



Confidential III

Welcome


DC Grids in Industry

Tobias Lüke from Phoenix Contact




2016: M.Sc. Electrical Engineering

Research Associate
@Paderborn University
@Fraunhofer ENAS



2018: Product Manager
2023: Technical Project Manager



Founded in 1923
in Essen (GER)
Now HQ in Blomberg

22,000 employees
in over 50 countries

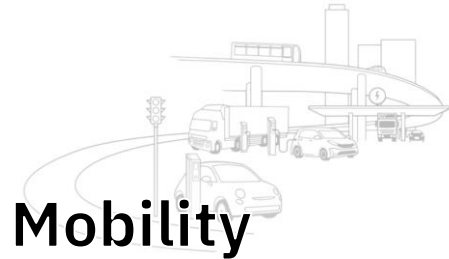
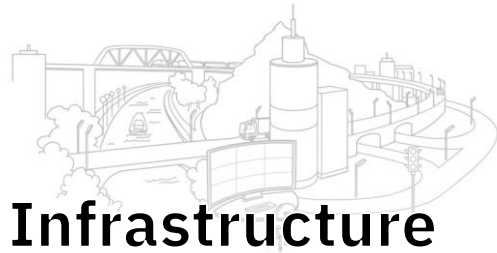
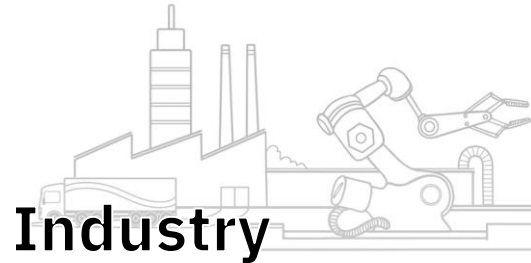
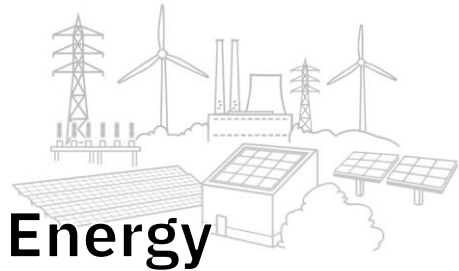


> 100,000 products for
industrial applications

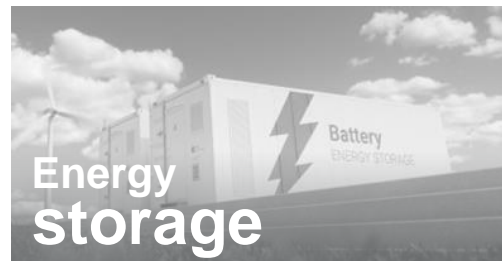
The All Electric Society

What is the All Electric Society?

Coupling of the relevant sectors

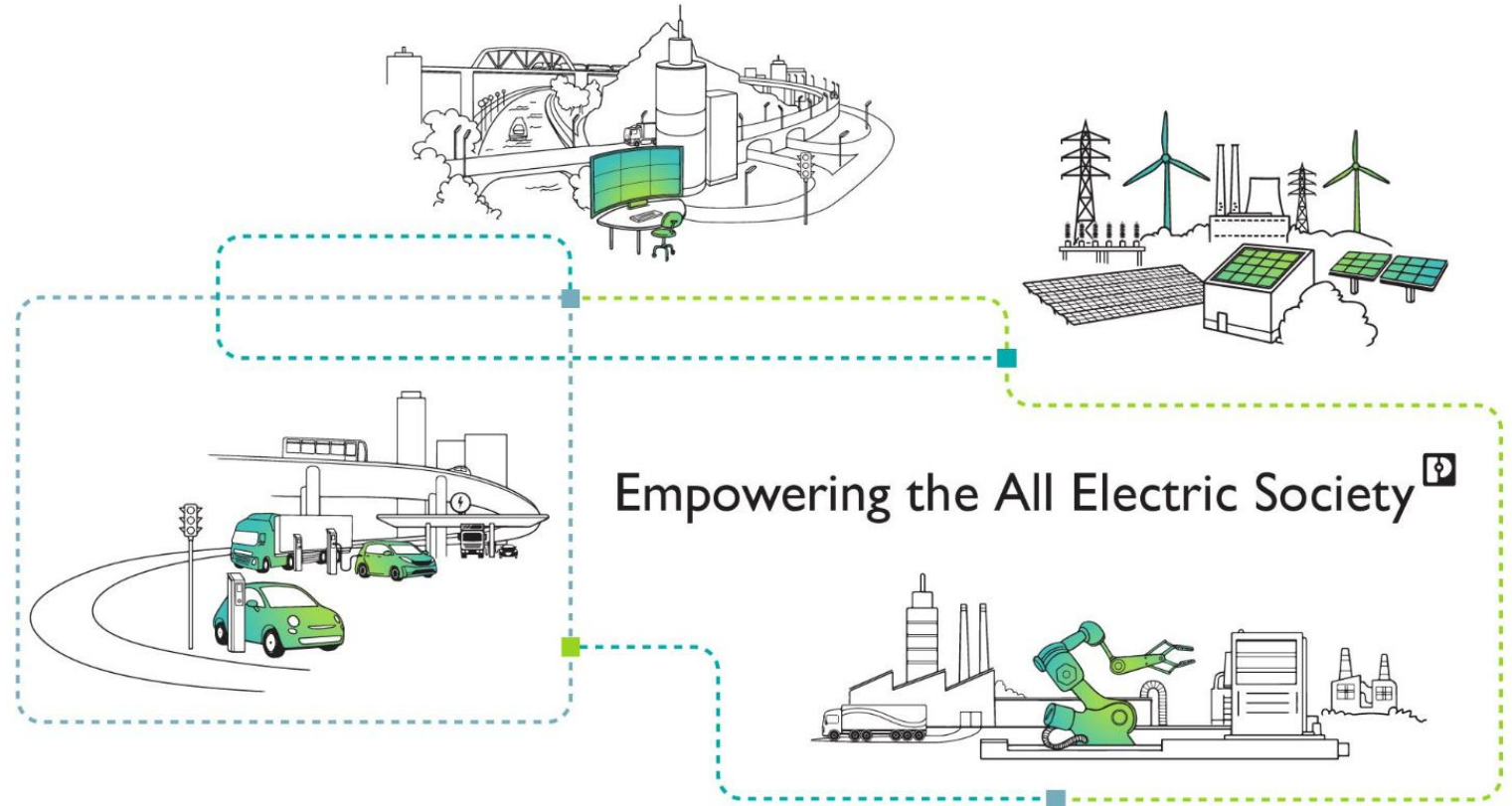


Optimizing the whole energy chain



All Electric Society in practice

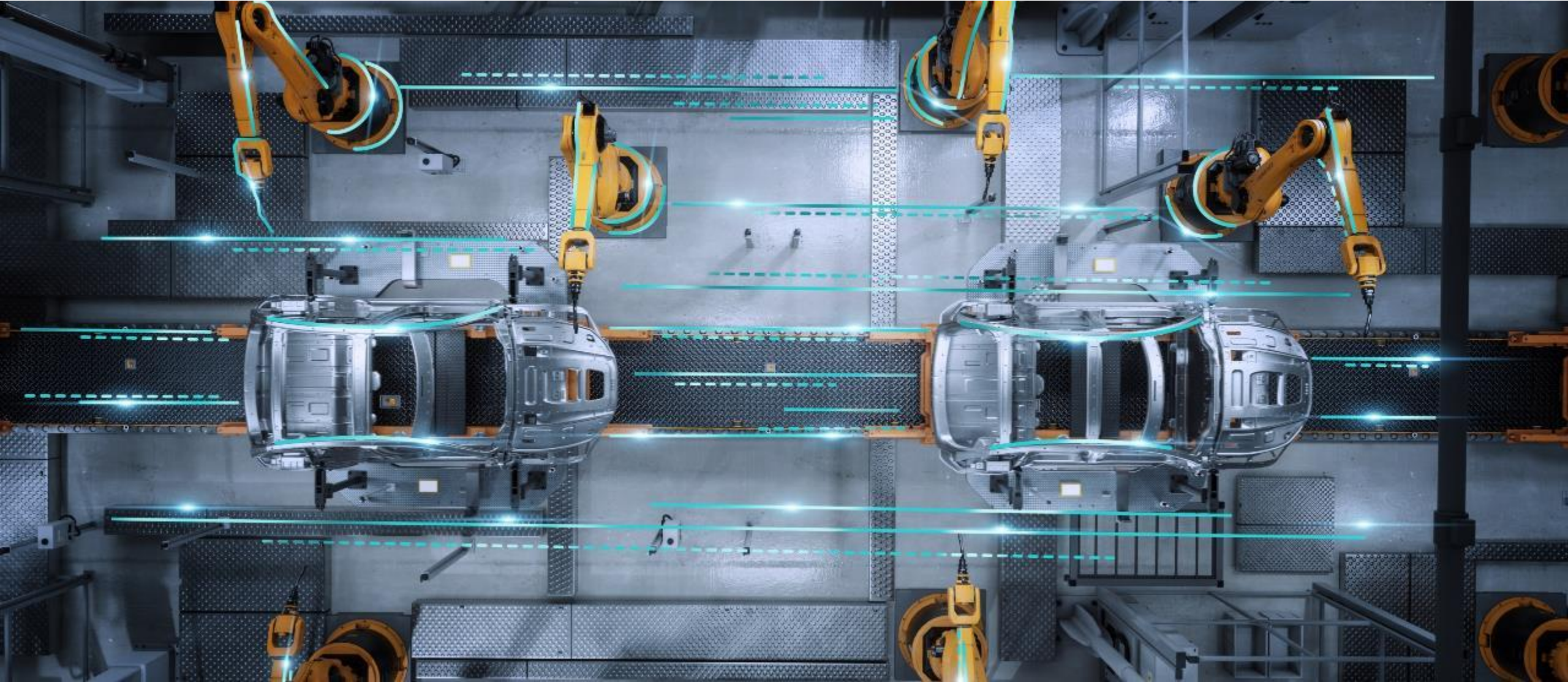
- Sector coupling as main driver
- Power generation, distribution, storage and consumption are integrated into one holistic system
- Achieve optimal flow control by analyzing data
- Effective communication enhances overall efficiency



