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DC MICROGRIDS FOR INDUSTRY AND LOW POWER CHARGING INFRASTRUCTURE

19. SYMPOSIUM ENERGIEINNOVATION, 11.-13.02.2026, GRAZ

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FEEI
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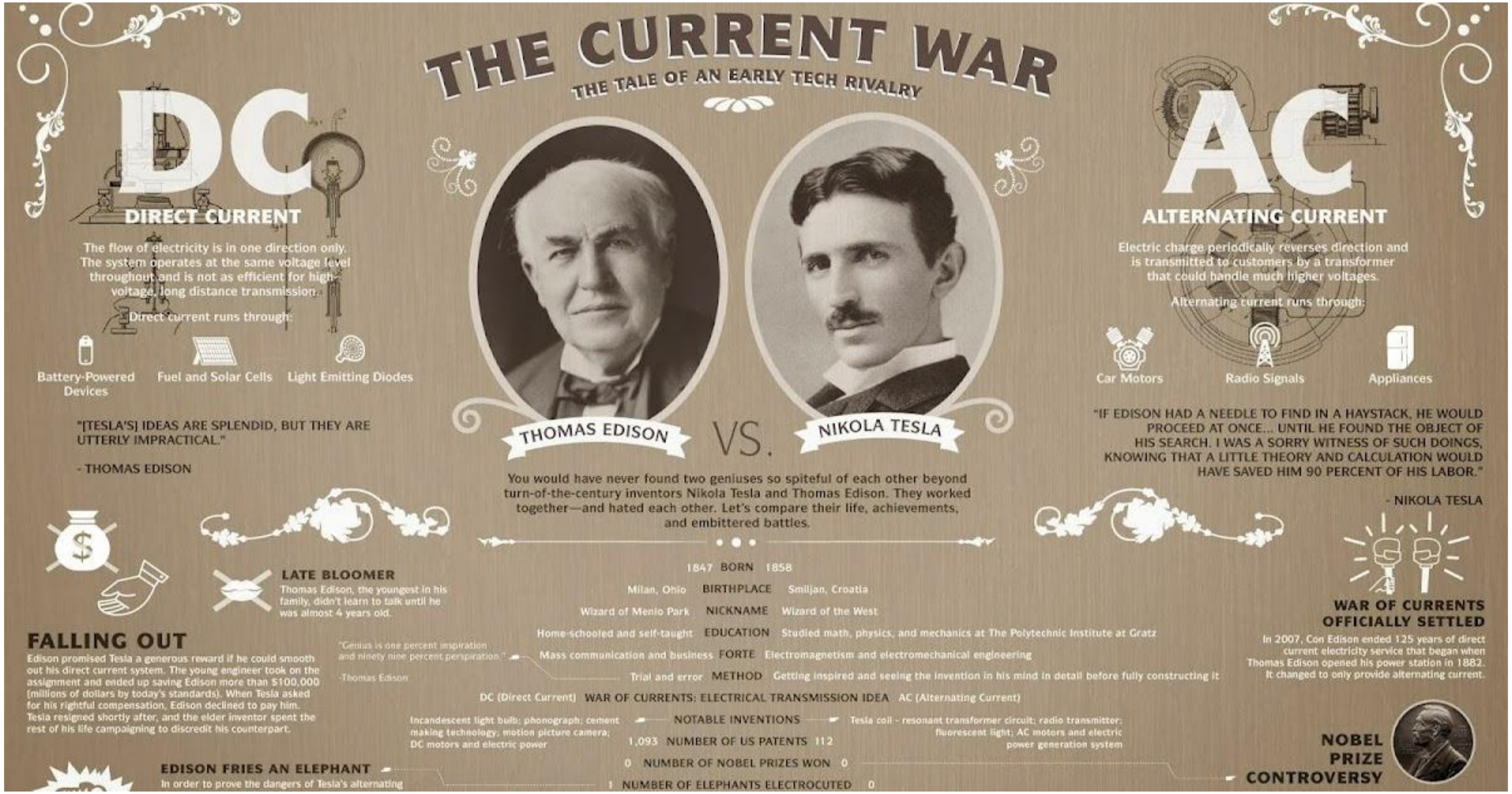
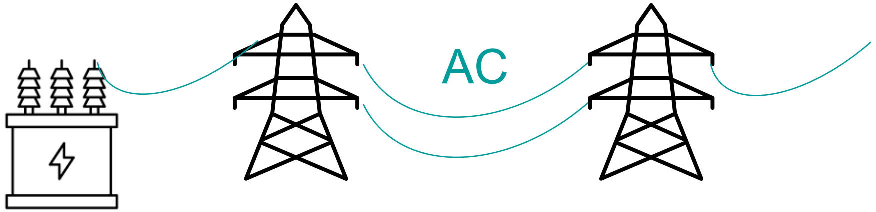
WHY DC

