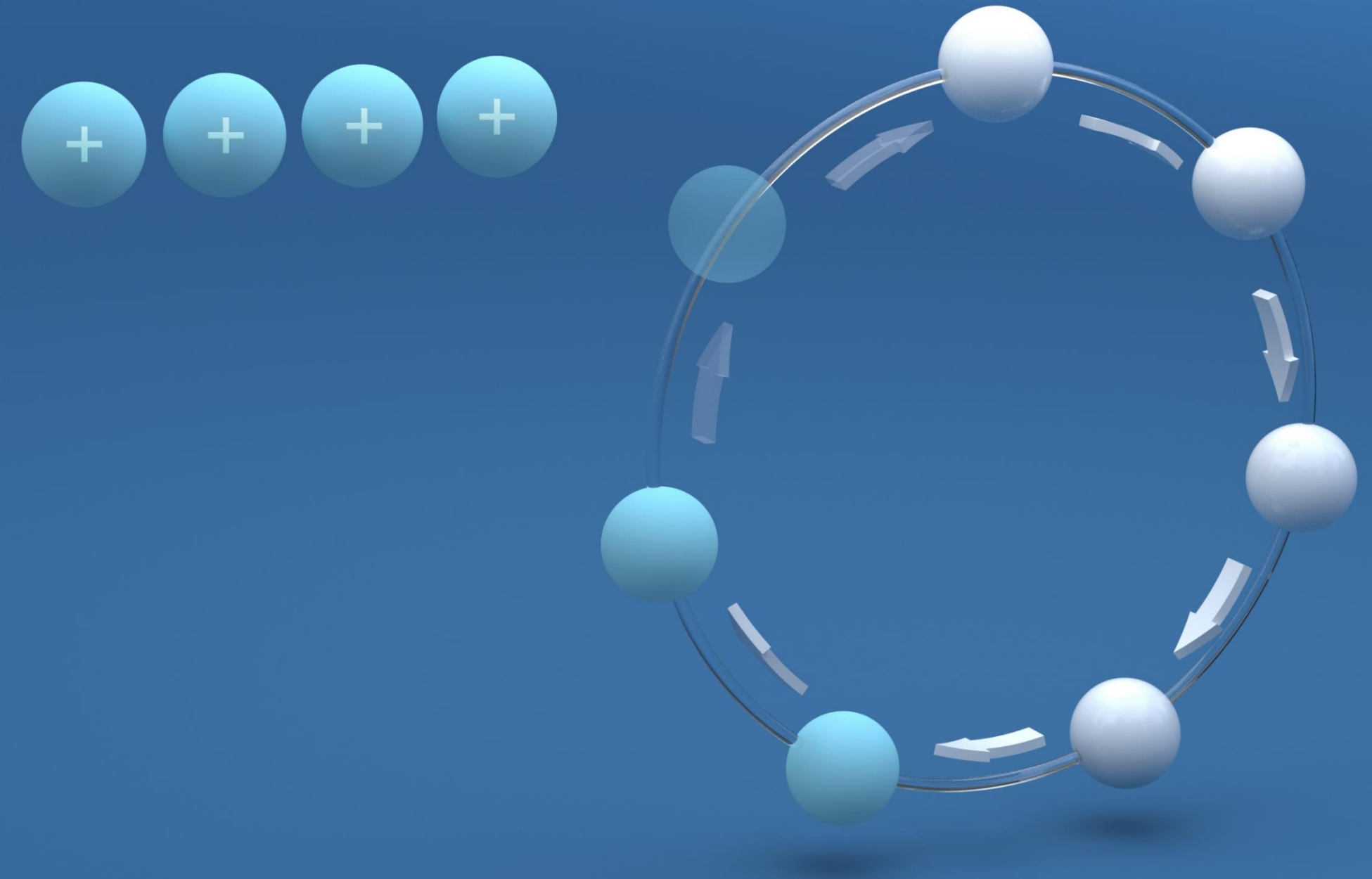


# ARADEx: Technology Modules Portfolio

We drive new energy for a greener future



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\* COMING SOON

# / Added values for your applications

## New functions in drivetrains by electrification & “softwareization”

**We believe that functions will become the main driver for the electrification of drivetrains in mobile working machines.**

- In the 1960's we saw a disruption in mobile working machines by “hydraulification” of the working processes. The improved control of force and movement enabled new functions and easier machine use. We expect new “electrification” to cause similar disruption.
- A main cornerstone will be to use the inverter-motor combination as a torque-sensor. And to use the perfect control to create new or greatly improved functionality of the working machines.
- Some of these new functions can be realized using the vehicle controllers, this is common technology in NC based production machines for instance. But many functions could be implemented using technology modules inside the inverters and DCDC converters, because the real-time coupling of actuator technology and simultaneous measurement opens doors for new technology. We combine the “electrification” with a “softwareization”.
- In this presentation we want to give an overview about the new possibilities we can offer for your applications.

# /Technology modules

## An overview

Technology modules are made to co-work with your machine controller and provide benefits for all high-speed functions.



