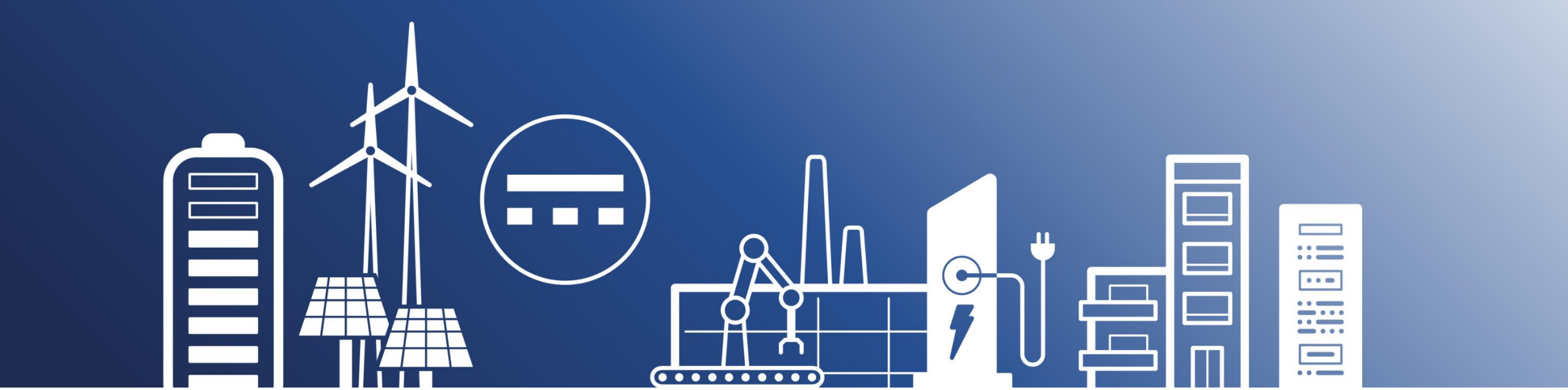


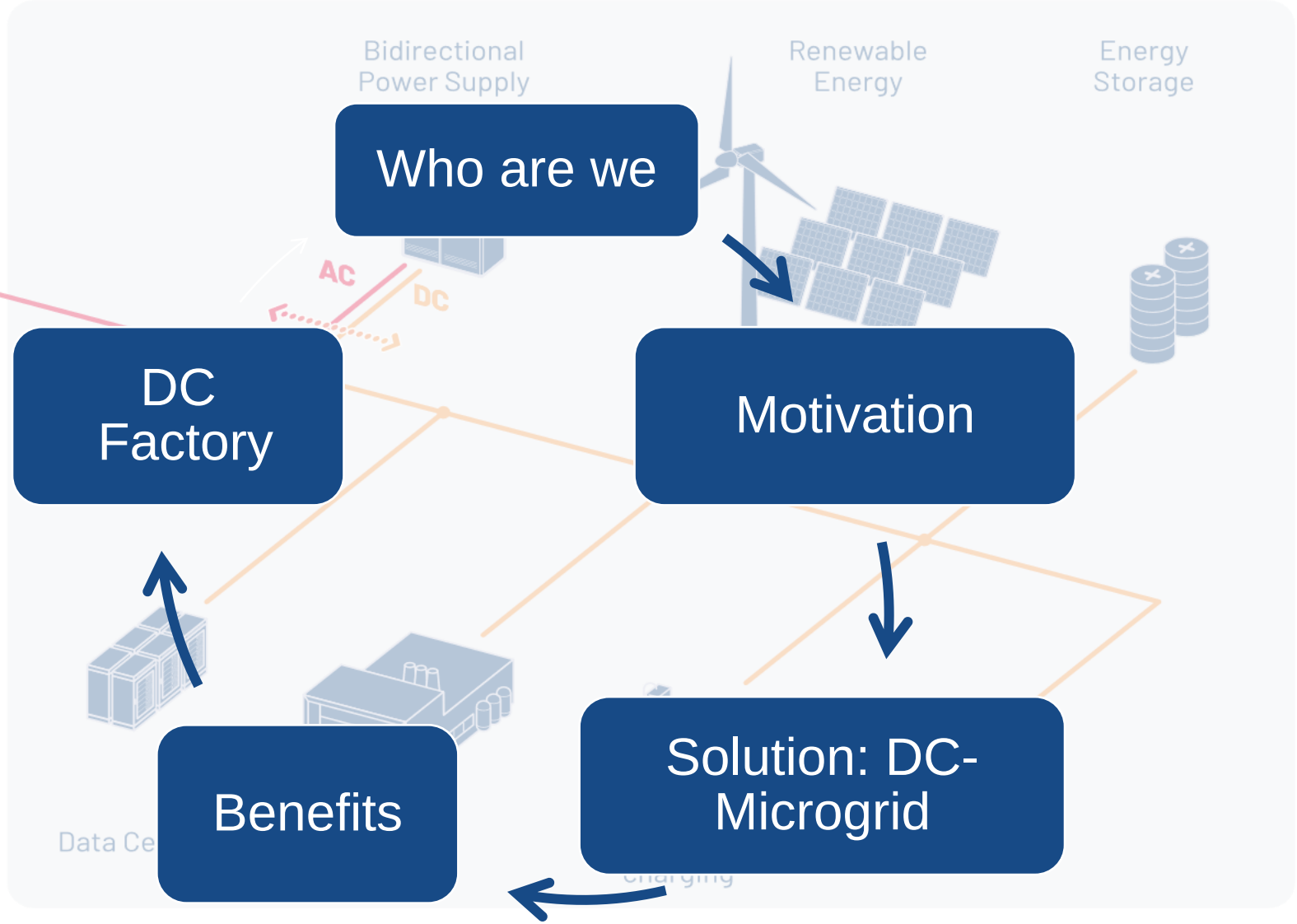
Die Gleichstromfabrik: Warum die Fabrik der Zukunft mit Gleichstrom läuft

Jahresveranstaltung Initiative Energieeffizienz- und Klimaschutz-Netzwerke

Dominik Maihöfner & Dr. Hartwig Stammberger

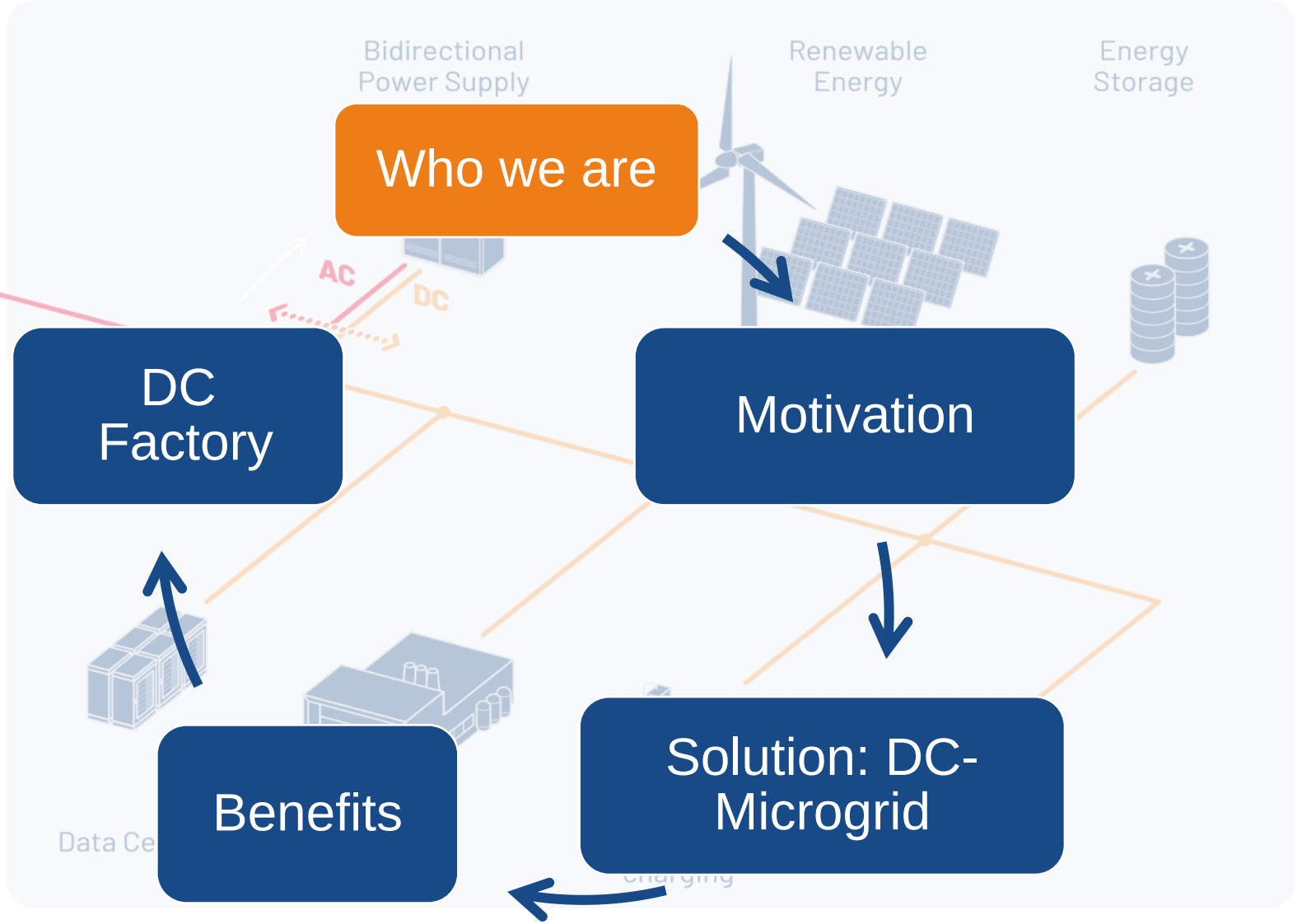
ODCA direct current by zvei

Content


AC Grid
Bidirectional Power Supply
Renewable Energy
Energy Storage
AC
DC
Who are we
DC Factory
Motivation
Solution: DC-Microgrid
Benefits

Content

Who we are



Industry Background
From DC-INDUSTRIE to Open DC Alliance

2019 Model application @ Daimler: 50 kVA welding

2013-16 AREUS
- Production cell
- 10 Partners
- Fundamentally confirmed functionality

2016-19 DC-INDUSTRIE
- 26 partners
- 4 applications
- Circuit breaker, drives, converters, system simulation, relay, cables, plugs
- DC Industrie System concept 1.0
- DC-Industrie (zvei.org)

2019-23 DC-INDUSTRIE2
- 39 partners
- 6 Pilot plants: Mercedes-Benz, BMW, Audi, Homag, Transfercenter OWL, FhG IISB
- Updated DC Industrie Systemconcept

Nov. 2022 ODCA
- 33 founding members

Nov. 2024 ODCA
- 72 members
- 11 countries
- 5 active Working Groups
- Full industrial DC System description: Updated system concept for DC-INDUSTRIE2 published (zvei.org)

Plenary @ Zumtobel Oct. 2024

Benefits of ODCA

Network: Connect with experts and peers in a trustful network.