… WE HAD THIS DISCUSSION ALREADY



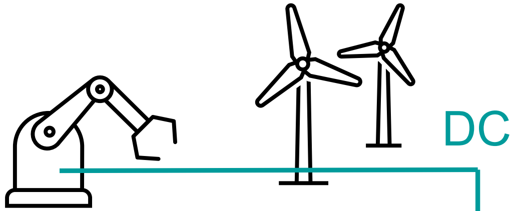
https://allabtinstru.blogspot.com/2016/09/the-war-of-currents-ac-vs-dc-power.html

MOTIVATION
DC AS A PART OF THE FUTURE

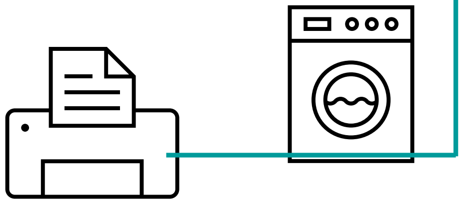


The Future is **Hybrid**, Not Exclusive

In 1880s
AC won due to the transmission over wide distances enabled by transformers



Today
End user devices, EVs, PV, battery energy storage (BESS) are operated at DC.
Due to the usage of Power Electronics a silent revolution started.



OUTLINE
THE DC ADVANTAGE

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- **Transmission Efficiency**
  - No skin effect and reactive power losses
- **Renewable Integration**
  - Native integration of photovoltaics and batteries
  - End-User Devices mostly operate already on DC
- **Grid stability**
  - Frequency synchronization vs. DC-bus voltage control
- **Footprint**
  - DC requires less conductor cross section

- **Structural deficit of copper supply**
  - A supply demand gap of 10Mt is expected in 2035 [1]
  - Saving copper will decrease costs dramatically

> *"Putting all these levers together, we project global copper demand to grow by around 70% to over 50 Mt per annum by 2050 – an average growth rate of 2% per year."* [2]

[1] https://www.bhp.com/news/bhp-insights/2024/09/how-copper-will-shape-our-future
[2] https://investingnews.com/bhp-copper-market-forecast/

DC IS ALREADY IMPLEMENTED

SOME USE CASES

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Use Cases

ODCA direct current by zvei

https://odca.zvei.org/use-cases

DC MICROGRIDS FOR INDUSTRY

GENERAL

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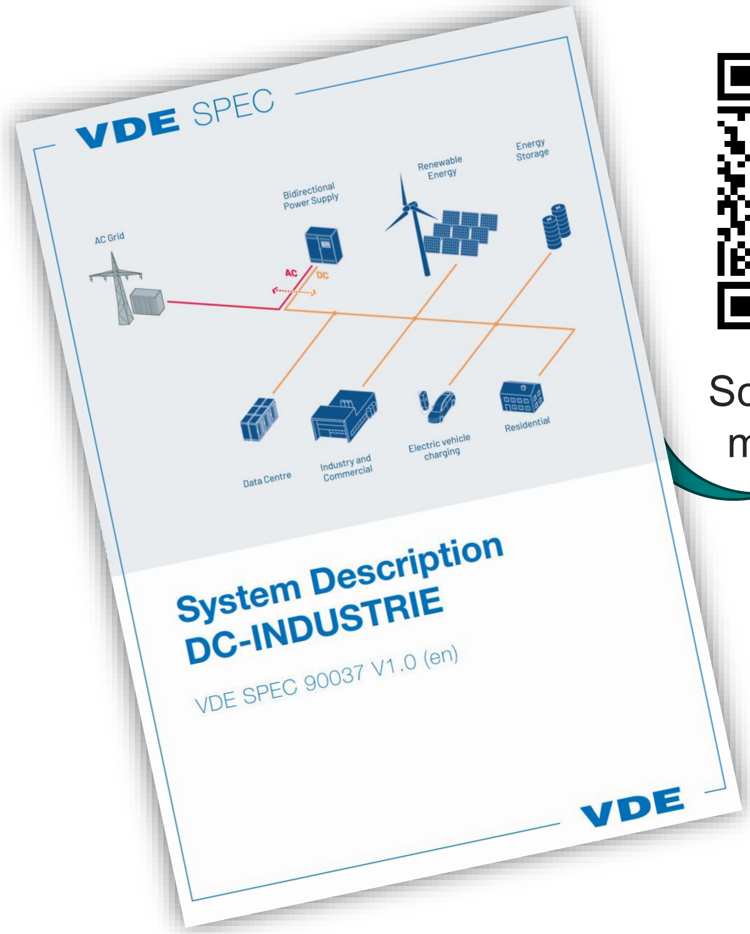
Key advantages of DC compared to AC:

- **Reduced copper cabling** requirements and **lower cable losses**
- **Decreased overall energy consumption** and the ability to recover braking energy
- **Direct** and efficient **integration of renewable** energy systems
- Increased system availability due to **fewer energy conversion stages** and, consequently, fewer components that may fail
- Lower infeed power and **reduced peak power demand** through the **integration of battery energy storage systems** (BESS)

https://experience.odca.zvei.org/benefits.html



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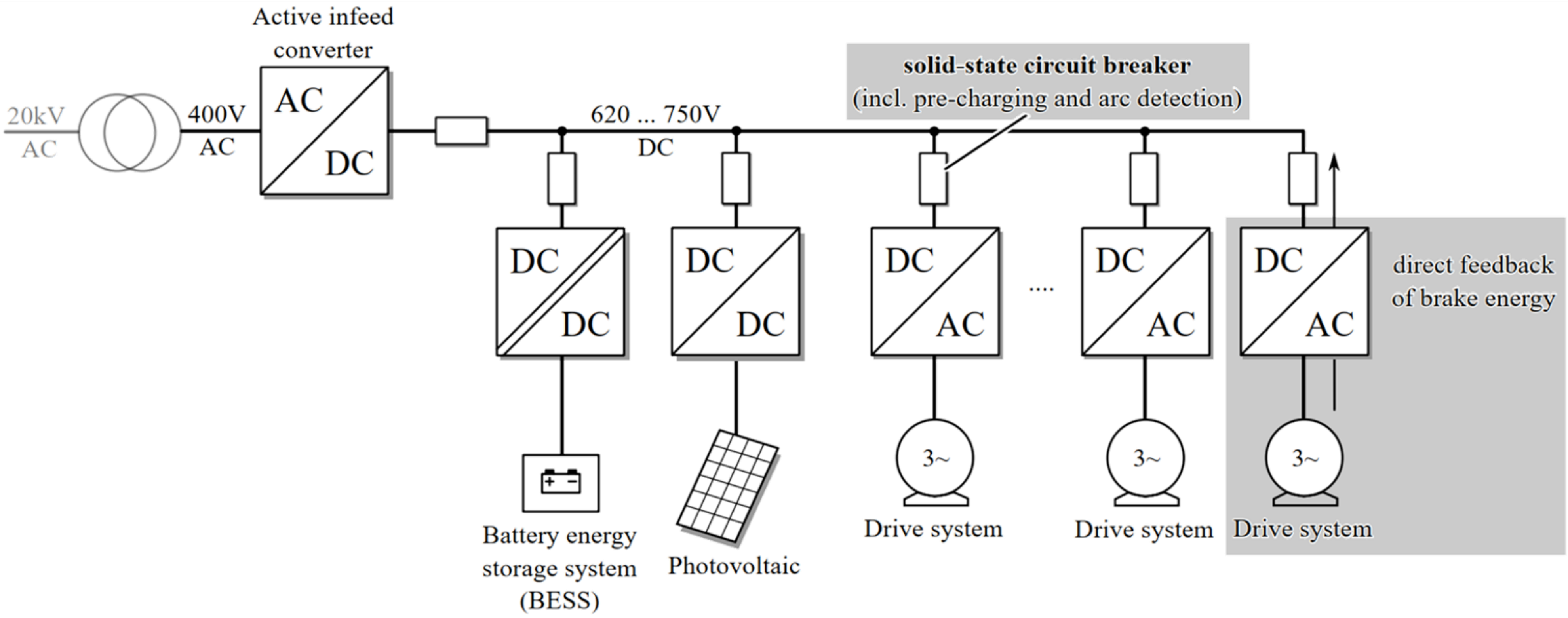
https://www.vde.com/resource/blob/2360634/86d934eebfb76ee6f480565c94d4d319/vde-spec-90037-v1-0--en--data.pdf