DIAGNOSTICS  
SUPPORT



POWER & VOLTAGE  
MANAGEMENT



HIGH-LEVEL DRIVE  
FUNCTIONALITY



SPECIAL  
FUNCTIONS



# / MultiDeviceAnalyser

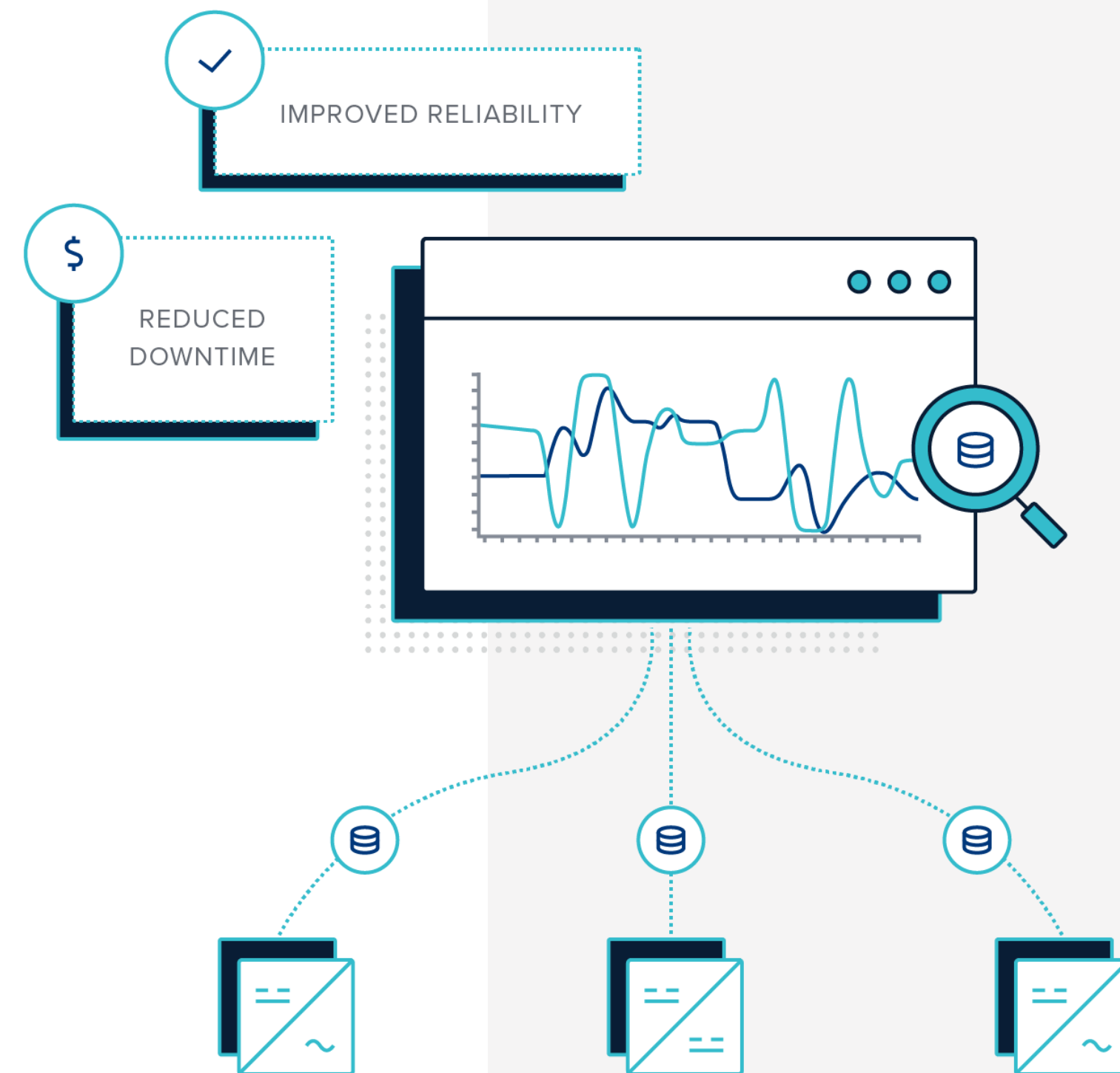
## Overview

"VECTOPOWER goes system": The MultiDeviceAnalyser function saves data from the internal oscilloscope function synchronously on multiple VECTOPOWER devices.

A critical error or command triggers data-saving on all VECTOPOWER devices on the same CAN bus.

The function can be implemented in VP600 inverter series 2, 3 and 4(EVO) as well as in VP5000 DC/DC.

- ★ Oscilloscope function for inverters & DC/DC in a system
- ★ Scalable for multiple devices in a system
- ★ Each device can act as source to trigger an event



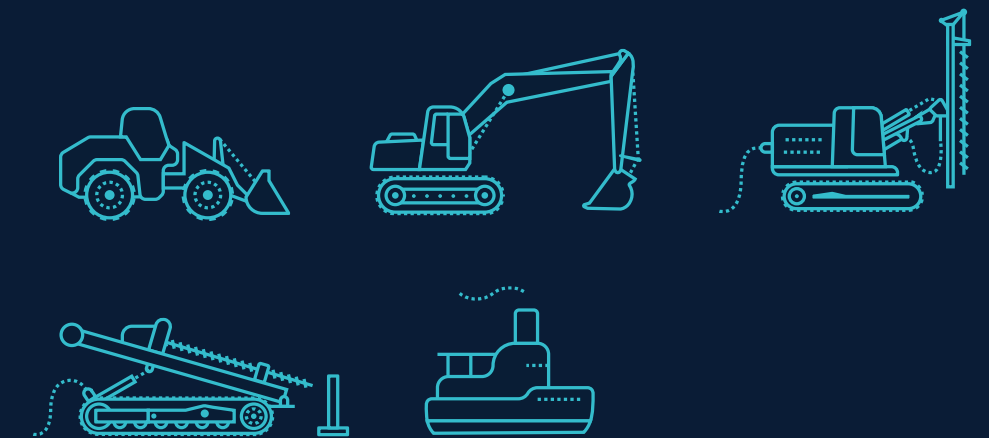
# / MultiDeviceAnalyser

## How MultiDeviceAnalyser works

The MultiDeviceAnalyser function saves data of the internal oscilloscope function synchronously on multiple VECTOPOWER devices:

- A VECTOPOWER VP600 inverter detects an effect which must be logged with Analyser-file. For example, the VP600 detects a short overvoltage situation on the high-voltage system.
- The VP600 relays this occurrence to all connected HV devices via a CAN message. In this example to another VP600 inverter and to a VP5000-DCDC which is connected to a fuel cell.
- The info is also relayed to the connected ECU, which can then collect all Analyser-files from all ARADEx devices and make it available for subsequent diagnostics.

## Application areas



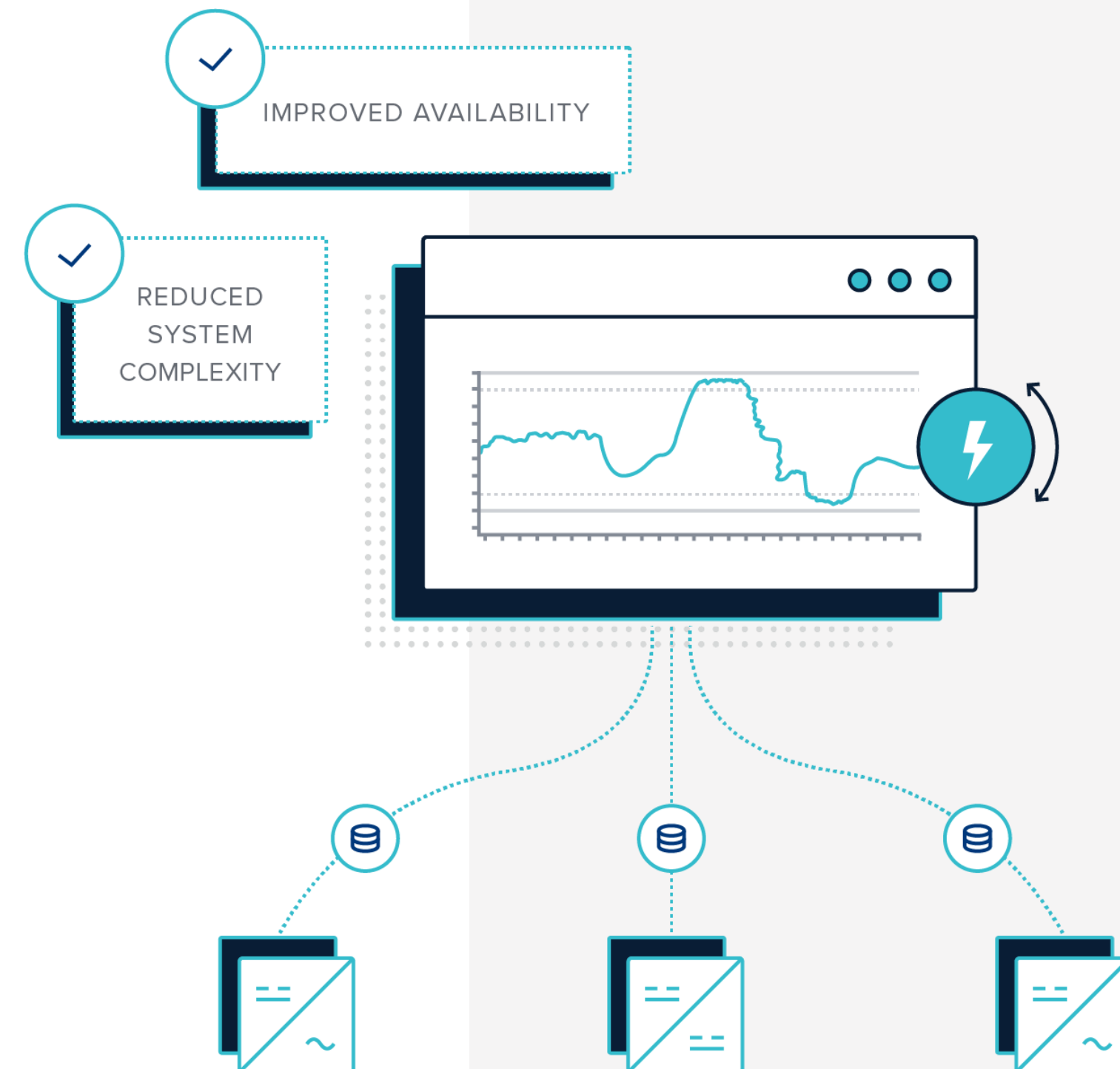
- For all systems with more than one VECTOPOWER device.
- Especially suitable for diagnostics of power management of complete HV system.

