WORKING PAPER: CLEAN AIR IN PORTS

Status: October 2014

This working paper of the NABU LIFE+ Project *Clean Air in Ports* aims at to collect and discuss measures that can be undertaken to reduce the air pollution in and from ports. Please note that at this point the paper is under construction and will be supplemented piece by piece. This paper by no means claims to cover all subjects completely, but instead asks for the input and thoughts of the reader.

INTRODUCTION

In September 2012, the German Nature and Biodiversity Conservation Union (NABU) and eight environmental organizations from six European countries started the EU-LIFE+ funded project "*Clean Air*", campaigning for better air quality throughout Europe. With its project *Clean Air in Ports* NABU contributes to this EU LIFE+ project. Reducing the air pollution from European ports will help the environment, the climate and the health of local residents. This paper aims to give an introduction to the problem and challenges of air pollution in ports and to collect possible measures and best practices for different stakeholder groups.

Over the three year period of the project, measures, best practices and examples for clean air in ports will be collected, discussed and then integrated into this paper. One source is the six workshops in European port cities NABU organizes as part of its project:

2013 in Hamburg (Germany) and Antwerp (Belgium)
2014 in Great Britain, the European Green Capital Copenhagen (Denmark) and Barcelona (Spain)
2015 in Gdansk (Poland)

As a result at the end of the project, this paper will be turned into a brochure Clean Air in Ports and published as a PDF.

1. Air Pollution in Ports –What are the Harmful Pollutants?

In Europe, about 420,000 people die prematurely because of poor air quality. According to World Health Organisation (WHO) 95% of Europeans living in urban environments are exposed to levels of air pollution considered dangerous to human health. In port cities the ports contribute massively to air pollution. But it is not only the ships that pollute the air with emissions from fuels that are up to a hundred times dirtier than road fuels. In the operating range of ports shunting locomotives, straddle carriers, reach stacker and heavy truck traffic are additional significant emitters.

Air pollution is a problem of many different pollutants. The project *Clean Air in Ports* focuses on three of them that are dangerous for human health, the environment and the climate and that are emitted mostly by diesel engines in the port: **sulphur dioxides (SO_2), nitrogen oxides (NO_x) and Particulate Matter (PM), with subgroups PM10, PM2.5 and UFP (Ultrafine Particle, <0.1 µm) with its component Black Carbon (BC).**

Carbon dioxide (CO_2) is not a 'traditional' air pollutant, but nevertheless harmful, especially for the climate as a so called *greenhouse gas*. The NABU project and this paper focus on 'traditional' air pollutants and will not take CO_2 into account. Still, CO_2 emissions from ports and ships are enormous and must be reduced. But there is a big overlap: Many measures aiming to reduce air-polluting emissions in ports also reduce CO_2 emissions and vice versa. Actually, most measures aiming to improve energy efficiency, thus reducing energy consumption, will have benefits in terms of air pollution. Although emission factors may depend on combustion conditions and such, air pollution is often related one way or the other to the use of energy or fuel.

1.1 Sulphur Oxides

SO_x emissions can be transported very long distances by wind. That is how coastal and even hinterland regions get polluted by emissions from shipping and port activities. When SO and SO_2 are oxidised in SO_4, they form sulphate aerosols which are so small that they belong to the group of Particulate Matter (PM). The European Air Quality Directive 2008/50/EC (article 22, see below) from the year 2008 sets the one-hour limit for sulphur dioxide at 350 $\mu g/m^3$ which may be exceeded more than 24 times a year. The daily limit of 125$\mu g/m^3$ may not be exceeded more than three times a year. (see Table 1: Air pollutant restrictions in the EU)

1.2 Nitrogen Oxides

NO_x arises during fuel combustion in the engines of ships, construction machinery, locomotives and trucks. If combustion time and temperature increase, NO_x emissions also rise. When a certain temperature threshold is passed, the increase grows rapidly.

The Air Quality Directive 2008/50/EC (article 22, see below) from 2008 sets a European-wide one-hour limit for NO_2 of 200 µg/m3 which may not be exceeded more than 18 times a year. Accompanying this, the limit per year is a daily average of 40 $\mu g/m^3$. In Hamburg, for example, ships alone account for 38 per cent of the NO_x emissions. (see Table 2: Air pollutant restrictions in the EU)

1.3 Particulate Matter (PM)

Particulate Matter (PM) are very small particles, that are – depending on their size – classified as PM10, PM2.5 or PM0.1. These are Particles with a diameter of less than 10 µm, respectively 2.5 µm, the smallest group with a size under 0.1 µm is also called Ultra Fine Particles (UFP). There is a natural concentration of PM in the atmosphere that consists of aerosol components like dust, marine salt or polls but it is enhanced by diverse anthropogenic effects like the burning of fuels or handling of goods. Especially the combustion of diesel and heavy fuel oil leads to a comparatively high amount of PM emissions. PM also develops when certain pollutants meet other substances. This form of PM is called “secondary particulate matter”. The smaller the particles are, the worse they affect human health. Especially harmful for human health are ultrafine particles (UFPs). They are not measured by mass as in case of PM, but by Particulate Number (PN). The most common measuring method for ultrafine particle is PN/cm³ (particle per cubic centimetre). When it comes to legislation and limits, only PM10 is regimented today (EU-Air Quality Directive): the average value is limited at 40 µg/m³ (per year) and the daily average value of 50 µg/m³ may not be exceeded on more than 35 days per year. (see Table 3: Air pollutant restrictions in the EU) From 2015 there is a limit value for PM2.5, too. In Hamburg, for example, ships account for around 17per cent of the PM10 emissions, including secondary PM.

1.3 Black Carbon

Black Carbon (BC) results of incomplete combustion of fossil- as well as bio-fuels and biomass. It is the major component of both anthropogenic and naturally occurring soot. It belongs to the group of PM2.5. Black Carbon has harmful health effects and is a so called *short lived climate pollutant* (see below). It also influences cloud formation and impacts regional circulation and rainfall patterns.

2. Effects of Air Pollution: Health, Environment and Climate

2.1 Health Effects of Air Pollution

Emissions from diesel engines contribute widely to the big number of people who get sick or even die prematurely because of air pollution:

- In June 2012 the World Health Organization (WHO) published a report that confirmed diesel exhausts as carcinogenic as asbestos[i].
- Emissions of sulphur dioxides (SO_2) are respiratory irritants and co-responsible for increased mortality rates, for example in the coastal areas of North America and Europe.
- NO_x emissions diminish the function of the lungs and increase the risk of cardiovascular diseases. NO_x also is a precursor of O_3 (ground level ozone) which is very dangerous for human health, too. O_3 can cause an irritation, impairment and inflammation of the respiratory system, headaches, an impairment of physical ability and an increase in the frequency of asthma attacks.
- PM emissions are correlated with more frequent asthma attacks, chronic bronchitis and lung cancer. They worsen heart- and lung diseases. It is assumed that children get more infections of the middle ear with increased PM exposure. In general, morbidity and mortality increase with more PM. The smaller the particles are, the deeper they get into the lungs where they cause the more serious consequences. It is likely, but not scientifically proofed that PM ends up in the blood stream, too. According to the European Environment Agency the exposure to PM2.5 shortens life expectancy in the EU by more than eight months.
- Respiratory problems, heart attacks, lung cancer and low birth weights are health effects associated with Black Carbon[ii]

Of the more than 400,000 yearly premature deaths in the EU that are linked to poor air quality, 60,000 can be attributed to shipping. Up to 98 percent of Europe's urban population is exposed to dangerous air pollution levels exceeding the World Health Organisation's (WHO) Air Quality Guidelines which are stricter compared to the EU regulations.

