Abstract: Ecology is more and more important for ever broader number of companies as well as local authorities and whole countries. Most of port authorities in northern Europe act as a public body but work in private environment which means that they have to follow rules set by both public as well as private sectors. Under these circumstances it is no surprise that significance of protection of natural resources along with diminishing of burden which ships and handling of goods at port terminals create for local community are one of focal points of port authorities. This article presents actions taken by the port of Hamburg aimed at protection of natural environment as well as of citizens of Hamburg from harmful emissions due to port economic activity.

Keywords: ecology, environmental protection, maritime ports

1. IMPORTANCE OF ENVIRONMENT PROTECTION IN THE PORT OF HAMBURG

Many big ports in Europe are located entirely or partly within urban areas i.e. in areas of relatively dense population which inflicts high intensity of touch points between the industry and its natural and social environment. In the past environmental or social issues (other than of port’s workforce) were considered to be far less important than economic ones. Nowadays, however, level of social consciousness and awareness of such problems is much higher and huge industrial organisms simply have to take them into consideration. The expectations of citizens living in close proximity to a port concerning the level of emissions, as well as port’s overall impact on its natural environment, are rising and in most cases are to some extend implemented in port’s policy of sustainable development. It applies also to companies located in port’s vicinity and more and more often to port’s direct and indirect customers, implementing corporate social responsibility programmes and
QHSE management systems, who increase pressure on port’s policy makers to ease its environmental impact. Last but not least, also the politicians and legislative framework enforces necessary measures to be taken to comply with increasing regulations concerning harmful externalities, of which a given port is a source. All three factors influence the port policy and as long as a port intentionally creates a program of sustainable development, the issue of environment protection simply has to be taken seriously into consideration.

Clearly, the port cannot be developed without considering its influence on the city as well as the city’s welfare relies heavily on the port. In Germany the ports usually belong to local authorities (for instance in Lübeck) or governments (Hamburg or Bremen), which pay attention to the voice of the public. For citizens of a port-city a harbour counts as a source of economic welfare on one side, but sometimes also as a hard neighbour putting a burden on its environment on the other side. As a result, the public often enquires about various topics concerning port development or specific incidents. One of such incidents took place on October, 4th 2014 in Hamburg when a container ship “Yang Ming Utmost” was leaving the port in clouds of black smoke. The cloud of smoke lingered over the beach area for some time and triggered anxiety and written queries at authorities [1], which had to be responded. Even though such events should by no means be considered as fault of port authorities, it is a clear sign that they have to take environment protection into account.

The importance of environment protection is extremely visible in planning and implementation of port development. Here a number of examples could be given in Hamburg, which celebrated in 2014 its 825th anniversary of the port’s establishment. Probably the most important development project concerns adjusting of the fairway channel to the port along the Lower and Outer Elbe River. On October 2nd, 2014, the Federal Administrative Court in Leipzig (FAC) was debating on granting the planning approval for this task [2]. The planned investment takes into consideration both legal regulations inclusive the European Water Framework Directive as well as complaints presented by environmental protection organisations. Even though both sides have been very well prepared and extensive studies have been presented (inter alia environmental impact assessment), the legal matter is that complex that FAC decided to delay its decision until the European Court of Justice has clarified certain legal questions in early spring 2015. This instance shows evidently that port development has to be very carefully elaborated with all due diligence and in dialogue with social partners and cannot be performed on an ad hoc basis. That rule has become a guideline for creation of port development policy in many ports including Hamburg.

“The Port Development Plan to 2025” published in October 2012 is a basic document explaining policy rules inclusive environment protection which had been created in this Hanseatic city in a dialogue with all parties having interest in or being dependent on port development inclusive port authorities, associations representing port companies and transport industry, representatives of local economy (e.g. chamber of commerce), trade unions and, last but not least, environmental associations and social partners. The document is an effect of long discussions of all concerned parties and corresponds to their requirements and expectations leading to identification of strategic guidelines, which Port of Hamburg Authority should follow: value creation, handling, quality and environment. Thus, protection of the environment became one of the most important goals for HPA
(Hamburg Port Authority) combining its actions in this area under the headword “green port”.

