

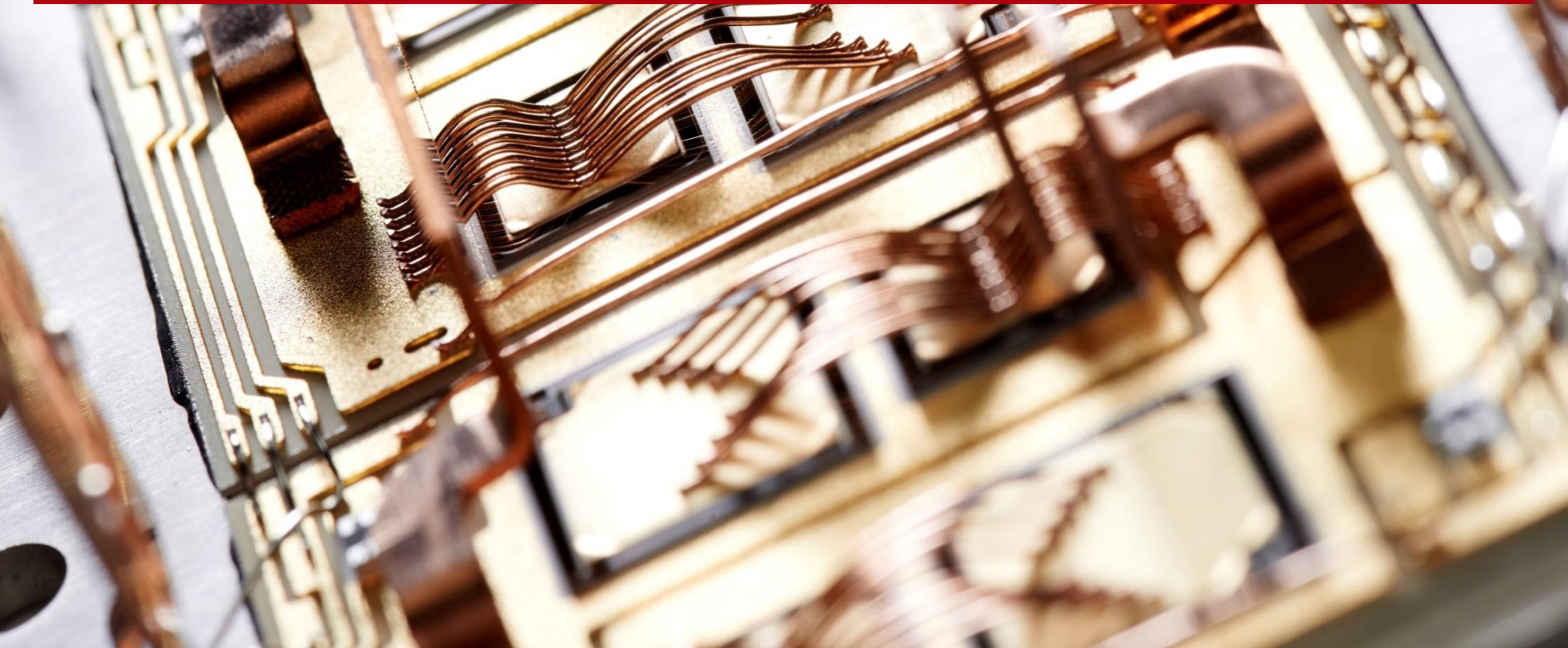
ENGINEERING
TOMORROW



Danfoss Silicon Power

Trends in Automotive and High Power

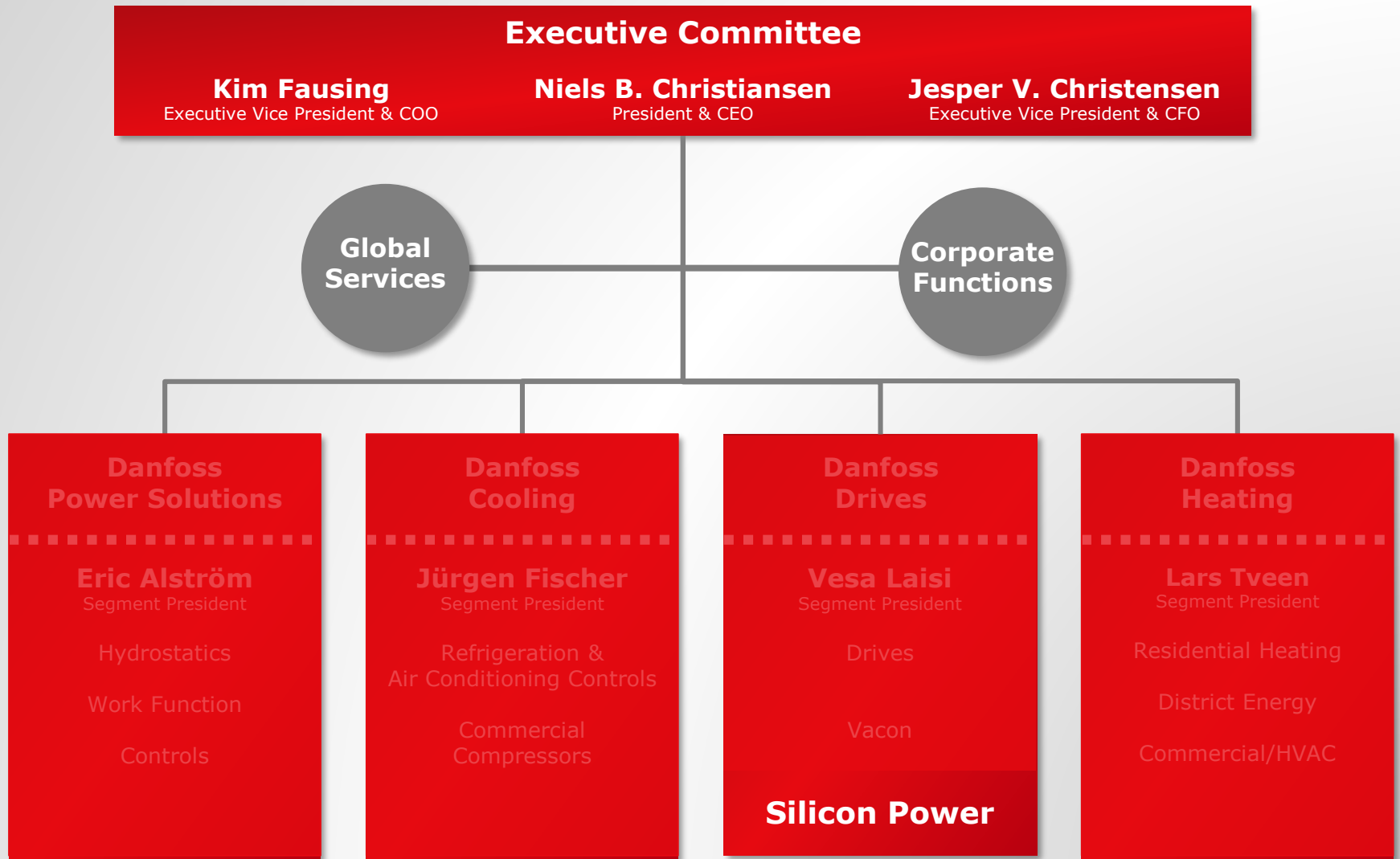
IEPE Aalborg – 18th January 2017



Content

- Introduction to Danfoss and Danfoss Silicon Power
- Trends in power electronics Automotive and High Power
- Technology Drivers supporting the markets
- Questions

Our organization





Danfoss Silicon Power: Customized Power Modules and Stacks

Facts & numbers:

- ~400 employees
- >5000m² production area
- 3900m² clean room, one of Europe's largest single contiguous clean rooms
- >25mio cars equipped with power modules from DSP
- >23GW wind turbines installed with Danfoss Silicon Power Technology

