ebs group

enhance

DC-LINK
ENERGY BACKUP SOLUTION

Safety for

wind turbines.

PROVEN IN THE FIELD. CERTIFIED. SCALABLE.



USE CASE

Use cases in wind turbines

Energy storage systems in wind turbines are required by law in many markets and are also necessary for operational purposes. enhance covers all four key use cases.

#1

FRT – Fault Ride Through

By law (EU 2016/631)

Wind turbines must withstand grid voltage dips and continue to feed power into the grid afterwards. Battery storage systems provide the necessary energy in the DC link. Some additional national requirements go beyond the EU minimum requirements.

#2

Black Start / Self-Sufficiency

Reliability

Self-sufficient restart after a total failure – without an external power source.

#3

Grid Forming – Island mode

Efficiency & Protection

Stabilizes the DC link during island mode. Prevents mechanical damage caused by standstill. The turbine remains aligned with the wind.

#4

Active Azimuth Control (Yaw)

Regulatory (regional)

Keeps the yaw axis active during a power outage. Mandatory in high-wind regions to reduce mechanical loads.

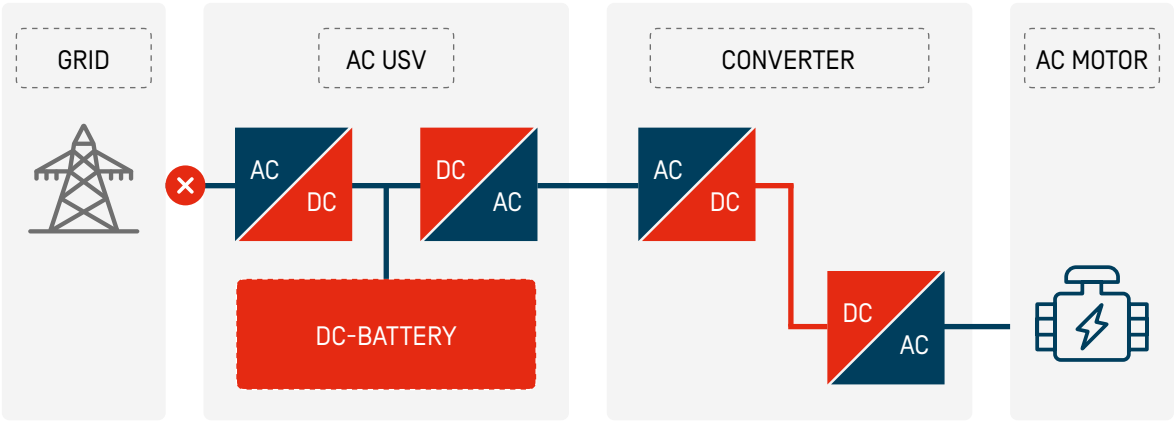


DC-LINK BATTERY

DC-Link battery vs. off-the-shelf AC-USV

Standard AC UPS solutions are not suitable for the use cases described. enhance is directly integrated into the DC-link and overcomes all limitations.

