ECO-EFFICIENCY IN TERMINAL OPERATIONS

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Over the years, the cargo handling industry has made tremendous strides in developing the eco-efficiency of cargo and material handling through more efficient machines, optimisation of cargo flows, as well as intelligent equipment and automation. The development has been driven by current megatrends such as urbanisation and digitalisation, as well as a growing concern for the environment.

The eco-efficiency of terminal operations encompasses three different angles, all of which are relevant for a container terminal. Firstly, various new solutions can shape the industry and minimise the environmental impact of terminal operations and equipment. Secondly, systems efficiency involves utilising technology and data to enable more efficient operations. Finally, the concept of resource efficiency encompasses upgrades and refurbishments that extend equipment and fleet lifetimes.

REGULATIONS

One of the most important drivers of eco-efficiency at terminals has been the rapidly developing legislation at various locations around the world. For example, California has introduced ambitious plans to reduce air pollution in port operations by moving towards zero-emissions through electrically powered technologies. Whether driven by environmental legislation, local pressure groups or pure economics, the need to reduce emissions, noise or over-complicated maintenance is growing also in many regions outside the US, and manufacturers around the world are moving fast to meet the growing demand for all-electric cargo handling equipment.

As environmental legislation becomes more stringent for CO2 and NOx emissions, an electric driveline with batteries or direct mains supply becomes the only viable alternative: it releases no emissions to the atmosphere, creates less noise, requires less maintenance with a smaller number of vehicle components and provides up to 50% better energy efficiency compared to a diesel-electric driveline.

EMISSION SOURCES

Industry studies show that typically the emissions in a container terminal come from three sources: the container ship, road vehicles, and the container handling equipment. The most significant source of airborne emissions at container terminals in developed countries is the container ship itself. This holds true even as tightened IMO regulations on nitrogen oxide and sulphur oxide emissions, along with increased requirements for the use of shore power, have considerably reduced vessel emissions at many ports.

Road vehicles are the second major source of emissions at the landside areas of container terminals. However, since these vehicles are not under the control of the terminal, there is little possibility for terminals to influence their emissions directly.

The third main contributor to emissions at container terminals is the container handling equipment, which can be divided into horizontal transportation, yard cranes, ship-to-shore cranes and mobile equipment. New developments such as electrification, hybrid technology and energy regeneration have significant potential to reduce or even completely eliminate on-site air emissions caused by container handling equipment.

HORIZONTAL TRANSPORTATION

The choice of horizontal transportation system also has a major impact on terminal emissions. Maintaining maximum productivity for the STS cranes is the single most critical factor for ensuring optimum performance for the entire terminal, so the horizontal transportation fleet needs sufficient capacity to avoid bottlenecks at the quay. A terminal concept based on terminal tractors will necessitate a relatively large fleet, as each container needs to be placed on top of the vehicle, while horizontal transportation with straddle or shuttle carriers requires fewer machines to handle the same number of containers.

Approximately 80% of straddle carriers currently deployed worldwide are diesel-electric machines, and many terminals in countries with less advanced emissions regulations continue to operate traditional all-diesel machines. However, hybrid systems are rapidly becoming the default choice for new terminals. At the time of writing, the only factor still keeping diesel-electric as a competitive choice is the low price of fuel worldwide, compared to the cost of the advanced battery technology required for hybrids.

Hybrid machines typically operate on battery power with their engines switched off up to 30% of the time. The most efficient hybrid straddle carriers on the market consume up to 40% less fuel than diesel-powered models, and emit on average over 50 tonnes less CO2 per year.

As the next stage in electrification, fully electric equipment decreases noise levels and enables zero emissions at the point of use. The latest generation of horizontal transport equipment includes fully electric straddle and shuttle carriers, as well as fast charge technology that permits charging at idle times during the equipment work cycle.

