Electrification of RTG Cranes in Ports and Terminals

A PEMA Information Paper

This Information Paper is intended to provide an overview of the energy saving and emissions reduction possibilities available today through the electrification of RTG cranes for container yard operations.

The goal is to provide ports, terminals and other interested parties with information on the state-of-the-art in electrification technology, plus practical advice on the selection and implementation of electrification systems both for new cranes and in retrofit installations.

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INTRODUCTION

DOCUMENT PURPOSE

This Information Paper is intended to provide an overview of the energy saving and emissions reduction possibilities available today through the electrification of rubber-tyred gantry cranes (RTGs) for container yard operations.

The goal is to provide ports, terminals and other interested parties with information on the state-of-the-art in electrification technology, plus practical advice on the selection and implementation of electrification systems both for new cranes and in retrofit installations.

The technologies and approaches outlined in this Information Paper are designed and proven to save fuel and reduce emissions, with positive impact for users' bottom line, environmental stewardship, social responsibility and public image.

PEMA cannot advocate or decide which solution, or combination of solutions, is the right choice for any particular facility. However, the intent here is to contribute to industry awareness of the possibilities now available, and the issues and options that ports and terminals consider when making their selection.

ABOUT THIS DOCUMENT

This document is one of a series of Information Papers developed by the Environment Committee (EVC) of the Port Equipment Manufacturers Association (PEMA). The series is intended to inform readers about the design, application and use of equipment and technology to reduce the energy consumption and environmental impact of port and terminal operations.

This document does not constitute professional advice, nor is it an exhaustive summary of the information available on the subject matter to which it refers.

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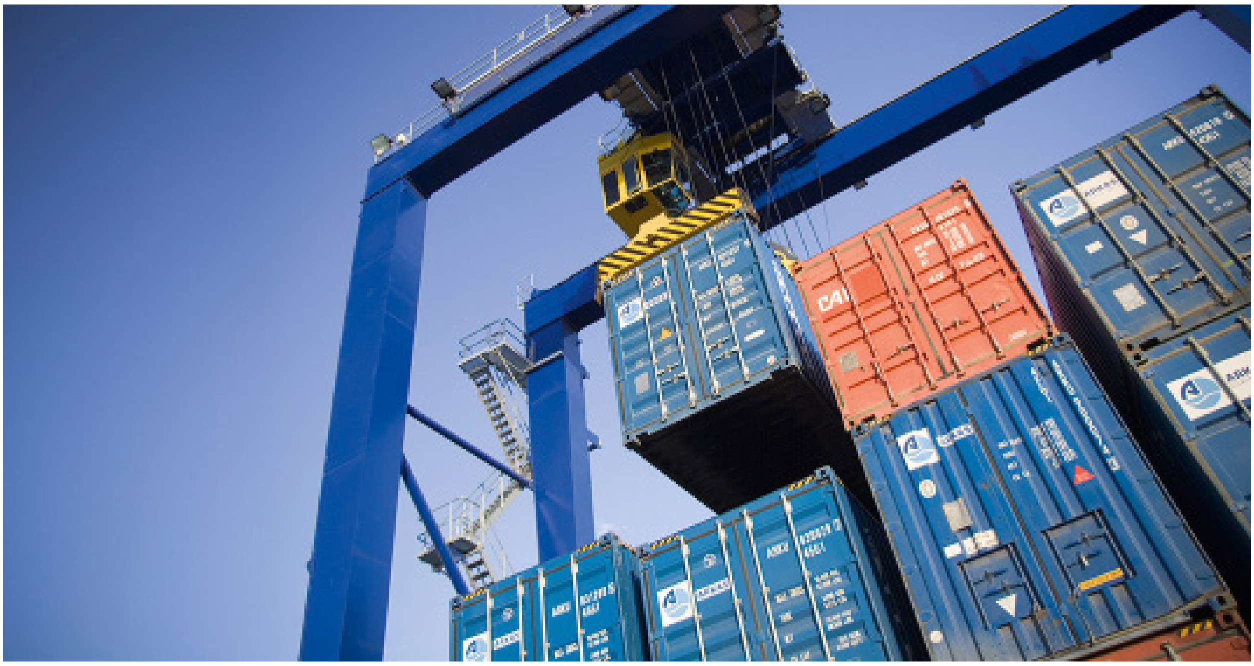


1 | EXECUTIVE SUMMARY

Ports around the world have been deploying ‘clean’ technologies pushed by a growing number of environmental initiatives and by a need to decrease dependency on fossil fuels for economic reasons.