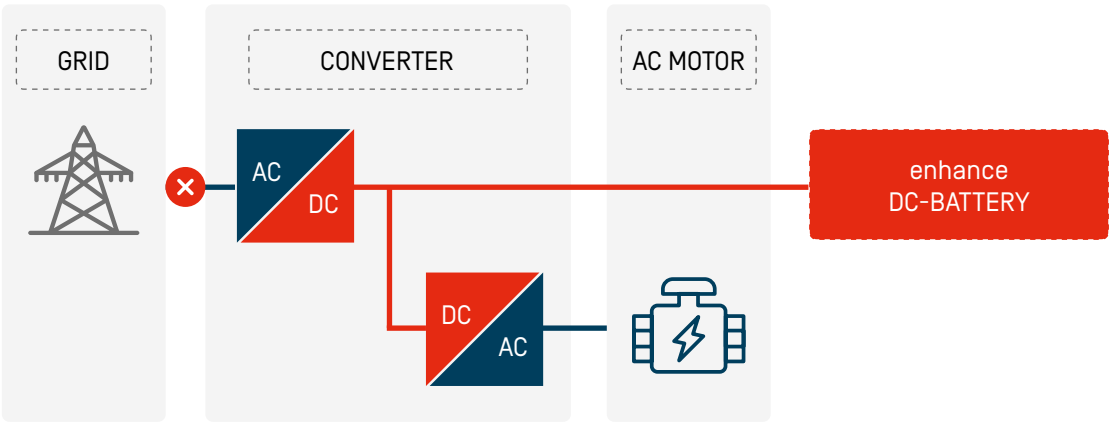
OFF-THE-SHELF AC-USV



WHY AC-USV FAILS

- → Environmental conditions (temperature, EMC)
- → No energy recovery possible
- → Footprint too large for the nacelle
- → Too slow (dynamic requirements)
- → High short-circuit power
- → High currents

enhance DC-LINK INTEGRATION



ADVANTAGES OF DC-LINK INTEGRATION

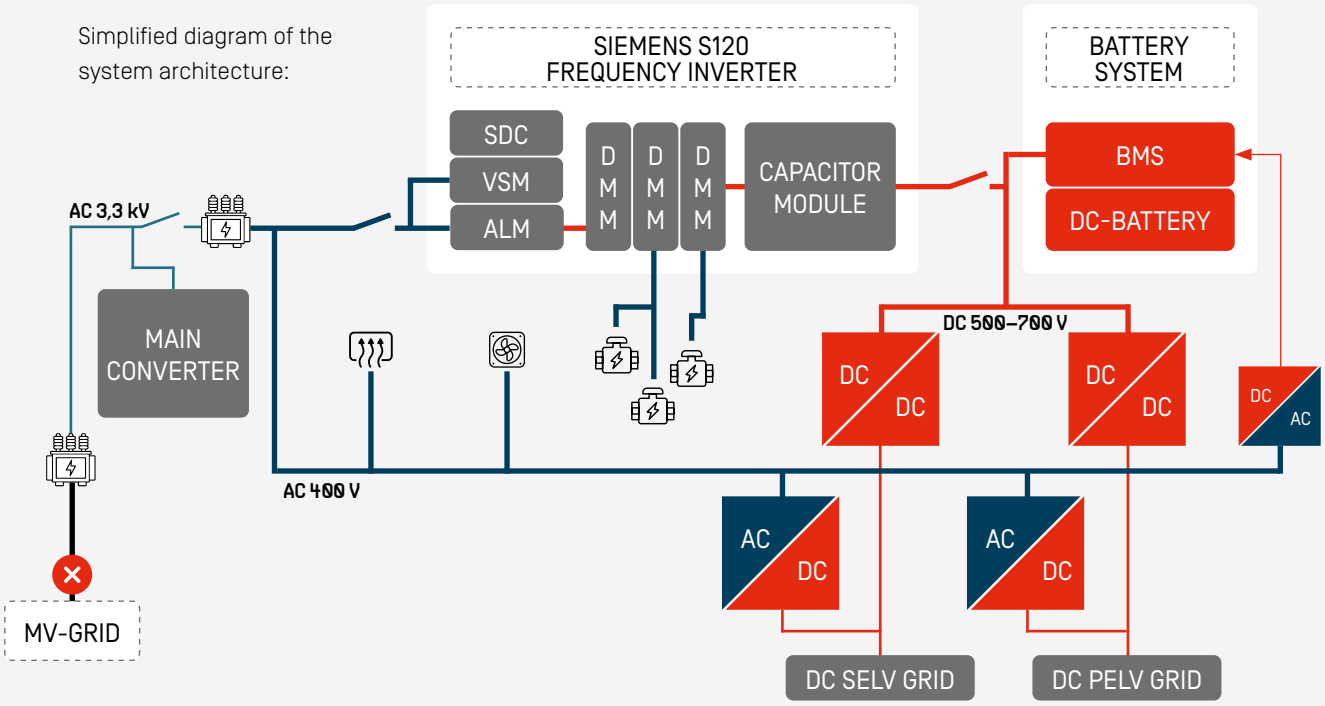
- → Less conversion stages
- → Higher efficiency
- → Smaller footprint, less waste heat
- → Regenerative braking possible
- → Scalable and modular
- → Lower grid connection power required
- → No grid disturbances / power quality issues
- → Immediate response without switching operations