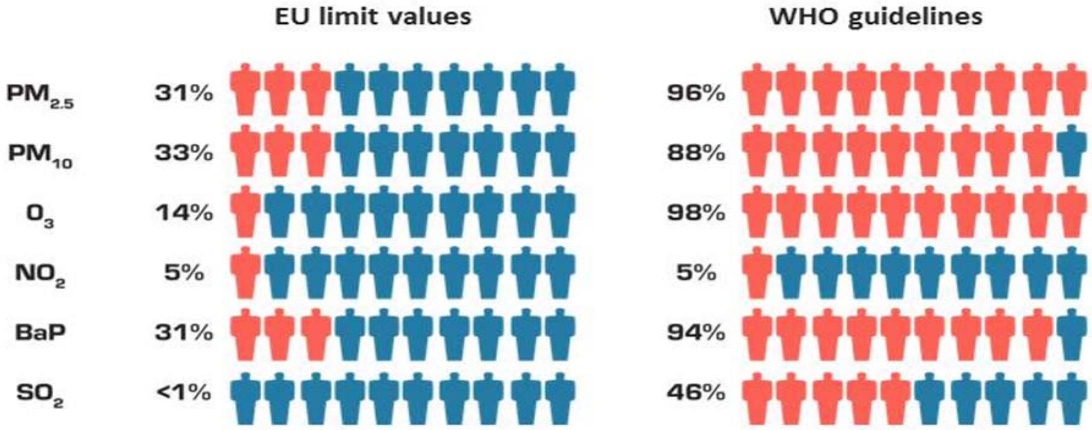

Figure 1: Urban population exposed to harmful air pollution. Source: European Environment Agency 2011

Latest scientific work of the virtual Helmholtz-Institute*[1] was presented at the Clean Air in Ports workshops in Hamburg, Amsterdam and Copenhagen. In order to analyse the effects of high emission concentrations in breathing air, the scientists for the first time applied a new method for exposing human lung cells directly to emissions. First results show that the health risks of NO_x and BC emissions are way higher than estimated before.

2.2 Environmental Damage of Air Pollution

Emissions of sulphur oxides (SO_x) respectively sulphur dioxide (SO_2) are harmful to plant vegetation and cause acid rain. High concentrations of nitrogen oxides (NO_x) cause eutrophication of lakes, soils and coastal areas (river mouths) and acidification of soils. Ground level ozone (O_3), which develops from NO_x, is very dangerous for plant vegetation. Recent research found that PM emissions contribute to forest decline.[iii] In Europe, nearly 200,000 km^2 (10 percent) of sensitive ecosystems are exposed to excess deposition of acidifying pollutants and some 1.1 million km^2 (68 percent) of sensitive terrestrial ecosystems are exposed to excess deposition of eutrophying nitrogen pollutants.[iv]

2.3 Global Warming and Air Pollution

Black Carbon belongs to the group of *short lived climate pollutants* (SLCPs). It is recognized that in order to keep global warming below 2^{o}C by 2050, the emissions of SLCPs need to be reduced drastically. The good news is that there are already measures available to do so. In 2013, Black Carbon was recognized to be the second strongest climate forcing agent after CO_2.The dark aerosols absorb solar radiation in atmosphere as well as they darken the surface when fall down. When deposited on ice and snow, black carbon causes both atmospheric warming and an increase of melting rate. This is especially bad for glaciers and for the arctic regions, where Black Carbon is responsible for more than 40 percent of the warming. BC particles emitted in the pole regions or carried to the Arctic settle on the white snow and ice surfaces and lower the albedo (reflection capacity) as well as the particles themselves warm up and thus contribute to melt ice faster. NO_x emissions are also contributing to climate warming, since NO_x is a precursor of the important greenhouse gas tropospheric ozone (O_3).

[1] * = contact details listed in Annex A

3. What are the Emitters in Ports?

There are several sources for air pollution in ports and in every port the different emitters have different shares on the pollution. The *Clean Air in Ports* project focuses its scope to the emitters of PM, SO_x and NO_x that belong to immediate port-business: ships (seagoing and inland vessel), non-road-mobile-machinery (NRMM) such as van carrier, AGVs (Automated Guided Vehicles), reach stacker and construction machinery, trucks, trains, conveyor vehicles and cars. Most of these engines are diesel powered and the burning of diesel causes a lot of PM, SO_2 and NO_x emissions especially if exhaust is not filtered.

The *Clean Air in Ports* project not deals with other emission sources such as from turnover business. The following passages present regulations for the air pollutants, possible measures for cleaning up the emissions from the different sources, followed by overall port-strategies and policy instruments.

4. Regulations for Air Quality

Many air polluting emissions are regulated on EU level. In September 2005, the Commission published its Thematic Strategy on Air Pollution; the aim is to cut the annual number of premature deaths caused by air pollution by 40% by 2020 from the 2000 level and to reduce the continuing damage to Europe's ecosystems. To do this the Strategy says that emissions of sulphur dioxide will need to be reduced by 82%, nitrogen oxides by 60% and fine particulate matter by 59% (compared to their 2000 levels). In particular, there are two major European directives dealing with air pollutants: The Ambient Air Quality (AAQ) directive (2008/50/EC) and the National Emission Ceilings (NEC) directive (2001/81/EC). The AAQ defines limit values for emissions of four of the projects pollutants (amongst others): SO_2, NO_x, PM10 and PM2.5 that are valid from 2012 onward (besides PM2.5 – from 2015). The limit values lack ambition – some are less strict compared to the WHO guidelines – and still get breached by many member states. A revision of the AAQ is urgently needed, but not on the horizon at the moment. The NEC directive defines limit values for the emissions of sulphur dioxides and nitrogen oxides (besides other emissions). Member states of the European Union have to adopt programs to comply with these ceilings. So far, emission reductions that could be achieved if all member states comply are still too little. And looking ahead, the 2020 targets proposed in the NEC directive actually allow 10-25 per cent higher emissions of SO_2 and NO_x than would result if just existing legislation would be enforced. BC is not included in the NEC directive, but might be in the future as the NEC directive is currently under revision (since 2013). This process is a chance to achieve significant air pollution reductions and by that contribute to health, environment and climate, but so far proposals lack ambition. European limit values are legally binding, and exceedances can result in the European Commission taking infringement action against the country at fault.