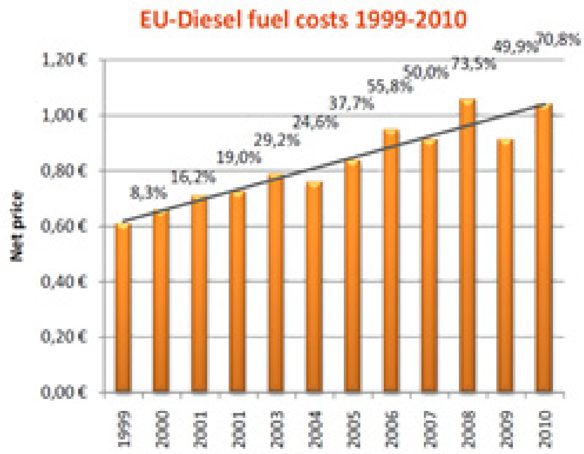
However, these technologies are at various levels of maturity and ports have different operational profiles. So, ports and terminals, beyond evaluating present needs, are also trying to ensure that their chosen pathways for development won’t lead them into a cul-de-sac – both when it comes to future legislation or the evolution of their own systems.

It is useful to understand the sweeping nature of the changes that have taken place in recent years. When the United Nations Framework Convention on Climate Change (UNFCCC) came into force in 1994, it set an overall framework for intergovernmental efforts worldwide to tackle the challenge posed by the impact of greenhouse gases (GHGs) on climate change.

Then in 2005, the Kyoto Protocol set binding targets for 37 industrialized countries and the European Community for reducing GHG emissions equating to an average of 5% against 1990 levels over the five-year period 2008-2012. For developed countries, this might even be increased to 30% by 2020 and 60-80% in the lead-up to 2050.

To date, diesel engines have been the main source of power for port handling equipment and vehicles. Therefore reducing emissions from these engines is now one of the keys to mitigating the hazardous effects of nitrous oxide (NOx) particulate matter (PM) both in and around terminals, as well as helping to meet national GHG reduction goals.

The environmental agenda is not the only driver for reducing the industry’s reliance on diesel: it is now also an economic cause for concern. During the container terminals’ big growth period of the 1980s and 1990s, diesel was one of the cheaper fuels. However, prices have risen steeply over the last 10 to 15 years and continue to do so. As the diagram shows, diesel prices in Europe increased 70% between 2009 and 2010. Other parts of the world have also seen significant increases in diesle fuel prices over recent years. Given that in some cases RTGs account for 50% of a container terminal’s diesel consumption, the economic imperative for taking action is as compelling as the environmental case.



Diesel fuel cost trends in the EU 1999-2010
Source: Conductix-Wampfler

Responding to these issues, the port equipment industry has made considerable progress over recent years in improving the performance of fossil-fuel driven equipment, as well as developing alternative power sources. As outlined in this Information Paper, electricity has now emerged as a viable alternative for powering RTG cranes in place of traditional diesel engines. The development and take-up of electrification has been quite swift over the past six years, and by 2012 an estimated 20% of RTGs worldwide were electrified.

There are now numerous types of electrification technology, some of which are already mature, but many of which are only now starting to show what kinds of cost and environmental yields may come from them. Energy regeneration is an example of low hanging fruit that is ripe for this market. However, although some technologies can successfully transfer from other sectors, others will require some entirely new equipment. Further, as yet there is no single pathway or system, and many synergies, such as data transfer and automation, are only now being explored.

2 | THE E-RTG TECHNOLOGY CONCEPT

With increasing pressure from the media, public and politicians to reduce reliance on fossil fuels and to decrease carbon dioxide emissions, plus fossil fuel costs at record levels creating a strong commercial imperative for action, it is not surprising that terminal operators have started to look for alternative energy supply solutions for RTG cranes.

Although there were some conceptual studies in the 1990s, it was not until 2006 that large-scale project developments started to convert diesel-powered RTGs to electrical RTGs, initially using cable reels. 2007 saw the first developments in China using conductor rail systems with plug connections. More recently, fully flexible 'drive-in' solutions have been successfully implemented in major terminal operations.

2.1 POLITICAL RESPONSES

Today, there are various working groups and committees around the world developing recommendations, special incentives and/or tax benefit schemes for terminal operators and shipping lines to reduce their fossil fuel consumption.

The graph below right shows the regional split of container throughput for the top 100 container ports worldwide. The majority of the containers today are handled in Asia, followed by Europe and North America.

