

A Cold Ironing Study on Modern Ports, Implementation and Benefits
Thriving for Worldwide Ports

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Thesis

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A Cold Ironing Study on Modern Ports, Implementation and Benefits
Thriving for Worldwide Ports

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ABSTRACT

Cold ironing lately is receiving much attention and being promoted as a prime strategy for reducing air emission generated from global maritime industry. This study focuses on the key role of cold ironing towards a “Greener Commercial Maritime Community”.

Although many different strategies are applied in modern worldwide ports, the concept of shore powering the ships while at berth is attracting much attention, with significant both financial and scientific sources being directed towards the adaptation / implementation of cold ironing technology.

This report presents an in-depth analysis of cold ironing application in modern ports and the benefits in an environmental and financial point of view.

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Chapter I

This report presents an in-depth analysis of specific air Emissions Control Options (ECO) that may be available now and in future to a wide variety of modern sea ports globally. The study focuses on providing shore-based energy to vessels while at berth, for powering a range of on-board activities. This technique is often referred as “Cold Ironing” or formally known as “Alternative Marine Power” (AMP). This report also takes under consideration the various challenges that emerge from the operation of cold ironing techniques in modern ports, in grounds of financial – technical – social and regulatory issues. Cold Ironing lately is receiving much attention, being promoted as one of the prime strategies, bearing great significance, with major contribution in reducing air emissions generated from global maritime industry. This report focuses on the key-role of Cold Ironing towards a “Greener Commercial Maritime Industry”.

1.1 What is Cold Ironing?

Cold ironing is a process where shore side electrical power is provided to ocean-going vessels, allowing them to shut down auxiliary diesel generators while they are docked.¹

The electrical power needed to keep running emergency equipment, cooling/heating, lighting and any other equipment (“hotelling activities”) is provided by a shore based generator or even directly from the port city’s power grid. The actual term comes from the act of turning off all internal-combustion engines and as a result “the vessel is going cold”. It first came into use when a range of vessels were equipped with fired iron clad engines; while these vessels were at berth there was no need of feeding the fire producing steam, used for propulsion, so the engines would lower their external temperature eventually going cold. In modern maritime industry it simply reflects the practice of connecting a vessel to an external shore based energy production facility.

The concept of “plugging in” a vessel at port allows completely shutting down all vessels’ diesel generators and practically eliminates pollution coming directly from shipboard emissions, especially in the port cities and the surrounding areas suffering from sooty air. Cold Ironing has been a practice for several decades in the military, and now is being seriously campaigned and developing for the global commercial shipping sector.

The power required for the vessels’ to continue its activities at berth is provided by a variety of sources: port city’s own power grid, in-port power plants or even via renewable energy sources. The last practice is by far one of the most environmental beneficial ways for applying cold ironing techniques, using a clean energy source and practically eliminating air emissions throughout the cold ironing chain.

¹ (Workgroup Recommendations and Other Potential Control Measures Diesel Initiatives Workgroup, Melinda Dower, 1/2/2007)

1.2 Background of Cold ironing

During the past years there has been a strong campaign for the necessity of using alternative marine power (AMP) at ports. This has resulted in serious commitments both from a statutory and industry point of view. The state of California is one of the leading authorities in imposing cold ironing at ports, with a number of regulations (*zero emission policy*). On the other hand the maritime industry has demonstrated numerous initiatives in complying with future air emissions limits and going as “green as possible”.

Initiatives for Air Emission Reduction at California and West Coast (US) Ports

The State of California is home to three of largest ports in US and also to a number of several other major ports, with San Pedro Bay Port of Los Angeles and Long Beach comprising the largest container port complex in US and the third largest globally. Statistical data illustrates a 40% increase of port traffic in Los Angeles and Long Beach ports, with future estimations suggesting that California ports traffic would be triple by 2020, compared to 2005 levels.

Evaluating all the above, California ports are already putting serious efforts in reducing air emissions with cold ironing dramatizing a significant role. The Port of Los Angeles No Net Increase (NNI) policy, an emission reduction strategy drafted by the port’s authority, declares the rollback of air emissions to October 2001 levels. One of proposals included in NNI requires the cold ironing of all passenger ships that call in the port five or more times per year. The Port of Long Beach adopted a *Green Port Policy*, intended to alter the port operations in a manner they comply with more environmental friendly standards. The port is under the commitment to provide shore based power to all new container terminals and even container terminals being in the process or reconstruction. This would result in the port requiring a number of vessels to utilize Alternative Marine Power (AMP) while at berth. Cold Ironing projects were currently being under development in three berths at the time of December 2005.

In early 2006, shore side power facilities construction, at berths 212-221 in the Port of Los Angeles were planned to be completed. The main purpose has been the provision of NYK Atlas container ship with shore side electrical power. The vessel was built in 2004 with cold ironing capabilities.

The Port of Los Angeles has already installed Alternative Marine Power (AMP) Infrastructure at pier 400 with plans to do so at berth locations 206-209. Within 2009, P&O Nedlloyd as the tenant of container terminal is required under the current lease signed, to provide the 70% of ships calling with shore sided power. Moreover the Port authority is seeking to expand cold ironing infrastructure at their terminal servicing passenger ships.

The Port of Oakland is on the process of evaluating the feasibility of installing shore power to its terminals, while the Port of San Francisco is pursuing funds for the potential building of shore based project at ship passenger terminals at Piers 30-32. Finally the Port of San Diego is considering providing passengers ships with AMP at B-Street Pier, a facility the port authorities plan to redevelop.

China Shipping Terminal (terminal 100) in Los Angeles port was retrofitted and shore based power plants were installed for ships to be plugged-in while “hotelling”. Following the trends, Princess Cruises, “one of the premiere cruise lines in the world” carrying “more than a million passengers each year”², has developed cold ironing infrastructure on board of several of the fleet’s cruise liners.

Efforts in reducing emission from a regulatory point of view

The following future air emissions reduction goals are outlined in the *South Coast Air Basin State Implementation Plan (SIP)* during 2003, the *Air Resources Board (ARB)* draft concerning *Goods Movement Emission Plan*, and also the *ARB Diesel Risk Reduction Plan*. In 2003, a revision of the South Coast Air Basin State Implementation Plan (SIP) generated additional requirements to Air Resources Board (ARB) for evaluating the use of cold ironing to ships with frequent scheduled visits to South Coast (US) ports. Moreover, the Air Resources Board (ARB) has documented a draft titled: *Emission Reduction Plan for the Ports and International Goods Movement in California* (December 1, 2005). The main purpose of this plan is the identification of several strategies for reducing air emission as a result of goods movements through California ports, including ocean-going vessels. ARB has signified the use of Cold Ironing as a potential strategy in these efforts for lowering air emissions. Additionally, the Air Resource Board established a future goal for reducing diesel PM in the air of California up to 85% by the year 2020, with cold ironing being recognized as a “major contributor” in achieving that goal.

² As proclaimed by the cruise company itself, <http://www.princess.com/aboutus/>

1.3 Environmental issues for Cold ironing

*“Emissions from shipping due to the combustion of marine fuels with high sulphur content contribute to air pollution in the form of sulphur dioxide and particulate matter, harming human health, damaging the environment, public and private property and cultural heritage and contributing to acidification. Human beings and the natural environment in coastal areas and in the vicinity of ports are particularly affected by pollution from ships with high sulphur fuels. Specific measures are therefore required in this regard”.*³

Ships traditionally were not subject to air emissions controls. The needs for electricity are met with the combustion of Heavy Fuel Oil (HFO) while hotelling. Many measurements indicate that one single ship is contributing to air pollution as high as 50 million vehicles per year, a fact that led to new regulations and mandates across the world aiming to decrease vessel generated air emissions.

The shipping industry is under pressure for controlling and reducing the GhG emissions produced by world sea trade. CO₂ is nowadays an issue of global significance and awareness. Additionally SO_x, NO_x & Particulate Matter, pollutants emitted directly from marine diesel engines have local & regional health and environmental impact. Seaport activities and are held responsible as “major” air pollutants:

*“...port activities are major contributors to smog and soot pollution that are responsible for 5,400 premature deaths ...140,000 incidences of asthma and respiratory problems, and nearly one million lost work days each year.”*⁴ Evidently, environmental issues consist one of the major motives for applying cold ironing in modern, with heavy traffic, ports.

Numerous reports indicate the alarming increase of CO₂ emissions in world scale contributing to greenhouse effect. Greenhouse effects such as global temperature rising and the elevation of sea level debate for the most significant challenges that world population will have to deal with. It has been made obvious that strong counter measures against global warming must be put into effect. The claims on behalf of maritime industry, as one of the greener forms of transporting freight globally, lies on the fact that much greater tonnage is carried by each vessel, compared with aircraft, trucks or cars, for the exact same amount of CO₂ emitted in the atmosphere.

Due to human activity there has been produced and emitted as much as 29,195,000,000 metric tons of CO₂ in the year 2006. This measurement is from burning fossil fuels without taking under consideration CO₂ production from deforestation etc. The data were collected by CDIAC⁵ for United Nations. US, a major pollutant with 5,752,289,000 metric tons of CO₂ is responsible of 20.2% of global emissions. Recent data released by International Energy Agency (IEA) presenting the world major contributors in GhG emissions suggesting that China is currently the greatest carbon dioxide emitter, with 21.5% of total CO₂ coming from the world largest country in matter of population. The emission rate has climbed up since past years and now is needed only 6.4 seconds for producing 1000 tons of CO₂!

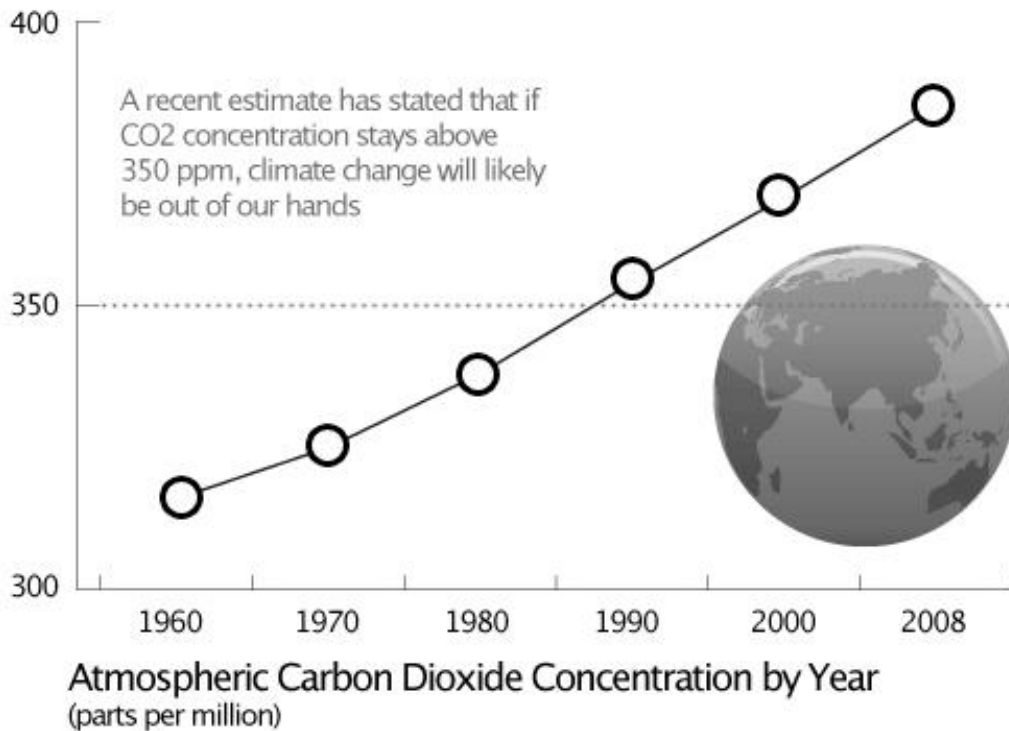
The amount of CO₂ total emissions for maintaining successfully the global temperature rising below the critical threshold of 2°C is 750bn tons between today (2009) and 2050. The rise of 2°C is widely claimed to be the boundary for “keeping under human control” an irreversible climate alteration in

³ *Official Journal of the European Union, 22.7.2005, DIRECTIVE 2005/33/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 6 July 2005 amending Directive 1999/32/EC*

⁴ *Barbara Boxer, United States Senator*

⁵ *Carbon Dioxide Information Analysis Centre: The CDIAC is an organization within the United States Department of Energy that has the primary responsibility for providing the US government and research community with global warming data and analysis as it pertains to energy issues.*

forthcoming years. On the other hand, strong objections are made, claiming that only a rise of 1.5°C due to global heating is acceptable and must be imposed as a realist goal. Measurements show that a single ton of CO₂ emitted is responsible for rising 0.00000000000015°C world temperature. Otherwise, keeping worldwide emissions at present current level, predictions are in favor of facing severe threats and worst case scenarios triggered by global climate change.



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Despite the fact that GhG emissions have effect on a world scale, the amount of CO₂ produced among various countries and territories is not equally distributed. 35 countries combined together are responsible for 90% of total CO₂ emissions. This list is referred as the C90 countries list, indicating the gap that exists between different industrial countries on how much they pollute the atmosphere. In December 2009 the United Nations Climate Change Conference took place in Copenhagen, Denmark. It includes the 15th Conference of the Parties⁷, mostly known as COP 15, to the United Nations Framework Convention on Climate Change⁸. The scope of this summit is to reach an agreement on climate change mitigation policies and strategies beyond 2012, year when Kyoto protocol⁹ “expires”. The countries and territories participating around the world are over 170 and among them major maritime countries. These maritime nations are accountable for 3.5% up to 4% of all climate change emissions caused by shipping.¹⁰ IMO has been campaigning strongly on the direction of applying policies and regulation on ships’ emissions.

The First Intercessional Meeting of the IMO Working Group on GhG Emissions from shipping industry was held in Oslo, Norway on 23-27 June, 2008. It was tasked with “developing the technical basis for the reduction mechanisms that may form part of a future IMO regime to control greenhouse gas

⁶ Source: www.environmentguardian.co.uk, www.nextgenpe.com

⁷ <http://en.cop15.dk/>

⁸ <http://unfccc.int/2860.php>

⁹ http://unfccc.int/kyoto_protocol/items/2830.php

¹⁰ John Vidal, environment editor, guardian.co.uk, Thursday 9 April 2009

emissions from international shipping, and a draft of the actual reduction mechanisms themselves, for further consideration by IMO's Marine Environment Protection Committee (MEPC¹¹)". Additionally, the Merchant Shipping (Pollution) Act is an Act of Parliament passed in the United Kingdom in 2006. It has three main purposes: to give effect to the Supplementary Fund Protocol 2003, to give effect to Annex IV of the MARPOL Convention, and to amend section 178(1) of the Merchant Shipping Act 1995.

All these parts of legislation and regulations make clearly the absence of a holistic framework on ships' emissions, especially those ones contributing mostly to greenhouse effect. Although maritime industry causes environmental pollution in numerous ways, some forms of pollution bare more significance compared to others. The regulations introduced by MARPOL include a variety of counter pollution measures. Incidents of sea environment pollution, as oil spills and chemical pollution have been drastically reduced during the last two decades, after implementing the MARPOL measures and regulations. These measures have been shown to be a successful step towards mitigating environmental impacts of shipping.

Although air pollution from ships does not have the direct cause and effect with, for example, an oil spill incident, it is a cause for a cumulative effect that combines to the overall air quality problems encountered by populations in many coastal areas, and also affects the natural environment, such as through acid rain.¹²

Air pollution from ships has been under international attention and criticism the last years due to high pollutant factors contained in vessel engines emissions. Despite the fact that aviation industry was held account for many years as critical pollutant, shipping industry is receiving lately much more criticism and attention over the emissions generated by large vessels. Exhaust emissions from ships are considered to be a significant source of air pollution, with 18-30% of all nitrogen oxide (NOx) and 9% of sulphur oxide pollution.¹³ The 15 largest ships emit about as much sulphur oxide pollution as all cars combined. Despite the numbers and "voices" implying that maritime community is one of key factors of global pollution, comparison of pollution data taken from automobile, airborne, railway and ship transportation systems display the efficiency/pollution factor of each transportation way. While a large vessel is a great pollutant itself, taken under consideration the amount of freight (e.g. oil products) carrying against the emissions direct from vessel's engine reveals the greater efficiency that seaborne trade via large ships has when compared to truck or air freight transportation.

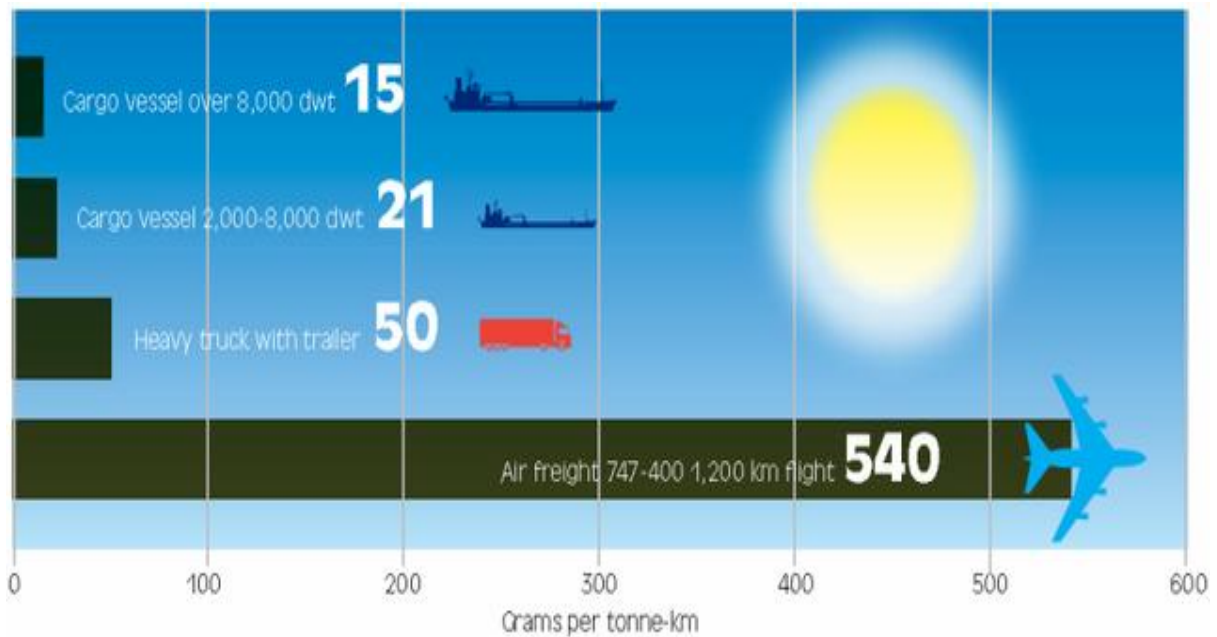
"Tim points out that the airline industry is much more high profile than the shipping industry, despite the fact that shipping is underpinning global trade. While we have to board the plane ourselves when we go on holiday, it's easy to forget about the ships that brought us those pineapples from Africa and DVD players from Asia Another example is the high profile of the large aircraft manufacturers and airlines: Boeing, Airbus, United Airlines and British Airways are all household names. Now name a company with a similar profile that makes big boats or sells ocean passages? Anyone?"¹⁴

¹¹ http://www.imo.org/newsroom/mainframe.asp?topic_id=109

¹² IMO and the Environment 2009 leaflet

¹³ John Vidal, environment editor, guardian.co.uk, Thursday 9 April 2009

¹⁴ Ships, planes, and carbon emissions, Catherine Brahic, Online environment reporter, March 05, 2007



90% of global trade is via sea with ships carrying billion of tonnage through world sea pathways .It is made obvious the great significance of sea trading when these numbers are taken under consideration. However it is not a justification for continuing in the future years with an unregulated shipping industry in matters of GhG emissions. Annex IV of MARPOL, under the sponsorship of International Maritime Organization, targets in lowering NOx, SOx and particulate emissions of ocean going vessels by imposing strict emission control of the diesel engines over 130 kW built after 01/2000. The parts that Annex IV of MARPOL focuses are on regulating the emissions generated by diesel engines on ships, by imposing a wide range of goal-based standards. Although the ultimate target of Annex IV lies in the abatement of pollution at seas, there is not currently a corresponding regulatory authority in global scale (MARPOL is under the IMO umbrella), defining the threshold of air pollution at seaports.

The next major target is towards port air pollution mitigation and several serious efforts must be put into accomplishing that goal. Amongst the various ways proposed in this direction, cold ironing techniques are emerging as one of the key strategies for modern seaports, in their effort for reducing and regulating in future port air pollution.

1.4 Social Issues for applying cold – ironing

The sector of marine transportation is a major contributor to air pollution significantly to coastal areas worldwide. Oceangoing vessels directly emit to the atmosphere as high as 1.2 – 1.6 metric tons of PM with diameter of 10 µm or less, specified as PM₁₀, 4.7–6.5 tons of sulphur oxides SO_x, and 5–6.9 tons of nitrogen oxides NO_x.¹⁵ Taking under consideration that roughly 70% of ship emissions occur in a range of 0-400 km from land, ongoing vessels have the potential of polluting highly the coastal areas.

In recent years the direct link between PM and negative health effects have been under serious investigation by many scientific researches mostly in health sector. There are serious indications associating PM with a range of health impacts including asthma, heart attacks, and hospital admissions. Particularly PM_{2.5} has been categorized to bear great responsibility in health effects as cardiopulmonary and lung cancer mortalities in populations exposed in coastal areas.¹⁶ Approximately 0.8 million deaths globally (1.2% of total premature mortalities annually) are estimated as a result of PM_{2.5}. With figures reaching alarming levels, ship air emissions are under focus for regulation in a global scale, taking under consideration that shipping industry is practically borderless.

In *ENVIRONMENTAL SCIENCE & TECHNOLOGY (VOL. 41, NO. 24, 2007)* an interesting paper on mortality from ship emissions states: “Our results indicate that shipping-related PM emissions from marine shipping contribute approximately 60,000 deaths annually at a global scale, with impacts concentrated in coastal regions on major trade routes. Most mortality effects are seen in Asia and Europe where high populations and high shipping-related PM concentrations coincide”¹⁷.

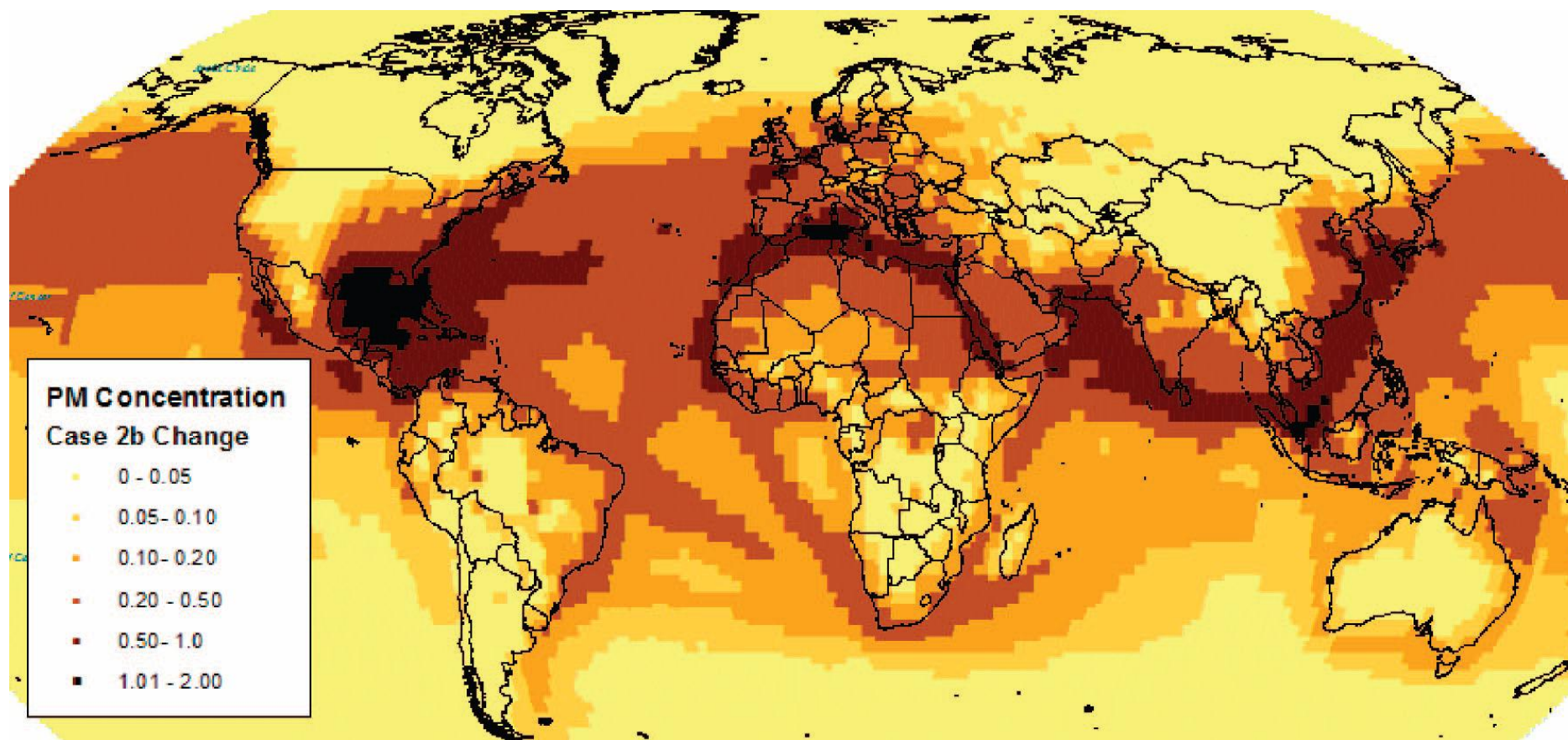
It is obvious that mortality numbers and health benefits could be realized in many areas globally by the mitigation of ship air emissions, particularly with effort to reduce PM_{2.5}. The assessments provided using the model, refer to several areas with high ship traffic although it is safe to identify similar areas that may experience same effects without long term measurements and cost. Moreover the results extracted are in accordance to regional health impacts data, fact that can prove encouraging in future global air emissions models development.

Average contribution of shipping to PM_{2.5} concentrations are show below in global and regional scale according to the specific model.

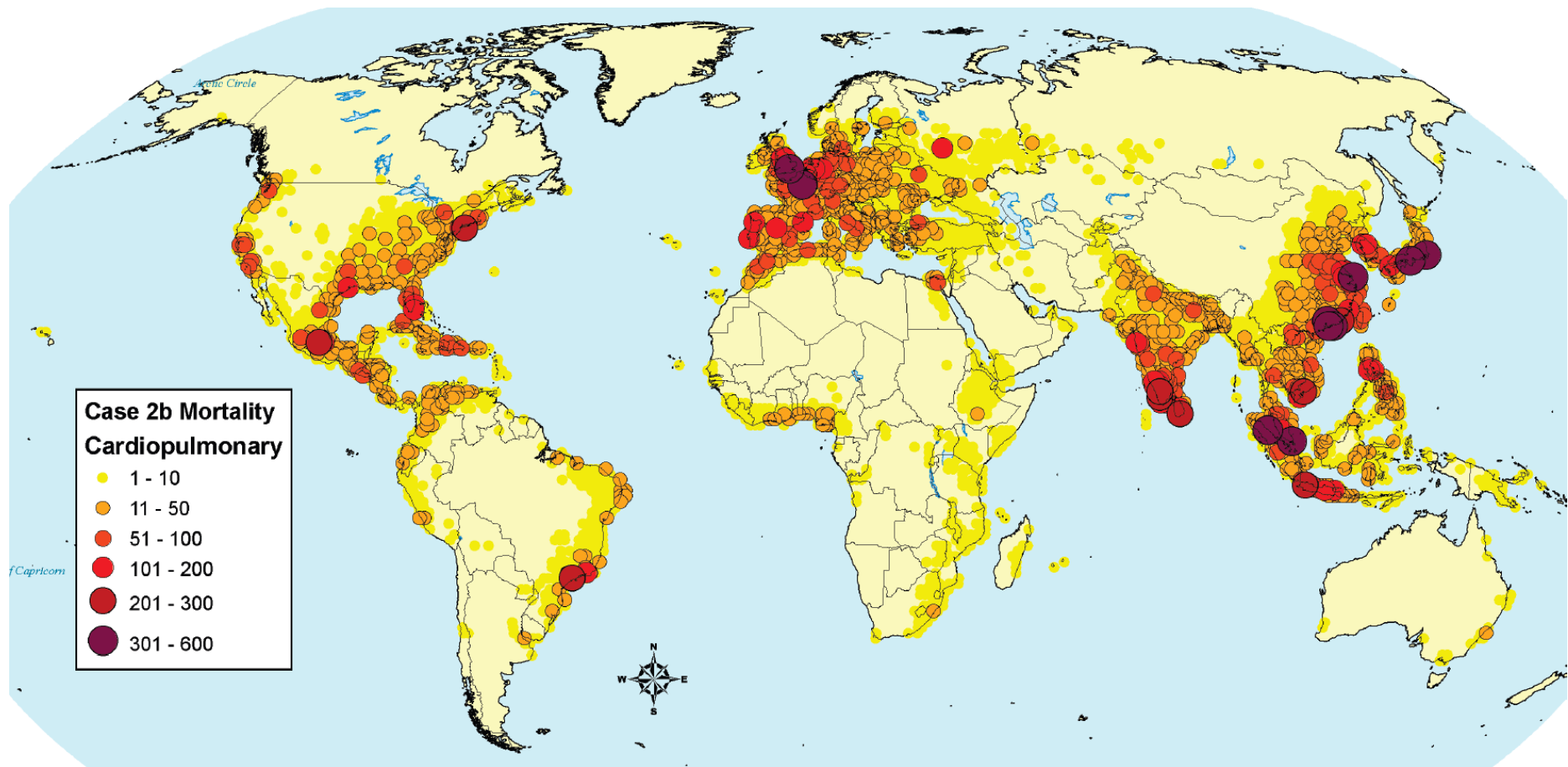
¹⁵ Corbett, J. J.; Koehler, H. W. Updated Emissions from Ocean Shipping. *J. Geophys. Res., D: Atmos.* **2003**, *108* (D20), 4650–4666. Corbett, J. J.; Wang, C.; Winebrake, J. J.; Green, E. Allocation and Forecasting of Global Ship Emissions; Clean Air Task Force and Friends of the Earth International: Boston, MA, January, 11, 2007; 26. Eyring, V.; Köhler, H. W.; van Aardenne, J.; Lauer, A. Emissions from international shipping: 1. The last 50 years. *J. Geophys. Res., D: Atmos.* **2005**, *110* (D17), D17305. Endresen, O.; Soergaard, E.; Sundet, J. K.; Dalsoeren, S. B.; Isaksen, I. S. A.; Berglen, T. F.; Gravis, G., Emission from international sea transportation and environmental impact. *J. Geophys. Res., D: Atmos.* **2003**, *108*, (D17.)

¹⁶ Pope, C. A.; Burnett, R. T.; Thun, M. J.; Calle, E. E.; Krewski, D.; Ito, K.; Thurston, G. D. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. *JAMA* **2002**, *287* (9), 1132–1141.

¹⁷ JAMES J. CORBETT, *, † JAMES J. WINEBRAKE, ‡ ERIN H. GREEN, † PRASAD KASIBHATLA, | VERONIKA EYRING, † LANDAXELLAUER †



Annual average contribution of shipping to PM_{2.5} concentrations (in µg/m³)



Cardiopulmonary mortality attributable to ship PM2.5 emissions worldwide

The entire above are clearly demonstrated in the directive of 2005/33/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 6 July 2005 stating amongst other interesting things the link between vessel air pollution and public health:

“Emissions from shipping due to the combustion of marine fuels with high sulphur content contribute to air pollution in the form of sulphur dioxide and particulate matter, harming human health, damaging the environment, public and private property and cultural heritage and contributing to acidification.”¹⁸

Except the measurements in mortality numbers, another aspect in need of further investigation is the public health perspective. Although the casualties are measured more or less precisely in the “air pollution war”, an index for estimating public health is hard to be defined. This is for measuring and estimating numerous and frequently elusive criterions, such as the “quality of an individual’s life” or even something as much immeasurable as “happiness index”¹⁹. It is although undisputed that heavy traffic ship areas are in the red zone regarding the attention that must be given on improving public health indexes.

A way of depicting the social impact of ship air pollution and the environmental degradation is by measuring health impacts by a much measurable and “cynical” aspect: by monitoring the social security costs regarding health expenses. Observing the increasing cost of health care as a result of air pollution and subsequent losses in manpower and work hours in local industries note the financial impact that ships air emission may have on regional economies. This is by no means an appropriate manner to reach conclusions in the kind of Environmental Control Options (ECO) needed to reduce ships air emissions but rather a way to visualize impacts on public health. (E.g. Downsizing the money spend for hospitals does not always indicate higher “public health standards” but also a possible reduction in hospital staff or medicine production costs.) USA has a total expenditure on health as a percentage of gross domestic products as high as 16.2% for 2009 against a 2.2% of Eritrea.²⁰ Nobody may suggest that the quality of health services provided is leveled.

Papers on “Health and Climate Change”²¹ are promoting the idea that tackling climate change by reducing CO₂ and GhG emissions will have major direct health benefits, especially in low income countries. Along the health standards improvement main economical benefits could be achieved. This fact must be taken under consideration when national negotiations are taking place.

Moreover, raising health standards by reducing GhG emissions may result in less health expenditure. *“Air quality standards announced by the EPA are estimated to yield health benefits in the USA of between 13 and 100 billion dollars.”²²* On January 25, 2010 the US Environmental Protection Agency proposed a tightening in national standards for NO_x pollutants and ozone in ground level. This is an outcome of the responsibility that EPA bears in protecting the public health.

