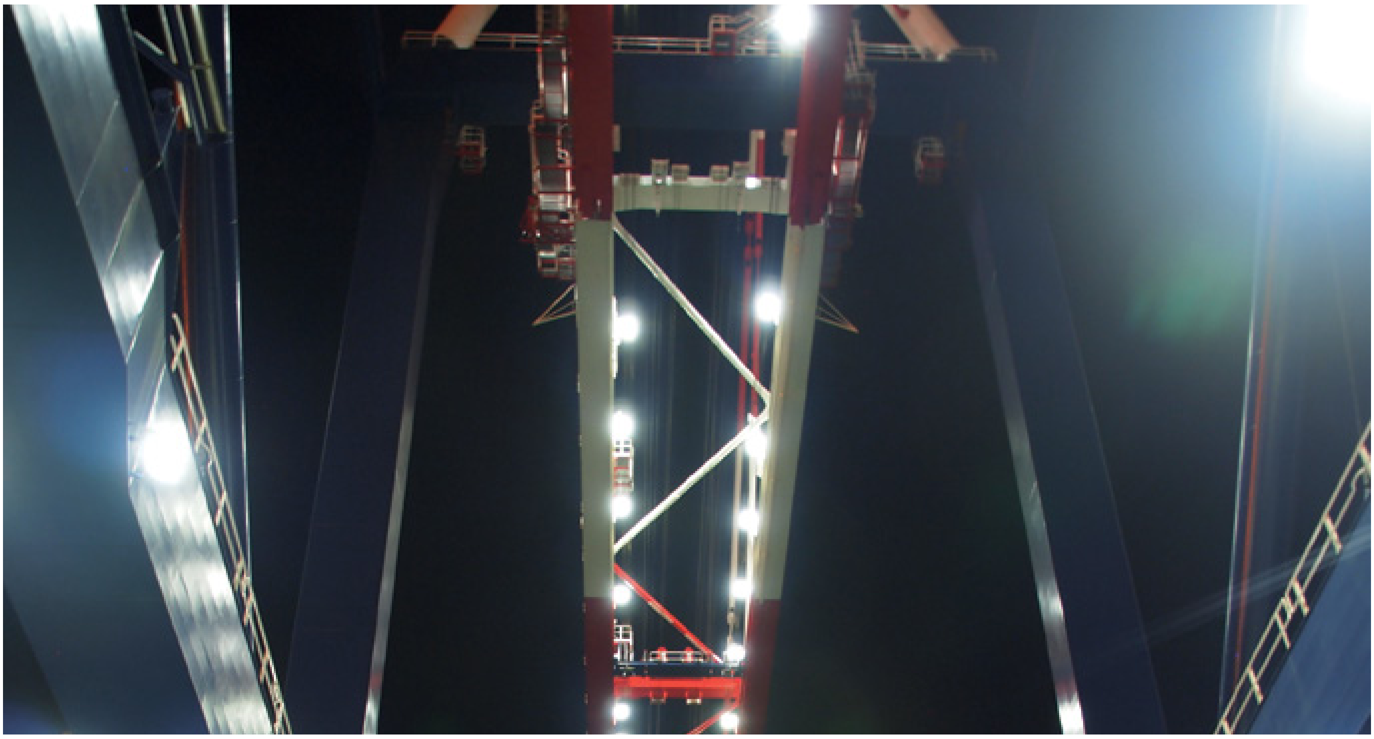
Lighting Technologies in Ports and Terminals

A PEMA Information Paper



This Information Paper provides an overview of the potential operational and environmental benefits of introducing new lighting technologies at ports and terminals.

PORT EQUIPMENT MANUFACTURERS ASSOCIATION

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INTRODUCTION

DOCUMENT PURPOSE

This Information Paper is intended to provide an overview of the potential operational and environmental benefits of introducing new lighting technologies at ports and terminals.

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

ABOUT THIS DOCUMENT

This document is part of a series of Information Papers developed by the Safety & Environment Committee (SEC) of the Port Equipment Manufacturers Association (PEMA). The Safety & Environment series is intended to inform readers about the design and use of equipment and technology to improve the safety of people, equipment and cargo, and to improve the energy and environmental performance, of port and terminal operations.