# / Smart-DC

## Overview

In distributed HV systems with several participants on the same DC line a major challenge is a smart solution of the overall power management. Real-time reaction is needed to realize the power management. The Smart-DC function solves this in a robust and reliable way and does not require a real-time bus communication. The function can be implemented in VP600 inverter series 2, 3, and 4(EVO)as well as in VP5000 DC/DC.

- ★ Power management in real-time
- ★ Available for both inverters and DC/DC converters
- ★ All devices function as a system without the need for CAN communication





# / Smart-DC

## How Smart-DC works

As an example, we assume a large wheel loader in a mining application, powered by public grid and with an additional battery for power-shaving. The battery supplies peak power and enables recuperation of energy. In this example we have several inverters for propulsion and hydraulics and a coupling to the public grid with an ARADEx AFE solution. The power-bottleneck is the grid connection via a self-unrolling cable drum. Based on Smart-DC we combined all participants of the HV system to enable maximum performance of the wheel loader.

- High power recuperation nearly exceeds the maximum power we can feed into the battery -> recuperation must be limited
- High power demand nearly exceeds the maximum power from battery and grid -> the power must be limited

## Application areas



Specifically for HV systems with parallel working energy suppliers and energy consumers:

- Cable-supplied machines
- Serial hybrids
- Fuel cell systems

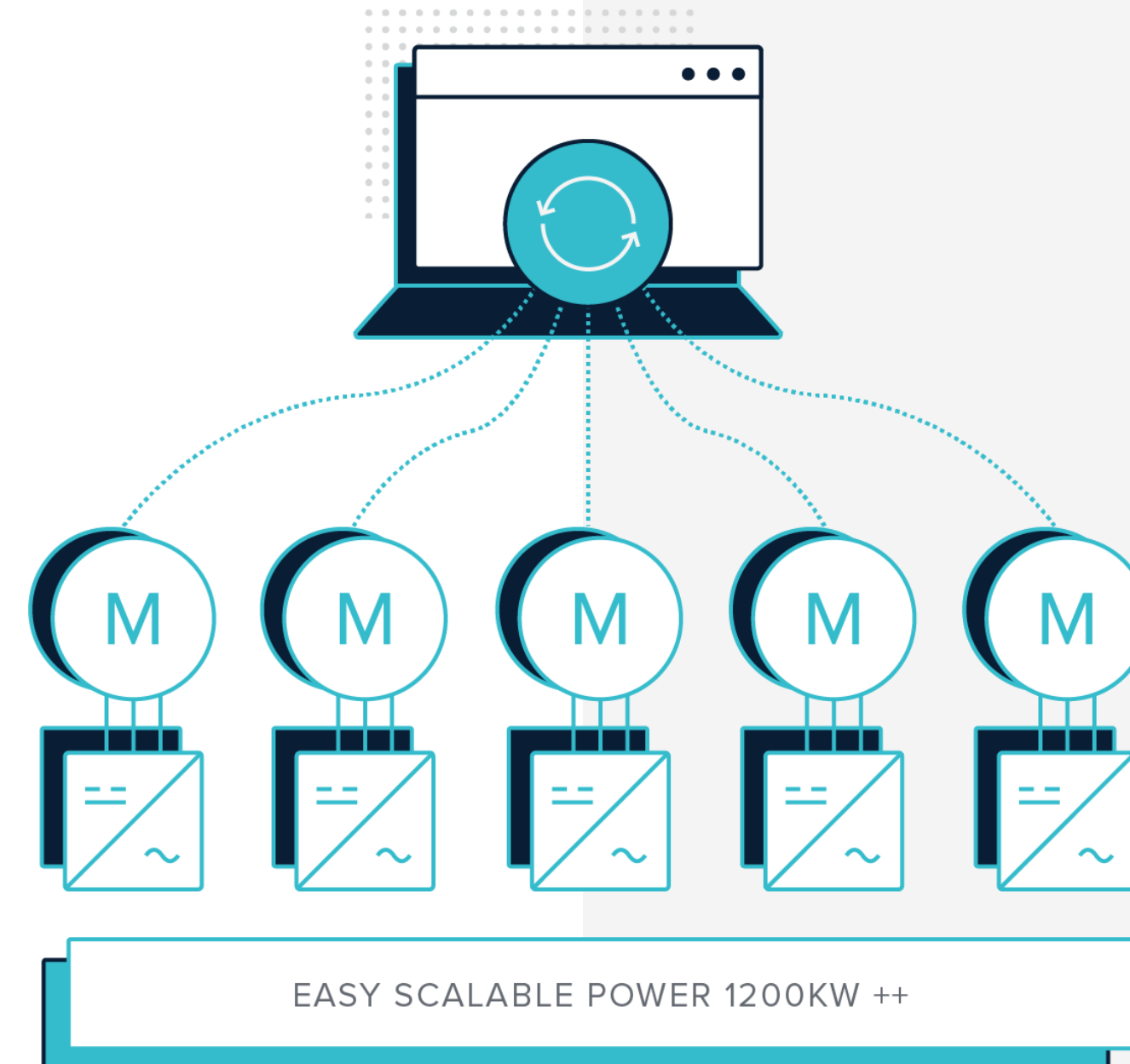


# / MasterSlave

## Overview

Up to 5 VECTOPOWER inverter-motor-packs can be synchronized to work in parallel operation. For implementing high power drivetrains with paralleled e-motors. The function can be implemented in VP600 inverter series 2, 3 and 4(EVO).

- ★ One master and up to 4 slaves create a system
- ★ Scalable total power
- ★ Even different motor types can be combined



# / MasterSlave

## How MasterSlave works

In a coupled system of several e-drives, we define one of the VECTOPOWER inverters as the master. The other inverters with the connected motors act as slaves. If one of the slaves is not available, function can continue with a reduced number of drives. If the master is not available, one of the other inverters can be defined as master. Thus, systems with high and very high power can be built from standardized components. In addition, system availability can be increased by this redundancy.

## Application areas



For high power drivetrains with more than 300kW continuous power:

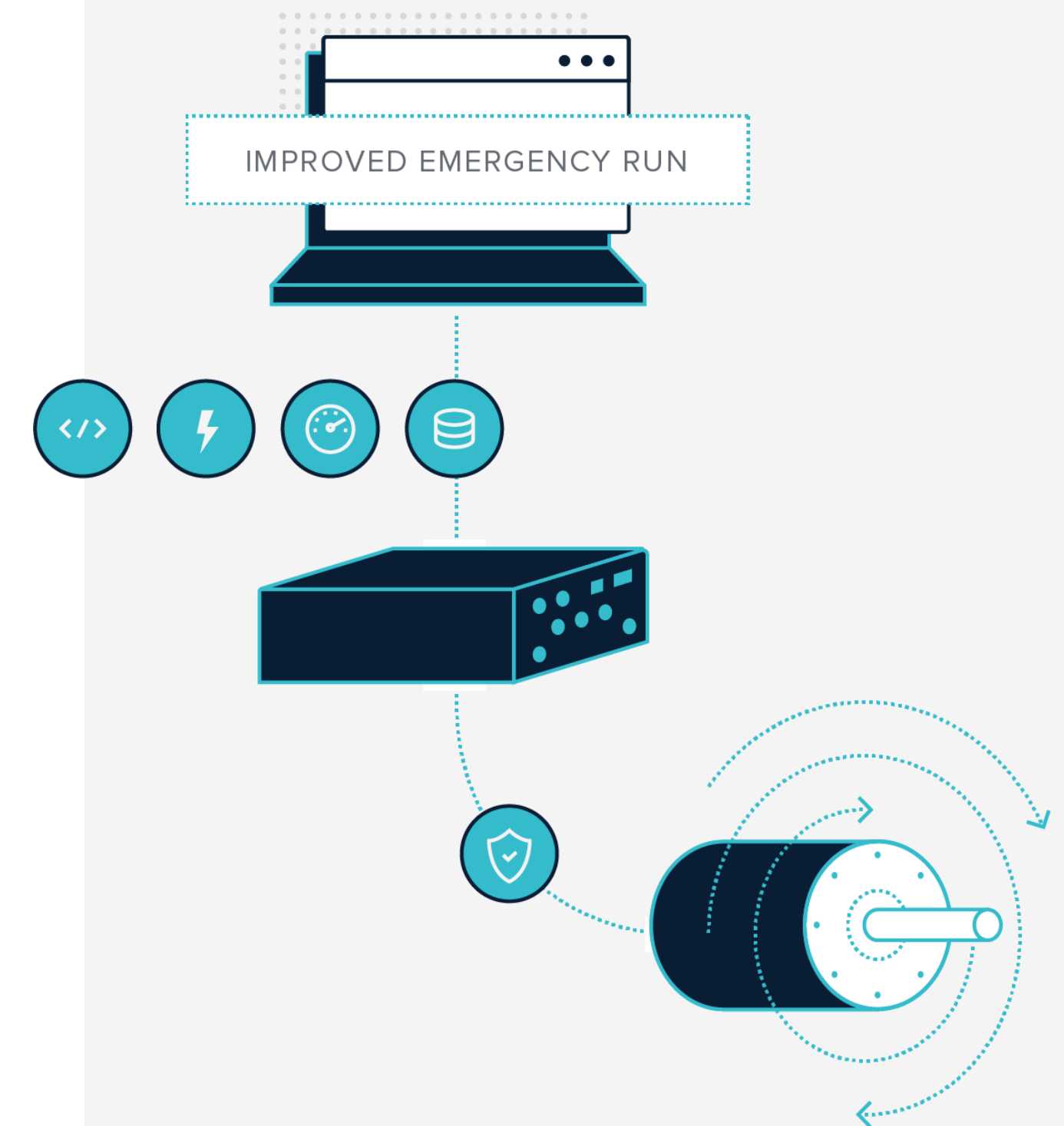
- Large dumpers
- Harvesters
- Large drilling machines

# / SmartShortCircuitBraking

## Overview

If an active all-phases-short-circuit is applied to a pm-reluctance motor as used for traction drives in special situations, the braking torque strongly depends on the speed of the motor. At higher speed levels the braking torque is very low. But at lower speed the braking torque increases and can be too high for some dedicated applications. The SmartShortCircuitBraking function allows use of the active short circuit without excessive braking torque.

- ★ Limits the braking torque in the application of an active short circuit
- ★ Acts as a fallback operation in case of a communication malfunction
- ★ Completely flexible function



# / SmartShortCircuitBraking

## How SmartShortCircuitBraking works

If the all-phase short circuit is activated, the motor speed is monitored constantly. Depending on the motor, it ensures that the active short circuit does not trigger any undesirably high braking torques at speeds above the rated speed.

Below this nominal speed, the active short circuit is interrupted in a definable speed window to prevent excessive braking torque.

- Made for pm-reluctance motors
- Adjustable by parameterization
- Can be implemented in VECTOPOWER inverter series 2, 3 and 4(EVO)

## Application areas



For applications where the short circuit function of VP600 inverter is required as a redundant fallback function and the braking torque must be limited simultaneously.

# / SlipAvoidance

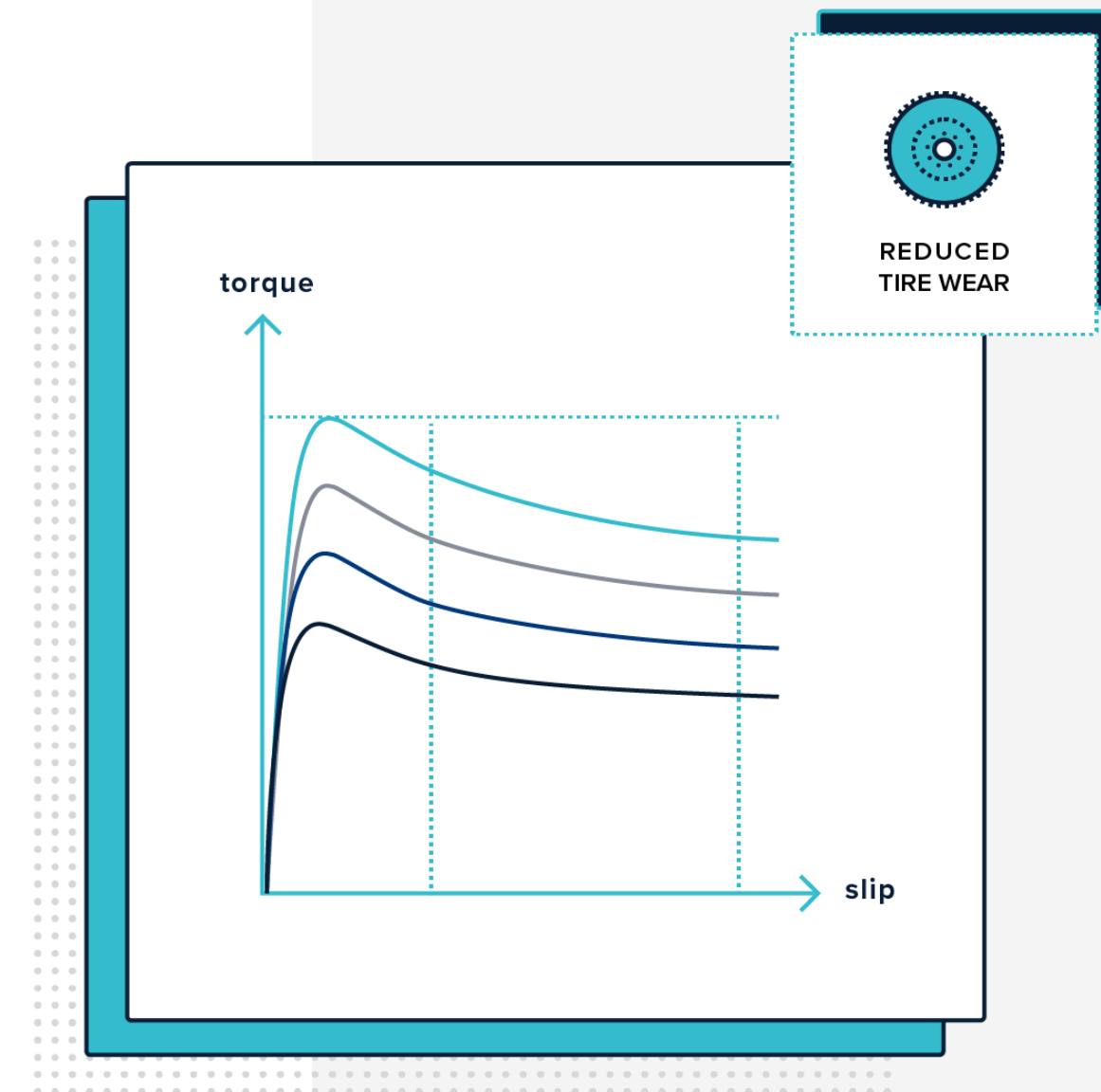
## Overview

Slip is necessary to create a moving force. In low slip area an increased slip increases moving force. Then in higher slip area the force decreases while wear drastically increases.

Slip also depends on the tires and the ground conditions.