The plan emphasizes the economic impact of the Port of Hamburg on the metropolitan region, which is enormous. In fact, giving about 133 thousands work places in Free and Hanseatic City of Hamburg and some 22 000 thousands more in surrounding areas depending directly and indirectly on the port, it is the biggest employer in the region. It creates high added value (EUR 12,6 billion in Hamburg and additional EUR 1,5 billion in the metropolitan region) and brings to the city of Hamburg tax revenues of EUR 751 million (according to Planco, all data refer to 2010) [3]. In 2013 the port handled 139,1 million tons, most of which in containers. The container throughput reached last year 9,3 million of TEUs, of which 3,9 million of TEUs were transhipped to other ports in Northern Europe and 5,4 million of TEUs were transported to/from Hamburg by land (59% thereof by truck).[4]

In its newest study on container volume development in the port of Hamburg, Bremen Institute ISL expects that by 2025 box handling shall reach 15,4 million TEUs and 18,6 million TEUs in 2030 [5] i.e. twice as much as in 2013. To handle such enormous volumes Hamburg needs not only efficient infrastructure and handling facilities or well-developed links with the hinterland, but also – what becomes more and more obvious - special policy to protect port’s natural environment, its employees as well as citizens of Hamburg from harmful effects of shipping and usual port activity.

This huge amount of cargo poses a potential threat to the environment as a source of noise (not only during day but in night time as well), pollution and congestion – just to name basic externalities only. It may probably be enough to put some rudimentary restrictions on emissions to fulfill legal requirements of environmental protection. Nevertheless, the Senate of Free and Hanseatic City of Hamburg has put in the Port Development Plan much more ambitious goals for HPA to acquire a top profile among ports “by pursuing ambitious environmental and climate objectives and actively promoting and applying innovative technologies and ideas” [3].

The Port Development Plan acknowledges rising consciousness and higher standard of environment protection in both the industry and local community and – in consequence - aims at sustainable port development in harmony with the city of Hamburg and environment to offer sustainable job and service quality around green supply chain and eventually gain public acceptance. To achieve this paramount goal the document indicates improvement of environmental performance and increase in efficiency as well as reduction of emissions and consumption as important actions to be taken.
2. LEGISLATIVE MEASURES TO IMPROVE THE ENVIRONMENT PROTECTION IN MARITIME TRANSPORT IN THE NORTHERN EUROPE

Legislative framework in reference to environmental protection in maritime transport is putting growing pressure on the industry. As a result, shipping and consequently also sea ports are obliged to take some necessary actions to comply with new regulations.

European seas are extremely exposed to pollution which is a consequence of high traffic in selected sea water areas, therefore European Commission is putting two priorities as motto of its activities: reduction of accidents at sea and reduction of environmental pollution. Environment protection (in respect of sea ports) is based on the following measures:

- Control of transportation of dangerous goods,
- Control of compliance to environmental standards (port state control),
- Double hull requirement (regulations banning port entry and transport of heavy oils in single hull ships),
- Reduction of pollution at sea (development of port reception facilities according to MARPOL Annexes I, II, IV, V - oily and noxious residues, sewage, garbage etc.),
- Reduction of pollution (SOx, NOx, PM) in the atmosphere (development of bunkering facilities in ports for alternative fuels),
- EU commitment to general climate change policy.
- In most cases those measures are focused on shipping rather than on ports. Nevertheless the latter usually have to prepare supporting infrastructure (i.e. LNG bunkering station) or at least some organisational measures (e.g. port state control office). A good example is the new regulation implementing sulphur emission control in selected sea areas.

From January 1st, 2015 all ships sailing on the Baltic Sea as well as the North Sea and the English Channel (so called Sulphur Emission Control Area) have to comply with new regulations of MARPOL convention annex VI concerning air quality and are obliged to restrict the emission of sulphur oxides to maximum 0.1 percent – down from 1 percent allowed until end of 2014. That is a huge leap in cutting emission of harmful substances, but also additional significant cost for shipping lines as the new regulation requires switching to low sulphur fuel which is one and a half as much expensive as usual heavy fuel oil. Most of container or bulk vessels engaged in global shipping are inclined to use LS (low sulphur) marine gas oil, as regulations outside SECA (Sulfur Emission Control Area) (in North Europe and North America) limit sulphur emission to 3,5 percent which is relatively easy manageable. Nevertheless there are also alternative solutions to reach required level of emissions attractive for short sea shipping. These measures include installation of on-board scrubbers to filter sulphur oxides from exhaust gas and switching to LNG as ship’s bunker. All above methods have some drawbacks, which have been summarized in Table 1 below:
Alternative solutions to comply with restrictions of SOx