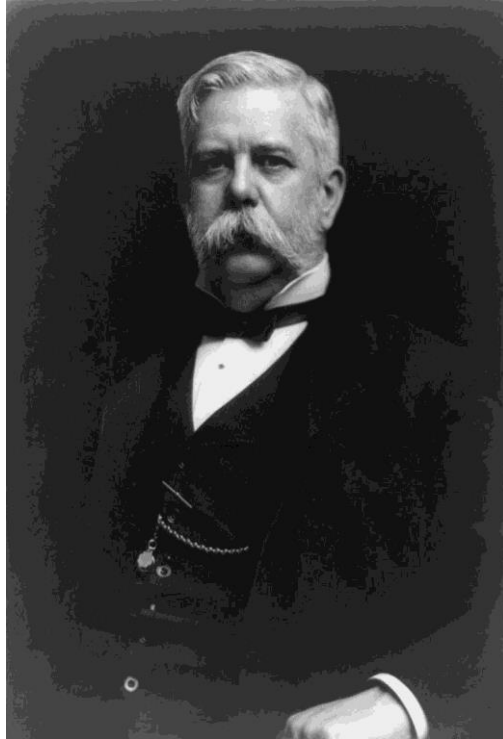
DC is a key technology on the way to the All Electric Society

DC Grids in Industry

The trend towards DC grids



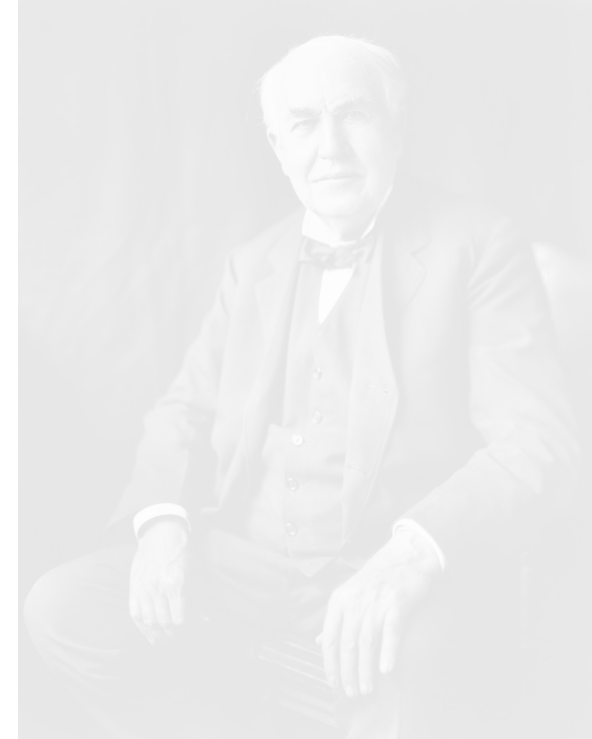
Once Upon a Time...



George Westinghouse

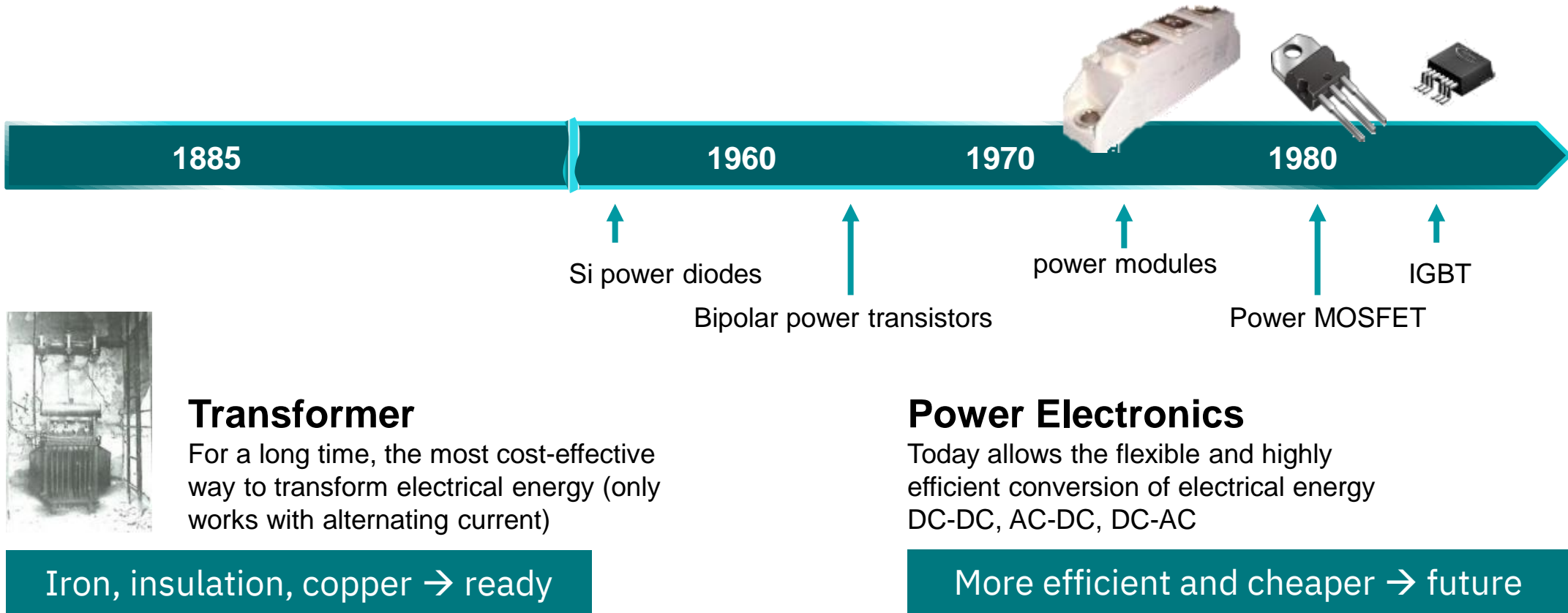
1893: World Expo Chicago

AC ⚡ DC



Thomas Alva Edison

AC: Because of the simple transformation of alternating current



Source: DC Industrie 2

Motivation for a DC Grid

ENERGY EFFICIENCY

Use breaking energy



LESS RESOURCES

Less copper and smaller components



PEAK SHAVING

Reduce load peaks



GRID STABILITY

Decrease dependency on public AC grid



SUSTAINABILITY

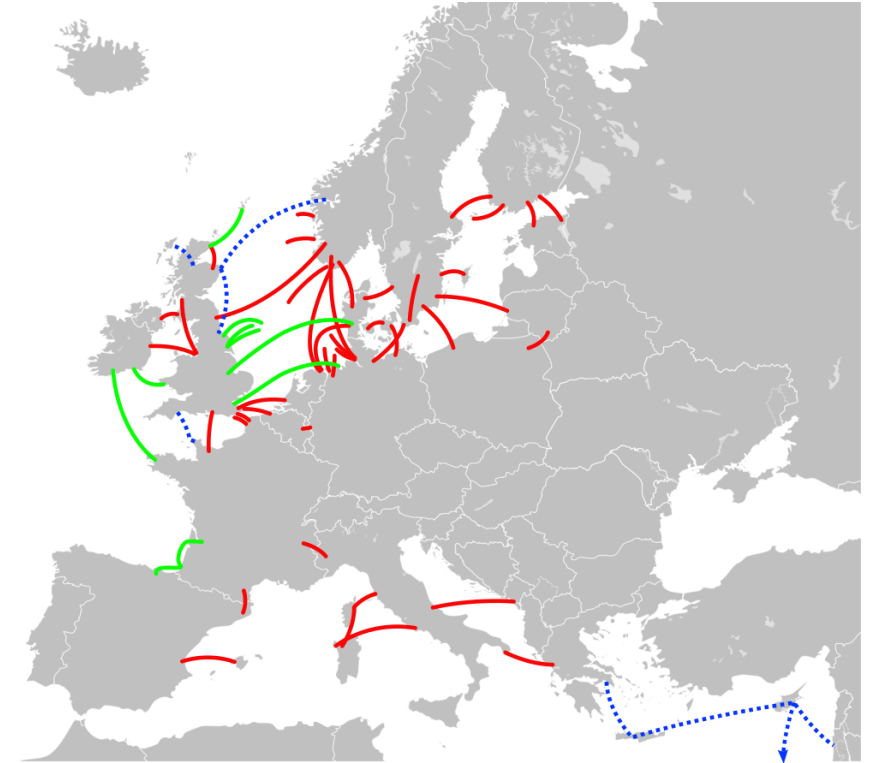
Integration of renewables



DC: Transmission

- HVDC, High Voltage Direct Current Transmission
- In Europe already a lot of High Voltage Direct Current Transmission exists. Especially for cable connection through the sea.
- In Germany a High Voltage Direct Current Transmission is planned from north to south to transmit wind energy to southern Germany (Südlink)

