Energy management and battery powered horizontal transportation at container terminals

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Executive summary

Today's container terminals face continuous pressure to improve their performance and cost-efficiency, while simultaneously needing to meet increasingly stringent emissions regulations. Battery-powered all-electric equipment is the obvious future solution for horizontal transportation of containers between the quay and container stack, but existing solutions have been limited by either long battery charge times or costly and complicated battery swapping systems.

Kalmar FastCharge™ is a cost-efficient, safe and scalable solution that eliminates the need for battery swapping while enabling zero emissions on site for horizontal transportation of containers. Kalmar FastCharge straddle and shuttle carriers as well as AGVs can use opportunity charging at strategically located charging stations, avoiding any disruption to horizontal transport operations.

High-powered fast charging technology thus offers a realistic way for container terminals to electrify their horizontal transportation while maintaining optimum performance. However, terminals often face uncertainty on whether their electrical infrastructure and power grid connections can handle the considerable peak power loads of heavy container handling equipment with fast-charge technology.

This white paper examines the ways in which FastCharge technology can be deployed without adverse effects on the electrical infrastructure of the terminal, even if the grid power feed is not originally designed to handle the multi-megawatt power peaks required by fleets of fast-charging container handling equipment. Smart energy management solutions that utilise active data monitoring from all points of the energy chain can enable intelligent energy management systems that link the energy usage of the terminal with supply and demand from local or nationwide power grids, while enabling container handling operations at the terminal to become locally free of exhaust emissions.

1. Introduction

In recent decades, container volumes handled worldwide have continuously increased as a result of globalisation, economic growth and the geographical distribution of activities. Overseas container transport costs have decreased due to economies of scale and a dramatic increase in vessel sizes from 4,000 TEU in the early 1990s to 18,000 and above today.

Larger container ships place heavier demands on terminal infrastructure to handle the increased number of containers moving to and from the quayside. A container ship only really makes money while at sea, so berthing time at the terminal needs to be as brief as possible. This can only be achieved by fast loading and unloading, which requires close coordination and efficient horizontal transportation between the quayside ship-to-shore cranes and the container stack.

Concurrently with these pressures towards improving performance and cost-effectiveness, terminals need to comply with increasingly stringent emissions regulations. Awareness of climate change has lead to several initiatives to restrain greenhouse gas emissions, which contribute to temperature rise worldwide. The Paris Agreement, signed by 195 member states, seeks to limit the global temperature rise to 1.5 °C above the pre-industrial level. The need to reduce emissions has also spread to the industrial sector and is driving a search for alternative eco-efficient solutions for vehicles and work machines.

TOWARDS AN ENERGY MANAGEMENT APPROACH

> ” Terminals need to comply with increasingly stringent emissions regulations.

It is Kalmar's view that eco-efficiency should encompass not only the container handling machine, but must be applied to the entire energy management of the container terminal. A terminal's energy system involves an interaction between the feeding electricity grid, the management and control systems, and the electrical load in the form of container handling machines. With added intelligent solutions, this chain – all the way from the grid feeder to individual charging stations and even the on-board batteries – can be optimised to gain higher efficiencies at each point. This results in better predictability of energy usage, fewer interruptions and improved productivity.

The increase in the number of electric consumers will require smarter energy grids in the years to come. Instead of just designing terminal infrastructure to handle peak usage, the future will demonstrate smart ways of optimising energy usage and tailoring the electrical system to function reliably even with lower volumes of power drawn from the grid.

> ” The operation models can be classified as coupled or uncoupled solutions.

2. Horizontal transportation

Horizontal transportation can be defined as the container traffic between ship-to-shore (STS) cranes and the yard. The operation models can be classified as coupled or uncoupled solutions. A coupled solution relies on the container-carrying equipment being under or at the backreach area of an STS, where it waits for the container to be placed on top of it. Examples of coupled systems are terminal tractors (TT) pulling trailers, as well as automated guided vehicles (AGVs). Both of these types of machines need to wait for containers near the quay crane. To avoid creating a bottleneck for the entire operation, coupled solutions thus require a relatively large fleet of machines.

By contrast, uncoupled solutions allow for more operational flexibility since the containers can be placed on the ground for shuttle or straddle carriers to pick them up. In this way, the quay crane can create an intermediate buffer at the backreach area when needed.

2.1 STRADDLE CARRIER OPERATION

Straddle carriers are typically used at medium-sized container terminals. Usually ship-to-shore (STS) cranes are used to load and unload the container ship. Straddle carriers then pick up the container from the quay and carry it to the container stacking area. Straddle carriers also take care of organising and managing the container storage, in addition to loading and unloading the containers to a truck or chassis on the land side of the terminal.