¹⁸ DIRECTIVE 2005/33/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 6 July 2005 amending Directive 1999/32/EC

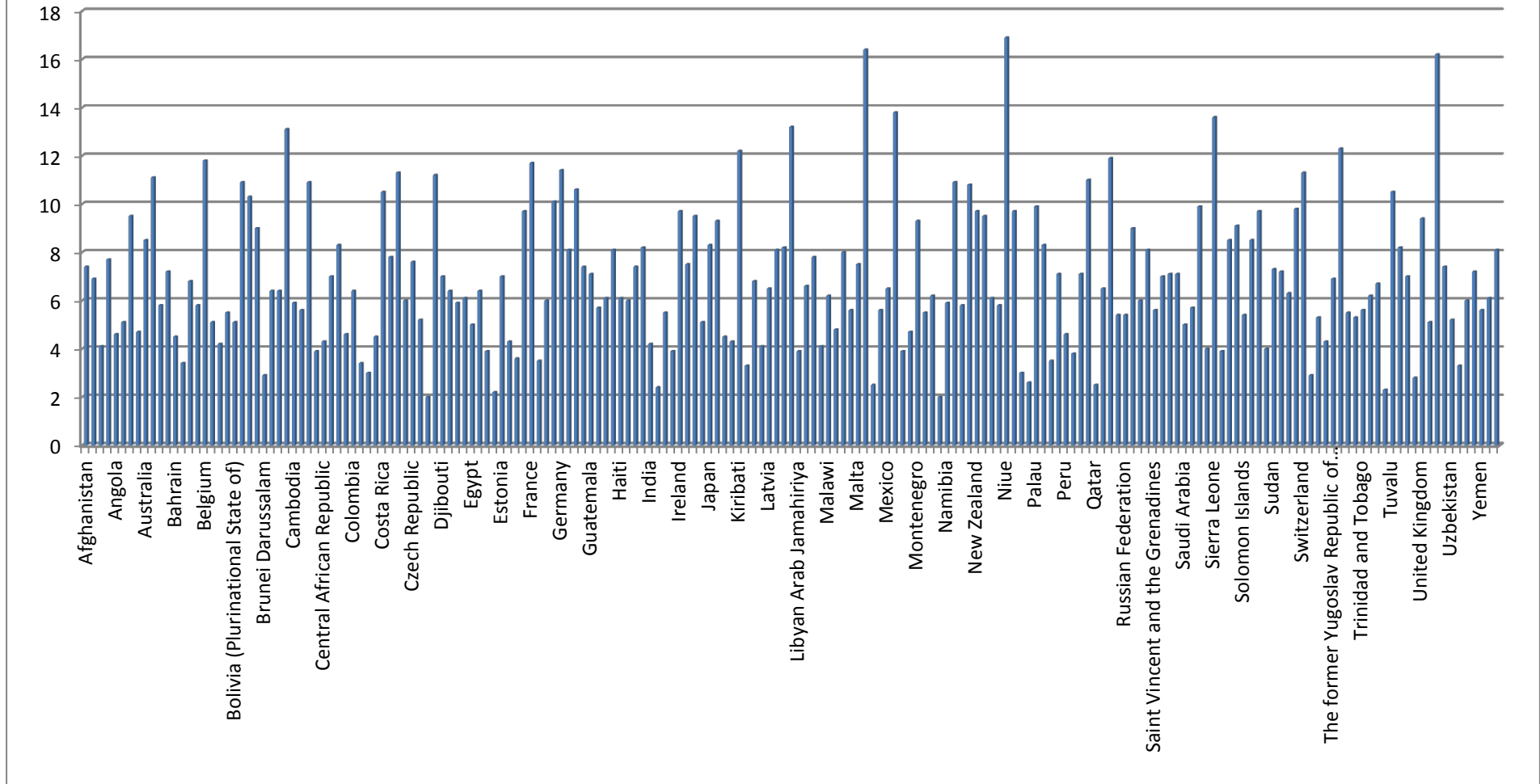
¹⁹ The index combines environmental impact with human well-being to measure the environmental efficiency with which, country by country, people live long and happy lives. Learn about the ideas behind the HPI, how it is calculated, why we need it and what it can teach us. <http://www.happyplanetindex.org/>

²⁰ Global Health Observatory Data Repository

²¹ MARTENS Pim, Health and climate change

²² Christer Ågren, Great health benefits from new US air quality standards

Total expenditure on health as a percentage of gross domestic product



²³ Data collected and analyzed from <http://www.who.int/research/en/> regarding health finance.

Port cities such as i.e. Los Angeles, Long Beach, Hong Kong, Piraeus, suffer from high levels of air pollution in form of particulate matter. This is an immediate effect of the economical significance they bear as major hubs in a globalised market. Since the majority of products are transported via sea routes the equilibrium of traffic is not balanced.

Breaking down the principle contributors of environmental degradation, especially in aspects of air pollution, some key factors are indentified.

Ship generated pollution: heavy fuel engines produce large amounts of CO₂, NO_x, PM_{2.5} and PM₁₀. In fact large scale transoceanic ships are considered *“the worst mobile source polluters on the planet. The 90,000 registered ocean going vessels worldwide are estimated to emit up to 3 percent of the total world inventory of greenhouse gas emissions”*.²⁴ These pollutants are emitted also in the regional area of the city - port hub. In the case of NO_x pollutants it also a contributor to the formation of ozone, a severe health threat lying over port cities. It is common practice for the vessels to stay from several hours up to days in terminals while the main engines and /or auxiliary generators are operating. Most container ships are propelled by a very large low-speed diesel engine. Onboard electrical power is provided by three to five auxiliary diesel engines, ranging in size from 500 kW to 3 MW each. It is arguably a notable source of emissions in port regions.

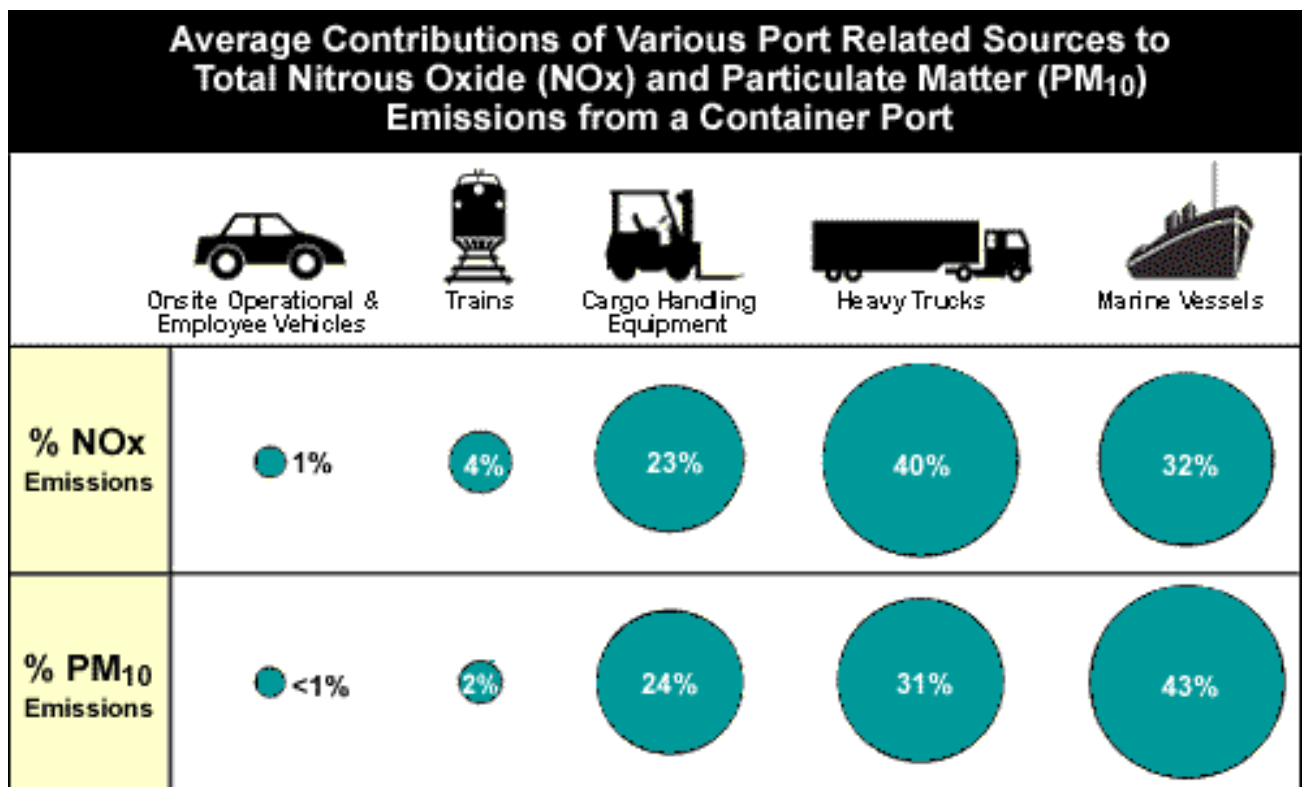
Harbor craft: Needs for two tugboats per ship is the average on most large vessel types in order to be guided safely into their births. Tugboats are considered greedy energy consumers given fact the large engines they have onboard. In full load condition these engines produce substantial levels of pollution. Moreover, when tugboats are idling, approximately 50% of their service time, the emission levels measured are notable. The idling of a tugboat requires the engines running and ready to respond to current workload that may occur. This fact means additional emissions in the air, port air specifically because this type of vessels operates inside the local port environment.

Cargo Handling Equipment emissions: In the case of containerships, once the TEUs are removed from vessels a sophisticated network of large fixed electric cranes is used for the handling process. Tractors on port sites, the most common equipment for cargo handling, are essentially downsized heavy duty trucks operating heavy duty diesel engines. Rubber tired gantry and smaller straddle cranes are other examples of cargo handling equipment. The cargo handling installations are non-tight controlled pollutants, because of their specific role in port operations. Instead cars are subject to international law and regulation due to the fact that 750 million of them are crossing the world's roads. This comparison shows how much “dirtier” an engine can be in terms of emissions, when it is used for certain operations. The engines in cargo handling vehicles meet off-road engines emissions standards, lagging at least a decade behind on road trucks. Cargo handling equipment is a capital pollutant in port areas and nearby residential areas, pointing out that an integrated strategy must be implemented for reducing harmful emissions. Port pollution counter measures may require the modernization of the fleet of cargo handling equipment, retrofitting the engines so more green fuels is used, like natural gas or electricity produced by renewable energy plants, replacing off-road diesel engines with modern complying with on road standards.

In port vehicle generated pollution: Despite the boost in using eco-friendly technology during recent years in cars (many of us are proud owners of hybrid or electrical cars), heavy duty trucks and cargo

²⁴ U.S. Container Ports and Air Pollution: A Perfect Storm, An Energy Futures, Inc. Study By James S. Cannon

trains operating within port facilities, exhaust notable amounts of pollutant factors. An estimated 30,000 fleet of trucks are routinely involved in the transportation of products towards and inwards the ten most important US ports. Due to the fact that it is a privatized sector of port operation, a controversy is created between financial sustainability and at the same time ecologically sensitive. Moreover the transportation via rail is a key factor of pollution in port area. Locomotives engines are overall more efficient in comparison with long diesel trucks. But the regulatory frame of locomotive operating is nearly uncontrollable. This means that rail engines predate almost every emission standard set for automobiles. A significant detail: a capable number of switching locomotives are operating exclusively within port limits and used in the transportation chain by facilitating only the first part of the process. By doing so the emission generated are “trapped” in the regional area, adding with more pollutants the already sooty air nearby port cities.

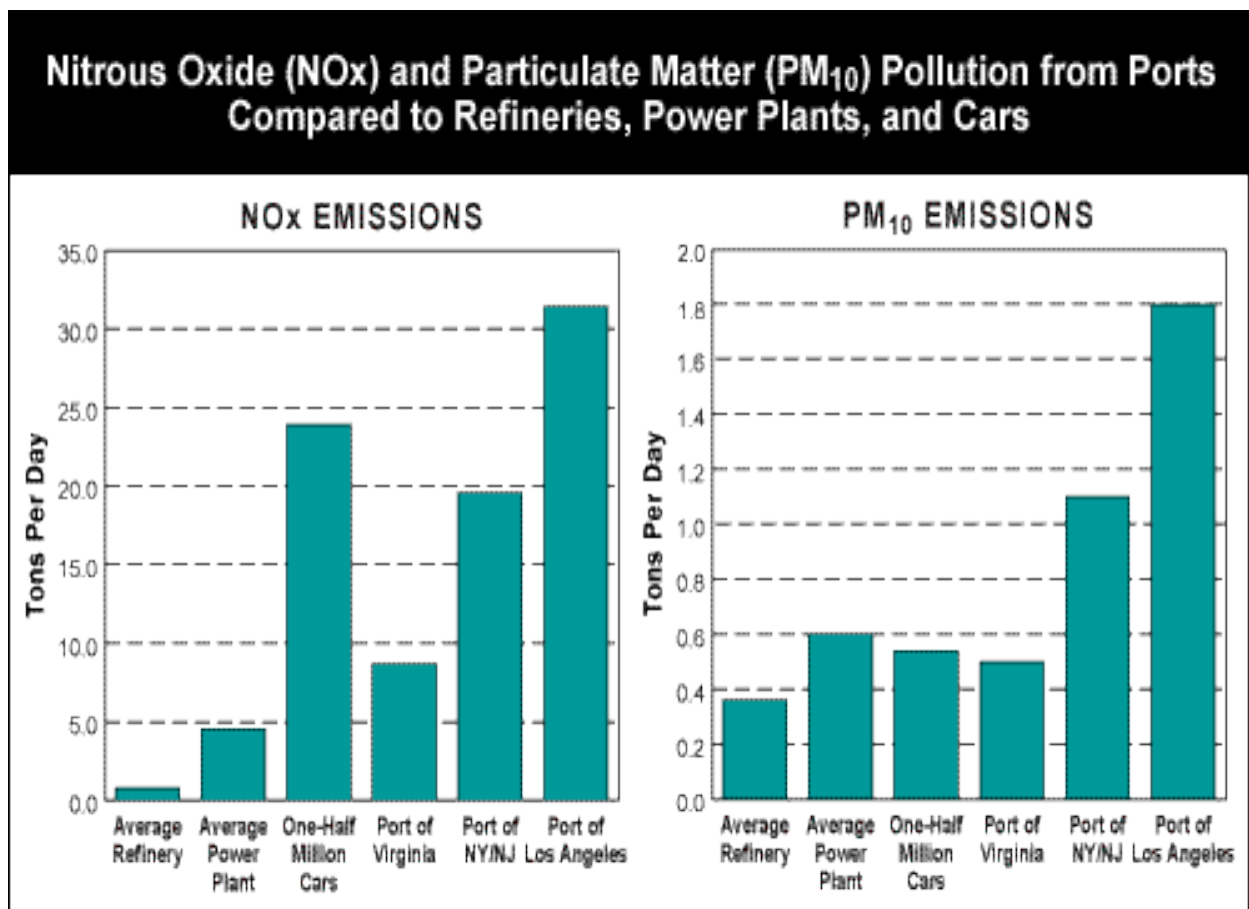


²⁵ Natural Resources Defense Council, NRDC, the earth’s best defense

Industry pollution: major port cities host a number of industries directly linked with the port operation as incoming/out coming hub. The model of port – hub coexisting adjacent to an industrial city is met in global scale. This means that in addition to port generated pollution there is another critical contributor to environmental degradation near port cities: its industrial infrastructure. The pair of port – industry emitting in the same region affects the local population located in the general area. Large scale industries such as refineries or coal based electricity production plants often neighbor port cities.

Although automobiles (including heavy duty vehicles), refineries and power plants are well known sources or pollutants in the atmosphere, the opinion that port generated emissions contribute more to the air pollution is advocated. Pollution from the above is tightly controlled by international legislation; on the contrary port pollution has been going long-term essentially unregulated.

Below, the measurements of major pollutant factors such as PM₁₀ and NO_x are graphically displayed, presenting an “inconvenient truth” when comparing other sources of pollution against some of the most significant US ports.



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²⁶ Natural Resources Defense Council, NRDC, the earth’s best defense

Health impacts of port air pollution: the range of effects polluted port city air is alarming widespread. Respiratory problems such as asthma, other problems like cardiovascular disease, lung cancer, and premature death are included in commonly met health effects in port city population. Many port cities operate nearby or even inside port limits, meaning residential areas sharing the same geographical space with high pollutant industries as refineries. Numerous researches have clearly shown the correlation between decreased lung function, allergies and bronchitis, when living nearby diesel truck routes.

CDC²⁷ Office of Surveillance, Epidemiology, and Laboratory Services measurements over a large number of major cities underlines the health risk. Under the framework titled Chronic Disease and the Environment, an “Environmental Quality and Metropolitan Area Data and Documentation²⁸” is published containing strong arguments indicating the effect of PM_{2.5} over public health. Using the methodology of Behavioral Risk Factor Surveillance System, CDC points out the direct link of respiratory and other health risk a number of capital cities residents are threatened. The following chart depicts the amount of PM_{2.5} measured in 2006 in different geophysical areas.

The levels of PM_{2.5} in L.A. , a major US port city hub and Great Falls ,Montana a city located in the distant north, without port generated pollution, advocate that the health hazards that undermine big port cities. The contradiction of deaths caused by cardiopulmonary diseases between rural areas and main industrial port cities is therefore hard evidence of the negative aspect particulate matter have on human health.

The quality of life both of residents and working population around the port city limits is affected remarkably by the port operations. Heavy industrialized areas such as port terminals are “bad neighbors”. Ports are usually not eye compelling landscapes, producing disturbing and hazardous levels of noise and suffer from heavy traffic. These problems are a stressful everyday reality that people around port areas have to cope with. But these problems may go further from annoying factors to life threatening ones. For example, noise pollution has been linked to a variety of health hazards such as hearing impairment, hypertension, sleep deprivation, reduced performance, and even aggressive behavior. At ports bordering residential neighborhoods, bright lights at night and the flashing lights of straddle carriers and forklifts can affect nearby residents, disrupting biological rhythms and causing stress and annoyance.²⁹

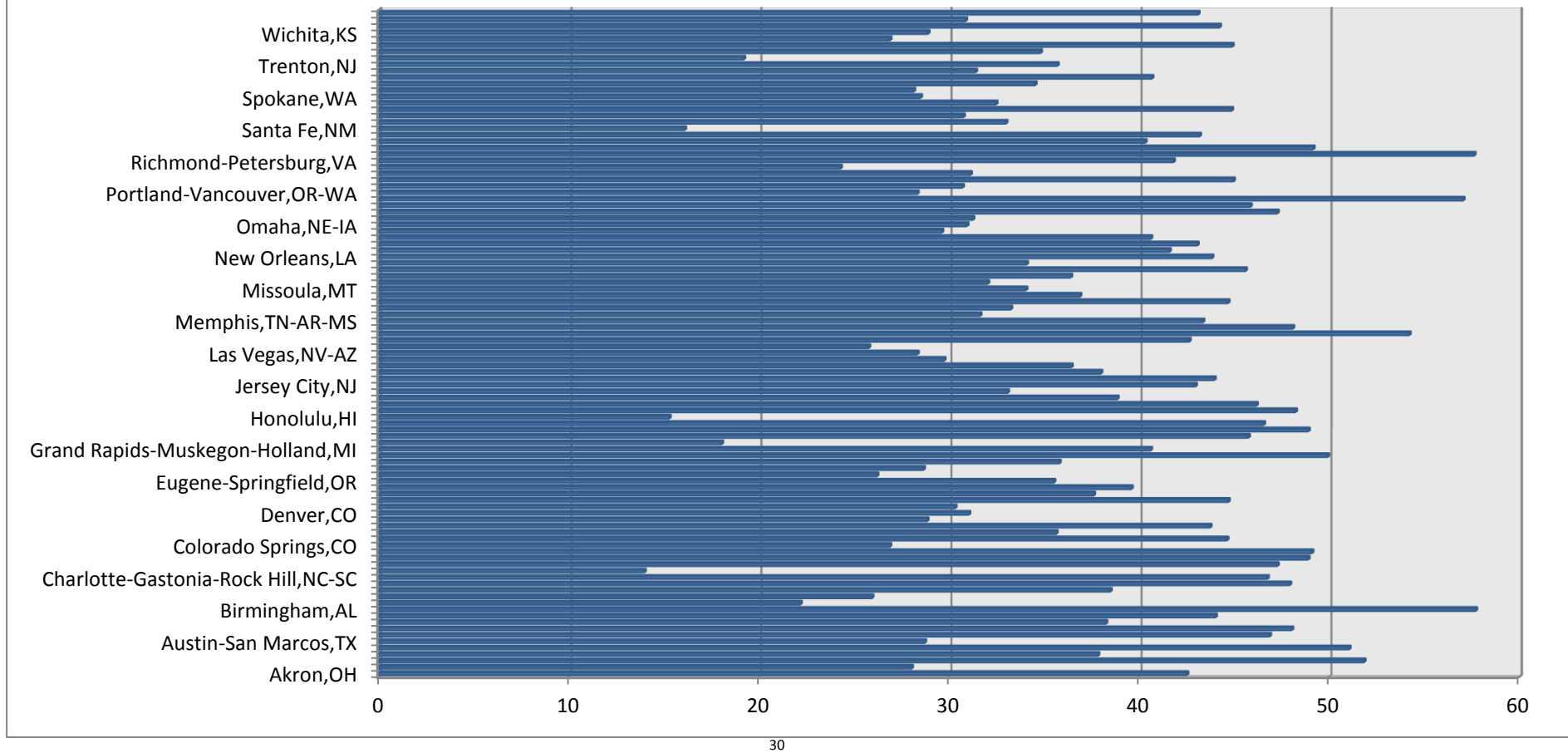
Additional factors have an immediate effect over the quality of life in port areas. Except the air quality in terms of pollutants present in the city air, the elevated noise levels and the traffic peaking in major routes around the port, a number of disadvantages for local population are identified. Resources especially such as water land and air are overused, leading the major port cities in uncontrolled growth, both in numbers and size. This growth is centralized and mostly financial boosted, so is done spontaneously and in a non-logical way. Although the major drawbacks installing in grand port city means, individuals are still eager to move and become part of the local financial chain. Low income working class people are less reluctant in installing in major port area due to the

²⁷ Centres for Disease Control and Prevention, <http://www.cdc.gov/>

²⁸ <http://www.cdc.gov/brfss/cde/2006.htm>, for the year of 2006

²⁹ World Health Organization (1999). *Guidelines for Community Noise*. ed. by Berglund, B., Lindvall, T., Schwela, D.H.. World Health Organization: 159 pp. Available online at: www.who.int/peh/noise/guidelines2.html. Last visited Jun 18, 2003.

Annual Summary of Particulate Matter (PM2.5) for selected MSAs, 2006



³⁰ Data processed after CDC measurements on Annual Summary of Particulate Matter (PM2.5) AQI Values for Selected Metropolitan Areas, 2006

workforce needed, thus more opportunities for higher income. The current workforce need is the key contributor in attracting excessive population numbers. Asian ports i.e. undergo an unprecedented growth projected both in financial and population index. Guangzhou³¹ with population as high as 35 million people is a typical example of vast, unregulated expansion triggered by economical factors. Rapid growth in many cases is linked with anarchy infrastructure development. Necessity driven development leads towards a centralized model of city due the port growth. This model is the one met around worldwide ports.

All the above consist more or less significant social issues that cold ironing implementation on port terminals may affect beneficially. It is not pronounced as “one size fits – all” solution to a very complex problem, rather than a technical way to mitigate port pollution effects on modern large scale globalised port cities.

³¹ <http://en.wikipedia.org/wiki/Guangzhou>

1.5 Emissions reduction efforts

Reducing emissions produced by internal combustion engines such as diesel engines, either located in industrial facilities or onboard large ocean tankers is a crucial, universal target. Numerous regulatory authorities including local governments, international organizations i.e. IMO are encouraging or even forcing of several “clean – air laws”. Although the commercial activity is more or less globalised the present days, it not under an umbrella of emission standards with non geographical jurisdiction. In the case of shipping produced emissions, this fact means a vessel is allowed to pollute less or more depending on its current coordinates. Switching to cleaner fuel on strictly regulated areas i.e. US ports is mandatory by the local authorities. On the contrary, heavy fuel burning, aggravating the local atmosphere with hazardous pollutants such as NO_x and SO_x is permitted in several port sites with less strict regulations. Clearly, the approach in reducing emissions is versatile and in many cases controversial.

Until present day various emissions mitigation policies are promoted on international waters. Amongst major regulatory authorities are IMO, EU Council and US authorities. Initiatives for environmental protection include a number of regulations, legislation acts and directives for policies aiming to mitigate the environmental impact coming directly from ships’ emissions. Towards the goal of a global agreement on ships emissions the Marine Environment Protection Committee of the IMO has issued in 1997 ANNEX VI of MARPOL 73/78 convention, establishing a global sulphur cap of 4.5% for bunker fuel, and a maximum of 1.5% in Sulphur Emission Control Areas, Baltic Sea and North Sea. ANNEX VI also prescribes emissions standards for NO_x levels in marine diesel engines but modern design engines were already in compliance. Its ratification from many countries means that almost 50% of world’s merchant fleet is complying with the preset standards. *“Annex VI entered into force on 19 May 2005 and a revised Annex VI with significant tighten emissions limits was adopted in October 2008 which entered into force on 1 July 2010”*.³²

GhG emissions reduction efforts and actions for the shipping industry by international Organizations are listed below. IMO’s resolutions, circular letters, working committees i.e. MEPC and working groups are included, although a selection is listed in this report.³³

The following information resources is provided by the MKC³⁴ in assisting the research for *“Air Pollution and Greenhouse Gas (GHG) Emissions from International Shipping (Marpol Annex VI (SO_x, NO_x, ODS, VOC) / Greenhouse Gas (CO₂) and Climate Change”*.

³² IMO, <http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Default.aspx>

³³ For more information regarding the IMO documentation refer to the annual publication list.

³⁴ Maritime Knowledge Center, IMO

1.5.1 IMO point of view

RESOLUTIONS³⁵

A 22/Res.929 Entry into force of Annex VI of MARPOL 73/7: Resolution adopted on 29 November 2001

A 23/Res.963 IMO policies and practices related to the reduction of greenhouse gas emissions from ships. Resolution adopted on 5 December 2003

MEPC.76 (40) Standard specification for shipboard incinerators. Resolution adopted on 25 September 1997

MEPC.82 (43) Guidelines for monitoring the world-wide average sulphur content of residual fuel oils supplied for use on board ships. Resolution adopted on 1 July 1999

MEPC.96 (47) Guidelines for the sampling of fuel oil for determination of compliance with Annex VI of MARPOL 73/78. Resolution adopted on 8 March 2002

MEPC.132 (53) Amendments to the Annex of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto. (Amendments to MARPOL Annex VI and the NOx Technical Code). Adopted on 22 July 2005.

MEPC.176 (58) Amendments to the Annex of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (Revised Marpol Annex VI)

MEPC.177 (58) Amendments to the Technical Code on Control of Emission of Nitrogen Oxides from marine Diesel Engines (NOx Technical Code 2008)

MEPC.198(62) 2011 guidelines addressing additional aspects to the NOx Technical Code 2008 with regard to particular requirements related to marine diesel engines fitted with selective catalyst reduction (SCR) systems)

MEPC.199 (62) 2011 guidelines for reception facilities under Marpol Annex VI

³⁵ Abbreviations: Association of European Manufacturers of Internal Combustion Engines (EUROMOT); Clean Shipping Coalition (CSC); Community of European Shipyards' Associations (CESA); Cruise Lines International Association (CLIA); European Commission (EC); International Association of Classification Societies (IACS); International Association of Drilling Contractors (IADC); Institute of Marine engineering Science and Technology (IMarEst); International Association of Independent Tanker Owners (INTERTANKO); International Association of Ports and Harbors (IAPH); International Bunker Industry Association (IBIA); International Council of Cruise Lines (ICCL), International Chamber of Shipping (ICS); Baltic and International Maritime Council (BIMCO); International Association of Dry Cargo Ship-owners (INTERCARGO); International Paint and Printing Ink Council (IPPIC); International Parcel Tankers Association (IPTA); International Petroleum Industry Environmental Conservation Association (IPIECA); International Organization for Standardization (ISO); International Towing Tank Conference (ITTC); International Transport Workers Federation (ITF); Oil Companies International Marine Forum (OCIMF); Friends of the Earth International (FOEI); Society of International Gas Tankers and Terminal Operators (SIGTTO); World Shipping Council (WSC)

MEPC.202 (62) Amendments to the Annex of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (designation of the United States Caribbean Sea Emission Control Area and exemption of certain ships operating in the North American Emission Control Area and the United States Caribbean Sea Emission Control Area under regulation 13 and 11 and appendix VII of Marpol Annex VI) 9

MEPC.203(62) Amendments to the Annex of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (inclusion of regulations on energy efficiency for ships in Marpol Annex VI)

1.5.2 INTERSESSIONAL MEETING OF THE BLG WORKING GROUP ON AIR POLLUTION

2nd Session (29 October – 2 November 2007)

BLG-WGAP 2/2 Revision of Marpol Annex VI and the NOx Technical Code. Outcome of the informal group of technical experts on the NOx Technical Code BLG-WGAP 2/2/1 Idem. Current text of the NOx Technical Code and agreed amendments

BLG-WGAP 2/2/3 Idem. Current text of Marpol Annex VI and agreed amendments.

BLG-WGAP 2/2/4 Idem. Maritime experience with selective catalytic reduction. Submitted by Norway

BLG-WGAP 2/2/5 Idem. NOx Technical Code: Proposals related to test cycles, —defeat device // and —Irrational emission control strategies//. Submitted by Norway

BLG-WGAP 2/2/6 Idem. Proposal for Tier II NOx emission standards for new engines. Submitted by China

BLG-WGAP 2/2/7 Idem. Measurement method for particulate matter emitted from marine engines. Submitted by the United States

BLG-WGAP 2/2/8 Idem. Proposals to amend the NOx Technical Code. Submitted by Euromot

BLG-WGAP 2/2/9 Idem. Justification for after-treatment technology (SCR). Submitted by Japan

BLG-WGAP 2/2/10 Idem. Comments on revision of the Summary of Tier III NOx proposals. Submitted by Japan

BLG-WGAP 2/2/11 Idem. Proposal of draft amendments to NOx Technical Code for certification of exhaust gas after-treatment device. Submitted by Japan

BLG-WGAP 2/2/12 Idem. NOx regulations for existing engines, Submitted by Germany

BLG-WGAP 2/2/13 Idem. Proposals on regulation of NOx emissions from existing engines. Submitted by Denmark¹⁶

BLG-WGAP 2/2/14 Idem. Control of fuel oil quality. Submitted by Denmark

BLG-WGAP 2/4/15 Idem. Simulation relating to effects for NOx regulation. Submitted by Japan

BLG-WGAP 2/4 Wash water discharge criteria for exhausting gas-SOx cleaning systems. Draft Wash water discharge criteria for on-board exhaust gas-SOx cleaning systems as approved by MEPC 56

BLG-WGAP 2/4/2 Idem. Comments on Wash water discharge criteria. Submitted by Japan

BLG-WGAP 2/4/3 Idem. Proposed amendments to BLG-WGAP 2/4. Submitted by Finland

BLG-WGAP 2/4/4 Idem. Idem. New research on acidification of shallow coastal waters. Submitted by Sweden

BLG-WGAP 2/5/1 Amendments to the guidelines for on-board exhaust gas-SOx cleaning systems. Proposed amendments to BLG-WGAP 2/5. Submitted by Euromot

BLG-WGAP 2/5/2 Idem. Proposed amendments to BLG-WGAP 2/5. Submitted by Finland

BLG-WGAP 2/INF. 2 Idem. Environmental and economic effects of BLG proposals for the Netherlands. Submitted by the Netherlands

BLG-WGAP 2/INF. 3 Idem. Information on NOx Tier II limit. Submitted by Japan

BLG-WGAP 2/INF.4 Idem. Information regarding airborne surveillance of exhaust gas emissions from ships.

1.5.3 EU point of view

Regarding the EU point of view in regulating GhG emissions from international shipping a number of regulations have been put into effect. Along with IMO, European Council has issued a total of ships' emissions control options. A listing of these acts of legislation follows:

DIRECTIVES, DECISIONS, REGULATIONS, RESOLUTIONS, PROPOSALS, COMMON POSITIONS AND RECOMMENDATIONS

Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community. In: Official Journal of the European Union, L 140, pp. 63-87, 5 June 2009.

Directive 2008/101/EC of the European parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community. : Official Journal of the European Union, L 8, pp 3-21, 13 January 2009.

European Parliament resolution of 12 July 2007 on a future maritime policy for the European Union: A European vision for the oceans and seas (2006/2299(INI)). Text adopted by Parliament on 12 July 2007. Provisional edition.

European Parliament Resolution on the thematic strategy on air pollution (2006/2060(INI)). 26 September 2006.

Commission Recommendation of 8 May 2006 on the promotion of shore-side electricity for use by ships at berth on Community ports. In: Official Journal of the European Union, L 125, 12 May 2005, pp 38-42

Directive 2005/33/EC of the European Parliament and of the Council of 6 July 2005 amending Directive 1999/32/EC. In: Official Journal of the European Union, L191, 22 July 2005, pp 59-69

Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms. In: Official Journal of the European Union, L 338, pp 18-23, 13 November 2004.

Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC. In: Official Journal of the European Union, L 275, pp 32-46, 25 October 2003.

Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants. In: Official Journal of the European Communities, L 309, pp 22-30, 27 November 2001

Council Directive 1999/32/EC of 26 April 1999 relating to a reduction in the sulphur content of certain liquid fuels and amending Directive 93/12/EEC. In: Official Journal of the European Communities L121, 11 May 1999, pp 13-18.

Common Position (EC) No. 57/98 adopted by the Council on 24 September 1998 with a view to adoption of Council Directive 98/.../EC relating to limit values for sulphur dioxide, nitrogen dioxide and oxide of nitrogen, particulate matter and lead in ambient air (98/C 360/04). In: Official Journal of the European Communities Vol. 41/No, C 360, 28 Nov 1998, pp 99-122

Common Position (EC) No. 50/98 adopted by the Council on 16 June 1998 with a view to adopting Council Decision 98/ .../EC, of ... amending Decision 93/389/EEC for a monitoring mechanism of Community CO₂ and other greenhouse gas emissions (98/C 333/03). In: Official Journal of the European Communities Vol. 41/No. C 333, 30 Oct 1998, pp 38-4550

Directive 97/68/EC of the European Parliament and of the Council of 16 December 1997 on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery. In: Official Journal of the European Communities Vol. 41/No. L 59, 27 Feb 1998

Common position (EC) No. 40/97 adopted by the Council on 7 October 1997 with a view to adopting Directive 97/.../EC of the European Parliament and of the Council relating to measures to be taken against air pollution by emissions from motor vehicles and amending Council Directive 70/220/EEC. In: Official Journal of the European Communities Vol. 40/C 351, 19 Nov 1997, pp 13-67

Directive 96/1/EC of the European Parliament and of the Council of 22 January 1996 amending Directive 88/77/EEC on the approximation of the laws of the Member States relating to the measures to be taken against the emission of gaseous and particulate pollutants from diesel engines for use in vehicles. In: Official Journal of the European Communities Vol. 39/No. L 40, 17 Feb 1996, pp 1-9

Council Directive 93/12/EEC of 23 March 1993 relating to the sulphur content of certain liquid fuels. In: Official Journal of the European Communities No. L 74, 27 Mar 1993, pp 81-83.