➤ DC transmission (100 – 1000 kV DC)

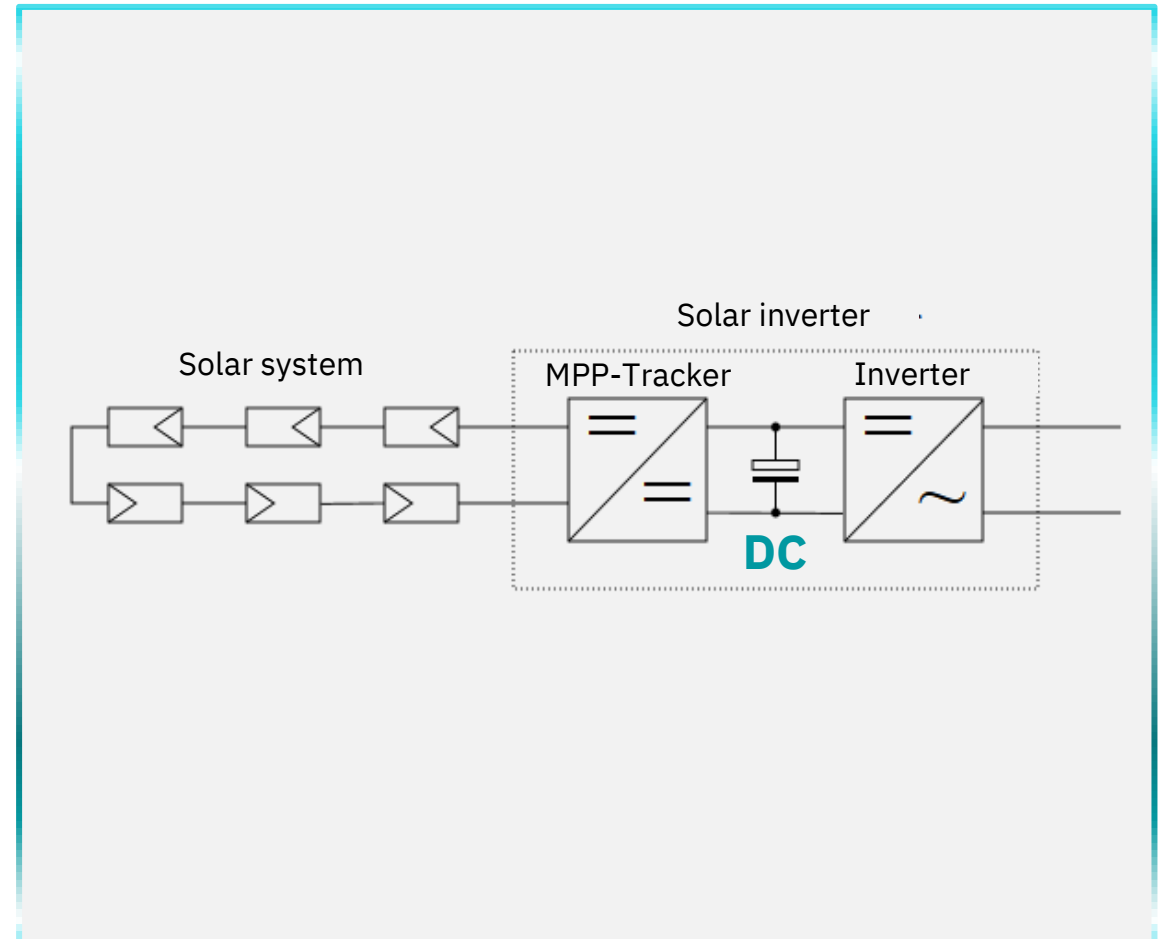


Source: Wikipedia

DC: Generation

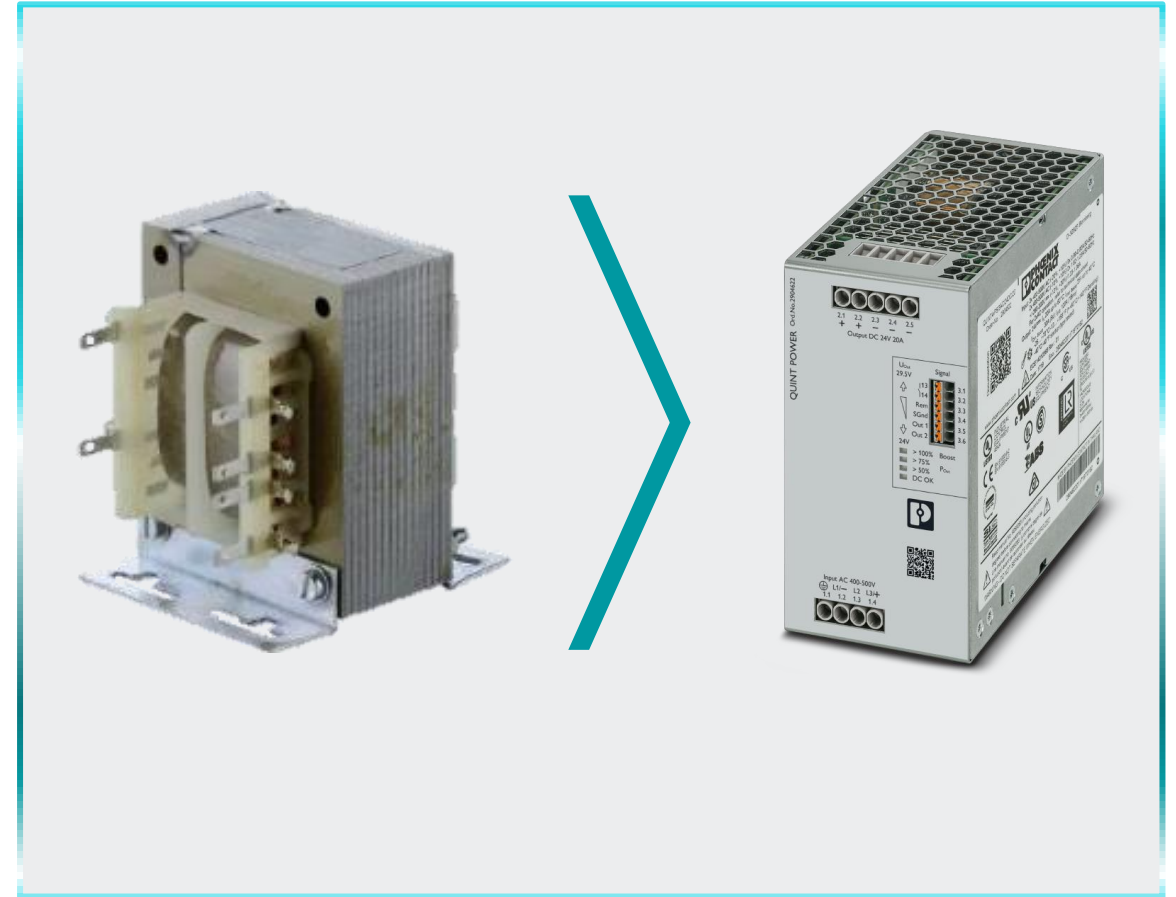
- PV feed-in: DC via converter into AC grid