2.1.1 ASIA

Alongside the need for Asian signatories to meet Kyoto's emission reduction targets, a number of Asian nations have been developing their own environmental targets. This includes China, where the government laid down goals for tackling carbon emissions in both its 11th and newest 12th Five-Year Plan, including a specific focus on reducing emissions levels at the country's container terminals. RTGs are widely used in Asian terminals, and due to fuel cost issues RTG electrification is anticipated to soon be a high priority for the whole region.

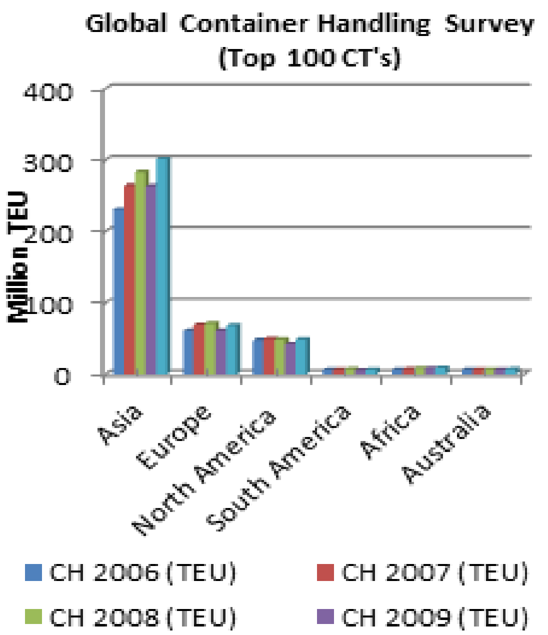
2.1.2 USA

The US Environmental Protection Agency (EPA) is an independent regulatory authority with a mandate to protect the environment and human health. In the ports

and terminals sector, EPA has developed the 'Clean Ports USA' programme. This is an incentive-based initiative designed to reduce emissions from existing diesel engines and non-road equipment, notable for its support of many innovative schemes.

2.1.3 EUROPE

Much has taken place under the Europe Commission's framework directive for Air Pollution, supported by moves such as the EC's 2007 Integrated Maritime Policy for European Ports which sets a 20% reduction target for Greenhouse gases by 2020, the European Ports Policy created in September 2008 and studies from bodies such as the European Sea Port Organization (ESPO) which demonstrate developing environmental management priorities.



Source: Conductix-Wampfler

3 | E-RTG SOLUTIONS

When in 2006 ports and terminal operators began to implement RTG electrification, the initial projects were based on available cable reel technology - as used already on rail-mounted gantry cranes (RMGs) or ship-to-shore (STS) cranes.

Today, there are several other technologies available and some of these have been specifically designed and developed for electrification of RTGs. One of the key challenges has been to maintain the flexibility of RTG cranes in container yard operations while at the same time reducing the dependency on fossil fuel energy. Today the market offers several proven and advanced solutions to convert RTGs to so-called 'E-RTGs'.

3.1 CABLE REELS

Cable reels in various spool designs and sizes have become standard for RMG cranes in container terminals worldwide. Cables, typically medium voltage designs, are wound onto large spools to enable linear travel along the crane rail. Spooling devices and cable protection systems guarantee safe operation.

Introducing cable reels on RTGs, which are designed to run not only in linear but in all possible directions, presents some special challenges both for the technology deployed and in terms of operational practicalities.

If the operation of an RTG can be limited mainly to linear travel inside a particular container block, the use of cables reels can be managed quite well. It becomes more difficult when the operation requires constant block changes and/or several RTGs operating in one single block. There is also a need to unplug and plug in again for block changes, a requirement that can cause significant delays.

In addition to operational challenges there are technical requirements that need to be considered for crane modification. The position of the cable reel on the crane needs to be defined according to the design of the machine and the mechanical structure.

Additional loads and mounting platforms may also need to be installed and there is significant extra weight. However, many new RTG cranes have cable reels pre-installed or are prepared for later fitting of cable reeling systems.

Using cable reels for RTG electrification means that no major structural work is required, in contrast to other approaches such as conductor rails. Many terminal operators view this as a significant benefit. However, as the retrofit of a cable reel on existing RTGs can be a significant project, the decision on the type of solution (reels or rails) is mainly driven by operational considerations and requirements.