Danfoss Silicon Power serves three industries



Renewables

← **30%**
SHARE OF SALES

Industry

← **30%**
SHARE OF SALES

Automotive

← **40%**
SHARE OF SALES

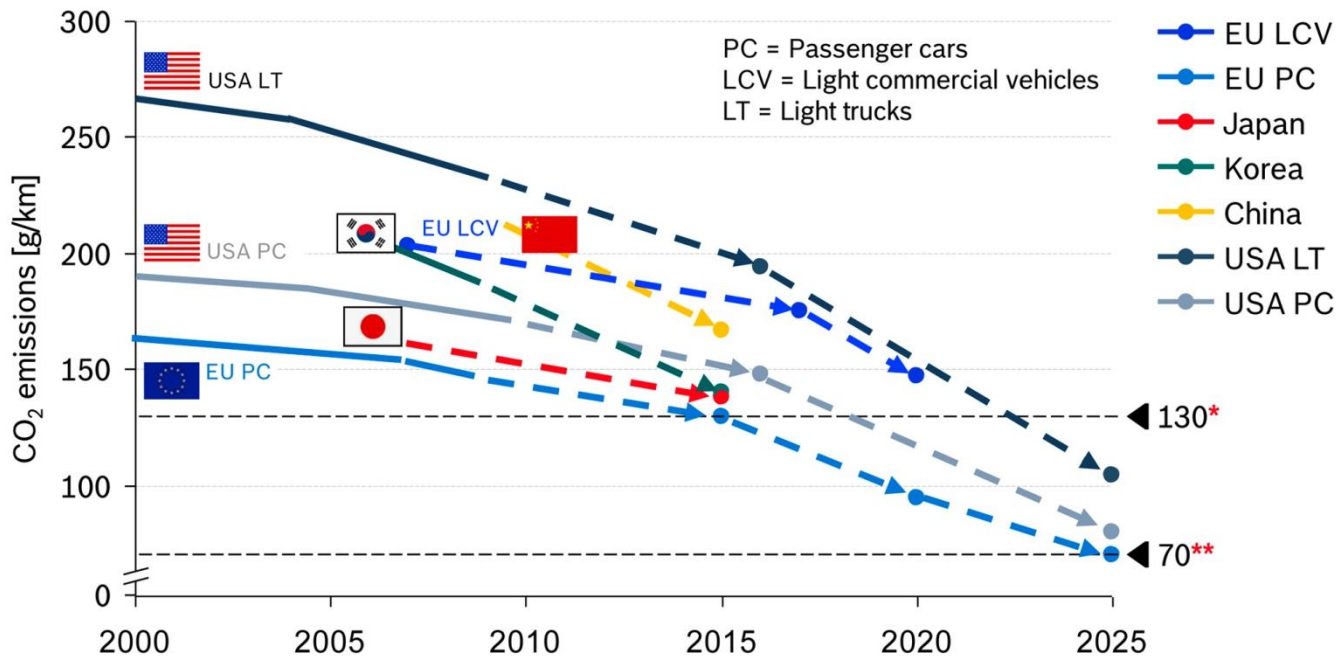
#6 World Wide
#3 in Europe
#1 World Wide in Mosfet Power Modules

What Drives Technology?

- Innovations in are driven through...
 - Strong need for radical improvements compared to todays solutions
 - Dedicated personalities urgin to make a difference
- The E-volution in automotive is a key driver of Power Electronics up to 1200V

EU-Legislation drives ambitious CO2 emission targets

CO₂ emission targets for new vehicles



* EU passenger cars (2015), ** EU passenger cars (proposal EU Commission for 2025)

Source: Robert Bosch GmbH

Europe

- 2015: 130 gr.
- 2021: 95 gr.
- 2025: 70 gr.