➤ DC intermediate circuits



DC: Conversion

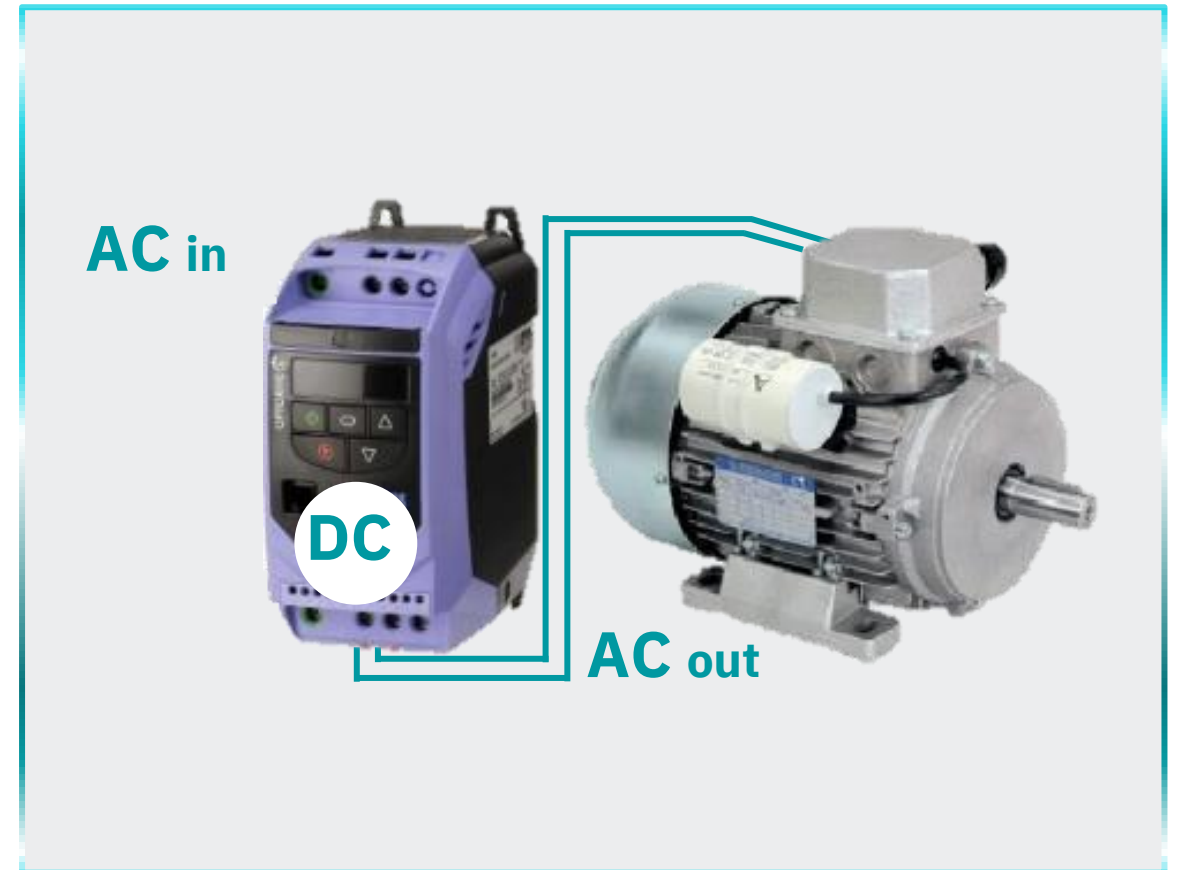
- 100 VA power supplies basing on steel-copper-Isolation transformers have an efficiency approximal 80 %
- Electronic AC-DC and DC-DC converters works with efficiencies of up to 98 %
- **SMPS/ DC-DC work also on DC internally**



DC: Consumer

- All consumer electronics internal works on DC
- Modern LED lighting is powered from AC to DC
- **Consumer electronics and LED lighting working on DC**

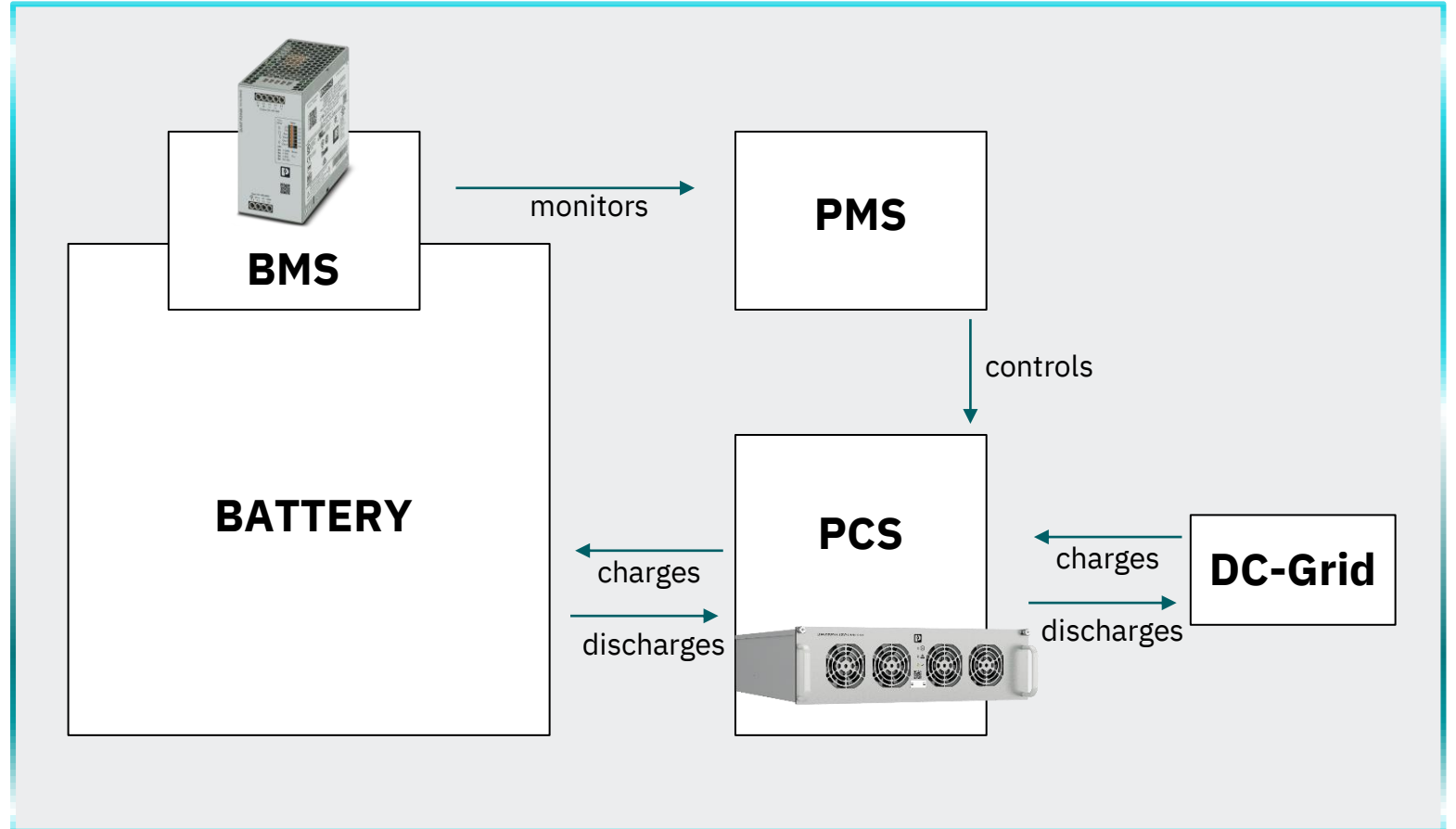
- Heat generating consumers (does not matter)
- Industrial drives via inverter
→ from AC via DC to AC-motor
- **DC intermediate circuits, there are (almost) no more three-phase current driven devices!**



DC: Storage

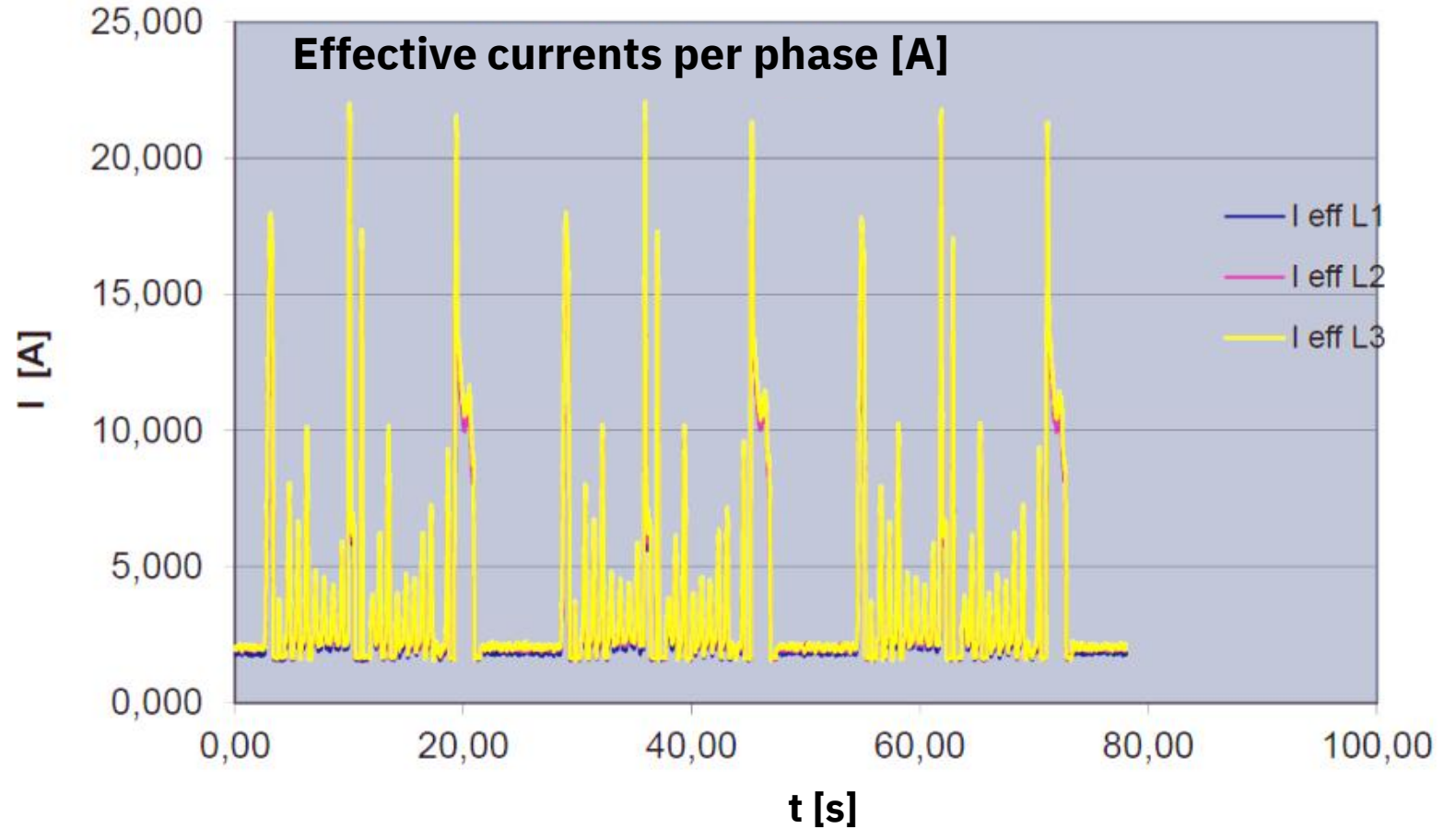
- **Battery**
Battery modules
- **BMS**
Battery Management System
- **PCS**
Power Conversion System
- **PMS**
Power Management System

