VISIONS

PORT TECHNOLOGY | NO. 8

HIGHLIGHTS

AVAHLE

THE FUTURE OF PORT LOGISTICS

ON THE WAY TOWARD THE EMISSION-FREE TERMINAL

Dear readers,

The transition toward automated, sustainable and efficient container handling has become a lived reality: ports are increasingly relying on electrified vehicle operations. The drivers behind this shift are emission regulations and rising energy prices. Sustainability and productivity are key competitive factors. In a dynamic industry such as port handling, more than mere electrification is required – it calls for innovative charging technologies that can be easily integrated into existing processes and structures without interrupting operations.

In this issue, we take a closer look at our latest innovations for sustainable and efficient port logistics. From the PowerDock as a charging solution for electric terminal vehicles, to VAHLE Battery Storages as an answer to the operational limits of conventional electrification of RTG cranes and TriMotion Compact as a current application example at Khalifa Port, we present our future-proof solutions for greener, smarter and higher-performance container terminals. With battery-powered systems as an alternative to diesel generators, port handling processes become not only more sustainable, but also more time- and cost-efficient.

Join us as we explore the future of port technology. Discover how Net Zero terminal operations will soon no longer be a vision of the future.

Enjoy reading and discovering!

Your Vision. Our Solution.

VAHLE POWERDOCK: AUTOMATION IN THE PORT

CHARGING INFRASTRUCTURE FOR FUTURE TERMINAL OPERATIONS

The electrification of port vehicles is gaining momentum worldwide. At the same time, existing charging solutions in terminal operations are increasingly reaching their limits. In particular, the manual plugging of high-power DC charging cables proves to be a weak point in the dense, high-traffic daily port environment.

Manual plugging as an operational risk
Tight cycle times, shift changes and varying parking positions mean that charging processes cannot always be carried out reliably. Mechanical wear on connectors, safety risks in the work area and additional personnel requirements are the result. In automated fleets, manually operated charging is also hardly practical.

Growing demands in terminal operations
At the same time, vehicle power requirements are increasing, as are expectations for availability, safety and repeatable processes. Downtime has an immediate impact on the entire material flow. Conventional plug-in solutions therefore limit the scalability of electrified fleets and increase operational risk in continuous 24/7 operation.

Underbody charging as the new standard
VAHLE‘s innovative PowerDock provides an alternative to manual plug-in charging by using an automated underbody charging process. Installed at surface level, the PowerDock charging system does not require extensive construction work for installation in a port‘s pavement and the power supply is provided via existing, market-standard DC charging using the CCS standard. This allows the PowerDock to be easily connected to existing charging infrastructure and used in different terminal layouts without permanently altering traffic routes, drainage or substructure. This offers a maintenance-friendly solution that is available above ground and enables step-by-step expansion across multiple charging points as power demand increase – even while the terminal remains in operation.

Flexible vehicle integration and retrofit
The PowerDock is designed for a wide range of vehicle types – from terminal trucks and AGVs to heavy industrial trucks. The robust receiver unit mounted on the vehicle underbody can be integrated both in new vehicles and as a retrofit in existing fleets. Standardized interfaces reduce complexity, simplify engineering and minimize integration and project risks.

ENERGY MEETS EFFICIENCY – POWERDOCK IN THE TERMINAL

Port operations require technology designed to function under harsh demanding conditions. With the PowerDock system from VAHLE, energy supply in the port becomes an integrated, safe and repeatable part of daily operations – consistently designed for terminal use and flexibly integrable into existing terminal structures.

Automated charging saves time without disrupting operations
It takes less than 60 seconds for power to flow from the moment the vehicle reaches the parking position. This makes the PowerDock ideal for opportunity charging during natural dwell times – for both manually operated and autonomous vehicles. Even short charging windows are sufficient to continuously top up batteries.

Built for everyday port operations
Dirt, sand, water and large parking tolerances are integral to terminal operations. The PowerDock is designed precisely for these conditions. Protected components and a tolerance-friendly mechanical design ensure reliable continuous operation in harsh and unpredictable environments.

