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Final

Port of Bar

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Table of Content

1 INTRODUCTION 4
2 RELEVANCE OF GREEN PORT ACTION PLAN 5
3 GOALS AND MEASURES OF GREEN PORT ACTION PLAN 7
4 IMPLEMENTED AND ONGOING IMPLEMENTATION OF GREEN PORT ACTION PLAN MEASURES ... 29
4.1 Led technology 29
4.2 Electric and hybrid vehicles 31
4.3 E - charging station 33
5 INITIATIVES IN PLANNING PHASE 35
5.1 Energy management system (EMS) 35
5.2 Electrification of Power Train 36
5.3 Solar photovoltaics 37
5.4 Adaptive lighting system 39
5.5 LED lighting 39
5.6 Nearly zero energy building 39
5.7 Optimization of HVAC system 39
5.8 Air curtains 40
5.9 Adaptive lighting 41
5.10 District heating/coolong 41
5.11 Seawater source heat pumps 41
5.12 Insulation 42
5.13 Demand-controlled ventilation 42
5.14 Adjusting air temperature 42
5.15 Energy efiiciency measures in IT data centre 42
5.16 Green roof 42
6 LONG TERMS INITIATIVES 43
6.1 LNG facilities 43
6.2 On-shore power supply (OPS) 44
6.3 LNG PowerPac 44
6.4 Small-scale Terminal for Bunkering and Regasification of LNG 46
7 CONCLUSION AND NEXT STEPS 49
8 FIGURES INDEX 51
9 TABLES INDEX 51
10 REFERENCES 51

1 INTRODUCTION

The objective of the SMARTPORT project is to promote innovative practices and tools to reduce CO_2 emissions and improve energy efficiency in the public sector.

In particular, activity A.T3.4 (Environmental Energy Planning in Port Areas) intends to develop or update a document for the port energy plan. In 2019. Port of Bar has developed an Action Plan for Sustainable and Low-carbon Port of Bar developed through the financial assistance of ADRION Interreg Programme and the project SUPAIR. The experts working on this plan were from Hamburg Port Consulting GmbH.

The Port of Bar has recognized the signs of the times early and started its “green port transformation”. The overall goal is to ensure an energy efficient and largely emission-free port operation to reduce costs, improve the port´s overall efficiency and increase its environmental performance. One essential part of the port´s overall “energy sustainability strategy” is the Green Port Action Plan at hand that provides detailed and concrete information on how to reduce environmental impacts of port operation in a cost-efficient manner. This extensive document is focused on technical documentation referred to the upgrading/optimization of port infrastructure and operations through the green upgrading of port infrastructure. Improvement of the port infrastructure refers to the modernization of substations and the power grid, on-shore electrical infrastructure to supply vessels during the stay in port, electrical infrastructure to supply port machinery (mobile harbour crane, etc.). Accordingly, the intent is for the port to move to a more efficient use of energy in port operations in order to reduce costs, improve its overall efficiency and increase environmental performance.

This document gathers the information contained in the Action Plan for Sustainable and Low-carbon Port of Bar (2019) and some updates of the plan as in the last years some of the proposed measures were implemented.

Figure 1: Drivers towards achieving more energy sustainable port operation

2 RELEVANCE OF GREEN PORT ACTION PLAN

The central reason for this development is the threat of climate change that is regarded as one of the defining challenges of the 21st century. Improving the energy-related sustainability in ports is directly linked to the pressure to reduce greenhouse gas (GHG) emissions in logistics. As the transport sector as a whole account for about one-fifth of GHG emissions worldwide, "greening" of ports and terminals is considered important to contribute to reducing such emissions and to mitigate climate change. It must also be considered that climate change could also have substantial impacts on the port industry – e.g., as a result of sea-level rise or sedimentation impacts.