➤ **Battery Energy Storage Systems run all on DC**



Example: Better DC than AC

- Industrial drives (non-continuous) in AC technology “Steady acceleration and braking“
- High short-term currents lead to disturbances in the AC voltage network.
- The electrical system must be designed for the maximum currents.
- The utilization of the system is poor and the peak loads lead to increased costs.



Example: Better DC than AC



- Non-continuous drives (e.g. robots)
→ regenerating the brake energy to a DC-bus leads to load balancing
- The braking energy is regenerated to the DC-bus. That leads to a balanced load on the DC-bus.
→ Use of recuperation
- Main motivation for the Research project



Fields of Application

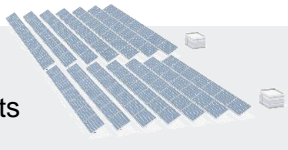
Fields of Application

Energy generation

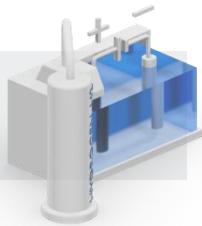
Offshore
Wind farms



Solar
power plants

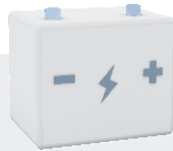


Fuel cells



Energy storage

Battery storage



Hydrogen
Generation



Energy distribution

Up to 380 /
220 kV



High Voltage
110 kV



Medium Voltage
10 / 20 kV



Low Voltage
under 1 kV / 1.5kV



Energy consumption

Factory and
Automotive



Offices and
Buildings



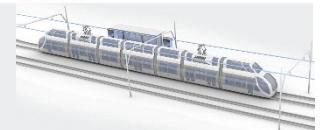
Data Centers



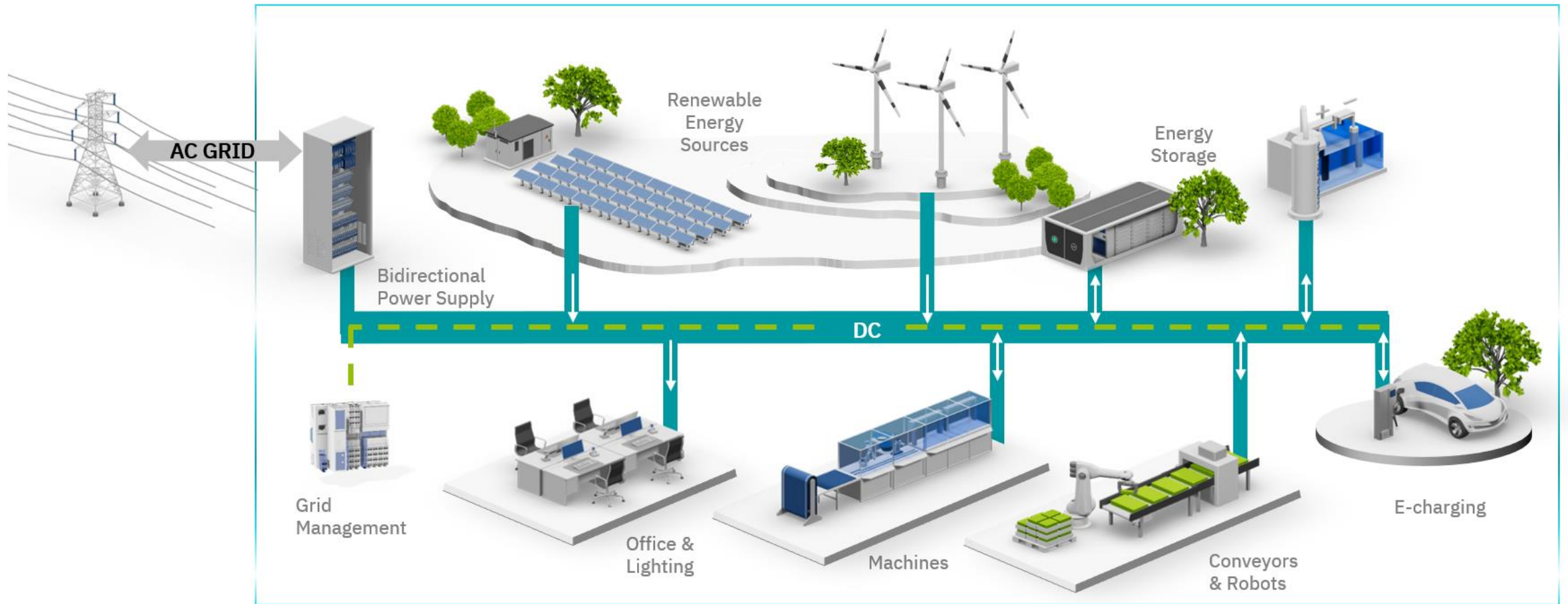
Charging
Parks



Railway

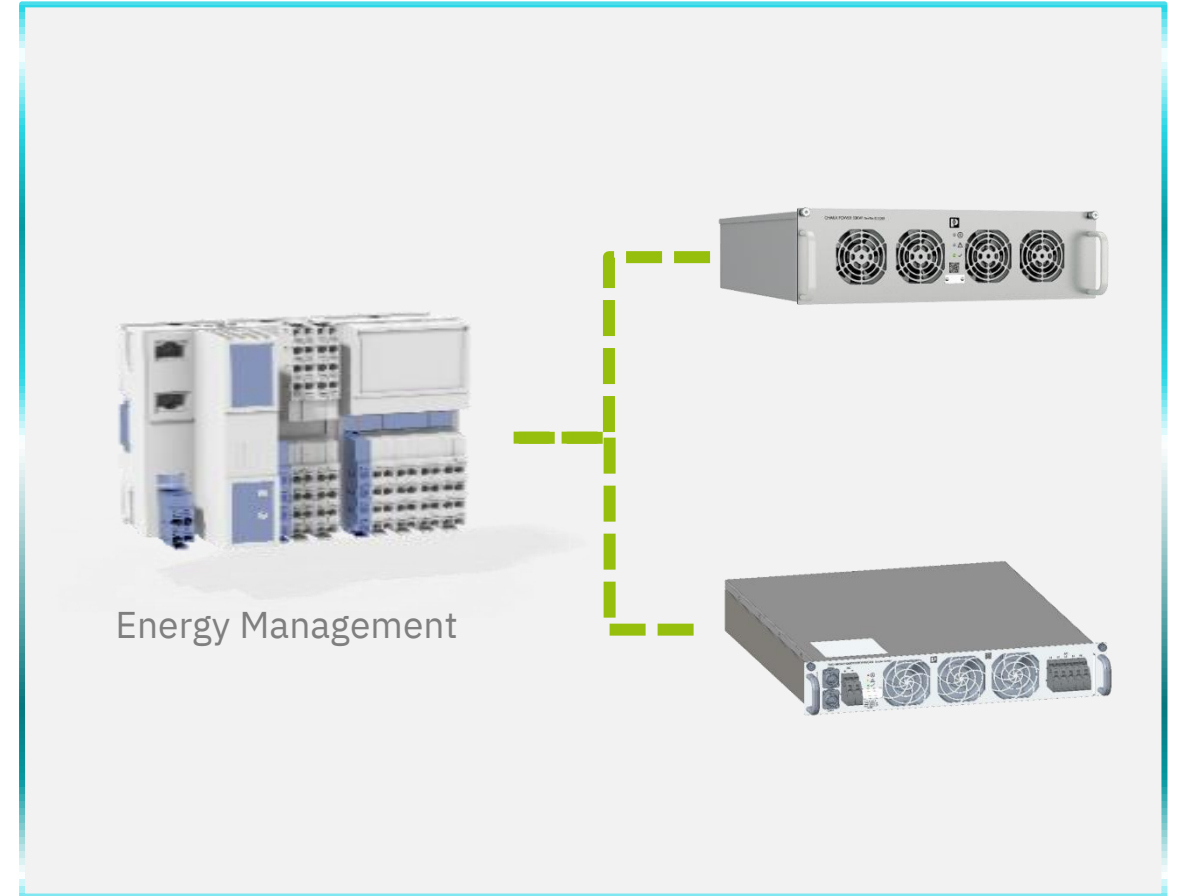


Idea of an industrial DC Grid



DC Grid Management

- High-Power modules build up the DC grid. Bidirectionality allows surplus energy to be fed back into the public grid.
- Control Technology intelligently controls the power parameters of the respective High-Power Module. This forms the basis of DC grid management.
- The intelligent interconnection of the high-power modules enables sector coupling within the DC grid and to the public grid.