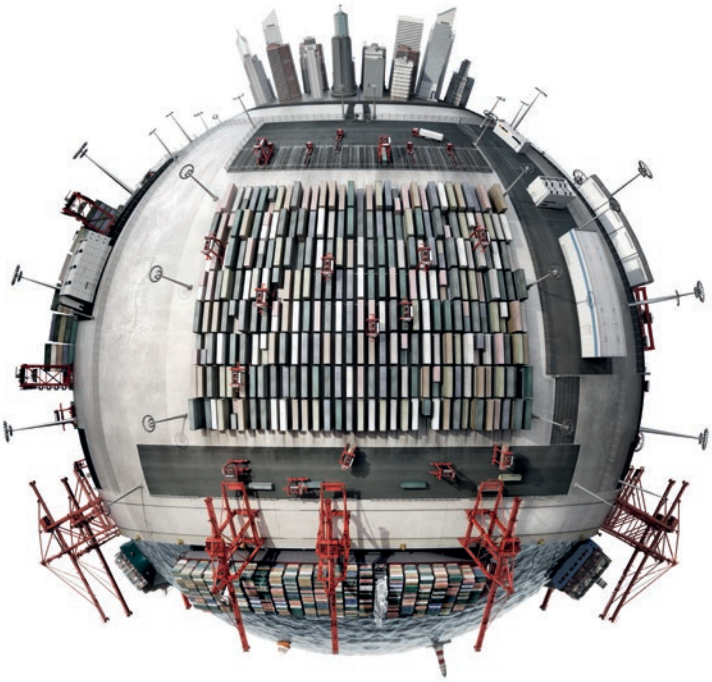


*Figure 1.
Kalmar AutoStrad™
operation.*

Straddle carrier operations enable high flexibility, as the storage area is basically an empty field. Nearly all container handling tasks can be carried out with a single type of machine, thus requiring fewer types of equipment to maintain. Straddle carriers also enable fully decoupled operations and can serve a given number of STS cranes with approximately half the fleet size of AGVs.

The principal limitation of straddle carrier based terminal concepts is the upper bound on stack capacity for a given land area, as straddle carriers only stack containers up to three-high. Straddle carriers also need empty space between container rows to accommodate the side frames of the machine.

Straddle carriers have been successfully automated for many years. From the point of view of energy management, straddle carriers pose some challenges for electrification, as the amount of energy needed by the machine can vary significantly depending on the weight of individual containers and the travelling distance during a given duty cycle.

> ”Straddle carriers have been successfully automated for many years.

2.2 SHUTTLE CARRIER WITH ASC

A variant on the straddle carrier concept is the shuttle carrier, which is essentially a smaller straddle carrier with two-high stacking capability. Shuttle carriers are typically used for container transport between STS cranes and ASCs (automatic stacking cranes) that take care of the container stacking. In a shuttle carrier / ASC design, landside truck handling is also managed by the ASC.

Figure 2. Shuttle carriers serving automated stacking cranes (ASCs) on the quayside.

This operation model enables significantly higher stack density and thus increased terminal capacity compared to straddle carrier operation. The downsides are a more fixed layout, less flexibility in operation and higher investment costs.

In some existing terminals, straddle carriers are also used in this type of operation between STS cranes and ASCs. Usually this is due to an existing machine fleet or to the need to include separate straddle carrier stacking capability in the operation. In this scenario, electrification of horizontal transport is easier, since the operation area is more limited and travelling distances are usually shorter.

2.3 AGV WITH ASC/RMG

Automated guided vehicles (AGV) were originally developed for industrial applications. In container operations, they were first introduced already in 1993 at Rotterdam.

AGVs are usually used to move containers between STS cranes and the stacking yard, which can be equipped with ASCs or RMG (rail-mounted gantry) cranes. The AGV is essentially a container-moving platform, which means coupled operation at the interfaces, i.e. the AGV will always wait under the crane to be served.

An AGV variant, the lift AGV, has the capability to pick up containers from dedicated container racks and leave the containers in similar structures at the ASC/RMG transfer area. This allows uncoupled operation, but requires additional investments into the container transfer racks – which can become obstacles for horizontal transportation – and into the integrated lifting platform of the AGV. Thus, the lift AGV has not yet gained ground as a solution for uncoupled operation. However, from the electrification point of view, the lift AGV presents great opportunities for opportunity charging during the actual duty cycle of the machine.

2.4 MANUAL TERMINAL TRACTOR WITH RTG

A container terminal with manually driven terminal tractors (prime movers) and a yard equipped with manual RTG (rubber-tyred gantry) cranes is currently the most common operation model in the world. The concept allows for high capacity and operational flexibility, but the downside is that the terminal needs to allow third-party road truck drivers to enter the stacking area. An operational model based on manual terminal tractors and traditional RTGs is also very labour-intensive. Terminal tractor fleets can be challenging to electrify efficiently due to the very large number of vehicles needed.

2.5 ELECTRIFYING DIFFERENT OPERATION MODELS

The Kalmar FastCharge solution can be used to electrify any heavy-duty vehicle, and can be retrofitted to existing equipment. The modular design enables fast incremental conversion of existing fleets without disrupting operations. For example, existing customer projects have demonstrated the possibility of converting a hybrid Kalmar straddle carrier to fully electric powertrain with FastCharge functionality within a timeframe of a few weeks.