Some challenges for cable reel implementation on RTGs can include:

- Significant additional weight and possibly mechanical modifications on the RTG
- The need to unplug and plug in again to change aisles
- Cable alignment between RTG and container stack and additional cable protection to avoid damage
- Additional measures have to be taken if a number of RTGs are to operate in any one lane

3.2 CONDUCTOR RAIL SOLUTIONS

Conductor rails - also known as busbar or conductor bar systems - are currently the preferred technology for overhead travelling cranes in most industrial applications. Conductor rails have proved over many decades to be a reliable means of providing energy to moving equipment, both indoor and outdoor, even in harsh environmental conditions.

The first use of conductor rails for RTG electrification was in China in 2007. The main concept, to provide a supported conductor rail system over the full length of a container block, has not changed since then. Today, around 75% of all converted and newly supplied E-RTG systems are electrified by conductor rails.

There are currently two main technologies to electrify RTGs with conductor rails: ‘Plug-In’ and ‘Drive-In’. In both systems, conductor rails are installed in parallel to the container block. The main difference is in the connection between the fixed rail and the mobile RTG cranes.

The main challenges for the conductor rail system include:

- When connected, there is a mechanical link between the E-RTG and the fixed structure so there is a need for safety devices to avoid accidental impacts
- The installation of the rail support on the yard fixes the layout of the terminal, making it more difficult to re-design it for future expansion or operational changes
- The Plug-In technology still retains the need to unplug and plug in again to change blocks, although this problem has been overcome with the Drive-In variant

3.2.1. PLUG-IN SOLUTION

The concept of an E-RTG with a plug connection is relatively simply. Electrical energy is provided through a conductor rail system running alongside the container block. The support structure of the conductor rails also includes a running track for a collector trolley.

The trolley, which holds the current collectors for 3-phase and earth connection, is pulled by a towing rope attached to the travelling RTG. The connection between the RTG and the rail system is managed by a cable and plug.

Plug-In systems are now well-proven as a practical, safe and reliable system, with several hundred installations worldwide. However, a downside is the connection and disconnection time when leaving

the block to transfer. This process can take several minutes and requires either the driver to climb down to perform this task by himself, or additional resources on the ground. Depending on the number of transfers required for the operation, this could be a significant time factor

3.2.2. DRIVE-IN SOLUTION

Drive-In systems also operate via an elevated conductor rail system, but the collector trolley is allowed to leave the rail at each end of the block through special drive-in zones and some mechanical assistance from the RTG.

Recent developments allow the change-over process to be managed by the driver direct from the cabin and the process takes less than one minute. Thus the Drive-In solution offers the full benefit of a conductor rail powered RTG without losing the flexibility of RTGs to move between blocks.

Many greenfield installations and an increasing number of new RTGs for existing facilities now specify Drive-In systems instead of Plug-In systems

3.3. OTHER TECHNICAL SOLUTIONS

In addition to the most commonly used reel and conductor rail solutions to electrify RTG cranes, a number of other technologies have been tested in various terminals around the world.

3.3.1 HIGH VOLTAGE POWER LINE

One such system, only trialled so far in a few test installations in China, is based on a concept drawn from the tram and trolley bus sector. Overhead power lines high above the top of the RTG supply power to the crane.

The requirement for supporting infrastructure with this system is significant. Also, the change from one block to another is complex and requires additional time and resources on the crane. However, the potential benefits include limited steel structures on the ground (except for several large towers) and ease of keeping crossroads clear for trucks or other handling equipment.

3.3.2 CABLE CHAINS

In some test applications energy chains have been introduced for E-RTG applications. The chain, including the installed cables, moves inside a dedicated above-ground guiding channel alongside the container stack. The connection between the RTG crane and chain is handled by a flexible arm that compensates for misalignments of the RTG.

This solution does however require additional personnel to change blocks, similar to the Plug-In and cable reel concepts. Further, the operation of several RTGs in one block is not easy to manage.

3.3.3 HYBRID CABLE REEL SKID SYSTEMS

Test installations have been set up to assess the possibility of separating the cable reel from the RTG by towing it on a separate trolley. So far only trial systems have been in operation.

4 | FUTURE TRENDS

The E-RTG is still a fairly new technology but in the several years since the first designs were introduced there has been rapid development driven by increasing market demand. This trend is expected to continue apace over the coming few years and the equipment industry is already working on even more advanced concepts for the future.

4.1 FULL E-RTG

On a 'full E-RTG' there is no diesel engine at all. The energy needed for a block change can be stored onboard using, for example, supercapacitors, batteries or other devices.