Exchange of Experience: Share insights, learn from others' experiences and get access to pioneering projects.

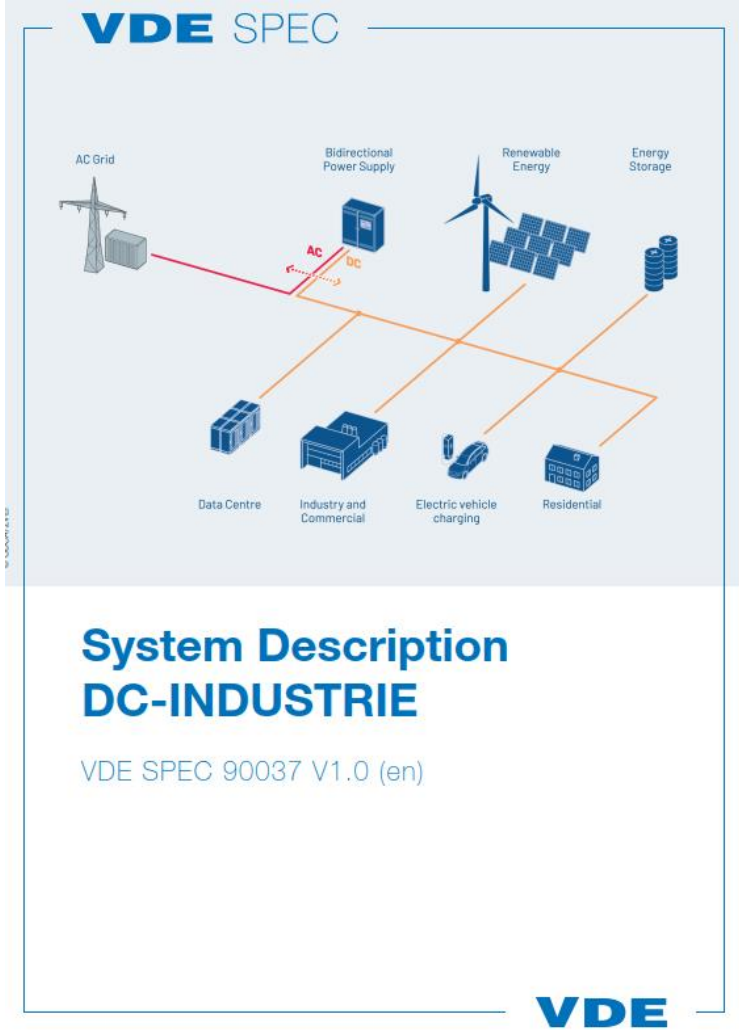
Best Practices: Gain access to design and integration expertise to reduce planning and installation efforts.

Standardization: Influence standardization committees and profit from a guideline for an innovative architecture.

Regulatory Support: Helping you navigate regulatory hurdles.

Knowledge Building: Learn the fundamentals of DC and explore various DC applications.

Public System Description
for Low Voltage DC Grids



ODCA System Document

VDE SPEC 90037

- **System description**
  - Openly available
  - Broad and deep expertise
    - 7 years
    - 100+ experts
- **Free download as German pre-standard**
  - VDE SPEC 90037

Fairs and Conferences

Overview of last and upcoming Events

Hanover Fair ´23
- Moving DC warehouse
- Several presentations on Energy Stage

Hanover Fair ´24
- ODCA experience
- Several presentations on All-Electric-Society Stage and Energy Stage

IAS ´24 - Shanghai
- ODCA experience
- Expert Presentation: “DC Advantages and Use Cases”

Upcoming
- SPS ´24
- S-Dialogue
- ICDCM ´25
- DC=IN `25

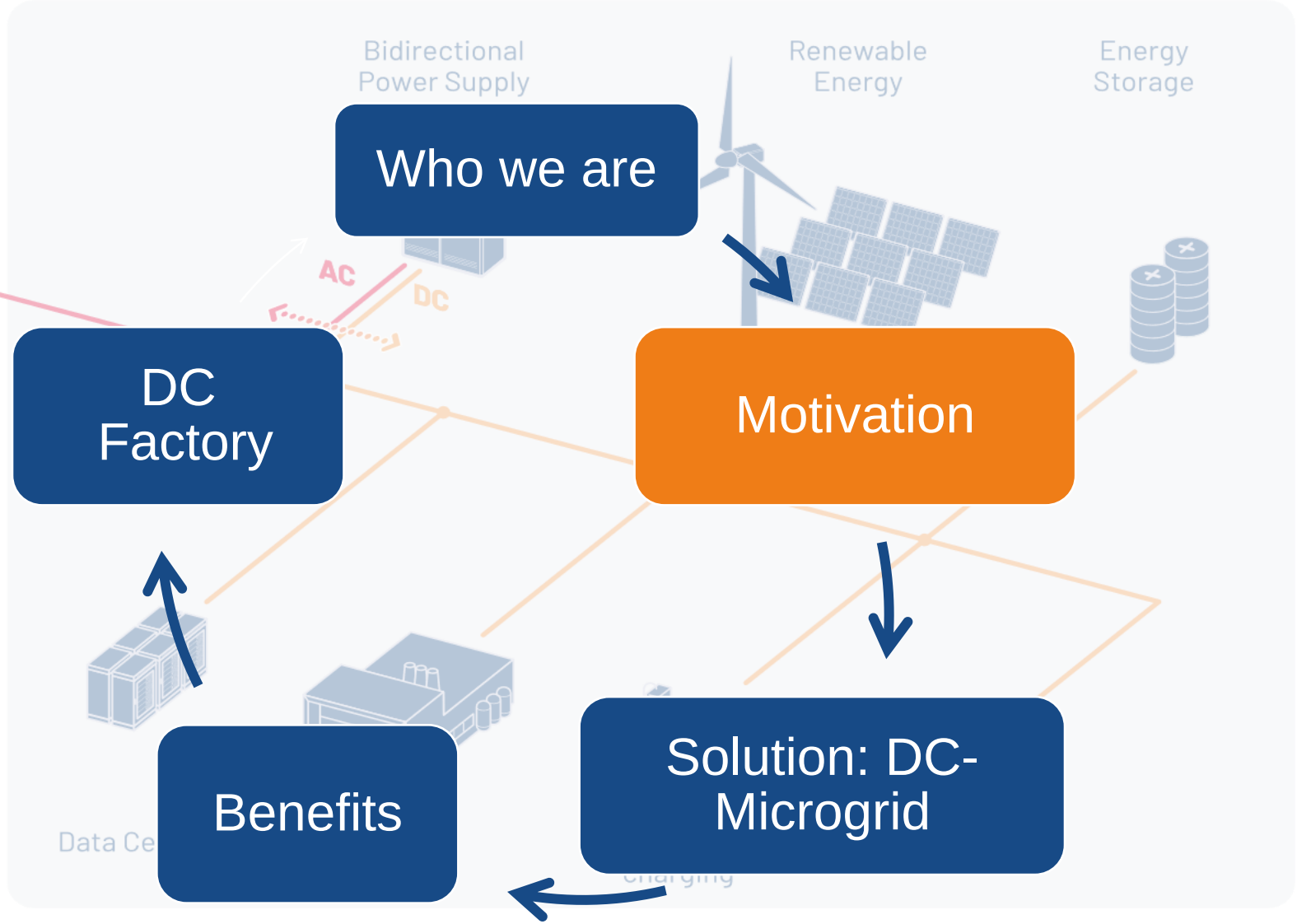
SPS ´23 - Nuremberg
- Expert Presentation: “How low-voltage direct current supports the energy transition”
- Good Morning Automation Interview

ICDCM ´24 - Columbia, SC
- Gold Sponsor
- Keynote: „DC-Microgrid Application, Use Cases and Standardization in Europe“

WEKA DC Conference ´24 - Munich
- Supported by ODCA
- Panel discussion, Keynotes and Presentations from/with ODCA
- Additional Poster session

