P2X Converter Design and Control

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ENGINEERING TOMORROW

Danfoss

Danfoss Drives business

Annual revenue
1.9bn
EUR

31.5m
drives delivered

>50m
cars equipped with power modules

1000
partner companies

Global presence
100,50,10
Countries
Sales & service offices
Factories

First mover since
1968

Source: Danfoss Annual Report 2022

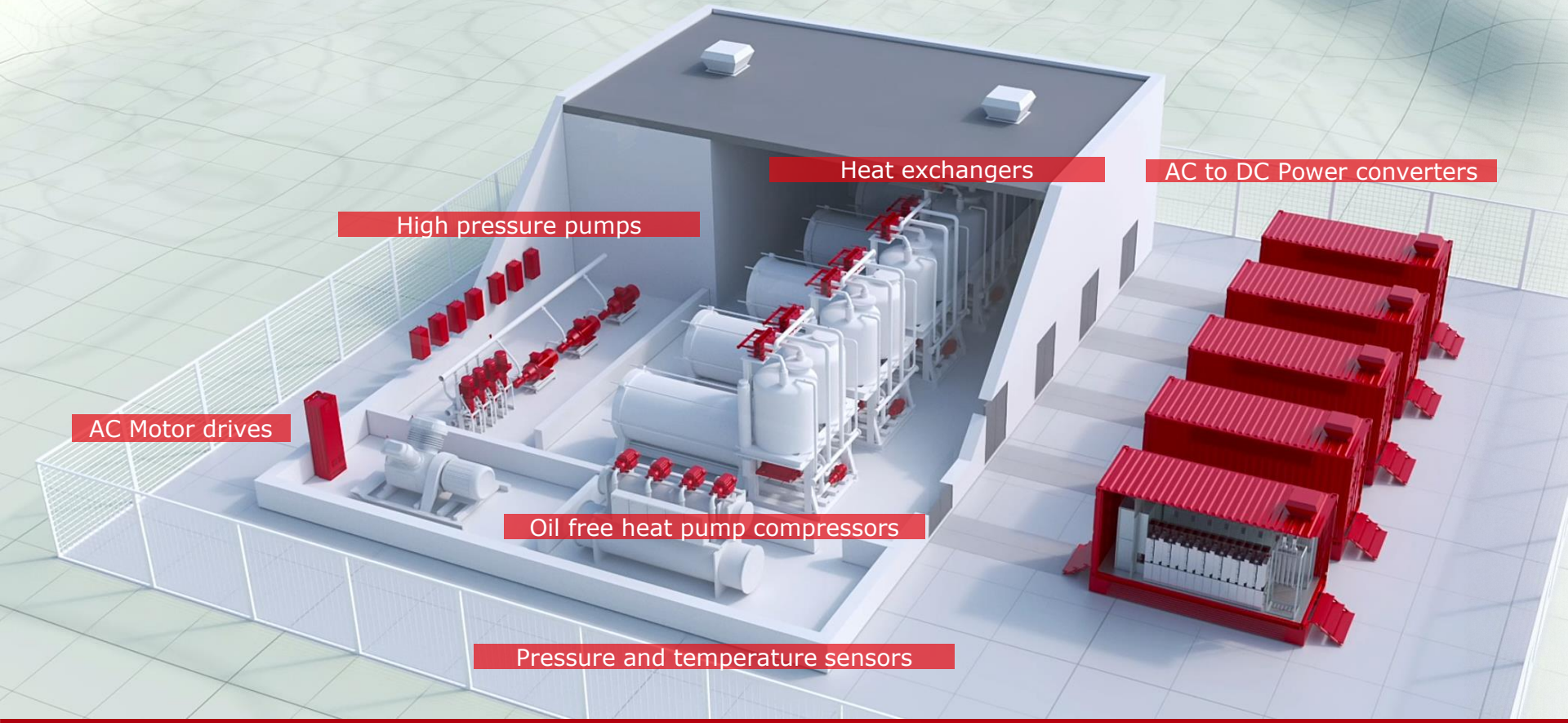
Danfoss Drives business expanding…

Power to Power…:

- Renewable sources
- Fuel Cells
- Chargers
- Energy storage
- Marine: Shore to Ship
- **PtX**