Table 4: Air pollutant restrictions in the EU. Source: EUR-Lex

Pollutant	Concentration	Legal nature	Period	Permitted exceedances/y
PM 2.5	25 µg/m³	target value (from 2015)	1y	-
PM 10	50 µg/m³	limit value	24h	35
long PM 10	40 µg/m³	limit value	1y	-
SO_2	350 µg/m³	limit value	1h	24
long SO_2	125 µg/m³	limit value	24h	3
NO_2	200 µg/m³	limit value	1h	18
long NO_2	40 µg/m³	limit value	1y	-

4.1 Regulations for Air Quality in Ports

For the single emitters in ports, there are unique EU directives, allowing different limit values of emissions. The sulphur emissions of ships are regulated by the directive 2012/33/EU regarding the sulphur content of marine fuels. Ships in Sulphur Emission Control Areas (SECAs) must use 1.5 percent sulphur fuel or better – started in the Baltic Sea in May 2006, extended to the North Sea and the Channel in autumn 2007. Ships at berth in EU-ports must use 0.1 percent sulphur fuel or better from 2010 onward (see also 5.4.4 ECA). The Directive also allows ships to use other technical abatement technologies that achieve the same or greater levels of emission reductions, provided it can be demonstrated that these technologies do not adversely affect the marine environment. The most often mentioned acceptable abatement technology is the desulphurization of exhaust gases via scrubbing. For BC and NO_x from ships there is currently no specific European legislation. Until now ships are not included in EU Emissions Trading Scheme (ETS).

Port equipment, building machineries, inland ships and trains are grouped as so called **Non-Road-Mobil-Machinery (NRMM)**. The directive 2012/46/EU deals with their emissions of SO_2 and NO_x and is under review at the moment. Problematic is that for the different engines very different limit values apply and that those are often too weak. A possible approach would be to align all NRMM values with the EURO VI norms from cars and trucks. It is necessary that the NRMM directive also includes PN limit values as UFPs are extremely harmful to human health.
Further, **cars and trucks** cause emissions in ports. Their SO_x and NO_x as well as CO_2 emissions are regulated by the directive 715/2007/EC and the directive 2005/55/EC respectively. The highest standards for cars and trucks, the so called EURO VI standard is quite ambitious, but since the turnover of the fleet is slow, still many vehicles with high emissions are on the (port) roads.

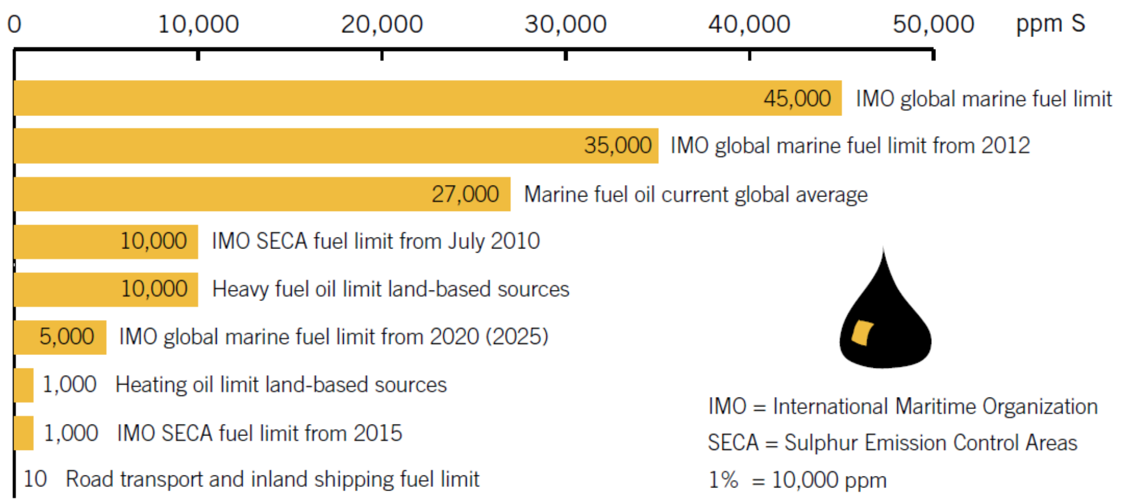

Figure 2: Fuel Sulphur Content. Source: AirClim 2011

When it comes to laws and regulations regarding air pollution in ports, the following directives are relevant:

→ The European directive 2012/33/EC as regards the sulphur content of marine fuels, limiting the sulphur content of marine fuels in ports to 0,1percent (when at berth for two or more hours)

Two major European directives are dealing with air pollutants:

→ The European Ambient Air Quality Directive (2008/50/EC) defines limit values for the three pollutants (amongst others) that are valid from 2012 onward.

→ The European NEC Directive (2001/81/EC), which defines National Emission Ceilings (NEC). Member states of the European Union have to adopt programs to comply with these ceilings.

Further regulations that affect the air pollution in ports:

→ Directive 97/68/EC and directive 2012/46/EU on the emission limits for so called Non-Road-Mobil-Machinery (NRMM), which affects for example port machineries and inland vessels

→ Directive 715/2007/EC is about the emissions limits for cars and light commercial vehicles.

→ Directive 2005/78/EC and Directive 2005/55/EC is about the emissions limits for trucks depending on the year they were built. Since 1st January 2013, new built trucks have to fulfil the EURO VI standard.

4.2 Required Legal Measures to Substantially Improve Air Quality

When it comes to European legislation, the directive on National Emission Ceilings (NECs) needs to be revised for the years 2020, 2025 and 2030 so that it achieves the EU's environmental objectives. New and strengthened sector legislation is needed to support the NECD as well as measures to ensure compliance and enforcement.
The EU air quality standards need to be in line with WHO's recommendations (so far they are below it). The revision of the NEC directive has to include Black Carbon and ambitious emission reduction goals. "The benefits of taking action far outweigh the costs in every policy scenario put forward by the Commission, yet the Commission's proposal is far from ambitious. Air pollution has high health, economic and environmental costs. To reduce these to a minimum within what is technically feasible would cost €51bn/yr but the health benefits would range between €58-207bn/yr. Instead the Commission has proposed a scenario that would achieve only limited benefits by 2030 at marginal costs" (EEB).

Regarding ships, the EU member states must take domestic action and push action in the IMO to cut ship emissions:

- Designate all European seas as Emission Control Areas (sulphur and nitrogen oxides)
- Improved emissions monitoring and compliance control, severe penalties for non-compliance
- Emission standards for PN and UFP
- Emission charges
- Emission standards or charges to cut NO_x from existing ships
- Obligatory slow steaming
- Develop and adopt an EU marine fuels quality directive

5. Measures for Single Emitters

5.1 Rail Transport

Technical measures

5.1.1. Emulsified fuel

Emulsified diesel is a diesel where water is mixed in. Because fuel and air are blended better and therefore burn more efficient – less fuel is needed. The advantage of emulsified diesel is that there are almost no changes on board necessary in order to use it. The CO_2 emissions decrease with water content. NO_x produced from emulsified fuel is significantly less than that produced from pure diesel under the same conditions.