SYSTEM

System architecture DC-link & SIEMENS S120

enhance is connected to the DC-link of the frequency converter (e.g., Siemens SINAMICS S120). The Siemens DMM (Double Motor Module) is used as a DC/DC converter (DCDCCONV technology extension)—no separate power converter is required.

Simplified diagram of the system architecture:

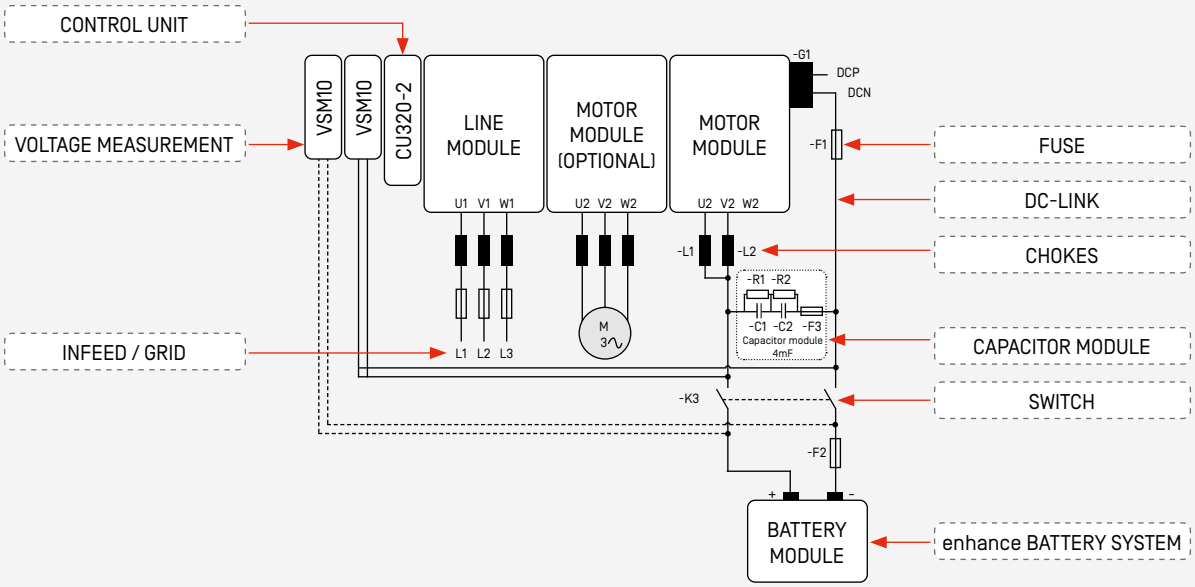


SPECIAL FEATURE: DMM AS A DC/DC CONVERTER

The Siemens DMM handles voltage conversion between the battery and the DC link. This eliminates the need for an additional external DC/DC converter—significantly reducing costs, space requirements, and losses.