3. Powering the port of the future

The concept of the future port encompasses numerous challenges, of which energy and its management will be one of the hardest, but also one of the most rewarding. Existing large port cranes (STS/ASC) are, for the most part, already connected to the local power grid, while the next generations of mobile port machinery are incrementally turning towards hybrid solutions and ultimately full battery-powered operation. In addition to meeting increasingly demanding emission norms, battery-driven machines are expected to bring cost savings through decreased maintenance needs and improved efficiency.

To support battery-operated machines, charging stations and their associated infrastructure need to be put in place, which increases the peak power consumption of the terminal. At brownfield terminals, where a charging station is installed and connected to an existing electric infrastructure, the peak power drawn from the grid may become an issue due to the lack of high-power feeders or because the peak power demand exceeds the capacity of the system.

> ” Renewable energy is of increasing interest to terminals.

Renewable energy is another field that is of increasing interest to terminals. Container terminals and their adjacent land areas often include large flat rooftop surfaces on which solar panels could potentially be installed for increased energy self-sufficiency. The vicinity of water could enable several other sources of renewable energy such as wave, tidal and wind power, which could help offset increased peak power consumption to some extent. However, to keep power consumption and generation within the designed limits, the consumption and generation of peak electric power needs to occur very close in time, which could be hard to achieve in practice.

Picture 1. Charging pantograph connected to the machine-side contact dome

THE SOLUTION: SMART POWER SYSTEMS

As a result, the practical answer to solving the challenge of terminal energy balance is to add intelligence to the complete power and energy management system all the way from the supplying grid to the final load. The load can also be a source of power, not only through regenerative energy harvesting, but also thanks to the inherent energy storage capabilities of battery-operated machines. The possibility of feeding battery power back to the terminal power grid via a compatible charging station is only one example of the myriad possibilities of intelligent energy management.

Individual but interconnected control of loads is the first step to actively managing the flow of energy. The next step is to add in some form of energy storage, which stores, for example, the regenerative power from all types of connected machines and redistributes it based on request, either to other loads or back to the power grid. The request for energy may be based on a rolling forecast of energy/power usage based on historical data. It may also come from the local power company for peak shaving or for frequency regulation outside the terminal. In other words, the controlled storage can handle the terminal's internal energy management while simultaneously participating in the local or even nationwide demand response market. Furthermore, it can enable the terminal to gain cost savings from purchasing grid power at lower prices during off-peak hours.

When supplemented by active data monitoring from all points of the energy chain as well as smart automated functionality, on-site energy storage capacity becomes one part of an intelligent energy management system for the whole terminal, while enabling container handling operations at the terminal to become locally free of exhaust emissions.

Picture 2. Powering the port of the future.

> The ultimate target is an emission-free horizontal transportation solution.

4. Why battery-powered?

As the interest in and requirements for battery-operated machinery increase, it is useful to examine the currently available portfolio of eco-efficient solutions. At the time of writing (early 2019), the industry standard diesel-electric powertrain has been gradually accompanied by the hybrid powertrain, a combination of diesel generator set and energy storage.

Current battery technology allows the diesel engine to be sized for average power, whereas the use of lower-capacity super-capacitors requires a larger engine sized for maximum power demand. These designs also feature regenerative energy systems to convert braking and spreader lowering energy into electric power that is stored again. An automated stop-start system chooses the optimal balance between engine and battery power, which also extends the operational life of engine and generator and enables longer maintenance intervals.

Consuming up to 40% less fuel than existing shuttle carriers on the market, Kalmar hybrid shuttle carriers with lithium-ion batteries emit over 50 tons less CO_2 per year than a traditional diesel unit. While hybrid systems provide excellent economy and reduced emissions, the ultimate target is an emission-free (at least at the point of use) horizontal transportation solution.

As environmental legislation becomes more stringent for SO_x, NO_x, particulate matter (PM) and CO_2, electric driveline with batteries is the only alternative. As well as no emissions to the atmosphere, the advantages of fully battery-powered systems include less noise, reduced maintenance with a smaller number of vehicle components, and up to 50% increased energy efficiency compared to diesel/electric driveline. The cost of maintaining on-site fuel storage and refuelling infrastructure is also saved.

BATTERY POWER IS THE KEY

With increasing on-board electrical components, the concept of a fully electric machine can be brought into discussion. By small incremental steps, it is feasible to increase the overall electrification of the machine, which reduces the use of hydraulic oil, simplifies maintenance and improves overall machine efficiency. Electrification is also a key step towards increasing the overall automation level of container handling equipment.

In addition to generators and batteries, alternative on-board power sources are constantly studied. For example, the much speculated hydrogen fuel cells could be part of the future range of available power units for all-electric container handling equipment. However, fuel cell technology currently lacks the hydrogen manufacturing capacity and distribution infrastructure that would enable it to compete cost-efficiently with existing power sources. At locations where hydrogen can be extracted as a natural byproduct of another industrial process, the use of hydrogen fuel cells may yet prove a viable option. However, it should be noted that a fuel cell would only replace the diesel generator as a power source, and the machine would still need a battery solution to store the generated energy.