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1 | EXECUTIVE SUMMARY

Considerable improvements have been made to industrial lighting technologies in recent years with, for example, the development of Light Emitting Diodes (LED) and Light Emitting Plasma (LEP). While there may have been a tendency to assume that lighting is peripheral to effective operations, it is increasingly accepted that lighting has a considerable impact on safety, efficiency, the environment, and operating costs.

While the initial cost of installing newer lighting technologies is typically higher than conventional lighting options, energy savings and reduced maintenance can result in a return on investment, (ROI), being realised in a relatively short timeframe. Real case scenarios suggest that energy savings can amount to between 55 and 60 per cent; while maintenance costs can fall by up to around 90 per cent.

Ports that have introduced newer lighting technologies often report other operational benefits. Although these improvements do not directly affect the bottom line, they can have an impact and are therefore worth considering. Many handling equipment operators prefer newer lighting sources as such technologies tend to offer improved perception of surrounding areas, and reduced glare irritation in low light conditions. Furthermore, improved lighting tends to improve safety and result in reduced operator fatigue.

As new crane installations increasingly adopt remote operation systems that incorporate video displays, visual detail is increasingly becoming a key factor when considering lighting options. The sharpness of the picture, and accuracy of colour rendering depicted on remote screens, are influenced by light quality, and also have an impact on operator performance.

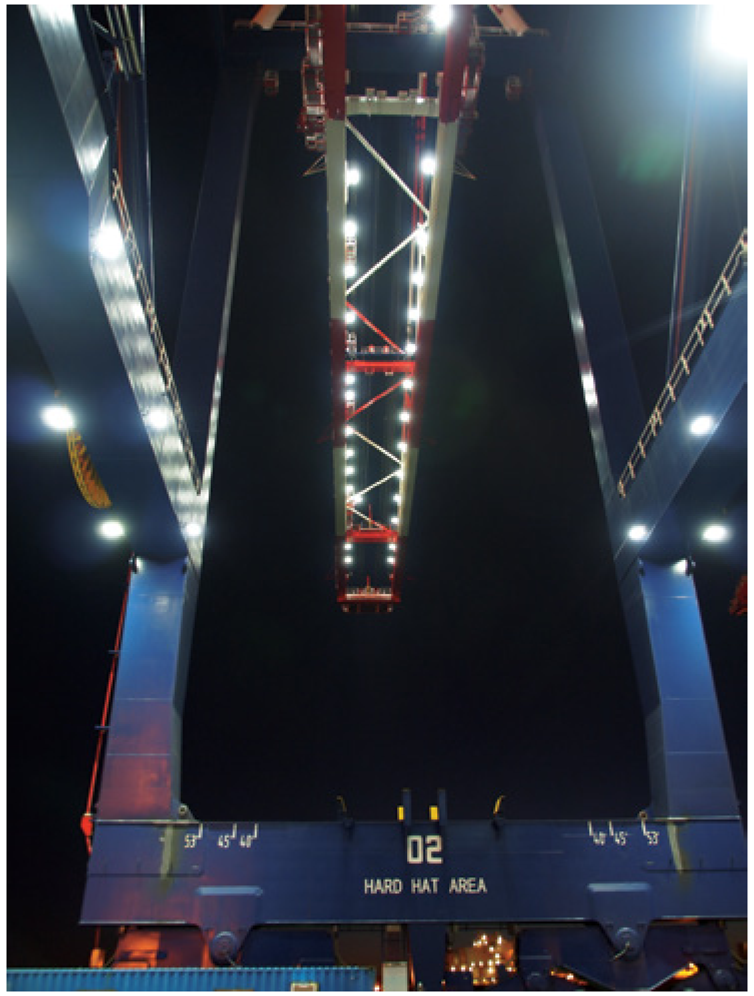
Areas that surround terminals also benefit from more modern light sources. Wildlife disturbed by light pollution has become an issue for many port cities. The directionality of newer lighting sources minimises nuisance levels of light, and promotes better relationships with both human and non-human neighbours.