SlipAvoidance reduces the slip during acceleration and deceleration phases of vehicle.

- ★ Reduces wear of tires
- ★ Improves driveability
- ★ Adjustable to the application



# / SlipAvoidance

## How SlipAvoidance works

Torque, speed and the change of speed is constantly measured. Comparison with stored data on the driveline and the vehicle in operation determines whether the slip is within the expected range. If not, the torque is reduced.

The required information is supplied from internal signals of the VECTOPOWER inverter, and no additional sensor is necessary.

- No additional sensors required
- Made for off-highway applications
- Function can be added to VECTOPOWER series 2, 3 and 4(EVO)

## Application areas



For all kind of wheel-based propulsion drives:

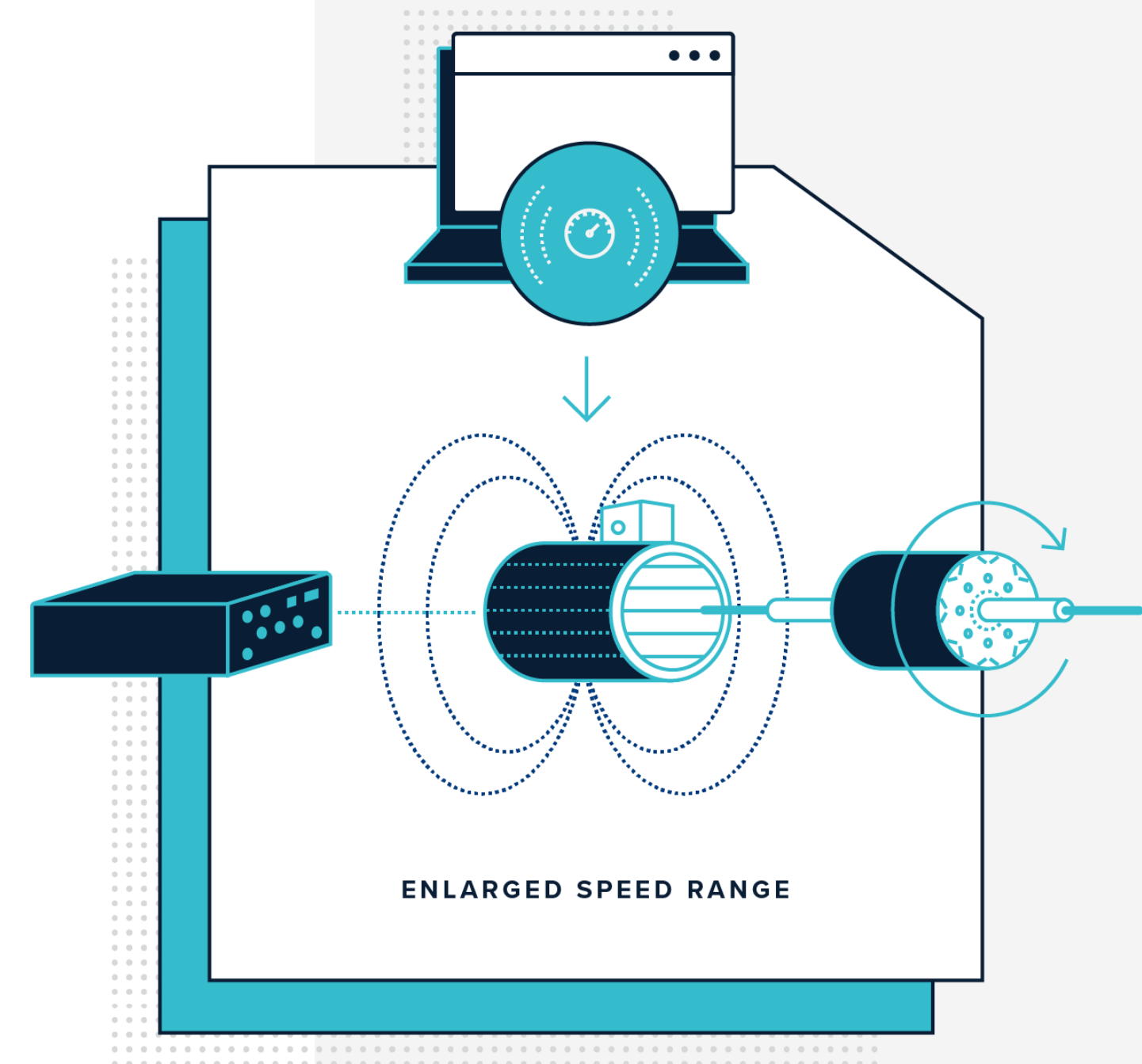
- Dumpers
- Wheel loaders
- Trucks
- Buses

# / AutomaticFieldWeakening

## Overview

This function makes a slight field weakening available for pure PM motors with surface mounted magnets which are used for various functional or auxiliary drives in mobile working machines. In the range above the nominal speed the power is nearly constant or only slightly reduced.

- ★ Made specifically for functional drives such as PTO, pumps....
- ★ Increases usable speed range of the motors up to +30%
- ★ Easy to apply





# / AutomaticFieldWeakening

## How AutomaticFieldWeakening works

Without knowledge or measurement of the dedicated motor parameters, this technology module enables operation of the motor with a small ratio of field-weakening to operate at higher than nominal speed with reduced torque.

This function can be used on the given motor parameters and normally without prior measurements on test benches.

- Made for pm motors with surface mounted magnets
- Can be used without dedicated parameter-finding on test benches
- Can be used for VECTOPOWER inverter series 2, 3 and 4(EVO)

## Application areas



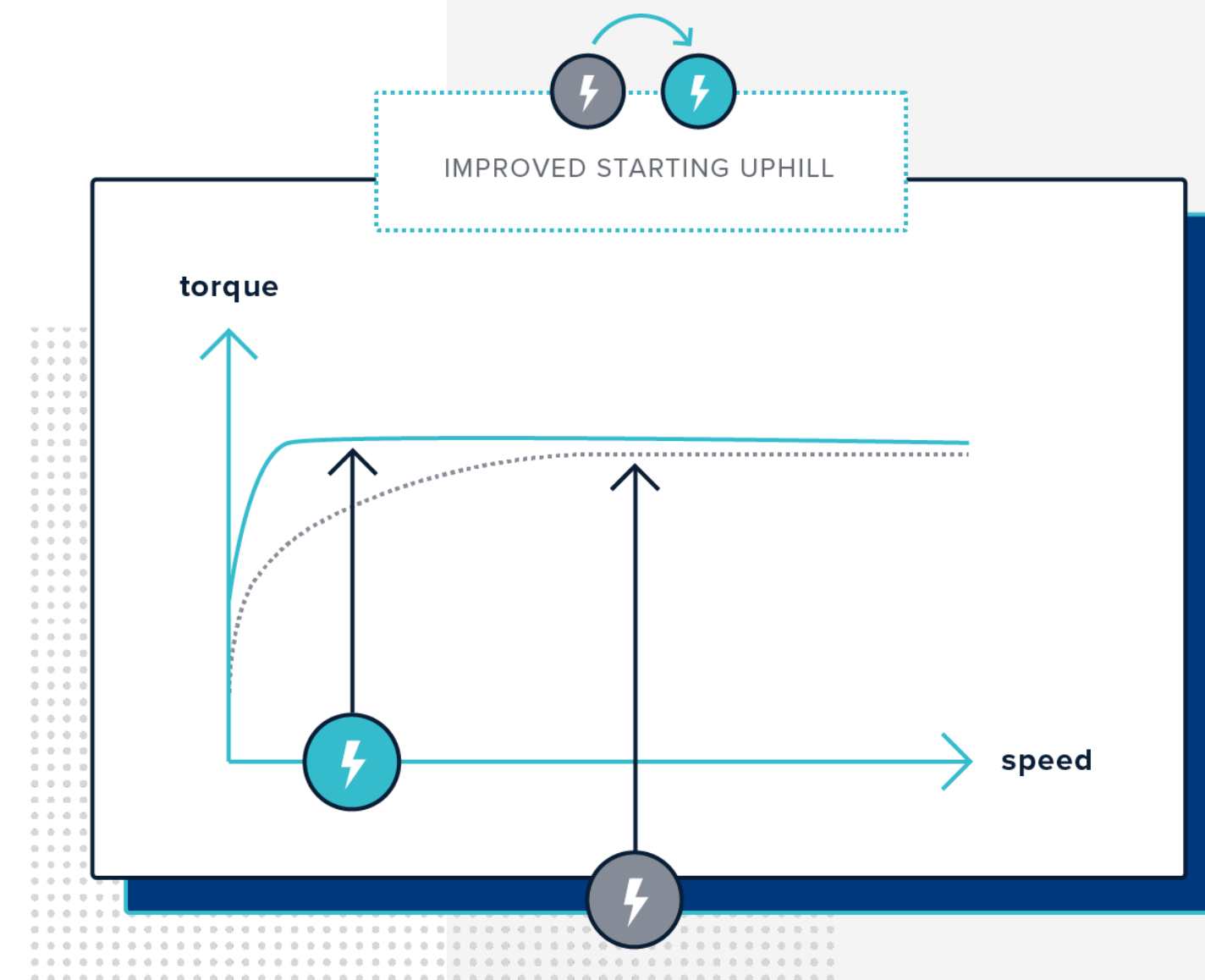
Using our auxiliary motors for operating hydraulic pumps for example.