ODCA Members
as of Nov. 2024

Content


AC Grid
Bidirectional Power Supply
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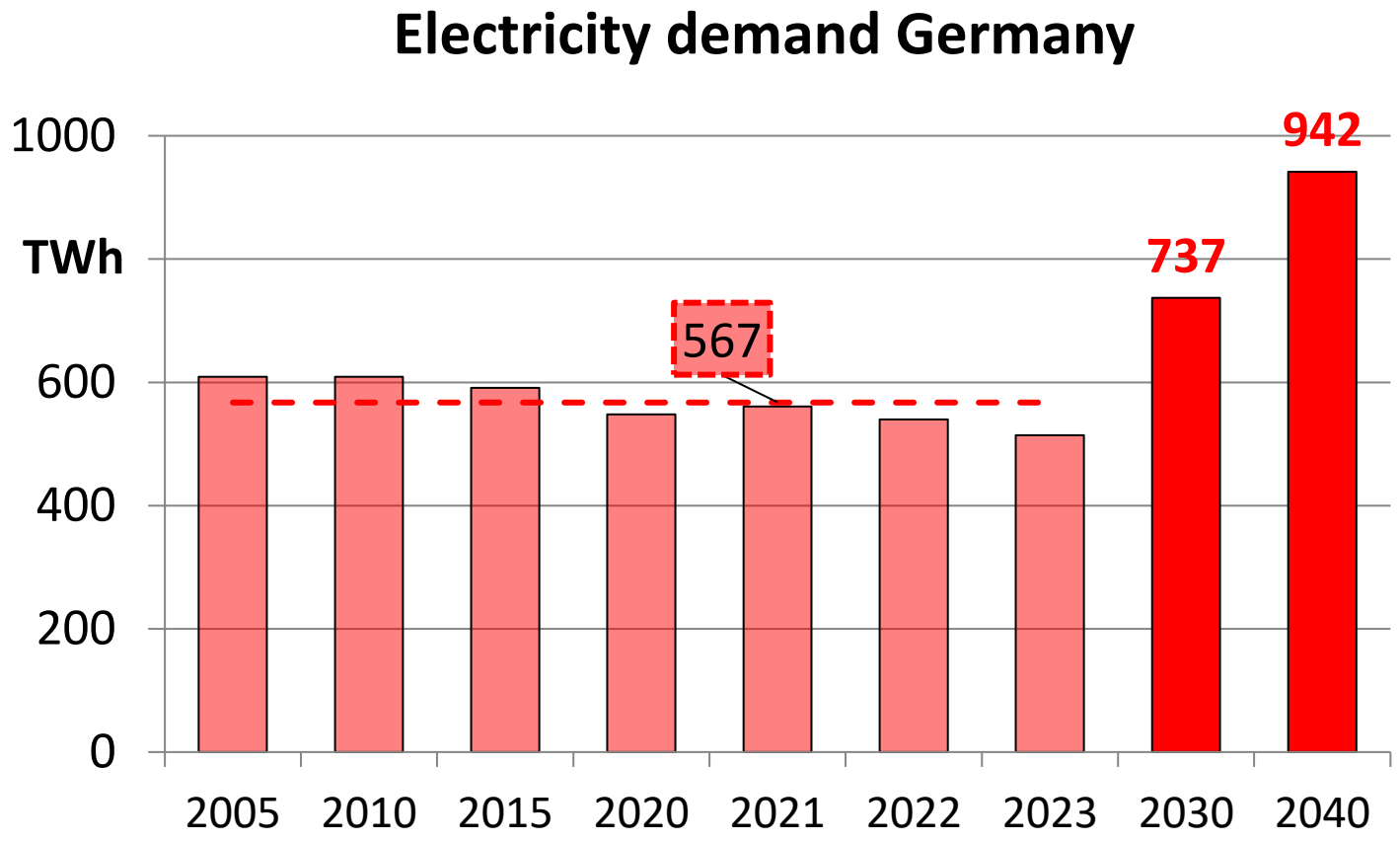
Motivation
Rising Electricity Demand

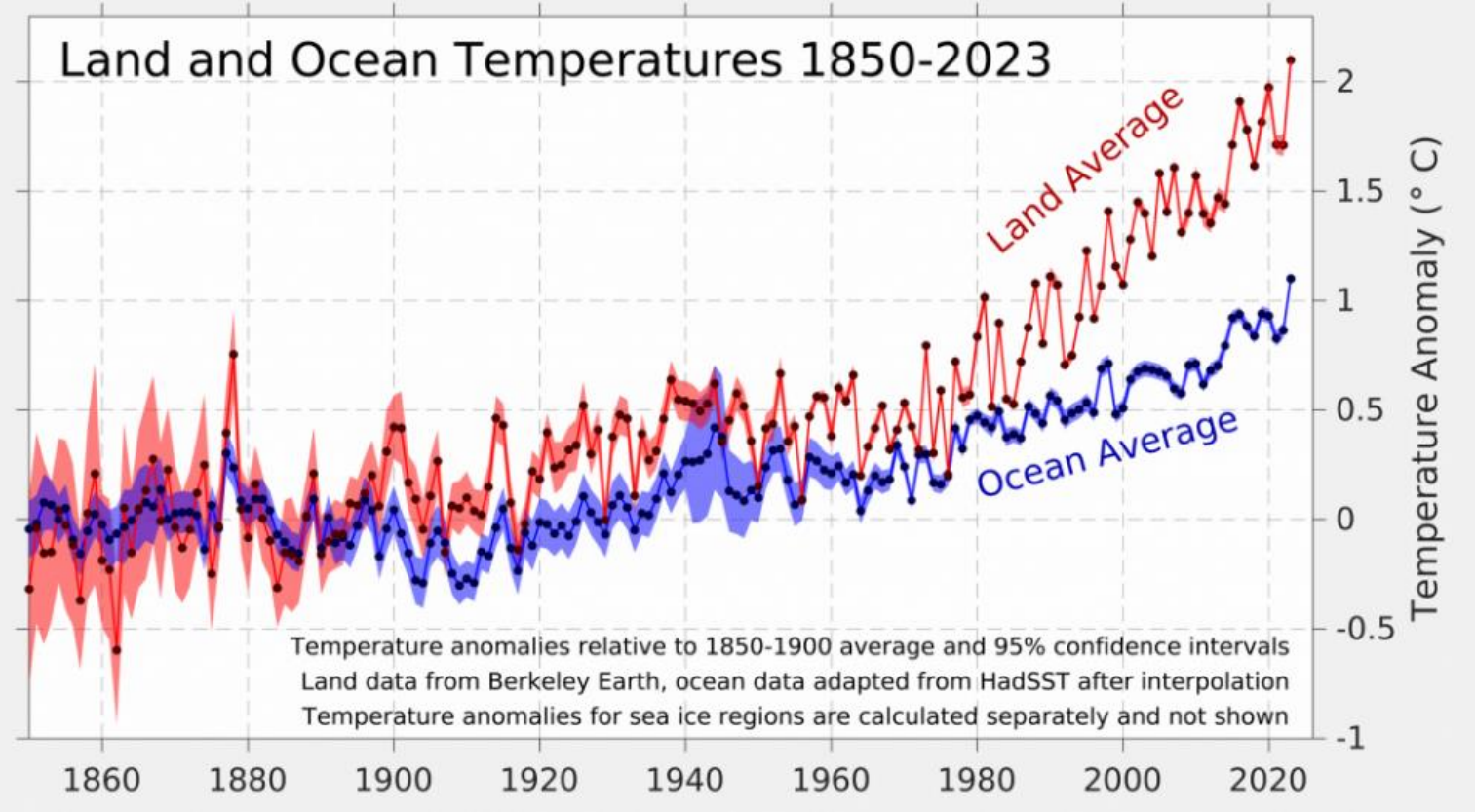
- **Electricity demand is rising**
  - Fossil to electric
  - +30% until 2030
- **Grid reaches / exceeds limitations**
- **New solutions needed**



Sources: https://ourworldindata.org/energy (actuals)
https://e-vc.org/wp-content/uploads/e.venture_Point_of_View_Strommarkt_2040.pdf (forecast)

Motivation
Global temperature rise

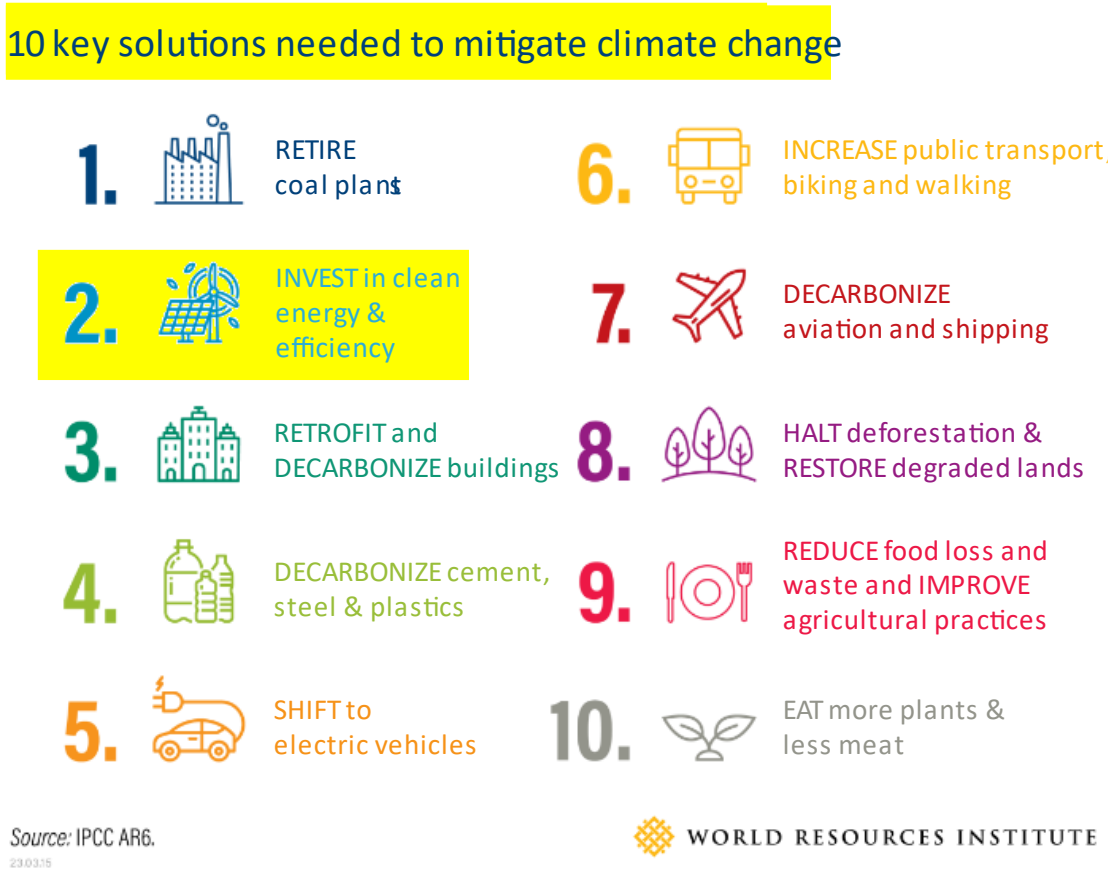
- **Last 9 years have been the 9 warmest years on record (> 100 000 years)**
- **Land mass warms faster than oceans**
- **CO_2 emissions are root cause**