LED Floodlight illuminating STS crane at Long Beach Container Terminal in Los Angeles, CA

The risk of accidents during lighting-related maintenance should also be considered when reviewing lighting options. Older lamps typically require replacement three or four times a year. The durability of newer technologies reduces maintenance requirements. The longer lifetimes of newer technologies, between 50,000 and 100,000 hours for some units, minimises replacement requirements and keeps technicians clear of active mobile equipment zones.

Further, newer lighting technologies, unlike many of their predecessors, tend to be at full illumination as soon as they are switched on. Conventional lighting solutions can take several minutes to achieve full illumination, which can leave areas poorly lit, or discourage operators from switching lights off in the first place, thereby wasting energy and resources. Newer light sources are typically immediately fully illuminated, making operators feel more comfortable about their surroundings, and allowing for improved movement around the yard or quay area.

Secondly, with the trend towards greater automation, lighting is simply not needed unless an automated area requires manual intervention or maintenance. In the past, it has been common to keep lights on for quick response maintenance.



LED Floodlight illuminating STS crane at Long Beach Container Terminal in Los Angeles, CA

With the instant-on quality of newer technologies, equipment may be operated with minimal lighting for the majority of the time.

While this paper focuses primarily on direct lighting of equipment, gate technologies, truck lanes, perimeter security, workshops and other machine-operator interfaces, near berth navigation and waterfront walkways are also likely to benefit from improved lighting quality.

2 | LIGHTING HISTORY

2.1 CONVENTIONAL LIGHTING TECHNOLOGIES

2.1.1 Metal Halide

Metal halide technology was developed in the 1960s. Although the efficiency of metal halide is perhaps less favourable to more contemporary technological developments, at the time it was an advanced technology. It provided a marked improvement to the mercury vapour options that had been developed previously. The colour rendering associated with metal halide is much higher than mercury vapour options, making it the preferred “High Intensity Discharge” option when colour accuracy is critical.

2.1.2 High Pressure Sodium

High-pressure sodium (HPS) lamps were developed around the same period as metal halide lamps. By using sodium, researchers developed an option with a greater degree of efficiency than other technologies available at the time. The amber glow of HPS fixtures is best suited for street lighting and industrial applications that do not require high colour rendering.

2.2 LIMITATIONS OF CONVENTIONAL LIGHTING TECHNOLOGIES

2.2.1 Maintenance

The lifetime of conventional lamps ranges from 2,000 to 40,000 hours. For fixtures that are continuously illuminated, this can result in relatively frequent replacement requirements.

2.2.2 Design Characteristics

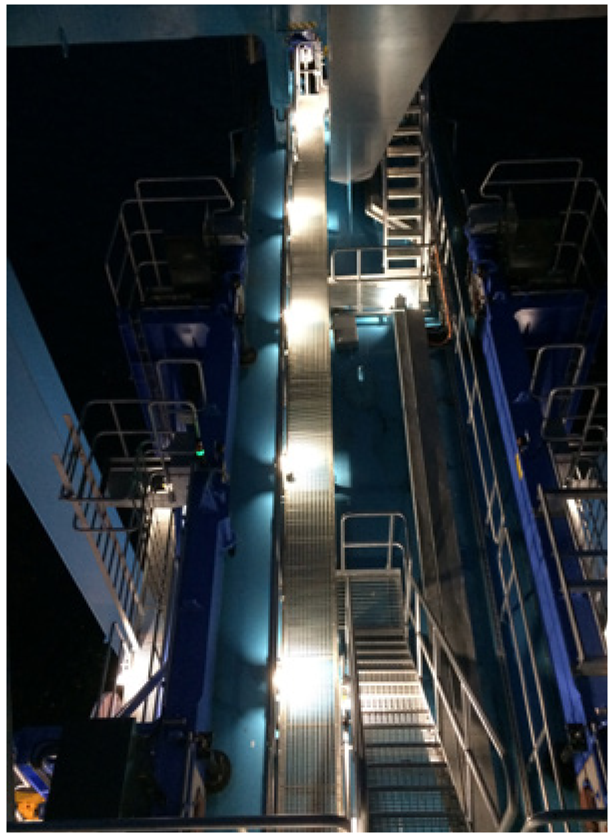
Conventional lamps tend to have larger profiles, a single source of light, and a reflector that traps considerable amounts of light. Although users enjoy a larger radius of light and wider coverage, the extent to which users are able to control and direct light is limited, and light loss can be considerable.

