

02nd CEMEP CONFERENCE

7th and 8th July 2022 in Milan, Italy

CEMEP sustainable products, systems & services



DC-INDUSTRIE2 | Isabella Bianchini, 8.07.2022

DC-INDUSTRIE2 – open DC grid for sustainable factories

Joint research project: DC-INDUSTRIE2 – Direct current for the factory of the future

Contact: Dr. Hartwig Stammberger (Eaton, Bonn, project coordinator)

Prof. Dr.-Ing. Holger Borcherding (TH OWL, Lemgo, scientific lead of the project) Supported by:



on the basis of a decision by the German Bundestag





Outline

• Research project DC-INDUSTRIE2

Industrial DC grid

o Voltage band and control of industrial DC grids

• Model applications in industrial companies and research centres

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Overview: research project DC-INDUSTRIE2

- Funded by the German Federal Government
 - Funding codes: 03EI6002A-Q
- 3 years until Sep. 2022
- 39 industry and research partners
 - About 140 engineers & researchers
- Objectives:
 - Safe and robust energy supply for production
 - Grid-supporting connection to the supply grid
 - Maximum use of decentralized, regenerative energy
 - Simple grid planning
- Implementation and validation
 - 7 model plants and transfer centers



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Status quo: Topology of an industrial AC grid







C-FMFD

DC-

Basic wiring of frequency converters is optimized for **motor** applications

In **braking** mode, the inverter needs to dispose of the stored energy.

The most common method is the **dissipation of the energy to heat** in braking resistors

Energy flow in generator mode





Energy flow

3~

0

mode

Motor

operation

Storage

Generator

Electrical energy exchange with a DC grid

3~ AC grid Infeed rectifier 3~ **DC grid**

DC grid (DC link)

- **Reduces effort**
- **Enables direct** ۲ energy exchange no additional components needed





Topology of an industrial DC grid



- For example, frequency converters
- Connecting the DC links with each other makes the many AC-to-DC conversion steps redundant.



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Advantages of DC grid for industrial plants

- Energy efficiency
 - Lower losses (typically 2-4% *)
 - Total recovery of braking energy *
 - Direct use of renewable energy sources *
 - Peak power reduction through suitable storage (up to 80%) *
- Resource efficiency
 - Reduction of copper use (cable wires)
 - Lower equipment costs and space savings in the field

Grid stability

- Additional investments for filtering and compensation can be omitted, and existing grids are supported
- Production failures due to grid disturbances are prevented / reduced
- Industrial Smart DC-Grid / flexibility
 - Infrastructure for intelligent control of energy flows enables advantages in energy purchasing
 - Modular planning and control design



*: Evaluated in model applications

DC

Voltage bands – here for active infeed converters 7th and 8th July 2022 in Milan, Italy



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Operating status – function of voltage and duration

Voltage level Bx and duration Sx determine operating status Ax

- A7 Prohibited
 - Damage very likely
- A6 Overvoltage protection active
- A5 Overvoltage protection not active
 - Devices may switch off
- A4 Abnormal status
 - Devices shall function dynamically
- A3 Normal operation
 - Full functionality
- A2 Acute undervoltage
 - Devices may reduce power
- A1 Blackout status
 - Switch off
 - Pre-charge on startup

Upper voltage limit Ux for nominal voltage 540 V / 650 V		Voltage band	<i>S1:</i> t < 100 μs	S2: 100 μs ≤ <i>t</i> ≤ 1 ms	S3a: 1 ms ≤ <i>t</i> ≤ 5 s	S3b: 5 s ≤ <i>t</i> ≤ 60 s	S4: t > 60 s
Voltage ᢣ	U6: 1500 V	B7	A7				
	U5: 1200 V	B6	A6	A7			
	U4: 880 V	B5	A6	A7	A7	A7	
	U3h· 800 V	B4	A4	A5	A5	A7	A7
	U3a: 750 V U2: 485 / 600 V U1: 400 V	B3h	A3	A3	A3	A4	A5
		B3I	A3	A3	A3	A3	A3
		B2	A4	A4	A2	A2	A1
		B1	A4	A2	A1	A1	-
	Time 🗲						

Based on IEC Technical Report TR63282 Ed. 1 2020-11



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Model applications of DC-INDUSTRIE

Mercedes-Benz

- Production cell with 4 robots
- Challenging energy demand (Al-welding)
- Continued from EU project AREUS



Mercedes-Benz

- Suspension track
- 5 individual carriers with slip rings

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C-EMEP DC-

• Homag

- Wood working machines
- Many loads
- Sensors & actors
- Integrated energy storage



• KHS

- Beverage container handling
- Open concept
- > 30 drives



Model applications of DC-INDUSTRIE2

• BMW

- Car body production cell
- Focus
 - Energy distribution & storage
 - Energy feedback to grid
 - Switching and protection



• KUKA

• Test cell with 4 robots • Focus: robot control

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Machines and Power Electro



- Fraunhofer IISB
 - DC infrastructure in office building, EV charging







Model applications of DC-INDUSTRIE2



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Model applications of DC-INDUSTRIE2



• Homag

- Wood working machines
- Three applications spread out in a factory hall
- Setup
 - Multiple connections to AC grid
 - Several storage options
 - Flywheel
 - Capacitors
 - Batteries
- Focus
 - Influence of long cables on voltage dips during supply failure or faults
 - Coordination between several active infeed converters

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Model applications of DC-INDUSTRIE2

• TH OWL

- Model electro-mechanical loads, up to 11 axes
- Storage

• Several infeed rectifiers

• Focus

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- Load behavior simulation in real time
- Test virtual machines in a DC environment
- Test of multiple failure scenarios



• Fraunhofer IPA

- Industrial power distribution
- Storage (battery, flywheel), virtual loads
- AC-DC transformation
- Protection and control concept
- Monitoring



More information and publications

- DC-Industrie Homepage
 <u>www.dc-industry.com</u>
- Publications (excerpt)
 - White paper
 - Several technical reports and papers
 - Textbook *The DC-Factory,* Hanser Verlag, 2021 <u>https://www.hanser-</u> <u>kundencenter.de/fachbuch/</u> <u>artikel/9783446471740</u>
 - English and German version available



 Computer & Automation
 <u>4 article technical paper series</u>

Projekt 'DC-Industrie' - Teil 1

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DC statt AC im Produktionsnetz

C-EMEP

Machines and Power Electro

DC-

22. März 2019, 01:00 Uhr | Holger Borcherding



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Why direct current and DC-INDUSTRIE?

- 1. Open system
- 2. Efficient integration of green energy
- 3. Lower energy consumption
- 4. Reduced connection power
- 5. Resource efficiency

6. Increased system availability











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Part of the committed DC-INDUSTRIE team



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Assoziierte Partner: ABB Stotz-Kontakt; <u>AMK Arnold Müller</u>; Audi; <u>Bauer Gear Motor</u>; Bender; <u>Danfoss</u>; DEHN; <u>ESR Pollmeier</u>; Gerotor; <u>Harting</u>; JEAN MÜLLER; <u>KUKA</u>; LEONI; <u>Maschinenfabrik Reinhausen</u>; Paul Vahle; <u>Puls</u>; Rittal; <u>SEW-PowerSystems</u>; Siemens; <u>TU Ilmenau</u>; Wöhner

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Thanks for the attention!

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