<table>
<thead>
<tr>
<th>Method</th>
<th>Shifting to low sulphur gas oil</th>
<th>LNG as bunker</th>
<th>Cleaning the exhaust gas (scrubbers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advantages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Limited investment necessary</td>
<td></td>
<td>– No SOx emission</td>
<td>– Emission of SOx down by up to 98%</td>
</tr>
<tr>
<td>– Decrease of emission of CO₂</td>
<td></td>
<td>– Decrease of emission of NOx</td>
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<td>– Decrease of emission of NOx</td>
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| Disadvantages                   |                                 |               |                                     |
| – Higher cost of bunker         |                                 | – New ships only |                                     |
| – No CO₂ reduction             |                                 | – Lack of standards/regulations |                                     |
| – Possible increase of price of low sulphur gas oil due to problems with low demand for heavy oil produced in refineries | | – Scarce bunker infrastructure |                                     |
| – New ships only                |                                 |               |                                     |
| – Lack of standards/regulations |                                 |               |                                     |
| – Scarce bunker infrastructure  |                                 |               |                                     |


LNG is considered as most promising solution. However, due to lack of standards and infrastructure, it is not an option of the first choice for shipping lines. At the moment there are just a few ships, mainly in Norway, which use LNG as bunker and one of the major problems is lack of bunkering stations in the ports. To address this particular problem Port of Hamburg Authority is preparing legal framework to allow for LNG bunkering within the port. The next step is setup of an LNG bunkering terminal which will be established by a private operator Bomin Linde LNG GmbH & Co. KG (Port Development Plan foresees investments in LNG bunker installations as a factor which will strengthen Hamburg’s competitive position as a regional container hub due to anticipated growing role of LNG powered feeder ships). HPA and The Linde Group have signed a memorandum of understanding to foster use of LNG as an environmentally friendly fuel in February 2012 and carried out a feasibility study to assess that this action can be economically viable.[7] The port is also trying to induce shipping lines by making LNG a more attractive alternative – a special discount in the port tariff has been introduced in 2015 for ships with extraordinary environmentally friendly propulsion systems (inclusive LNG) labelled with “blue angel” certificate granted by the German government.[8]

The problem of air pollution is concerned not only with sea passage, but also with ship’s manoeuvring within port’s area as well as power generation during ship’s stay in a port. Even though the result of both sources of air pollution is basically the same, these are two different problems which have to be solved in different ways. In case of ship’s movements within the port, the solution is basically similar to solution enforced in SECA, whereas the best solution to on-board power generation is to replace it with much more environmentally friendly solutions basing on power generated on land. Some of such solutions will be discussed in the next chapter.

Definitely, the sulphur control is not the only legislative measure that has been or will be taken to protect the environment. In the incoming years new regulations are expected to come into force to cope with the problem of emission control of nitrogen oxides and carbon dioxide as well as ballast water treatment on ships.
Whatever solution is chosen in respect to fighting the excess air pollution emissions, either on high seas or in ports, it inflicts higher operational costs for shipping lines and their customers. In the same time, however, the quality of air in the region shall improve. In effect a process of acidification of soil and water, which leads to deterioration of human health (almost 50% of Europeans live in areas where air quality standards are not met) and impairs plant vegetation, is to be put under control. Statistic data confirm that air pollutant deposit originating from shipping is a serious problem especially in the Scandinavian countries: in Denmark sulphur from shipping counts for 39% of all air pollutant deposits whereas in Sweden and Norway it reaches 25% (data for 2008)[8], therefore new regulations concerning emission control are especially important in the North Europe. Emission control shall reduce annual health damage caused by air pollution originating from ships in the North and Baltic Seas to 14,1 billion € in 2020 from 22,0 billion € in 2000.[9]