Strong growth in Power to Power Converters

Hydrogen Electrolysis – Powered by Danfoss

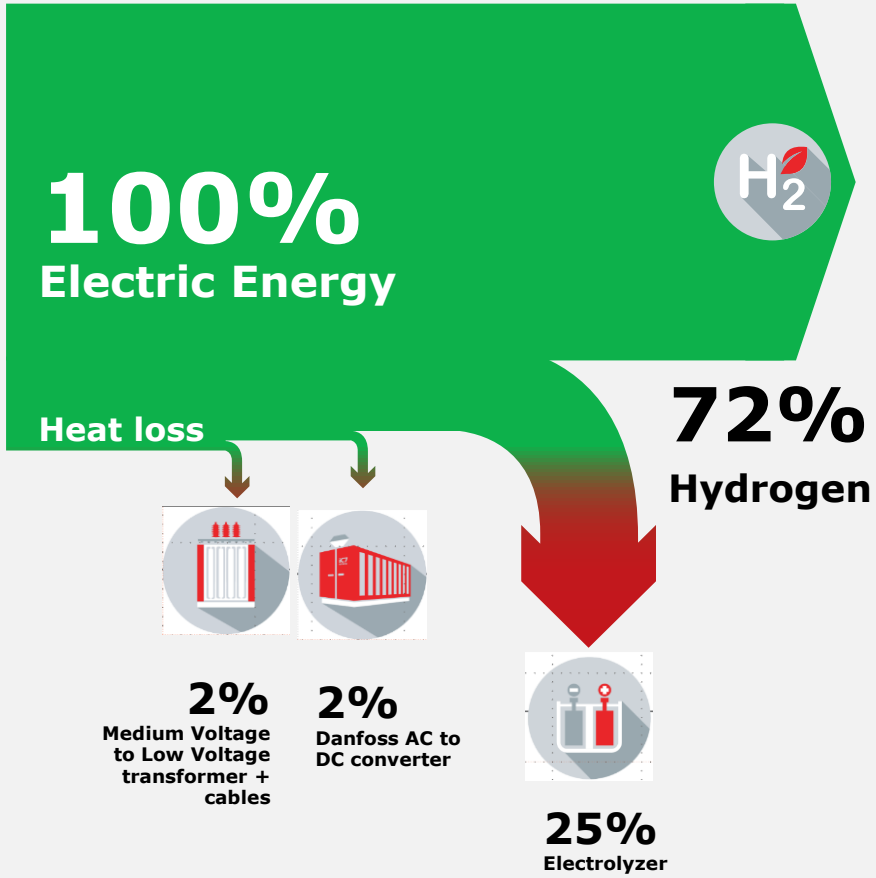


Technologies
for PtX converters

- Power Electronics
  - Advanced (WBG) components
  - Advanced topologies
  - Galvanic Isolation
  - Medium Voltage solutions
  - Multi-Megawatt converters
- Control and Diagnostics
  - Grid, converter and electrolyzer control
  - Condition based monitoring
- Thermal management
  - Liquid cooling
  - Heat pumps
- Digital twins…

Research Challenges **for PtX converters**

- Energy Efficiency
  - System level
  - Converter level
- Control
  - Loss
  - Start up
  - Fault handling
  - Supply Flexibility
  - Lifetime