enhance ARCHITECTURE

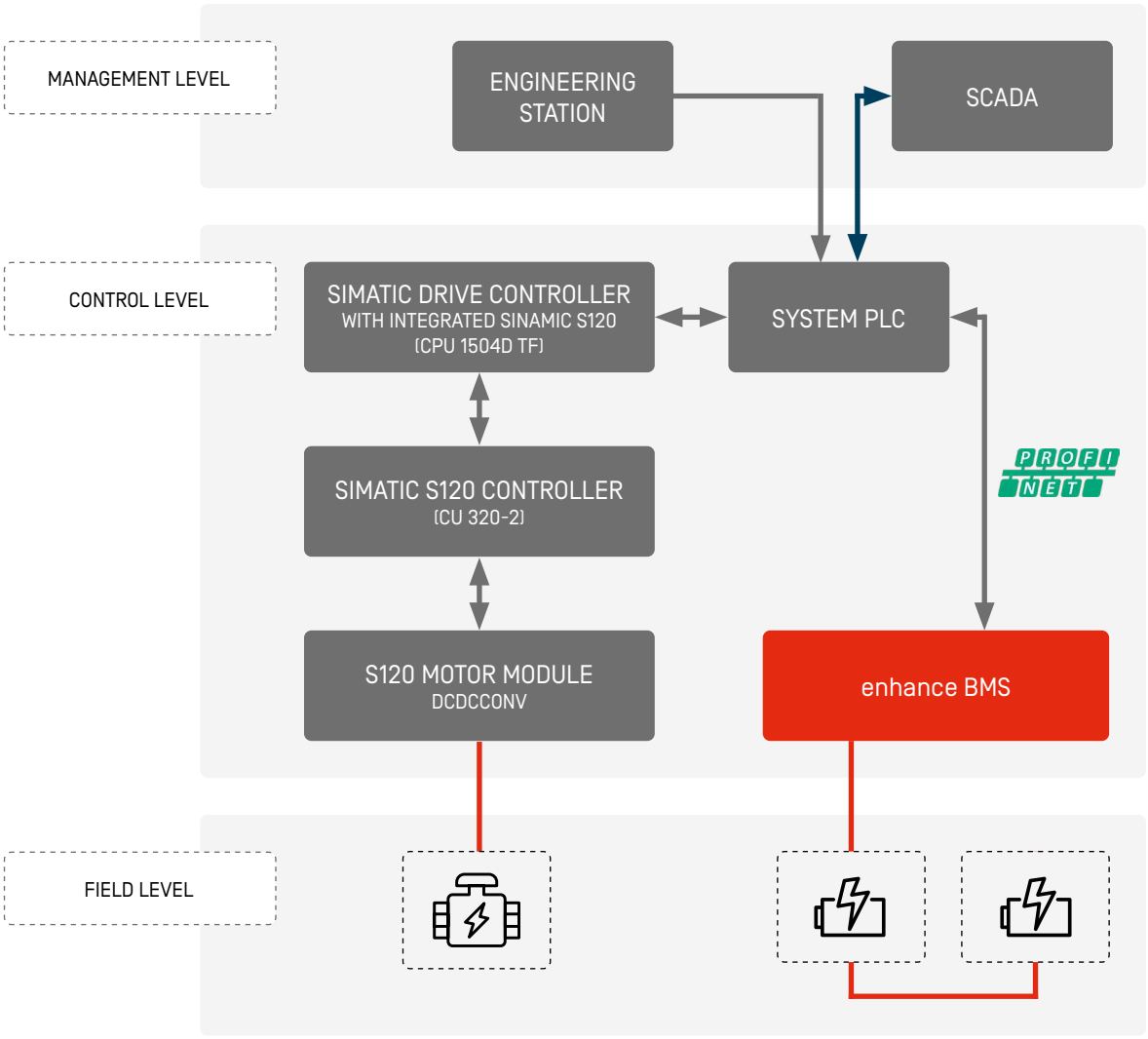
The motor module is fully integrated into the S120 drive system. To operate the enhance system, compatible chokes, smoothing capacitors, and fuses are required.



COMMUNICATION

Communication structure

enhance can be easily integrated into all three control levels. Communication takes place via industry-standard protocols such as PROFINET, Modbus, CAN, or TCP/IP (Ethernet). Example of a simplified representation of the communication structure: enhance battery system with an S120 drive system.