3. RISING PRESSURE OF PORT CUSTOMERS TO IMPROVE ENVIRONMENTAL PROTECTION

In fact, not only politicians and governments are trying to put pressure on ships to reduce pollution and environmental impact. Also shippers i.e. customers of shipping lines (and indirectly also port customers), express their growing concern and higher requirements concerning environmental protection by shipping. Environment protection has become an important part of broader activities carried out in line with corporate social responsibility policy. An example of how good practice can be spread among enterprises is a so called Clean Shipping Index, introduced by leading world shippers (including ABB, Akzo Nobel, Alfa Laval, KappAhl, Stora Enso Logistics and others) to evaluate performance of carriers providing transport by sea. Clean Shipping Index has been created by two Swedish scien-
tists, Ulf Duus and Jan Ahlbom, who checked a number of ships calling Gothenburg and based on this investigation - listed several technical solutions reducing adverse effects of shipping on air and water pollution. By comparison of performance of selected vessels to a reference ship in five areas (level of emission of carbon dioxide, nitrogen oxides, particulate matter and sulphur oxides as well as use of chemicals and handling of ship’s waste, sewage and ballast water), Clean Shipping Index enables an environmental ranking of ships. It is understandable for cargo owners and easy and inexpensive for shipping lines. Carriers have to answer online simply 20 questions per vessel and eventually have their ships verified by a renowned organization including Bureau Veritas, Germanischer Lloyd, DNV and others. The driving force is preferential treatment of carriers and their ships by shippers looking for environmentally acceptable shipping.

A similar initiative that actively supports climate protection (called World Port Climate Initiative) has been introduced by a number of key ports including Hamburg, Rotterdam, Los Angeles, Busan and others which are concerned by greenhouse gas emissions by shipping. A major project of WPCI is an Environmental Ship Index (ESI), a special measure of ships performance in environment protection, which identifies ships performing better in reduction of air pollution than current emission standards. The ESI Index can be used by shipping lines as promotion tool of their environmental policy actions, however, the main idea of the index is to use it as a tool for port authorities to identify ships contributing to environment protection and to reward relevant shipping lines by purely economic incentives. Thus, carriers will enjoy some economic benefits as well as good reputation which eventually be reflected in growing provision of services. Shippers receive a tool to implement sustainable goals as well as positive consumer experience and, last but not least, ports enjoy cleaner air and increased acceptance.

HPA engaged itself in World Port Climate Initiative (WPCI) as reduction of emissions is one of its priorities. To support shipping line investing in low-emission technology, HPA uses financial incentives in form of discounts on port tariff rates. The WPCI members are convinced that in the future more ports will join the initiative thus giving even more reasons to shipping lines to deploy “green ships”.

4. BETTER INFRASTRUCTURE AND OPTIMIZED CARGO FLOW WITH SMARTPORT LOGISTICS

To get the best results in handling environmental protection it is advisable to address this problem in a holistic manner rather than to apply isolated measures. HPA together with the city of Hamburg has launched a major program called smartPORT. SmartPORT addresses different problems and objectives, therefore it has been divided into separate smartPORT projects inclusive smartPORT energy, logistics, maintenance of infrastructure and cruise industry.

SmartPORT logistics, which is based on three pillars i.e. intelligent infrastructure, efficient traffic flows and optimizing trade flows, has been started to increase the efficiency of
Intelligent infrastructure is a system which consists not only of road or rail tracks or fairway channels for ships, but also of information, which has to be gathered and processed. The information processing infrastructure is not fully completed yet, but the plan foresees creation of an intermodal Port Traffic Centre which shall combine all transport modes and help to increase the capacity of the whole port infrastructure. In the future it will control road and rail networks, manage the available parking places as well as movement of vessels within the port.

Some elements of the system have already been built. In case of road network, the system provides automatic collection of data on traffic flow thanks to detectors installed throughout the port. Various detectors (inductive loops, video detection, Bluetooth), which are currently being installed on port roads, gather information on traffic density, average speed of vehicles, traffic jams and disturbances etc. and convey the data via fibre optic cables or radio to Port Road Management Centre which merges it with inputs from all other available sources and analyzes to make a short-term prediction which is consecutively passed to truck drivers and to other services as well. PRMC provides:

- Real-time traffic information,
- Dynamic traffic management via information tables located on port’s roads,
- Incident management system,
- Car park management,
- Traffic management on roads leading to port terminals.

Communication with truckers has been provided since 2011 via LED message boards called DIVA (dynamic traffic volume information system), which inform on congestion, accidents, maintenance works and times when collapsible bridges are closed for road traffic etc. Thus optimized traffic limits emission of CO2, noise and time spent in traffic jams which in consequence lead to optimized trip planning and savings of money and time.

The next step in road traffic management is a Smart Road project which will use to even larger extent all options which the IT technology can offer to monitor road network better and provide more accurate picture of the actual situation (inclusive traffic, environmental pollution, wind direction and force, road lighting etc.).