YARD AND QUAY CRANES

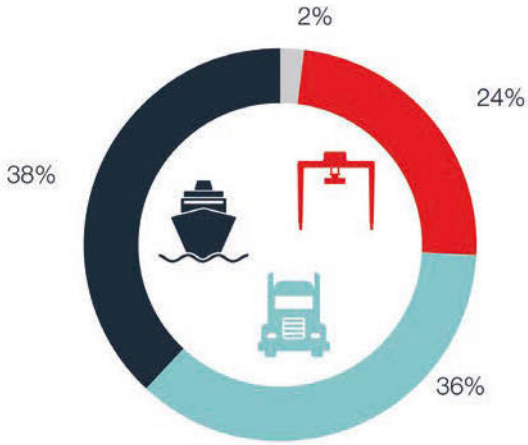
Automatic stacking cranes (ASCs), rail-mounted gantry cranes (RMGs) and ship-to-shore (STS) cranes always operate on grid power, so they are, by default, zero-emissions systems on-site. Kalmar ASC, RMG and mains supplied RTG cranes also include energy recovery system for harvesting kinetic energy, improving the efficiency further. Along with electric RTGs, ASCs are used at several ports worldwide that are undertaking zero-emissions transition programs over the next few years.

ELECTRIC MOBILE EQUIPMENT

Electric drive is fundamentally different from diesel-powered driveline technology, offering several compelling long-term benefits. Electrical power in mobile equipment (reachstackers, empty container handlers, forklift trucks and terminal tractors) is a relatively new development, but electric drives are a highly mature and commoditised technology. Transitioning to zero-emission electric drive will enable longer and more stable product life cycles, which ultimately benefits both manufacturers and customers.

The total lifecycle costs of electric-powered machines are radically lower than for diesel-powered equipment. The main reasons for this are simplified drive installation due to fewer wearing parts, as well as less consumables such as engine and lubrication oils.

A major contributor to mobile equipment electrification has been the transition from traditional lead batteries to rapidly progressing Lithium-ion (Li-ion) technology. Lead batteries have not been able store enough energy to run heavy machines in tough driving conditions, but the advance of Li-ion technology is making it feasible to electrify machines beyond the lightest categories of forklifts and other mobile equipment.



Average breakdown of emission sources at a container terminal.

Technologies & innovations	Fleet management applications	Other possible actions
Efficient diesel engines	Optimising fleet size	Educating operations and drivers
Energy regeneration	Optimising route	
Hybrid technologies	Minimising waiting time	
Electrification of equipment		
Equipment automation		

Overview of typical means to reduce air emissions produced by container handling equipment.

SYSTEMS EFFICIENCY AND PROCESS AUTOMATION

In addition to developments in container handling equipment, terminal operators also need to consider systems efficiency, i.e. solutions that use technology and data to optimise operational eco-efficiency on a larger scale. The Terminal Operating System (TOS) and equipment control system (such as Kalmar TLS) are key components in ensuring optimum performance and efficiency at a terminal, and they also contribute significantly to the eco-efficiency of operations.

Beyond the core software of the terminal, equipment performance management solutions (e.g. Kalmar Insight) can bring together data from the entire fleet. Operators can aggregate data from multiple sites and access this information via mobile or other screens. Performance management solutions enable the real-time review of equipment fleets in operation by playing back relevant information and supporting decisions that will have an immediate impact on the terminal's business.

Process automation modules and digital services are typically the first solutions taken into use by terminals that seek to improve their performance and eco-efficiency through automation. Process automation improves the eco-efficiency of day-to-day operations by automating actions within the terminal that would previously have been performed manually. Automated systems ensure that equipment is always used optimally, and even with manually driven equipment, process automation solutions can assist operators across a range of operational tasks, by making it easier, quicker and safer for them to move containers. Applications range from automatic identification and tracking of incoming trucks and containers to fleet handling and tracking, automatic job allocation to crane operators, and anti-collision systems in the container stack.

RESOURCE EFFICIENCY

Finally, a key component of eco-efficiency is making optimum use of existing resources. For example, the lifetime of quay cranes can be extended significantly through festoon installation as well as the replacement or refurbishment of trolley rails, control systems, motors and cable reels. Crane heightening and boom extension projects are being undertaken at many terminals around the world, as port operators seek to make the best use of their existing equipment and meet the demands of handling new supersized container ships.