Warm-up periods can be lengthy with conventional lighting technologies. Metal halide and HPS lamps can take up to 20 minutes to reach full intensity following a restrike. This creates downtime, which can affect operations. Conventional lights are therefore often left on to avoid these warm-up periods.

Conventional lamps also tend to contain fragile components such as glass and filaments, thus increasing the risk of damage during transportation, installation and operation.

With some conventional lighting options, colours are not rendered entirely accurately. For example, under the amber glow of HPS fixtures, colours can become distorted.

Conventional lighting options also create energy that is not directly converted into light and is therefore wasted.



LED lighting on the walkway of an STS crane at a port in Norway

3 | LED TECHNOLOGIES

Although LED technology first appeared in 1962, it has only become more widely used in recent years due to a number of improvements in the technology such as light quality, increased efficiency, and enhanced sustainability.

3.1 MAINTENANCE

3.1.1 Integrity of the Light Source

LED fixtures – and comparable newer lighting technologies – typically have longer lifespans than conventional lamps, lasting between 50,000 to 100,000 hours. This substantially reduces unscheduled equipment downtime due to lamp replacement. These fixtures are also less likely to fail catastrophically; rather, they slowly dim, losing intensity. LED fixtures are determined to have "failed" when light output reaches 70 per cent of original levels.

LEDs are solid state devices containing no moving parts, no filaments and no glass, thereby reducing the risk of damage during transportation, installation and operation, even in demanding environments such as container and bulk handling applications. LED lights reach full intensity the moment they are switched on; and on/off cycles have no negative impact on expected lifespan.

3.1.2 Improved Safety

Access to light fixtures on container and bulk handling equipment can be challenging. With LED and other newer lighting fixtures, maintenance costs tend to be minimised, as re-lamping should not be required during the usable lifetime of the product. According to the Bureau of Labor Statistics in the US, 9 per cent of worksite conditions contributing to injuries involving longshore operations were bad lighting or low visibility.

3.2 DESIGN CHARACTERISTICS

3.2.1 Energy and Cost Savings

LED and other newer lighting fixtures use less energy than conventional light sources to provide more light output. Many operators that use LED lighting on container and bulk handling equipment have reported reductions in energy usage associated with lighting of up to 95 per cent.

3.2.2 Responsible Use of Light

New lighting technologies allow operators to have greater control over how light sources affect the surrounding environment in terms of light pollution, light spill, and glare.

LEDs and similar technologies are smaller and more controllable light sources than conventional options. Each LED, for example, can be controlled through lensing to direct light where it is needed, and reduce light pollution, light spill and glare. Compared to some conventional lighting, LEDs can decrease light pollution by up to 50 per cent, and energy waste by up to 70 per cent.

3.2.2.1 Light Pollution

Light pollution refers to wasted artificial light directed upwards to the sky. It causes an otherwise dark sky to be illuminated with excessive, unnecessary lighting from below. Light pollution disturbs wildlife, wastes energy and obscures our view of the night sky. Organisations such as the International Dark-Sky Association are increasing the industry's awareness of light pollution in an effort to "preserve the night". The association has instituted a certification programme for manufacturers of lighting fixtures to minimise light pollution.

3.2.2.2 Light Spill and Light Trespass

Light spill refers to light that is cast in unintended spaces. Conventional lighting technology and inefficient design are the main causes of light spill. Light trespass is a more severe variety. It is a type of light spill characterised by excessive light creating a nuisance.

3.2.2.3 Glare

Glare is a visual sensation created by excess, uncontrolled brightness. It is a key lighting design factor to consider, especially for outdoor applications. Glare can be characterised in two ways: 'discomfort glare' creates an irritation and/or eventual pain for an operator; and 'disability glare' creates an actual reduction in visibility. Either issue impairs the ability of a person to perform tasks and affects productivity and safety.