A problem in a busy port like Hamburg can be created by trucks looking for a parking place. As space in the port is expensive, it is not possible to provide excess parking space to accommodate all truckers in all possible locations. Eventually, it may lead to additional and unnecessary traffic caused by drivers looking for an appropriate parking. HPA is creating a comprehensive parking management system that will assist truckers and ensure that existing facilities are optimally used. Truckers will be communicated via mobile app with functions like available bay detection and administration.

As already mentioned, not only road infrastructure is in focus of HPA. In case of port’s railway network there is already a dedicated IT management system (HABIS) which supports management of rail traffic in Hamburg. To manage the rail infrastructure better, critical railway points (switches) will be equipped, under a pilot project, with versatile sensors which will measure various parameters whenever the point is switched or crossed. Thanks to information on actual conditions in major points, the operational management will be able to make better decisions and it will be easier to plan maintenance measures.
Along with roads and rail tracks also the river Elbe and port channels and basins are used for traffic. In March 2014 a dedicated IT system for planning ship movements in the port and in the estuary of the river Elbe (PRISE) was introduced after one year trial. This task is getting on importance as in Hamburg the number of big vessels navigating in narrow time-frames is growing constantly. The system gathers information from terminals, pilots, shipping companies, tugs and Harbour Master Authority as well as from German Federal Maritime and Hydrographic Agency (e.g. actual water level) and processes it to enable berth planning, provision of status information on ships’ positions, communication with relevant parties (tugs, terminals etc.) and more.

5. REDUCTION OF EMISSIONS WITH smartPORT ENERGY

A milestone in Hamburg’s green policy is an important project smartPORT energy which HPA has been carrying out since 2012 together with administration of Free and Hanseatic City of Hamburg (Fig. 2.). The idea of smartPORT energy project is energy transition in the port towards renewable energy as well as lower energy consumption by increasing energy efficiency and by promotion of ecologically friendly mobility. The expected result shall be better use of available resources thanks to general reduction of energy consumption and reduction of harmful emissions.

The renewable energy in the port comes from three different sources: wind installations, solar panels and biomass. Wind installations in Northern Germany are more and more important. In the port they are also present but the number of installations is limited – currently there are six wind turbines generating power of 20 MW. HPA is currently inspecting potential wind plant sites within the port and plans to construct seven of them by 2015. In 2014 HPA prepared a list of available roofs in the port, where solar panels could be installed. The companies which administer those building have been requested to install photovoltaic panels on its roofs. Biomass should be obtained as waste from green areas (e.g. lawn etc.) in the port.

In fact, many companies operating within the port area have already implemented some energy saving measures after joining voluntarily an environmental program “Enterprises for Resource Protection” run by city authorities. The program, in which port companies receive both consulting and financial support to implement energy saving investments, encompasses such activities as preparation of footprint analysis, introduction of energy management system or reduction of emissions by modernization of existing buildings.
Substantial potential is seen in co-generation (production of electric power and heat), cross-company use of waste heat (i.e. waste heat produced in excess by one company could be used by another company as well) and intelligent grid management. Another very promising project within this program is connected to use of hydrogen produced from renewable energies as storage of energy. Hydrogen could then be used to power motors or in fuel cells.

Innovative mobility concept is focusing on emission reduction through reduction of unnecessary traffic, modal shift of traffic from road to rail and/or inland waterways and through avoidance of harmful emissions which include air pollution, noise and also light. Especially air pollution is being criticized by the public. According to Lutz M. Birke, Enterprise and Port Strategy Manager at HPA, nitrogen oxides (NOx) and particulate matter (PM10) arising from ship traffic contribute to 38% and 17% of total emissions in Hamburg respectively. Huge sources of harmful emissions are diesel generators on ships running during ships’ stay in the port. To address this problem, HPA will build a shore power supply installation (“cold ironing”, see Fig. 3) for cruise ships in Altona which should be completed by 2015.
By the same time external electric supply installation for container ships shall be made available. As part of a pilot project “Green Shipping Line” between ports of Hamburg and Shanghai, which is supported by Federal Ministry of Transport and digital Infrastructure, external power supply for cargo ships will enable the latter to switch off their generators thus contributing to improvement of air quality in the port.