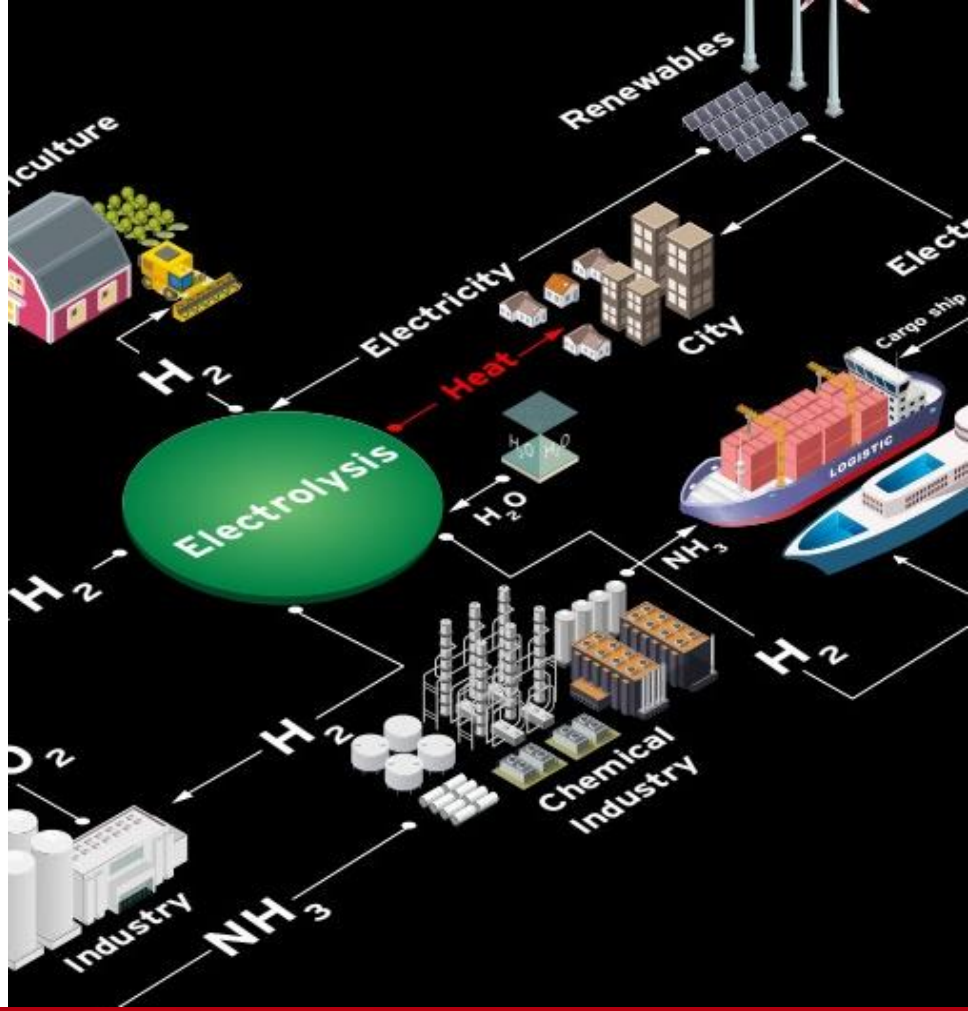


Research Challenges **for PtX converters**

- Grid Integration
  - Grid friendliness
    - Distortion free operation
    - Harmonics elimination
    - “Dynamic load impedance”
  - Grid code compliance
- Grid Services
  - New revenue streams
    - Frequency support
    - Balancing
    - Stability

Research Challenges **for PtX (converters)**

- Scalability for HUGE plants
  - Converter size and modularity
  - Electrolyzer voltage and currents
- Sector Coupling (District Energy)
  - High temperature heat pumps
  - Heat dynamics of PtX Systems
- Sustainability
  - Energy & Carbon Cycle
  - Resources & Recycling
- Cost



Research Programs (PtX)

- IFD Innomissions
  - MissionGreenFuels
- React Lighthouses
  - Green Energy and Sector Coupling
- Indo-Danish Research
  - Green Fuels including Green H_2
- Business Finland
  - Challenge Competition
- US, Department of Energy
  - Clean Hydrogen Technologies
- EU Innovation Fund
  - REPowerEU

Perspectives

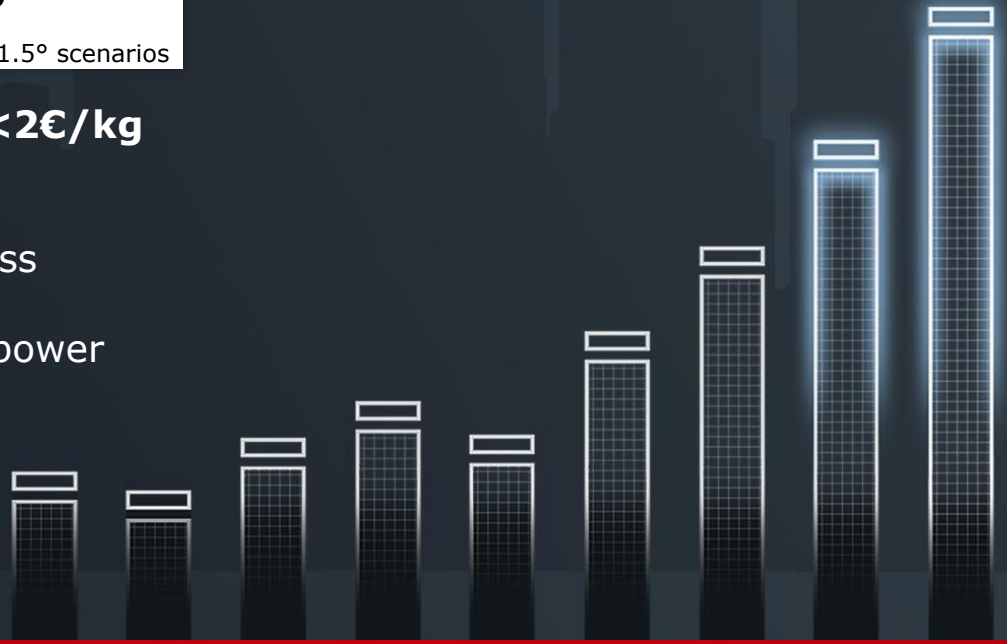
PtX converters

Installed base…
350GW in 2030
3600GW in 2050

IEA Net Zero Emissions / IRENA 1.5° scenarios

Levelized cost of hydrogen <2€/kg

- Increased efficiency
- Increased cost-competitiveness
- Increased grid friendliness
- Optimized solutions for high-power
- Medium voltage solutions



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