The major challenge of this concept is to store enough energy for the RTG to be able to move from one block to another without a diesel generator.

A key advantage however is that the energy which is released during lowering can be recovered (see section 4.5). The first test cranes are now in operation in Asia and the results so far look very promising.

4.2 FULLY AUTOMATED E-RTGs

Another trend set to emerge is the development of fully automated and electrified RTGs. The ultimate goal is to operate the RTG inside the block without any driver on board, while running on electricity.

One critical factor for the automation of RTG cranes is data communication. This can either be done by fibre optic technologies using cable reels on RTGs or by wireless communication systems parallel to the conductor rail system.

This development for RTGs is still in its early stages. However for RMG cranes the technology is well advanced and already used in more than 20 major terminals worldwide, with some very large projects also now under development.

4.3 DATA COMMUNICATION

In the future, the challenge will be to transmit information alongside the electricity and already terminals are putting phrases like 'full scale fail-safe data communication' into their electrification specifications.

While customers are initially considering low density 'process' data being transmitted to the terminal operating system (TOS) or other control software, this seems to be a step on the way to full automation of E-RTGs .

Therefore the issue is to help ports put in place a system that is not just able to be integrated into the TOS as it stands, but can also be a platform for the further development of remotely operated, semi or fully automated E-RTGs; position control already being a function of TOS systems. To this end, ports are looking at a high data transfer rate, around 100 mbps, which can send real, lifelike images to the control room that could enable the E-RTG to eventually be driven remotely.

4.3.1 INTERFERENCE

However ports are 'noisy' environments with radar and electrical interference from many different sources including unshielded generators, a proportion of which are beyond the operator's ability to dampen or control as they arise from visiting trucks and vessels of all descriptions. This means that any system that aims to go beyond merely being a process data connection has to be robust as 'fail-safe' issues like emergency stops are paramount for remotely operated or automated E-RTGs.

Cable reel E-RTGs are better able to cope with this kind of environment as they can simply run a fibre optic data wire along with the energy cabling. A physical connection such as this gives you an unlimited data rate as well as being very reliable and robust, with little interference.

Conductor rail E-RTGs on the other hand will have to rely on transmitted data links which need to overcome the issue of interference, so quite focused short range connections would seem to be best. Presently available technologies include:

- Industrial ethernet
- A 'leaky co-axial' data line which keeps noise to a minimum by limiting the pick up field around the cable.

- A 'slotted microwave guide' (SMG) data link that would be held within a steel profile (which shields the line) running alongside the energy bars.

4.4 POWER CONNECTIONS

There are a number of considerations about whether to use AC power straight from the grid or convert it to DC power. These choices are also entwined with the potential for energy regeneration.

For installations that do not have an energy regeneration component now, but may do so in the future, consideration must still be given to extending the necessary voltage distribution, as well as to designing the right configuration for feeding in and absorption of regenerative energy, in order to avoid future drastic reorganisation of the system, Note that every extension of the grid or crane numbers will need some kind of power compensation.

4.4.1 AC E-RTG CONDUCTOR RAIL OR REEL

Using a common DC-bus onboard the RTG is more efficient because it allows some onboard power sharing between the motion drives (travel, hoist, turn etc) if taking place simultaneously. However, there is good reason to consider using an AC grid input, whether this is a conductor rail or reel type E-RTG system.

The main benefit of an AC conductor rail or reel type E-RTG is that these designs take advantage of the grid's own power management systems. Further, both reel and conductor rail AC E-RTGs are relatively mature technologies, usually relying on a standard industry inverter that converts AC to DC onboard.

4.4.2 DC CONDUCTOR RAIL

An alternative would be a DC feed over the conductor rail. Overall there are fewer components in the system as only one rectifier is needed for multiple RTGs.

The biggest issue is that the power management would be generally more difficult. Most DC applications only have a short power run, whereas with a rail system this could extend to hundreds of metres. Components would also need to be very

much more robust than for normal industrial drives (others that use this technology such as trams and trains have specially designed drives and the crane industry would have to develop its own). With a DC system and multiple cranes there is also a chance of exciting a resonance that could generate high enough currents to destroy equipment. It would be hard to mitigate against this as the resonant frequencies will vary as the cranes move up and down the rails.

4.5 ENERGY REGENERATION

Energy regeneration is potentially 'low hanging fruit' for E-RTG systems. While most E-RTGs today are of the non-regenerative AC supplied kind that simply dissipate excess energy through resistors, tapping into and then storing energy regained from lowering a container on an E-RTG should be easier than with traditional diesel powered cranes because of the existing grid connection.