DC MICROGRIDS FOR INDUSTRY

GENERAL



DC MICROGRIDS FOR INDUSTRY

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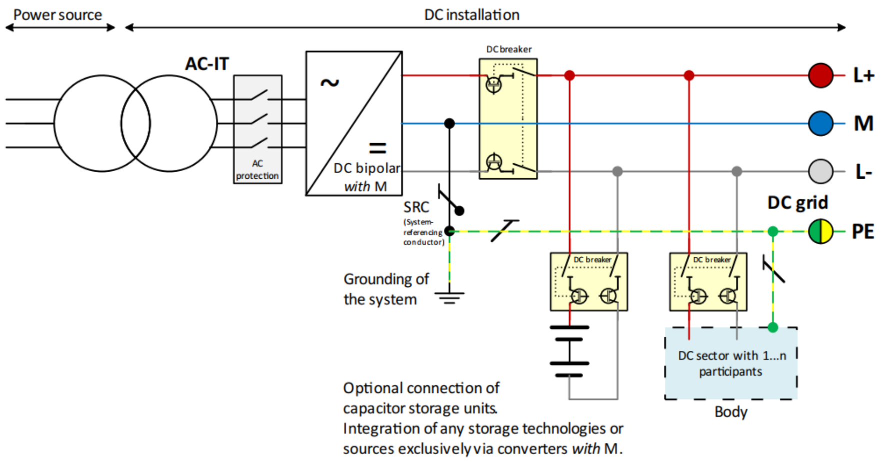
INTRODUCTION

- Different layout concepts similar to AC such as

DC-TN-S system with midpoint grounding



- Power balance in DC microgrids is maintained by using a specific DC bus voltage band to signal power adjustments

Table 7.1: Voltage bands and limit values (based on [11.]) , see footnote 25 on U6

Band	Nominal voltage: 540 V	Nominal voltage: 650 V
B7	**Forbidden band** - Damage of devices is very likely	
U6	2000 V	
B6	**Overvoltage protection band** - Switching operations can cause this voltage range - Surge protection devices (SPDs) operate and try to protect devices	
U5	880 V	
B5	**Temporary overvoltage band** - Surge protection devices (SPD) are **not** active - Breakers disconnect in this band - Insulation and components shall withstand this for up to 5 s - Devices may lose functionality in order to protect themselves	
U4	800 V	
B4	**Overvoltage band** - Devices may reduce their power - This shall not last longer than 60s - Measures to reduce the voltage must be taken (e.g. charge storage, switch-on power resistors)	
U3	750 V	
B3	**Nominal band** - Normal operating range - Devices shall be operated permanently - Devices perform with their rated power	
U2	485 V	620 V
B2	**Emergency band** - Overload condition - Loads have to be reduced - AIC must only be operated for a few milliseconds	
U1	400 V	
B1	**Blackout Band** - Smart Breakers disconnect - Band will be used during pre-charging - Occurs briefly during short-circuit conditions	

VDE Verband der Elektrotechnik Elektronik Informationstechnik e. V. (2020). System Description: DC-INDUSTRIE (VDE SPEC 90037 V1.0 (en)).

DC MICROGRIDS FOR INDUSTRY

COPPER SAVINGS

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- Analysis considers installation condition **B2 according to OVE E 8101** (international equivalent: IEC 60364), assumption: cable length 100m