Safety and retrofit capability in the terminal environment
A central aspect of the PowerDock system is the safety of the charging process. The system features protective contact covers on both the stationary and mobile sides, which are only released after the system is parked. Power flows exclusively after complete mechanical docking and successful CCS communication.

Continuous sensor monitoring tracks, among other parameters, temperature values throughout the entire charging process. In the event of deviations or faults, the system automatically transitions to a safe state.

This makes the PowerDock the technological foundation for automated, scalable energy supply across the entire terminal.

PowerDock at a glance

- **Plug-free charging from below:** no manual plugging
- **Easy installation:** surface-mounted, connection to existing DC chargers
- **Fast readiness:** under 60 seconds from parking position to power flow
- **Robust for everyday port use:** designed for dirt, water and large tolerances
- **For manual and autonomous vehicles:** suitable for mixed fleets in 24/7 operation
- **Easy integration:** compatible with existing terminal environments

Ready for change? Partner with VAHLE

Shape the future of port logistics with VAHLE. Together with terminal operators and OEMs, we are driving automated, electrified and connected processes forward. Get in touch to learn more about the PowerDock system – scan the QR code or visit vahle.com/request

CONTAINER HANDLING IN TRANSITION

SYSTEMICALLY MANAGING ENERGY SUPPLY AT THE TERMINAL

For two decades, electrified rubber-tired gantry cranes (eRTGs) have enabled efficient, low-emission terminal operations. However, in an environment where high power demands, fluctuating load profiles and limited grid capacities converge, conventional electrification quickly reaches its limits. With manual energy supply, charging becomes an operational bottleneck. What is needed are solutions that actively manage energy and integrate it seamlessly into ongoing operations.

WHEN ENERGY BECOMES A STRATEGIC FACTOR IN CONTAINER HANDLING

eRTGs are increasingly becoming the standard. As eRTGs become the standard in container handling environments, there is an emphasis integrating their power supplies into operational workflows without slowing down or disrupting ongoing processes.

Complexity in everyday operations – new rules for energy
Continuous operation, sudden load peaks and changing environmental conditions in container terminals are pushing conventional energy supply concepts to their limits. At the same time, manual charging processes are proving to be a structural obstacle, as they are prone to errors, difficult to plan and incompatible with automated workflows.

This makes a shift in perspective necessary: energy must not only be provided – it must become controllable. This is where modular battery systems come into play. They make it possible to temporarily store energy, retrieve it as needed and decouple individual processes from the power grid for defined periods. This creates new operational opportunities, such as independently and emission-free travel movements between container blocks.

Foundation for automation and decarbonization
Battery systems thus form the basis for automated processes while also facilitating the integration of renewable energy. Energy becomes an integral part of the system architecture – and a decisive lever for the next stage of evolution in terminal operations.

Strategize for tomorrow's port concepts with VAHLE
VAHLE's guiding principle „Your Vision. Our Solution." highlights how we specialize in customized system solutions for unique, specific requirements. We work with clients to create modular and scalable concepts, drawing on years of proven expertise and industry-leading technology.

VAHLE's battery systems are suitable both for new construction projects and for existing eRTG fleets, where they can be deployed as retrofit components. In this way, decarbonization targets become real success models – and modern terminals become Net Zero pioneers.

VAHLE BATTERY STORAGE: ENERGY REIMAGINED

POWER WHEN IT'S NEEDED

Battery-supported energy modules such as VAHLE Battery Storage reliably supply electrified rubber-tired gantry cranes (eRTGs) with power – without reliance on the grid. Battery systems thus become high-performance buffers: by temporarily storing energy and providing it on demand, they specifically relieve the local power grid during peak loads.

Depending on requirements, two predefined battery types are available, while the enclosure and eHouse environment remain identical. The actual battery configuration, however, can be flexibly adapted to the respective crane, its duty cycle and the application – such as aisle transfer, hybrid operation or peak shaving. This is based on modules that can be connected in series and/or parallel as needed to achieve the required voltage and energy capacity.