Furthermore, an increasing number of port stakeholders (e.g., regulatory authorities or customers) demand for a better management of negative externalities caused by port operations and thus a reduction of port-related emissions. Although the whole shipping and port sector is currently responsible for only about 2.5% of global GHG emissions, it is expected that these emissions will rise considerably in the future, mainly due to the increased worldwide transport demand (see Figure 2). Hence, it can be expected that GHG emission regulations, especially in the EU, will become more stringent in the future. It must also be considered that, like all other sectors, port operation should achieve a reduction in emissions as soon as possible, as stated in the Paris Agreement from the United Nations Framework Convention on Climate Change (UNFCCC).

Also, energy sustainability has become a promising means for ports to improve profitability. Significant energy saving potentials can be exploited by improving operations, adopting energy efficient technologies and using renewable energy sources. For instance, the implementation of an energy management system can help reveal energy efficiency improvements across the whole port area.

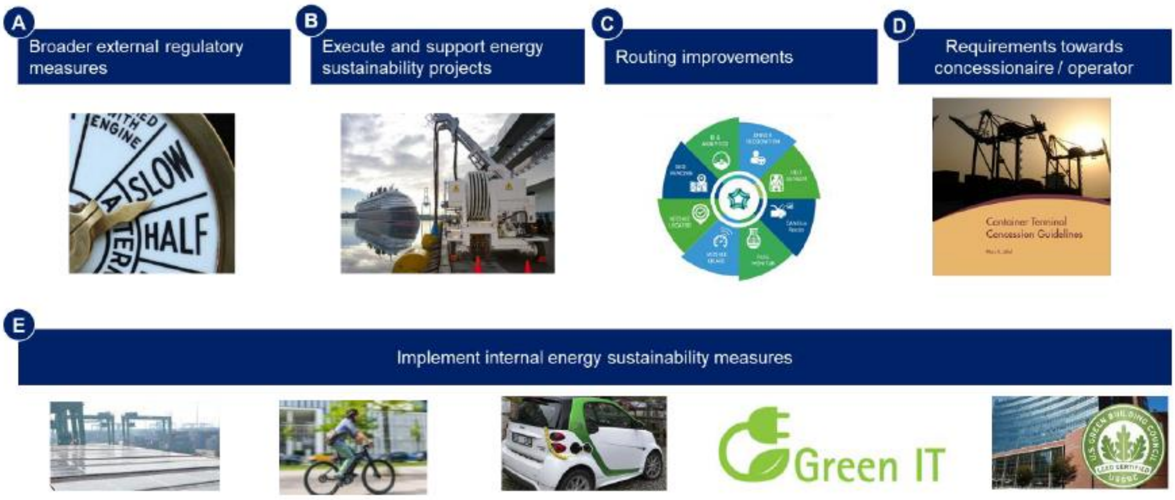

Figure 2: Potential energy sustainability measures for a port authority (Source: HPC, 2019)

Finally, port initiatives aiming to achieve an environmental-friendly port operation could also lead to an improved corporate image, which may be associated with direct and indirect benefits. Going "green" also has a positive impact on employee morale since e.g., employees better identify themselves with green businesses.

The increasing importance of achieving a "green port transformation" is also reflected in the fact that according to the European Sea Ports Organization ESPO, air pollution and energy efficiency are already their top two environmental port priorities since 2016.

The relevance for the Green Port Action Plan arises in particular for the following reasons:

- Threat of climate change, probably also causing negative consequences for the port sector;
- Increasing environmental regulatory requirements (international, national and local) and stakeholder demands (e.g., customers and residents); and
- Increasing competitive pressure in the port sector, which is why the pressure to reduce energy costs and improve a port`s efficiency has increased sharply.

As a consequence of this, the Port of Bar intends to use energy in the port in the most efficient way and thus become a regional energy sustainability leader.

3 GOALS AND MEASURES OF GREEN PORT ACTION PLAN

Port of Bar is the main cargo port of the country, carrying out most of the national maritime transport. The current port's equipment is at present significantly impacting the surrounding environment, mainly through carbon dioxide emissions.