5. Fast charging

From experiences in electrifying horizontal container transportation, it is clear that charging of onboard batteries has to be quick and needs to take place along the natural route of the machine with minimum rerouting. This maximises machine availability and allows flexible task scheduling.

Horizontal transportation operations have many variables in predicting energy consumption, such as changes in the travelled distance; acceleration and deceleration rates; container weight variations; cyclic operation of auxiliary loads, and environmental conditions. This results in a degree of energy uncertainty, which can be addressed by using high-powered opportunity charging. This places additional demands on the battery system, as the batteries need to be able to accept high charging currents without propagating a voltage imbalance between the battery cells. Additionally, the battery cooling system has to be designed to overcome the heating effect of high-power charging.

Charging of Kalmar FastCharge shuttle and straddle carriers is achieved with an inverted pantograph direct current charging system, fully automated in operation and similar to systems used on electric buses. The location of the current collector on the upper frame or side pillar of the vehicle adds to the safety of the solution and protects it from damage.

Alternative charging components are used on the Kalmar FastCharge AGV, on which the charging contact needs to be located on the side or bottom of the machine. In practice, a linearly actuated charging contact that connects with its counterpart on the AGV side panel has been found to be the most reliable and maintenance-friendly solution.

Picture 3. Kalmar FastCharge system.

> ” Charging of onboard batteries has to be quick and needs to take place along the natural route of the machine.

FASTCHARGE TECHNICAL OVERVIEW

The FastCharge solution is designed as containerised equipment (10’ or 20’ high cube sea container depending on the supply voltage level) that is fed from the local power grid and used to charge machine on-board batteries. The electric supply is first transformed to the required voltage level, then filtered and converted to actively controlled DC (direct current) output, which is connected to the charging contact. Each container can be equipped with two charging contacts, which allows two machines to be charged at the same time, or a single machine with higher power. The charging power for a single machine can be doubled even in the middle of the charging sequence, if the other machine leaves the charging station.

For connecting to the local power grid supply, the flexibility of accepting various voltage levels is essential. The available voltage can change from low voltage (< 1 kV) to medium/high voltage levels (> 1 kV), which are all manageable by selecting the correct incoming switchgear and transformer components. The average apparent power drawn from the grid during a charging sequence can be up to 610-630 kVA depending on the status of the charger auxiliary loads such as the cooling system.

By using the principle of opportunity charging (charging whenever possible between tasks or during natural idle times), the charge sequences can be kept short. This maximises machine availability and maintains a high battery state of charge.

When deploying multiple chargers, intelligent power management plays a major role. For example, for ten charging stations used simultaneously (an unlikely but possible scenario), the total power drawn from the grid would be 6.1-6.3 MVA. Even if charging the battery from empty to full, the charge sequence only takes five to six minutes, which is not a problem for a terminal at which high-power feeders are already in place and this type of load cycle is normal. In terminals that are not initially designed for power peaks of several megawatts, it is possible to use charger-to-charger communication to manage the total load based on a preset limit or load cycle.

ON-SITE ENERGY STORAGE

The fast-charging system can also be augmented with an additional stationary battery storage, which acts as an energy buffer in parallel to the charging station. The energy storage can be charged with small power from the grid over a flexible time period, which means that power peaks for charging don’t affect the grid, but only the battery storage. This helps to decrease the gridside load, stabilise the terminal distribution grid and increase the overall quality of electric power at the terminal. The energy storage unit can be located close to the charging station to reduce the effect of power peaks, or as a more general augmentation to the entire electricity system of the terminal.