5.1.2. Locomotives with idling control

If a locomotive is equipped with idle control, the main engine can be shut down if it's not needed. A smaller, more efficient diesel engine operates instead. It ensures that oil and fuel are available and that the water temperature is proper. This technology saves fuel and minimizes noise.

5.1.3. Locomotive drives

Diesel-electric drives consume less fuel in comparison to diesel-hydraulic locomotives whereas pure electric drives do not need fuel at all – they are powered electrically. Only if this electricity comes from renewable sources, those engines reduce overall air pollution. In a harbour with cargo handling cranes and container gantries electrification is not possible for every track, because it hinders the access to wagons from above. If electrification is installed at ground level it blocks the tracks being passed by other vehicles. This dilemma can be answered by locomotives with batteries or hybrid locomotives with additional diesel engine to charge the battery.

Example: The inland *Port of Magdeburg** has a hybrid diesel-electric plug-in locomotive with battery that is supposed to refinance its own investment costs. It saves up to 50% fuel and 70% emissions. The loading energy comes from a wind turbine build on the site of the port or from a board diesel engine that can also be used for traction.

5.1.4. Light freight wagons

If wagons are built lighter, they need less energy to be moved.
Example: The *Hamburger Hafen und Logistik AG (HHLA)**, together with a partner company, developed a space optimised and light freight car that can transport >10 percent more containers on one full train. A 720 meter Train can carry 108 TEU in comparison to 88 TEU on conventional Train. This reduces CO_2 and other emissions by around 10 per cent.

5.2 Road Transport

Organizational measures

5.2.1. Efficient coordination of arrival and departure

If arrival and departure of trucks are coordinated so that trucks drive the shortest ways and do not drive empty when not necessary, a lot of fuel and thereby emissions can be saved.

Technical measures

5.2.2. Exhaust aftertreatment systems

Most trucks have a diesel engine that causes a lot of soot emissions. Due to their bigger size and the bigger size of their engine, their soot emissions are up to 30 per cent higher (per km) than those from cars. Trucks can be retrofitted with particulate filters, and the technology for this is on the market, but the current EU-regulations do not require the (retro) fitting so far. From 2013 onwards, new built trucks have to have a particulate filter.

Trucks also cause a lot of NO_x emissions. In ports the emissions are especially high because slow driving causes more NO_x emissions – and trucks cannot drive very fast in ports. The EU regulation for NO_x from trucks has not been ambitious in the last years – again, from 2013 on and only new built trucks have to follow a stricter emission standard.

One measure could be that the port authority allows only "clean trucks" in the harbour area: For example it would only allow trucks with the EURO V standard and a diesel particulate filter (DPF) and an SCR-Catalyst (selective catalytic reduction) or alternative drive technologies to enter. Dirtier trucks are either not allowed to enter the port or have to pay a pollution fee.
Example: The *Port of Los Angeles* (PoLA) started a "*Clean Truck Program*" in 2005 that successively banned trucks who did not meet certain standards. Ban 1 (in 2008): no trucks built before the year 1989 are allowed to enter. Ban 2 (2010): no trucks built before the year 1992 and no trucks built in the years 1994-2003 that have no retrofit allowed to enter. Ban 3 (2012): all trucks not meeting the standards of the US Environmental Protection Agency (EPA) launched by EPA's National Clean Diesel Campaign are forbidden.

Average Emission Reductions for Trucks (in percent)

Technology	PM	NOx	HC	CO
Diesel Oxidation Catalyst (DOC)	20-40		40-70	40-60
Diesel Particulate Filter (DPF)	85-95		85-95	50-90
Selective Catalytic Reduction (SCR) *		up to 75		

***should be combined with DOC or DPF systems to reduce PM, HC and CO emissions.**

5.2.3. Alternative drives and fuels

LPG, LNG, CNG, fuel cells and electric engines are adequate alternatives for most propulsion machinery ranging from car to ship. Already common is the use of LPG (Liquid Propane Gas) and CNG (Compressed Natural Gas) to power trucks, cars, busses and NRMM like forklifts. Emissions are lower than for gasoline and diesel; LPG powered forklifts are even allowed to operate indoors. Hydrogen fuel cell drives are already in use, too. The production of hydrogen has to be powered by renewable energies; otherwise the required high input of electric energy would generate a great amount of emissions.
Another alternative to diesel-powered trucks is the use of LNG (Liquefied Natural Gas). LNG-powered trucks meet the requirements for EURO VI and LNG as well as CNG can be produced as bio-gas by fermentation of biomass.
Example: The PoLA encouraged within the "Clean Truck Program" concessionaires to buy new LNG-trucks with a funding and an incentive program.

5.2.4. Fuel Cells

Fuel cells generate energy through an electrochemical reaction of hydrogen and oxygen. The only emissions are water vapour and heat. The fuel is hydrogen. It has to be generated by electricity in advance and loaded at a fuel station. If the needed electricity is produced by renewable energy fuel cells are a zero emission technology. The propulsion power is generated by an electric motor. Fuel cells have high efficiencies and little noise.

5.2.5. Electric cars and trucks

The use of electric cars and trucks saves emissions, since those automotives do not cause fumes. But only if

the energy is produced from renewable sources those vehicles contribute to overall cleaner air – if the energy is produced by conventional power plants the air pollution problem is only relocated. Another way to charge the batteries or power the engine directly is to use fuel cells (s. 5.2.4.).
<u>Examples</u>: The *Port of Magdeburg** as well as *HHLA* uses electric vehicles with exchangeable batteries, so charging the batteries is not time consuming.
The *HHLA** has the biggest fleet of electric cars of the north-range ports.

5.2.6. Fuel switch for cars and trucks

Cars and trucks can either switch to a cleaner diesel fuel mixed with sustainable bio fuels. Or the fleet in a port can switch from gasoline and diesel to LPG, CNG or Fuel Cell. Projects for LNG are also underway.

5.2.7. Driver training

The training of truck drivers as a short term and low-threshold measure can contribute save fuel.
<u>Example</u>: *Eurogate* recorded a saving of around 7% in fuel combustion after a truck driver training.

5.3 NRMM, Cranes and Van Carriers

Organizational measures

5.3.1. Efficient coordination of the processes of loading and unloading of ships

By optimizing the processes of loading and unloading ships, a lot of fuel can be saved. Intelligent track planning, avoiding empty drives and thorough planning of space and ship landing place can contribute to save energy.
<u>Example</u>: The *HHLA** saves through that measure, mostly by transporting more containers on one voyage of a carrier, fuel in a six-digit number.

Technical measures

5.3.2. Ultra-low-sulphur diesel only together with particulate filter in NRMM

(Retro-)fitting with a particulate filter is possible for most of the construction machineries and inland ships. The prerequisite, the use of a cleaner fuel, is already mandatory.

5.3.3. Gas-fuelled forklifts

Forklifts can be fuelled with liquefied petroleum gas (LPG), propane gas or natural gas. The advantage of this is not only that it causes almost no air polluting emissions, but that it is very quiet, too. Within buildings, this way of cargo handling is done since quite some time in order to protect the workers from poisonous emissions.