Source: https://berkeleyearth.org/global-temperature-report-for-2023/

One Solution
Energy efficiency

- **IPCC report 2023**
  - Power generation, buildings, industry, and transport are responsible for close to 80% of global emissions
  - One key solution is investment in clean energy & efficiency (2.)
- **DC is part of the solution**



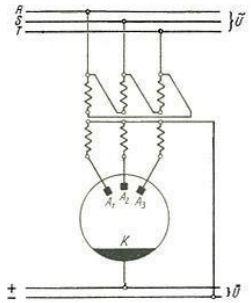
Source: https://www.wri.org/insights/2023-ipcc-ar6-synthesis-report-climate-change-findings and https://www.ipcc.ch/report/ar6/syr/

DC Technology
Development since 1890

1890

AC triumphs DC

Limitation in DC grids, as conversions were not easily possible



1921

Mercury vapour rectifier

Development of power electronics (AC rectification) pushes DC system

1938

New application

First direct current locomotive system

1947

First transistor

Bell Laboratories invents first transistor

1954

Gotland I

First high-voltage DC system transmission (100 kV, 20 MW)

1972

Thyristor conversion

Boosted DC system control and efficiency, especially in industry and power supply

1997

IGBT conversion

Enhanced DC system control

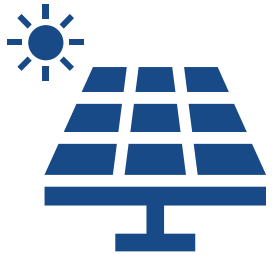
Today