HPA is planning provision of a number of alternatives to onshore power supply including mobile generators operated with natural gas, barges with generators operated with LNG or fuel cells. An LNG generator on a barge seems to be a highly interesting option due to its flexibility. Hamburg-based Hybrid Port Energy GmbH, a subsidiary of Becker Marine Systems GmbH & Co. KG, designed a LNG Hybrid Barge which will act as low emission electrical power to cruise ships mooring in a port.[12] The idea of LNG Hybrid Barge is based on use of LNG to generate electric energy which can be delivered to lighter’s propulsion unit or fed to other vessel as external power supply. For its innovative approach, in 2013 the project won the Baltic Sea Forum’s prize “Baltic Sea Clean Maritime Award” in Infrastructure Development.[13] The first vessel was already constructed in September 2014 and christened in Hamburg on October 18th last year in Hamburg, where it will stay to provide power supply to AIDA Cruises ships. Five generators onboard of the barge “Hummel” generate up to 7,5 MW energy which responds to requirements of an average cruise vessel (the LNG hybrid barge was designed to address requirements of ships belonging to AIDA Cruises which was actively engaged in the construction process and delivered necessary know-how). AIDAsol was the first cruise ship in Hamburg to get power from the LNG hybrid barge on a trial basis. However, regular operations shall be commenced in the new cruise shipping season of 2015.

The above measures focus on ship’s emission control, nevertheless the road traffic is also a significant source of pollution. Introduction of sulphur emission regulations in the North Sea and in the Baltic Sea started some projects on usage of LNG as propulsion system on ships as well as alternative power for trucks. Today LNG as fuel for ships is of neg-
ligible importance, but it will definitely rise soon as it solves problems of future restriction compliance to regulations concerning emissions of oxides of nitrogen and particulate matter (e.g. MARPOL Annex VI). The smartPORT energy project is trying to evaluate a possibility of use of LNG instead of diesel to power trucks entering the port.

Fig 4. Examples of different power outlets used in different ports worldwide, which are considered for implementation in Hamburg (up left: installation for cruise ships in Los Angeles (11 kV), down left: installation for smaller container ships in Shanghai Waigaoqiao (440 V), right: installation for big container ships in Kaohsiung, Taiwan (6,6 kV))


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6. SUSTAINABILITY ENHANCEMENT AND INCREASED EFFICIENCY ON TERMINALS

HHLA (Hamburger Hafen und Logistik AG), the biggest terminal operator in Hamburg, is an excellent example of how seriously companies in Hamburg are committed to environment protection. Actually, the environment is one of the pillars of company’s sustainability strategy and its performance in this area puts it as one of the industry leaders. For instance, HHLA issued a declaration of compliance with the German Sustainability Code, which is still unique in the maritime industry. The company is in following fields of environmental activity:
- Ecological transport chains,
- Space conservation,
- Nature conservation,
- Climate protection [16].

A good measure of climate protection is reduction of CO2. HHLA undertakes a number of actions in this area and, moreover, publishing its carbon footprint since 2008. Although the absolute emission of CO2 by HHLA is rising, the emission per container is falling down and the target is reduction of CO2 emission per box by at least 30% by 2020. In 2013 emissions per container were lower by 24,9% already, therefore a set target seems to be achievable easily.

In order to fulfil the set goal, HHLA is undertaking a number of measures e.g.:
- Use of company’s own locomotives with electric engines,
- Electro mobility - conversion of handling equipment to electricity instead of diesel encompassing:
  - Cars,
  - AGVs¹,
  - Container and rail gantry cranes,

¹ Automated Guided Vehicle – automatic vehicles (without driver) which transport containers between STS gantry cranes on quayside and container yard
Improvement of energy mix by bigger share of electric energy from renewable sources (two large dimensioned solar power panel implementations mounted on roofs of HHLA produce approx. 570,000 kWh solar power electricity p.a.),

Reduction of travelled distances of containers on terminals thanks to real-time optimization (IT support) [16],

Emission-free heating by using biological gases (fermentation gases of the sewage plant Köhlbrandhöft are used for production of heating in the building of CTT Terminal - reduction of CO2 by approx. 1,000 tons p.a.) [14],

Switch to diesel-electric van carriers instead of pure diesel van carriers,[18]

Reduction of container handlings by quad-spreaders (spreaders able to handle 4 TEU at once) and dual cycle (explained later).