Council Directive of 3 December 1987 on the approximation of the laws of the Member States relating to the measures to be taken against the emission of gaseous pollutants from diesel engines for use in vehicles (88/77/EEC). In: Official Journal of the European Communities No. L 36, 9 Feb 1988, pp 33-6

Directive of the European Parliament and of the Council on ambient air quality and cleaner air for Europe. Brussels, European Parliament, March 2008. (2005/0183 (COD)); (PE-CONS 3696/07)

In November 2002, a strategy to reduce air pollution generated by ship traffic has been published by the EU Commission along with a proposal in reducing the sulphur content in marine fuel oil used for burning in modern technology ships. The proposal (COM/2002/0595 final) finally published as directive (2005/33/EC), entering in force on 11 August 2005 and applied a ceiling of sulphur concentration at 1.5% in marine fuels in the regions of North Sea, including the English Channel and the Baltic Sea. In addition the directive (2005/33/EC) request for 0.1% of sulphur content fuel used at berth inside European ports. This is a critical point for underlining the benefits of using alternative marine power, or commonly referred as cold ironing systems. To promote the abatement of SO_x emissions the EU has moved in the direction of restricting marine gas oil with sulphur content levels higher of 0,1% to be marketed within EU. The implementation of these rules rests on each EU member state, by conducting regular checks on marine fuel oil used and their sulphur content percentage.

In spite of the long period this legislation has been adopted, maritime industry and ship-owners are requesting additional time for full adaptation. As example is given the technical modifications that must be made when switching between fuel oils. As of 29 December 2009 the Commission has issued a decision that the technical challenges are minor and request for full implementation of the sulphur content ceiling, with several northern countries announcing they will “strictly enforcing the sulphur regulation.”³⁶

Furthermore the Commission has expressed their support for Community action to reduce NO_x emissions from ships. NO_x emissions would continue to rise although the implementation of 2008 IMO standards regarding the emissions.

³⁶ <http://airclim.org/acidnews/2010/AN1-10.php#44>, **New EU sulphur regulations in ports**

1.5.4 UN point of view

United Nations (UN) efforts include the work provided by UN Convention Framework on Climate Change (UNFCCC). The famous Kyoto protocol and the discussion around its expansion with implementing more rigorous rules for pollution prevention in the following years is an example of multinational agreement in common efforts towards air pollution abatement. Some of the UNFCCC publications are listed below:

UNITED NATIONS

UN Convention Framework on Climate Change (UNFCCC). Done in New York, 9 May 1992. Kyoto Protocol to the United Nations framework convention on climate change - Japan (1-10 December 1997: Kyoto). New York: UN, 1997- (FCCC/CP/1997/L.7/Add.1; 1997. Language(s): ENG, FRE, SPA, RUS.

UN Convention Framework on Climate Change (UNFCCC). United Nations Climate Change Conference - Bali, 3 -14 December 2007. Gateway to the UN System's Work on Climate Change.

UNFCCC CLIMATE CHANGE SECRETARIAT / UNITED NATION ENVIRONMENT PROGRAMME (IUC) (UNEP)

-UNFCCC Convention on Climate Change. Bonn, Climate Change Secretariat, 2007. (UNEP/IUC/2007)

-UNFCCC The Kyoto Protocol to the Convention on Climate Change. Bonn, Climate Change Secretariat, 2007.

(UNEP/IUC/2007)

- UNFCCC: report of the Conference of the Parties on its 13th Session, held in Bali from 3 to 15 December 2007.

Addendum: Part 2 _ action taken by the Conference of the Parties at its 13th Session. (FCCC/CP/2007/Add.1

Convention on Long-Range Transboundary Air Pollution (LRTAP). Geneva, 13 November 1979.

- The 1985 Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per

cent

- The 1988 Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes

- The 1991 Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes

- *The 1994 Protocol on further reduction of sulphur emissions*
- *Other Protocols to the Convention*

Emissions resulting from Fuel used for International Transport: Aviation and Marine "Bunker Fuels".

Airborne sulphur pollution: Effects and control. New York, UN, 1984 (Airborne Pollution Studies No.1)

Committee for Development Policy - The international development agenda and the climate change challenge. New York: UN, 2007- (ISBN: 978-92-1-104571-0)

Report of the Secretary-General's High-Level Advisory Group on climate change financing. 5 November 2010

UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT (UNCTAD)

- *Controlling carbon dioxide emissions: The tradable permit system. Geneva: UNCTAD, 1995 (ISBN: 92-1-112373-9)*

- *Combating global warming: Possible rules, regulations and administrative arrangements for a global market in CO2 emission entitlements. New York: UN, 1994- (UNCTAD/GID/8) (ISBN: 92-1-112372-0)*

- *Maritime transport and the climate change challenge. Multi-year expert meeting on transport and trade facilitation. Geneva, 16-18 February 2009.*

UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP) / SUSTAINABLE DEVELOPMENT INTERNATIONAL - Climate action. Nairobi/London: UNEP/Sustainable Development International, 2007 (ISBN: 978-0-9554408-5-4)

UNITED NATION ENVIRONMENT PROGRAMME (UNEP) – Bridging the emissions gap. A UNEP synthesis report. 2011. (ISBN 978-92-807-3229-0)

WORLD HEALTH ORGANIZATION (WHO). International Program on Chemical Safety (IPCS) - Diesel fuel and exhaust emissions. Geneva: WHO, 1996- (Environmental Health Criteria 171) (ISBN: 92-4-157171-3)

WORLD METEOROLOGICAL ORGANIZATION (WMO)

- *The state of Polar research. A statement from the International Council for Science / World Meteorological Organization Joint Committee for the International Polar Year 2007-2008. Geneva, WMO, 2009*

- *State of the climate in 2006. Geneva, WMO, 2008. (ISBN 92-63-11020-4)*

The list of initiatives taken is a long one. This fact indicates that air pollution abatement is a priority in the shipping industry and the nations based on sea trading for financial growth. Although the strategy followed in achieving the objectives, meaning reducing GhG emissions and slowing down the climate change factors, may vary amongst different governments and organizations, the common cause they serve is crucial for achieving the aversion of climate change.

1.6 Why choosing Cold Ironing as prime strategy?

“The main advantage of cold ironing is that it transfers power production from dirty shipboard sources to much cleaner central power stations.”³⁷

Ever since the EPA³⁸ proposed the use of tougher standards for engines operation and fuel burning for US ships there has been a lot of discussion regarding the ways for complying with the these new emissions control rules. The use of cold iron techniques for powering vessels while at birth or “hotelling” enables the main and auxiliary engines and generators to shut down, lowering emissions next to zero. Besides a number of different techniques for powering vessels are available to this day. This section is dedicated to promoting the use of cold ironing techniques by presenting the benefits and the technical advantages that shore based power provision bears in contrast with other powering options in terminals.

US navy has been using alternative marine power for running combat ships at birth for reducing “wear and tear” on ship equipment. Although the reduction of emissions was not the prime goal when implementing this technique, the benefits of bringing down the amount of pollutants and the fuel saving were obvious.

The key benefits and technical advantages of using of shore power electricity are more or less stated above: Health benefits sourcing from pollution and noise reduction, financial benefits by shutting down the vessel’s engines and therefore longest lifetime of machinery and many more.

The technical advantages of implementing cold ironing are numerous. There is no need for sophisticated infrastructure and costly technology to be applied. The context of connecting the vessel on the power grid thus allowing the vessel to completely “switch off” is the context of using alternative marine power. The last years an increasing number of vessels are built with the necessary equipment for cold ironing at birth pre installed, while other ships are retrofitted in order to be able to apply cold ironing energy supply within modern ports. Also the ports are benefited in multiple levels with significant reduction of air pollutants and noise abatement. The connection on grid power need 30 to 60 minutes to be completed so no extra time at birth is needed for ships when cold ironing.

Using cold ironing techniques for powering up ships at terminals is simple, cost effective and already a tested way for combating air emissions and environmental degradation. The following parts of this study focus on different aspects of cold ironing as an Emission Control Option (ECO) with references to the technical, financial and management challenges for implementing on modern ports.

³⁷ Bill Siuru, Professional Mariner, Issue Date: Issue #113, May 2008

³⁸ Environmental Protection Agency

Chapter II

2.1 Implementation of Cold ironing in modern ports

With an increasing climate/environmental awareness and concern about future oil prices, onshore power Supply (OPS) is getting more and more attention from media, shipping lines and ports. Until today only a few Baltic Sea region ports have implemented and are active in using OPS, but the interest is growing³⁹

In this section several cold ironing systems implementation on modern ports is presented. The ports are picked for their outstanding significance as commercial and financial hubs. Also it has been taken under consideration the port size and the amount of traffic they meet annually. Therefore the following list of ports include major US, European and rest of rest of the world port facilities, representative of the globalised sea trading.

Challenges in the implementation of cold ironing are sometimes enormous. Standardized equipment and procedures do not exist, with most efforts currently made by IMO and ISO⁴⁰. The installation of cold ironing equipment on shore regarding the location and the number of receptions hubs is often a wild guess that port authorities have to make. Despite the technical challenges that the international port and shipping community is trying to overcome, the goal is the full implementation of all ships – all ports model for cold ironing procedures globally. Towards this direction a considerable number of important ports have already set the example.

This report will present a limited number of ports that have introduced cold ironing capabilities for a variety of vessel types. It is not implied that the following list of ports is complete. The selection is made on the point of view of the importance both geographically and commercially of each port. Due to the rapid expansion of cold ironing technology the number of ports implementing alternative marine power is growing.

³⁹ Paper: On Shore Power Supply Implementation Process in the Ports of Baltic States, Riga Technical University, Unbedahts A., Siliņa I. On Shore Power Supply Implementation Process in the Ports of Baltic States // Tehniskās zinātnes, Latvija, Rīga, 24.-27. October, 2011. - pp 208-208.

⁴⁰ International Organization of Standards.

2.1.1 US ports

2.1.1.1 The POLA case:

Cold ironing or Alternative Maritime Power™, or “AMP™ as it referred by the Port of Los Angeles authorities is “a one-of-a-kind air quality program that focuses on reducing emissions from container vessels docked at the Port of Los Angeles”⁴¹. Although the technology itself was used by Baltic ferries and cruise ships operating in Alaska, the POLA is the first Port in the world to use cold ironing techniques for container ships. On the date of June 21, 2004 the port authorities announced the opening of berth 100 with cold ironing capabilities on West Basin Container Terminal. Following that year on August 9 the first container ship to be built with Alternative Marine Power capabilities, NYK Atlas called at the port. Additional berths have been equipped with cold ironing systems since then. Today, the berths that can provide shore power energy include Yusen Terminal at berth 214 (2006), Evergreen’s Sea Side Terminal at berth 230 (2010), and the Cruise Terminal at berths 92 and 93A (2011).⁴²

The California Air Resources Board (CARB)⁴³ adopted a regulation in 2007 aiming to the container ship emissions abatement. The Harbor Department in compliance to the CARB resolutions that begins on January 1st, 2014 on all major container terminals, has scheduled to 24 Alternative Marine Power to be installed at various berths. The implementation of cold ironing techniques has key role in the effort to reduce air pollution originating from large container ships that call at POLA. Although the efforts of container ship emissions reduction are strong, other vessels types also contribute to the port atmosphere pollution.

On February 24, 2011, the Port of Los Angeles became the first port worldwide to provide AMP to three separate cruise lines. Disney Cruise Line, Princess Cruises and Norwegian Cruise Line have all taken advantage of unique “AMP Mobile” technology developed specifically for the World Cruise Center.

According to the port authorities the “World Cruise Center” is the only port in the world that can handle the connection of two individual cruise ships at the same time. The voltage used in the majority of cruise ships electrical distribution systems is 6.6kV or 11kV. Both voltages are “serviced” at the port cold ironing capable berths. Currently, the demand in electrical power is between 8MW and 13MW. The POLA’s World Cruise Ships Center has the capability of providing up to 40MW of power in two cruise ships, 20MW for each vessel.

Although the requirements are guided by the state laws and regulations, the measures for mitigating vessels’ emissions in ports must not be uniformed. This means the port authorities must consider the specific circumstances on a case-by-case implementation of cold ironing systems. A fixed percentages requirement may not target the proper vessel in matters of air pollution. On the

⁴¹ http://www.portoflosangeles.org/environment/alt_maritime_power.asp

⁴² Info provided by the port authorities itself

http://www.portoflosangeles.org/environment/alt_maritime_power.asp

⁴³ <http://www.arb.ca.gov/homepage.htm>

other hand a more careful consideration on what measure applies on what vessel may produce significant results in the battle against air pollution in ports.

2.1.1.2 The POLB case:

The Port of Long Beach (POLB) is currently ranked second most busy container ports in US, directly or indirectly providing with 30.000 jobs in the regional area. In the fiscal year of 2002, 65.5 million metric tons of cargo valued over 100 billion USD was moved through the Port.⁴⁴

The Port authorities have commissioned many studies over the past years in order to measure the various aspects of air pollutant factors and propose solutions. Environ⁴⁵ has issued a Cold iron feasibility study for the Port of Long Beach concluding in many interesting results.

Cold Ironing, a technology *“which dramatically cuts air pollution from cargo vessels”* has arrived at the Port of Long Beach with the completion of a new wharf on Pier G. the newly retrofitted berth 232 is located in the container cargo facility of POLB port , leased by the port to ITS⁴⁶.

The shore side power system at Pier G has a capacity of 7.5 MVA, or about 6 MW, enough to power about 4,000 homes. Japan-based shipping giant “K” Line, the parent company of ITS, has outfitted five ships to operate on shore side power.

The introduction of shore side power at Pier G is part of a major, 10-year \$800 million redevelopment of the terminal by the Port for the tenant, ITS. Berth 232 is a new wharf; the future steps are to wire shore power to all of the operating berths at Pier G. The shore power-equipped berth at Pier G will handle 50 vessel calls a year. About \$8 million was spent by the Port of Long Beach to equip the dock with shore power. The Port is nearing completion on work to equip a BP liquid bulk petroleum terminal with shore power. When it is completed, it will be the country’s first such terminal with shore power.⁴⁷

In designing the cold ironing facilities at pier G, some special aspects were implemented. These include special outlet boxes by Cavotec, large numbers of conduits, extensive and redundant protection systems to prevent a wide range of possible accidents, damages and casualties. The voltage is transformed down from 12kV to operating voltage of 6.6kV, providing up to 6MW in power capacity. The cold ironing provision systems also require substations, electrical current transformers, switchgears, conduit, cables and outlets.

⁴⁴ Cold iron cost effectiveness study for POLB, vol 1, issued by Environ.

⁴⁵ <http://www.environcorp.com/Home.aspx>

⁴⁶ International Transportation Services, <http://www.itslb.com/Main/Default.aspx>

⁴⁷ Shoreside Power Fact Sheet, POLB

Due to the lack of set standards set the POLB authorities and Engineering division have issued a design standards draft. The document titled *Design Standard for Shore to Ship Power, February 24, 2004*⁴⁸ is stating the design assumptions the division has come to be the basis for the design of substations, feeders, shore power receptacles and ship plugs.

The following technical details (items 1-11) referring to the installations standards that would be implemented is directly extracted from Port of Long Beach Authority Engineering Division. These standards are announced to the public for the shipping companies to retrofit their on-board equipment for using cold ironing systems while at berth.

Listed below are the design assumptions for the Shore to Ship Power for a ship at berth, which shall be the basis for the design of the substation, feeders and shore power receptacles and ship plugs. The Port of Long Beach will design and provide installation in conformance with items 1 through 11 listed below. Points 12.1 through 12.4 are clarification notes.

- 1. The incoming service voltage to the shore power substation will be 12,000 volts to be supplied by the local utility company or a feeder from an electrical substation.*
- 2. The shore power system will provide power to the wharf outlets at 6,600 volts, 3 phases, 60 Hertz with a grounding circuit conductor.*
- 3. The design load for each ship is 7,500 KVA.*
- 4. Each berth shall have access to shore power outlets at five locations along the wharf, spaced approximately 220 Feet (67 Meters) apart, each of which will be designed to supply 7,500 KVA of electric power. (Berth is defined as the space one ship occupies along the wharf). In the future a fewer number of power outlets may be installed due to improved standard system design.*
- 5. A substation with a capacity of approximately 7,500 KVA will be designed, with capacity for powering one berth at the design load of 7,500 KVA per berth.*
- 6. At each berth, the substation will have capacity for a maximum of one shore power outlet operating at any one time, at full load. A physical interlocking device, such as a key interlock, will be designed into the shore power outlets and the associated circuit breakers at the substation to prevent personnel from connecting to the outlets unless the circuit breaker is open, and the circuit is not energized.*
- 7. The substation switchgear will be designed to power one of the five shore power outlets at a time, per berth. The switchgear will be designed for five outlet locations. One circuit breaker for each outlet feeder will be provided in the switchgear design. Each of the paralleled conductors used for feeders, shall have an electrical current sensor to monitor the conductor ampacity. This current sensor will cause the circuit breaker to trip in the event maximum ampacity is exceeded in either parallel conductor. This will be implemented to limit current capacity to prevent burnout of the conductors.*

⁴⁸ <http://www.polb.com/civica/filebank/blobdload.asp?BlobID=2158>

8. *The shore power outlet will consist of two 350 Amp receptacles rated for 6,600 volts, housed in a single weatherproof enclosure. The receptacles will utilize a push-pull coupling device which will be factory built into the receptacle units. One receptacle shall be identified with a red color and another receptacle with a blue color. Each receptacle shall have a separate keyway to assure plugs cannot be switched from one receptacle to another. These receptacles shall be Cavotec Co. part numbers PC5-VX04-K1850R for the Port of Long Beach, Engineering Division red, and PC5-VX04-K1850B for the blue. These receptacles will be housed inside a "Power Unit" manufactured by Cavotec Co. catalog number PC5-AX04-K1855. (Receptacles are also referred to as sockets). Furthermore, each receptacle shall have a separate Kirk® Key to keep the receptacle cover in place when de-energized. After the plugs from the ship are engaged to the receptacles on shore, both Kirk® Keys from the receptacles will be required at the feeder circuit breaker to allow the circuit breaker to activate and energize the feeder.*
9. *Each of the receptacles specified in item 8 will have two special pins reserved for Ground Check control wires, in addition to the three power pins. These control wires will be energized from the switchgear where the circuit breaker for the feeder of the outlet is located, utilizing a ground check relay. The intent of the ground check relay and this wiring is to trip the circuit breaker when personnel disengage the plug from the receptacle while the plug and receptacles are energized. Since the Ground Check pins will disengage first, before the power pins do, the ground check circuit will therefore be interrupted and thus send a signal to the ground check relay to trip the respective circuit breaker. Ground Check wiring aboard the ship must conform to the shore-side wiring to assure proper operation of the ground check system when plugs from the ship are engaged with the receptacles on shore.*
10. *The shore power substation will be located near the wharf, but not on the wharf, to avoid interference with terminal operations.*
11. *The shore power substation will be designed with dry-type transformers, instead of liquid filled transformers. One 7,500 KVA dry-type transformer will be designed at the substation, with capacity to supply continuous power to a ship.*

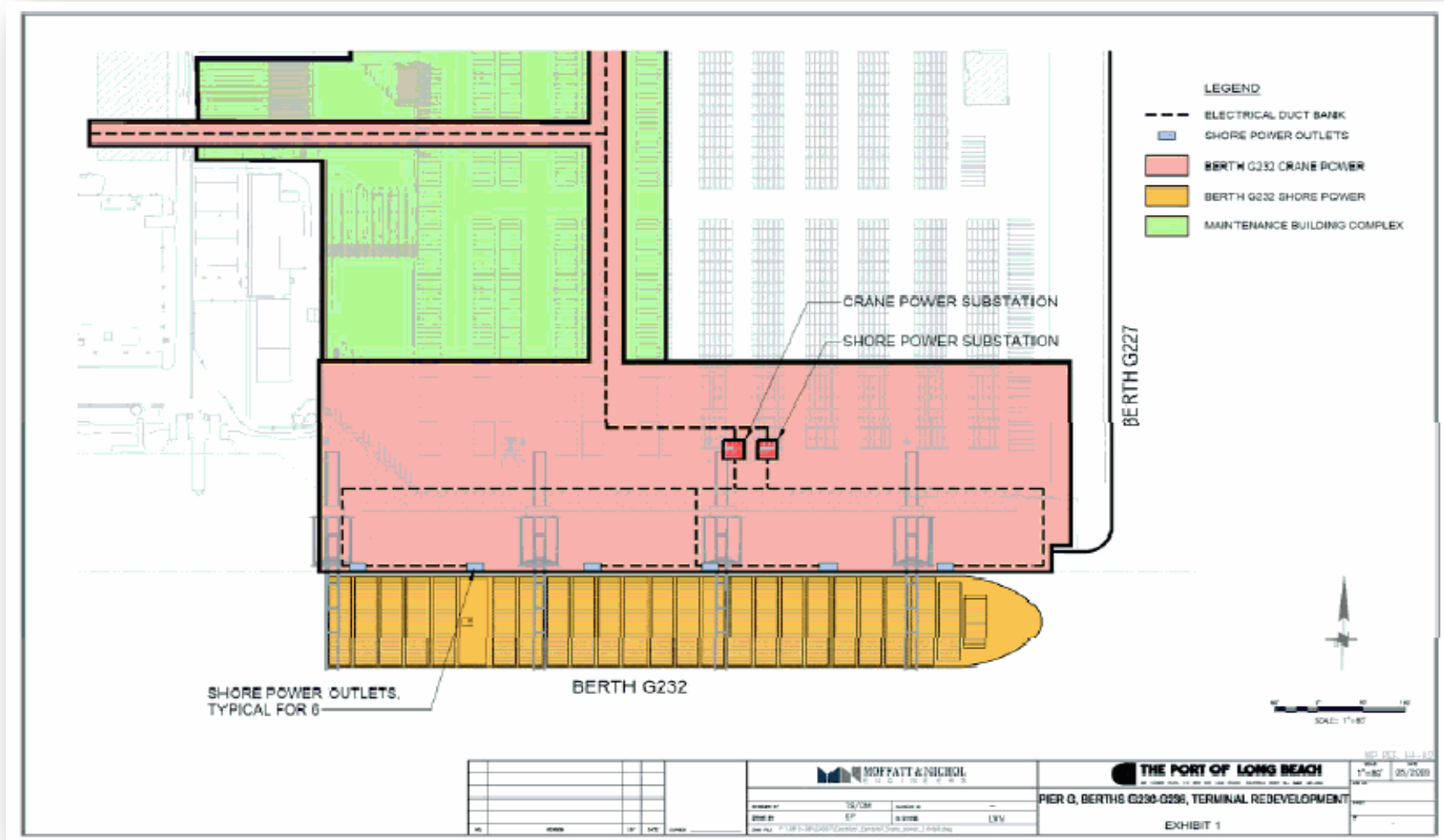
THE FOLLOWING ARE NOTES FOR CLARIFICATION

12. *The following notes are listed here to clarify additional requirements to complete the shore to ship power system design. However the design and equipment needed for these additional requirements shall be the responsibility of the ship owner/operator and shall be located on the ship.*
 - 12.1.1 *The shore power design will not include synchronizing switchgear, therefore when a ship connects to the shore power system, there will be a break in its on-board power during the switchover. If the ship has synchronizers and is capable of putting them to use, the ship may do so.*
 - 12.1.2 *Cable handling to accommodate tide changes and vessel movement will be achieved with equipment on the ship and the design and procurement of this equipment shall be the responsibility of the ship owner/operator. The landside*

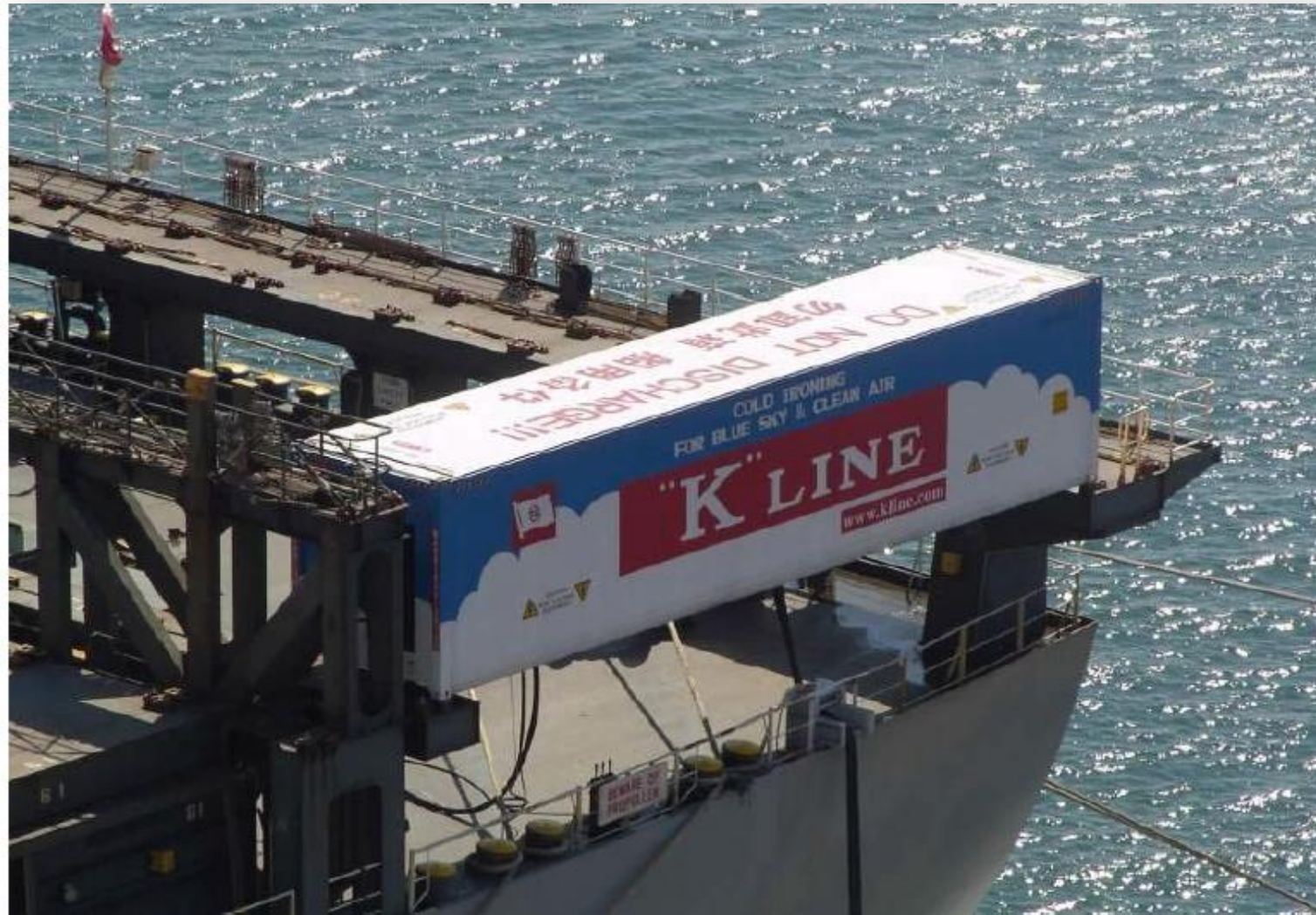
shore power receptacles will be fixed and unmovable inside their respective outlets. This implies that the cable manager system, such as a Cavotec Co. manufactured unit, shall be located on the ship.

- 12.1.3 The plugs on the ship's cable manager system shall match the receptacles that the Port of Long Beach will provide in the wharf outlet. The shipside plugs shall be Cavotec Co. part number PC5-SX04-K1850FOR for red colored plug and PC5-SX04-K1850FOB for blue colored plug. These plugs have provisions to accommodate fiber optic cable as part of the cable manager system located on the ship. If the use of fiber optic cable is not desired, the same plug may be used for power cables only, or same plug with no fiber optic provisions may be substituted. Both of the specified plugs must be connected to shore-side receptacles to successfully transmit shore power to the ship. Furthermore, the cables from the shipside plugs to the ship's electrical switchgear must be of equal length and terminated at a single overcurrent device or single bus.*
- 12.1.4 The Port of Long Beach will not provide fiber optic cable, or electrical control wires of any type within the wharf outlets except for those controls that are explicitly identified and specified above. Should the ship or terminal operator choose to install fiber optic cable or electric control wires, the wharf structure will contain spare conduits for this purpose.*⁴⁹

⁴⁹ Directly extracted Port of Long Beach, Engineering Division, "Design Standard for Shore to Ship Power February 24, 2004, <http://www.polb.com/civica/filebank/blobdload.asp?BlobID=2158>



⁵⁰ <http://www.polb.com/civica/filebank/blobload.asp?BlobID=5778>



⁵¹ ITS Shore to Ship Connection Container Ship of "K" lines, Port of Long Beach

2.1.1.3 Port of Oakland case:

About the Port of Oakland: The Port of Oakland oversees the Oakland seaport, Oakland International Airport and 19 miles of waterfront. The Oakland seaport is the 4th busiest container port in the U.S.; Oakland International Airport offers more than 200 daily non-stop flights to 40 domestic and international destinations; and the Port's commercial real estate includes Jack London Square, Oakland's premier entertainment spot along the waterfront. The Port of Oakland was established in 1927 and is an independent department of the City of Oakland.⁵²

On July 2007 the Oakland Board of Port Commissioners approved a \$275,000 investment on testing a new technology as an alternative to the traditional cold ironing method. While the same principles apply here, the source of electrical power is provided by Liquefied Natural Gas (LNG) instead of the power grid. With an estimated cost of \$90,000,000 for redesigning and modifying the infrastructure needed for "mobile shore power", as it is called by the port authorities, the Port of Oakland shows its commitment to "environmental innovation"⁵³.

The reason for using LNG as prime source of energy for powering hotelling ships is the inadequacy of the existing power grid to handle the electricity demands for large scale vessels. The reduction of health hazards such particulate matter and air pollutants sourcing from docked ships would allegedly be equal to the classic cold ironing methods.

A Press release on February 3, 2011 was stating that the Port authorities have added \$5 million to the necessary funds for port's shore power project. The press release was explaining the various ways the Port would use to secure the funds and it was also stating its environmental goals for reducing "the health risk from seaport sources of diesel emissions by 85% by 2020"⁵⁴

The choice of implementing shore power for ship powering at berth is estimated by the port's officials to reduce the pollutant emissions by 33 tons on an annual base, a strong argument for implementing cold ironing systems.

⁵² Info extracted by www.portofoakland.com

⁵³ Port of Oakland Executive Director Omar Benjamin, commenting on mobile shoreside power.

⁵⁴ Port of Oakland Executive Director Omar R. Benjamin

2.1.2 Europe ports

2.1.2.1 Port of Gothenburg case:

About the port of Gothenburg: The Port of Gothenburg is the largest port in the Nordic region. Its geographical location and 26 daily rail shuttles put key export companies throughout the whole of Scandinavia and the Baltic Region within easy reach. The Port of Gothenburg has a wide range of ocean routes within and outside Europe, and is the only port in Sweden with the capacity to receive the largest container vessels with direct links to other parts of the world. The Port of Gothenburg has terminals for Ro-Ro goods, containers, passengers, oil and vehicles.⁵⁵

“Port of Gothenburg is proud and happy to have received the environmental “Oscar” for its intensive work on reducing local air pollutants, greenhouse gas emissions and noise.”⁵⁶

The port of Gothenburg was the first in the world to implement cold ironing energy provision for ongoing vessels. The vessels at berth were provided with high voltage electrical power resulting in the complete shut off of their main engines and auxiliary generators. Provision of electricity via cold ironing methods goes back on 2000 at the Ro/Ro terminal.

Nowadays the shore power projects has developed to the limit that virtually one out of three vessels calling at the Port of Gothenburg can completely rely on cold ironing systems, thus shutting down all their polluting engines.

Moreover, by utilizing two local wind turbines for generating “green electrical power” the port ensures that extra power is generated in an environmental friendly way, contributing in the abatement of air pollutant factors such as NO_x and SO_x common side products of power plants.

Stena Line⁵⁷ has inaugurated a shore power supply facility in January 2011 for the company’s operating ferries operating between Germany and Sweden. By applying cold ironing techniques the port authorities claim to minimize the effects of auxiliary engines emissions while in port. The onshore power facility has been collaboration between the Port of Gothenburg, ABB and Stena Lines. When completed, all five Stena Lines ferries and passengers vessels would be able to plug in the ports facilities for electrification, resulting in 33% use of cold ironing systems by all ships calling at the port, a “unique figure in international terms”⁵⁸

*“Gothenburg is a living port city and shipping is part of the city's soul. It is a matter of ensuring that the highly important ferry traffic is as optimal as possible in environmental terms, especially close to the city centre. Connecting the vessels to onshore power supply is a forceful measure to reduce emissions and noise”.*⁵⁹

⁵⁵ Info extracted by www.portgot.se

⁵⁶ <http://www.portgot.se/prod/hamnen/ghab/dalis2b.nsf/vyPublicerade/B9761872AF07B984C125719400312C6E?OpenDocument>

⁵⁷ <http://www.stenaline.com/stena-line>

⁵⁸ Media - Press releases Cleaner shipping at the Port of Gothenburg Jan 26, 2011

⁵⁹ Magnus Kårestedt, chief executive of the Port of Gothenburg.

The facility has implemented technology that transforms the electrical current from 50Hz, frequency standardised in European market to 60Hz, used by the vast majority of ongoing vessels.

At present cold ironing systems are used for passenger and freight ferries, while research conducted by the port authorities is targeting towards plugging in containerships and large cruise ships across European waters.

2.1.2.2 Port of Antwerp case:

About the port of Antwerp: The **port of Antwerp** in Belgium is a port in the heart of Europe accessible to capesize ships. Antwerp stands at the upper end of the tidal estuary of the Scheldt. The estuary is navigable by ships of more than 100,000 Gross Tons as far as 80 km inland. The inland location means that the port of Antwerp enjoys a more central location in Europe than the majority of North Sea ports. Antwerp's docks are connected to the hinterland by rail, waterway and road. As a result the port of Antwerp has become one of Europe's largest sea ports, ranking second behind Rotterdam by total freight shipped⁶⁰.

A press release on May 2008 was informing the public that the Port authorities have taken a step towards cutting down the environmental and health threatening emissions from ships while in port by installing shore side power utilities for vessel powering. Shore power has been used before for barges and Port's own tug and dredger fleet, until mid 2008 when the trial project of powering up large scale vessels, wide range collaboration between Independent Maritime Terminal (IMT)⁶¹, Port authorities and the Flemish community took place. The trial project was for providing with electrical power the seagoing ships of Independent Container Line (ICL)⁶².

The port authorities attach great significance to cold ironing technology used at the Port of Antwerp, as it an integrated form of combating air pollution generated from vessels at ports.