SiC thyristor converter

10x higher voltage, 4x higher reverse voltage
100x faster switching frequency

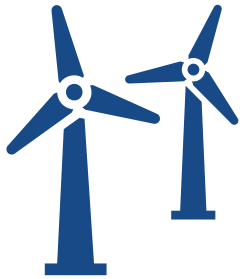
Source: Wikipedia / Lapp

DC is Nothing New
Existing DC applications



Photovoltaics

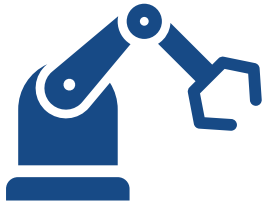
Battery storage



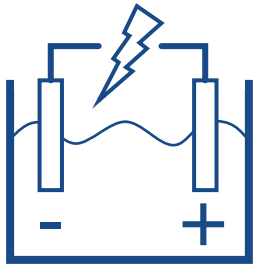
Wind energy

Rail

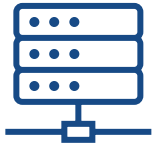
E-cars



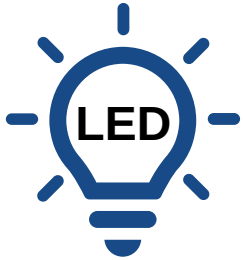
Industry



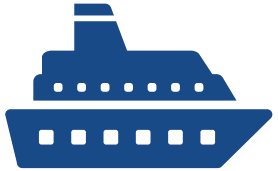
H_2 Electrolyser



Data & IT

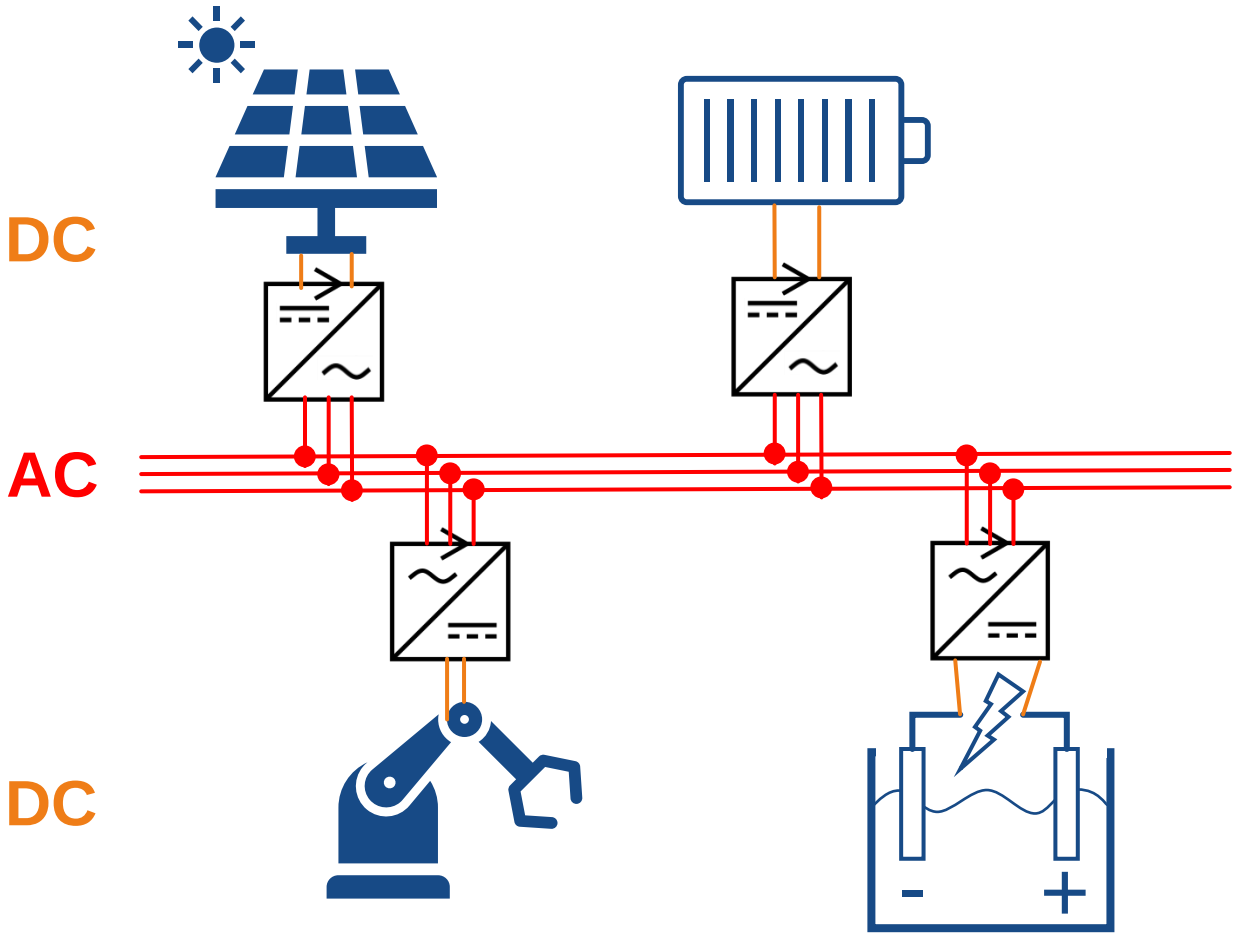


Lighting



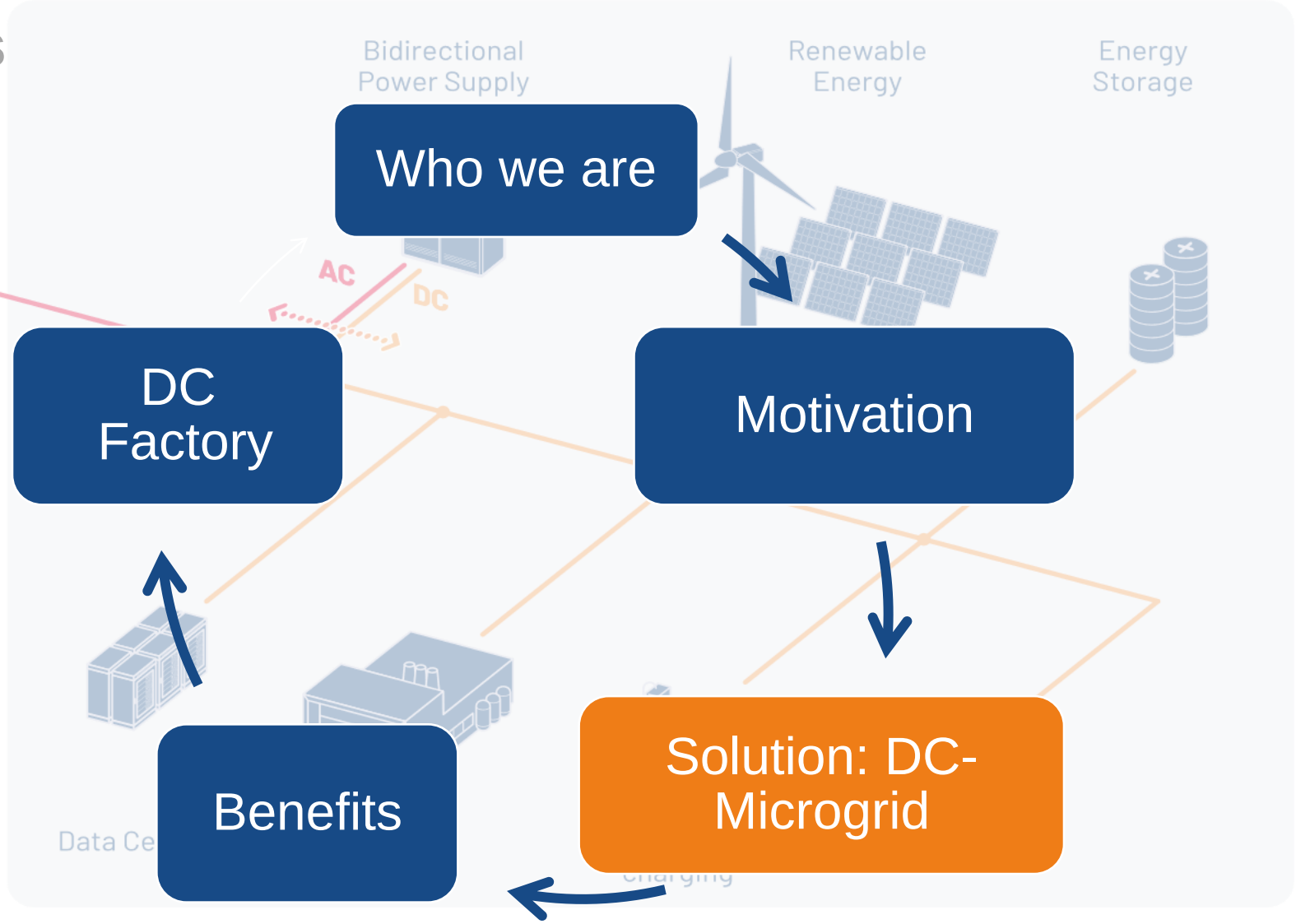
Marine

Actual Problem

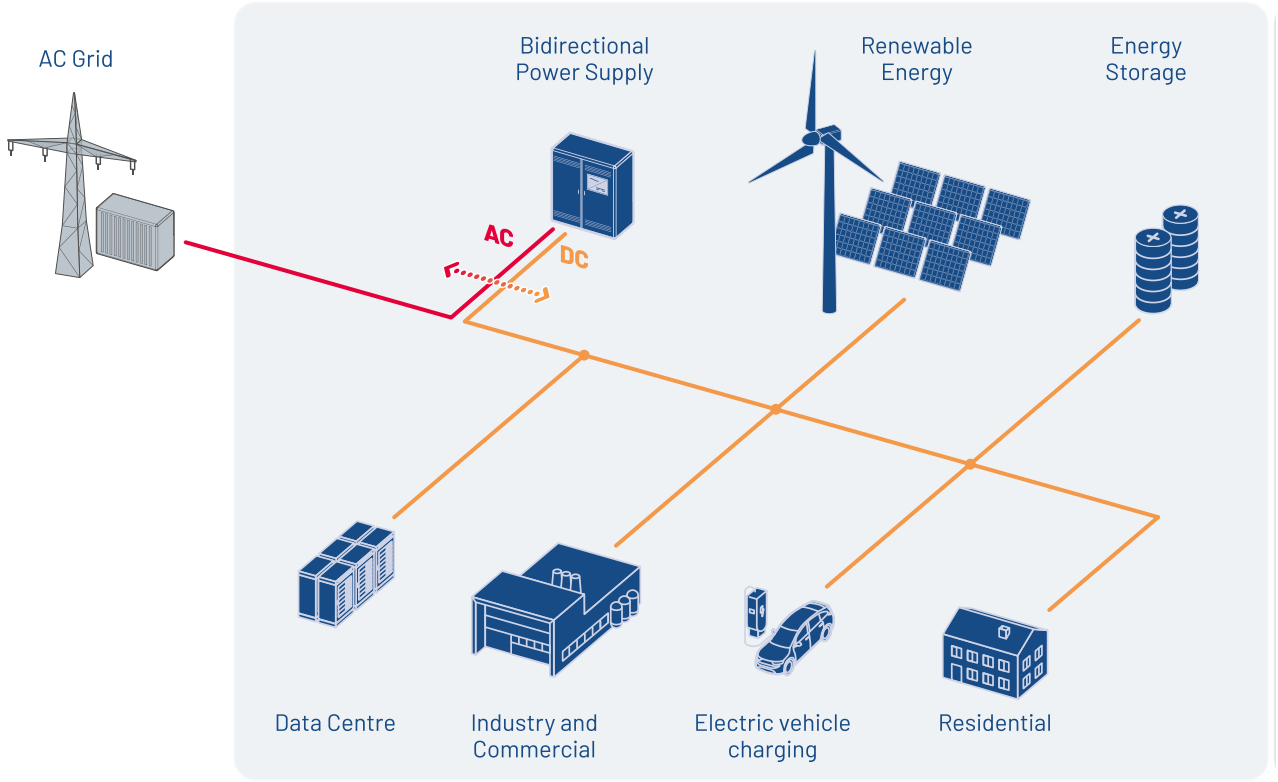


- **Multiple conversions from direct current DC to alternating current AC and vice-versa**
  - Many devices
  - Many resources
  - A lot of wiring
  - Maintenance
  - Power loss
- **In one word: Waste**

Content
DC-Microgrids



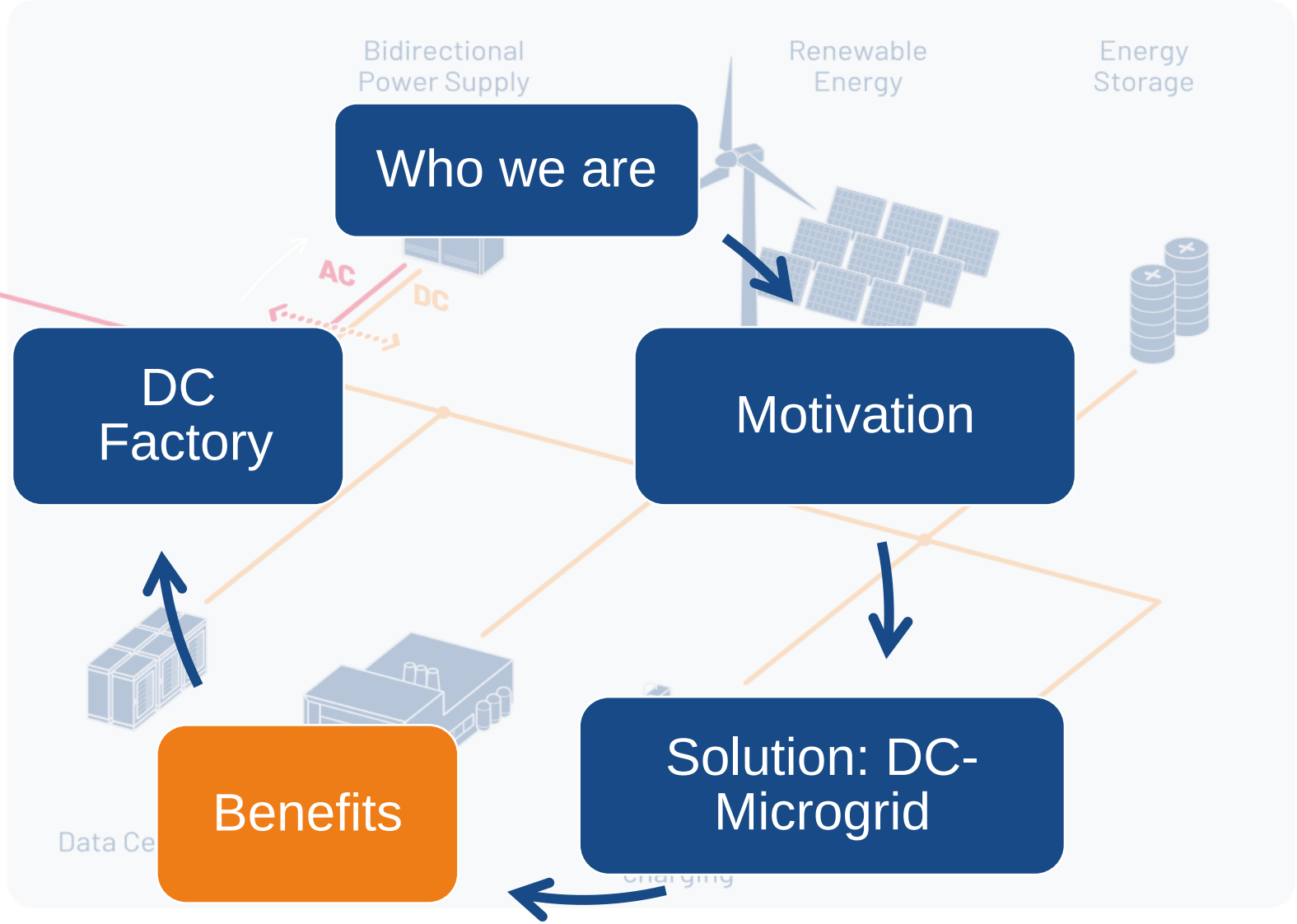
Solution
DC Microgrids



- **Simply connect “all things DC” with each other**
- **Fewer conversion steps (AC→DC, DC→AC)**
  - Fewer losses
  - Less maintenance
  - Fewer resources
- **Central connection to supply grid**