HHLA is operating battery electric AGVs since 2011, when first two vehicles were delivered to CTA by manufacturer (Gottwald Port Technology). Thanks to the newest technology, an 11 ton battery pack ensures uninterrupted work of the AGV for ca. 20 hours (up to 60 t payload) whereas exchange of battery takes only about 5 minutes and proceeds fully automatically. Recently HHLA together with partners (Gottwald, Vattenfall, Universities of Oldenburg, Göttingen and Clausthal) has initiated a so called BESIC project (Battery Electric Heavy Goods Transports within the Intelligent Container Terminal Operation), supported by the Federal Ministry of Economics and Technology.[17] BESIC project assumes a broader use of fully electric AGVs at terminals and investigates coordination of battery charging times with terminal operations requirements and with available renewable energy in electricity grid. For the purpose of the project a fleet of battery electric AGVs is being enlarged to 10 vehicles. Ideally, all batteries shall be charged with electric energy made from renewable energy sources, which eventually shall be produced by HHLA itself at own solar plants or wind farms. A potential success of the BESIC project will initiate a process of transferring all vehicles to electric energy at HHLA terminals which eventually shall ensure that all machines used between quayside and delivery zone shall be free from CO2 emission (powered exclusively by electric energy). At the same time the level of noise at a terminal shall be reduced significantly as well [15].

Higher efficiency of operations, which eventually also improves environmental impact of HHLA’s container terminals, means also more TEU per handling or less handlings to load and unload a ship. Since recently HHLA testing quad-spreaders capable of lifting 2 x 40 ft containers at once (in so called tandem mode), and dual cycle, which reduces a number of spreaders’ empty runs (Container Terminal Altenwerder is the first terminal worldwide to implement dual cycle into its production system) as well as optimized way for AGVs and van carriers between a STS gantry crane and container yard.

In January 2015 HHLA deployed twelve new van-carriers at its container terminal Burchardkai (CTB), which offer extremely low emission. The machines, which have been constructed by engineers of Terex Port Solutions in Würzburg, take all benefits of hybrid diesel-electric and ad-blue technology which significantly improve their environmental impact: nitrogen oxides are down by 94 percent (to max 0,5 g/kWh) and PM by 95 percent (to 0,025 g/kWh) in comparison to former models.[18]
7. CONCLUSION

Environment protection as a path leading to sustainability is never ending process which has to be consequently followed. The city of Hamburg has gained an honourable title of the European Green Capital 2011 for its pro-active attitude. The actions initiated by the city of Hamburg, as well as by Hamburg Port Authority, including projects smartPORT energy and smartPORT logistics projects as well as other activities prove that Hamburg is intending to stay on a road to ecologically friendly development and significantly reduce emissions generated by the port industry. HPA is piloting various initiatives aimed at creating sufficient incentives for port operators and shipowners as well as truckers and rail carriers to switch to low emission technologies and optimized transportation. In the same time it is improving the existing infrastructure to optimize the port traffic to avoid traffic jams and expendable traffic creating unnecessary emissions. The port stands in front of a LNG revolution, which will make shipping in the Northern Europe even more environmentally friendly and further increase advantages of maritime transportation compared to trucking or even to rail transportation. In a port like Hamburg a key to success is wider use of LNG in ports combined with e-mobility and smart grid powered by renewable energy.

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OCHRONA ŚRODOWISKA JAKO KLUCZOWA ZASADA POLITYKI NA RZECZ ZRÓWNOJĄCEGO ROZWOJU W PORCIE HAMBURG

Streszczenie: Tematyka ochrony zasobów naturalnych nabiera w ostatnich latach coraz większego znaczenia wraz ze wzrostem świadomości ekologicznej. Na strategiczne decyzje administracji portów zlokalizowanych w silnie zarubianych obszarach wpływa lokalna społeczność domagającą się zmniejszenia negatywnych oddziaływań portu na lokalne środowisko, ale również partnerzy gospodarczy, w tym załadowcy i firmy transportowe, również oczekujący większego zaangażowania w ochronę środowiska. W tych okolicznościach nie jest zaskoczeniem, że ochrona środowiska naturalnego w otoczeniu portów, obejmująca działania służące ograniczeniu negatywnych oddziaływań (emisji) wywołanych przez ruch statków, prace przeładunkowe
i transport wewnątrzportowy itp., staje się jednym z kluczowych problemów strategicznego planowania rozwoju portów. W artykule przedstawiono działania podjęte przez zarząd portu w Hamburgu mające na celu ochronę środowiska naturalnego poprzez ograniczenie szkodliwych emisji, których źródłem są statki oraz pojazdy, urządzenia i instalacje portowe.

Słowa kluczowe: ekologia, ochrona środowiska, porty morskie