*The total investment cost of the shore power facilities amounts to 1,117,829 Euros, with IMT receiving financial support from the Port Authority and the Flemish Community. By supporting the shore power project, Antwerp Port Authority is also helping to meet its commitment for practical, port-related measures contributing towards implementation of the particulates action plan drawn up at the end of last year by the Flemish Government, Antwerp City Council and the Port Authority itself.*⁶³

⁶⁰ http://en.wikipedia.org/wiki/Port_of_antwerp

⁶¹ <http://www.icl-ltd.com/View.aspx?page=service/imt>

⁶² <http://www.icl-ltd.com/>

⁶³ Financial data extracted from PRESS RELEASE: Port of Antwerp launches unique trial project with shore power for seagoing ships,

http://www.portofantwerp.com/portal/page/portal/POA_EN/Actueel/Nieuws/Persberichten/PB%20Walstroo mE.pdf

Comparison of emissions by diesel engines (Ro and MD) and shore power in the following table:

Emissions (in g/kWh)	NO _x	SO _x	VOS	PM
Diesel Engines (2.7% S)	12.47	12.30	0.40	0.80
Diesel Engines (0.1% S)	11.80	0.46	0.40	0.30
Shore Power	0.35	0.46	0.02	0.03
Emissions (in g/kWh)	CO	CO ²	CH ₄	N ² O
Diesel Engine	0.9-1.3	690-720	0.004-0.01	0.031
Shore Power	0.0125	330	0.028	0.014
Reduction	99%	>50%	-	>50%

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⁶⁴http://www.portofantwerp.com/portal/page/portal/POA_EN/Actueel/Publicaties/APN/Port%20News%2057/APN57_UK.pdf

2.1.2.3 Port of Stockholm case:

About the Port of Stockholm: Ports of Stockholm forms an important part of the infrastructure for the transport of goods and people. Each year more than 11 million passengers and nine million metric tons of goods pass through the capital of Sweden's ports simply, efficiently and cost-effectively. Transport by sea is also a good eco-friendly alternative, with the enormous advantages of groupage transportation. The blue route is the green one to and from Stockholm. Port of Stockholm offer quay-berths, facilities and services for ferry, cruise and goods traffic. Port of Stockholm is also responsible for the development and maintenance of inner-city quays, as well as services for archipelago and other waterborne local traffic.⁶⁵

The first shore power utility was installed at the Port of Stockholm as back as 1985, servicing vessels operating to Aland Island. In 2006 The Tallink passenger ferries Viktoria I and Romantika commenced the use of a new cold ironing low voltage systems located in Freeport Terminal at the Port of Stockholm. This shore power utility can provide 690V at standardised 50Hz frequency by 12 cables connected to the vessel side. One major advantage of this technology is that the connection/disconnection time can be brought down to 5 minutes.

2.1.3 Rest of the world

2.1.3.1 Port of Shanghai case:

The port authority has commissioned a feasibility study on using shore power at ChanHuaBing terminal. Although the study came out that an investment in green cold ironing technology was feasible the lack of infrastructure of power grid and power distributing was noted in the feasibility study as major drawback factors.

⁶⁵ <http://www.stockholmshamn.se/en/About-us/>

2.2 Future Plans for using Alternative Marine Power in major Ports

Currently the plans for implementing shore based power supply for vessels are globalised. Many ports around the world have expressed their concern in mitigating the air pollution and minimizing the environmental degradation cost by implementing green technologies. The ports below are currently investing or examining their perspective towards the use of cold ironing systems at their respective terminals.

US based ports

- *Port of New York*
- *Port of Tacoma*
- *Port of Vancouver*
- *Port of San Diego*
- *Port of Houston*
- *Port of San Francisco*
- *Port of Richmond*
- *Port of Seattle*

Europe based ports

- *Port of Rotterdam*
- *Port of Bergen*
- *Port of Oslo*
- *Port of Helsinki*
- *Port of Tallinn*
- *Port of Rome*

Asia based ports

- *Port of Tokyo*
- *Port of Yokohama*
- *Port of Osaka*
- *Port of Shanghai*

2.3 Technical issues of cold ironing facilities

In general there is no common set of standards in the use of cold ironing systems at berths. The port management has to rely on already finished projects for guidelines on how to install the suitable gear to facilitate the shore powering of vessels.

The energy flow chart from the energy utility to the ship's electrical room is listed below. Although it may vary notably, in most cases is similar to that:

- Power connection to the utility
- Transformation from the utility voltage to a distribution voltage
- Switchgear to the transformer to project the outgoing cable
- Cables and conduits to carry the power to the switchgears and receptacles pits
- Multiple switchgear units near the berth face to distribute and switch power to the receptacles pits
- Multiple receptacles pits along the deck at berth face
- Flexible cable with plugs and cable management system
- On ship distribution transformation and synchronization

Power supply

The power needed for providing the vessels with electricity is usually provided at the utility level thus providing a degree of isolation from the main terminal distribution, minimizing the impact in case the cold ironing system fails and providing a separately metered service if required. The voltage coming from the utility may be at distribution standards, 10 kV up to 40 kV or at a transmission level, up to 60kV.

Land Side

Containerships typically operate with three-phase, at 60Hz and voltage of 440V (distribution voltage) or 6.6kV. In the last case a transformer to step down the voltage is required. The transformer capabilities should be considered in order to meet current and future energy requirements of ships. With future ships trends for larger vessels this aspect should be considered thoroughly. A Maersk 14.000 TEU has 1.300 reefer plugs and a 10.500 TEU has accordingly 900 plugs. Using an estimated need of 5kV voltage for each plug, the total reefer area could easily draw as much as 4.5MW. So the increase in vessels capacities should be considered when installing cold ironing systems.

A switchgear cell is required between the transformer output side and the cables leading to the dock face with protective relaying for the transformer and the feeding cables respectively.

Cables and conduits could be similar to the rest of the terminal for handling reasons. In the effort to keep the cables in manageable size, a typical of 4MVA is considered as adequate. Thus two-cable joint cable can provide up to 8MVA of power.

The preferred medium for the controls circuitry is fiber optic. This area needs of further investigation and research as it is currently gaping. The alignment must be precise between the shore and the ship's side for the connection to be successful.

Vessel side

The majority of operating ships have a distribution voltage of either 440V or 6.6kV and frequency of 60 Hz. The 440V distribution systems are not ideal for providing shore based power because of the high amperage required. In order to reduce the losses caused by the augmented electrical resistance the supply of electrical power is performed in the following manner: the voltage up to the berth face is as high as 6.6kV and a step-down transformer that can be located either on board of the ship or at the berth face provides with 440V the distribution systems.

The step-down transformer and the cable management system should reside onboard for smother operation. Ships can be retrofitted for using cold ironing or built with the necessary gear implemented on the vessel.

The process of turning from ship's own power to shore power is realized in two ways. The first requires turning off the ship's power for a short period of time and then switching to shore power. On the other hand the ship's engines are running at berth and simultaneously electrical shower power is provided. The last scenario provides a bumpless transition of power aspect that is critical in a cruise ship where energy demands are constant and elevated. A short time power interruption can be tolerated in a containership, although it is basic engineering that power interruptions are detrimental to equipment reliability and lifetime. As a result the synchronization of power sources, ship's generators and shore based is promoted globally regardless the type of commercial vessel.

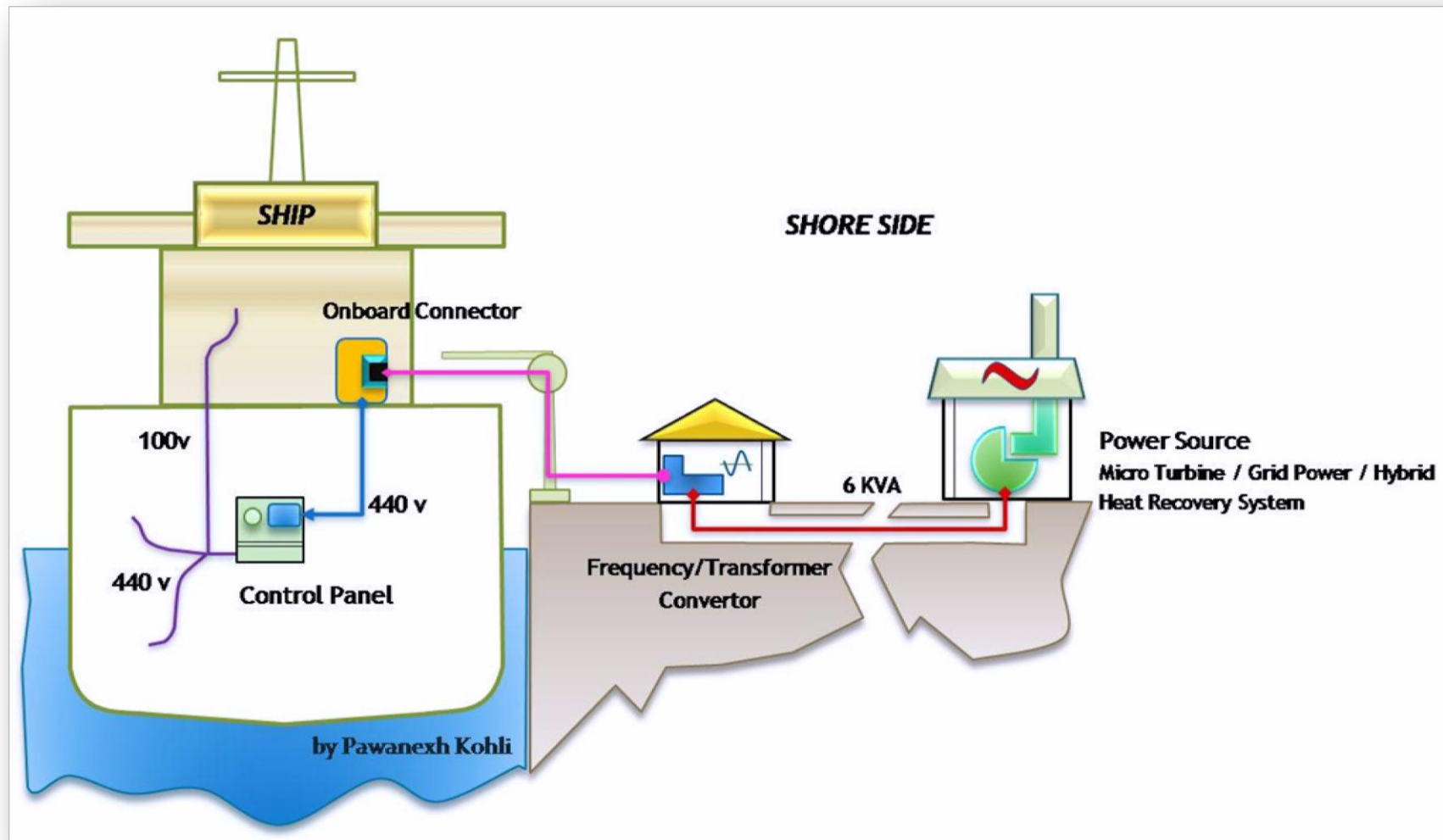
Flexible cables with plugs and the cable management system are considered more practical to be implemented onboard the ship. Aligning the cables with the electrical room of ships with large scale cranes requires extensive handling and operations performed by the terminals personnel.

While at berth the ships main and/or auxiliary engines and generators are on and running for contributing to the ships energy vigorous needs. The cold ironing is required to provide to the vessel large amounts of energy (electricity). These electricity needs are typically estimate bellow in this report for a specific case of vessel (containership). This numbers may vary notably depending on the ship's type and size.

2.3.1 Case study of containership: Load requirement in port

- Operating voltage: AC 440V / 220V
- Automation system: Gavazzi, Sulzer – operates on AC 220V – DC 24V
- Diesel generators: Bergen diesel KRG 7590KW (2x1430KW, 3x1260KW, 1x950KW)

TYPE	KW
EMERGENCY GENERATOR - ESSENTIAL SERVICES BACKUP	110
SHORE CONNECTION MAX CAPACITY OF CB	195
LIGHTING - INTERNAL	70
ACCOMODATION / CONTROL ROOM AIR CONDITIONERS	112
PROVISION ROOM COMPRESSORS	12
ESSENTIAL SERVICES (SW/LT/CW PUMPS/BOILER)	10
PURIFIERS - HFO,LO	23
EMERGENCY SERVICES - FIRE PUMPS	26
BILGE PUMPS	26
BALLAST PUMPS	37
MACHINERY SPACE VENTILATION	105
CARGO HOLD VENTILATION	20
GALLEY SERVICES	25
MOORING WINCHES	50
CONTAINER OPERATING LOAD (CYCLING 60% LOAD)	2400
SHIPS CARGO GANTRIES	850
ANTI-HEELING PUMPS	105
MAIN/ SERVICE AIR COMPRESSORS	110
BOW THRUSTERS (EMERGENCY USE)	670
STEERING GEAR (PRE-SAILING TEST)	37

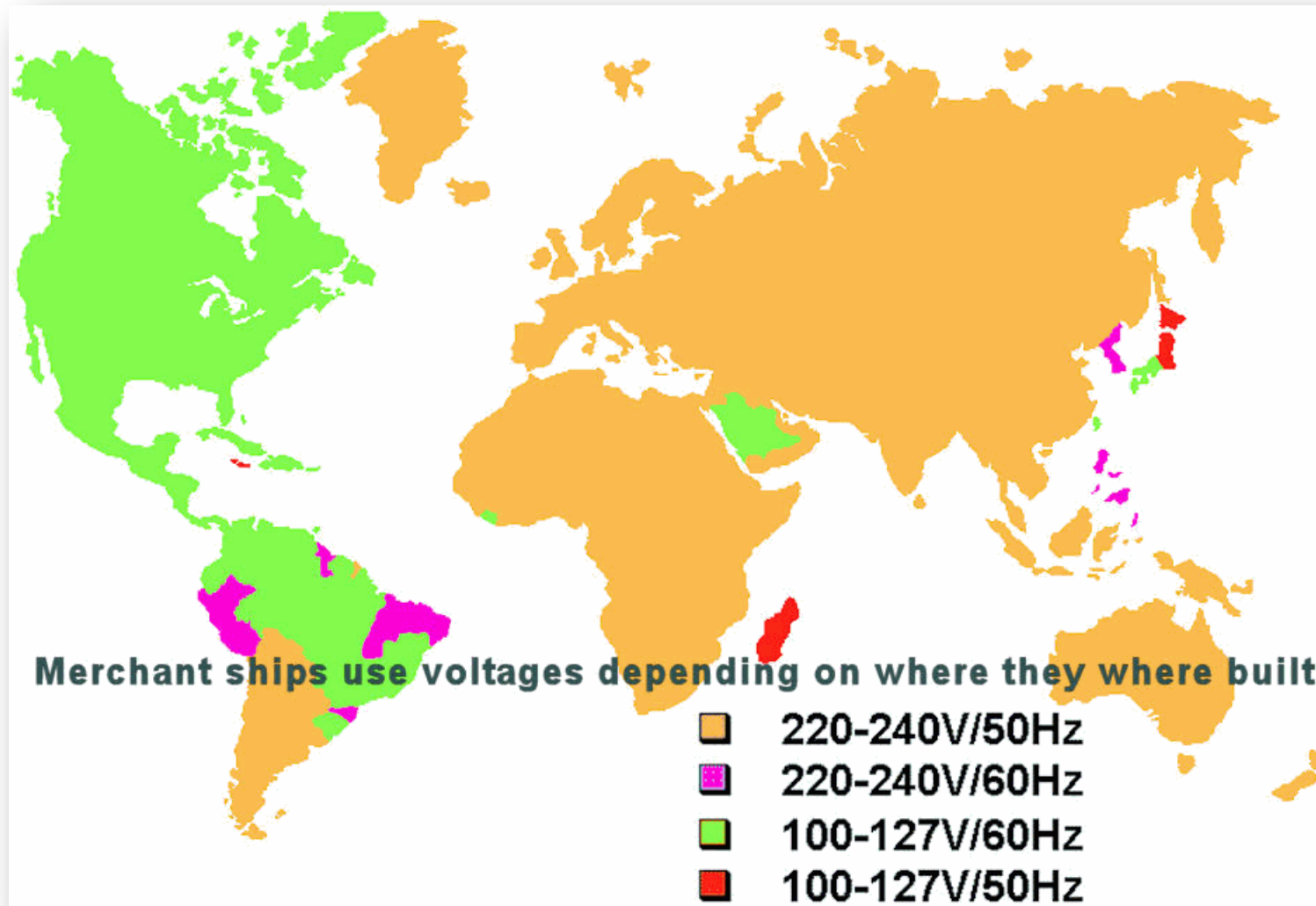


⁶⁶Proposed Cold Ironing implementation at berth

⁶⁶ By Pawanehi Koxli, source <http://upload.wikimedia.org/wikipedia/commons/9/9f/PxKohliColdIron.jpg>

The use of compatible energy systems for the provision of vessels with electricity is linked directly with the needs of each type of vessel calling at the terminal. The table below indicates a rough estimation for the electrical power that each type of vessel requires in average.

Average power requirements at berth for various type of vessels	
Containership	1 - 4 MW
Cruise Ship	7 MW
Reefer	2 - 5 MW
Ro-Ro	700 kW
Tanker	5 - 6 MW
Bulk - general cargo ship	300 kW - 1 MW



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⁶⁷ http://upload.wikimedia.org/wikipedia/en/8/8f/Voltage_and_frequency.png

[57]

2.4 Cold ironing standards “gap”

An initial meeting with participants the Port of Los Angeles (POLA), the Port of Long Beach (POLB), and the Port of Rotterdam was held in September 2006 in order to initiate the standardization process for the implementation of cold ironing globally. These ports having a leading role in promoting the use of alternative marine power, agreed to a Publicly Available Specification (PAS) that could serve as a pathway before the ratification of the official cold ironing standards.

In the same direction, ISO⁶⁸ has initiated a workgroup to develop a shore power set of standards. The workgroup has been working under the umbrella of Technical Committee 8 and Sub-committee 3 (TC8/SC-3). This workgroup has 11 participating countries:

(China (SAC) Denmark (DS) Germany (DIN) Italy (UNI) Japan (JISC) Korea, Republic of (KATS) Netherlands (NEN) Portugal (IPQ) Russian Federation (GOST R) United Kingdom (BSI))

and 12 observing countries:

(Bulgaria (BDS) Croatia (HZN) Cuba (NC) France (AFNOR) India (BIS) Iran, Islamic Republic of (ISIRI) Norway (SN) Poland (PKN) Romania (ASRO) Slovakia (SUTN)Turkey (TSE) Ukraine (DSSU)).

The workgroup has under development a set of standards for cold ironing provision. Under the title “Cold ironing -- Part 1: High Voltage Shore Connection (HVSC) Systems – General requirements ISO/IEC/IEEE DIS 80005-1”⁶⁹ number the team is in the process of standardization cold ironing techniques for global use.

More Information is coming from the IEEE on work that is currently done for setting those standards that are currently missing. IEEE Electrical shore-to-Ship Power Connections workgroup is another group of industry experts collaborating with the ISO workgroup to shape the cold ironing standards.

“Recent developments indicate that many ports are going to encourage or require certain vessels to connect to shore power for the duration of port visits to reduce air pollution emissions. These shore-to-ship connection capacities typically exceed 5 MW. Coordinated development of analytical techniques, port infrastructure and shipboard electrical plants will facilitate the implementation of the “any ship, any port” concept. The IEEE P1713 and IEEE 60092-510 Working Groups will develop standards covering system components necessary for connecting large commercial ships including the shore power supply, shore connection boxes, cable connections, ship incoming panel and control systems. The IEEE 60092-510 Working Group is working with IEC and ISO on a joint international standard.”⁷⁰

⁶⁸ International Organization for Standardization , www.iso.org

⁶⁹ http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=53588

⁷⁰ Info of the workgroup <http://standards.ieee.org/develop/wg/ShorePwr.html>

A list of the active workgroups with information on the subject they are currently developing:

- P80005-1 - IEEE/ISO/IEC Draft Standard for Cold Ironing - Part 1: High Voltage Shore Connection (HVSC) Systems- General Requirements

*“This international standard (standard) describes HVSC systems, on board the ship and on shore, to supply the ship with electrical power from shore. This standard is applicable to the design, installation and testing of HVSC systems and addresses: * HV shore distribution system, * shore-to-ship connection and interface equipment, * transformers/reactors, * semiconductor / rotating convertors, * ship distribution system, and * control, monitoring, interlocking and power management system. This standard does not apply to the electrical power supply during docking periods, e.g. dry docking and other out of service maintenance and repair. NOTE 1 Additional and/or alternative requirements may be imposed by the National Administration or Authorities within whose jurisdiction the ship is intended to operate and/or by the Owners or Authorities responsible for a shore supply or distribution system. NOTE 2 it is expected that HVSC systems will have practicable applications for ships requiring 1 MW or more or ships with HV main supply. NOTE 3 Low-voltage shore connection systems are not covered by this standard.”⁷¹*

- P80005-2 - Cold Ironing Part 2: High Voltage Shore Connection (HVSC) Systems - Communication Interface Description

“This standard describes the data interfaces of shore and ships as well as step-by-step the procedures for the onshore power supply communication. All arguments, which are written in italics in this standard, are signals of the telegrams. In the interface descriptions the address and data type are specified.”

Already published standards include:

- ISO 28460:2010 Petroleum and natural gas industries -- Installation and equipment for liquefied natural gas -- Ship-to-shore interface and port operations.⁷²

Abstract:

“ ISO 28460:2010 specifies the requirements for ship, terminal and port service providers to ensure the safe transit of an LNG carrier through the port area and the safe and efficient transfer of its cargo. It is applicable to pilotage and vessel traffic services (VTS); tug and mooring boat operators; terminal operators; ship operators; suppliers of bunkers, lubricants and stores and other providers of services whilst the LNG carrier is moored alongside the terminal. ISO 28460:2010 includes provisions for a ship's safe transit, berthing, mooring and unberthing at the jetty; cargo transfer; access from jetty to ship; operational communications between ship and shore; all instrumentation, data and electrical connections used across the interface, including OPS (cold ironing), where applicable; the liquid nitrogen connection (where fitted); ballast water considerations. ISO 28460:2010 applies only to conventional onshore LNG terminals and to the handling of LNGC's in international trade. However, it can provide guidance for offshore and coastal operations.”

⁷¹ <http://standards.ieee.org/develop/project/80005-1.html>

⁷² http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=44712

The various aspects of cold ironing that require standardization are numerous. The shipping industry is moving towards the globalization of the techniques and procedures followed when providing shore based power to different types of vessels with a wide range of energy needs. The result would be a working model of “any ship - any place – any time” across the global modern port hubs.

Appendix A contains the results of the 55TH session (agenda item 4) of the MARINE ENVIRONMENT PROTECTION COMMITTEE related to the standardization process of cold ironing in ports.

Chapter III

3.1 Legislation towards Cold-Ironing in modern major ports.

Towards the direction of full implementation of cold ironing techniques in key modern port-hubs, the legislative framework has a substantial part to fill in. By setting the ground rules for air pollution abatement in the maritime industry context, the process of transforming the shipping into a much “greener” business is dramatically accelerated. Self – regulation in imposing any emission standards and limitation during the past years has literally failed.

A major reason for this is that ship air pollution occurs miles away from residential areas. “In this meaning a logistic company may receive negative feedback from its clients for not using cleaner trucks and therefore revenue losses. On the other hand no one “sees” the smoggy emissions of a large scale containership while crossing the Atlantic Ocean to provide our societies with bananas or DVDs”.⁷³

The efforts in imposing international rules and laws for the emission levels has been promoted by many major key players in global scale. Numerous types of legislations and sets of standards are nowadays controlling the pollution produced by maritime industry. State laws, flag regulations, local authorities specifications in emission patterns of ships and international treaties or/and committees have direct impact in forming the basic rules in shipping market.

An easy conclusion is that recent legislation for austere measures in air pollution has boosted the development of alternative marine power technologies. Although the concept of providing vessels with shore side power is still in the phase of development, it has been around for the past 20 years. Bearing that in mind it is safe to assume that the recent legislation passed in California has put cold ironing on the map as a prime strategy for air pollution abatement.

Cold Ironing is “*not yet a success*”⁷⁴ because the environmental oriented legislation was recently applied in US and Europe. This fact underlines the value of forcing the progress of technology and primarily its implementation by suitable legal tools.

⁷³ Author, 2012, explaining the weakness of emissions self regulation to my grandmother.

⁷⁴ KEY FACTORS AND BARRIERS TO THE ADOPTION OF COLD IRONING IN EUROPE Giulia Arduino David Carrillo Murillo Claudio Ferrari

3.2 Background of legislation–regulatory issues for air emissions control in shipping industry

Historically the ships' emissions were undergoing for many years unregulated. Many local governments and authorities, especially those of environmental sensitive areas and ports such as Vienna had imposed a more strict set of regulations to be followed by vessels calling at their ports. Since the effort was one sided and results were not the anticipated ones. Most of the international environmental rules and regulations were imposed during the last 10-15 years.

In 2004 the MARPOL Convention (73/78) has placed a ceiling on sulphur emissions generated by ships making mandatory the use of <4.5% sulphur based fuel oil by 2010. The convention's target is set at less than 0.5% by the year 2020 plus the total prohibition of emitting deliberately ozone depleting substances.

Moreover in the year 2005, EU issued the directive 2005/33/EC, limiting the amount of sulphur to 0.1% in all types of marine fuel used while at berth for vessels "hotelling" more than 2 hours in European ports, since 2010.

The following year (2006) EU Recommendation 2006/339/EG came into designed for member-countries to promote cold ironing electricity facilities. The EC recommendation also urged for the development of harmonized international standards, providing also guidance on costs and benefits on the field of connecting ships to the power grid.

A summary of actions and measures taken is available in Appendix A for further study.

In 2011 IMO adopted mandatory measures targeting to reduce the GhG emissions generated by shipping activities, introducing chapter 4 of Annex VI. These measures make mandatory the adoption of ENERGY EFFICIENT DESIGN INDEX (EEDI) for new vessels and the SHIP ENERGY EFFICIENCY MANAGEMENT PLAN (SEEMP) both for new and prior built ships. These set of regulation are expected to enter in force on Jan 1st 2013.

Maritime and Coastguard Agency⁷⁵, an executive agency of the department of transport of UK government, issued the *"The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008 implement the 1997 Protocol to the International Convention on the Prevention of Pollution from Ships (MARPOL 73/78"* describing the technical aspects of MARPOL Annex VI implementation in the United Kingdom. This document contains the regulations that must be followed by the shipping community for protecting the environment.

US efforts on forcing the use of more eco-friendly technology on vessel operations are constant. Many agencies and authorities such as the Air Resources Board (ARB) and South Coast Air Basin State Implementation Plan (SIP) have issued rules and regulations aiming at ship generated air pollution abatement.

⁷⁵ <http://www.dft.gov.uk/mca/>

Especially in the US pieces of legislation, the reference on cold ironing technology as a powerful tool for achieving environmental protection goals is obvious. It is evident that shutting down heavy fuel marine diesel engines inside international ports and powering vessels with shore side electricity gains a lot of attention as a major strategy against pollutant vessel emissions.

California Environmental protection Agency has outlined the regulations that will control the cold ironing process on US ports. During the shore power workgroup the basics of alternative marine power have been shaped. Taking under consideration the Goods Movement Emission Reduction Plan the workgroup has indentified strategies that may be adopted by the international maritime societies aiming to reduce the impact of vessel emissions. Cold Ironing is figuring as a prime strategy due to the efficiency on cutting back emissions, a fact that leads to regulations in favour of cold ironing techniques implementation.

CARB has issued a substantial number of regulations as one of the major legislature bodies in the US for environmental protection issues. Summarising, the regulations for reducing the hotelling emissions at berth apply to any individual *“who owns, operates, charters, rents, or leases any container ship, passenger ship, or refrigerated cargo ship that visits a California port or any person who owns or operates a port or terminal located at a port where container, passenger, or refrigerated cargo (reefer) ships visit.”*⁷⁶

The regulation presented by the agency demonstrates the course of actions that is to be followed both from the perspective of port’s point of view and vessels side.

The following regulation *“allows for two main options to reduce hotelling emissions. First, ship operators can shut down their auxiliary engines while in port, except for three or five permissible hours of total operation per visit (“limited engine use” option). Alternatively, operators can implement a fleet-based option to reduce the emissions from the auxiliary engines in the fleet by specified percentages while docked (“emissions reduction option”). The “limited engine use” option requires that the operators of container ships, passenger ships, and reefers that visit California ports shut down their auxiliary engines for most of their stay while hotelling. Auxiliary engines would be allowed to run for three or five hours per visit. Specifically, these auxiliary engines must be shut down for at least 50 percent of a fleet’s total visits to a California port in 2014 and at least 80 percent of the fleet’s total visits to a port in 2020. While auxiliary engines are shut down, the ship’s onboard electrical needs must be satisfied by some other source of power, presumably the region’s electrical grid. An alternative compliance option is the “emissions reduction option,” in which ship operators would be required to reduce their fleet’s auxiliary engine emissions at a port by specific percentages and by specific dates. The specified percent reductions apply to the fleet’s engines, rather than to individual engines. The compliance dates for this option vary based on the emission reduction technique applied to the fleets.*

⁷⁶ <http://www.arb.ca.gov/regact/2007/shorepwr07/tsd.pdf>

The emission reduction techniques that could be applied to a fleet include: 1) using selected vessels for grid-supplied power based on potential auxiliary engine emission reductions rather than fleet visit percentages; 2) using distributed generation equipment to provide power to a vessel; 3) using alternative emission controls onboard a vessel or located adjacent to the vessel; and 4) using a combination of these techniques.”⁷⁷

⁷⁷ <http://www.arb.ca.gov/regact/2007/shorepwr07/tsd.pdf>

The rising interest in environmental issues around shipping activities is depicted strongly in the maritime press with numerous reports for the upcoming changes in the way ships “may pollute” the marine environment and especially major port hubs. The following extracts amongst many other references underlines the attention that cold ironing draws as a powerful tool against hazardous marine diesel engines emissions:

'Lines could face air quality lawsuits on US west coast'. "Shipping lines calling at Californian ports face the risk of hugely expensive lawsuits that they will almost certainly lose unless vessel emissions are cut. A number of carriers are now taking power from the shore when in certain ports such as Los Angeles rather than use their own engines, a method known as cold ironing. But there are no fixed rules yet in place and no industry agreement about the best way to improve air quality around the ports." - LLOYD'S LIST, 7 March 2005 (No.58865), p 6

'Editorial: Emitting hot air'. "Legislation will soon be forthcoming, say various influential US west coasters, to require visiting ships, already compelled to pursue all sorts of curious navigational stratagems when entering and leaving Californian ports, to "cold iron" - operate on shore power when alongside. Like all prescriptions driven by environmental lobbies with one end in mind, the problems are grossly minimised." - LLOYD'S LIST, 23 June 2006 (No.59193), p 7

'Editorial: A demand for greener ships'. "Despite the industry's insistence that the carriage of goods by sea is fundamentally the most environmentally friendly means of transport, a lot of people are not convinced. Indeed, there is a growing body of environmental regulation piling up on the shipping industry that it will have to digest and implement in the short to medium term. Atmospheric emissions constitute a major challenge, with nobody really suggesting that the new limits on sulphur for the Baltic, and soon the North Sea, will be the end of the affair. There is pressure in the US, led by powerful environmental interests 88 in California, for far tighter controls on sulphur, CO2 and particulates that will more or less mandate "cold ironing" in port. This sort of view will surely spread around the world." - LLOYD'S LIST, 3 October 2006 (No.59264), p 7

'Why power firms must get switched on to cold ironing'. "Carnival chief says utility companies must view shoreside electricity as "a clean air initiative, not a revenue maker". THE practice of cold ironing, or use of shoreside electricity while in port, will catch on in the cruise industry only if a "critical mass" of interested ships materialises and altruistic power utilities decide to give their profit-making urge a temporary rest, says a leading Carnival executive. - LLOYD'S LIST, 16 March 2007 (No. 59,379), p. 3

'UK gives cold shoulder to EU shoreside power move'. "UK ports and their shipping line customers must rally together to stop Brussels demanding cold ironing systems to cut air pollution. That is the message from both the UK government and industry leaders, amid fears that the European Commission is moving in favour of shoreside electricity for ships - a controversial solution that does not necessarily reduce power consumption." - LLOYD'S LIST, 15 November 2007 (No.59, 548), p 1

Energy savings of 25 per cent with a Siplink cold iron'. "Siemens Power Transmission and Distribution has launched a new ship to-shore cold ironing solution to enable ships in port to be connected to the medium voltage network of the local power supply company. The new system, called Siplink, enables ships to shut down their diesel generating sets while in port, reducing exhaust gases, soot, fine dust and noise and also offering potential energy savings of between 25 and 30 per cent." – SHIPPING WORLD AND SHIPBUILDER, December/January 2008 (Vol.208 No.4239), p 44

CARB moves on cold ironing'. "Mary Nichols, Chairman of the California Air Resources Board (CARB), has highlighted two port-related emissions reductions programmes that will dramatically reduce diesel particulate matter pollution from ships and trucks throughout the state by 2014. The first requires operators of certain types of ocean-going vessels to shut down their diesel auxiliary machinery while docked at the state's busiest ports in favour of using shore-based electrical power." - MER (Marine Engineers Review), February 2008 (pp 40-41)

'Cold ironing trial for Xin Ya Zhou'. "One of the largest ships to switch off its engines and use shoreside power, often called cold ironing, has successfully completed a trial at the Port of Los Angeles, writes Craig Eason." LLOYD'S LIST, 15 July 2008 (No.59, 714), p 7

EU puts damper on cold ironing - By Justin Stares "Cold ironing or shore-side electricity for ships will be costly and will not lead to a significant decrease in greenhouse gas emissions, a European Union workshop has heard. Shore -side electricity "would require high investments and a significant technical complexity whilst only providing limited emission reduction", said the authors of a report launched by the European Commission. The workshop in Brussels earlier this month urged lawmakers to take a "holistic" approach to the issue, said the European Sea Ports Organisation." LLOYD'S LIST, 19 May 2009, p 2

3.3 MARPOL Annex VI regarding air pollution from vessel engines.

This section of the study focuses to the aspects that the MARPOL convention regulates over the shipping activities and the concerns that rise from the pollution the sector produces

IMO included ANNEX VI in the MARPOL convention in 1997 in an effort to reduce the air pollution generated primarily from heavy duty marine diesel engines (Regulations for the Prevention of Air Pollution from Ships-Annex VI). A substantial number of major maritime countries have ratified the regulations described by Annex VI.

Annex VI includes measures aiming in mitigating air pollution by imposing rules and regulations controlling and preventing air within limits. Between other requirements, Annex VI sets a ceiling of sulphur content in fuel oil. Also the levels of NOx emissions are strictly defined for marine diesel engines.

Moreover the measures in ports receiving oil tankers and the processes followed for measuring VOCs are described in this part of the MARPOL convention.

3.4 Future goals

Based on the progress over the MARPOL ratification by a large section of IMO member countries, a set of targets has been formed for measuring and evaluating the "anti-pollution" efforts made by the international maritime industry.

The main changes would see a significant reduction progressively, setting the emissions ceiling as high as 0.50% until 2020 regarding the SO_x emissions, and up to 0.1% for the Sulphur Emission Control Areas (SECAs).

Moreover progressive reduction in NO_x emissions is agreed upon the MARPOL Annex VI convention, with stringer control, introducing the TIER-III engines with sophisticated design and lowered emissions operating in Emissions Control Areas such as the Baltic Sea and the North Sea.