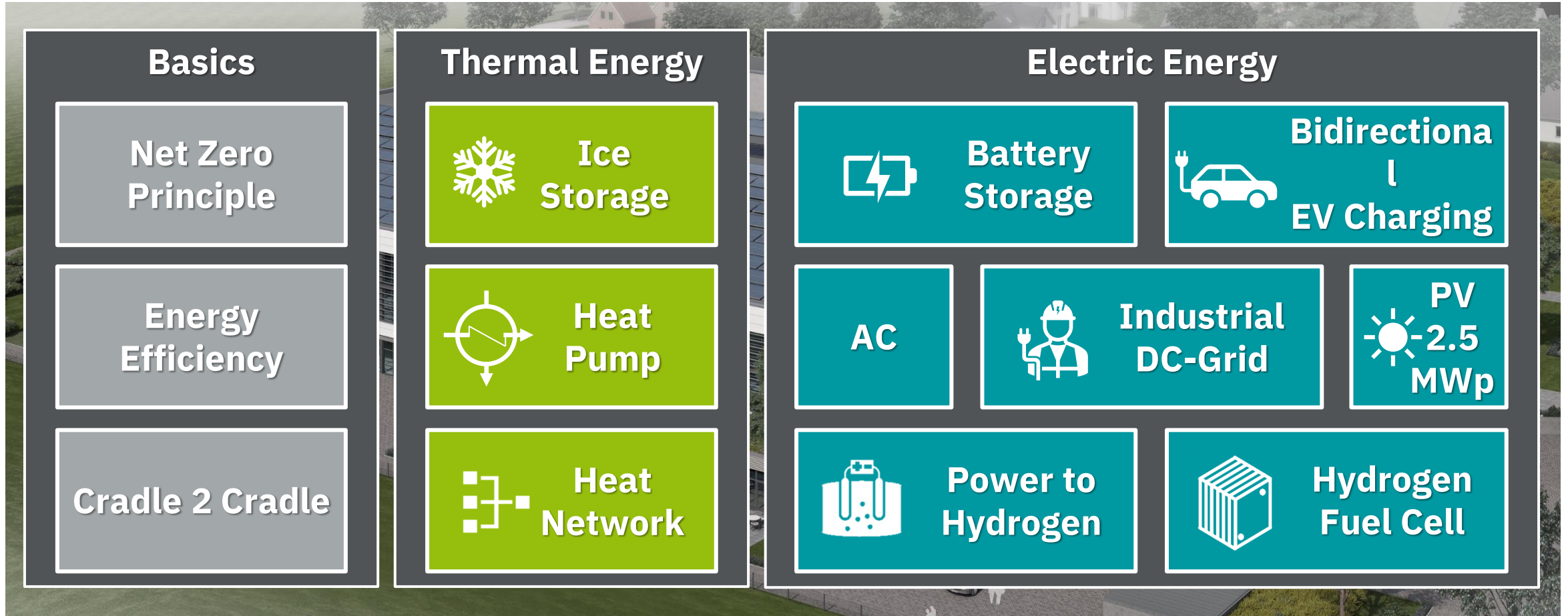
DC Grids in Industry

Own Application: Phoenix Contact Blomberg - G60

Building G60 is our blueprint for smart and sustainable sector coupling (Industry, Energy, Infrastructure, Mobility)