4.5.1 PREVIOUS DEVELOPMENT

Part of the groundwork is already in place as there has been some previous development of energy regeneration, mainly on standard RTGs, where batteries, superconductors or flywheels acted as an onboard energy store.

For example there has been a test project in China where superconductors were used to hold the power gained from the load's downward motion and others where flywheels or battery packs were used to absorb the regenerated energy then release it to supplement the power needed for peak loads.

These have their limitations: flywheels and super capacitors can absorb the regenerated energy quickly but can only hold it for a short period and battery packs don't recharge fast enough at present to make very efficient use of the brief, high-power burst of energy available (for more detailed analysis of hybrid systems, see PEMA's previous Environmental Technologies paper).

If a diesel engine were to be avoided completely for conductor rail systems, some kind of energy storage is needed to move the RTG between stacks. However, energy storage devices are still quite expensive and the savings, including environmental ones, should be quantified and compared to the investment to ensure a positive ROI.

4.5.2 REGENERATIVE AC SUPPLIED E-RTGS

An AC supplied E-RTG would replace the traditional inverter with a module that, as well as converting AC power to DC, would also be able to send clean regenerated energy back into the grid. Further, unlike DC units, there's no resonance risk.

On the other hand, AC conductor rail installations would best be advised to use a transformer between the conductor rail and the RTG's feed into the grid to isolate any electrical disturbances that could be passed between the cranes.

4.5.3 REGENERATIVE DC SUPPLIED E-RTGS

Regenerative DC connector rail units, with some development of their bars and brushes, could feed reclaimed energy directly back into the DC system. Further, they could also allow different RTGs to share regenerated energy between them (similar to the power sharing between movements onboard a single non-regenerative crane) making for possibly significant efficiency gains. However, again the power management is much harder to achieve.

5 | REFERENCES

The following is a reference list of ports and terminals known to have installed E-RTG technology. The list does not claim to be exhaustive, but gives an indication of the range of facilities worldwide now operating the various types of E-RTG technology.

AMERICAS REFERENCE LIST

Country	Operator/Location	Year	Type
Columbia	Contecar / Cartegena	2013	Conductor rail drive in
Ecuador	Contecon / Guayaquil	2011	Conductor rail plug in
Ecuador	Contecon Extension / Guayaqull	2013	Conductor rail plug in
Mexico	HPH/LCT Mexico I / Lazaro Cardenas	2012	Conductor rail drive in
Mexico	SSA Manzanillo / Manzanillo	2012	Cable reel plug in
Panama	HPH/PPC / Balboa	2012	Conductor rail drive in
Panama	ZPMC/PPC / Cristobal	2013	Conductor rail drive in
Panama	MIT / Colon	2009	Cable reel plug in
Panama	MIT / Colon	2011	Cable reel plug in
Panama	HPH/PPC / Balboa	2012	Conductor rail drive in
USA	WBCT / Los Angeles	2008	Cable reel plug in
USA	Georgia Ports Authority / Georgia	2012	Conductor rail drive in
USA	Georgia Ports Authority / Georgia	2012	Conductor rail drive in
USA	APM Terminals / Los Angeles	2013	Conductor rail drive in

ASIA PACIFIC REFERENCE LIST

Country	Operator/Location	Year	Type
China	GOCT 2 / Guangzhou	2013	Conductor rail drive in
China	GOCT 1 / Guangzhou	2012	Conductor rail drive in
China	NCT / Guangzhou	2010	Conductor rail drive in
China	NCT / Guangzhou	2012	Conductor rail drive in
China	NCT 2 / Guangzhou	2010	Conductor rail drive in
China	NCT P3 / Guangzhou	2011	Conductor rail drive in
China	COSCO HIT CT8 / Hong Kong	2011	Conductor rail drive in
China	COSCO HIT / Hong Kong	2008	Conductor rail plug in
China	HIT / Hong Kong	2008	Conductor rail plug in
China	HIT CT4 / Hong Kong	2011	Conductor rail drive in
China	HIT CT4 / Hong Kong	2011	Conductor rail drive in
China	HIT CT4.1 / Hong Kong	2007	Conductor rail plug in
China	HIT CT9 / Hong Kong	2011	Conductor rail drive in
China	HIT CT9 / Hong Kong	2011	Conductor rail drive in
China	MTL / Hong Kong	2011	Conductor rail drive in
China	MTL / Hong Kong	2010	Conductor rail drive in