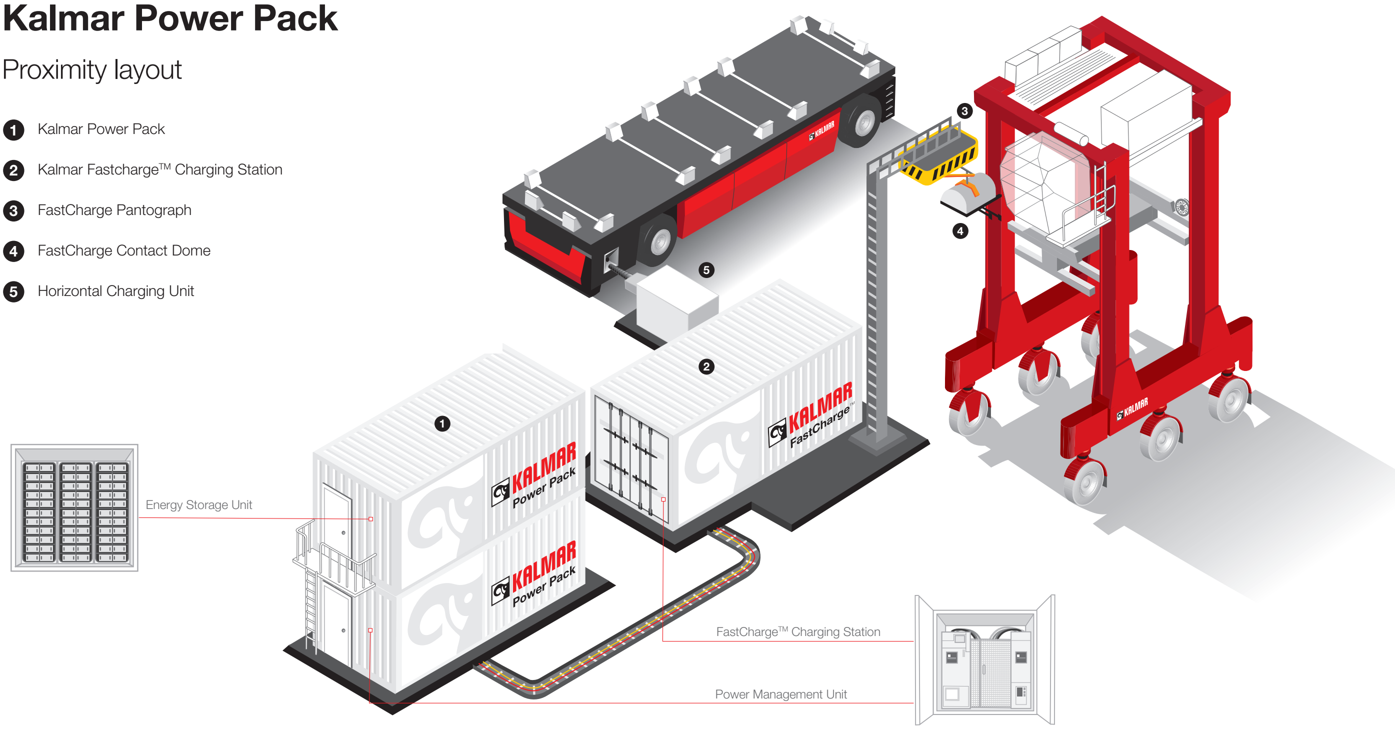
Power quality is an often-neglected factor that is essential to address with electric loads that have non-linear characteristics. Kalmar charging

Figure 3. Kalmar Power Pack system deployed as an energy buffer for a FastCharge station.

Kalmar Power Pack

Proximity layout

1. Kalmar Power Pack
2. Kalmar Fastcharge™ Charging Station
3. FastCharge Pantograph
4. FastCharge Contact Dome
5. Horizontal Charging Unit



stations and stationary energy storage units are equipped with active power electronics and filtering, which improve the quality of electrical grid power and prolong the lifetime of electric components.

The impact of FastCharge equipment on the local power grid, in terms of harmonics and total reactive power requirement, is minimised with intelligent charging system control and careful component selection. During a charging sequence, the THD (Total Harmonic Distortion) due to load non-linearity is less than 2% and the power factor is 0.98 and above.

Kalmar thoroughly addresses the electrical infrastructure at terminals to ensure that feeders, cable dimensioning and the selectivity of fault protection meet the requirements of high-power fast charging. Several FastCharge containers can be connected downstream of a single feeder in a so-called daisy chain, since each container is equipped with its own switchgear with current, voltage and fault protection features.

Alternative non-contact methods such as inductive charging have been investigated but are unable to deliver the required power without considerable energy loss. Fast-charge battery technology makes it possible to utilise very high charging rates, which are scalable up to 600 kW. One pantograph located along the FastCharge shuttle carrier route can serve several vehicles as charging is very flexible. Since driving cycles are short, frequent thirty-second charging periods (depending on the shuttle cycle and state of battery charge) do not slow down container transfers and enable the vehicle to be utilised to its maximum effectiveness.

This frequent charging avoids the deep discharge that can shorten the life of any battery. Pantograph charging stations can also be positioned more easily than battery exchange stations, with convenient locations on shuttle routes to eliminate disruption of the shuttle work cycle.

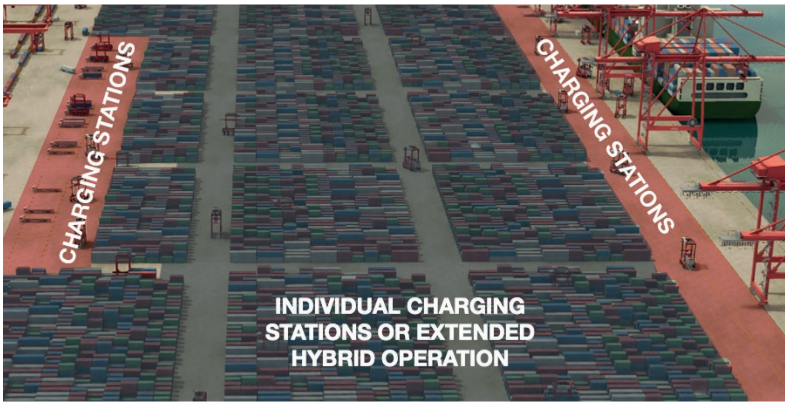


Figure 4. A straddle carrier terminal allows considerable flexibility in charging station installation.