In addition to the modernisation of the main components (control system, electric motors, cabin etc.), both cranes and horizontal transport equipment can benefit from safety additions such as stacker platforms, boom anti-collision systems and improved cameras. Environmental and energy saving options such as electrification and/or fuel saving engine controllers can provide significant improvements to the eco-efficiency of existing machines. At the same time, automation and operator assisting features (e.g. spreader soft landing) also extend equipment lifespans by reducing wear and tear in use.

Rubber-tyred gantry cranes (RTGs) are the most popular equipment choice for container stacking at terminals around the world. With a global installation base of some 8,000 machines, approximately 60% of the world's container terminals use RTGs. Some 75% of installed RTGs are diesel-electric, but a significant percentage of new cranes operate on grid power.

RTGs have historically been powered by large constant-speed diesel generators, which are not optimal from the perspective of fuel consumption. In recent years, constant-speed generators have increasingly been supplanted by variable speed generators as well as smart power solutions that help reduce fuel consumption and emissions. RTG electrification is a major trend at container terminals worldwide. In addition to cost savings due to reduced fuel consumption at the terminal, RTG electrification significantly decreases emissions on-site.

Diesel Electric RTG (5,000 hours per year)

Consumption l/h	CO_2kg/hour	CO_2KG/YEAR	Annual CO_2 reduction in a 5 RTG fleet	Annual CO_2 reduction in a 20 RTG fleet
13 litres/hour	34.8	173,940	869,700	3,478,800
15 litres/hour	40.1	200,700	1,003,500	4,014,000
17 litres/hour	45.5	227,460	1,137,300	4,549,200
19 litres/hour	50.8	254,220	1,271,100	5,084,400
21 litres/hour	56.2	280,980	1,404,900	5,619,600
23 litres/hour	61.5	307,740	1,538,700	6,154,800

Electric RTGs produce zero CO_2, NOX and PM emissions at the point of use

Potential CO_2 emission reduction of RTG electrification

Emission factor used for calculations is 2.676 kgCO2e/l

INDUSTRY OUTLOOK

As container ports face increasingly stringent environmental regulations as well as a highly competitive global business landscape, port operators will need to focus on reducing emissions from their operations.

Currently, the demand for low-emissions and/or electric technology for container handling varies widely between geographies and industries. Several container ports around the world have already unveiled roadmaps that bring together all aspects of emission reduction or even eventually enable them to reach zero on-site emissions.

Many manufacturers – including Kalmar – believe that new container handling equipment will be, by default, electric-powered within the next decade. As a result, manufacturers are focusing significant resources on deploying electric drives in equipment. Kalmar has announced that its full offering will be available as electrically powered by 2021.

However, going electric is only one step in a larger future roadmap of improving efficiency in container and material handling. Automated and driverless systems are the ongoing next phase in the evolution, but electrification forms the basis for their adoption.

The electric and digital future is coming fast, and the discussion of how and when to accomplish this transformation needs to start right now. Eco-efficiency is becoming a standard in cargo handling, and to meet the demands of the future, terminals need to take a wider view on improving their operations. This perspective must encompass not only the eco-efficiency of current and future terminal equipment, but also systems and resource efficiency on a larger scale.

ABOUT THE AUTHOR

Peter is responsible for Offering Development at Kalmar comprising the widest range of cargo handling solutions and services to ports, terminals, distribution centres and the heavy industry. The portfolio covers a full range from Mobile Equipment including Reachstackers, ForkLift Trucks and Terminal Tractors to Cranes as well as Horisontal transportation, Automation and Software solutions. Currently the main task is to transfer the entire Kalmar portfolio into eco-efficient solutions through electrification, digitalisation and automation. Peter has over 30 years of extensive experience in Engineering, R&D, Strategy and Business Development with various research and development leadership positions from related industries such as the Volvo Group and BAE Systems.

ABOUT THE ORGANIZATION

Kalmar, part of Cargotec, offers the widest range of cargo handling solutions and services to ports, terminals, distribution centres and to heavy industry. Kalmar is the industry forerunner in terminal automation and in energy efficient container handling, with one in four container movements around the globe being handled by a Kalmar solution. Through its extensive product portfolio, global service network and ability to enable a seamless integration of different terminal processes, Kalmar improves the efficiency of every move.

ENQUIRIES

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