5.3.4. Fuel Cells

Fuel cells exceed environmental standards set for example by the EPA for emissions, efficiency, and noise. At ports, they can be used instead of diesel generators (s. 5.2.4.). Fuel cells have high efficiencies, little noise, and zero emissions of sulphur dioxide, nitrogen oxide, particulates and CO_2.

5.3.5. Electric Machinery

Most mobile machineries can be equipped with electronic drives: ship to shore cranes, rail mounted gantry cranes and automated stacking cranes, Automated Guided Vehicles (AGVs) and van carrier. It is important that the energy for those electric devices comes from renewable energies to reduce overall emissions.
<u>Examples</u>: The battery-AGVs of Terex port solutions* presented at the Antwerp workshop, are heavy duty vehicles for the automated transportation of containers. The battery exchange and charging is fully automatic and there is no reduction of the vehicle performance, only a very short downtime for battery change. The station is integrated in an existing software system. The battery-AGVs cause less noise and no

local emissions. If the power comes from renewable sources, the battery-AGVs are independent from crude oil and diesel price trends and availabilities. The electric propulsion leads to less maintenance work compared to diesel as well as diesel- electric drives. Since there is no start up time, productivity increases.
Example: The *HHLA** has battery-AGVs in place since at CT-Altenwerder 2011. The batteries in the charger station are preferentially charged if there is a peak in wind energy supply. See presentation at Hamburg workshop (Mr. Pietsch) and Antwerp workshop (Mr. Kötter). (Nabu.de/ports) This technology will be introduced at *Rotterdam's Maasvlakte II* and in the *Port of Long Beach (PoLB).*

5.3.6. Hydrogen Injection

This technology injects hydrogen in the diesel engine of harbour machines. In a presentation of *MSC Home Terminals** at the Antwerp workshop, it was shown that this technology leads to greater power of the engines (6 percent) and a better fuel economy (9-12 percent, due to optimization of combustion process within the engine). NO_x emissions are decreased about 18.7 percent, the PM emissions by 85 percent. The technology can be retrofitted and will be amortised via the fuel savings within a year.

5.4 Water Transport

Air pollution emissions from ships are continuously growing, while land-based emissions are gradually coming down. If things are left as they are, by 2020 shipping will be the biggest single emitter of air pollution in Europe, surpassing the emissions from all land-based sources together.

Organizational measures

5.4.1. "Eco Sailing"

Just as car drivers, ship sailors can be trained to sail smarter in order to sail energy efficient.
Example: The *Port of Antwerp*'s *(APA)** tug boats sail slower and by that save 5-15 per cent fuel.

5.4.2. Slow steaming (ocean going vessels)

In general, slowing down can save a relevant quantity of fuel and avoid costs and emissions. A port can require ships to slow down when entering the port waters. At the coasts of the United States, all ocean-going vessels must slow down (to typically 12 knots) when they are within 10 nautical miles (nm) of a US port.
Examples: The *PoLB, Port of New York-New Jersey* and *Port of LA* (California) set up an incentive program for ships to slow down voluntarily when entering a zone 40nm around the port. The Californian Air Resources Board (CARB) estimated in a study that if all ships were to reduce their speed to 12 knots starting 40nm outside the port, the air pollution would be decreased: PM by 31 per cent, NO_x by 36 percent, SO_x by 29 percent. It has to be taken into consideration that most ship owners stated in a survey that they would speed up once they left the 40nm zone, which would diminish or even undo the effects on air quality. This leads to considerations of having a general speed reduction and/or combining speed reduction in ports with Virtual Arrival (below).

5.4.3. Virtual Arrival (ocean going vessels)

So far, ships just head for a port and when they reach it, often have to wait until there is a slot for them to berth. The new concept of Virtual Arrival uses weather analysis and algorithms to calculate and agree a notional vessel arrival time, so that the ship will arrive 'just in time'. By introducing this slot system ships can optimize operations: they plan their journey and book a slot in advance. This means they can save waiting time and in addition use less fuel. This may lead to a radical reduction in (bunker) fuel consumption and emissions On the other hand can this management lead to less congestion and more safety in a port.

5.4.4. ECA

Emission Control Areas (ECAs) are sea areas, where the amount of one or more kind of emissions is limited. ECAs are introduced by the International Maritime organisation (IMO) of the United Nations. In Europe there are three SECAs (Sulphur Emission Control Areas) so far: in the Baltic- and the North Sea and the English Channel. These were as well introduced by the IMO and put into European law by the directive 2012/32/EC that also regulates the sulphur content of ships berthing at a port for more than two hours. In order to limit air pollution from international shipping effectively, SECAs and NECAs (NO_x Emission Control Areas), too, are needed in all European waters.

Maximum sulphur content in fuel	IMO			EU		
	2012	2015	2020	2012	2015	2020
Non SECAs	3.5%	3.5%	0.5%[1]	3.5%	3.5%	0.5%[2]
SECAs	1.0%	0.1%	0.1%	1.0%	0.1%**	0.1%[2]
Passenger Ships	-	-	-	1.5%	1.5%	0.1%[2]
At berth				0.1%	0.1%	0.1%

Technical measures

The dirtiest fuel, with a maximum allowed sulphur content of up to 3.5 per cent (heavy fuel oil, HFO), is burnt by ships when sailing outside ECAs. At berth (in Europe), ships have to use fuels with a maximum of 0.1 per cent sulphur. It is estimated that all ships worldwide burn 250 million tons of HFO per year.

Emissions from ships are estimated to cause up to 50,000 premature deaths in Europe every year. Contrary to the impression one might have, ships are sailing close to shore most of the time. As a result, their emissions get carried up to 400 km inland. The transport of this pollution is done by the wind and may vary according to climatic conditions. Some ports can only be reached through one single river, like the ports of Hamburg, Rotterdam and Antwerp. These access channels are incriminating for the people living in that area.

5.4.5. Use of low sulphur-diesel

Even though high-sea-ships at berth in Europe have to use fuel with “only” a maximum sulphur content of 0.1 per cent, this still is a problem because this fuel is still a hundred times dirtier compared to road diesel (0.001 per cent sulphur) and most ships are not equipped with exhaust gas cleaning technology. Moreover, ships can switch to HFO as soon as they leave a port – unless they are in a SECA where the limit is 1.0 percent, but that is still dirty. Although cleaner fuels lead to reductions in harmful emissions, this is not sufficient. Further, BC and NO_x emissions are still too high.

5.4.6. Diesel particulate filter (DPF)

Diesel particulate filters (DPFs) are exhaust gas aftertreatment systems that significantly reduce emissions from diesel-fuelled vehicles and equipment. DPFs typically use a porous ceramic or cordierite substrate or metallic filter to physically trap particulate matter (PM) and remove it from the exhaust stream. Passive filters require operating temperatures high enough to initiate combustion of collected soot. In addition, filters require periodic maintenance to clean out non-combustible materials, such as ash. DPFs can be coupled with closed crankcase ventilation, selective catalytic reduction (SCR) or lean NO_x catalyst technologies for additional emission reductions.