6. Power optimisation and automation

> ”The automation path consists of four levels.

AGVs, AutoShuttles and AutoStrads benefit from automated operation and charging cycles that are based on optimised sequences that maximise efficiency at a minimum cost per move. The operation and scheduling of tasks is automated and embedded in the Kalmar Terminal Logistic System (TLS), which is used to control and monitor the fleet of machines and charging stations.

Kalmar TLS can be further connected to other systems in order to expand the functionalities of the overall operation. In this way, the machines can be automated step-by-step from automation-ready manual operation through semi-automation to fully automated. The automation path consists of four levels.

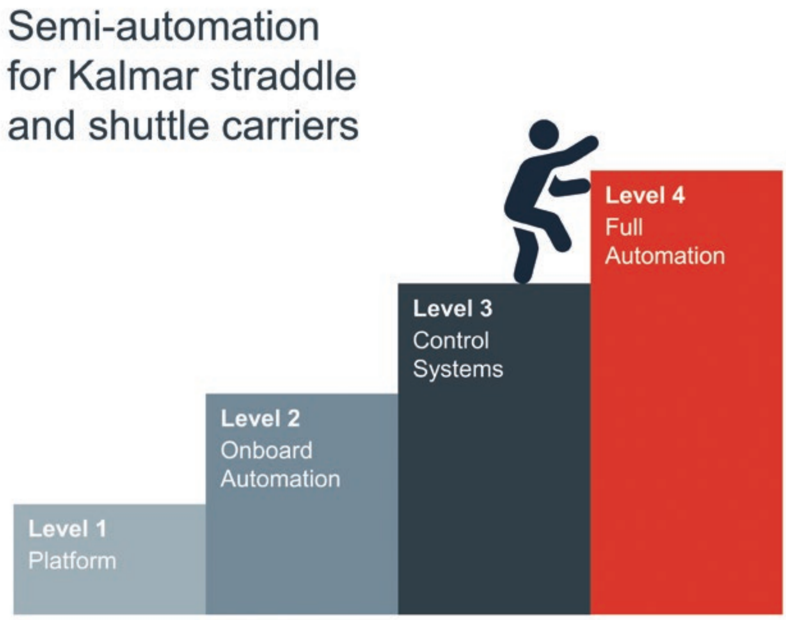


Figure 5. Automation levels for horizontal transportation of containers.

Increasing the level of automation introduces new possibilities for optimising also the use of electricity in operations. Machine acceleration and deceleration, top and cornering speed as well as the use of auxiliary loads can be adjusted to improve the overall efficiency of the electric powertrain, which ultimately improves the productivity of the terminal as a whole. Automation and digitalisation enable smart scheduling of charge cycles as part of the route planning of horizontal transportation equipment, and the entire operation can be optimised incrementally through machine learning solutions that utilise the vast amount of operational data generated by connected systems.

Automated machines can also be easily configured for optimised driving performance for improved eco-efficiency. Research carried out by Kalmar indicates that when moving a 25-ton container with a straddle carrier equipped with electric driveline, limiting the top speed of the machine from 28 km/h to 25 km/h reduced the relative energy consumption by 6.5 %. If the speed was reduced further to 20 km/h, consumption dropped by 11 %.

In operations that include natural waiting times for the machines during work cycles, this reduction in top speed can be easily implemented without impacting productivity, and careful management of the top speed of horizontal transportation equipment should be taken as one of the most immediately accessible ways of improving energy efficiency at a terminal.

7. Kalmar battery-powered solutions

7.1 KALMAR FASTCHARGE SHUTTLE AND STRADDLE CARRIERS

Available in both manually operated and automated versions, the Kalmar FastCharge shuttle and straddle carrier offer a flexible concept for existing and greenfield terminals. At hybrid terminals that are introducing ASCs block by block, shuttle and straddle carriers offer the unique opportunity for gradual expansion while retaining fully decoupled container transfers.

When compared to hybrid systems, the FastCharge architecture essentially removes the diesel engine, adds battery capacity, and introduces the charging interface as well as some components to manage the onboard power distribution. The power unit can be retrofitted from hybrid to FastCharge thanks to the modular design of the electric architecture.

FastCharge machines are equipped with a plug-in charging system with lower power to help keep the battery state of charge at an optimal level e.g. during maintenance or at other parking locations. Charging can be done with a standard industrial 32A three-phase plug.

When modernising a terminal with increasing levels of automation, existing manual shuttles and straddle carriers can be fully automated, which leads to an improved return on the original investment as well as optimised TCO (total cost of ownership).