Building Blocks for Sector Coupling and Energy Efficiency



New Building G60 - sustainable concept - photovoltaic

approx. 6200 sqm photo-voltaic on the roof and additionally a PV open field





Photo
Voltaics

**1.5
MWp**





New Building G 60 - smart DC - Grid



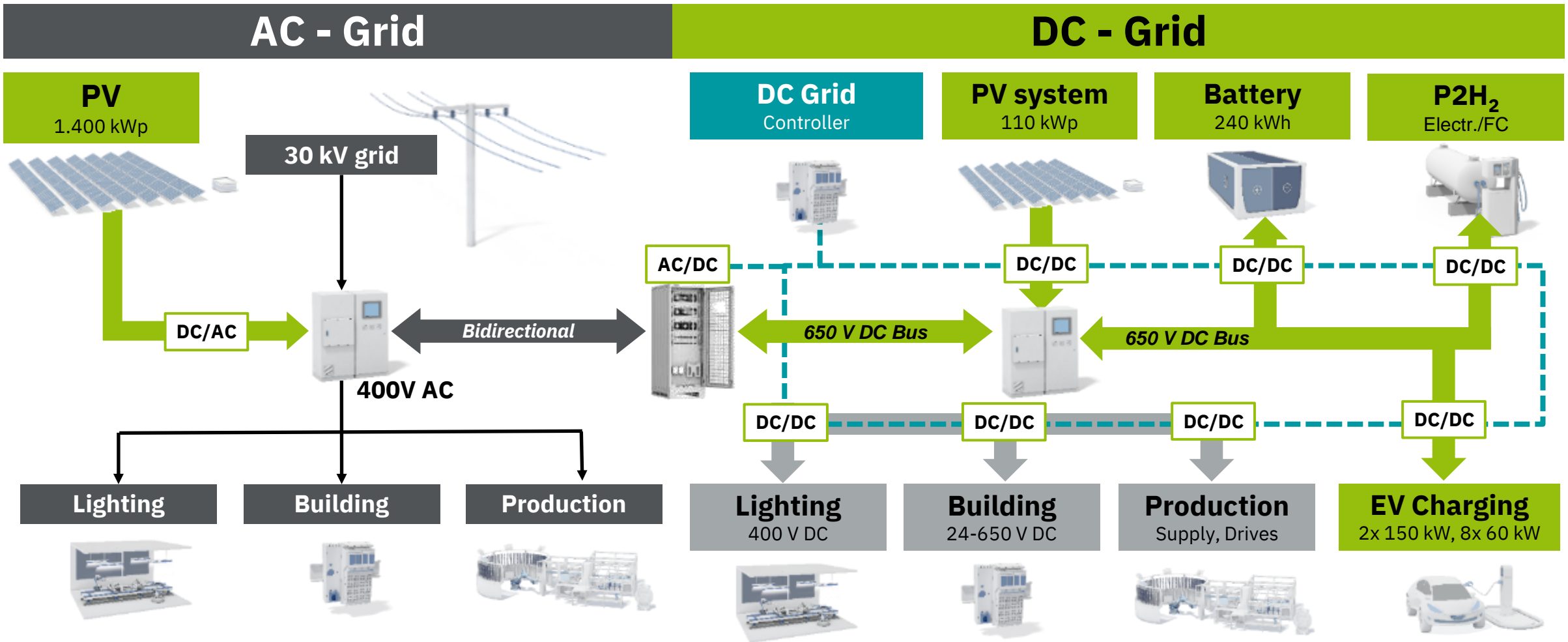

Photo
Voltaics
110
kWp

**Industrial
DC
Applications**

 **Industrial
DC Grid**

 **E-Mobility
Charging**

New Building - G 60 - smart DC - Grid

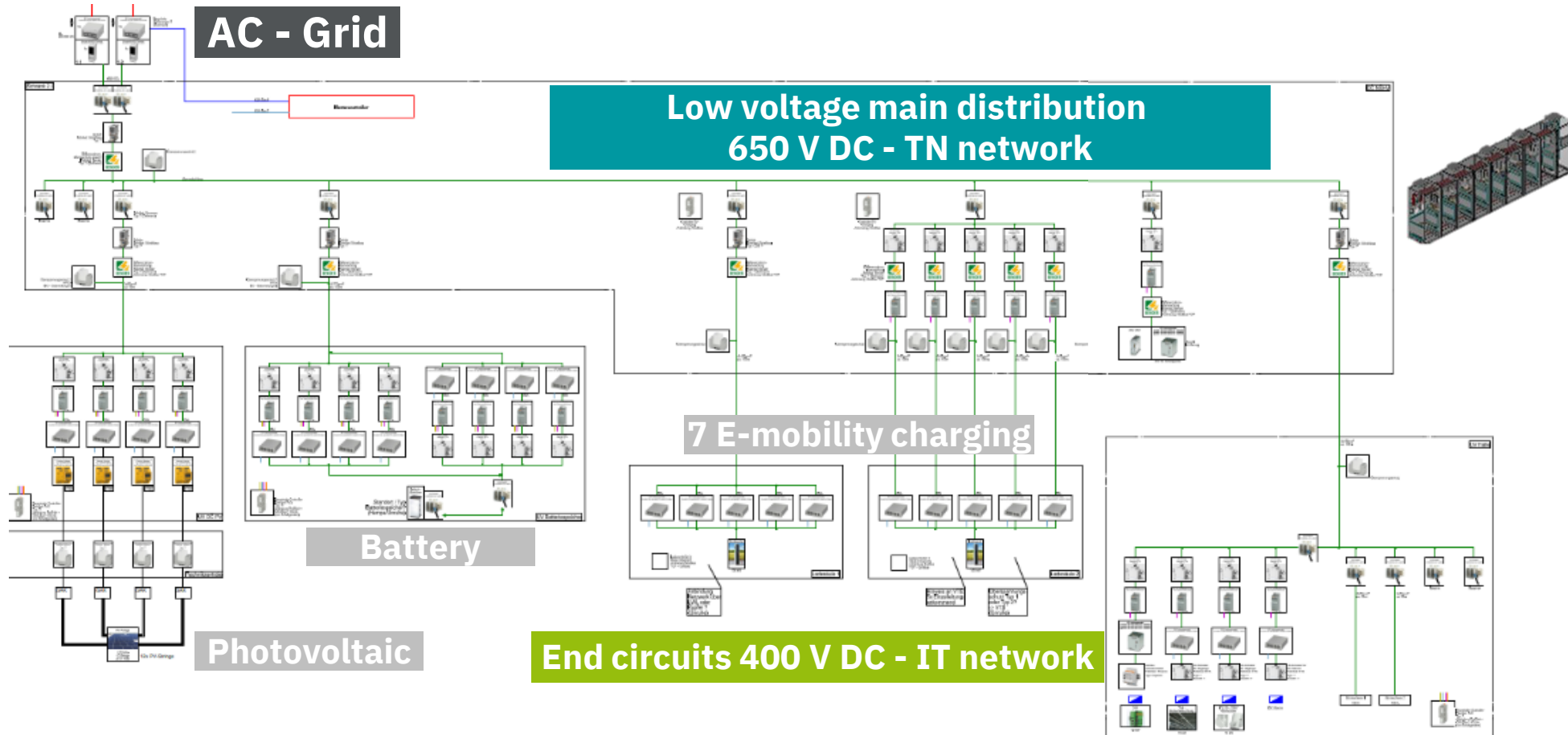


Challenges on the way to our DC Grids

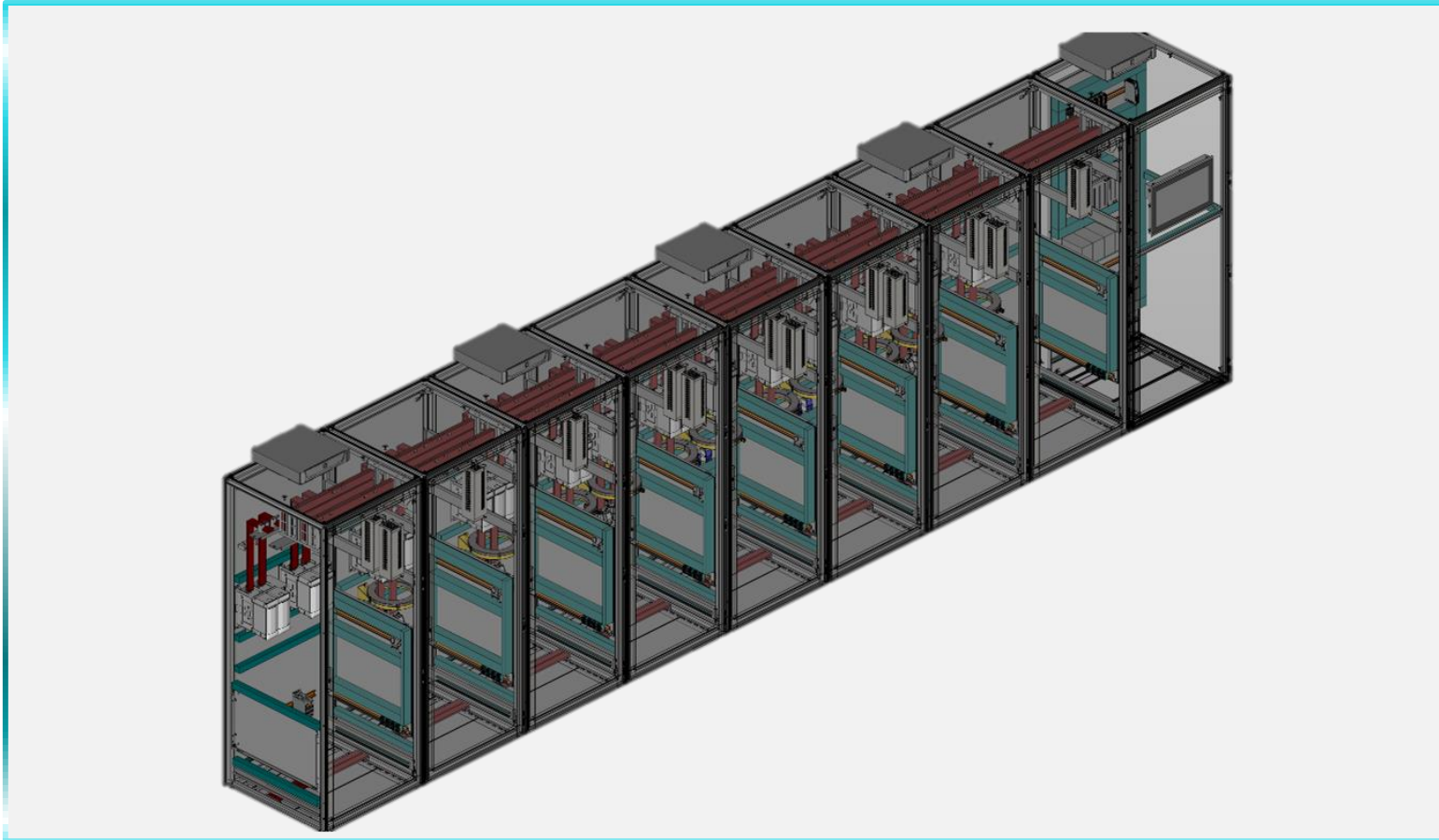
- Appropriate components and cables
 - Power supplies
 - Arc suppression
 - Protection against overvoltage and overcurrent
 - Switching high voltage DC
- Grid and load management
- Standardization and certification
- Solution:
 - Working with partners
 - Develop new products



New Building - G 60 - smart DC - Grid - Circuit diagram



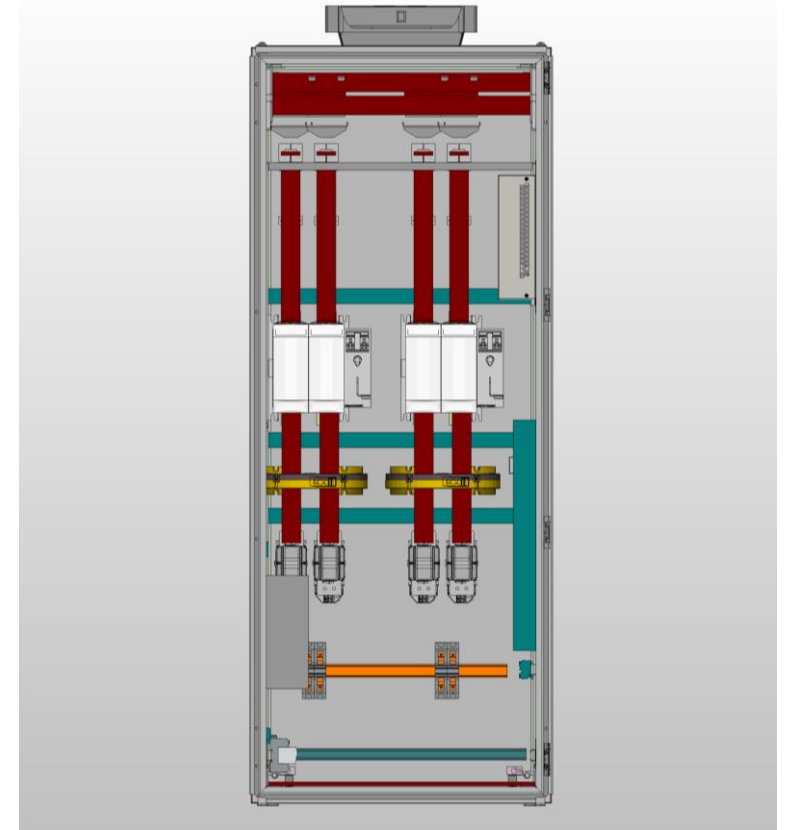
Status DC Grid



- The cabinets are assembled and equipped
 - The main distribution is installed
 - Sub distribution is installed
- PV on the roof is finished
- Final check up is ongoing
- BESS is in place will be connected to the DC grid shortly
- DC Charging station are built up and soon connected to the DC infrastructure