BATTERY SYSTEM INTERFACES

Interface	Signal/Medium	Function
Ethernet	Fieldbus + TCP/IP	Communication with the drive controller
Main Power	480–680 VDC	Power connection to the motor module
24 VDC Supply	24 VDC / 1 A	Power supply to the BMS electronics (external)
Safety Circuit	24 VDC / PWM	Integration into the system's safety circuit

FEATURES

Feature: Power priority mux

The BMS includes a power priority multiplexer that intelligently switches the power source for the BMS electronics between an external 24-VDC supply and the internal high-voltage battery.

WHEN OPERATING ON MAINS POWER

→ External 24 VDC powers the BMS electronics
→ The battery is not discharged
→ Maximum efficiency

IN THE EVENT OF A POWER OUTAGE

→ The HV battery automatically powers the BMS
→ No manual intervention required
→ The BMS remains active at all times
→ All protective functions remain intact

Feature: Pre-charging

When connecting the battery to the DC link, the capacitors must be monitored and charged with current limiting.

WHY PRE-CHARGING IS NECESSARY

Without pre-charging, high inrush currents occur when the system is switched on, which can trip fuses, damage contactors and semiconductors, and cause capacitors to age rapidly. This is particularly critical in island mode: The battery supplies high currents without the damping effect of the mains impedance—the line module cannot kick in.

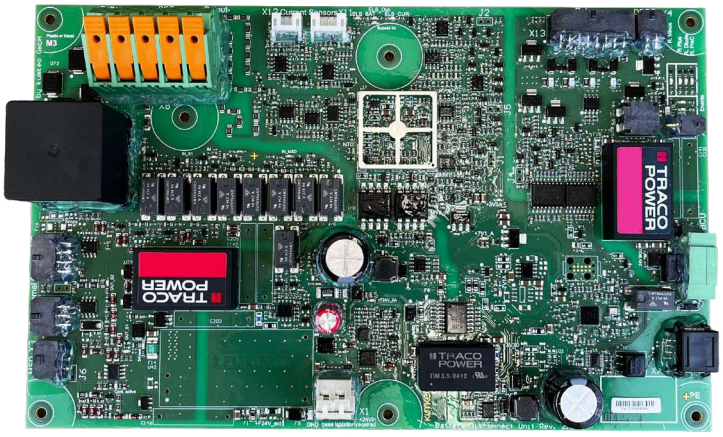
Trigger event	Description
Power Restore	DC-Link must be charged in a controlled manner after a power outage.
Error Reset	Reinitialize the capacitors after the error has been acknowledged.
Battery Reconnection	After maintenance or module replacement.
Maintenance Mode	Controlled restart after service.
Emergency Stop	Orderly restart after a safety shutdown.

CHALLENGE & CONCLUSION

Main challenge: battery system at the DC-link

Operating a battery system at the DC-link of a frequency converter places exceptional demands on the battery management system. Standard BMSs are unsuitable for this purpose.

Challenge	Details
DC-Link Control	Voltage control algorithm, suppression of DC oscillations, pre-charging.
Energy Recovery	Battery must accept high C-rates during regenerative braking.
EMC / DC-Link Interference	PWM frequencies of 2–16 kHz, massive current ramps (di/dt), common-ground routing, current and voltage ripple.
Industrial Load Profiles	Microcycles, high and rapid power fluctuations.
Industrial Requirements	Availability, efficiency, robustness, safety, cost-effectiveness.



Battery Disconnect Unit (BDU)

ADDITIONAL CHALLENGES IN ISLAND MODE

→ DC-link oscillations during partial-load operation (no stabilizing grid)
→ Unexpected protective shutdowns (trips) during load changes
→ EMC interference during grid-forming operation
→ Protection concept required for limited short-circuit capacity

CONCLUSION: WHY THE ebs BATTERY MANAGEMENT SYSTEM

→ First BMS qualified for operation on the Siemens S120
→ Specially developed voltage control algorithm for DC-link environments
→ Full EMC qualification in accordance with converter standards
→ High ripple tolerance; 6 kV insulation
→ Operating altitude up to 4,000 m

REQUIREMENTS

Environmental and service requirements

enhance has been developed and certified for use under the extreme conditions inside the nacelle of a wind turbine.