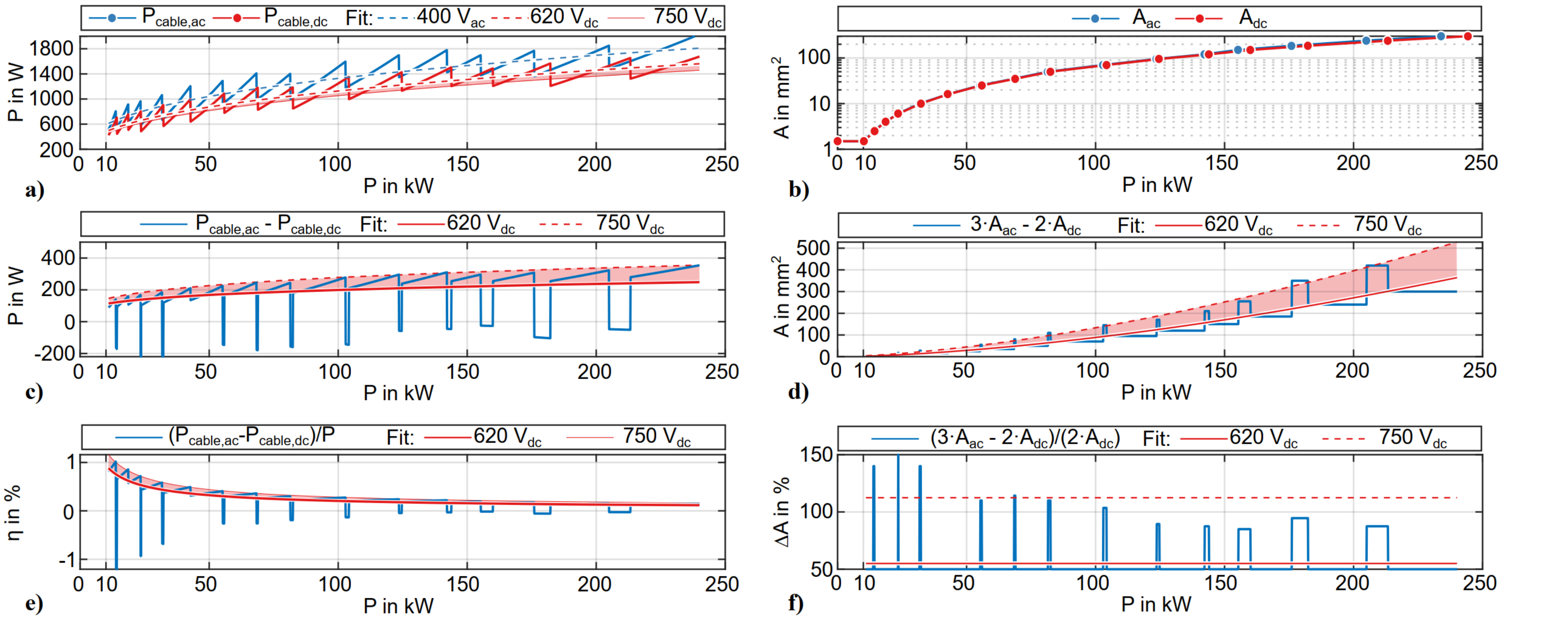

Figure: Comparison of ohmic losses and conductor cross-sections for AC (400 V) and DC (620 V - 750 V) systems (100 m). a) transmission losses; b) cross-sections per OVE E 8101 / IEC 60364 (B2); c) loss delta; d) total conducting area, e) efficiency impact and f) percentage variance.

DC MICROGRIDS FOR INDUSTRY

SOLID STATE CIRCUIT BREAKER

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Mandatory features:

- Short circuit protection
- Reliable isolation

Optional features:

- Pre-charging of DC-lines
- Switch off at low voltage
- Voltage and current monitoring

Depending on **layout and grounding**:

- A two-pole SSCB is needed

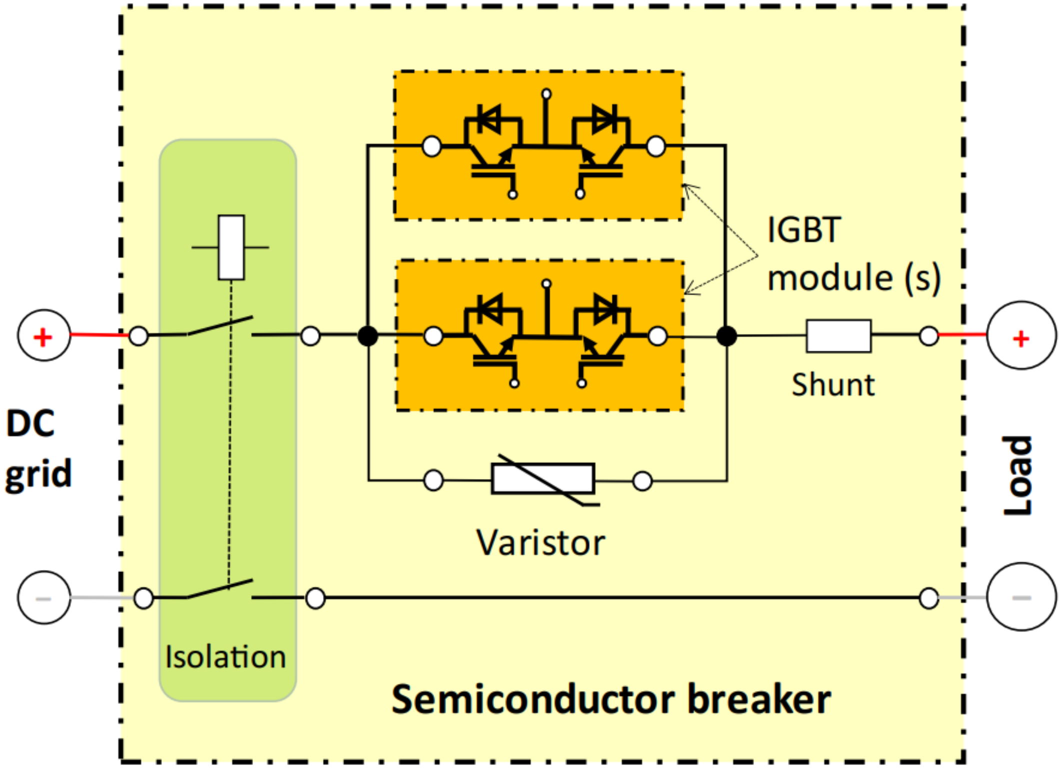

Figure 12.10 Schematic circuit diagram of a single-pole semiconductor breaker [29.]

VDE Verband der Elektrotechnik Elektronik Informationstechnik e. V. (2020). System Description: DC-INDUSTRIE (VDE SPEC 90037 V1.0 (en)).

DC MICROGRIDS FOR INDUSTRY

SOLID STATE CIRCUIT BREAKER

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Proof of concept

- Reaction times of less than 200ns
- Hall based current sensing
- Analog detection circuit
- SiC semiconductors

New trend with wide-band-gap semiconductors

- Utilization of JFETs

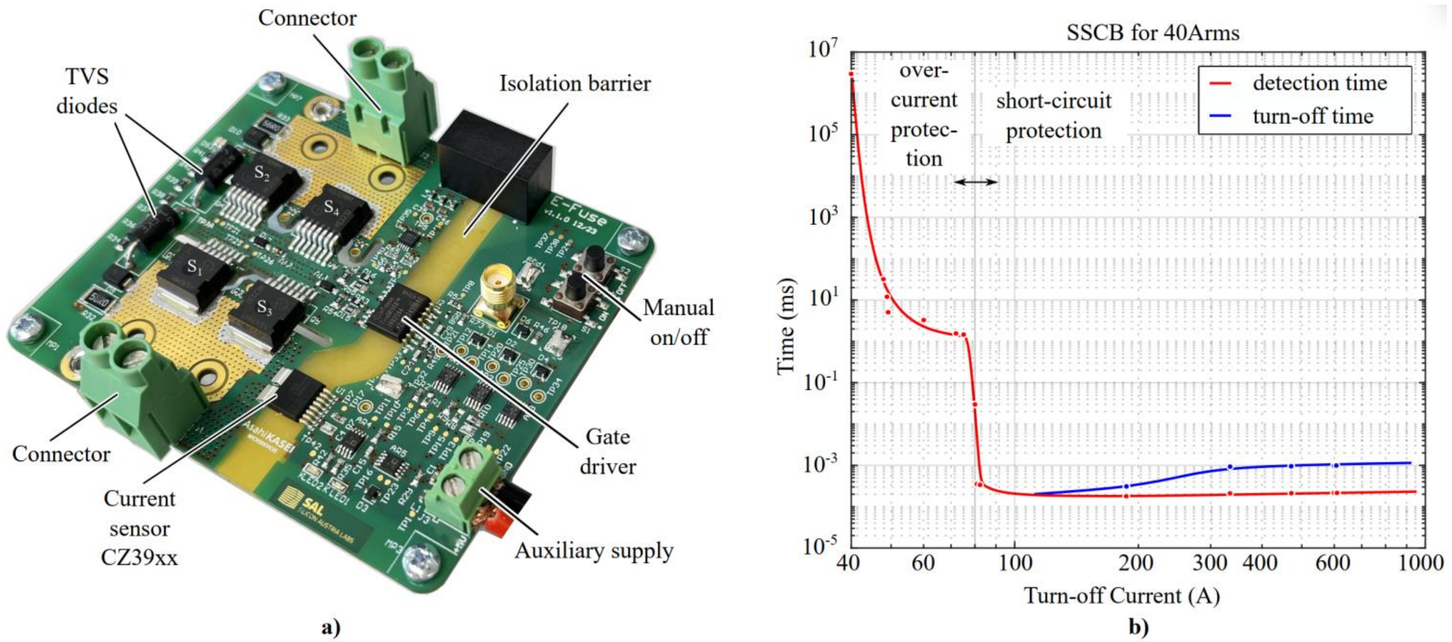

Figure: Proof-of-concept of an automotive Solid-State Circuit Breaker (SSCB), commonly referred to as an E-Fuse [7]. a) Layout of the PCB and its primary components; b) Characterization of the system's reaction and turn-off times.