The debate over the cut back of SO_x emissions and PM was rather intense and lead to the adoption of several standards for a feasible reduction of polluting factors produced by marine diesel engines. The key elements of these standards are:⁷⁸

- *the sulphur limit applicable in Emission Control Areas beginning on 1 March 2010 would be 1.00% (10,000 ppm), reduced from the current 1.50% (15,000 ppm);*
- *the global sulphur cap would be reduced to 3.50% (35,000 ppm), from the current 4.50% (45,000 ppm), effective from 1 January 2012;*
- *the sulphur limit applicable in Emission Control Areas effective from 1 January 2015 would be 0.10 % (1,000 ppm);*
- *the global sulphur cap would be reduced to 0.50% (5,000 ppm) effective from 1 January 2020, subject to a feasibility review to be completed no later than 2018. Should the 2018 review reach a negative conclusion, the effective date would default to 1 January 2025; and*
- *introduction of a fuel availability provision under regulation 18 Fuel Oil Availability and Quality that outlines what actions are appropriate should a ship be unable to obtain the fuel necessary to comply with a given requirement under regulation 14.*

⁷⁸ *Marine Environment Protection Committee (MEPC) - 57th session: 31 March - 4 April 2008*

Chapter IV

4.1 Potential emissions reduction by implementing cold ironing techniques; achieving balance of emissions for energy production

The ultimate scope of cold ironing and several alternatives technologies is common: to reduce the emissions footprint produced both at seas and in ports. The cold ironing technology offers a significant way of lowering ship diesel engines emissions while at berth. The potential reduction of health hazardous emissions are directly linked with the process used in each and every case and the “connection pattern” applied in every vessel that is equipped with alternative marine power gear and installations.

In measuring the potential pollutant emissions reduction, the use of a sophisticated inventory for GhG emissions is crucial. Carbon Footprint Working Group with its World Ports Climate Initiative⁷⁹ has taken a step forward in the effort to establish awareness of the need of adopting measures and setting ground rules in the maritime activities.

*“The World Ports Climate Initiative (WPCI) was established to raise awareness in the port and maritime community of the need for action regarding greenhouse gas emissions, to initiate studies, strategies and actions to reduce greenhouse gas emissions, to provide a platform for the maritime port sector for the exchange of information, and to make available information on the effects of climate change on the maritime port environment and measures for its mitigation”.*⁸⁰

The WPCI chief goals include:

- *Deepen the support for WPCI among the world’s ports*
- *Promote information sharing*
- *Establish a framework for CO₂ footprint inventory and management*
- *Establish Environmental Ship Indexing and increase support for this measurement*
- *Organize global support for WPCI goals among regional and global organization*

⁷⁹ <http://wpci.iaphworldports.org/about-us/index.html>

⁸⁰ From WPCI Mission Statement, http://wpci.nl/about_us/mission_statement.php

The WPCI has issued the Carbon Footprint Guidance Document in order to provide “a platform for the exchange of information”⁸¹ with the intention to serve as resourceful guide to carbon footprinting and carbon emissions inventories for worldwide ports trying to improve their GhG emissions inventories. It is WPCI’s goal to develop “a collaborative approach toward collecting information, estimating emissions, and developing plans to reduce the footprint of port operations.”⁸²

Before measuring the potential benefits in carbon reduction emissions, an agreement must be reached between the different sides and the approach each side attempts. The WPCI has described several emissions estimation methods. This report focuses on emissions produced by ocean going vessels.

Transportation by sea consists one of the most efficient transportation modes when emission footprint patterns are compared. Although, due to the diversity of engine types, workload, cargo types, operational modes or even the fuel type used to produce the necessary power, modelling the emission footprint is complicated, if not practical impossible. Ocean going vessels (OGVs) are one of the most efficient ways for transporting products and at the same time one of the largest source of carbon emissions.

“The emission sources for OGVs include propulsion systems that provide movement for the ship through water, auxiliary power systems that provide for the electrical demands during ship operations, and auxiliary boilers which produce hot water and steam for use in the engine room and for crew amenities.”⁸³

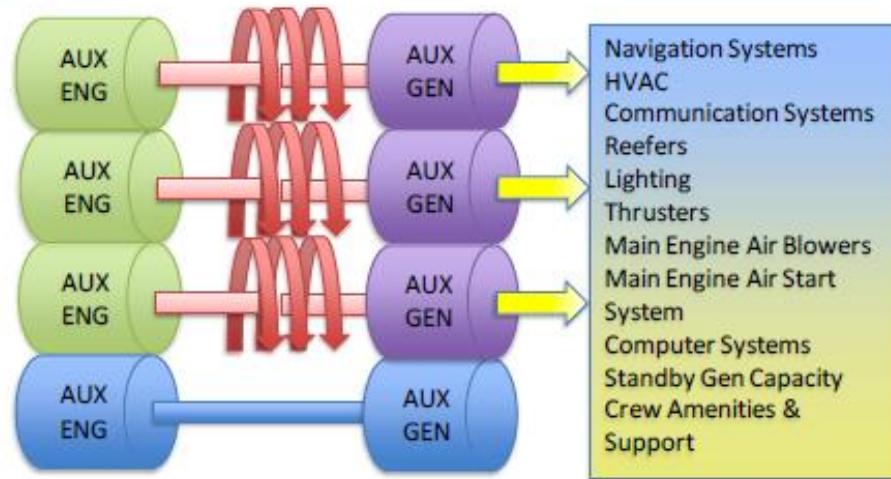
The various propulsion systems transform fuel chemical energy into power used for the ship’s movement into water. The table below depicts the different propulsion types implemented in a brief manner.

⁸¹ Carbon Footprinting for ports – Guidance Document Draft Nov. 2009

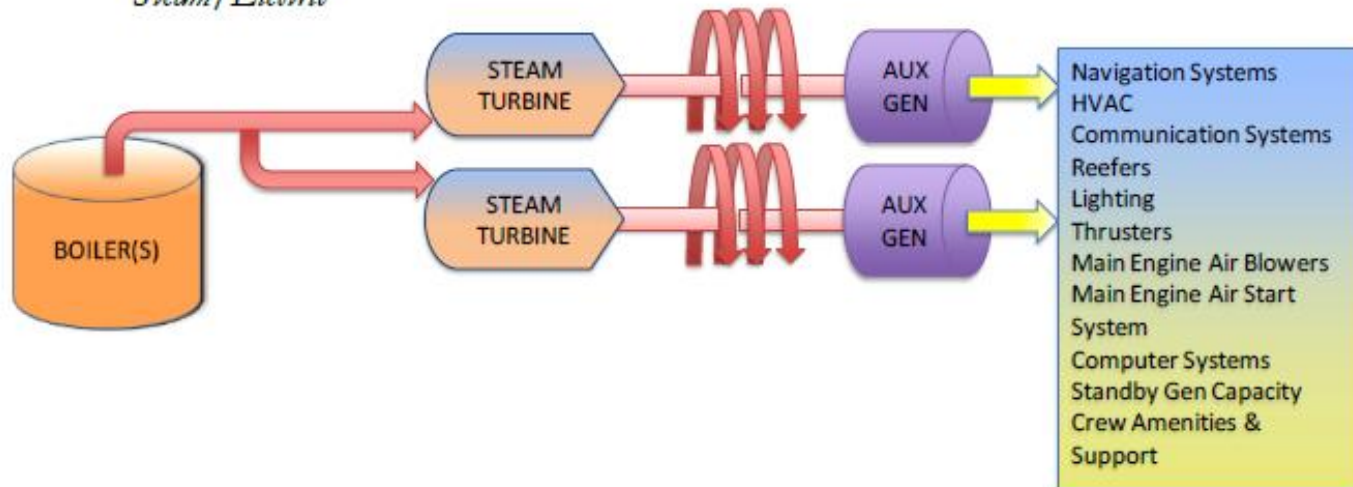
⁸² Carbon Footprinting for ports – Guidance Document Draft Nov. 2009, Preface

⁸³ Carbon Footprinting for ports – Guidance Document Draft Nov. 2009, Ocean Going Vessels

Diesel/Electric



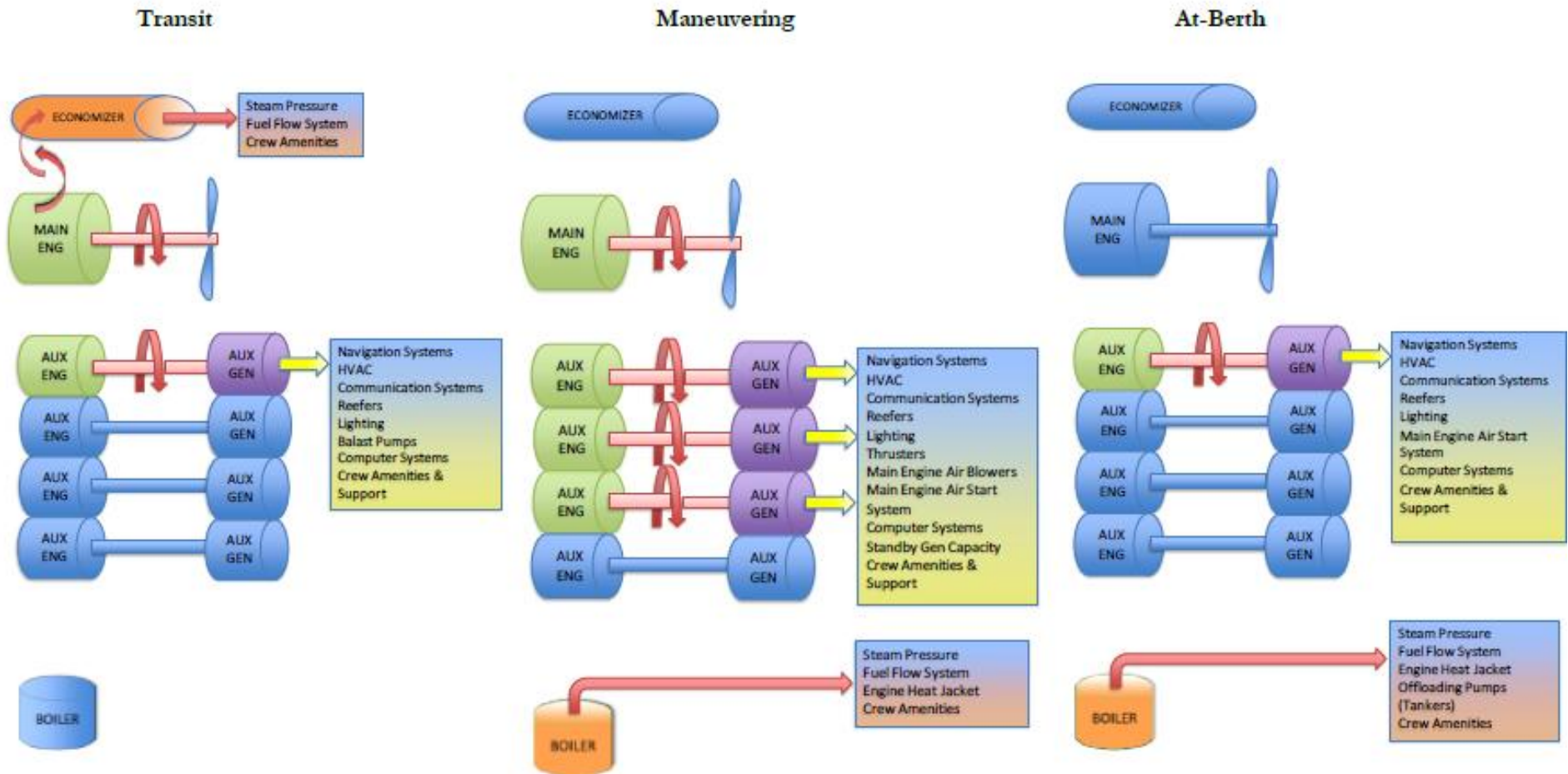
Steam/Electric



⁸⁴ Carbon Footprinting for ports – Guidance Document Draft Nov. 2009

Generally, there are three states of vessel operation:

- **Hotelling mode**
the ship is docked, berthed or anchored and it can be assumed typically that the vessel is not moving having its main engines powered off, auxiliary engines load usually at high levels due to discharge of its payload and with auxiliary boiler running to keep the fuel systems and propulsion engine warm in case of emergency.
- **Manoeuvring**
during harbour approaches, berth departing or navigation through confined waters (i.e. rivers). In this mode the propulsion engines are generally working at low loads due to the fact that ships speed is typically low. On the other hand, auxiliary engines are on their highest load, as on-board equipment is online. Fuel consumption is low for the propulsion engine, highest consumption for auxiliary engines.
- **Transit**
In this mode the vessel is sailing in open waters with cruising speed typically. The propulsion engines are on high load and auxiliary engines are on low load. Accordingly the fuel consumption is high for the main propulsion engines and low for the auxiliary engines.



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Implementation of cold ironing technology in modern ports is raising several issues, with the most important among them to be:

“Does the provision of ships at berth with shore side power reduce the total carbon emissions?”

To reach to a safe conclusion, some key factors must be examined. One of the most significant is the source of the extra electrical power needed in order for ships at berth to shut off their pollution generating engines. The “kind” of electrical energy i.e. coal generated or by using renewable energy, plays a key role in the final carbon balance and whether or not the project of shore side powering the ships is eco- friendly or harmful to the environment. These estimations must not only take under consideration the local effect of powering down the main and auxiliary engines inside ports. The tools utilised must be nationwide orientated or even global-wise. Applying the right method in calculating the carbon balance between ship side pollution and electrical plant emissions is crucial if the goal of achieving air pollution abatement is to be reached.

In the case of electrical power provision by the national grid, the demanded power is generated in a remote area and transferred to the port before distributed to berths with the necessary equipment. Power plants that use coal or fossil fuel are emitting in the atmosphere large amounts of carbon and numerous others pollutants. On the contrary electrical energy that is produced in an environmental friendly manner, such as by using wind and solar energy or by hydroelectric plants contributes significantly in the carbon equilibrium. The production by a stationary source is controllable and strictly defined under local authorities.

The use of different prime sources for producing electrical energy is extremely important in the implementation of cold ironing in modern ports. By connecting the vessels at berth on the national power grid the port authorities must be certain that the total carbon emissions are lower than by having ships auxiliary engines running. On the other hand, the port area would be local benefited with less sooty air but the total amount of emissions could be elevated.

In estimating the carbon emission in producing and transferring the electrical power at ports for cold ironing needs, the electrical losses must be calculated and the additional emissions generated for simply transferring the electrical energy from the source (i.e. plant) to the consumer (in our case the ship at berth).

To bypass the above drawbacks of directly connecting ships on-grid, the electrical energy production takes place next to the berth having as prime fuel Liquefied Natural Gas (LNG). There are many technological applications of this method, with substantial environmental benefits. Most significant is the amount of emissions produced that are several times lowed when compared to coal combustion or fuel oil use.

The LNG fuel is considered as environmental safe, using it for power production for vessels calling at ports. An electrical generator retrofitted for using LNG as fuel instead of diesel oil is placed next to the dock, providing with electrical power the ship while in hotelling state. This allows the main and auxiliary engines to completely shut off, helping saving millions of CO₂ tons emitted directly to the port environment.

The equipment needed is usually placed inside a TEU container attached to a truck, making it very mobile and easy to access at any berth. An alternative way is to place the generator container onboard and connect directly to the ship's electrical room. This method is portrayed below.



⁸⁶ http://i.pmcndn.net/z/img/67656_1419_1_o.jpg

The benefits of plugging in the ships on-grid are indisputable for the local atmosphere. The environmental degradation of residential areas nearby busy ports is severe and directly linked to health hazards and cancer related diseases.

A holistic approach for calculating the energy needs of ships at berth requires an extensive inventory of various vessel type energy demands. The following table demonstrates the variance of energy demands while at berth for a number of ships. It is clear that the levels of electrical energy demands in each case are a result of the ships type and payload. Cruise ships and reefers are on the top of energy consumers while at berth, fact that makes them prime candidates for implementing cold ironing technology on these vessels.

The graphs following visualize the demand of electrical energy of several characteristic ships that call modern ports. Also the hours that these ships spend at berth (hotelling) and finally the calls per year at ports.

SHIP NAME	VESSEL TYPE	YEAR BUILT	HOTELLING ENERGY DEMANDS kW	HOTELLING HOURS	CALLS PER YEAR
VICTORIA BRIDGE	CONTAINERSHIP	1998	600	44	10
HANFIN PARIS	CONTAINERSHIP	1997	4800	63	10
LIHUE	CONTAINERSHIP	1971	1700	50	16
OOCL CALIFORNIA	CONTAINERSHIP/REEFER	1996	5200	121	8
CHIQUITA JOY	REEFER	1994	3500	68	25
ECSTASY	CRUISESHIP	1991	7000	12	52
ALASKAN FRONTIEN	TANKER	2004	3780	33	15
CHEVRON WASHINGTON	TANKER	1976	2300	32	16
GROTON	TANKER	1982	300	56	24
ANSAC HARMONY	RO-RO	1998	1250	60	1
PYXIS	BULK CARRIER	1986	1510	17	9

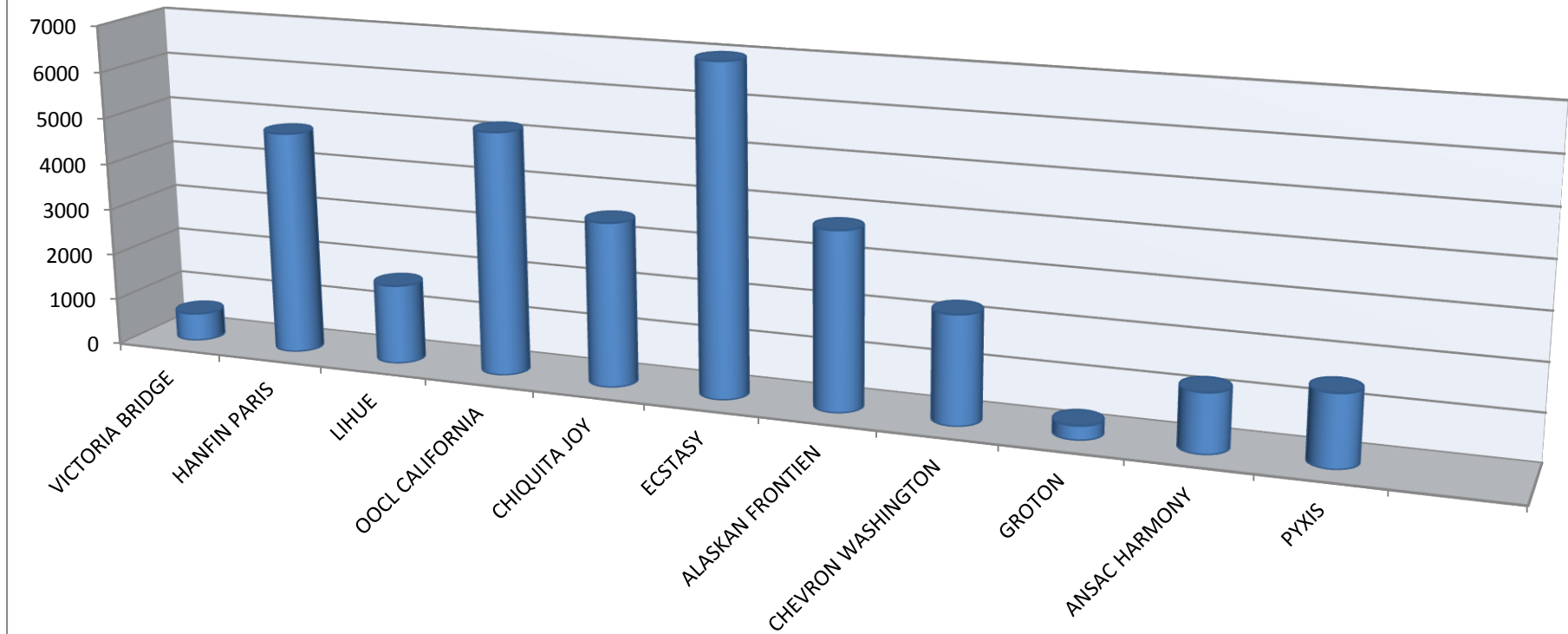
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⁸⁷ COLD IRONING COST EFFECTIVENESS PORT OF LONG BEACH, Prepared by ENVIRON International Corporation Los Angeles, California March 30, 2004

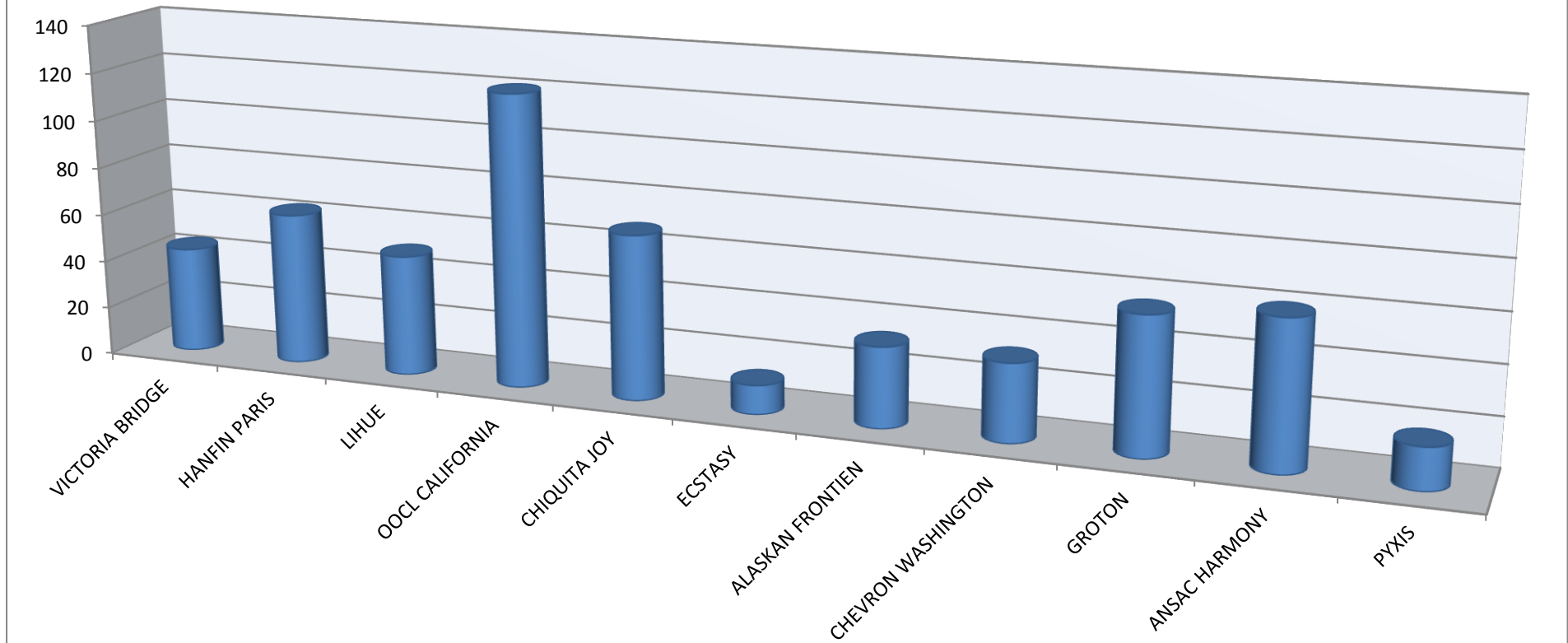
[77]

A Cold Ironing Study on Modern Ports, Implementation and Benefits Thriving for Worldwide Ports

Hotelling Energy Demand Case Study kW

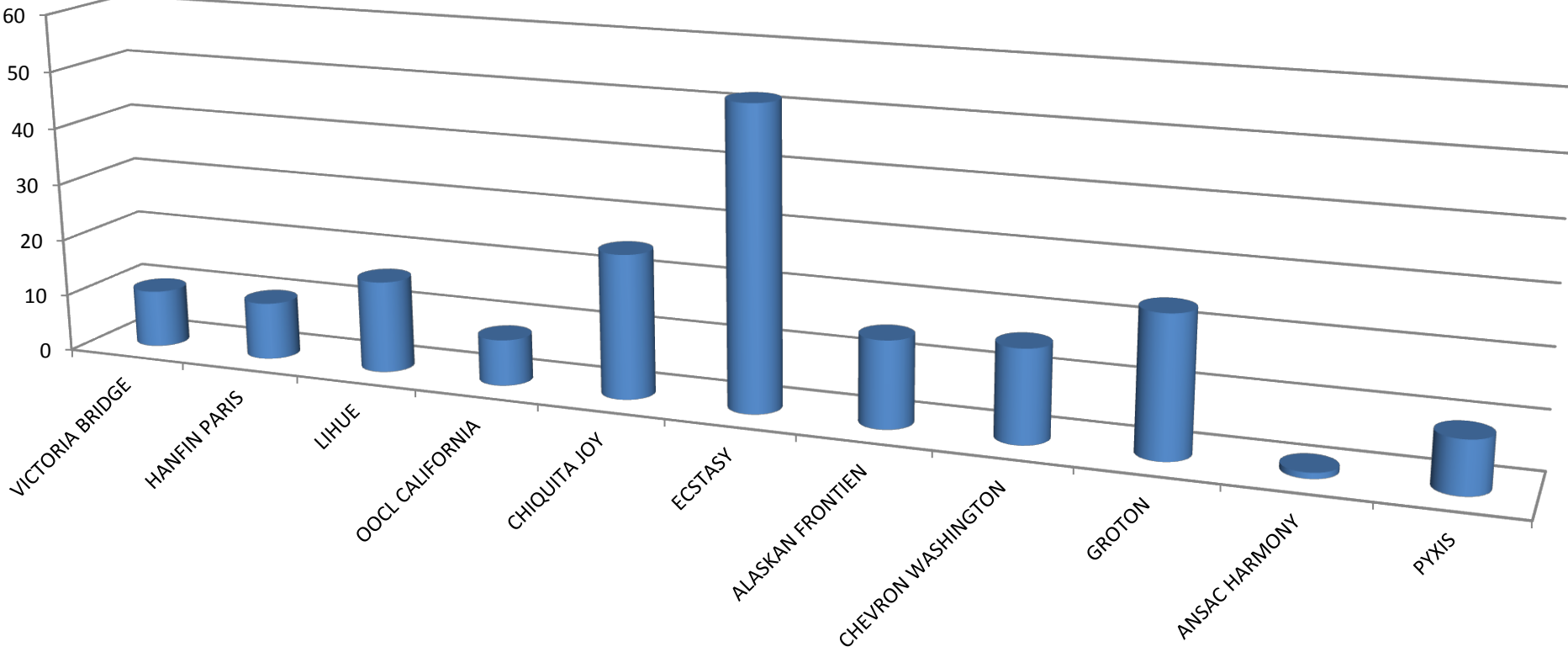


Hotelling hours



[79]

Calls per year



The energy production location, either in a power plant or on port site remains the principle question. In the effort to estimate all the various parameters and inputs in order to estimate whether is environmentally assisting to provide the ships with shore side power, International Association of Ports and Harbors⁸⁸ have created the IAPH Tool Box for Port Air Clean Programs⁸⁹.

“The purpose of this Tool Box is to provide ports, members and non members of the International Association of Ports and Harbors (IAPH) quick access to information, options and tools that can be used to start the planning process to address port-related air quality issues.”

The IAPH calculation tool is a simple way for obtaining a general feeling about the costs and benefits of cold ironing techniques. It takes under consideration the number of ships that are provide with shore power electrical energy and their fuel consumption.

“The OPS calculation tool provides a means of calculating the overall emissions reductions to be achieved by a given OPS project. In the tool, the energy source serves as a variable, allowing emission cuts to be calculated for several alternative scenarios.”⁹⁰

The two prime goals of this tool are the following: annual cost and benefits estimation and the annual emission reduction calculation. Moreover the IAPH tool asses various parameters on cost and emissions.

For calculating the cost effectiveness aspect, the costs are equalled against the total amount of pollutant emissions prevented. The relative harmfulness of different air pollutant come from a study by AEA technology, (see Appendix B for detailed information).

The information regarding the use of IAPH toolbox for emission reduction follows, directly extracted by the IAPH manual for OPS calculation model.

The following information is directly by the creators of the particular model for use research use. Several case studies are also available for educational purposes and for raising the public concern on the benefits that onshore power supply application for modern worldwide port hubs.

⁸⁸ <http://www.iaphworldports.org/>

⁸⁹ A Reference Guide provided by the International Association of Ports and Harbors (IAPH)

⁹⁰ <http://wpci.iaphworldports.org/onshore-power-supply/environment-and-health/emission-calculation.html>

4.2 ONSHORE POWER SUPPLY CALCULATION TOOL⁹¹

4.2.1 OPS calculation model

The tool can be used to calculate emission reductions, financial costs and benefits and emission benefits on an annual basis. The tool calculates the additional annual costs for the integral OPS project, not for individual parties such as vessel and terminal/port operators. Benefits are expressed as negative costs.

The tool can be used:

- to calculate the costs and benefits of specific projects
- to identify the influence of particular factors
- to estimate cost effectiveness
- to run different scenarios for break-even analyses.

4.2.2 Structure

The tool contains three sheets with calculations for different vessel types and one sheet with basic data. The former sheets contain input data (operational and cost data) and formulae for calculating annual costs and emissions reductions. Further down, general data, investment costs and operational costs can be filled in. For comparison, OPS and use of auxiliary engines are listed in parallel. Input data can be filled out in the white-coloured cells. All these cells can be changed according to your particular preferences and used to estimate the effect of certain choices.

⁹¹ <http://wpci.iaphworldports.org/onshore-power-supply/implementation/ops-calculation-tool.html>

4.2.3 Manual

Below, a stepwise manual for working with the tool is provided. The capital letters indicated can be found in the left-hand side of the tool.

A	Under “General information”, data can be entered on how frequently ships are berthed and for how long. These data are needed to calculate operational costs and emission changes.
B	Depreciation period and interest rate affect annual costs, with higher interest rates and shorter depreciation periods leading to higher annual costs.
C	Here the investments costs at the terminal can be filled in. The tool distinguishes various cost categories, which are summed to yield the total investment costs. Annual costs are calculated using the interest rate and depreciation period. Investment costs are not relevant for the auxiliary engines, as these are vital outside the ports.
D	In this section the shipside investments costs are filled in. A range of cost categories are listed, which are summed to yield the total investment costs. Annual costs are calculated using the interest rate and depreciation period.
E	The operational costs depend on fuel and electricity consumption levels, fuel and electricity prices and electricity taxes. From these data, annual costs are calculated. Savings on auxiliary engine maintenance costs can be filled in here, with negative costs standing for benefits. The total benefits are calculated from the number of hours at berth, as input to the General information section. There is an option to calculate with a CO2 price in advance. This option enables simulation of the influence of inclusion of the Maritime industry in the EU ETS on the cost effectiveness of OPS.

F	The total annual costs are calculated by summing the various cost categories under B to F. The costs or benefits accruing from using OPS can be calculated by comparing the 'auxiliary engine costs' with the 'OPS costs' (row 65), the outcome of which is presented in Box I.
G	The emission benefits are calculated by using emission factors from the data section and total annual consumption figures. Total annual consumption is calculated on the basis of the ships' consumption and the number and duration of port calls. The emission benefits can be found by comparing the figures in rows 76-80. The type of fuel can be changed from diesel to HFO here, as well as the energy source used for power generation (by clicking on a pull-down menu)
H	The total annual costs can be calculated by subtracting the 'auxiliary engine costs' from the 'OPS costs'. Negative costs mean that OPS yield a financial benefit. The cost effectiveness is expressed in Euro per unit of pollution. Pollution units are used to sum the various air pollutants, with SO ₂ and PM being judged to be 2.2 and 12.8 times more harmful on the basis of a study by AEA Technology (2005).
I	For each pollutant the relative emission reduction is calculated using the figures in rows 76-80.

Note: the basic data can be changed in the 'data' sheet. These basic data include emission factors for fuel burning and power consumption.