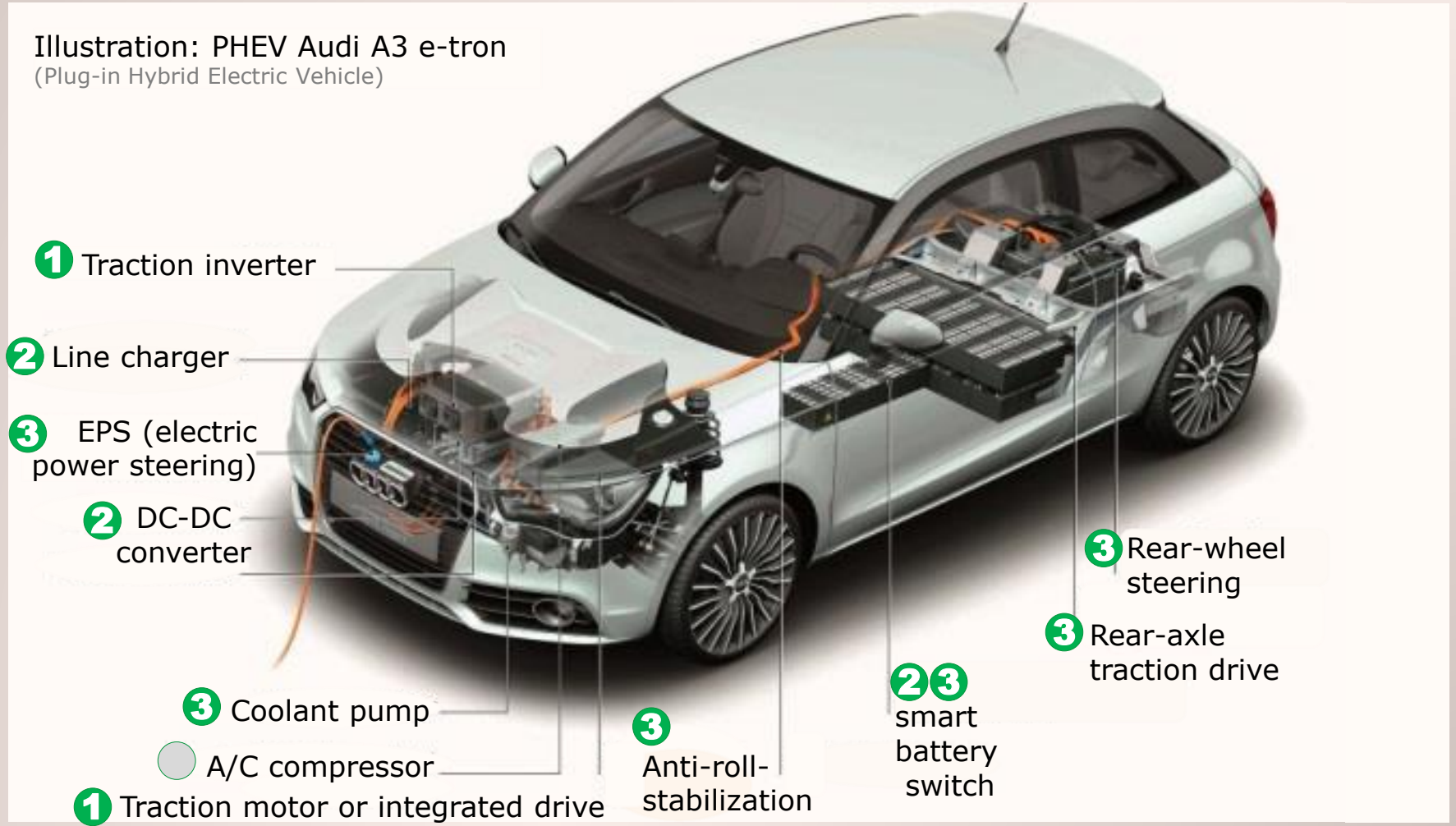
Super-credits for Battery-Electric- and Hybrid-Electric Vehicle

Penalty:

2021: 95 € / gr.

Power electronic applications contributing to automotive energy-efficiency

Illustration: PHEV Audi A3 e-tron
(Plug-in Hybrid Electric Vehicle)



Source: Audi, Danfoss Key Account Automotive

Danfoss Automotive Power Modules



From first idea to
high-volume series product

Developed in close co-
operation with customers
(Automotive Tier-1 / OEM)

Source: Danfoss Silicon Power

Power Electronics enters a broad number of platforms and applications

IGBT Module

Traction / Hybrid



BMW i3 with range extender



Porsche Panamera



Porsche Cayenne



Peugeot



BMW 3; 5 active hybrid



VW Jetta

MOSFET

EPS



Cadillac



Porsche



Mercedes Benz

Source: Danfoss Key Account Automotive

The Automotive Industry is moving towards electricfication

VW: „As of 2019 will the Modular Electrification Building blocks MEB allow new models for all classes“



Porsche builds 320 kW Fast Charging System



Renault: „1000-Kilometer BEV is already possible today“



Mercedes Benz: „Four new Electrical models planned up til 2020“



VW: „New Buzz with 600 km driving range and 30 minutes Quick-charging“ (Batterie: 110 kWh)



High power density and reliability spiced with efficient liquid cooling...