Langbauer, T., Feibel, T., Huang, Z., Okada, I., & Shikama, T. (2024, June). A high voltage eFuse for automotive applications. Bodo's Power Systems, 34–38. https://www.bodospower.com/

DC MICROGRIDS FOR LOW POWER CHARGING GENERAL

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Current Infrastructure:

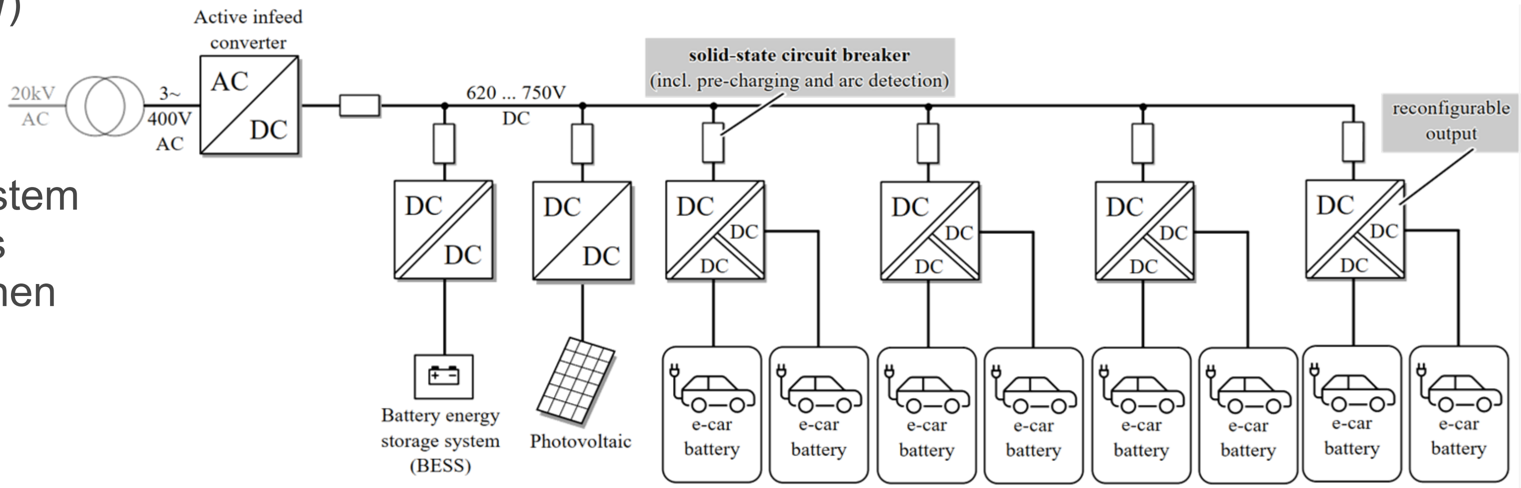
- Existing low power EV charging predominantly uses **AC** (typically from **7kW** up to **22kW**)

System Efficiency with Renewables:

- Integrating EV charging within an ecosystem that includes **PV** and **BESS** necessitates multiple inefficient power conversions when using AC chargers.

Advantage of a DC Bus:

- Implementing a direct **DC bus** architecture enhances overall system



DC MICROGRIDS FOR LOW POWER CHARGING SHIFT IN OWNERSHIP

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Charging-as-a-Service:

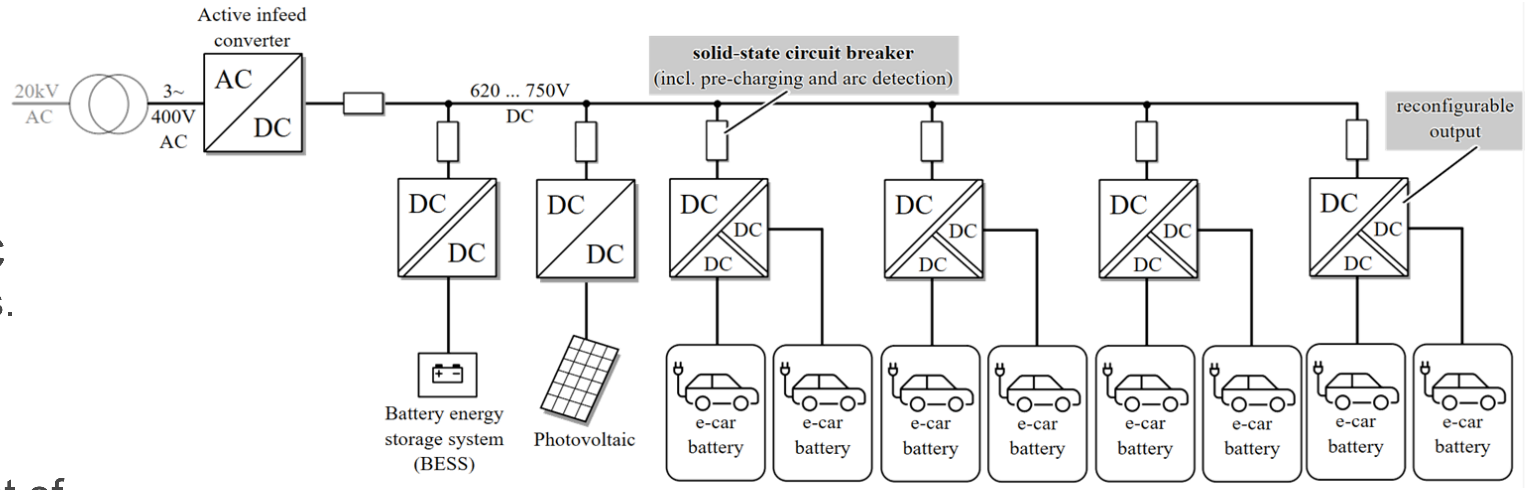
- Site hosts can now use "turnkey" models where a third party owns and maintains the DC equipment, and the host pays a predictable monthly fee.

Attractivity:

- Retailers (supermarkets, malls) view DC charging to attract high-value customers.

Return of Investment:

- For industrial fleet owners, the initial cost of DC charging stations is recouped through lower vehicle costs and better energy efficiency



DC MICROGRIDS FOR LOW POWER CHARGING CONVERTER CONCEPT

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Architecture:

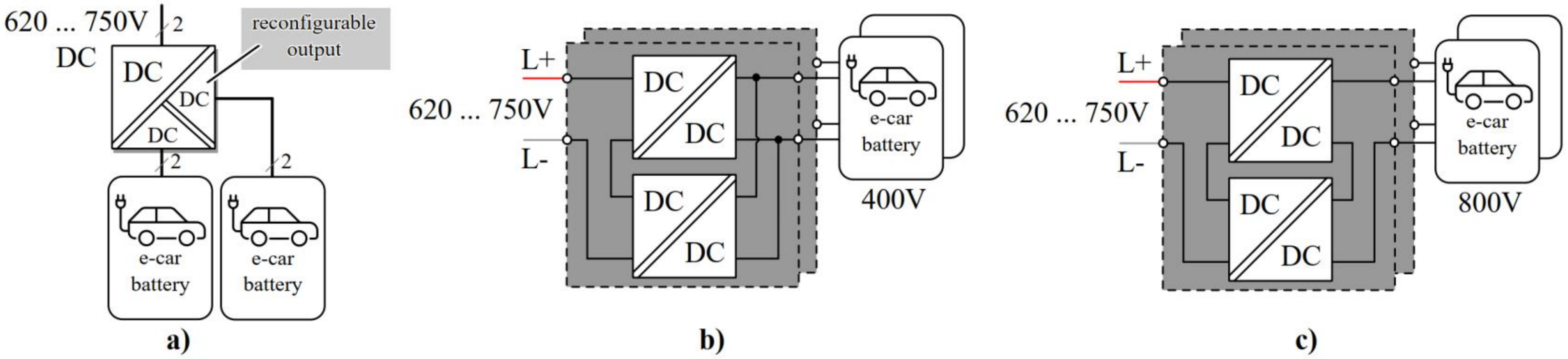
- The system comprises multiple converter modules (e.g., four modules of 6.25 kW each) and a switch matrix.

Functionality:

- The switch matrix connects the modules to distribute charging power to one or multiple EVs (both 400V and 800V possible)

Benefits:

- The modules have synergies with BESS (Battery Energy Storage Systems) and can be mass-produced, likely to help manage grid demand, store renewable energy, and reduce operational costs.



CONCLUSIONES

DC MICROGRIDS

- **DC Microgrids** are a viable, efficient industrial solution.
- They provide substantial **copper and energy savings** (55%+ copper reduction).
- A **post-2035 shift** to off-board DC electromobility is underway.
- **Off-board DC** systems boost efficiency, eliminate conversion losses, and enable lighter vehicles.

- **Technical hurdles**
  - Arc Faults
  - Corrosion
- **Knowledge/Experience Gap:**
  - Lack of specific expertise is a major barrier to success.

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THANK YOU FOR YOUR ATTENTION!

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