# / DynamicParameterAllocation

## Overview

The DynamicParameterAllocation DyPA is a sector-based 2-dimensional parameterized adaption of PWM-frequency and control-parameter of the current control in inverter. This specific function increases possible peak-current at zero and low speed of the motors.

- ★ Increases maximum torque at zero and low speed
- ★ Automatically adapts to driving situation in real-time
- ★ Can be implemented in VECTOPOWER series 2, 3, 4(EVO)



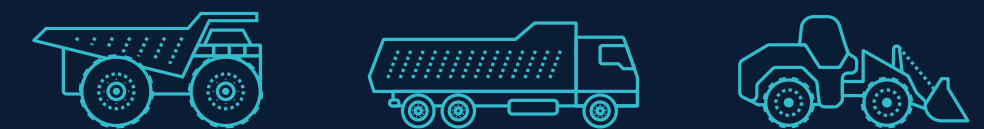
# / DynamicParameterAllocation

## How DynamicParameterAllocation works

The physics of the semiconductors of 3-phase inverters dictate that the possible phase current at very low rotational frequency is reduced in comparison to higher speed. At zero speed we have less than 50% of current in comparison to nominal speed of most applications.

If we lower the PWM frequency, we can increase the possible current. For example, at 1kHz PWM and zero speed we can increase the current by 40-50% in comparison to 4 kHz PWM. But the lowered PWM is only required if there is high torque demand not, for instance, when driving on the level. For this reason, DynamicParameterAllocation works 2-dimensionally, dependent upon speed and torque demand.

## Application areas



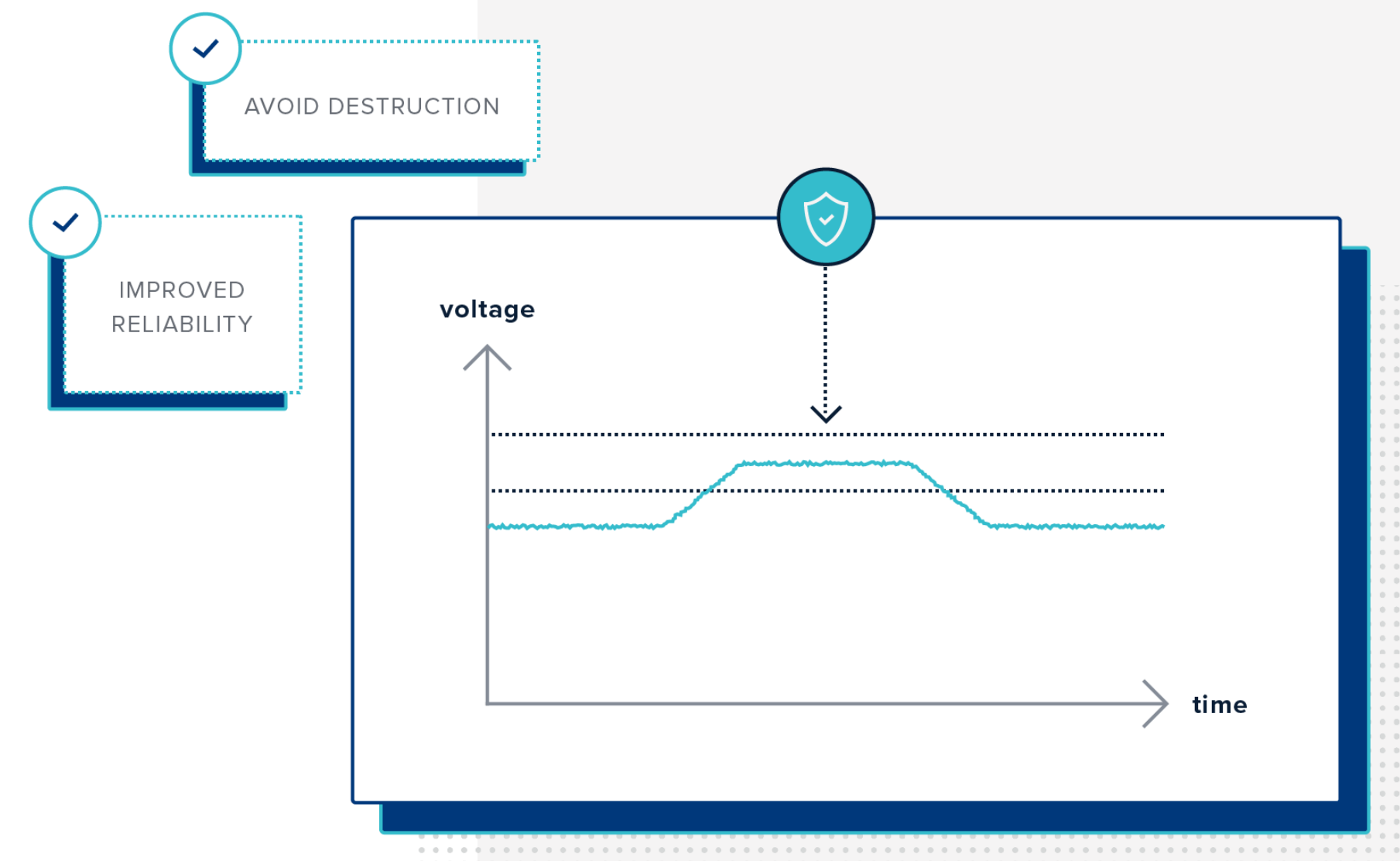
For all kinds of wheel-based propulsion drives.

# / ShortCircuitOnOvervoltage

## Overview

Using PM-reluctance motors with a high field-weakening factor, active short circuit function is required in the event of motor control malfunction in order to avoid overvoltage in the system. The additional function ShortCircuitOnOvervoltage allows application of the short circuit depending on the real DC voltage of the HV system.

- ★ Avoids overvoltage and destruction.
- ★ Works when communication to the vehicle controller is lost
- ★ As an inverter function it works in real-time



# / ShortCircuitOnOvervoltage

## How ShortCircuitOnOvervoltage works

The VECTOPOWER inverter measures the DC voltage in real-time and dependent on the measured value decides to apply an all-phase short circuit to a connected pm-reluctance motor. If DC voltage moves below a defined value, the VECTOPOWER can release the short circuit for a very short time to feed energy into the DC link.