The installation of a DPF can reduce soot emissions from a ship almost completely, especially the UFP that are not reduced by switching to a LSF. A prerequisite for the installation of such a filter is the use of distillate fuel. For ocean going vessels soot particulate filters are ready to use. Some smaller ships as those in ports (fire brigades, tugs) and inland ships already utilise with soot particulate filters. Even Germany's market leader for cruise ships announced in 2013 to equip its whole fleet with DPFs.

5.4.7. Selective catalytic reduction system (SCR)

Selective Catalytic Reduction (SCR) Systems convert NO_x emissions to N_2 (nitrogen gas) and oxygen. The catalytic reaction requires certain temperature criteria for NO_x reduction to occur. As with DPFs, knowing the age and type of each engine in the fleet as well as the drive cycles of the vehicles is important. Data logging must be performed to determine if the exhaust gas temperatures meet the specific SCR system requirements.

SCRs eliminate most of the NO_x emissions from the ship`s exhaust fumes. The fumes need to have a certain temperature for the SCR to function. Soot particulate filters and SCRs can be combined. More than 500 ocean-going vessels already have an SCR built in.
Example: The *APA** has an SCRT (= SCR with integrated soot filter) exhaust gas treatment on a tug boat.

5.4.8. Exhaust Gas Recirculation (EGR)

EGR is recirculating exhaust gas from the stack of a diesel engine into an EGR valve which is timed with the intake valves to allow some exhaust back into the cylinder for compression and the power stroke. Thus less fuel is used on the power stroke giving the engine better fuel economy and less gaseous emissions. However, with this system there is more particulate exhaust, which requires a DPF.

5.4.9. Seawater scrubbing

So called "*scrubbers*" wash the ship's exhaust gases in a subsequent treatment process and thus clean it from harmful particles and residues. Ships can be retrofitted with scrubbers. Scrubbers reduce the sulphur emissions by 70 to 95 percent and even lower PM and NO_x emissions to some extent.
Wet scrubbers: There are two types, with open or closed loops. The open scrubber uses sea water that is cleaned and discharged back to sea after the treatment. A closed loop scrubber uses fresh water. Scrubbers produce the left-over substance "sludge" that has to be carried onboard until it can be disposed of on shore.
Dry scrubbers work with granulate that binds parts of the toxic elements. In every case, large quantities of hazardous waste are produced that have to be further proceeded on land. Those hundreds of tons of toxic material contain heavy metals, metalloids, polycyclic aromatic hydrocarbons (PAH), PCB and oil hydro carbonates. Right now, there is no sufficient surveillance system that guarantees the proper disposal of the scrubber waste. There is no satisfactory control if all ship owners are willing to pay the extra fees for environmentally sound disposal and care for proper waste handling in the aftermath. By now not many harbours have facilities for to handle this kind of waste in environmental friendly concern.
Since scrubbers lower the temperature of the exhaust fumes, they cannot be combined with an SCR (see 5.4.7.) without further energy expanditure. Scrubbers can be easily turned on and off, so there is no way to control how long a scrubber has been used on a ship. It is very likely that scrubbers are turned off after leaving an ECA since they consume energy and produce waste that has to be disposed for charge. In many cases it is very likely that the costs for retrofitting old ships or equipping new ones with scrubbers as well as constant maintenance and waste fees exceeding the costs for a permanent switch to MGO. Scrubbers prolong the usage of heavy fuel and complicate the use of SCR.

NABU recommends the installation of selective catalytic reduction systems (SCR) and particle filters by simultaneously switching to MDO for the benefit of health, environment and climate.

5.4.10. Power Supply from Land

Ships should be equipped with plug in for OPS (s. 5.5.7.) or other external energy suppliers like swimming small-scale power plants that run on LNG. If harbours have OPS the ships at berth should be forced to use it e.g. via bonus-malus-fee system.

5.4.11. Engines for tug boats

CCR I and II are emission standards for inland vessel engines and for boats operating in harbours such as tug boats.

Example: The tug boat main engines at the *Antwerp Port Authority** can easily be transformed from CCR I to the stricter CCR II, by changing some valve regulation on the pistons of the engine. In the meanwhile tug boats have been transformed this way.

5.4.12. Fuel Cells

Fuel cells generate energy through an electrochemical reaction of hydrogen and oxygen the only emissions are water vapour and heat. Fuel cells have high efficiency, little noise, and zero emissions of sulphur dioxide, nitrogen oxide and particulates (see 5.2.4.). They can produce electricity to power an electric engine or to load a battery.

5.4.13. Liquefied natural gas (LNG) as ship fuel

Liquefied Natural Gas (LNG) can be used as a fuel for ships. It reduces the emissions of the three air pollutants focused in this project: there are no SO_2 emissions and the emissions of PM and NO_x can be reduced up to 90 per cent. But the positive effect on the climate is discussed controversial, because the so called "methane slip" may be even worse compared to HFO: Methane is a greenhouse gas that gets emitted to some extent when LNG is used and handled. It is about 25 times more harmful for the climate than CO_2 (timeframe: 100years). So if a lot of methane gets emitted, LNG is more harmful for the climate than CO_2. A study by the IMO (2009)[v] says that the methane slip reduces the net global warming benefit from 25 per cent to 15 per cent when ships switch to LNG to replace HFO.

Further, security matters are currently under discussion, not only for the ships but also for the handling in the supply chain. LNG has to be cooled in supply chain and tank, thus there is a certain amount of energy that has to be added to the calculation.

5.4.14. Ships with hybrid engines

Ships equipped with diesel-electric drives with diesel combination and electric propulsion enhanced by battery and maybe combined with plug in to charge at berth can save fuel and emissions.

Example: Scandlines has equipped ferries on the Puttgarden-Rødby line with batteries. These ferries use energy from batteries to start in the harbour and charge batteries when reduce speed at arrival. Additionally these ferries are equipped with scrubbers.

Example: The *APA** does a feasibility studies on hybrid propulsion of tug boats.

5.4.15. Battery Ship

Full battery ships are on the way. Ships can sail locally emission free and if loading electricity is generated from renewable sources will contribute to reduce overall shipping emissions. Because of short range these ships until further battery technology development will be tight to short distances or hopper transport with loading capacity in served ports.

Example: The *MS Fjordlys* operating on the Norwegian Sognefjord from end 2014. The 80-meter aluminium catamaran drives all-electric with two electric motors of 450 kilowatts. In the ports the lithium-ion battery recharges in just ten minutes, the electricity comes from hydropower.

The ferry annually saves one million litres of diesel fuel and avoids the emission of approximately 2,700 tons of CO_2 and 37 tons of NO_x per year.