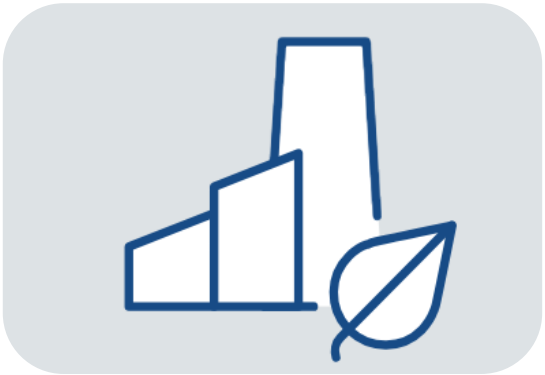
Content

Benefits



Benefits of DC
In Low Voltage Industry Grids

Peak Power reduction



Resource efficient

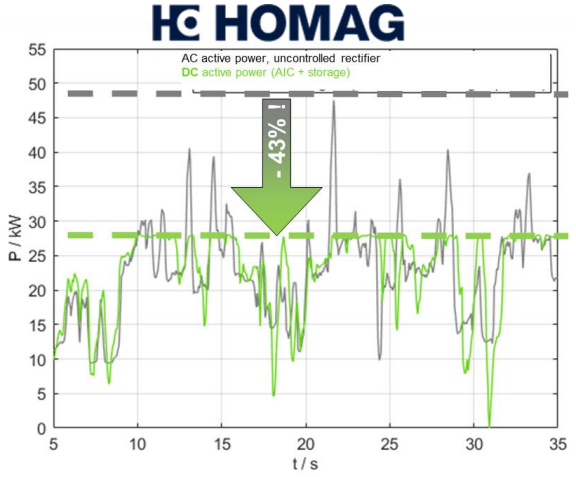
Energy efficient

Resilient

Peak Power Reduction
Wood Working Example

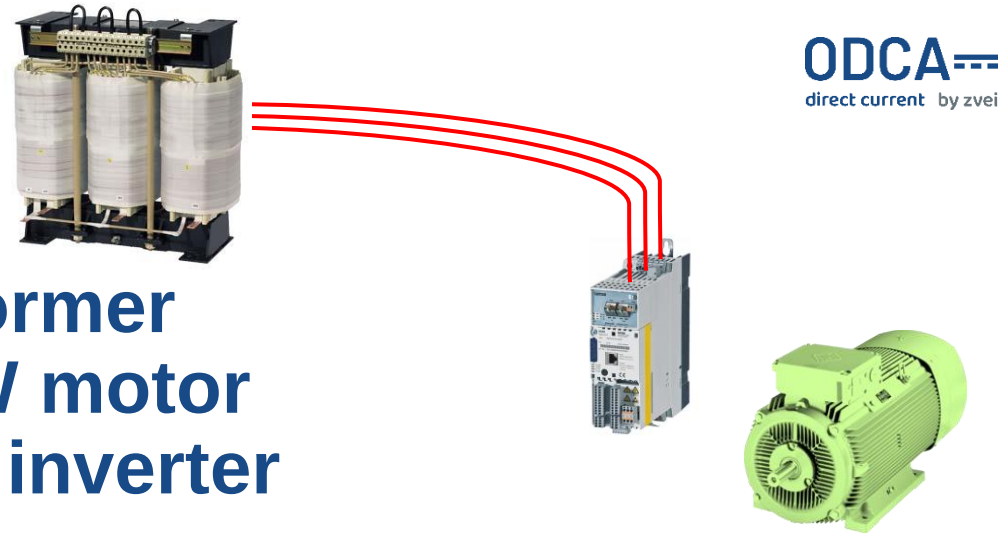
Wood working example

- ✓ Lower peak power rates
- ✓ Smaller transformer
- ✓ Smaller bus bars and cable cross sections



Source: https://odca.zvei.org/resources/publications/updated-system-concept-for-dc-industrie2-published

Resource Efficient
Cabling



Cabling from transformer to inverter for 7.5 kW motor driven by frequency inverter

- ✓ 50 % less copper
- ✓ 50 % lower power loss
- ✓ 2500 € / year savings
  - Per km of cable for 2 shift operation
  - @ 10 ct / kWh

	400 V AC	650 V DC
Current	20 A	14 A
Cable cross section	2.5 mm²	1.5 mm²
Total copper	10 mm²	4.5 mm²
Power loss	8.6 W/m	4.3 W/m

Source: https://odca.zvei.org/resources/publications/dc-industrie2-project-presentation

Energy Efficient
Braking Energy

Recovery of braking energy

- ✓ Not wasted in braking resistors
- ✓ No extra cooling needed

Resilient
Storage and Components

Energy storage

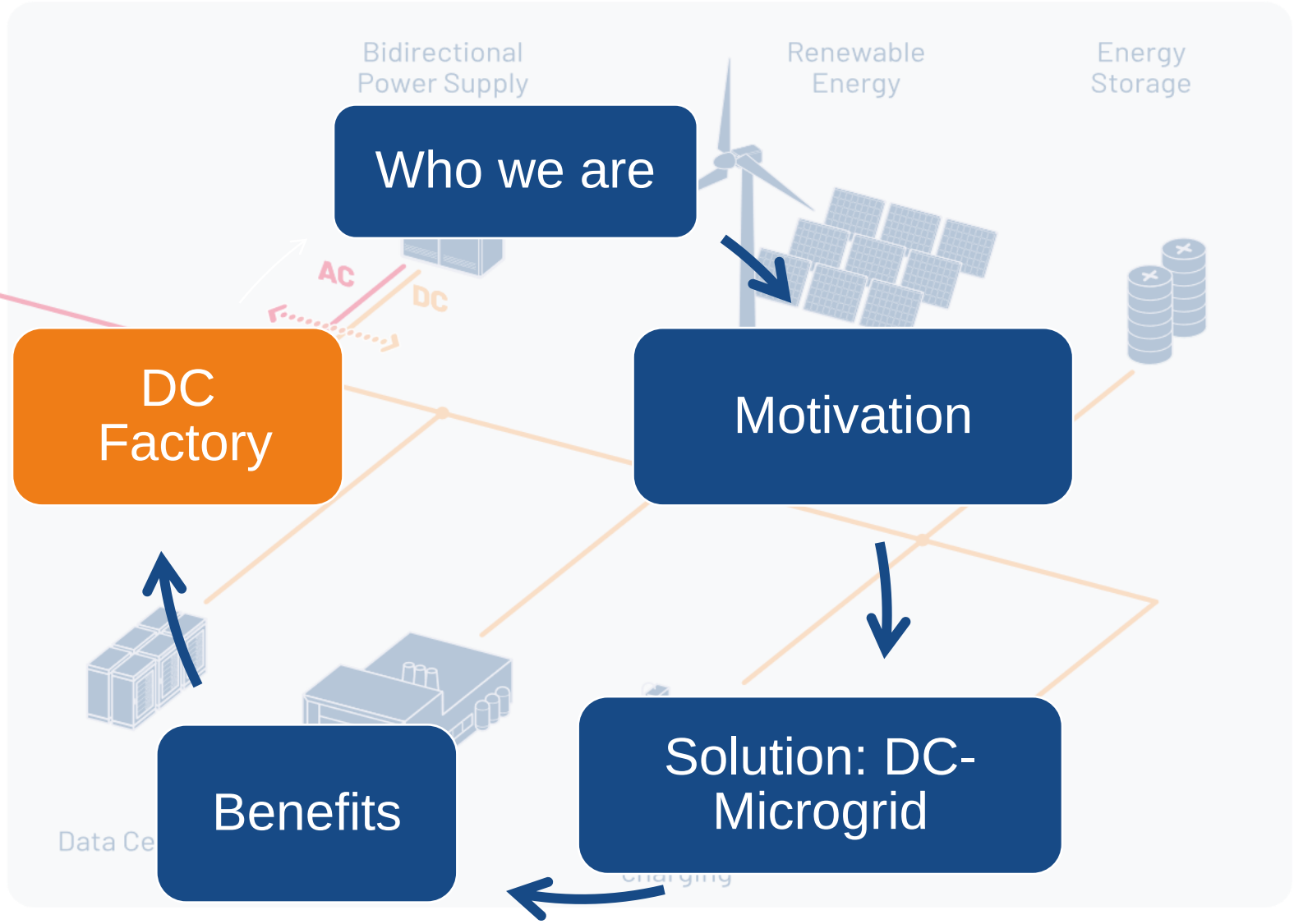
- ✓ Complete the production cycle in case of power outages

- ✓ Continue operation in island mode

Fewer components

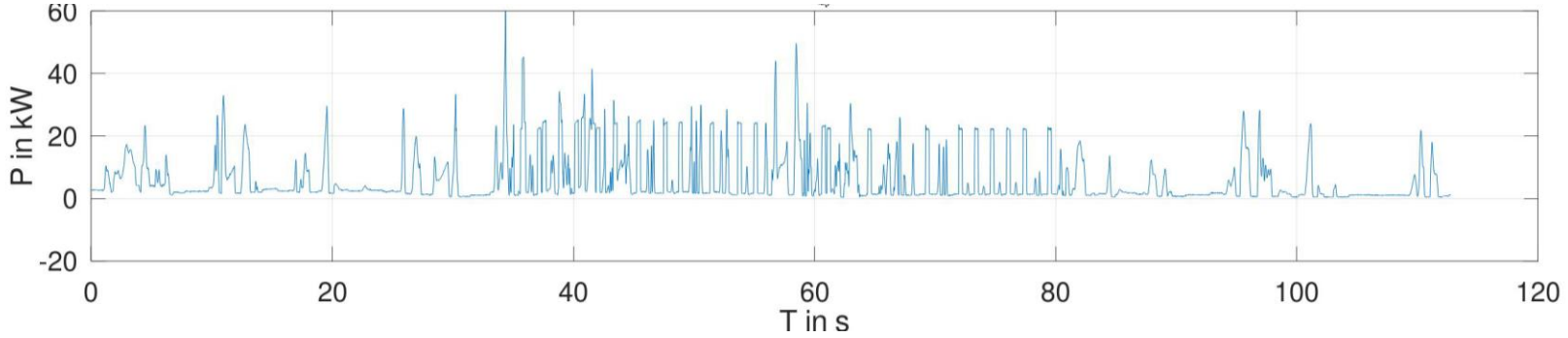
- ✓ Less maintenance, longer lifetime (e.g. LED lighting)