Using this function the DC-voltage can be held in a defined range.

- Made for pm-reluctance motors
- Can be used to keep the DC link active as energy supply during short circuit braking
- Can be used for VECTOPOWER inverter series 2, 3 and 4(EVO)

## Application areas



For all kind of wheel-based propulsion drives:

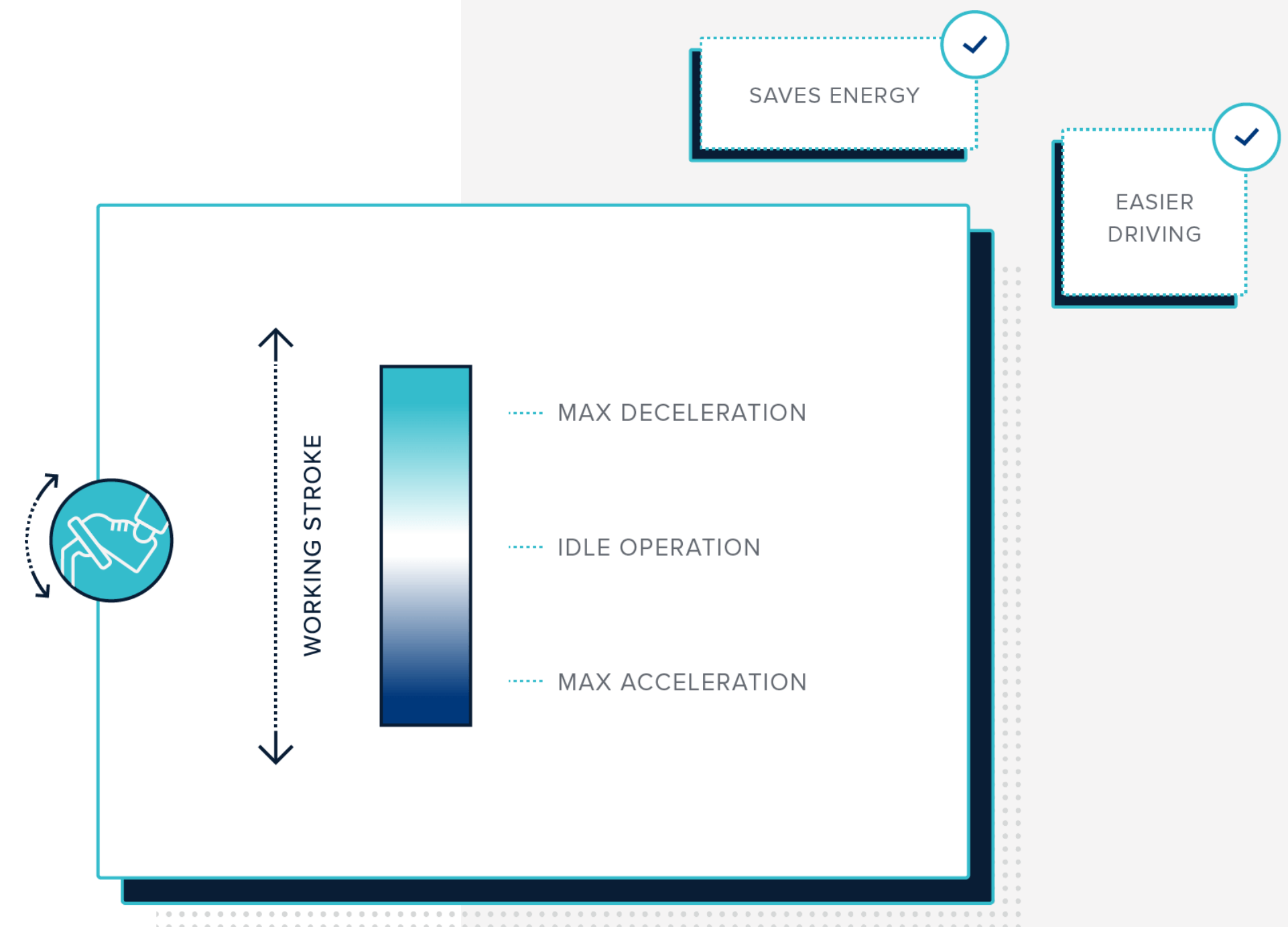
- Dumpers
- Wheel loaders
- Trucks
- Buses

# / OnePedalDrive

## Overview

For off-highway-applications only, such as wheel loaders. The acceleration pedal is used for acceleration and electric braking. The function is similar to that used in modern battery electric cars: The upper part of the stroke of the acceleration pedal is used for braking and the lower part is used for acceleration.

- ★ Improves dynamic traction and thus improves performance of the machine or vehicle.
- ★ Improves efficiency by perfect transition between acceleration and deceleration without delay



# / OnePedalDrive

## How OnePedalDrive works

Just by using the acceleration pedal of the vehicle or mobile machine the driver can accelerate and decelerate infinitely variably. This makes driving easier, especially if we combine the limits for acceleration and deceleration with the driving condition of the vehicle, which is measured by special sensor for incline, acceleration, gyro... Moreover, the recuperation function becomes more efficient.

- Can be combined with SlipAvoidance to improve drivability and wear of tires.
- The function can be implemented in VP600 inverter series 2, 3 and 4(EVO).

## Application areas



- Wheel loaders
- Dumpers
- Dozers



# / Contactor Aging Monitoring

COMING SOON

## Overview

For monitoring the wear of the power relays inside VP5000-DC/DC200 and the upcoming FCDC-models.

- ★ Allows the logging of internal power relays
- ★ Can be used for diagnostics
- ★ Can be used for estimation of remaining lifetime



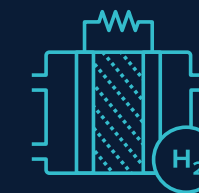
# / ContactorAgingMonitoring

COMING SOON

## How ContactorAgingMonitoring works

The switching function of internal high-power relays is counted and stored in a persistent memory.

## Application areas



Fuel cells with VP5000-DCDC200HL.