REAL-WORLD REFERENCES

Kalmar FastCharge straddle and shuttle carriers are already being deployed at several terminals around the world. In Porsgrunn, Norway, Kalmar is delivering a unique, fully digitalised container handling solution for world leading mineral fertiliser company Yara. Kalmar will provide the autonomous loading and unloading solution for the world's first autonomous and electric container vessel Yara Birkeland, as well as transportation between the fertiliser production facilities and the quay. The Kalmar solution consists of one Kalmar automated rail mounted gantry crane (AutoRMG), three Kalmar FastCharge AutoStrads™, a FastCharge charging station and related automation and safety systems. The solution will be implemented in phases, with the level of automation gradually increased over time. The end result will be a fully autonomous, mixed-traffic and zero-emission solution in an industrial environment.

> ”The end result will be a fully autonomous, mixed-traffic and zero-emission solution.

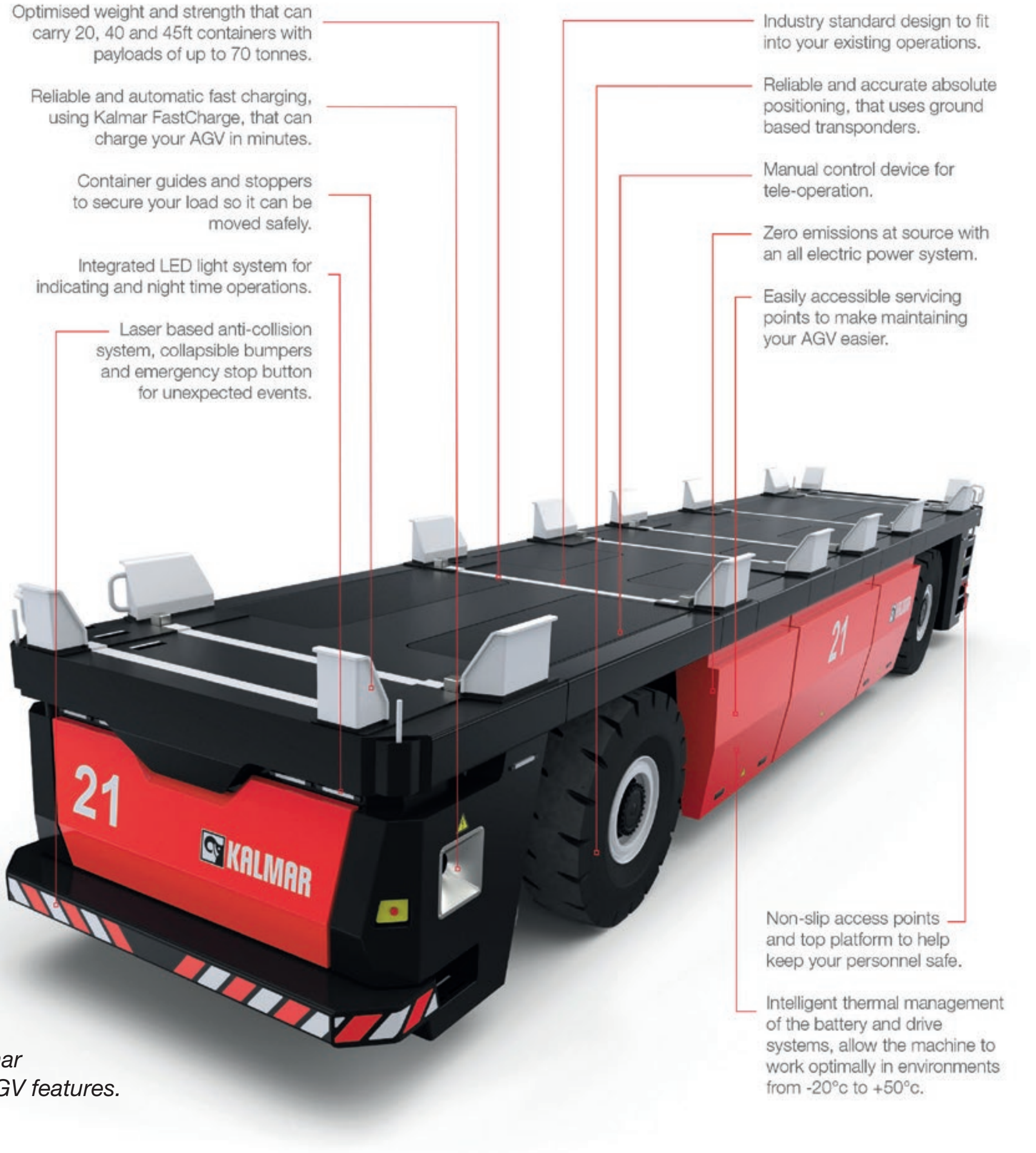
Starting in 2019, Kalmar is delivering an integrated container handling solution at Qube's Moorebank Logistics Park (MLP) in south-western Sydney, Australia, that includes four Kalmar automated stacking cranes, eight automated Kalmar rail-mounted gantry cranes, as well as eight hybrid Kalmar FastCharge AutoShuttles™ and their charging stations.

Picture 4. Kalmar FastCharge AGV.