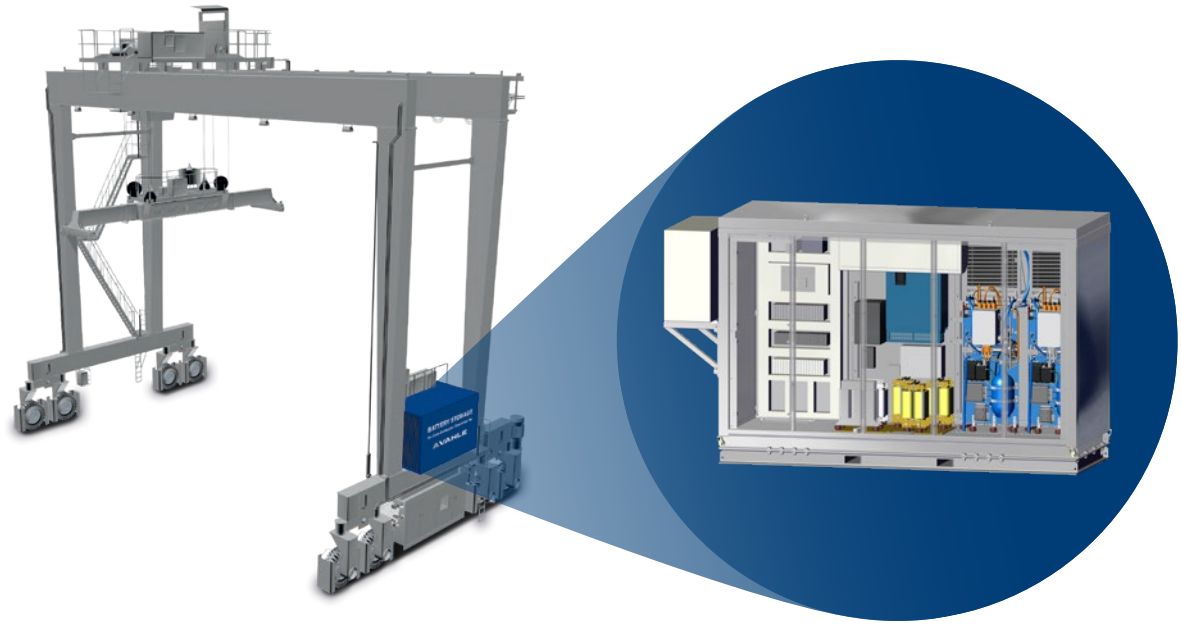
Thanks to a high C-rate – which describes how quickly a battery can be charged or discharged relative to its capacity – and advanced cooling technology, even batteries with comparatively low capacity can deliver large amounts of energy at short notice. This reduces both capital and operating costs.

By leveraging energy recuperation potential and selectively decoupling from the power grid, energy becomes a flexible resource and renewable energy sources can be meaningfully integrated. As a result, energy costs decrease while travel movements – such as aisle transfers – become fully autonomous and emission-free.

Using energy flows intelligently

Battery systems expand the scope of action in energy management. They store surplus energy, for example from braking processes and make it available again when needed. Locally generated electricity from renewable sources – such as PV systems – can also be buffered and used at a later time.

This creates an integrated energy system that links consumption, storage and recuperation. Energy flows are not only balanced, but actively managed – an essential step toward greater efficiency in terminal operations.



PEAK SHAVING, AUTONOMY AND SAFETY: BATTERY SYSTEMS OF THE NEXT GENERATION

Container terminals demand technology that operates reliably under continuous load. High utilization, harsh environmental conditions and permanent duty cycles leave little room for fluctuations. What matters most is not only performance, but above all operational reliability.

Stability under extreme conditions
Lithium-ion batteries deliver their best performance at around 25 °C. Even small temperature differences between cells can significantly reduce the usable energy of the entire system. Excessive thermal stress accelerates cell aging and shortens service life – a safety risk that must not be underestimated.

