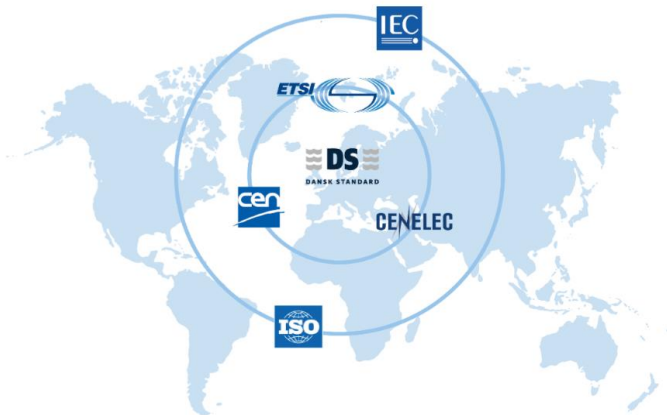
Implementation of standards and labelling schemes and their advantage on the world market, by Schneider Electric



IEC (International Electrotechnical Commission)
ISO (International Organization for Standardization)
ETSI (European Telecommunications Standards Institute)
CEN (Comité Européen de Normalisation)
CENELEC (Comité Européen de Normalisation Electrotechnique)
DS (Danish Standards Institute)
BS (British Standard Institute)
Each country has there own standard institut

Present by: Jakob Svendsen

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Kolding Site history

A Research & Design Center
within ITD of Software (Strategy & Marketing) and 3PP (Date Center Systems)

Easy access

> **Founded in1942 and named Silcon**
  - Production of special condensators for car industry.
  - Specializing in converting power AC/DC or DC/AC
> Main focus was UPS applications from the late 1970´s
> On the Danish stock market 1990
> **Acquired in 1998 by American Power Conversion Corp.**
> 2000: 530 employees
> 2001: Manufacturing operations moved to low cost.
> 2002 : 160 employees
> The **transformation** to a R&D center begins
> **Acquired in 2007 by Schneider Electric**
> 2021: Approx. 200 employees

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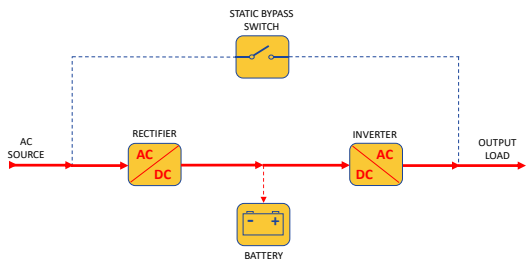
Uninterruptible power supply (UPS):



Easy UPS 3-serie

Galaxy

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The UPS standards:

IEC 62040-1 (Uninterruptible power systems (UPS) - Part 1: **Safety requirements**)

IEC 62040-2 (Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility **(EMC) requirements**)

IEC 62040-3 (Uninterruptible power systems (UPS) - Part 3 : method of specifying the **performance and test requirements**)

IEC 62040-4 (Uninterruptible power systems (UPS) - Part 4 : **environmental aspects** - Requirements and reporting)

UPS High efficiency modes, ECO Mode vs. ECOnversion

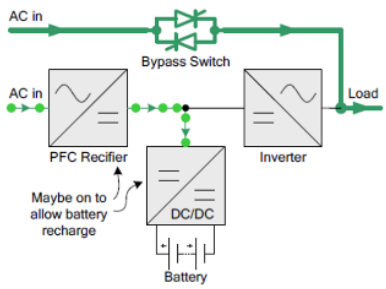

Fig1. In ECO Mode the DC bus i being charged through the PFC to allow the batteries to be charged. Efficiency is about 99%.

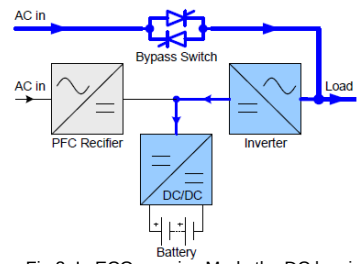

Fig 2. In ECOnversion Mode the DC bus is being charged through the inverter to allow the batteries to be charged. Efficiency is up to 99% depending on the load.