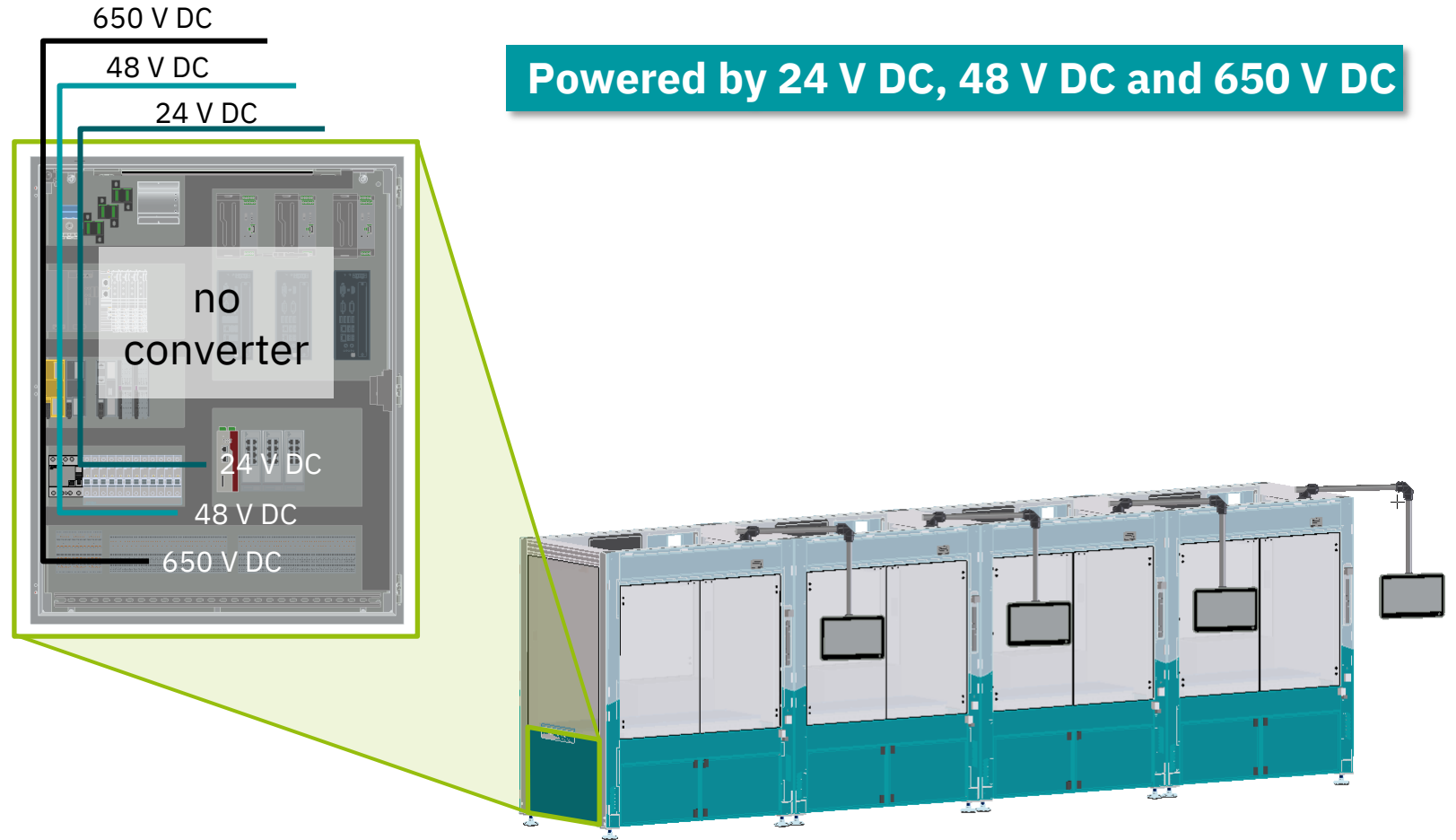
Motivation for the implementation of an Industrial DC Grid

- Gain experience with DC grid planning, installation and operation
- Optimizing the DC Grid Controller by real life operation experience
- Testing and practical experience with DC components from Phoenix Contact and other brands
- Investigations on DC powered production machines

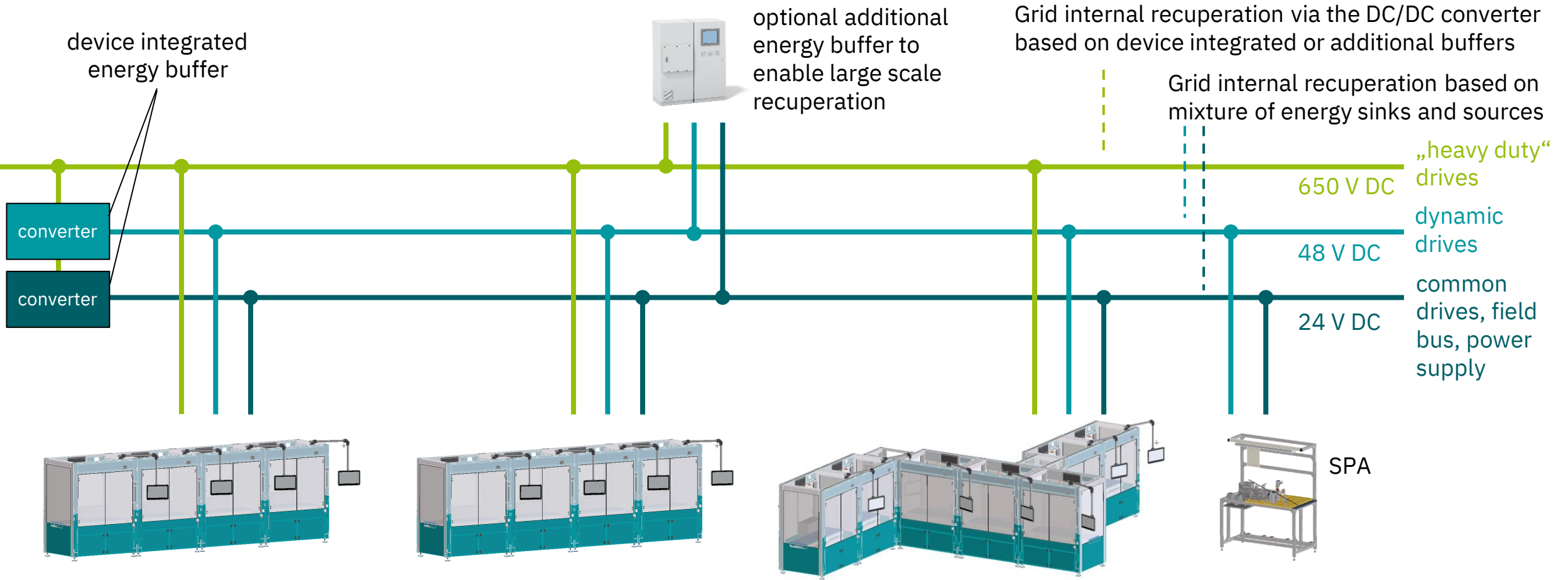


Investigations on DC powered production machines

- No converters
- Direct connection of the drives
- Direct connection of “heavy duty” drives to the 650 V DC bus
- Recuperation via all DC bus levels



Investigations on DC powered production machines



Current situation

Community Activities



Vision

- Derived from the project DC-Industrie
- Over 50 members from industry, research and university
- Blueprints for further applications

Mission

- Support the social goal of a resource-conserving and CO2-neutral world.

Vision

- Build the international DC ecosystem and establish DC technology across applications.

- Ecosystem: Close cooperation between users, planners, manufacturers, suppliers, research institutions and associations
- Dissemination: International dissemination of knowledge and solutions on DC grids. Conformity label for investment security for manufacturers and users.
- Technology, research and standardization: Implementation of requirements. Platform for the design of further research projects. Target group-relevant standardization
- Politics and regulation: Direct current is an important building block for the energy transition. Support in the development of the necessary framework conditions.

International activities



DC Grids in Industry

International activities



400 V DC – 800 VDC (DCI)
→ 800 V DC (IT)
→ +/- 400 V DC (TN)
And further system concepts
under discussion (mining,
maritime, data center ...)



(+/-) 750 V DC
1500 V DC



(+/-) 350 V DC
(+/-) 700 V DC (1400 VDC)



600 V DC
1500 V DC



Up to 1500 V DC



(+/-) 375 V DC
600 V DC
(+/-) 750 V DC (1500 V DC)



380 V DC
700 V DC



1500 VDC
(IEC 60038)

DC Grids in Industry

DC Products

Power supply



HP Modules



New
2024

Speedstarter



Measure/
Monitoring



New
2024

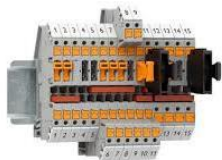
Overtoltage
protection



E-Mobility



Terminal blocks



Connector



DC charging plug



Plugging/pulling
under load



New
2024

DC/DC converter



New Products

More
Coming

Does DC power grids in industry solve grid congestion?



Renewable Energy Integration

Efficient Energy Distribution

Reduced dependency on public grid

DC Grids in Industry

Questions & Answers





Confidential III

Welcome

DC Grids in Industry

Fields of Application



Automotive



Factory Automation



Building Automation



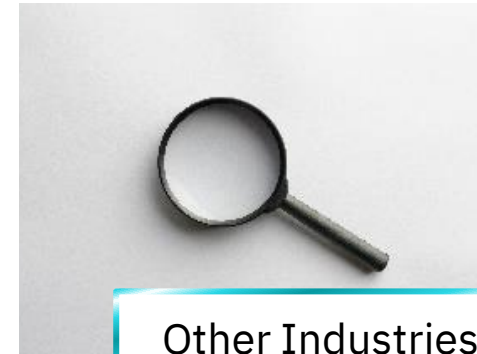
Energy



Railway



Data Center



Other Industries