To realize this vision, in this plan Port of Bar pursues three main energy sustainability goals to:

- **Main goal 1:** Reduce port-related energy consumption continuously;
- **Main goal 2:** Mitigate GHG emissions and air pollutions in the port area continuously;
- **Main goal 3:** Avoid or reduce ship GHG & air emissions in the port area.

To achieve these main goals in the" Action plan for sustainable and low-Carbon Port of Bar" (Green plan) a broad range of specific measures were defined. After the definition of possible measures, they were evaluated based on their two types of potentials: the quality of a measure with regard to their potential on reducing local air pollutants and greenhouse gas emissions as well as to reduce the total amount of fossil energy consumed the port and based on the amount of effort it takes to implement that measure (financial and operational).

Applying this evaluation framework helped Port of Bar to prioritize potential energy sustainability measures. Based on this evaluation criteria, it was possible to reduce the set of potential measures to a limited subset, which contains only the measures that are feasible and promising for the Port of Bar. The most promising measures are chosen with a high impact / effort ratio, namely having a high impact on energy sustainability and, requiring low effort for implementation.

Some of the measures are given in the image below with the representation of their impact and the level of effort to be taken in order to enforce them.

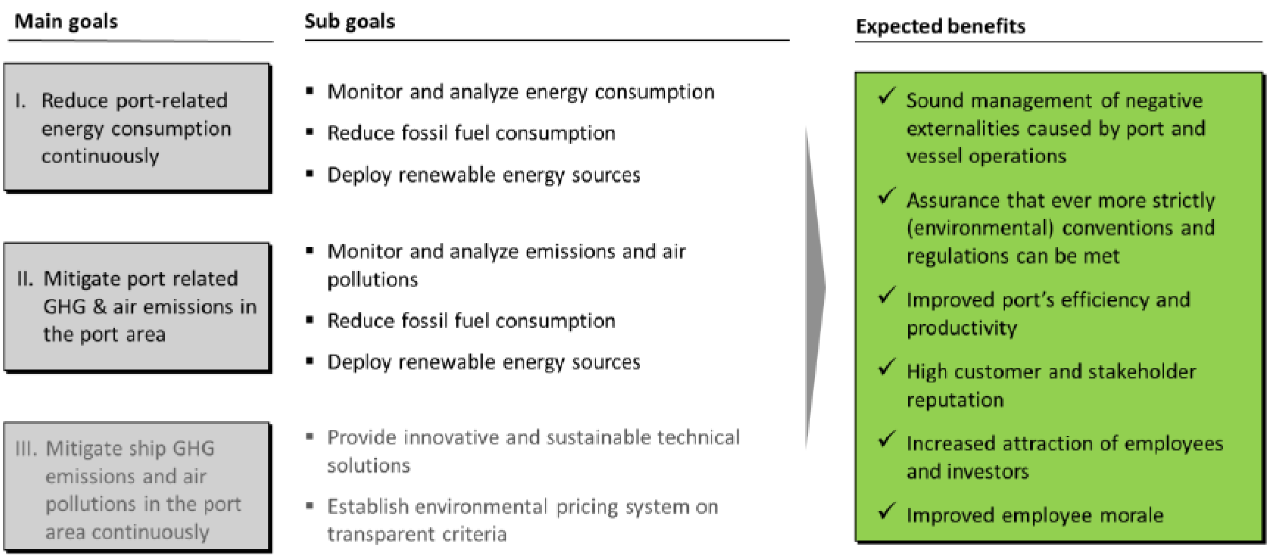

Figure 3: Port of Bar energy sustainability goals

Table 1: Energy sustainability measures for the Port of Bar to reduce port related emissions and energy consumption (main goal 1 and 2)