VAHLE therefore relies on the most efficient cooling technology available: immersion cooling. The cells are immersed in an electrically non-conductive liquid, allowing heat to be dissipated quickly and the temperature to be kept constant throughout the entire battery system. Even under extreme ambient conditions from –25 °C to +55 °C, the cell temperature remains at around 25 °C. This ensures optimal performance, maximum safety and a long, predictable service life.

Safety without compromise
A worst-case scenario for lithium-ion batteries is thermal runaway, in which a cell overheats and, in extreme cases, can trigger a fire. Immersion cooling offers a decisive advantage here: it prevents the chain reaction in which one cell overheats the next. This principle of preventing a thermal chain reaction is considered the highest standard of modern battery architecture and significantly increases operational safety.

Thinking economically, acting sustainably
Technical robustness and efficiency translate directly into economic benefits: consistent performance profiles reduce energy demand, while controlled operating conditions minimize wear and maintenance effort. At the same time, battery systems make a measurable contribution to emission reduction and become a central building block for sustainable operations.

Immersion cooling

With immersion cooling, battery cells are located directly in an electrically non-conductive liquid. Heat is absorbed directly at the point where it is generated.

This ensures a uniform temperature throughout the system and prevents critical hotspots.

- ⊕ Homogeneous temperature distribution
- ⊕ Constant cell temperature (25 °C ± 2 °C)
- ⊕ High efficiency of heat dissipation
- ⊕ Extended service life and reduced total ownership cost

Future-proof energy

VAHLE is your partner for future-ready terminal concepts. Scan the QR code or visit vahle.com/request

ELECTRIFICATION WITH TRIMOTION COMPACT

SUSTAINABLE AND COST-EFFECTIVE: 300 METRIC TONS LESS CO_2

Large-scale CO_2 savings: Since December 2024, the VAHLE system solution TriMotion Compact has been successfully in operation at Khalifa Port in Abu Dhabi. The port is operated by AD Ports Group and CMA Terminals. The project clearly demonstrates how electrification and automation can be implemented under real terminal conditions – robustly, scalably and without interfering with ongoing operations.

Electrify instead of refuel

The system replaces diesel-powered generator units on rubber-tired gantry cranes (RTGs). Electrified and automated systems such as TriMotion Compact can therefore save up to 300 metric tons of CO_2 per year* at the terminal – equivalent to the annual energy consumption of approximately 45 four-person households in Germany.

More than a technical solution

Through its contribution to emission reduction in global supply chains, TriMotion Compact becomes a key driver of sustainable infrastructure and economically efficient terminal operations. The solution thus represents a proven, practical step toward Net Zero terminal operations – already a reality today.

CO_2 savings per retrofit per year

Approximately 110 flights
between Frankfurt and New York

Around 1.9 million kilometers driven by car

About 9,000 kilograms of beef
(including production, transport, feed)

* Based on an assumed RTG operating time of 4,000 hours per year and a diesel consumption of approx. 30 liters.