Technical Details

Parameter	Value
Operating temperature	–20 °C to +60 °C*
Transport vibration	2M5 (EN IEC 60721-3-2)
Operating vibration	3M12 (EN IEC 60721-3-3)
Operating altitude	up to 4,000 m above sea level
EMC – Voltage ripple BAT+/–	1 V @ 4 kHz
EMC – Voltage ripple BAT+/GND	400 V @ 4 kHz
EMC – Voltage edge BAT+/GND	10 kV/µs
EMC – Current ripple	2 A
EMC – Magnetic fields	10 A/m @ 50 Hz
Battery life	12 years or 2,000 cycles
Routine maintenance	None
Replacement	At the module level

*in case of battery module climate control



enhance L in cabinet



enhance M

SPECIFICATIONS

Technical specifications

enhance L

Parameter	4 modules	6 modules	8 modules
Rated voltage	307 V	461 V	614 V
Rated energy	32 kWh	48 kWh	64 kWh
Max. discharge current	100 A (kont.) / 200 A (Peak, 10 s)		
Protection class	IP 30		
Dimensions per battery module	775 x 357 x 162 mm		
Weight per battery module	63 kg		
Certification	UN 38.3, CE		
Insulation	6 kV		
Operating altitude	up to 4,000 m above sea level		

enhance M

	Value
Rated voltage	510–690 V
Rated capacity	15 Ah
Rated energy	9,2 kWh
Max. discharge current	20 A
Protection class	IP 30
Dimensions	600 x 400 x 533 mm
Weight	83 kg
Certification	UN 38.3, CE
Insulation	6 kV
Operating altitude	up to 4,000 m above sea level

ADVANTAGES

System advantages

Modular design

Scalable and easily adaptable to various turbines and power classes.

Highly efficient

Direct DC-link integration, braking energy – minimal losses.

Safe LiFePO4

No thermal runaway, minimal fire safety requirements, low initial costs.

12-year lifespan

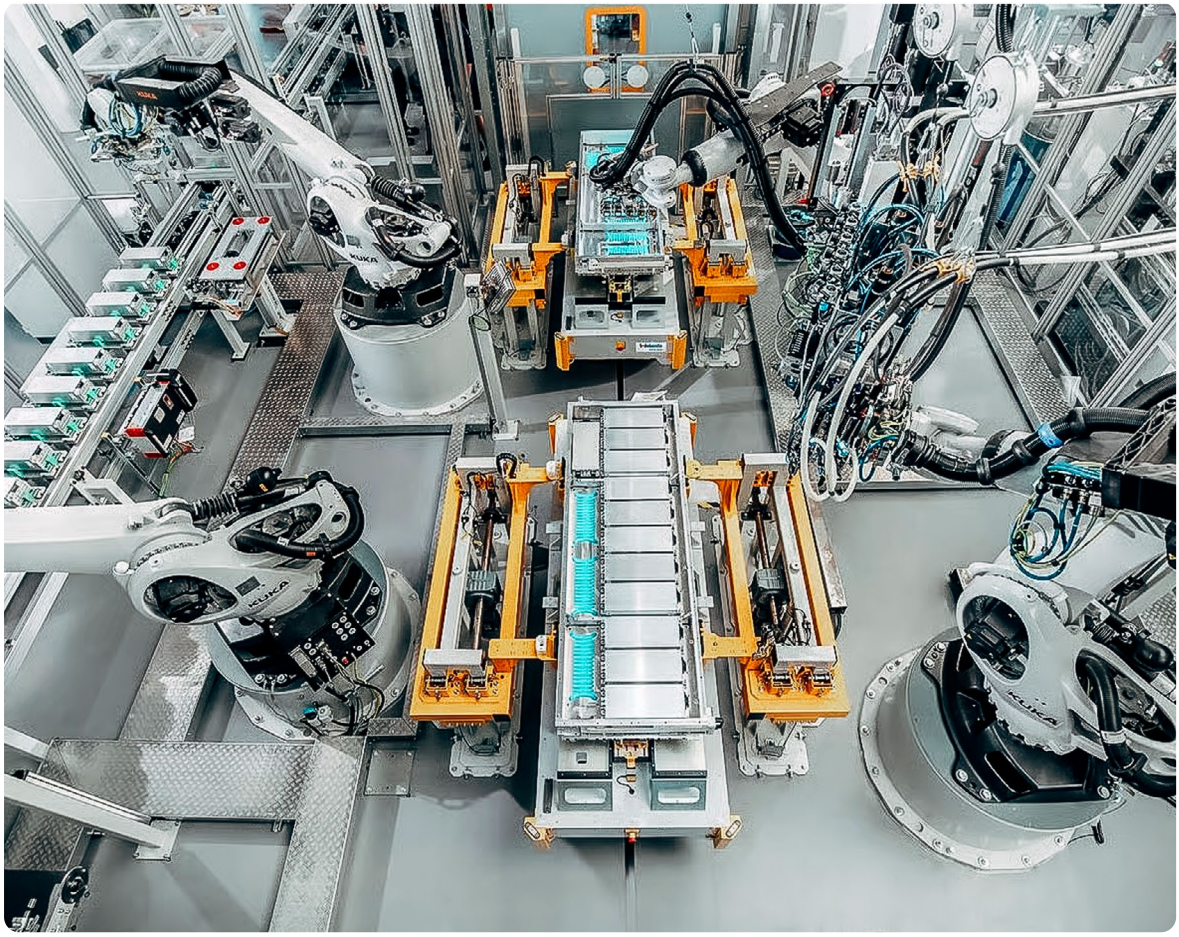
Up to 2,000 cycles, no routine maintenance, replacement at the module level.