4.3.1 CASE STUDY



RORO, 1,5 MVA connection 25000 GT

[85]

A Cold Ironing Study on Modern Ports, Implementation and Benefits Thriving for Worldwide Ports

A General information

ships

calls per year per ship

hours at berth connected

OPS

INVESTMENT COSTS

Input	Yearly costs (€)	
General info investment		
interest rate	<input type="text" value="6%"/>	
depreciation (years)	<input type="text" value="10"/>	
investment costs terminal		
high voltage connection from grid (including transformer) (€)	<input type="text" value="200.000"/>	
freq. converter (€)	<input type="text" value="-"/>	
cable installation (€)	<input type="text" value="225.000"/>	
total investments (€)	<input type="text" value="425.000"/>	
maintenance, contract and electricity transport costs (15%) (€)	<input type="text" value="63.750"/>	
	121.494	
investment costs ships		
transformer (€)	<input type="text" value="200.000"/>	
main switchboard, control panel (€)	<input type="text" value="100.000"/>	
cabling (€)	<input type="text" value="3.000"/>	
cable reel system (€)	<input type="text" value="152.000"/>	
total investments (€)	<input type="text" value="455.000"/>	
	123.640	
OPERATIONAL COSTS		
Input	Yearly costs (€)	
Electricity costs		
Electricity price (€/ kWh)	<input type="text" value="0,08"/>	
tax (€/ kWh)	<input type="text" value="0,03"/>	
Consumption (kW)	<input type="text" value="800"/>	
	201.600	
Saved maintenance		
Maintenance per engine (€/ h)	<input type="text" value="-2"/>	
number of engines	<input type="text" value="3"/>	
	-11520	
TOTAL COSTS (€)	435.214	
POLLUTION		
Input	pollution units	
Electricity source	<input type="text" value="EU mix"/>	
Pollutants	Emissions (ton)	Pollution units
CO2	672,0	
NOx	0,7	672
PM	0,0	72
SO2	0,9	1.944
Total		2.688

Auxiliary engines

INVESTMENT COSTS

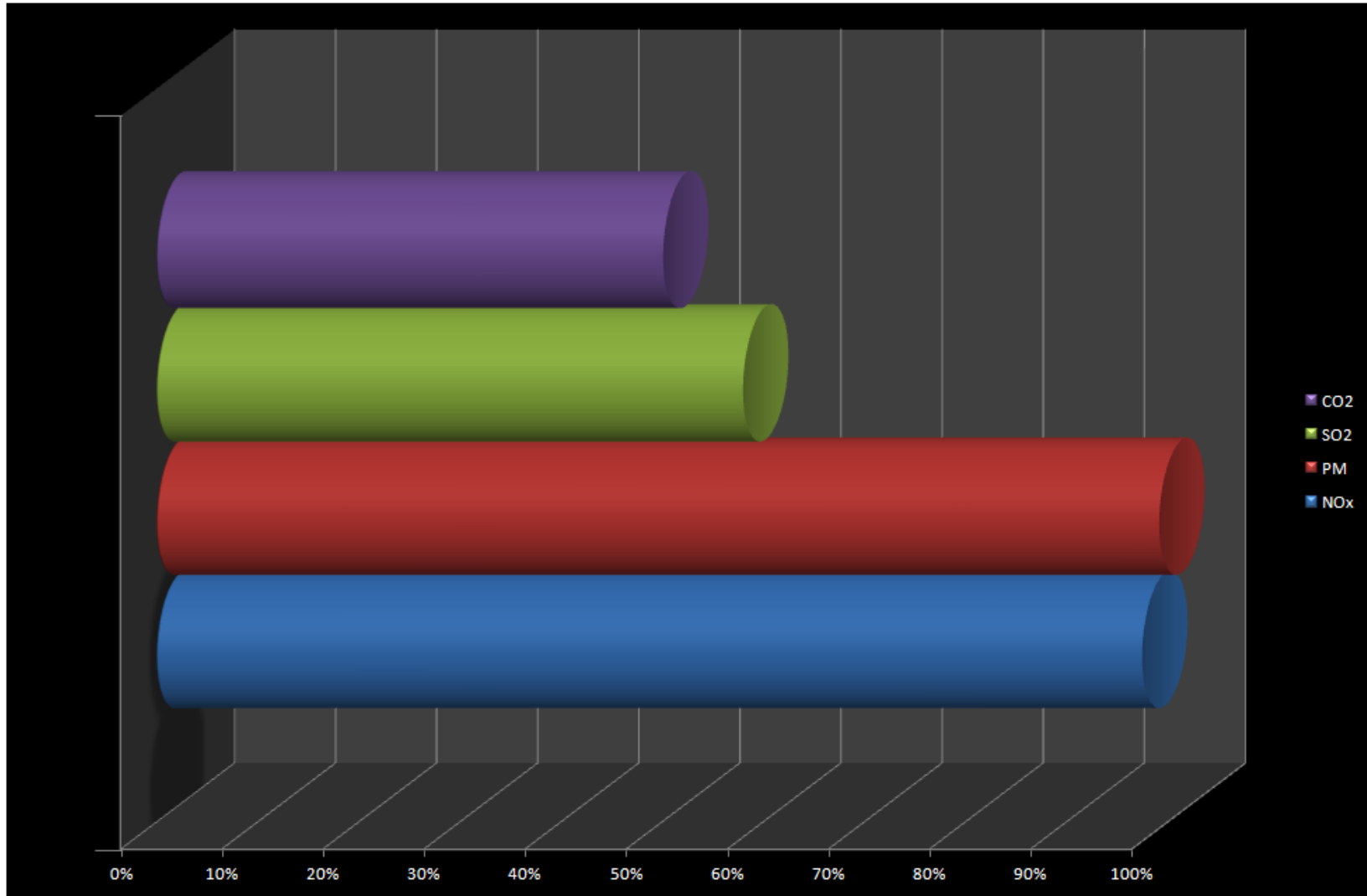
Input terminal	Yearly costs (€)	
General info		
no investments	<input type="text"/>	
investment costs terminal		
no investments	<input type="text"/>	
investment costs ships		
no investments	<input type="text"/>	
OPERATIONAL COSTS		
Input terminal	Yearly costs (€)	
Fuel costs		
Diesel (USD/ton)	<input type="text" value="650"/>	
Consumption (ton/h)	<input type="text" value="0,2"/>	
	181.210	
ETS costs		
ETS CO2 price	<input type="text" value="0"/>	
	0	
TOTAL COSTS	181.210	
POLLUTION		
Input	pollution units	
Fuel	<input type="text" value="Diesel"/>	
Pollutants	Emissions (ton)	Pollution units
CO2	1301,7	
NOx	20,7	20.728
PM	0,9	11.354
SO2	2,1	4.646
Total		44.728

H Total yearly costs (€) 254.004
cost effectiveness (€ / pollution unit) 6,0

I Emission reductions electricity

NOx	98%
PM	99%
SO2	58%
CO2	50%

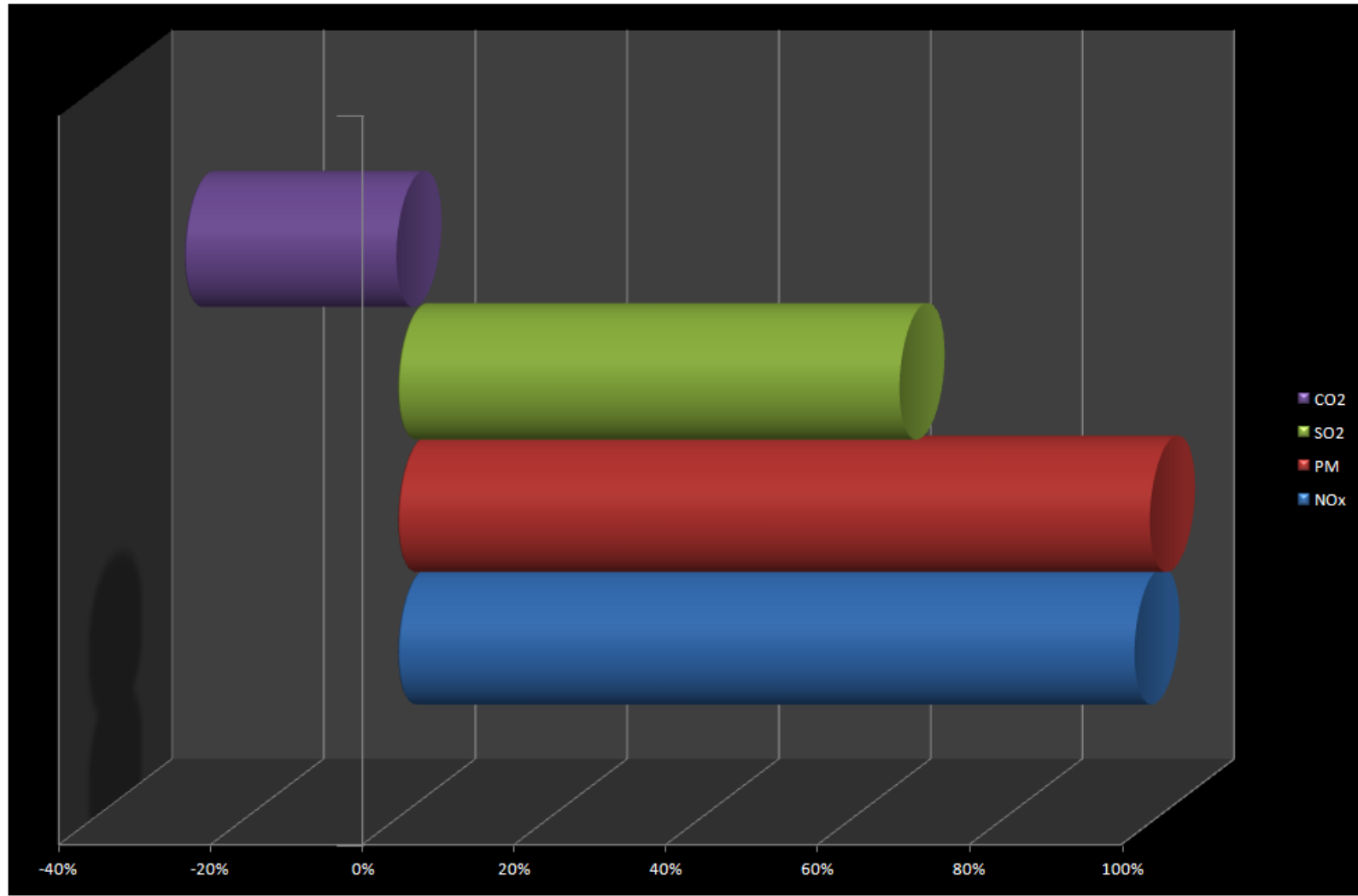
Emissions reduction (%) EU MIX



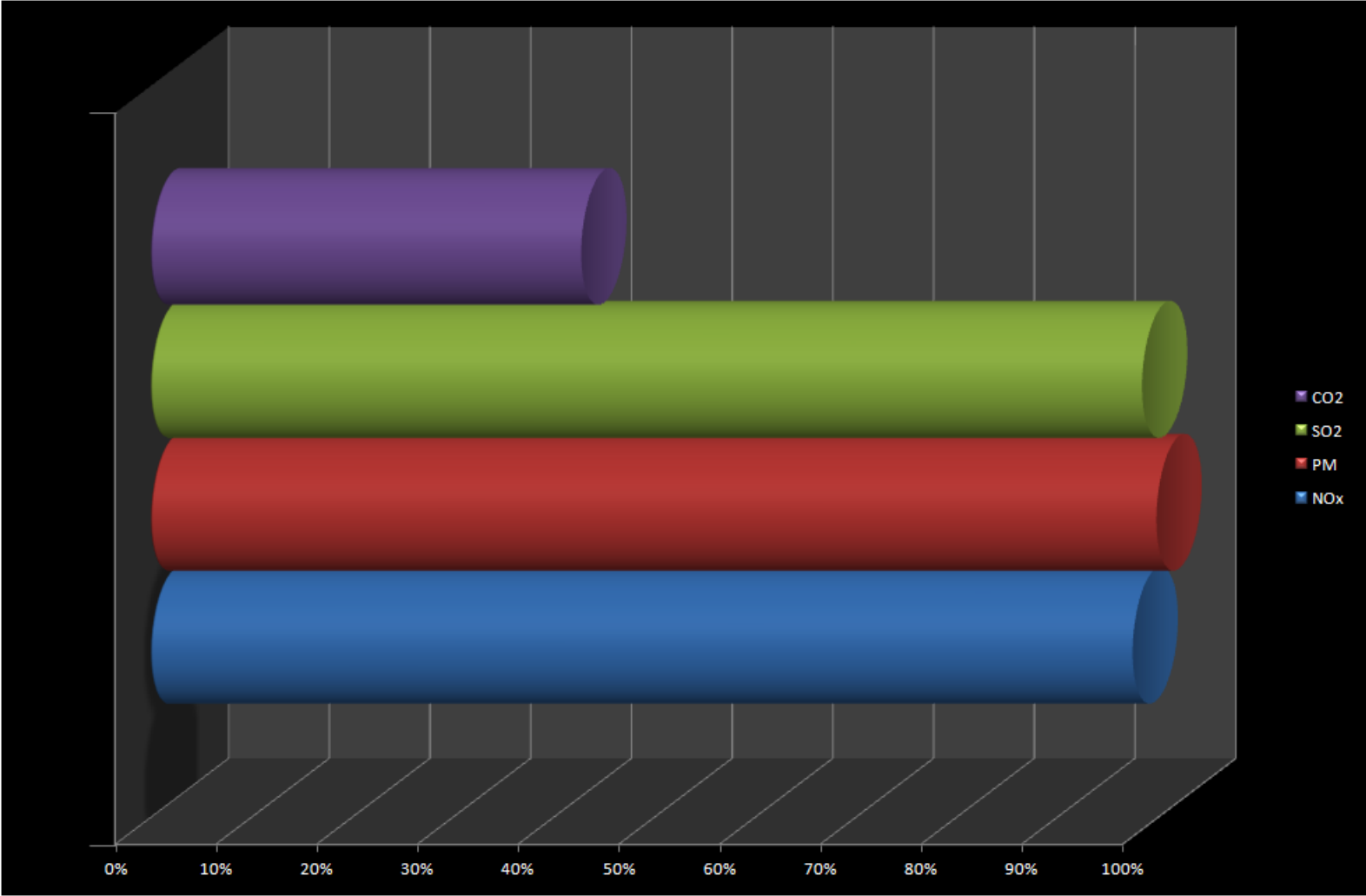
[87]

A Cold Ironing Study on Modern Ports, Implementation and Benefits Thriving for Worldwide Ports

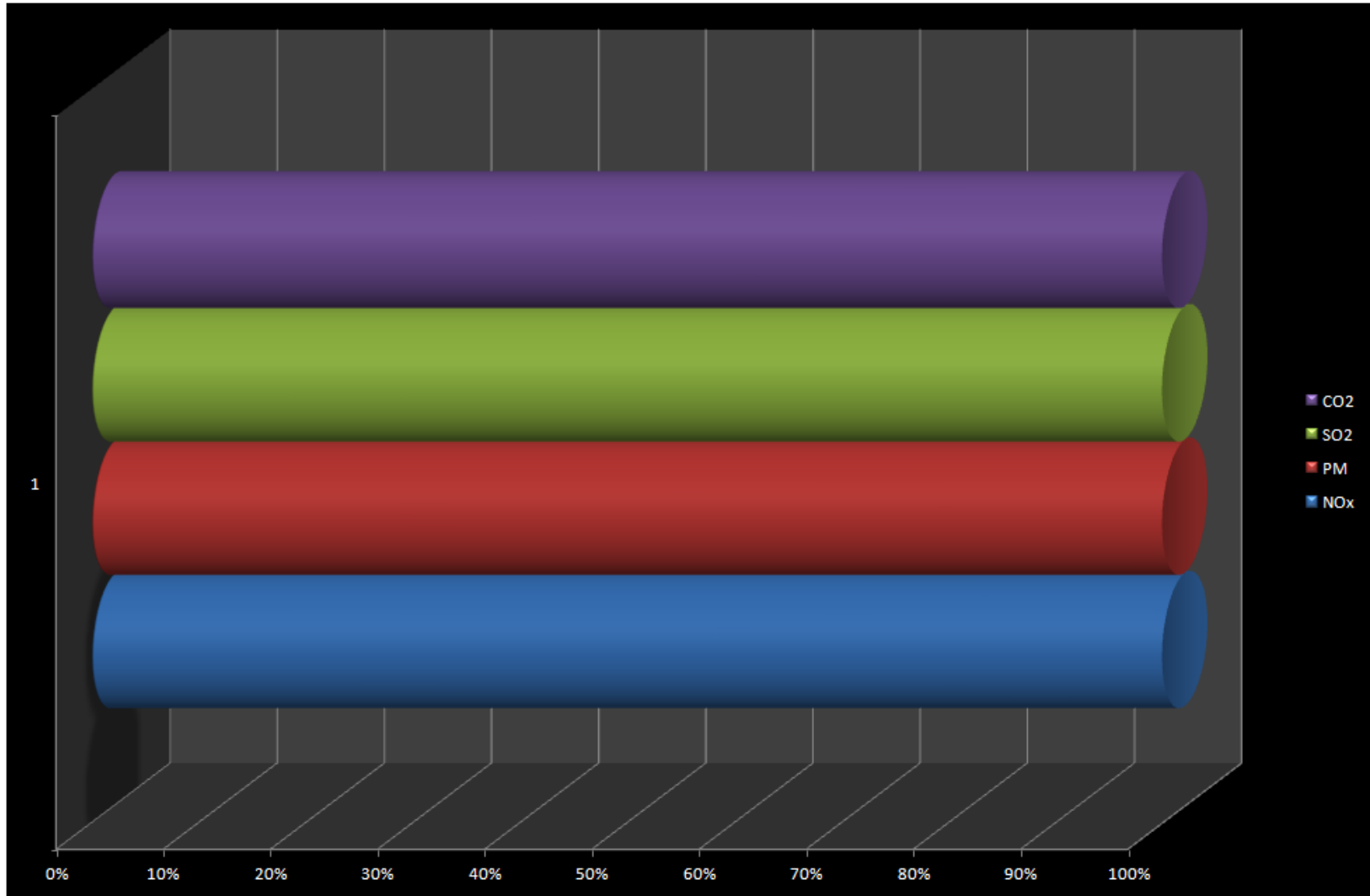
Emissions reduction (%) coal



Emissions reduction (%) natural gas



Emissions reduction (%) renewable energy sources



[90]

THEODOROS G. PAPOUTSOGLU

4.3.2 CASE STUDY



CONTAINER 7 MVA Connection, 7500 GT/6500TEU (500 reefers)

[91]

A Cold Ironing Study on Modern Ports, Implementation and Benefits Thriving for Worldwide Ports

General information	
ships	<input type="text" value="6"/>
calls per year per ship	<input type="text" value="8"/>
hours at berth connected	<input type="text" value="24"/>

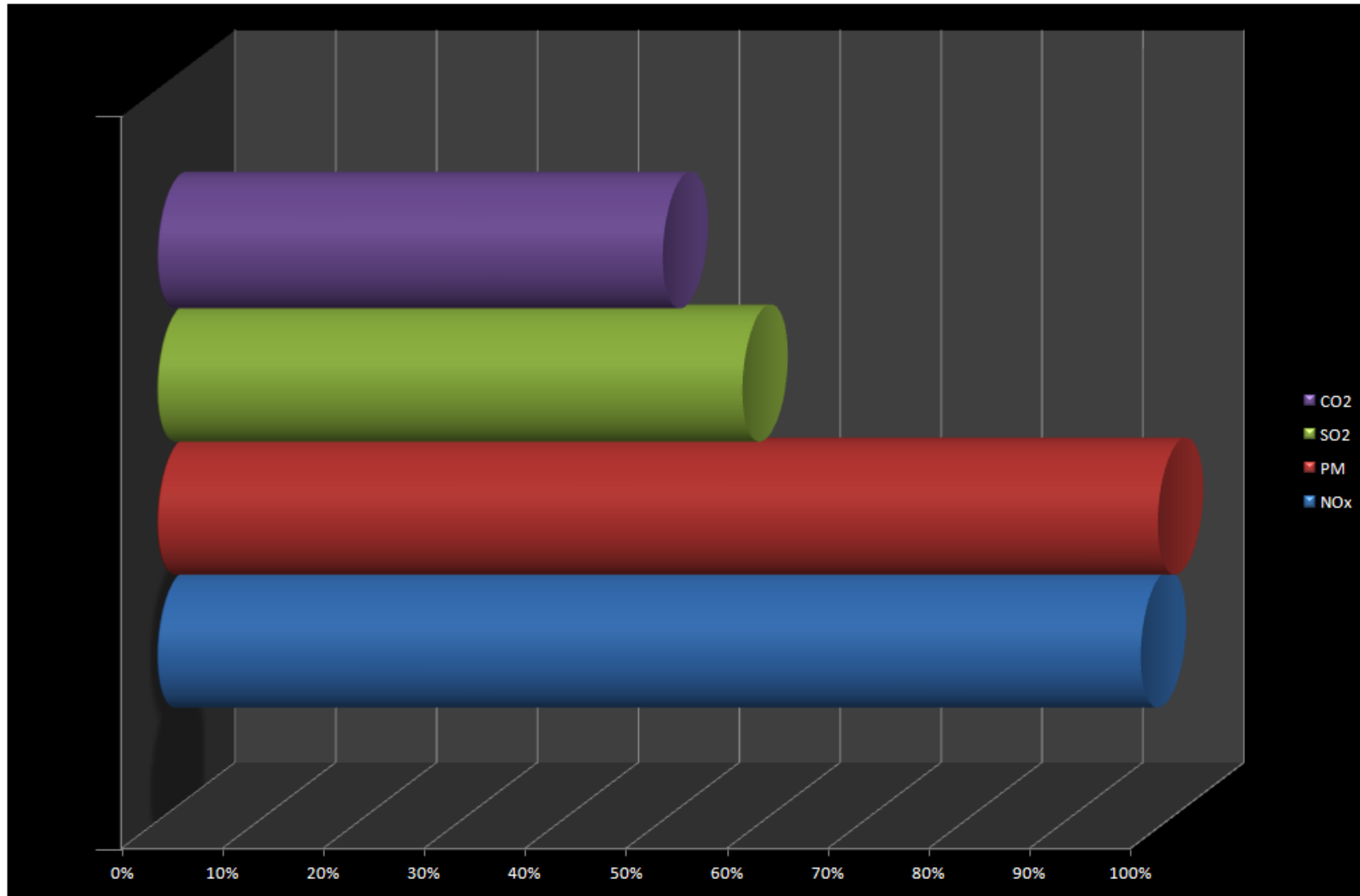
OPS	
INVESTMENT COSTS	
Input	Yearly costs (€)
General info investment	
interest rate	<input type="text" value="6%"/>
depreciation (years)	<input type="text" value="10"/>
investment costs terminal	
high voltage connection from grid (including transformer) (€)	<input type="text" value="1.000.000"/>
freq. converter (€)	<input type="text" value="500.000"/>
cable installation (€)	<input type="text" value="225.000"/>
total investments (€)	<input type="text" value="1.725.000"/>
maintenance, contract and electricity transport costs (15%) (€)	<input type="text" value="258.750"/>
	493.122
investment costs ships	
transformer (€)	<input type="text" value="300.000"/>
main switchboard, control panel (€)	<input type="text" value="100.000"/>
cabling (€)	<input type="text" value="3.000"/>
cable reel system (€)	<input type="text" value="152.000"/>
total investments (€)	<input type="text" value="555.000"/>
	452.440
OPERATIONAL COSTS	
Input	Yearly costs (€)
Electricity costs	
Electricity price (€/ kWh)	<input type="text" value="0,08"/>
tax (€/ kWh)	<input type="text" value="0,03"/>
Consumption (kW)	<input type="text" value="2.000"/>
	241.920
Saved maintenance	
Maintainance per engine (€/ h)	<input type="text" value="-2"/>
number of engines	<input type="text" value="3"/>
	-5529,6
TOTAL COSTS (€)	1.181.953
POLLUTION	
Input	pollution units
Electricity source	<input type="text" value="wind/water/nuclear"/>
Pollutants	Emissions (ton) Pollution units
CO2	0,0 0
NOx	0,0 0
PM	0,0 0
SO2	0,0 0
Total	0

Auxiliary engines	
INVESTMENT COSTS	
Input terminal	Yearly costs (€)
General info	
no investments	<input type="text"/>
investment costs terminal	
no investments	<input type="text"/>
investment costs ships	
no investments	<input type="text"/>
OPERATIONAL COSTS	
Input terminal	Yearly costs (€)
Fuel costs	
Diesel (USD/ton)	<input type="text" value="650"/>
Consumption (ton/h)	<input type="text" value="0,4"/>
	217.452
ETS costs	
ETS CO2 price	<input type="text" value="0"/>
	0
	217.452
POLLUTION	
Input	pollution units
Fuel	<input type="text" value="Diesel"/>
Pollutants	Emissions (ton) Pollution units
CO2	1622,0 34,469
NOx	34,0 13,623
PM	1,1 5,576
SO2	2,5 13,660
Total	33,628

Total yearly costs (€)	964.501
cost effectiveness (€ / pollution unit)	18,0

Emission reductions electricity	
NOx	100%
PM	100%
SO2	100%
CO2	100%

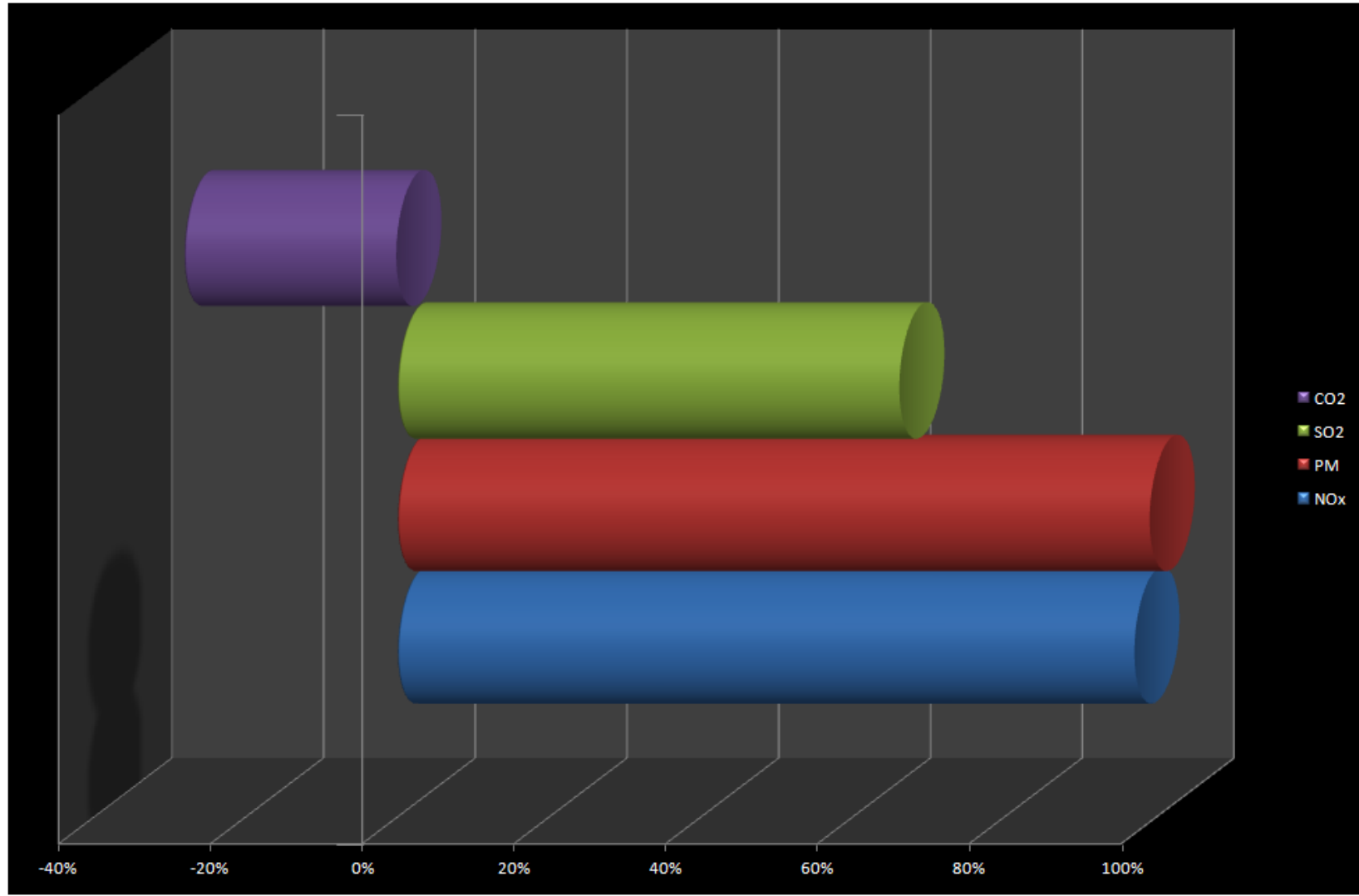
Emissions reduction (%) EU MIX



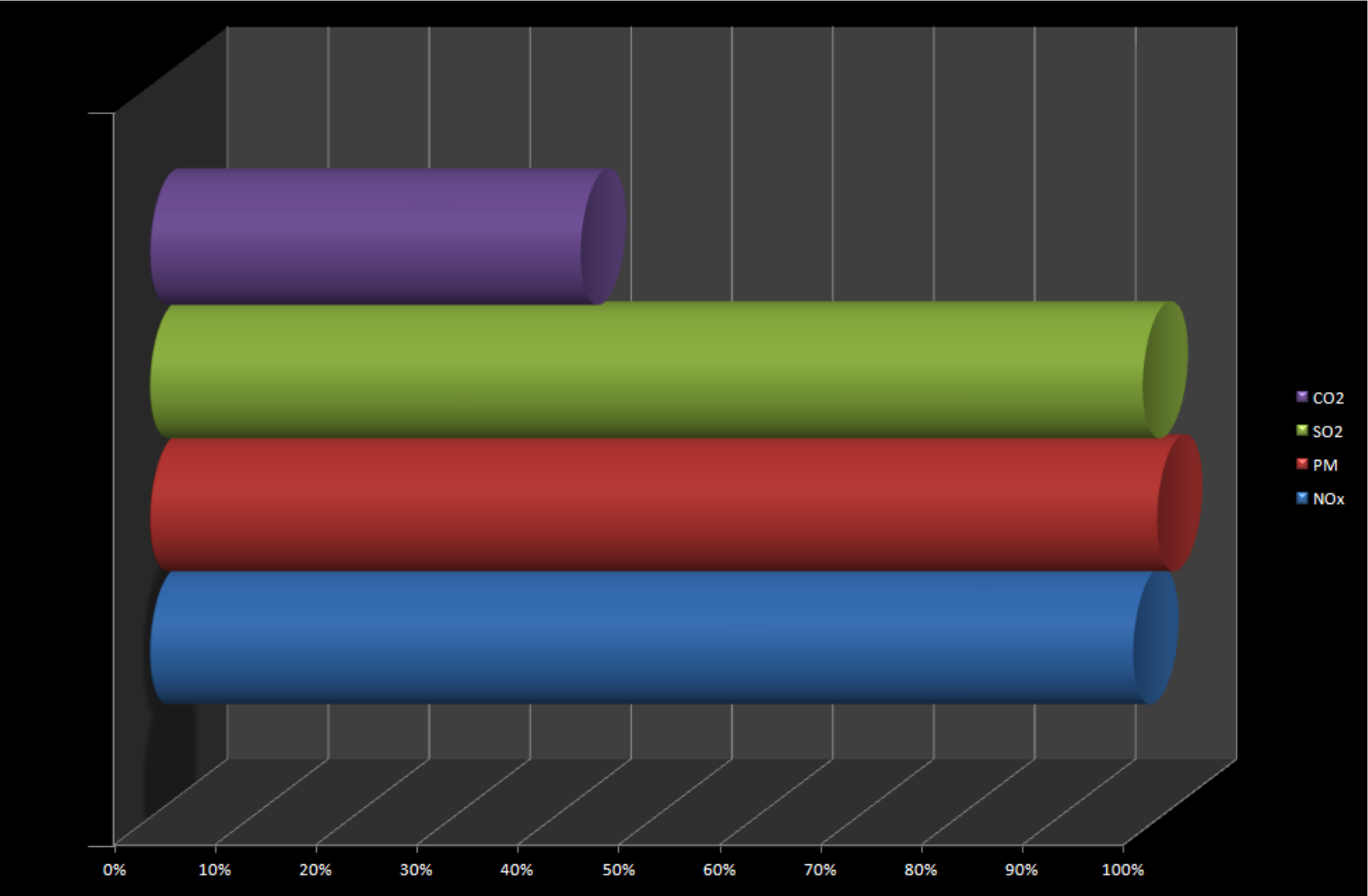
[93]

A Cold Ironing Study on Modern Ports, Implementation and Benefits Thriving for Worldwide Ports

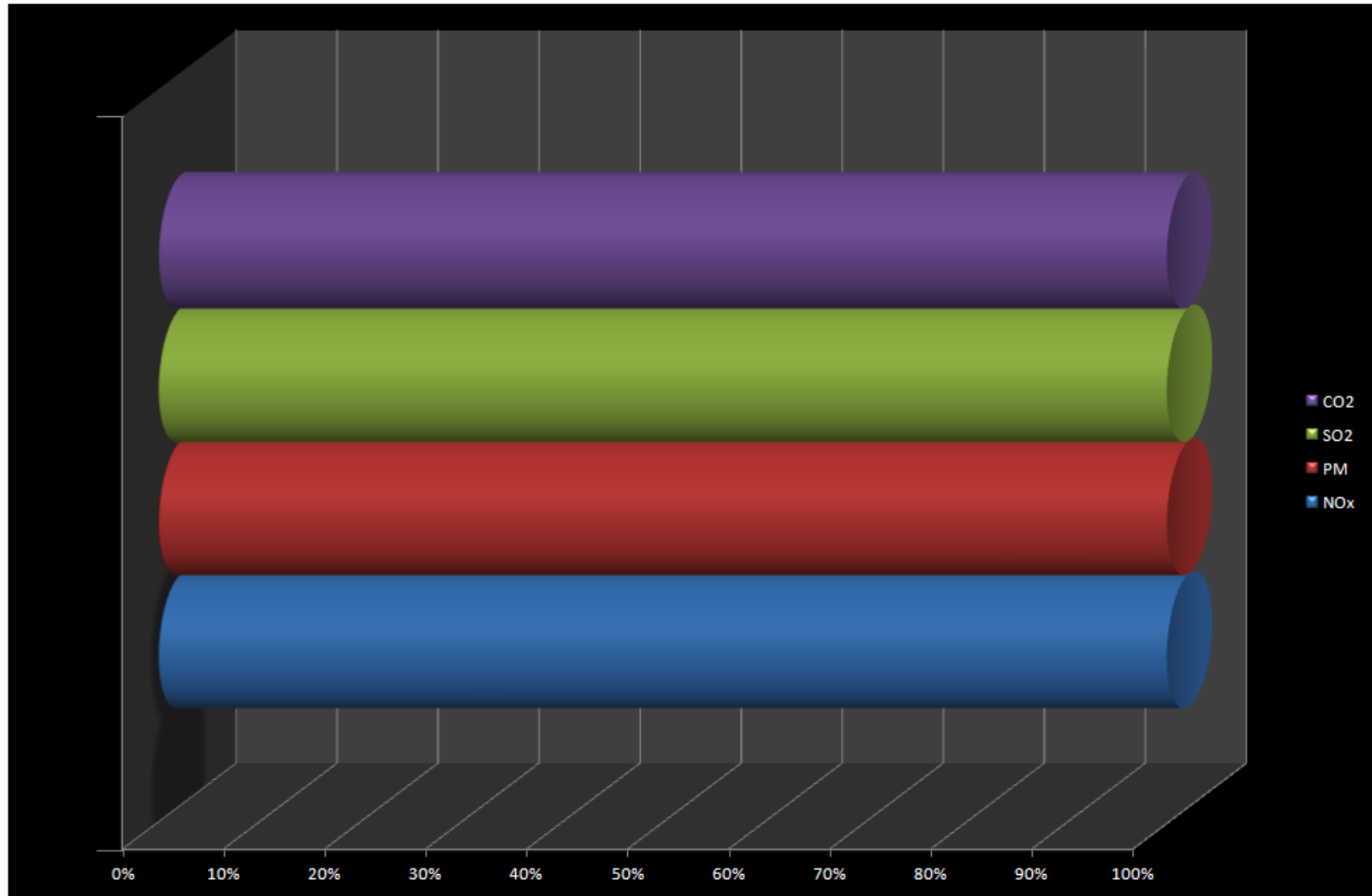
Emissions reduction (%) coal



Emissions reduction (%) natural gas



Emissions reduction (%) renewable energy sources



[96]

THEODOROS G. PAPOUTSOGLU

4.3.3 CASE STUDY



CRUISE SHIP 12 MVA connection, 80.000 GT

[97]

A Cold Ironing Study on Modern Ports, Implementation and Benefits Thriving for Worldwide Ports

A General information

ships

calls per year per ship

hours at berth connected

OPS

INVESTMENT COSTS

Input	Yearly costs (€)	
General info investment		
interest rate	<input type="text" value="6%"/>	
depreciation (years)	<input type="text" value="10"/>	
investment costs terminal		
high voltage connection from grid (including transformer) (€)	<input type="text" value="3.500.000"/>	
freq. converter (€)	<input type="text" value="-"/>	
cable installation (€)	<input type="text" value="225.000"/>	
total investments (€)	<input type="text" value="3.725.000"/>	
maintenance, contract and electricity transport costs (15%) (€)	<input type="text" value="558.750"/>	
	1.064.858	
investment costs ships		
transformer (€)	<input type="text" value="450.000"/>	
main swithboard, control panel (€)	<input type="text" value="100.000"/>	
cabling (€)	<input type="text" value="5.000"/>	
cable reel system (€)	<input type="text" value="300.000"/>	
total investments (€)	<input type="text" value="855.000"/>	
	232.334	
OPERATIONAL COSTS		
Input	Yearly costs (€)	
Electricity costs		
Electricity price (€/ kWh)	<input type="text" value="0,08"/>	
tax (€/ kWh)	<input type="text" value="-"/>	
Consumption (kW)	<input type="text" value="7.000"/>	
	672.000	
Saved maintenance		
Maintainance per engine (€/ h)	<input type="text" value="-2"/>	
number of engines	<input type="text" value="5"/>	
	-9600	
TOTAL COSTS (€)	1.959.592	
POLLUTION		
Input	pollution units	
Electricity source	<input type="text" value="coal"/>	
Pollutants	Emissions (ton)	Pollution units
CO2	7576,8	
NOx	7,4	3,418
PM	0,0	350
SO2	3,1	6,808
Total		10,618