ASIA PACIFIC CONT'D

Country	Operator/Location	Year	Type
China	MTL CT9 / Hong Kong	2008	Conductor rail plug in
China	MTL CT9 / Hong Kong	2008	Conductor rail plug in
China	Ningbo Beilun 3 / Ningbo	2007	Conductor rail plug in
China	Test phase / Ningbo	2010	Conductor rail drive in
China	SCT / Shenzhen	2007	Conductor rail plug in
China	SCT 1 / Shenzhen	2008	Conductor rail plug in
China	SCT 2 / Shenzhen	2008	Conductor rail plug in
China	SCT 3 / Shenzhen	2009	Conductor rail drive in
China	SCT 4 / Shenzhen	2010	Conductor rail drive in
China	SCT 5 / Shenzhen	2010	Conductor rail drive in
China	YICT 3a / Shenzhen	2007	Conductor rail plug in
China	YICT 3A / Shenzhen	2009	Conductor rail plug in
China	YICT 3E/1 / Shenzhen	2009	Conductor rail plug in
China	YICT 3E/2 / Shenzhen	2009	Conductor rail plug in
China	YICT 3E/2 / Shenzhen	2011	Conductor rail plug in
China	TACT / Tianjin	2008	Conductor rail plug in
China	TACT / Tianjin	2010	Conductor rail plug in
China	TOCT / Tianjin	2008	Conductor rail plug in
China	DDCT / Xiamen	2008	Conductor rail plug in
China	HTCT / Xiamen	2008	Conductor rail plug in
China	NCCT / Yinkgkou	2010	Conductor rail drive in
China	YKCT / Yingkou	2010	Conductor rail drive in
China	YKCT extension / Yingkou	2011	Conductor rail drive in
China	YKGP / Yingkou	2010	Conductor rail drive in
China	YKGP / Yingkou	2010	Conductor rail drive in
China	YKPG / Yingkou	2011	Conductor rail drive in
China	NCCT / Yingkou Port	2008	Conductor rail plug in
India	Adani / Hazira	2012	Conductor rail drive in
India	Adani CT2 / Mundra	2011	Conductor rail drive in
India	Adani CT3 / Mundra	2012	Conductor rail drive in
Japan	NUCT / Nagoya	2011	Conductor rail plug in
Japan	NUCT T2 / Nagoya	2010	Conductor rail plug in
Japan	KYCT/ Yokohama	2007	Cable reel plug in
Japan	Mitsui MES / Hakata	2010	Conductor rail drive in
Malaysia	Northport / Klang	2012	Cable reel plug in
Malaysia	Penang / Penang	2011	Conductor rail drive in
Malaysia	APM Terminals / Tanjung Pelepas	2012	Conductor rail drive in
Malaysia	APM Terminals / Tanjung Pelepas	2013	Conductor rail drive in

ASIA PACIFIC CONT'D

Country	Terminal /Port	Year	Type
Singapore	Oakwell/PSA / Jurong Island	2012	Conductor rail drive in
Singapore	PSA Keppel / Singapore	2012	Conductor rail drive in
South Korea	4th Port Dong Bang / Busan	2008	Cable reel plug in
South Korea	Dongbu / Busan	2008	Cable reel plug in
South Korea	HBCT / Busan	2007	Cable reel plug in
South Korea	HBCT / Busan	2008	Cable reel plug in
South Korea	KCTC / Busan	2007	Cable reel plug in
South Korea	PECT / Busan	2008	Cable reel plug in
South Korea	Samjin Dongkook / Busan	2008	Cable reel plug in
South Korea	Samjin Dongkook / Busan	2008	Cable reel plug in
South Korea	Se Bang / Busan	2012	Cable reel plug in
South Korea	UTC / Busan	2007	Cable reel plug in
South Korea	UTC / Busan	2007	Cable reel plug in
South Korea	Korea Express / Gwangyang	2010	Conductor rail drive in
South Korea	E1 / Incheon	2008	Cable reel plug in
South Korea	Hanjin / Incheon	2009	Cable reel plug in
South Korea	Korean Express / Incheon	2009	Cable reel plug in
South Korea	Korean Express / Incheon	2010	Cable reel plug in
South Korea	Sun Kwang / Incheon	2007	Cable reel plug in
South Korea	Sun Kwang / Incheon	2009	Cable reel plug in
South Korea	Sun Kwang / Incheon	2006	Cable reel plug in
South Korea	KIT / Kwang Yang	2009	Cable reel plug in
South Korea	KIT / Kwang Yang	2011	Cable reel plug in
South Korea	Pyeong Taek / Kyungi-do	2009	Cable reel plug in
South Korea	Pyeong Taek / Pyeong Taek	2010	Cable reel plug in
South Korea	Jung II Terminal / Ulsan	2007	Cable reel plug in
Taiwan	Evergreen Terminal / Kaoshlung	2009	Conductor rail plug in
Taiwan	ULIC / Keelung	2013	Conductor rail plug in
Taiwan	Evergreen / Taichung	2011	Conductor rail plug in
Taiwan	Evergreen Taichung / Taichung	2013	Conductor rail plug in
Thailand	APMT LCB1 / Laem Chabang	2013	Conductor rail drive in
Vietnam	Saigon New Port./ Saigon	2009	Cable reel plug in
Vietnam	Saigon New Port./ Saigon	2009	Cable reel plug in
Vietnam	Saigon New Port./ Saigon	2010	Cable reel plug in
Vietnam	Saigon New Port./ Saigon	2010	Cable reel plug in
Vietnam	Saigon New Port./ Saigon	2011	Cable reel plug in
Vietnam	Saigon New Port ./ Saigon	2012	Cable reel plug in