7.2 KALMAR FASTCHARGE AGV

Kalmar is extending its customers' choice by introducing the FastCharge AGV, an exhaust emission free option for coupled horizontal transportation. Designed in-house, the Kalmar AGV is built with the same modular thinking as the Kalmar straddle and shuttle carriers.

Starting from operational analysis, the availability of machines for operations is maximised through flexible charging sequences and intelligent fleet management. With added connectivity to the Kalmar Insight solution suite, it is possible to gain even more benefits from data-driven performance optimisation.



Optimised weight and strength that can carry 20, 40 and 45ft containers with payloads of up to 70 tonnes.

Reliable and automatic fast charging, using Kalmar FastCharge, that can charge your AGV in minutes.

Container guides and stoppers to secure your load so it can be moved safely.

Integrated LED light system for indicating and night time operations.

Laser based anti-collision system, collapsible bumpers and emergency stop button for unexpected events.

Industry standard design to fit into your existing operations.

Reliable and accurate absolute positioning, that uses ground based transponders.

Manual control device for tele-operation.

Zero emissions at source with an all electric power system.

Easily accessible servicing points to make maintaining your AGV easier.

Non-slip access points and top platform to help keep your personnel safe.

Intelligent thermal management of the battery and drive systems, allow the machine to work optimally in environments from -20°c to +50°c.

Figure 6. Kalmar FastCharge AGV features.

8. Case study: DP World London Gateway

DP World is a leading enabler of global trade, operating multiple related businesses from marine and inland terminals, maritime services, logistics and ancillary services to technology-driven trade solutions. The company operates 78 marine and inland terminals supported by over 50 related businesses in over 40 countries across six continents.

DP World London Gateway is the UK's most integrated logistics hub; a state-of-the-art, globally connected deep-sea port and rail terminal, on the same site as an expansive land bank for the flexible and fast development of logistics facilities and warehouses. With its tri-modal combination of deep-sea port and logistics park, DP World London Gateway provides the most efficient link between deep-sea shipping and the largest consumer markets in the UK.

Kalmar has delivered an extensive container handling solution for DP World London Gateway, which also includes a joint FastCharge shuttle carrier development project. With the first phase of the contract, signed in 2011, Kalmar deployed the Navis TOS, 40 automatic stacking cranes and 28 shuttle carriers, with commercial operations starting in 2013. In the second phase, signed 2014, a further 20 automatic stacking cranes and 12 hybrid shuttle carriers were added.

The FastCharge joint development project started in July 2017, and live operation began in April 2018. Kalmar modified an existing hybrid shuttle carrier to a fully electric FastCharge shuttle carrier. The charging system consists of the charging station and pantograph charging contact, with the containerised charging station connected to the local power grid.

The charging system is located at the waterside in the maintenance aisle between two ASC blocks. The shuttle carrier charges during idle periods under the principle of opportunity charging, and the charging time is between 30 to 180 seconds at full charging power. The charging sequence is fully automated, and the driver has to only engage the parking brake to begin the charging procedure. All essential information about charging status is provided to the driver in the cabin display, and the charging can be stopped manually if needed.

The FastCharge concept enables DP World London Gateway to attain lower emissions, less noise and less maintenance for its horizontal transportation equipment. Opportunity charging ensures high efficiency and uninterrupted availability for the machines, enabling a more eco-efficient operation without compromising performance.

9. Conclusion

The future of container handling is, without a doubt, electric. However, until now, the discussion of terminal electrification has focused largely on the technical details of equipment design as well as developments in charging and battery technology. It is Kalmar's view that electrification needs to be considered from a more extended perspective that encompasses the entire energy management of the terminal, alongside intelligent power grids, automation, digitalisation and the increasing connectivity of global logistics chains.

Forward-looking companies in all areas of industry – including container handling – have the opportunity of working together with their customers to improve eco-efficiency and conserve resources for the greater benefit of society as a whole. The electric equipment and smart systems already available today give the possibility of looking at things from a wider vantage point, not only improving the energy efficiency of individual components, but also changing the entire terminal energy chain for the better, for good.

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Juho works in the Intelligent Horizontal Transportation Solutions (IHTS) business line in Kalmar’s Automation and Projects Division. He has worked at Kalmar close to five years in challenging R&D projects and is responsible for e.g. the design and engineering of the FastCharge™ solution. Juho’s background is in hybrid and electric vehicle development for the automotive industry, and he holds degrees in automotive engineering and automation technology (M.Eng).

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Henrik Häggblom works at Kalmar as head of horizontal transportation equipment engineering, R&D and product management. He is responsible for leading the transformation of the existing Kalmar horizontal transportation offering into automated and electrically powered intelligent solutions. Henrik has 15 years of experience from production, engineering, management and sourcing activities related to heavy working machines. Most recently, Henrik has led the development of Kalmar FastCharge™, the industry's first fast charging solution for electric powered shuttle/straddle carriers and AGVs. Henrik holds a M.Sc degree in logistics and industrial economics.

KALMAR

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