5.4.16. Ships with wind propulsion

There are some projects on the move to drive ships, also big cargo ships, by wind. In combination with an engine, this can be quite successful by providing additional or even main power especially on longer distances. There are different ideas and mechanisms which are discussed and tested. Several new technologies are already implemented or on the way. Ranging from traditional and revolutionary sailing ships with diverse kinds of propulsion utilisation to single kites that can be retrofit on existing ships. A

fundamentally new ship design is needed if the vessel itself is used as a sail to systematically utilise wind propulsion. One project is the so called *vindskip*.
Example: According to *Skysails* one kite equals up to 2,000 kW of propulsion power and saves about 15 percent of fuel. *Skysails* technology is already available and installed on a hand full of vessels. www.skysails.info
Example: *Flettner rotors*, aid the ship's propulsion by means of the magnus effect — the perpendicular force that is exerted on a spinning body moving through a fluid stream. A 7000kW system is already working on the 2010 launched E-Ship 1.
Example: The *Vindskip* of Norwegian *Lade AS* is a large car carrier. The hull functions as sail. Software calculates the best route concerning wind and weather conditions. It is assumed to save 60 percent of fuel and 80 percent of emissions.

5.5 Measures for Ports

Organizational measures

5.5.1. Energy efficiency

Most forms of energy efficiency also reduce air pollution. When less fuel is burnt, fewer emissions are set free. Further, if electric energy is managed in an intelligent way, it is possible to restore parts of the energy for example while lowering heavy charges.

5.5.2. Energy management system

Energy management systems with professional monitoring and control can help to lower the energy consumption in complex processes.
Example: *Eurogate* reduced the energy demand per handled container by 13.5% from 2008 to 2014.

5.5.3. Awareness raising and training of employees

One relevant measure to enhance environmental changes – for air quality and others – is to raise the awareness of all people working in a port (for companies doing business in the port, the port authority or for shipping companies) about the topic. Each person can contribute and make a change, for example by saving energy or by bringing up ideas for cleaning up the air. Building up on this, employees should be trained about air pollution measures in their specific field of work.
Example: The *HHLA** and *Eurogate* do such trainings.

5.5.3. Include ports in Low Emission Zones (LEZs)

A political measure would be to include ports into Low Emission Zones (LEZs). This could mean stricter regulations for diesel engines, for example only EURO V trucks are allowed in the port or NRMM have to have a particulate filter. It also would imply a reduction commitment and monitoring stations (see 6). Example: The *APA** has performed a feasibility study on implementation of LEZ for trucks in the port area together with the city of Antwerp.

5.5.4. Change port-own traffic

The port itself can change its fleet to cleaner vehicles.
Examples: The *HHLA** has the biggest fleet of electric cars within northern range ports. The *APA** uses bicycles for service and for commuting and keeps on improving the so-called eco-score of its car fleet. It has decided to replace most of the diesel powered cars for short distances by (hybrid) gasoline or CNG driven cars.

Technical measures

5.5.4. Electric equipment wherever feasible (energy from renewable sources)

This measure prohibits local air pollution and if supplied with electricity from renewable sources it also eliminates all harmful air pollutants in total.

5.5.5. Passive houses

Even for port buildings measures can be undertaken to save energy and thereby reduce harmful air pollutants. A passive house does not use energy at all.

Example: The *Hamburg Port Authority (HPA)* in 2013 erected an office building as in passive house standard.

5.5.6. General power supply from alternative sources

As ports implement cold ironing and successively power machinery, trucks and trains with electricity, it is very important that this energy comes from renewable sources. Some ports already have wind turbines or solar panels on their ground. Ideally all energy used in a port comes from renewable sources.
Examples: The inland *Port of Magdeburg* has a wind turbine that directly supplies the new electric locomotive (5.1.3). The excess energy is delivered into the general grid.
On some of the *HHLA** logistics buildings there are solar panels which produced more than 550,000 kWh electricity in 2012. By that, HHLA has the third biggest solar panel in the city of Hamburg.

5.5.7. On Shore Power Supply

Many ships, in particular cruise ships, have to keep their engines running when lay in port in order to supply on board equipment with energy. For example, one big cruise ship needs as much power as a city of 200,000 inhabitants. When they get connected to power supply from land or by barge (LNG), ships can shut down their engines and by that reduce their emissions of air pollutants at least for the time berthing. But as soon as they leave the harbour, ships have to use fuel again and this is often HFO.

a) Cold Ironing/ Onshore Power Supply (OPS)

Cold ironing provides ships with electricity at berth thus they can shut down their engines. For OPS it is not necessary to build a supplementary power plant, they can be affiliated to regional grid. After many years of negotiations, an international standard for cold ironing was adopted in 2012, making it more attractive for ports and ship owners to invest. Still, the energy management is crucial but difficult when running OPS. The power for OPS must be produced by renewable energies; otherwise the air pollution is just shifted to the location of the power plant. In comparison to on site production there has to be recognized a transport los in energy additionally. EU in 2011 permitted a reduced tax rate for electricity, which is directly provided to vessels at berth. This legislation contemporaneous is implemented in Germany, Sweden and other EU countries.

Examples: The Port of Stockholm, which was represented at the workshop in Hamburg, had their first OPS up and running already in 1985. The Antwerp Port Authority supplies all its 21 tugs boats with OPS and has the 1st OPS installation for ocean going vessels in Europe installed.
The PoLA, PoLB and Port of Oakland equipped several container- and cruise berth with OPS (in the US called “Alternative Maritime Power” (AMP)).
Gothenburg, Antwerp, Rotterdam, Lübeck and Oslo already run OPS systems for Ferry and Cargo ships.
In Hamburg the first OPS for cruise ships is planned to start operation at Cruise Terminal Altona in February 2015.
The Ports of Amsterdam, Antwerp, Gothenburg and Hamburg have launched a working group within WPCI to foster and coordinate OPS.

b) Shore-side/barge-side electricity-supply from liquefied natural gas (LNG)

This measure produces energy from LNG on shore or on a barge and delivers it to a ship, which can shut down its engines while at berth and by that reduce its emissions of air pollutants. The same concerns for methane slip and security account for such electricity supply as mentioned above (5.4.9). The technical infrastructure for this energy supply is simpler compared to shore-side electrical power (above) and already implemented in some places. Another option would be an LNG plug-in to power the ships engine with LNG while at berth.

Example: An LNG fired power supply barge is working at Hamburg's Hafen City Cruise Terminal since autumn 2015. It was set up by Becker Marine Systems in cooperation with AIDA cruises to serve vessels at berth with electricity. In winter the barge will be able to feed electricity as well as heat into the on shore grids.

6. Port Policy and Regional Policy

Ports are not an island. They are located within a region and often in or next to a city – both having regulations on air pollution, too, so it seems to be reasonable to integrate the different policies.

6.1 Incentives for a modal shift

The port authority can set incentives to transport more goods by train and inland ship instead of truck. Again, this is only an advantage if locomotives are cleaner (see 5.1). Also, if the inland ships run on clean(er) fuel and are equipped with exhaust aftertreatment (SCR-Catalyst and Particle filter), the port authority can set incentives to transport more goods on inland ships instead of trucks.

6.2 Develop a general emission reduction strategy or an environmental policy for the port

Some ports have given themselves their own air quality strategy. As a first step it is important to calculate the emissions of a port and attribute it to different sources. Than a plan must be developed, how much emissions should be reduced until when, where and possibly how. It is crucial to have a valid monitoring system for such a project.