Low operating costs

Low operating expenses over the entire lifecycle – no service contract required.

Compact design

Suitable for standard control cabinets.



APPLICATIONS

Other applications

enhance is not only suitable for wind turbines. The DC-link principle is universally applicable to all frequency converter applications.



INDUSTRIAL MACHINERY & MANUFACTURING

Pumps & Extruders
Printing & Paper Machines
Test Bench Drives

- → Orderly Shutdown in Case of Power Failure
- → Product and Machine Protection
- → Uninterrupted Operation
- → Power Recycling



INTRALOGISTICS & MATERIAL HANDLING

Hoisting Equipment
Cranes
Conveyor Systems

- → Emergency Lowering
- → Safety Brake
- → Load Securing
- → Emergency Stop, Controlled Shutdown

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TRANSPORTATION & MOBILITY

Passenger Transport
Hybrid Drives
Special-Purpose Vehicles

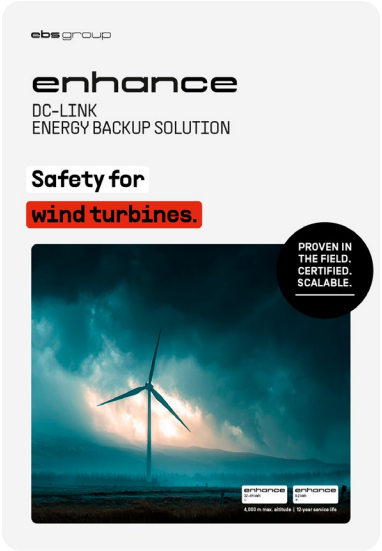
- → Emergency Operation
- → Drive Noise Reduced Operation
- → Peak Shaving



ENERGY & INFRASTRUCTURE

Microgrids
Industrial Energy Systems

- → Grid Stabilization
- → Smart Load Management
- → Usage Optimization



ecore DC-LINK ENERGY BACKUP SOLUTION.
Safety for Wind Turbines.

Have questions? We're happy to provide more information.
Visit ebs-group.io/enhance or send us an email –
our enhance team is ready to discuss your project.

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