IEC 62040-3:2021

5.3.2 Characteristics to be declared by the manufacturer

The manufacturer shall declare the actual and applicable output characteristics, including

a Performance classification (V__ __ ___ in accordance with 5.3.4)
b Rated voltage and steady state variation
c Rated frequency and free-running (non-synchronised) variation
d Maximum frequency range accepted by the UPS inverter for synchronization with bypass and maximum resulting phase angle between the inverter and bypass voltage waveforms
e Rate of change of frequency (slew-rate) when synchronizing
f Number of phases available
g Neutral availability
h a.c. power distribution system compatibility (TN, TT or IT as defined in IEC 60364-1)
i Total harmonic distortion (THD) of voltage while supplying rated steady state linear load and when supplying rated steady-state reference non-linear load as specified in annex E and while operating
- in **normal mode**
- in **stored energy mode**

NOTE 2 A double-conversion UPS is an example of a UPS providing VFI performance (see 5.3.4)

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IEC 62040-3:2021

5.3.4 Performance classification

5.3.4.1 General

The manufacturer shall classify **UPS** complying with this document in accordance with the coding AAA BB CC as detailed in 5.3.4.

AAA = VI ,VFI or VFD

BB = Voltage waveform characteristic
describing the steady-state waveform of the voltage when operating in:

- normal or bypass mode	(1st character)
- stored energy mode	(2nd character)

"S": voltage waveform is sinusoidal
- presenting total harmonic distortion ≤ 8% and individual harmonic distortion within limits of "Table 2 – Compatibility levels for individual harmonic voltages in low voltage networks" under all linear and reference non-linear load conditions.

AND

5.3.4.4 Dynamic output performance CC

5.3.4.4.1 General

The dynamic output performance CC is a set of characters describing the voltage variation caused by

- the change of mode of operation (1st character), and
- the **step load** application (2nd character),

where each character takes form of either 1, 2 or 3 as described in the following subclauses.

The dynamic output performance is verified by performing the electrical type tests in 6.4.2.10.2, 6.4.2.10.3, 6.4.2.10.4 (for the 1st character) and in 6.4.2.10.5 (for the 2nd character).

VFI (voltage and frequency independent)
VFD (voltage and frequency dependent)

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Output performance classifications:

Output performance classifications							
Input dependency classification (AAA)			Output voltage waveform classification (BB)		Dynamic output performance classification (CC)		
V- Voltage, F-Frequency, D-Dependent, I-Independent			Normal mode (1st character)	Stored energy mode (2nd character)	Change of operating mode (1st character)	Step load application (2nd character)	
3 combinations: VFD/VI/VFI			9 possible combinations: **SS**/SX/**SY**/XS/XX/XY/YS/YX/YY		9 possible combinations: **11**/12/13/21/22/23/**31**/32/**33**		
Definitions							
Type	Input voltage	Input frequency	Type	With linear and non-linear load applied in each operating mode	Class	Max output voltage interruption	Compatible load types
VFD	Dependent	Dependent	Y	Non-sinusoidal	3	10 ms	General-purpose IT loads
VI	Independent	Dependent	X	Sinusoidal with THD* ≤ 12 %, IHD**within limits[9]	2	1 ms	Critical loads
VFI	Independent	Independent	S	Sinusoidal with THD* ≤ 8 %, IHD** within limits[10]	1	0 ms	Sensitive critical loads

* THD means total harmonic distortion. ** IHD means individual harmonic distortion.
Common combinations shown in **bold**.

Life Is On Schneider Electric

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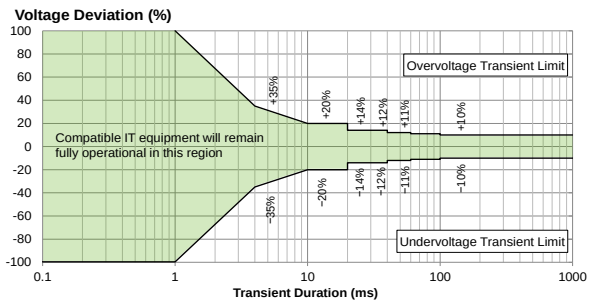
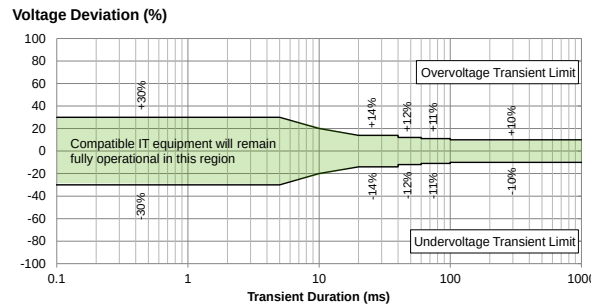
Definition of classes:



Class 2



Class 1

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ECOnversion is a class 1 operation

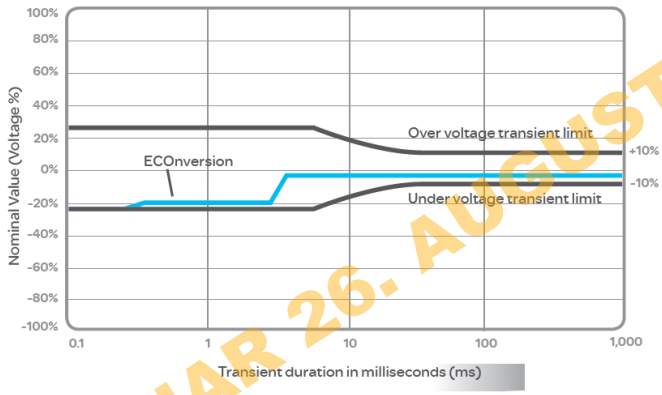

Illustration of the system output voltage is kept within limits of a class 1 system rating according IEC 62040-3

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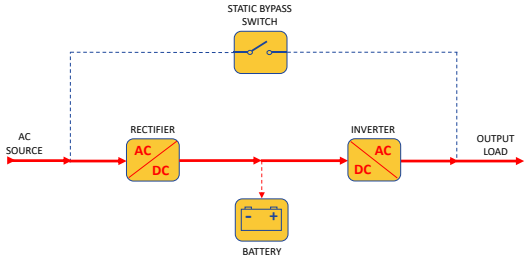
The output performance is summarized as **VFI-SS-11** according to IEC 62040-3:2021



=> **AAA-BB-CC** = **VFI-SS-11**

On-line normal mode double conversion on-line UPS topology

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How can we use this, as marketing and make it visible for the costumer ?

- 3rd Parts test (UL witness test):

Table 2: Derived from UL test report (10-23-2014) (IEC 62040-3: 2011-3 2nd Edition). Test conducted on 200 kVA unit at 400 V.

	Normal op	ECO Mode	ECOnversion
Load [%]	Efficiency [%]	Efficiency [%]	Efficiency [%]
10	93.33	96.84	94.54
25	95.86	98.58	97.56
50	96.37	99.09	98.64
75	96.24	99.24	98.97
100	95.72	99.27	99.06

AAA-BB-CCC (according IEC 62040-3:2011)

Marking

=>

ECOnversion
VFI-SS-111
Performance
Verified per
IEC62040-3

Label placed on the product

Homepage: www.verify.UL.com

Uninterrupted Power Supply

Company:

Schneider Electric IT Corporation, FKA APC American Power Conversion

Verify ID:

A422015

Expiration date:

November 06, 2019 - November 05, 2021

ECOnversion
VFI-SS-111
Performance
Verified per
IEC62040-3

Note: According to the new IEC 62040-3:2021 the VFI-SS-111 will be change to VFI-SS-11 and will be renewed november 2021.

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Potential of power electronics to support green transition

- **Preben Holm:** IEC 62477-1 and it's use in risk assessment
- **Norbert Hanigovszki:** Ecodesign and energy efficiency of variable speed drives
- **Jacob Lynge:** Testing of motors and associated frequency drives
- **Jakob Svendsen:** Implementation of standards and labelling schemes and their advantage on the world market
- Panel discussion and the opportunity to ask questions about the influence of standards and power electronics on the green transition

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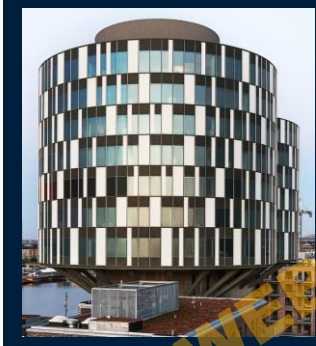
Panel-discussion



Potential of power electronics to support green transition

- The Danish committee (S-522) have now presented some relevant topics of power electronics.
- We will now open a panel debate.
- Ask questions through the chat, stating your first name and company/institution.

Preben Holm

Jacob Lynge

Norbert Hanigovszki

Jakob Svendsen

Søren Storm
sst@ds.dk

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