3.2.3 Light Quality

Due to the light quality and the precise directional nature of newer technologies, traditional lighting fixtures can often be replaced with fewer, newer fixtures. In many of those installations where newer technologies have been installed, users have reported increases in light levels – doubling in some areas – even with fewer fixtures. The defined optics of, for example, LED lighting has also been found to illuminate areas that were previously considered unreachable with conventional lighting options. Overall, productivity and working conditions can be improved while usable space can be maximised.

3.2.3.1 General Operator Feedback

Positive operator feedback regarding newer lighting technologies continues to emerge across the industry. In addition to the reduction in glare, compared to conventional lighting, such fixtures can improve light quality and night visibility due to higher colour rendering and increased uniformity.

3.2.3.2 Colour Temperature

LEDs can vary in colour from a very blue, cool white light to a more yellow, warmer white light. Colour temperature is measured in Kelvins on a scale of 1,500 to 8,000. The higher the number is, the cooler the colour temperature. LED lights typically fall within a range of 4,000K to 6,000K while traditional technologies have a warmer temperature. High-pressure sodium lamps have a colour temperature of about 2,200K, and metal halide lamps range from 3,800K to 4,000K.

Colour temperature impacts the way that colours are seen and the general mood of an environment. Higher colour temperatures often produce a highly rendered light but can cause a location to feel cold and impersonal. A warmer light can decrease the rendering of colours but will create a more relaxed, comfortable setting. The importance of colour and mood to the application should be considered when choosing a colour temperature for LED fixtures.

3.2.3.3 Colour Rendering

Newer lighting alternatives typically have a broad colour spectrum, allowing colour identification of more than 70 per cent. These qualities will also improve the visual images captured by remote cameras.

3.2.4 Disposal

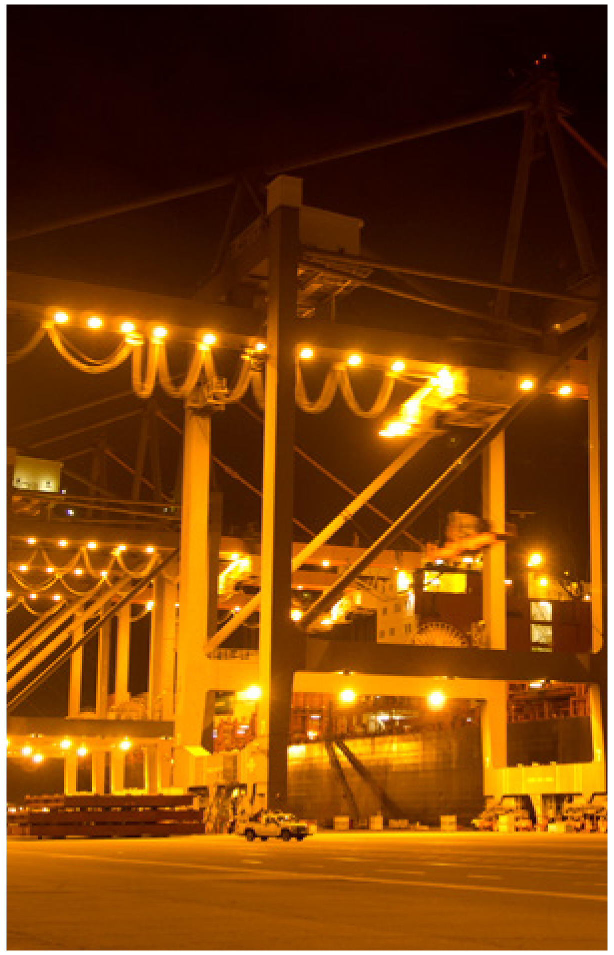
Newer lighting alternatives do not generally contain hazardous materials, thereby allowing for easy disposal of the fixture after its service life. Metal halide lamps contains small amounts of mercury. Although this does not pose a risk to users, such lamps should be collected separately for disposal.

3.3 ROI

The initial cost of installing newer lighting technologies tends to be higher than conventional lighting techniques. However, with respect to container and bulk handling equipment, the energy savings, elimination of lamp and ballast replacement, and reduced maintenance costs can be sufficient to pay for newer lighting technologies after as little as one to two years, especially if specified on new equipment.