...Are strong trends and driving demands in the automotive industry

This comes along with:

- Customization
- High level of integration
- Increasing voltage – incl. SiC as an option
- High Reliability/Robustness
- Low weight to power rating ratio

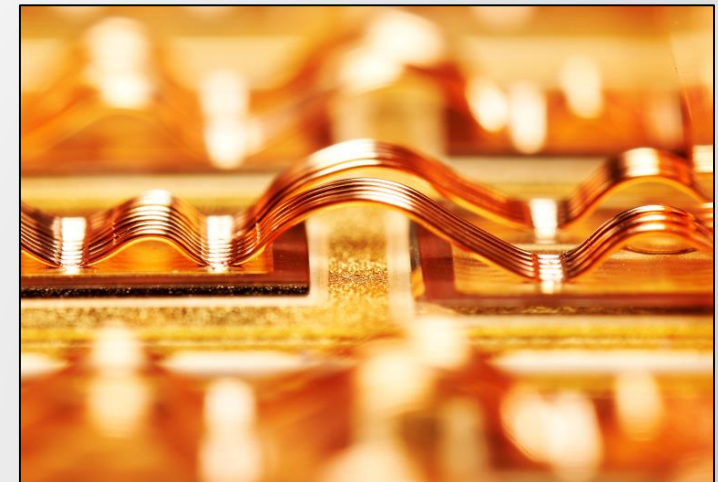
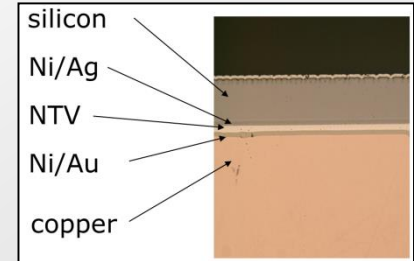


Concept for integrated Traction Inverter
(Source: ECPE / FhG-IISB)

New & highly innovative technologies needed in order to deliver on trends and demands

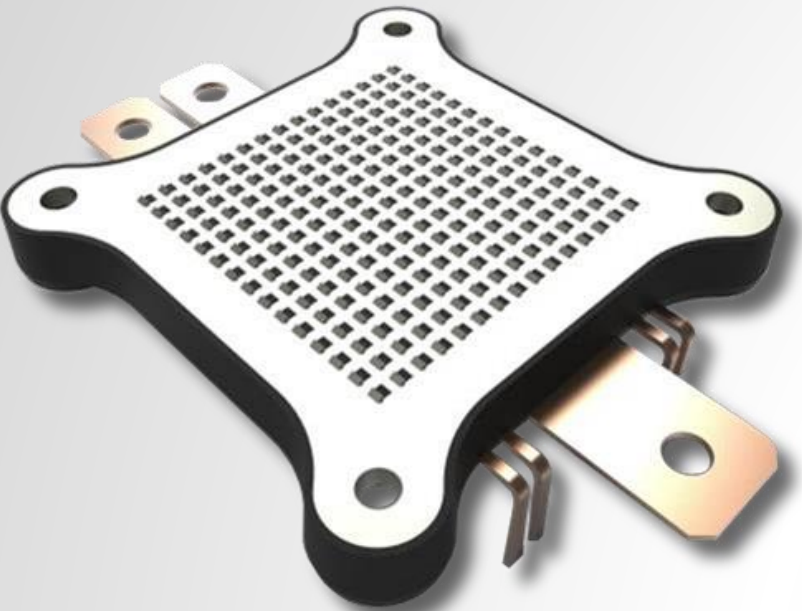
Danfoss has the right technologies and value proposition

- Innovative technologies available:
 - Danfoss Bond Buffer® - DBB®
 - Danfoss ShowerPower® liquid cooling
 - Sintering of semiconductors to DCB
 - Molding
 - Handling of SiC in best possible way
 - Innovative solutions on materials for improved reliability



Danfoss Bond Buffer Copper Wire Bonding

Combining the best into dedicated products



Combining our strong technologies:

- Danfoss Bond Buffer®
- ShowerPower®
- Molding technology



Long Life
Highest power density
No derating
High reliability
High efficiency

Example:

Direct liquid cooled power module for automotive traction drives

Danfoss is a strong, reliable partner with the mindset and technologies of **TOMORROW**

Already today Danfoss delivers highly differentiated products and technologies in both automotive and renewable industries

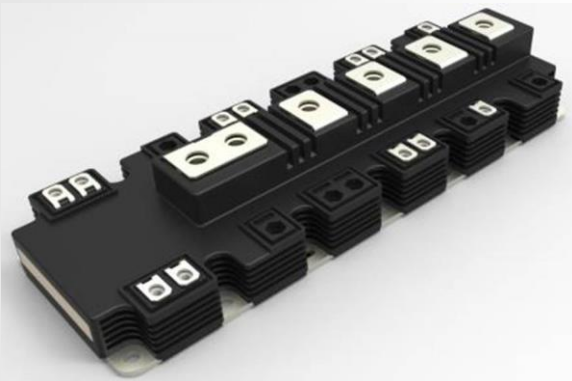
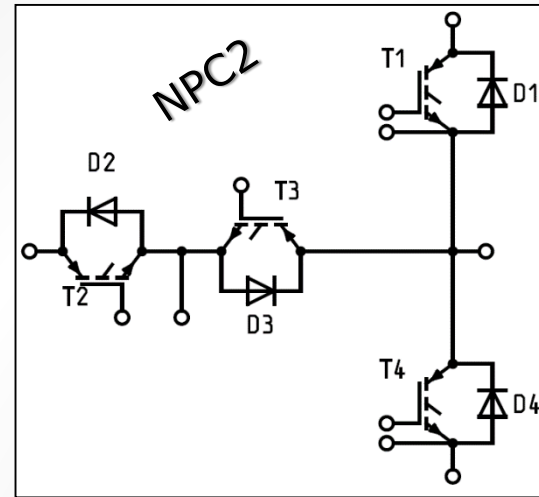
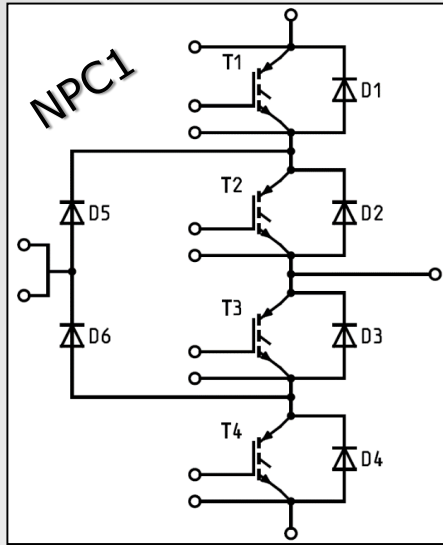
**4GW in EPS
application p.a.**

**10GW in automotive
traction applications
p.a.**

**12-15GW in wind and
solar applications**

***-all based in deep customer and application knowledge
combined with strong technological capabilities***

Three-Level Topologies are introduced for Renewables using unique P3L modules



Three Level offers:

- Smaller output voltage steps
- Cleaner output waveforms
- Higher power quality
- Less filtering effort
- Reduced cost

Trends in power electronics

- Automotive and High Power

- Scale is the key driver for new technology in power electronics
- The next large scale development is the e-evolution in the car industry
- All new technologies will mitigate into high power technologies
- Danfoss is a key driver enabling the new technologies into the market

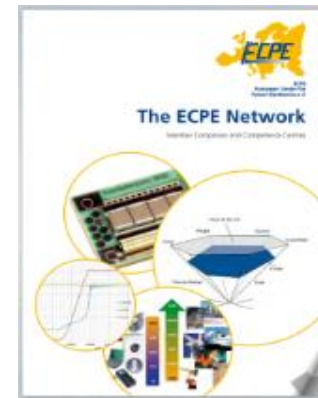
Danfoss Research Cooperation Partners



Danfoss Partners in European Center for Power Electronics



ECPE has 74 Industry Partners from 9 European countries



Source: ECPE Network Brochure 2015



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