EUROPE, AFRICA AND MIDDLE EAST REFERENCE LIST

Country	Terminal / Port	Year	Type
Portugal	PSA Sines / Sines	2011	Cable reel plug in
Russia	NCC Nutep / Novorossiysk	2007	Cable reel plug in
Russia	NCC Nutep / Novorossiysk	2011	Cable reel plug in
Russia	NCC Nutep / Novorossiysk	2010	Cable reel plug in
Russia	NUTEP II / Novorossiysk	2012	Cable reel plug in
Russia	NCC FPT/ St. Petersburg	2007	Cable reel plug in
Russia	NCC / Ust Luga	2010	Cable reel plug in
Russia	CJSC / Vladivostok	2011	Cable reel plug in
Turkey	Mardas / Ambarli	2011	Conductor rail drive in
Turkey	Borusan Lojistik / Borusan	2011	Conductor rail drive in
Turkey	OEM / Evyap	2012	Conductor rail drive in
Turkey	Evyapport / Evyap Sabun	2012	Conductor rail drive in
Turkey	Gemport / Gemlik	2011	Conductor rail plug in
Turkey	Kumport / Istanbul	2012	Conductor rail plug in
Turkey	Main Terminal / Istanbul	2012	Conductor rail plug in
Turkey	Marport / Istanbul	2011	Conductor rail plug in
Turkey	West Terminal / Istanbul	2012	Conductor rail plug in
Turkey	Yilport / Istanbul	2011	Conductor rail drive in
Turkey	Nemport / Izmir	2010	Cable reel plug in
Turkey	Nemport / Izmir	2011	Cable reel plug in
Turkey	PSA / Mersin	2012	Cable reel plug in
UAE	DPW Jebel Ali / Dubai	2011	Cable reel plug in

ABOUT THE AUTHORS & PEMA

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ABOUT PEMA

Founded in late 2004, the mission of PEMA is to provide a forum and public voice for the global port equipment and technology sectors, reflecting their critical role in enabling safe, secure, sustainable and productive ports, and thereby supporting world maritime trade.

Chief among the aims of the Association is to provide a forum for the exchange of views on trends in the design, manufacture and operation of port equipment and technology worldwide.

PEMA also aims to promote and support the global role of the equipment and technology industries, by raising awareness with the media, customers and other stakeholders; forging relations with other port industry associations and bodies; and contributing to best practice initiatives.

MEMBERSHIP OF PEMA

PEMA membership is open to:

- Manufacturers/suppliers of port equipment
- Manufacturers/suppliers of port equipment components
- Suppliers of technology that interfaces with or controls the operation of port equipment
- Consultants in port and equipment design, specification and operations

Please visit www.pema.org for more information or email the PEMA Secretariat at info@pema.org

PEMA CONSTITUTION & OFFICES

PEMA was constituted by agreement dated 9 December 2004 as a non profit making international association (association internationale sans but lucratif /internationale vereniging zonder winstoogmerk) PEMA is governed by the Belgian Law of 27 June 1921 on “associations without a profit motive, international associations without a profit motive and institutions of public utility” (Articles 46 to 57).

Company Number/ Numéro d’entreprise/ Ondernemingsnummer 0873.895.962 RPM (Bruxelles)

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