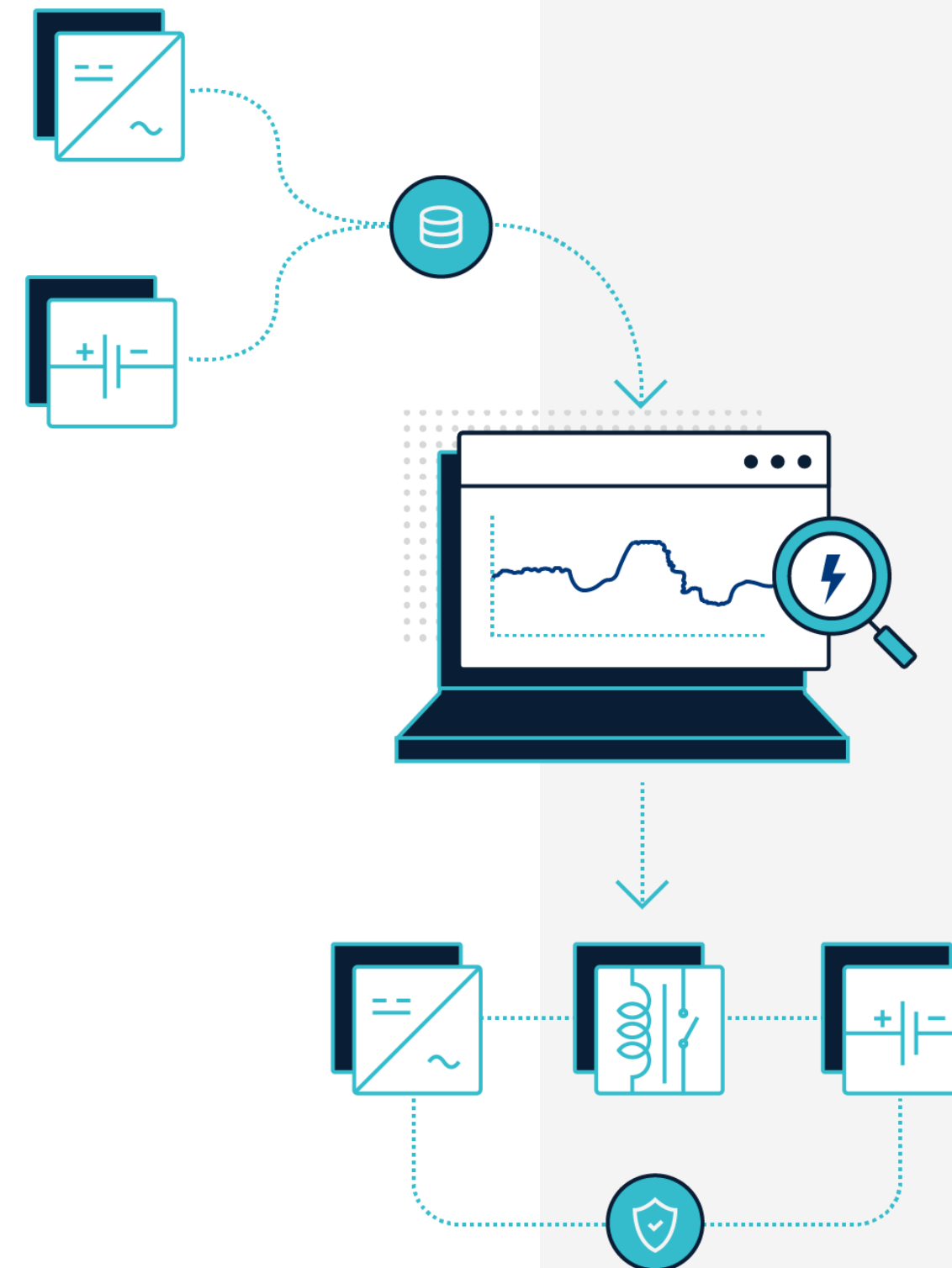
# / ExternalPrecharge

COMING SOON

## Overview

Starts a HV-system to ramp-up the DC voltage using the external precharge-resistors. The function is implemented in the integrated PLC of the VP600 inverters and VP5000 DCDC. A digital I/O (24V level) is set to switch an external relay and thus to switch a precharge resistor and main power. This function is available for VP5000-DCDC200, VP5000, VP600-18W361, 369, 345. The function is already integrated in the VP5000-DCDC200HL.

- ★ Can be built into nearly every HV system
- ★ No external sensors necessary



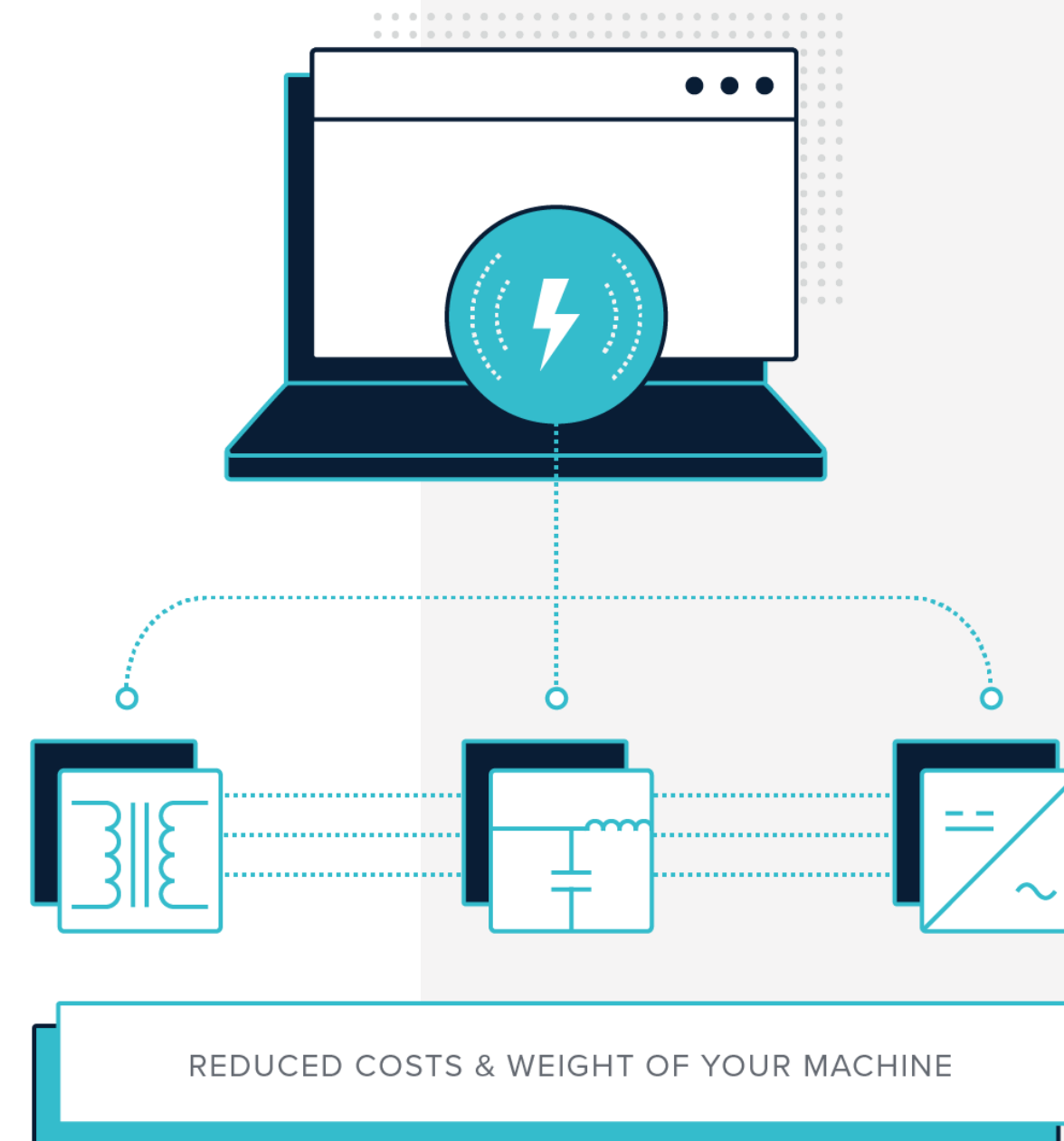
# / AFE\_Boost

COMING SOON

## Overview

Enables use of the AFE-function with boost function for short time overload in both directions.

- ★ Saves weight and volume
- ★ Saves costs



# / AFE\_Boost

COMING SOON

## How AFE\_Boost works

AFE\_Boost is an upgrade-function and requires dedicated VECTOPOWER AFE-hardware (inverter plus specially designed filters) with integrated function AFE as basis.

- Boost up to 50% is possible, depending on timing and model
- This function can be implemented in the following VP600 inverters: VP600-18W361, VP600-18W369, VP600-28W345.

## Application areas



AFE\_Boost is beneficial for all mobile working machines working from a grid connection.

# / Challenge us

## Review of your application

**Challenge us with your application, your demands and your ideas!**

- Our experienced engineers can support the HV-dimensioning and the project planning for your application.
- You receive the result as an electronic document: cornerstones of your project regarding electrification or hybridization including dimensioning.
- Contact our sales team for more information.



Thanks for your attention!

**Optimized usability  
and performance  
for the best e-mobility**



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