Auxiliary engines

INVESTMENT COSTS

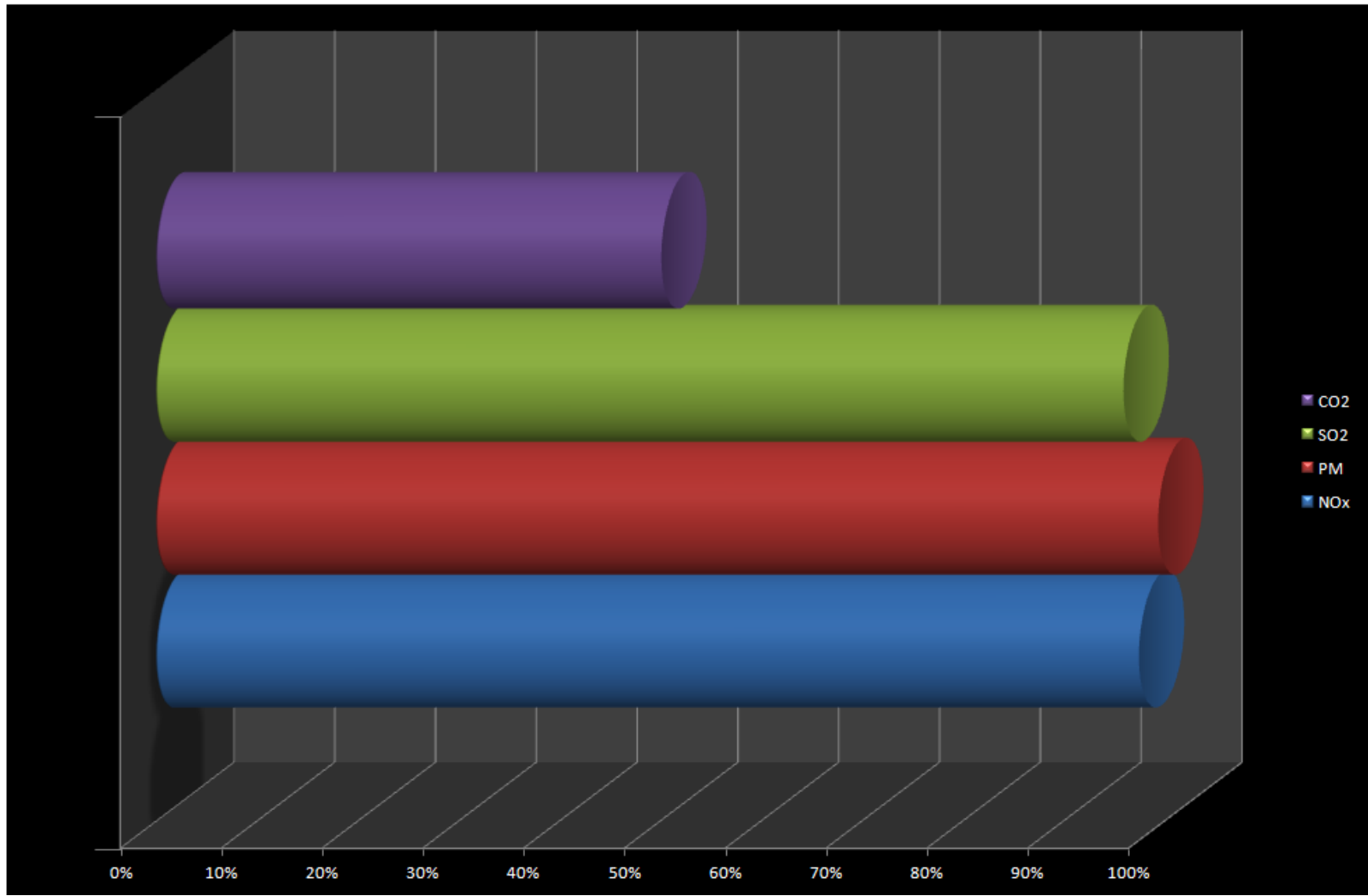
Input terminal	Yearly costs (€)	
General info		
no investments	<input type="text"/>	
investment costs terminal		
no investments	<input type="text"/>	
investment costs ships		
no investments	<input type="text"/>	
OPERATIONAL COSTS		
Input terminal	Yearly costs (€)	
Fuel costs		
Diesel (USD/ton)	<input type="text" value="650"/>	
Consumption (ton/h)	<input type="text" value="1,5"/>	
	792.792	
ETS costs		
ETS CO2 price	<input type="text" value="0"/>	
	0	
TOTAL COSTS	792.792	
POLLUTION		
Input	pollution units	
Fuel	<input type="text" value="HFO"/>	
Pollutants	Emissions (ton)	Pollution units
CO2	5913,6	
NOx	125,7	125,694
PM	5,8	74,275
SO2	89,8	219,543
Total		419,493

Total yearly costs (€) **1.166.800**

cost effectiveness (€ / pollution unit) **2,9**

Emission reductions electricity	
NOx	97%
PM	100%
SO2	97%
CO2	-28%

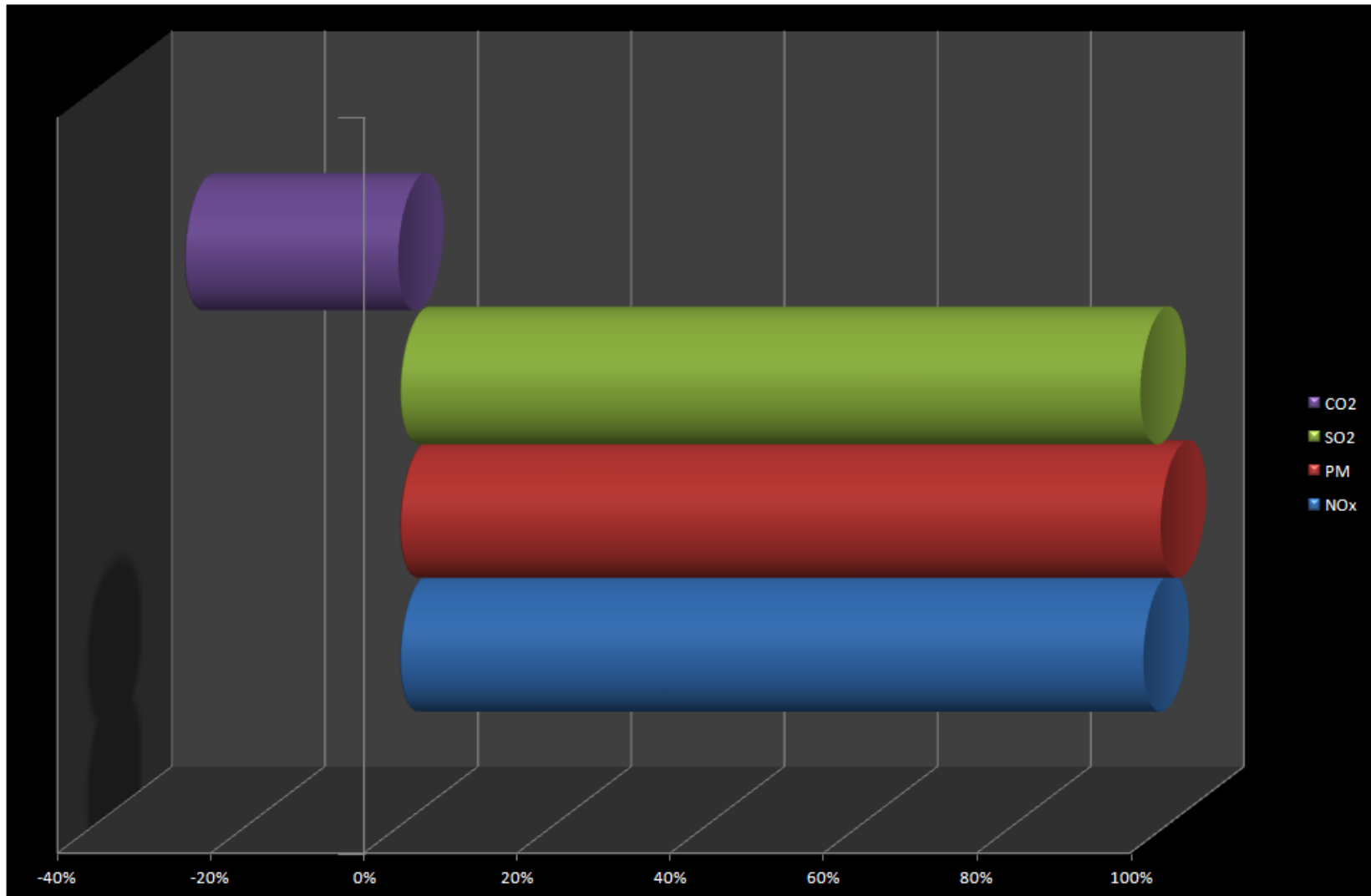
Emissions reduction (%) EU MIX



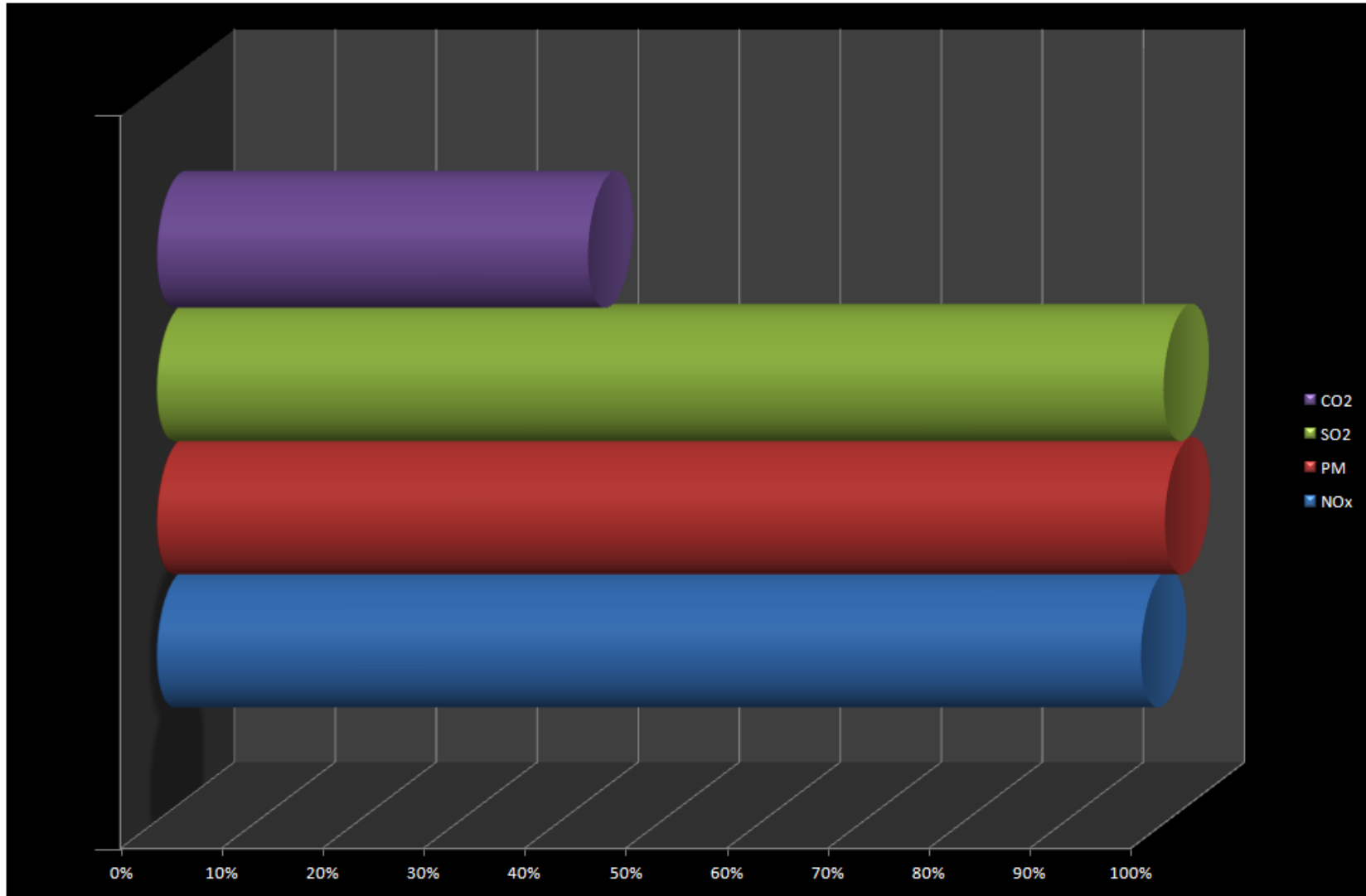
[99]

A Cold Ironing Study on Modern Ports, Implementation and Benefits Thriving for Worldwide Ports

Emissions reduction (%) coal



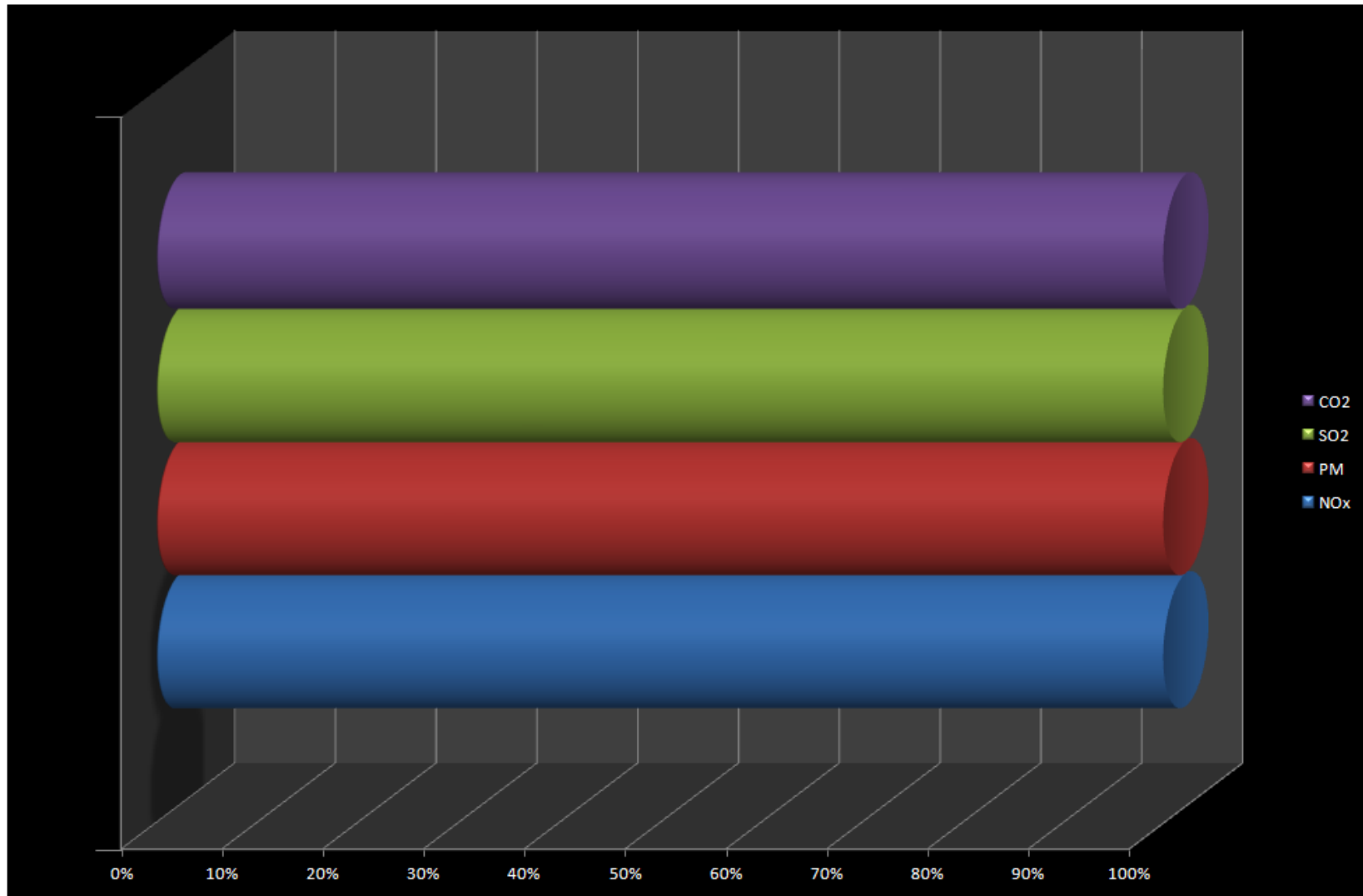
Emissions reduction (%) natural gas



[101]

A Cold Ironing Study on Modern Ports, Implementation and Benefits Thriving for Worldwide Ports

Emissions reduction (%) renewable energy source



4.4 Is Cold ironing cost effective?

Despite the environmental benefits of applying onshore power supply for a wide variety of vessel types in terms of emissions reduction, the potential cost effectiveness is the key factor whether modern ports would choose to implement it as an alternative strategy to discontinue the use of auxiliary engines inside ports and residential areas. The total amount of investment and running costs bears major significance in the decision to implement cold ironing techniques.

The WPCI pinpoints the crucial elements that port authorities examine in installing onshore power supply systems.

“Investments At quays close to a residential or industrial area, high-voltage power (6-20 kV) may often be available close at hand or within a few kilometres. In most ports there is access to electricity at different voltage levels. It is important, though, to be duly aware of issues of availability, because the costs of supplying high-voltage power can vary significantly if investment in transformer stations is required.”⁹²

Assessing the final cost of the installation required to cold ironing the ships at berth it is necessary to break down the individual costs.

Shore side costs:

- i. High Voltage electrical power supply cost
- ii. Potential need for frequency converters
- iii. Transformers
- iv. Electrical Control Panel
- v. Switchboard
- vi. Underground cable conduits and canalization

Onboard costs:

- vii. Power transformer
- viii. Distribution of electrical power systems
- ix. Switchboard
- x. Control panel
- xi. Cable reel system (possible and on berth)

⁹² <http://wpci.iaphworldports.org/onshore-power-supply/cost/investments.html>

The systems with the most significant impact on cold ironing cost are the supply of high voltage electrical power from an outside source i.e. a power plant located remotely from the port and also the frequency converters that may be required. If these costs are compared to underground cabling and canalization, the last ones are a fraction of the total investment costs.

Another cost difference may occur by the variations in the cold ironing system layout. Accordingly to the installation pattern that may be used the potential demand for onboard transformers and the use of barges may elevate the total cost significantly. On the other hand connecting the vessel to low voltage OPS eliminates the needs of an onboard transformer although it depends on shore side crane for cable handling, meaning more personnel.

“The most modern solution, built in accordance with the forthcoming IEC/ISO/IEEE standard, will be a high-voltage connection to vessels.”⁹³

The transportation cost of electricity from the national power grid to modern port’s berth is estimated up to 4 million USD. This number is varies depending *“the port location, power demand, voltage and frequency and vessel type”⁹⁴*.

The feasibility in several ports is presenting major variances on the final cost of investment due to the fact of the differences between the infrastructures already installed. For example in the port of Rotterdam the cold ironing investment was calculated up to 4 million USD per berth, a figure several times greater than the port of Gothenburg where the cost was estimated for two berths up to 225 thousands €.

Last but not least the shipside investment is significant. The modifications required plus the installation of numerous systems needed for shore side power provisions are in the range between 300 thousands and 2 million USD. This has to do primary with the potential requirement of an onboard transformer and whether the vessel was built with cold ironing capabilities or retrofitted afterwards. In the case of retrofitted vessels, the investment costs rise dramatically.

Implementation and financing cold ironing systems include a variety of different parties. In many cases the local governments and authorities have undertaken major investment projects for the use of greener solution like shore power. The potential cutbacks on CO₂ emissions raise the international interest of different parts of the worldwide shipping company.

⁹³ <http://wpci.iaphworldports.org/onshore-power-supply/cost/investments.html>

⁹⁴ <http://wpci.iaphworldports.org/onshore-power-supply/cost/investments.html>

4.5 Feasibility of investment.

The economics behind the potential investment of both public and private sector on cold ironing systems are those that define the potential upgrade of berth to integrate shore based systems of electrification for the calling vessels. The various types of ships that the cold ironing infrastructure systems will have to provide with electrical energy add more variable to the equation whether the investment is “profitable” both financially for ports / ship-owners and environmentally friendlier.

The cost effectiveness is calculated as the ratio between costs and benefits in form of less tons of emissions of hazardous pollutants. By applying this rule different measures that are often elusive i.e. environmental benefits can be quantified.

In measuring the feasibility of cold ironing systems and the sequential costs in need for the investment in a modern international port some cost effectiveness steps must be taken. Some cost cutting measures are the following.⁹⁵

- *The greater the number of hours an OPS system is used per year, the lower the costs per unit of pollutant emitted. A doubling of the number of hours at berth would increase cost effectiveness by roughly a factor 2.*
- *If no frequency converter is needed, investments costs may be an estimated 10 % to 30 % lower, depending on the local situation.*
- *If high-voltage power is available, the investment costs per berth will be much lower, as high-voltage supply generally requires significant investments.*
- *By reducing onboard power consumption, both operational costs and investment costs can be saved.*

⁹⁵ As described in <http://wpci.iaphworldports.org/onshore-power-supply/cost/cost-effectiveness.html>

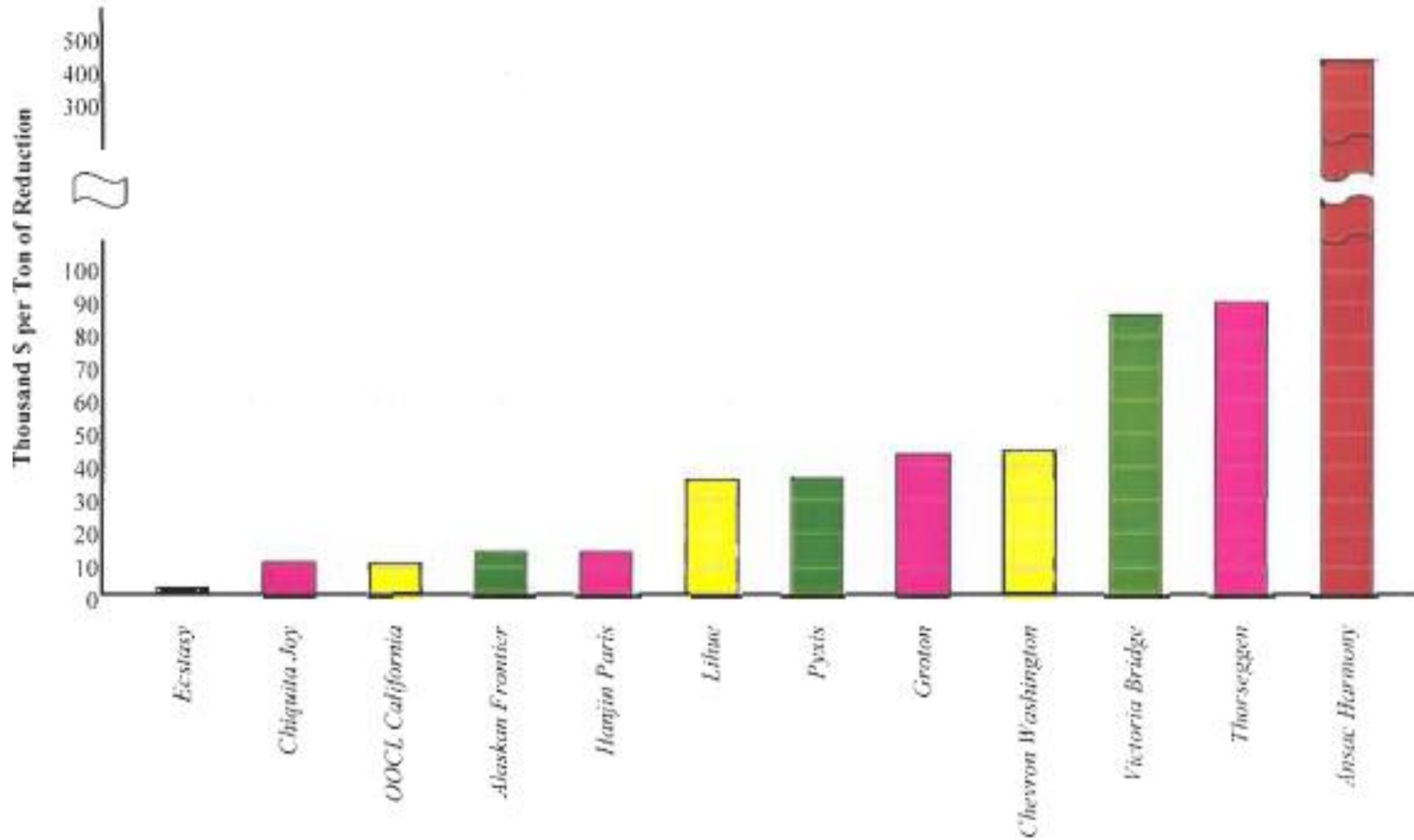
$$\text{Cost Effectiveness} \left(\frac{\$}{\text{ton}} \right) = \frac{\text{Total Net Present Value} (\$)}{\text{Total Emission Reduction of All pollutants over the Project Life (tons)}}$$

In the Environ Cold Ironing Cost Effectiveness for the Port of Long Beach report presents in a thorough way the types of vessels that are favourable candidates for shore based provision of electricity. Collecting the data from 12 vessels that operate in the port of Long Beach, the report come to several occlusions about the type of vessels that would be suitable for cold ironing.

Vessels Name	Vessel Type	Vessel Operator	Pier and Berth	Terminal Operator	Cost Effectiveness (\$/ton)
<i>Ecstasy</i>	Cruise	Carnival	H4	Carnival	\$9,000
<i>Chiquita Joy</i>	Reefer	Great White	E24	CUT	\$11,000
<i>OOCL California</i>	Container/ Reefer	OOCL	F8	LBCT	\$11,000
<i>Alaskan Frontier</i>	Tanker	Alaska Tanker	T121	BP/ARCO	\$15,000
<i>Hanjin Paris</i>	Container	HANJIN	T136	TTI	\$15,000

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⁹⁶ COLD IRONING COST EFFECTIVENESS PORT OF LONG BEACH, Prepared by ENVIRON International Corporation Los Angeles, California March 30, 2004



⁹⁷ COLD IRONING COST EFFECTIVENESS PORT OF LONG BEACH, Prepared by ENVIRON International Corporation Los Angeles, California March 30, 2004

Numerous feasibility studies have come to the outcome that the cold ironing is financial feasible. The types of vessels that are more cost effective to implement shore power systems are the containerships and reefers and the large scale passenger ships including the cruise ships. Especially the last ones are the perfect candidate for provision of electrical power by shore sided systems due to the numerous calls on annual basis and the powering needs while at berth.

Chapter V

5.1 Benefits and Concerns

Benefits

The benefits of implementing cold ironing in modern ports are outnumbering the concerns that the costs or other factor may raise. In many aspects the advantages of cutting back emissions by electrifying ships shore side are obvious.

Environmentally, this report has presented the potential emissions reduction of applying cold ironing on a variety of ship types and scales. Cold ironing is the fastest method in terms of measurable results in air pollution abatement. The tool box provided by WPCI calculates the total amount of tons of pollutant emissions that are avoided, in different case scenarios and with different inputs each time. For example these case studies include the production of electrical power by fossil fuel or by renewable energy such as solar and wind power.

Socially, the regional are benefited largely by the dramatically improved levels of environmental pollution and mostly by the cutting back of toxic emissions of unregulated marine diesel engines. Moreover the improved working conditions in port help the personnel effectiveness, lowering the health costs in form of hospitalizations related with health hazards caused by the sooty air surrounding the harbor area.

Vessel operators, currently under large pressure by international organizations and local governments within the operating ports, have an alternative to costly cleaner fuels with low sulphur content. This option of connecting to the port supply network could pose as a very attractive option for ship-owners both for commercial aspect and in order to achieve environmental improvements.

For port operators on the other hand, the provision of shore side electrical power to vessels at berth generate additional revenues while cold ironing contributes to air pollution abatement and compliance to stricter environmental standards.

Concerns

The advantages of using cold ironing techniques in ships at berth are appealing and considerably outweigh the difficulties, technical or financial. Although the method of turning off completely the ships polluting engines while hotelling has a variety of financial, technical and environmental positive impacts, it would be unrealistic to proclaim that the implementation of the system comes without numerous concerns.

First of all the cost of infrastructure including cables, powering sources, power cables and complex handling systems along with transformers, switchgears and convertors is notably high. Bearing that in mind, a thorough financial feasibility research must be conducted for each case of using cold ironing systems, to clarify if a costly investment would be profitable and environmental assisting.

The compatibility of different electrical systems often using different voltages and frequencies (50-60Hz), depending the location the vessel was built is a major issue. The standardization gap problem must be addressed and examined with caution by the international shipping industry.

The regulations for safety in maritime are substantial for the protection of human lives at sea and the keeping casualties and sever or minor injuries as low as possible. SOLAS⁹⁸ convention is regarded as one of the most significant treaties for the life protection at seas. The cold ironing systems and standards must be aligned with the SOLAS norms as well as all international treaties.

Adding to the list of concerns coming from the use of alternative marine power one can refer to the “quality of power” provided for the protection of ships electronic gear and installations as well the legalities of the various stakeholders concerning the use of cold ironing at modern ports.

⁹⁸ [http://www.imo.org/about/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-\(solas\),-1974.aspx](http://www.imo.org/about/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-(solas),-1974.aspx)

Chapter VI

6.1 Strategic players in the Market

In this part of the study the main “actors” of suppliers of cold ironing systems are presented. The information below is solely for educational purposes and further research. The suppliers of alternative marine power systems provide systems for connecting the vessels at berth to the power grid, thus allowing them to completely shut off their auxiliary engines. The following information and graphic representations were directly extracted from “*SHORE-SIDE POWER SUPPLY: A feasibility study and a technical solution for an on-shore electrical infrastructure to supply vessels with electric power while in port*”, Master of Science Thesis by PATRIK ERICSSON, ISMIR FAZLAGIC.⁹⁹

- **ABB**

ABB is one of the major suppliers for vessels and harbors worldwide. ABB is also one of the biggest suppliers in the world for main switchboards in vessels. When Port of Göteborg wanted to construct the world’s first high-voltage connection dedicated for Ro/Ro vessels, ABB was contracted to perform the installation and the design of the high-voltage shore-side supply. When Princess Cruise Lines wanted help to install the power management and monitoring system onboard the vessels, ABB installed the necessary equipment onboard.

- **Siemens**

SIHARBOR is the name of Siemens shore-side power supply system. The installation in Lübeck, as presented in a previous chapter, has been constructed by Siemens. This Port is the only reference for the SIHARBOR system today. Siemens has developed a shore connection system, called Siplink, which is used for connecting vessels that operate with 60 Hz to the European grid. According to Siemens, Siplink enables linking between a ship’s onboard power system to the existing onshore power grid even if the system frequencies are different. Nevertheless, Siplink has not yet been installed in any port. The only installation with the Siplink system is found in a shipyard in Flensburg. The shipyard utilizes the Siplink when installing a vessel’s on-board electrical system. In this installation Siplink provides a 60 Hz power supply with adjustable voltage, which is also used as a test load when checking the electric system. Shore-side Power Supply Part B - Market review

⁹⁹ SHORE-SIDE POWER SUPPLY

A feasibility study and a technical solution for an on-shore electrical infrastructure to supply vessels with electric power while in port Master of Science Thesis PATRIK ERICSSON ISMIR FAZLAGIC
Department of Energy and Environment Division of electric power engineering Masters program in Electric Power Engineering CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden, 200

- **Cavotec**

Cavotec has 18 years of experience with shore-side connections. They have world leading systems for cable reels and their plugs and sockets have practically become a standard for shore-side connections. Cavotec has already equipped 14 vessels with cable reels or with plugs and sockets to be able to connect to shore, see Figure B32, Figure B33 and Figure B34. The company has been involved in many shore-side power supply projects and supplied most equipment for the connection onboard the vessel.

- **Sam Electronics**

Since 2003 Sam Electronics has delivered twenty shore-side power supply equipment to both ships and ports. Sam Electronics was contracted by Port of Los Angeles to supply the necessary equipment for the first AMP terminal equipped in Port of Los Angeles. Sam Electronics has also been contracted by Port of Antwerp to construct the world's first terminal that can supply electricity to 50 and 60 Hz vessels. Nevertheless, Sam Electronics is the biggest actor on the market that has references for their low-voltage, 400 V, and high-voltage, 6.6 and 11 kV, solutions. They have also supplied container and barge systems outfitted with the necessary equipment for shore-side power supply. A container with the corresponding shore-side equipment located on the vessel. The container configuration fitted inside the vessel.

- **Terasaki**

Terasaki has been developing onboard marine systems since the 90s. Port of Los Angeles contacted Terasaki to design a high-voltage, 6.6 kV, AMP supply. The company offers a high-voltage shore-side power supply, 6.6 kV, similar to the installations in Port of Göteborg. Terasaki is also able to offer 50 Hz shore-side power supply equipment, but there is no indication that the company can supply equipment for 50 Hz and 60 Hz connections.