Content
DC Factory

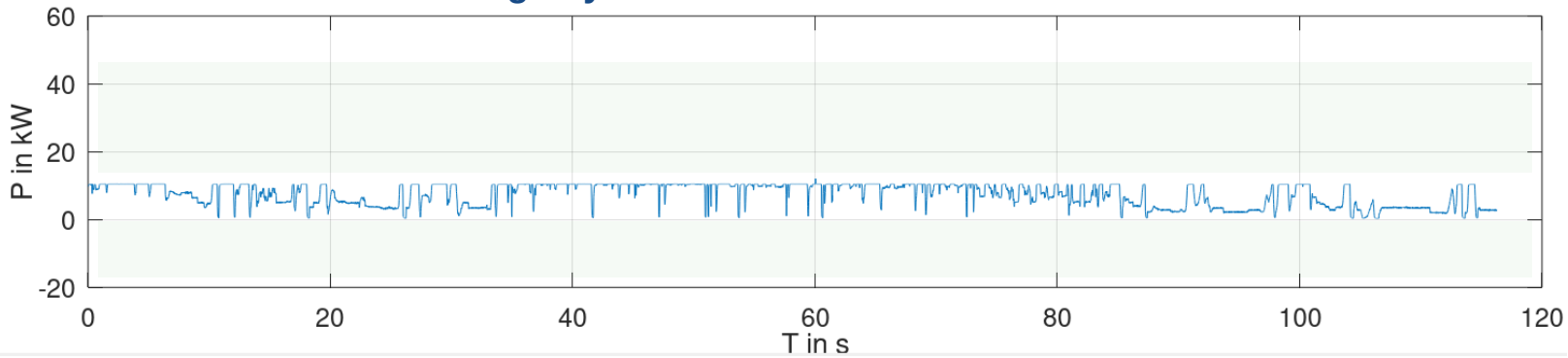


Application
KUKA - Comparison Measurment

AC Production Cell

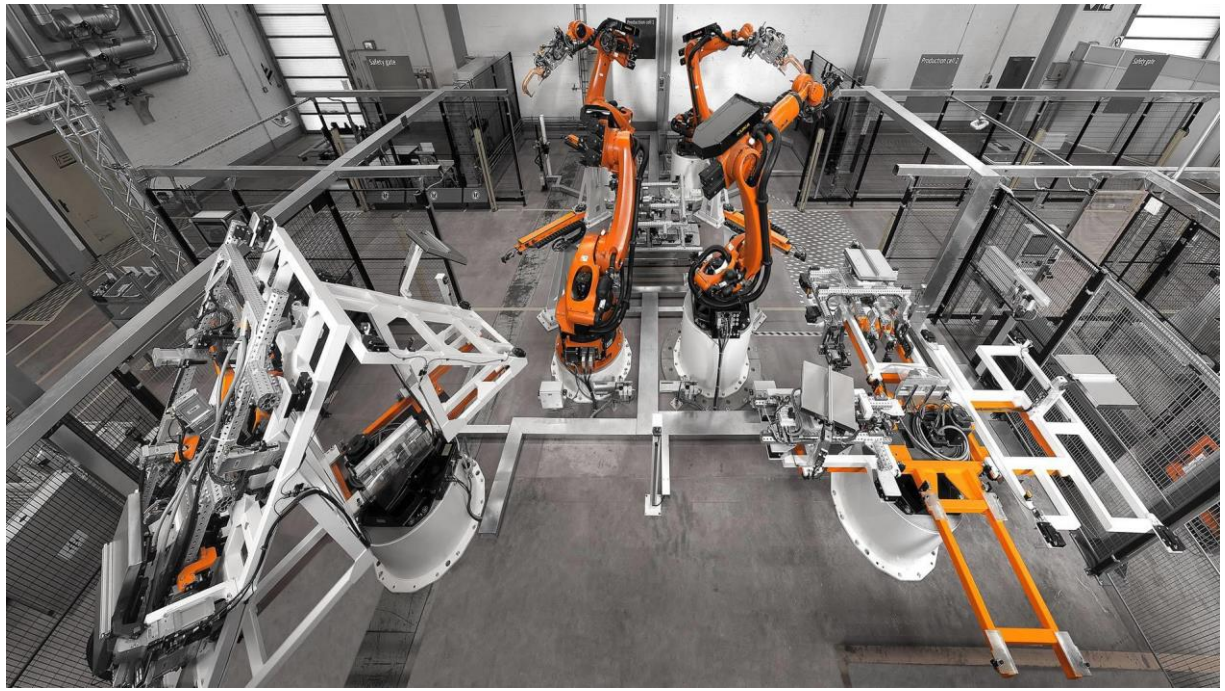


DC Production Cell with Storage System



Source: DC Grids in Automation| Christoph Steinherr| Feb 2023 | www.kuka.com

Application
KUKA - Results



- **Active Infeed Converter**
  - Reduction of the AC grid disturbances
- **Storage**
  - 80 % peak power reduction
- **Robots**
  - 7.2% energy savings
  - Depending on the application, up to 20 % energy savings can be achieved
  - No limitation of dynamic movements by braking resistors

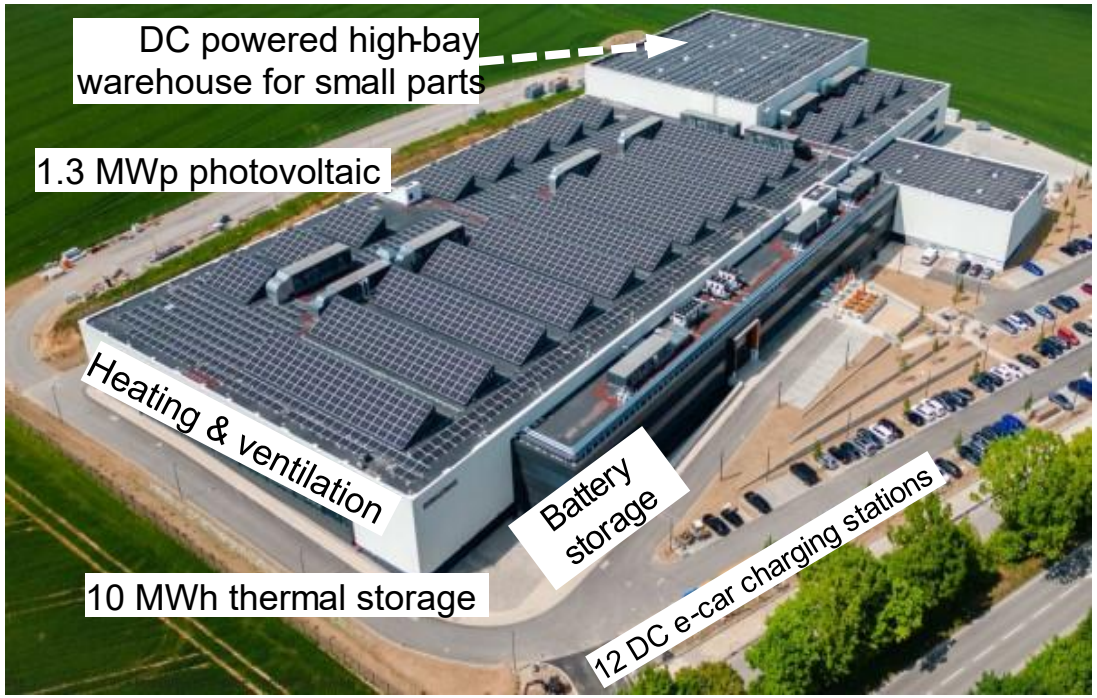
Source: DC Grids in Automation| Christoph Steinherr| Feb 2023 | www.kuka.com

Application
Mercedes-Benz Factory 56

- Large distances & power
- 222.000 m² production area
- 2 MW DC grid for hall infrastructure
- Heating & Air condition
- Load shifting with utility

Source: https://odca.zvei.org/resources/publications/dc-industrie2-project-presentation