Examples: The *Port of New York/New Jersey*, *the PoLB and PoLA*, together the *Port of Seattle*, *Port of Tacoma* and *Port Metro Vancouver* (Northwest Ports Clean Air Strategy).

The *HHLA** aims to develop a zero emission terminal.

6.3 Economic Instruments

6.3.1. Ecological Port Fees for Ships

The idea of an environmental port fee is that ships get a reduction in their port fee if they fulfil certain ecological requirements.

Example: The *Port of Turku* (Finland) grants a reduction in the port fee if the sulphur content of the fuel used is <0.5percent or if the nitrogen content is below 10g/kWh.

See also 7.3

6.3.2. Fuel Switch for OGV

Some ports grant ships a reduced port fee, if they voluntarily switch to low sulphur fuel while in port.

Example: The *Port of Gothenburg (Sweden)* has a program that rewards vessels which use marine gas oil (MGO), liquefied natural gas (LNG), or another, similar fuel with a maximum of 0.1 percent sulphur content. In 2013 the program saved 120 metric tonnes (mt) of sulphur emissions, 13 mt more than measurements in the year before[vi].

7. Policy Among Ports

One general problem is that most ports are competitors about ships calling. But for cleaning up the air, it is necessary that they coordinate, network and tune measures. A major impact can be made by an environmental adjustment of port fees.

7.1 Environmental Port Index

The "Clean Baltic Sea Shipping" is developing and "Environmental Port Index". Until then it collects best practices and identifies Key Performance Indicators (KPIs). Amongst other goals, it aims at "creating a joint strategy for differentiated port dues and reducing ship-borne air pollution at sea, in ports and in cities"[vii]. So far, just a hand full of ports is participating in the project.

7.2 The World Port Climate Initiative (WPCI)

The "World Port Climate Initiative" (WPCI) was founded in 2008 by the "International Association of Ports and Harbours" (IAPH). WPCI provides information and platform on numerous measures and techniques to reduce emissions in harbours and from shipping. It ranges from information on LNG and OPS to the Environmental Ship Index (ESI). WPCI provides a GHG and pollutant footprint calculator called Air quality and Greenhouse Gas Tool Box. WPCI provides best practice examples in monitoring greenhouse gas emissions in ports. Many of these measures from all kind of engines also reduce the emissions of NO_x and soot particles, such as slow steaming, fuel savings and OPS.

7.3 Environmental/clean/green Ship Indices

Worldwide, there are about 50 different indices on clean(er) ships, eventually most recognized is the **Environmental Ship Index** (ESI), which is a project of the above WPCI. In many ports ships with above average environmental performance in ESI can get reduced harbour fees. For example the APA* grants reduction for ships based on the ESI and has in 2012 granted 500,000€.

The **Clean Shipping Index** allows real-time, quantified insights into the environmental performance of single ships. Ships and carriers are evaluated based on levels of emission of Carbon Dioxide (CO_2), Nitrogen Oxides (NO_x), Sulphur Oxides (SO_x) and particulate matter (PM). The index also includes use of chemicals, how carriers take care of their wastes on board, and how they treat different discharges to water, such as sewage and ballast water. Most shipping companies have entered detailed fleet data to the index. Thus logistic companies can asses and compare their chosen shipment providers.

The **Energy Efficiency Design Index** (EEDI), approved in July 2011 by the International Maritime Organization (IMO), is the first globally-binding standard. It applies to 180 states and entered into force on 1 January 2013. The index requires new ships to become more energy efficient, with standards that will be made increasingly more stringent over time. The EEDI is a non-prescriptive, performance-based mechanism that leaves the choice of technologies to use in a specific ship design to the industry. As long as the required energy-efficiency level is attained, ship designers and builders would be free to use the most cost-efficient solutions for the ship to comply with the regulations.

7.4 Voluntarily measures

Some ports agree on certain environmental measures or regulations in bilateral arrangements with other ports or with ship owners. Example: The *Port of Stockholm* made a trilateral agreement in 1990 with two ferry lines between Sweden and Finland, not to exceed the sulphur content of the fuel used over 0.5 percent.

Annex A: Glossary

AGV	Automated Guided Vehicle
APA	Antwerp Port Authority
BC	Black Carbon is a component of fine particulate matter ($PM \leq 2.5$ µm)
CCAC	Climate and Clean Air Coalition
CCWG	Clean Cargo Working Group
CNG	Compressed Natural Gas
CSI	Clean Shipping Index
CT	Container Terminal
CWF	Climate Works Foundation
DPF	Diesel Particle Filter
EEB	European Environmental Bureau
EEDI	Energy Efficiency Design Index
EPA	Environmental Protection Agency (US)
EPI	Environmental Port Index
ESI	Environmental Ship Index
ESPO	European Seaport Organisation
GHG	Green House Gas
HFO	Heavy Fuel Oil
HHLA	Hamburger Hafen und Logistik AG
HPA	Hamburg Port Authority
IAPH	International Association of Ports and Harbours
IMO	International Maritime Organization of the UN
KPI	Key Performance Indicators (at Environmental Port Index)
LEZ	Low Emission Zones
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MARPOL	International Convention for the Prevention of Marine Pollution
MDO	Marine Diesel Oil
MGO	Marine Gas Oil
MEPC	Marine Environment Protection Committee by IMO
NABU	Naturschutz Bund (German Nature and Biodiversity Conservation Union)
NECA	Nitrogen Emission Control Area
NM	Nautical Mile, 1NM = 1 minute of arc = 1,852 meter

NO_x	Nitrogen Oxides
NRMM	Non-Road-Mobile-Machinery
OPS	Onshore Power Supply; also Cold Ironing and Shore Side Electricity
OGV	Ocean Going Vessels
PM	Particulate Matter, classified by size of particles
PM2.5	Concentration of Particulate Matter with dimension smaller than 2.5 µm
PM10	Concentration of Particulate Matter with dimension smaller than 10 µm
PN	Particulate Number
PoLA	Port of Los Angeles
PoLB	Port of Long Beach
SCR	Selective Catalytic Reduction, in here used to describe the Catalyst (tech.)
SECA	Sulphur Emission Control Area
SLCPs	Short Lived Climate Pollutants
SO_x	Sulphur Oxides
SO_2	Sulphur Dioxide
TEU	Twenty-foot equivalent unit; standard container of 6.1x2.44m
UFP	Ultra Fine Particles $\leq$ 0.1 µm
WHO	World Health Organization
WPCI	The World Port Climate Initiative

Annex B: Contacts

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The EU-Project Clean Air

Each year more than 400,000 people die prematurely from the direct consequences of poor air quality throughout the European Union. That is one of the reasons why in September 2012, the German Nature and Biodiversity Conservation Union (NABU) and eight environmental organizations from six European countries started the EU-LIFE+ project Clean Air, campaigning for better air quality throughout Europe. The project is supported by the EU-Commission. Please find further Information on the project at www.cleanair-europe.org

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vi http://www.portofgothenburg.com/News-desk/News-articles/Campaign-saved-120-tonnes-of-sulfur-emissions/
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