- **Patton & Cooke**

When Princess Cruise Lines needed a high-voltage shore-side power supply for their four Sun Class vessels in Port of Juneau, Patton & Cooke were contracted to perform the installation and design for the shore-side power system at Port of Juneau. B4.7 Callenberg Engineering Inc Callenberg Fläkt Marine, previously ABB Fläkt Marine, has developed, supplied and supported the Marine industry for seven decades. When Princess Cruise Lines wanted to connect their vessels to a high-voltage shore-side supply, Callenberg Engineering was contacted. Callenberg Engineering began to work on the means of delivering the power to the ships, and the main task was to identify and produce samples of candidate power cables that would safely transmit the required voltage and power to the ship. An additional gantry carrying the high-voltage cables together with custom made plugs was supplied by the company.¹⁰⁰

¹⁰⁰ SHORE-SIDE POWER SUPPLY

A feasibility study and a technical solution for an on-shore electrical infrastructure to supply vessels with electric power while in port Master of Science Thesis PATRIK ERICSSON ISMIR FAZLAGIC
Department of Energy and Environment Division of electric power engineering Masters program in Electric Power Engineering CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden, 200

----- Appendix A -----



MARINE ENVIRONMENT PROTECTION
COMMITTEE
55th session
Agenda item 4

MEPC 55/4/10
15 August 2006
Original: ENGLISH

PREVENTION OF AIR POLLUTION FROM SHIPS

Standardization of on-shore power supply

Submitted by the Institute of Marine Engineering, Science and Technology (IMarEST)

SUMMARY

Executive summary: Having reviewed the Secretariat paper (MEPC 55/4/6) on liaison with international and intergovernmental organizations regarding proposals for the standardization of on-shore power supply for ships in port, IMarEST makes general comments and identifies further considerations which should be taken into account

Action to be taken: Paragraph 11

Related documents: MEPC 54/4/3 and MEPC 55/4/6

1 This document is submitted in accordance with paragraph 4.10.5 of the Committee's Guidelines and in connection with document MEPC 55/4/6 by the Secretariat which follows up proposals on the standardization of on-shore power supply (cold ironing) submitted by Germany and Sweden in document MEPC 54/4/3. The Institute of Marine Engineering Science and Technology (IMarEST) has reviewed the proposals by means of a group drawn from various maritime interests. It supports the proposals and agrees that a standardization process for on-shore power supply is important for the operation of ships. However, it believes that some technical issues have not been fully understood or addressed in the work done to date and it would wish to be involved in any further work towards a standardization process for on-shore power supply to ships.

Background

2 The proposal in document MEPC 54/4/3 refers to work by Entec for the European Commission Directorate General Environment under the Service Contract on Ship Emissions: Assignment, Abatement and Market-based Instruments for which a specific task (2a) looked at shore-side electricity in August 2005. The paper provides excellent information and argues logically with regard to the advantages, and disadvantages, for ships using shore power. The main advantage, in terms of emissions is the expectation that the electrical energy needed by the ship is more efficiently and more cleanly produced in bulk as part of the port's national infrastructure. The point is made by Entec, and echoed in the proposal by Germany and Sweden,

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that this balance of advantage relies on many issues which may not be fixed over time and in certain circumstances the provision of shore power to a ship may not be the optimum arrangement.

Comments by IMarEST

3 The work by Entec notes some difficulties in transferring to shore power and anticipates dead bus transfers entailing temporary loss of power supply. This is unnecessary, shore supply is commonly used by warships of all navies and procedures avoid any interruption of power supply during connection to shore power. Similarly cruise liners have recently started using shore power and again procedures specifically avoid any loss of supply.

4 The work by Entec envisages shore supplied power being provided in the range of 6 to 20 kV. Such a range is unacceptable for standardisation and needs closer definition. In addition voltages of this level (by shore definition Medium Voltage and by marine definition High Voltage) will be entirely unsuitable for ships with only Low Voltage Systems (below 1,000 V AC). The additional equipment installation requirements, segregation, access control and crew training arising from the presence of MV Voltage in the ship would be unacceptable.

5 A “one size fits all” solution for all ships is not technically or economically practicable or justifiable. A major comment by the IMarEST on the proposal is that plurality must be stressed: there is certainly the need for the standardization of systems but not for the development of a standard system. There will need to be standards for medium voltage connections, standards for low voltage connections and standards covering a range of power levels. (All with seamless transfer of power).

6 Some Ports associated with Cruise Ships already have a number of 6 and 11 kV, 14 MW, shore connection points and increasing numbers of these ships have the necessary shipboard equipment. Any standard adopted should not make this equipment subject to any major change as this would ignore the positive experience gained to date and put an unnecessary and unfair burden on the pioneers in this field.

7 Plug connector systems have become standardised worldwide, yet distinct, to prevent cross connection between differing voltages, for example:

60Hz 440V 3 phase systems,
50Hz 400V 3 phase systems,
60Hz 110V 1 phase systems,
50Hz 230V 1 phase systems.

All or any of which systems may be fitted to different types/nationality of ships. Any standard developed for the supply of shore power to ships should take account of these existing connectors and their uses.

Subjects for further consideration

8 Considering ports, harbours and terminals, it is recommended that compulsory use of “cold-ironing” is avoided. Many UK ports (London included) have disparate and very small terminals many of which are miles from a decent electrical supply. Compulsion for “cold ironing”, without any kind of lower limit to size of ship and power demand, would effectively close these very useful terminals down as their only option would be to arrange shore generators.

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9 The way in which ports and harbours to cope with the different frequency and voltage requirements of the various ships that might visit will need very careful consideration. The technical issues associated with interconnection of two separate (and differing) electrical power systems are complex and extensive these have been largely overlooked in the work conducted to date. As well as the issues already noted with regard to voltage and transfer procedures the following will need consideration in any further work:

- Earthing arrangements,
- Personnel safety systems,
- Stability,
- Harmonic Distortion,
- Protection,
- Voltage Transient duration and recovery,
- Frequency transient duration and recovery.

Conclusion

10 IMarEST is supportive of Germany and Sweden's proposal to initiate a standardization process for on-shore power supply (cold ironing). However some technical issues have not been fully understood or addressed in the work done to date; this needs rectification early in any subsequent process. The IMarEST would like to be involved in any further work towards a standardization process for on-shore power supply (cold ironing).

Action requested of the Committee

11 The Committee is invited to consider the above information and take action as appropriate.

----- Appendix B -----

The following documentation is taken by the WPCI website regarding the OPS calculation tools. The tool instruction manual and a hypothetical scenario are described in this section.

Manual

Below, a stepwise manual for working with the tool is provided. The capital letters indicated can be found in the left-hand side of the tool.

A	Under "General information", data can be entered on how frequently ships are berthed and for how long. These data are needed to calculate operational costs and emission changes.
B	Depreciation period and interest rate affect annual costs, with higher interest rates and shorter depreciation periods leading to higher annual costs.
C	Here the investments costs at the terminal can be filled in. The tool distinguishes various cost categories, which are summed to yield the total investment costs. Annual costs are calculated using the interest rate and depreciation period. Investment costs are not relevant for the auxiliary engines, as these are vital outside the ports.
D	In this section the shipside investments costs are filled in. A range of cost categories are listed, which are summed to yield the total investment costs. Annual costs are calculated using the interest rate and depreciation period.
E	The operational costs depend on fuel and electricity consumption levels, fuel and electricity prices and electricity taxes. From these data, annual costs are calculated. Savings on auxiliary engine maintenance costs can be filled in here, with negative costs standing for benefits. The total benefits are calculated from the number of hours at berth, as input to the General information section. There is an option to calculate with a CO ₂ price in advance. This option enables simulation of the influence of inclusion of the Maritime industry in the EU ETS on the cost effectiveness of OPS.
F	The total annual costs are calculated by summing the various cost categories under B to F. The costs or benefits accruing from using OPS can be calculated by comparing the 'auxiliary engine costs' with the 'OPS costs' (row 65), the outcome of which is presented in Box I.
G	The emission benefits are calculated by using emission factors from the data section and total annual consumption figures. Total annual consumption is calculated on the basis of the ships' consumption and the number and duration of port calls. The emission benefits can be found by comparing the figures in rows 76-80. The type of fuel can be changed from diesel to HFO here, as well as the energy source used for power generation (by clicking on a pull-down menu).
H	The total annual costs can be calculated by subtracting the 'auxiliary engine costs' from the 'OPS costs'. Negative costs mean that OPS yields a financial benefit. The cost effectiveness is expressed in Euro per unit of pollution. Pollution units are used to sum the various air pollutants, with SO ₂ and PM being judged to be 2.2 and 12.8 times more harmful on the basis of a study by AEA Technology (2005).
I	For each pollutant the relative emission reduction is calculated using the figures in rows 76-80.

Note: the basic data can be changed in the 'data' sheet. These basic data include emission factors for fuel burning and power consumption.

A

General information

ships	<input type="text" value="10"/>
calls per year per ship	<input type="text" value="100"/>
hours at berth connected	<input type="text" value="12"/>

OPS

INVESTMENT COSTS

B

	Input	Yearly costs (€)
General info investment costs		
interest rate	<input type="text" value="6%"/>	
depreciation (years)	<input type="text" value="10"/>	

C

investment costs terminal		
high voltage connection from grid (including transformer) (€)	<input type="text" value="200.000"/>	121.494
freq, converter (€)	<input type="text" value="-"/>	
cable installation (€)	<input type="text" value="225.000"/>	
total investments (€)	<input type="text" value="425.000"/>	
maintenance, contract and electricity transport costs (15%) (€)	<input type="text" value="63.750"/>	

D

investment costs ships		
transformer (€)	<input type="text" value="200.000"/>	

	main switchboard, control panel (€)	<input type="text" value="100.000"/>	618.199
	cabling (€)	<input type="text" value="3.000"/>	
	cable reel system (€)	<input type="text" value="152.000"/>	
	total investments (€)	<input type="text" value="455.000"/>	
OPERATIONAL COSTS			
	Input		Yearly costs (€)
E	Electricity costs		1.008.000
	Electricity price (€/ kWh)	<input type="text" value="0,08"/>	
	tax (€/ kWh)	<input type="text" value="0,03"/>	
	Consumption (kW)	<input type="text" value="800"/>	
	Saved maintenance		-57600
Maintenance per engine (€/ h)	<input type="text" value="-2"/>		
	number of engines	<input type="text" value="3"/>	
F	TOTAL COSTS (€)		1.690.093

POLLUTION		
Input	pollution units	
Electricity source	EU mix	
	Emissions (ton)	Pollution units
CO2	3360,0	
NOx	3,4	3.360
PM	0,0	369
SO2	4,4	9.715
Total		13.444

Auxiliary engines	
INVESTMENT COSTS	
Input terminal	Yearly costs (€)
General info investment costs	
no investments	<input type="text"/>
investment costs terminal	
no investments	<input type="text"/>
investment costs ships	
no investments	<input type="text"/>

OPERATIONAL COSTS		
Input terminal		Yearly costs (€)
Fuel costs		
Diesel (USD/ton)	<input type="text" value="650"/>	906.048
Consumption (ton/h)	<input type="text" value="0,2"/>	
ETS costs		
ETS CO2 price	<input type="text" value="0"/>	0
		906.048

POLLUTION		
Input	pollution units	
Fuel	<input type="text" value="Diesel"/>	
Pollutants	Emissions (ton)	Pollution units
CO2	6758,4	
NOx	143,6	143.616
PM	4,4	56.771
SO2	10,6	23.232
Total		223.619

Total yearly costs (€)	784.045
cost effectiveness (€ / pollution unit)	3,7

Emission reductions electricity	
NOx	98%
PM	99%
SO2	58%
CO2	50%

----- Appendix C -----

TOOL BOX FOR PORT CLEAN AIR PROGRAMS

Improving Air Quality While Promoting Business Development

Engine standards



TOOL BOX FOR PORT CLEAN AIR PROGRAMS

Improving Air Quality While Promoting Business Development

2007

In April 2007, the IMO's Bulk Liquid and Gas Subcommittee held a meeting in London to discuss ocean/sea going vessel emission standards under Annex VI. The subcommittee noted that the contribution of ship emissions is greatly impacting air quality in many parts of the world and that emissions will continue to grow with the growth in global trade. In addition, the IMO noted that action is required to avoid proliferation of unilateral regional or national regulations.

Proposals from the meeting included:

- "Narrowing" of options on emission reduction strategies;
- Consolidate USA and BIMCO proposals into one "global/regional" option;
- INTERTANKO proposal – agreement on the use of distillate fuels as proposed or equivalent emission limits, allowing for LSFO or use of emission control technology(s);
- New engines – propose for Tier II engines 2 to 3.5 g/kWh reductions vs. 2011 standard and water or selective catalytic reduction technology based Tier III engines as of 2015 – 2016;
- Existing engines – bring to current standard;
- Efficient and effective instruments to address air pollution and climate change;
- Holistic approaches involving oil producers and engine manufacturers; and
- Inclusive approach engaging governments, industry and the scientific community.

ENGINE STANDARDS

Background

Ports around the world depend on the efficiency of the diesel engine to power port operations in each source category – ocean/sea-going vessels, harbor craft, cargo handling equipment, trucks and locomotives. Though diesel engines are the most efficient power sources compared to other internal combustion engines, they are significant contributors to air pollution. Environmental regulations are calling for cleaner engine standards and advanced emission controls to address the negative impact from diesel emissions.

The following fact sheet provides an overview on international engine emission standards. Emission standards are set requirements that limit the amount of pollutants that can be released into the atmosphere. There are emission standards set for both onroad and offroad vehicles and equipment. Generally, emission standards regulate emissions for oxides of nitrogen (NO_x), particulate matter (PM) or soot, carbon monoxide (CO), or volatile hydrocarbons (depends on international engine standard).



TOOL BOX FOR PORT CLEAN AIR PROGRAMS
Improving Air Quality While Promoting Business Development

European Union Emission Standards

The European Union currently has emission standards set for all road vehicles, locomotives, and 'nonroad mobile machinery.' However, no engine standards apply to ocean/sea-going vehicles and airplanes.

Euro Norm Emissions for Category N2, EDC, (2000 and Up)

Standard	Date	CO (g/kWh)	NOx (g/kWh)	HC (g/kWh)	Particulates (g/kWh)
Euro 0	1988-1992	12.30	15.8	2.60	None
Euro I	1992-1995	4.90	9.00	1.23	0.40
Euro II	1995-1999	4.00	7.00	1.10	0.15
Euro III	1999-2005	2.10	5.00	0.66	0.10
Euro IV	2005-2008	1.50	3.50	0.46	0.02
Euro V	2008-2012	1.50	2.00	0.46	0.02
Euro VI	Proposed regulations under review.				

Euro Norm Emissions for (Older) ECE R49

Standard	Date	CO (g/kWh)	NOx (g/kWh)	HC (g/kWh)	Particulates (g/kWh)
Euro 0	1988-1992	11.20	2.40	2.40	None
Euro I	1992-1995	4.50	1.10	1.10	0.36
Euro II	1995-1999	4.00	1.10	1.10	0.15

Heavy-Duty Diesel Truck and Bus Engines

The following table summarizes emission standards and implementation dates for heavy-duty trucks and bus engines.

EU Emission Standards for HD Diesel Engines, g/kWh (smoke in m -1)

Standard	Date	Test	CO	HC	NOx	PM	Smoke
Euro I	1992, > 85 kW		4.5	1.1	8.0	.36	
Euro II	1996		4.0	1.1	7.0	.25	
	1998		4.0	1.1	7.0	.15	
Euro III	1999	ESC & ELR	1.5	0.25	2.0	0.02	0.15
	2000	ESC & ELR	2.1	0.66	5.0	0.10 0.13	0.8
Euro IV	2005		1.5	0.46	3.5	0.02	0.5
Euro V	2008		1.5	0.46	2.0	0.02	0.5

The Euro III standard includes changes in the engine test cycles (2000). Two new test cycles replace the old steady-state engine test cycle ECE R-49. The two test cycles include the European Stationary Cycle (ESC) and the European Transient Cycle (ETC). The European Load Response (ELR) measures smoke opacity.



TOOL BOX FOR PORT CLEAN AIR PROGRAMS
Improving Air Quality While Promoting Business Development

Nonroad Diesel Engines

Regulations for nonroad diesels were first introduced in 1997 in two stages depending on the engine power output; Stage I – 1999 and Stage II – 2001 to 2004. Nonroad equipment included industrial drilling rigs, compressors, construction wheel loaders, bulldozers, nonroad trucks, highway excavators, forklift trucks, road maintenance equipment, snow plows, ground support equipment, air ports, aerial lifts and mobile cranes. However, ships, locomotives, aircraft, and generating sets were not covered by Stage I and II standards.

In 2004, the European Parliament adopted Stage III and IV emission standards. Stage III emission standards include a phase-in schedule from 2006 to 2013. Stage IV will come into compliance in 2014. Both Stages III and IV include emission standards for locomotives and marine engines. Standards apply only to new vehicles and equipment. Replacement engines to be used in machinery already in use (except for rail car, locomotive and harbor craft propulsion engines) should comply with the limit values that the engine to be replaced had to meet when originally placed on the market.

Stage III/ IV Engine Standards

The following table provides a summary for Stage III and IV engine standards. Stage III standards are divided into two sub-stages: Stage III A and Stage III B. The limits are set for all nonroad diesel engines of indicated power range for use I applications and do not apply to locomotive, rail cars and harbor craft propulsion engines.

Stage III B standards include PM limit of 0.025 g/kW-hr, which represents about 90% emission reductions compared to Stage II. In order to meet the 90% reduction, emission control technologies will have to be applied such as diesel particulate filters (DPFs). Stage IV introduces stringent NOx standards of 0.4 g/kWh also requiring the use of a NOx emission control technology.

Stage III A Standards for Nonroad Engines

Category	Net Power kW	Date	CO	NOx+HC		PM
				g/kWh		
H	130 ≤ P ≤ 560	2006	3.5	4.0	0.2	
I	75 ≤ P < 130	2007	5.0	4.0	0.3	
J	37 ≤ P < 75	2008	5.0	4.7	0.4	
K	19 ≤ P < 37	2007	5.5	7.5	0.6	

State III B Standards for Nonroad Engines

Category	Net Power kW	Date	CO	HC		NOx	PM
				g/kWh			
L	130 ≤ P ≤ 560	2011	3.5	0.19	2.0	0.025	
M	75 ≤ P < 130	2012	5.0	0.19	3.3	0.025	
N	56 ≤ P < 75	2012	5.0	0.19	3.3	0.025	
P	37 ≤ P < 56	2013	5.0	4.7 (NOx+HC)		0.025	



TOOL BOX FOR PORT CLEAN AIR PROGRAMS
Improving Air Quality While Promoting Business Development

Stage IV Standards for Nonroad Engines

Category	Net Power	Date	CO	HC	NO _x	PM
	kW					
Q	130 ≤ P ≤ 560	2014	3.5	0.19	0.4	0.025
R	56 ≤ P < 130	2014	5.0	0.19	0.4	0.025

The Nonroad Transient Cycle (NRTC) test procedure was developed to represent emissions during real conditions in cooperation with the United States Environmental Protection Agency.

Stage III A Standards for Harbor Craft

Category	Displacement	Date	CO	NO _x +HC	PM
	Dm ³ per cylinder				
V1:1	D ≤ 0.9, P > 37 kW	2007	5.0	7.5	0.40
V1:2	0.9 < D ≤ 1.2		5.0	7.2	0.30
V1:3	1.2 < D ≤ 2.5		5.0	7.2	0.20
V1:4	2.5 < D ≤ 5		5.0	7.2	0.20
V2:1	5 < D ≤ 15		5.0	7.8	0.27
V2:2	15 < D ≤ 20, P ≤ 3300 kW	2009	5.0	8.7	0.50
V2:3	15 < D ≤ 20, P > 3300 kW		5.0	9.8	0.50
V2:4	20 < D ≤ 25		5.0	9.8	0.50
V2:5	25 < D ≤ 30		5.0	11.0	0.50

Stage III A Standards for Rail Traction Engines

*HC = 0.4 g/kWh-hr and NO_x = 7.4 g/kWh-hr for engines of P > 2000 kW and D > 5 liters/cylinder

Category	Net Power	Date	CO	HC	HC+NO _x	NO _x	PM
	kW						
RC A	130 < P	2006	3.5	-	4.0	-	0.2
RL A	130 ≤ P ≤ 560	2007	3.5	-	4.0	-	0.2
RH A	P > 560	2009	3.5	0.5*	-	6.0*	0.2

Stage III B Standards for Rail Traction Engines

Category	Net Power	Date	CO	HC	HC+NO _x	NO _x	PM
	kW						
RC B	130 < P	2012	3.5	0.19	-	2.0	0.025
R B	130 < P	2012	3.5	-	4.0	-	0.025

By the end of 2007, Stage III and IV emission standards will undergo technical review. This will determine the feasibility of standards, and recommended relaxing or tightening of the limits, as it may be appropriate.



TOOL BOX FOR PORT CLEAN AIR PROGRAMS

Improving Air Quality While Promoting Business Development

United States Emission Standards

The United States Environmental Protection Agency set national engine emission standards. In some states such as California, engine standards are set independently for that state. Some of the most strict engine standards in the world are set by the California Air Resources Board.

Heavy-Duty Vehicles and Buses

Heavy-duty diesel vehicles are defined by their gross vehicle weight rate (GVWR). Federal regulations set emission standards for heavy-duty vehicles with a GVWR of 8,500 pounds and higher and California's heavy-duty vehicle emission standards start at 14,000 pounds.

Diesel engines in heavy-duty vehicles are broken down into service classes. These include:

- ▶ Light heavy-duty diesel engines: $8,500 < \text{LHDDE} < 19,500$ ($14,000 < \text{LHDDE} < 19,500$ in California, 1995+)
- ▶ Medium heavy-duty diesel engines: $19,500 \leq \text{MHDDE} \leq 33,000$
- ▶ Heavy heavy-duty diesel engines (including urban bus): $\text{HHDE} > 33,000$

Basic standards are expressed in g/bhp·hr and require emission testing over the transient FTP engine dynamometer.

Model Year 1987 – 2003

The following table summarizes federal (EPA) and California (CARB) emission standards for HDDVs.



TOOL BOX FOR PORT CLEAN AIR PROGRAMS
Improving Air Quality While Promoting Business Development

EPA Emission Standards for HDDV Engines, g/bhp-hr

Year	HC	CO	NOx	PM
Heavy Duty Diesel Truck Engines				
1988	1.3	15.5	10.7	0.60
1990	1.3	15.5	6.0	0.60
1991	1.3	15.5	5.0	0.25
1994	1.3	15.5	5.0	0.10
1998	1.3	15.5	4.0	0.10
Urban Bus Engines				
1991	1.3	15.5	5.0	0.25
1993	1.3	15.5	5.0	0.10
1994	1.3	15.5	5.0	0.07
1996	1.3	15.5	5.0	0.05
1998	1.3	15.5	4.0	0.05

California Emission Standard for HDDV Engines, g/bhp-hr

Year	NMHC	THC	CO	NOx	PM
Heavy-Duty Diesel Truck Engines					
1987	-	1.3	15.5	6.0	0.60
1991	1.2	1.3	15.5	5.0	0.25
1994	1.2	1.3	15.5	5.0	0.10
Urban Bus Engines					
1991	1.2	1.3	15.5	5.0	0.10
1994	1.2	1.3	15.5	5.0	0.07
1996	1.2	1.3	15.5	4.0	0.05

The HDDV emission standards include a useful life and warranty period.

- ▶ LHDDE – 8 years/110,000 miles
- ▶ MHDDE – 8 years/185,000 miles
- ▶ HHDDE – 8 years/290,000 miles



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Model Year 2004 and Later

In October 1997, EPA adopted new emission standards for model year 2004 and later for heavy-duty diesel truck and bus engines.

EPA Emission Standards for MY 2004 and Later HDDV Diesel Engines, g/bhp-hr

Option	NMHC + NOx	NMHC
1	2.4	n/a
2	2.5	0.5

Under this ruling, all emission standards other than NMHC and NOx applying to 1998 and later model year heavy-duty engines would continue at their 1998 levels.

Useful life requirements were significantly extended compared to earlier rulings.

- ▶ LHDDE – 110,000 miles/10 years
- ▶ MHDDE – 185,000 miles/10 years
- ▶ HHDDE – 435,000 miles/10 years

The federal 2004 standards for highway trucks are coordinated with California standards.

Model Year 2007 and Later

Emission standards were set for heavy-duty trucks model year 2007 and newer in December 2000. California Air Resources Board adopted very similar standards in October 2001. The rule included two important approaches to further emission reductions; stricter emission standards and diesel fuel regulations.

Emission Standards

The emission standards for HDDVs model year 2007 and newer included:

- ▶ PM 0.01 g/bhp-hr
- ▶ NOx 0.20 g/bhp-hr
- ▶ NMHC 0.14 g/bhp-hr

In 2007, the PM emission standard will take in full effect. Standards for NOx and NMHC will be phased in between 2007 to 2010.

Crankcase Emissions

As a part of the 2007 regulation for HDDVs, crankcase emissions will be eliminated. Through the use of emission control technologies, crankcase emissions will be routed back to the engine intake or to the exhaust upstream as a means of recycling the emissions back through the crank shaft.



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Cleaner Fuels

As of July 2006, all on-highway diesel fuel required a lower sulfur content of 15 parts per million (ppm) from the 500 ppm on-highway diesel fuel. Retail stations and wholesale purchasers were required to meet this standard by selling the 15 ppm ultra low sulfur diesel fuel (ULSD) by September 2006. ULSD is a "technology enabler" for sulfur-intolerant exhaust emission control technologies, such as diesel particulate filters and NO_x catalyst, technologies that are necessary to meet 2007 emission standards.

Nonroad Equipment

Similar to the onroad regulations for cleaner engines and the use of ultra low sulfur diesel fuel, the US EPA introduced the Clean Air Nonroad Diesel Rule in May 2004. This comprehensive rule requires that emissions be reduced by integrating engine and fuel controls as approach to achieve the greatest emission reductions. New nonroad engines are required to have emission control technologies similar to onroad HDDVs. This regulation will help reduce exhaust emissions by more than 90 percent.

EPA's Clean Air Nonroad Diesel Rule applies to diesel engines in most construction, agricultural, industrial, and airport equipment. The standards will take effect for new engines in 2008 and will be completely phased in by 2014.

Nonroad Emission Standards, g/hp-hr

Rated Power	First Year that Standards Apply	PM	NO _x
hp < 25	2008	0.30	-
25 ≤ hp < 75	2013	0.02	3.5*
75 ≤ hp < 175	2012 – 2013	0.01	0.30
175 ≤ hp < 750	2011 – 2013	0.01	0.30
hp ≥ 750	2011 – 2014, 2015	0.075, 0.02/0.03**	2.6/0.50

* 3.5 g/hp-hr standard includes both NO_x and nonmethane hydrocarbons.

** The 0.02 g/hp-hr standard applies to gensets; the 0.03 g/hp-hr standard applies to other engines.

2011 to 2014 – 0.50 applies to gensets over 1200 hp.

2015 – 0.50 applies to all gensets.

Nonroad Diesel Fuel Rule

In 2007, all nonroad equipment will be required to use lower sulfur diesel fuel with a maximum sulfur content of 500 ppm. By 2010, all nonroad equipment will be required to use on-highway ULSD with a sulfur content of 15 ppm. This limit also applies to locomotive and marine applications (though not very large marine engines that depend on residual fuel).



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Locomotive and Marine Engines

In March 2007, the EPA proposed more stringent exhaust emission standards for locomotives and marine diesel engines. The new emission standards would significantly reduce harmful emissions of PM and NO_x. Under this program, three approaches would be put in place.

1. Tighten emission standards for existing locomotives when they are remanufactured. These standards would take effect as soon as certified remanufacture systems are available (as early as 2008), but no later than 2010 (2013 for Tier 2 locomotives).
2. Set near-term engine-out emission standards, referred to as Tier 3 standards, for newly-built locomotives and marine diesel engines. These standards would reflect the application of emission control technologies to reduce PM and NO_x exhaust emissions and would start a phase-in by 2009.
3. Set longer-term standards, referred to as Tier 4 standards, for newly-built locomotives and marine diesel engines that reflect the application of high-efficiency aftertreatment technology. These standards would apply to marine engines in 2014 and locomotives by 2015. By 2012, ULSD will be available for US locomotives and marine engines, which would be a "technology enabler" for some emission control technologies such as diesel particulate filters (DPFs).

In addition to these standards, EPA is proposing provisions to eliminate unnecessary idling.

Locomotive Engines

The regulations would apply to all line-haul, passenger, and switch locomotives that operate extensively within the United States, including newly manufactured locomotives and remanufactured locomotives that were originally manufactured after 1972. There is a primary exception that new remanufacturing standards would not apply to existing fleets of locomotives owned by very small railroads.

Marine Engines

The regulations would apply to newly-built marine diesel engines with displacements less than 30 liters per cylinder installed on vessels flagged or registered in the United States. The marine diesel engines are divided into three categories.

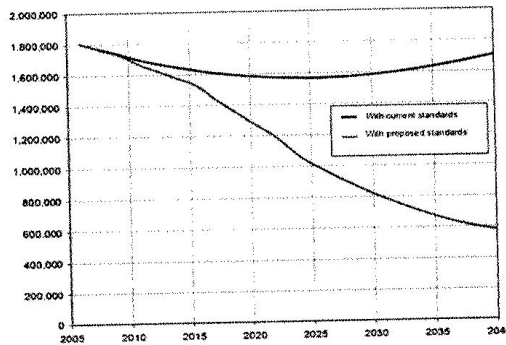
- ▶ Category 1 – engines above 50 horsepower (hp) and up to 5 liters per cylinder displacement.
- ▶ Category 2 – engines 5 to 30 liters per cylinder.
- ▶ Category 3 – engines 30 per cylinder.



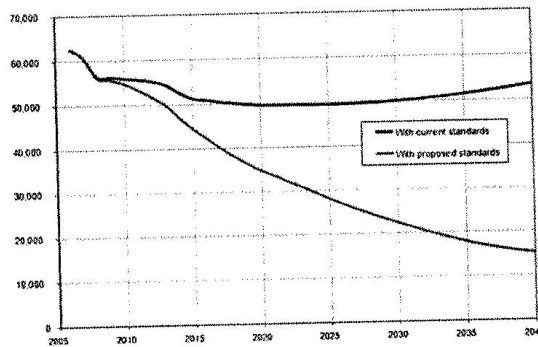
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The following figures provide projected emission reductions for NOx and PM under the new emission standards for locomotive and marine diesel engines.¹

Projected NOx Emissions (tons per year 'with' and 'without' Proposed New Controls)



Projected PM Emissions (tons per year 'with' and 'without' Proposed New Controls)



¹ NOx and PM figures from EPA fact sheet on *Locomotive and Marine Diesel Engines Proposed Rule*, March 2007

REFERENCES

Web:

- <http://www.princess.com/aboutus>
- www.environmentguardian.co.uk
- www.nextgenpe.com
- <http://en.cop15.dk/>
- <http://unfccc.int/2860.php>
- http://unfccc.int/kyoto_protocol/items/2830.php
- http://www.imo.org/newsroom/mainframe.asp?topic_id=109
- <http://www.happyplanetindex.org/>
- <http://www.who.int/research/en>
- <http://www.cdc.gov/>
- <http://www.cdc.gov/brfss/cde/2006.htm>,
- www.who.int/peh/noise/guidelines2.html
- <http://en.wikipedia.org/wiki/Guangzhou>
- <http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Default.aspx>
- <http://airclim.org/acidnews/2010/AN1-10.php>
- http://www.portoflosangeles.org/environment/alt_maritime_power.asp
- <http://www.arb.ca.gov/homepage.htm>
- <http://www.itslb.com/Main/Default.aspx>
- <http://www.vironcorp.com/Home.aspx>
- <http://www.polb.com/civica/filebank/blobdload.asp?BlobID=2158>
- <http://www.polb.com/civica/filebank/blobdload.asp?BlobID=2158>
- <http://www.polb.com/civica/filebank/blobdload.asp?BlobID=5778>
- www.portofoakland.com
- www.portgot.se
- <http://www.portgot.se/prod/hamnen/ghab/dalis2b.nsf/vyPublicerade/B9761872AF07B984C125719400312C6E?OpenDocument>
- [http://www.stenaline.com/stena-line`](http://www.stenaline.com/stena-line)
- http://www.portofantwerp.com/portal/page/portal/POA_EN/Actueel/Nieuws/Persberichten/PB%20WalstroomE.pdf
- <http://www.stockholmshamnar.se/en/About-us/>
- <http://upload.wikimedia.org/wikipedia/commons/9/9f/PxKohliColdIron.jpg>
- <http://standards.ieee.org/develop/wg/ShorePwr.html>
- http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=53588

- www.iso.org
- <http://www.arb.ca.gov/regact/2007/shorepwr07/tsd.pdf>
- <http://wpci.iaphworldports.org/about-us/index.html>
- <http://www.iaphworldports.org/>
- <http://wpci.iaphworldports.org/onshore-power-supply/implementation/ops-calculation-tool.html>
- <http://wpci.iaphworldports.org/onshore-power-supply/cost/investments.html>
- <http://wpci.iaphworldports.org/onshore-power-supply/cost/cost-effectiveness.html>
- [http://www.imo.org/about/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-\(solas\),-1974.aspx](http://www.imo.org/about/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-(solas),-1974.aspx)

BIBLIOGRAPHY

(Workgroup Recommendations and Other Potential Control Measures Diesel Initiatives Workgroup, Melinda Dower, 1/2/2007)

Official Journal of the European Union, 22.7.2005, DIRECTIVE 2005/33/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 6 July 2005 amending Directive 1999/32/EC

*Carbon Dioxide Information Analysis Centre: The **CDIAC** is an organization within the United States Department of Energy that has the primary responsibility for providing the US government and research community with global warming data and analysis as it pertains to energy issues.*

IMO and the Environment 2009 leaflet.

John Vidal, environment editor, guardian.co.uk, Thursday 9 April 200

Ships, planes, and carbon emissions, Catherine Brahic, Online environment reporter, March 05, 2007

*Corbett, J. J.; Koehler, H. W. Updated Emissions from Ocean Shipping. J. Geophys. Res., D: Atmos. **2003**, 108 (D20), 4650–4666.*

Corbett, J. J.; Wang, C.; Winebrake, J. J.; Green, E. Allocation and Forecasting of Global Ship Emissions; Clean Air Task Force and Friends of the Earth International: Boston, MA, January, 11, 2007;

26 Eyring, V.; Köhler, H. W.; van Aardenne, J.; Lauer, A. Emissions from international shipping: 1. The last 50 years.

*J. Geophys. Res., D: Atmos. **2005**, 110 (D17), D17305. Endresen, O.; Soergaard, E.; Sundet, J. K.; Dalsoeren, S. B.; Isaksen, I. S. A.; Berglen, T. F.; Gravir, G., Emission from international sea transportation and environmental impact. J. Geophys. Res., D: Atmos. **2003**, 108, (D17.)*

Pope, C. A.; Burnett, R. T.; Thun, M. J.; Calle, E. E.; Krewski, D.; Ito, K.; Thurston, G. D. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution.

DIRECTIVE 2005/33/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 6 July 2005 amending Directive 1999/32/EC

MARTENS Pim, Health and climate change

Christer Ågren, Great health benefits from new US air quality standards

World Health Organization (1999). Guidelines for Community Noise. ed. by Berglund, B., Lindvall, T., Schwela, D.H.. World Health Organization: 159 pp. Available online at: www.who.int/peh/noise/guidelines2.html. Last visited Jun 18, 2003.

SHORE-SIDE POWER SUPPLY A feasibility study and a technical solution for an on-shore electrical infrastructure to supply vessels with electric power while in port Master of Science Thesis PATRIK ERICSSON ISMIR FAZLAGIC´ Department of Energy and Environment Division of electric power engineering Masters program in Electric Power Engineering CHALMERS UNIVERSITY OF TECHNOLOGY Göteborg, Sweden, 200