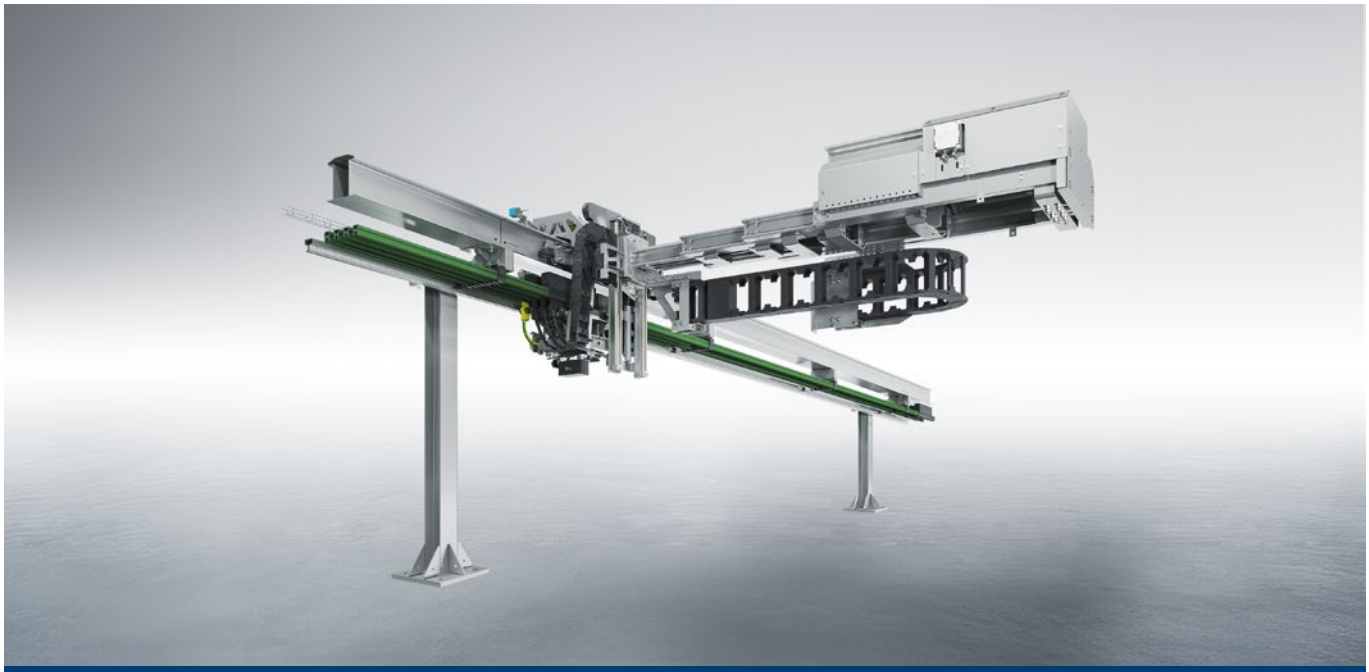
ELECTRIFICATION IN ACTION FOR GREENER PORTS

What began two decades ago as a response to rising oil prices has now become an established standard in terminal operations: electrification and automation. Vehicles and handling equipment that no longer rely on diesel but operate electrically form the foundation for cost-effective and climate-friendly container handling.

At the same time, increasing automation boosts efficiency and safety for personnel and processes. This clearly shows that profitability and sustainability are not contradictions – they go hand in hand. Proof of this can be seen in the electrified rubber-tired gantry cranes (eRTGs) at Modern Terminal Hong Kong, which have been operating successfully and reliably for more than 15 years.

VAHLE as a technology partner
For many years, VAHLE has been an active pioneer of electrified and automated terminal facilities. As a system provider, VAHLE delivers innovative solutions that address the challenges of modern terminal operations and container handling – and supports port operators as a reliable partner with extensive practical know-how and expertise.

Efficient and retrofit-ready
A current example of VAHLE's terminal solutions is TriMotion Compact at Khalifa Port. The compact electrification system for automated RTG applications sustainably increases the efficiency of electric RTG operations and is equally suitable for retrofit projects and new installations.



TriMotion Compact – benefits at a glance

- ⊕ **Synchronous control:** supply of multiple eRTGs on a single route
- ⊕ **Compact design:** easy to retrofit
- ⊕ **Fast availability:** standardized (DIN/EN/ISO) hardware and optimized local sourcing options
- ⊕ **Combined energy and data transmission:** all-in-one system
- ⊕ **Plug & Play:** easy installation and fast commissioning
- ⊕ **Fully remote-capable:** control from the operator desk

VAHLE SERVICE – FOR A TROUBLE-FREE FUTURE

MAXIMUM AVAILABILITY, MINIMAL DOWNTIME

Whether eRTG Cranes, STS Cranes, Straddle Carriers, RMG Cranes or Automated guided vehicles (AGV) – regular maintenance, professional cleaning, and precise inspection ensure reliable and future-proof port operations.

With preventative and predictive service, seamless spare parts supply and our protect programs, we keep your systems efficient, safe and consistently powerful.

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