Some utility companies also offer incentive programmes for users of newer lighting technologies, further improving ROI.

Rising electricity costs could also increase ROI of newer technologies, and for applications that require fewer fixtures to achieve the same light output, costs could be further offset.



High pressure sodium lighting on an STS crane at Port of Los Angeles

4 | CURRENT AND EMERGING TRENDS

4.1 PROGRAMMING

Floodlights using newer lighting technologies, and installed on equipment such as ASC trolleys and girders, can be programmed to remain switched off during normal operations. This reduces energy use and light pollution. Programming can be optimised with LED technology since lights are instantly at full intensity. Without that benefit, the productivity lost during long warm-up times would exceed the benefits of turning the lights off when they were not in use.

LED floodlights illuminate an ARMG crane at a US port

4.2 DIMMING

Another control option that LED technology offers is diming. A system can be installed that controls light output from zero to 100 per cent for certain areas that do not require full illumination at all times. Adjustments can be made for the time of day or night, and for the type of activity occurring in given illuminated areas. When an operator has multiple light sources in one fixture, the potential opportunities are considerable.

4.3 THE DEVELOPMENT OF LED TECHNOLOGY

The efficiency of LED technologies continues to be developed with, for example, energy use decreasing relative to light output. In just three years, the typical efficacy of an LED fixture has increased from 60-80 lumens per watt to more than 100 lumens per watt.

Table 1: Comparison of key characteristics for HID and LED lighting features

Characteristic	HID	LED
Cost		30-50% higher cost than HID
Rated Life	2,000-40,000 hours	50,000-100,000 hours
Directionality	Larger radius of light; up to 90% light loss	Control of light minimizes light pollution, light spill and glare
Colour Temperature	<4000K – not representative of natural light	4,000-6,000K – mimics natural daylight
Colour Rendering	25% colours not seen accurately	More colour accuracy
Disposal	Hazardous contents; separate collection	No special disposal requirements
Energy Usage	Up to 90% of energy not converted into light	Up to 95% less energy usage than HID
Controls	Limited ability to incorporate lighting controls	Allows for simple integration of programming and dimming

4.4 LED LIGHTING ON EQUIPMENT

The specification of LED light fixtures on ASCs is becoming increasingly widespread in the ports and terminals sector. The same is true of STS cranes, and LED fixtures on walkways, and in interior spaces, are also more and more common. LED technology with main floodlighting on STS cranes continues to increase, although this is not yet the industry standard.

LED floodlighting on an STS crane in Norway

4.5 LIGHT EMITTING PLASMA

Another developing lighting technology is LEP. LEP lamps have no electrodes, no glass-to-metal seals, and no secondary materials inside the capsule making them efficient and robust. LEPs also offer a high degree of light output directionality, and the ability to dim instantaneously, (to around 20 per cent of full power).

LEP and LED have been chosen for high mast and yard lighting applications, but both technologies currently face challenges in reaching the required illumination levels when mounting heights exceed 40m, or poles are spaced beyond certain distances from one another.

LED lighting on an ASC at a port in the Netherlands

5 | CONCLUSIONS

Conventional lighting technologies remain popular across the industry for a variety of reasons, including, crucially, relatively low installation costs compared to newer technologies, and colour rendering advantages in certain applications. However, a growing number of operators are discovering the operational and environmental benefits of newer lighting technologies.

While requiring greater initial investment, newer technologies tend to offer longer operational lifetimes, reduced maintenance requirements, and superior performance when compared to many conventional lighting techniques.

Furthermore, newer lighting technologies such as LED and LEP, continue to evolve, suggesting that further improvements in safety, operational and environmental performance could be realised with such technologies in the years ahead.

ABOUT THE AUTHORS & PEMA

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ABOUT PEMA

Founded in 2004, PEMA provides a forum and public voice for the global port equipment and technology sectors. The Association has seen strong growth in recent years, and now has more than 95 member companies representing all facets of the industry, including crane, equipment and component manufacturers; automation, software and technology providers; consultants and other experts.

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.

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PEMA membership is open to:

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- 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

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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).

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