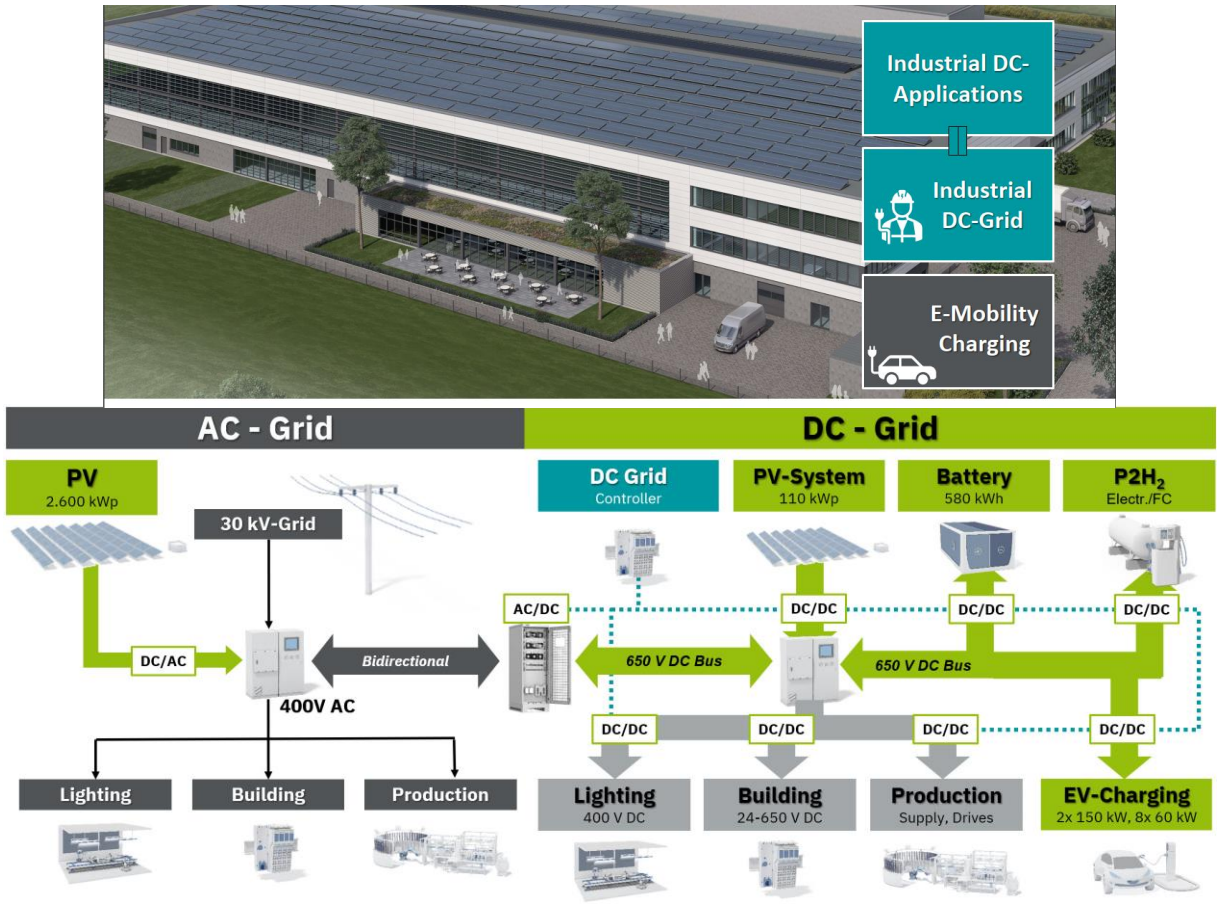
Application
Schaltbau NExT Factory



© **Schaltbau GmbH:** https://www.schaltbau.com/en/about-us/current-events/news-and-press/press-releases/schaltbau-opens-next-factory-in-velden/

- **Opened Sep. 2023**
- **1.3 MWp PV**
  - >70 % self-consumption
- **Peak infeed-power reduction**
  - 30% overall
  - 85% lower in fully automated high-bay warehouse
- **35% lower energy cost**
- **System description as base for approval**

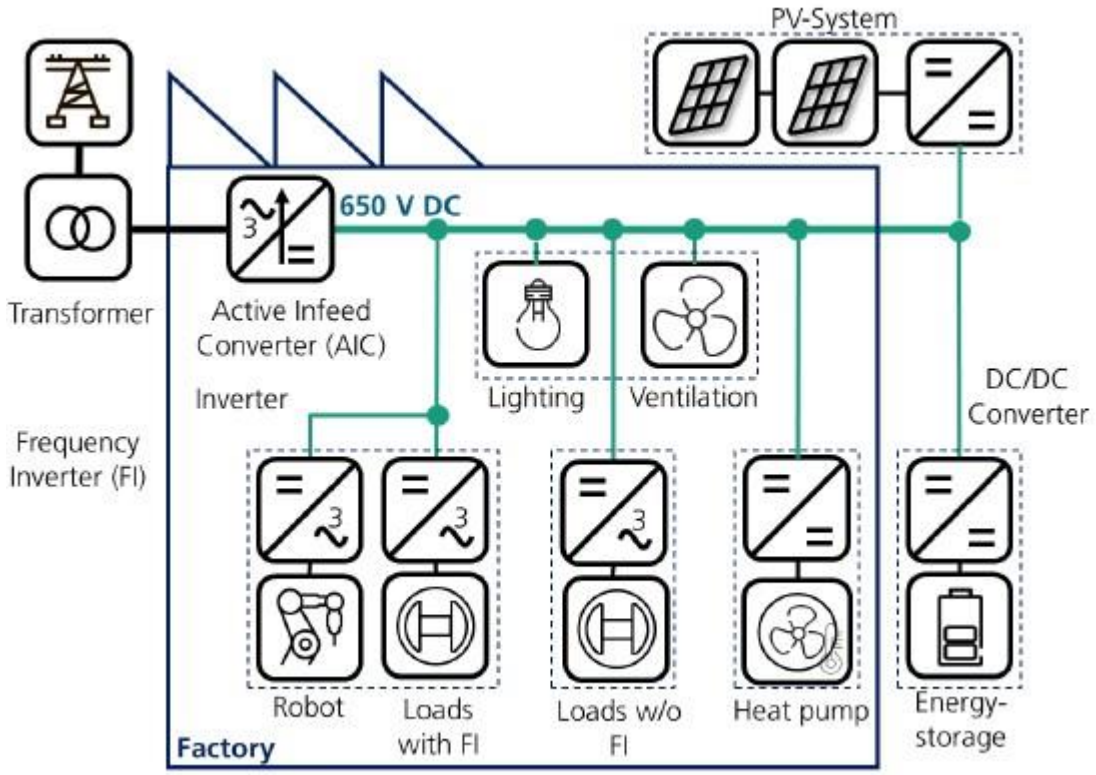
Application
Phoenix Contact – G60



- Sector coupling
- Thermal (ice-)storage
- Power to H2 planned
- 2.5 MWp PV
- 300 kWh battery storage

Example Calculation ROI

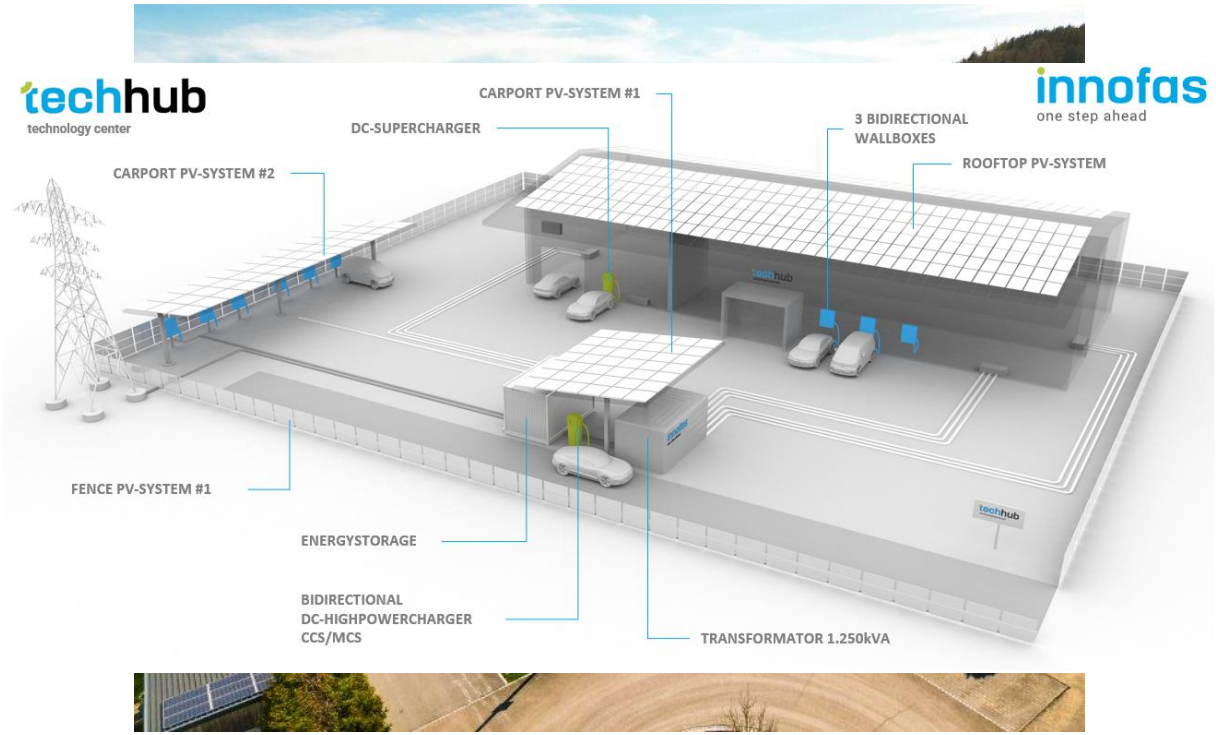
[Open Direct Current Alliance (zvei.org)]



Properties	Value	Unit
Overall efficiency AC	81.88	%
Overall efficiency DC	88.37	%
Efficiency increase	6.49	%
Total need AC with PV	17 263.04	MWh/a
Total need DC with PV	15 110.24	MWh/a
Comparison of total need	87.53	%
Energy saved	2 152.80	MWh/a
Cost savings vs. AC	430 559.99	€/a
CO2 savings	762.09	tCO_2eq/a
Additional investment for DC	1 513 681.22	€
Amortisation period	3.52	years

Properties	Value	Unit
Total output of the factory	5	MW
Total energy of the factory per year	18 750	MWh/a
Factory size	15 000	m^2
Energy price	0.20	€/kWh
CO_2-emissions	354	gCO_2eq/kWh
Output of the production loads	3 925	kW
Heat pump output	530	kW
Power of the ventilation system	395	kW
Power of the lighting system	150	kW
Output of the PV system	530	kWp
Utilisation of the PV system	Self-consumption optimisation in combination with battery storage	

Application other than Industry
innofas TechHub Dollnstein



Source: https://www.innofas.de/techhub

- **PV (rooftop and carports)**
- **Energy storage with automotive second life modules**
- **Charging infrastructure (AC and DC)**
  - Galvanic isolated DC/DC coupled bidirectional 350kW EV charging with CCS and MCS Plug
  - Voltage range: 200V – 1300V, direct coupled to the storage system without DC/DC converter

Next steps:

- **Solar fence**
- **DC lighting in building**

Contact info

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Chair of the Board of Open DC Alliance

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WE CAN DO BETTER – WITH DC!

Cost-efficient

Energy-efficient

Material-efficient

CO_2-efficient

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