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
Energy consumer group: whole port								
1	Energy / emission target	O	After setting an appropriate emission and energy baseline, a team should set up an emission / energy target in terms of percentage of baseline in a given year (for details see Section 2.4). Goals help to measure progress towards a target, making energy efficiency more tangible and yielding quantifiable results. The efforts for implementation are moderate; however, the goal must be realistic.	H	L	X	X	X
2	Energy management system (EMS)	O	Implementing an EMS to monitor, quantify and control overall energy consumption. To introduce a EMS, it is highly recommended to create an energy management department or to appoint an energy manager. The Port of Koper could reduce their energy consumption by more than 10% through the implementation of an EMS.	H	M	X	X	X
3	Energy audits	O	Energy audits are a good way to identify energy saving measures that are techno-economically feasible. The purpose of energy auditing is to analyze the energy use of the facility (e.g. port location) being audited, to work out the potential for energy savings, and to present a profitability calculation on the basis of the proposed investments and savings.	H	M	X	X	X
4	Smart grid applications	O	Under the context of a harbor terminal, the deployment of smart grid technology can be explained by three major aspects, namely: installation of onsite generation and storage devices, adoption of new communication and automation measures, and finally optimal management of all active resources in the grid. The efforts for implementation can be high while significant energy savings can be exploited.	L	H	X		
5	Employee suggestion system	B	One proven mean to involve employees into the process of striving towards energy sustainability is to introduce an employee suggestion system. Awards for bringing in ideas with a high impact on energy sustainability can further promote participation and increase employees' motivation.	M	L	X	X	
6	Employee environment training	B	Creating a "green mindset" of the employees through short training sessions and explain, how energy can be saved can result in notable energy and emission savings.	M	L	X	X	X

[1] O = Operation / R = Resource / B = Behaviour
[2] L = Low / M = Medium / H = HIgh

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
7	Employee bus shuttle services	O	A staff shuttle bus is an initiative designed to offer company staff an alternative to the car. Through this measure, traffic congestions in the port area can be reduced or even prevented. Productivity and employee satisfaction can rise accordingly.	L	M	X	X	X
8	Provision of bicycles for commuting purposes		Encouraging employees to bike to work can be part of a port's overall "green" strategy or simply a way for the employees to stay fit.	L	M	X	X	X
9	Obtain “green” energy	O	Instead of producing renewable energy on-site, green energy can also usually be procured from an energy producer. In general, this is an easy way to implement measure to improve the eco-balance of a port. The additional costs depend on local conditions. Even if no renewable energy can be procured, this measure can be implemented by “carbon offsetting”. Carbon offset is a reduction in emissions of GHG made in order to compensate for or to offset an emission made elsewhere – e.g. by investing in wind-power projects at home.	H	L		X	
10	Bundling of power	O	The idea is that the port bundles all small consumers within its boundaries and negotiates with the power suppliers. With the purchase power of this big amount of power needed it is possible to negotiate contracts for delivery of green power from renewable sources for the same price as the individual small consumers had to pay for "normal" power. The port as power distributor can also exchange surplus power to other port energy consumer.	L	M	X		
11	Cross-company use of waste heat	R	Some port-based businesses produce more industrial waste heat than they can use for their own purposes. Supplying the surplus to neighboring companies may prove an ideal ecological and economic solution.	M	H	X	X	X
12	Renewable energy: Solar photovoltaics (PV)	R	In terms of ease of installation and maintenance, PV is clearly the most convenient way to generate renewable electric energy. Many projects have been implemented in ports. In 2014, for example, a large solar panel park was opened on the roof of the RDM Scheepsbouwloods in the Port of Rotterdam and solar panels have also been installed on cold storage facilities. It is worth noting that sufficient space needs to be available (which is usually the case on warehouse roofs) and the technical and economic feasibility is case dependent. In a number of ports worldwide, solar energy is used actively. Examples: • One of the largest solar power units in the Port of Hamburg has been installed in 2011 on the roof of the Logistics Center Altenwerder,	H	L		X	

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			which was owned by the HHLA, producing around 460,000 kWh of CO_2-free energy annually. • The Port of LA has constructed a solar rooftop on its World Cruise Center capable of generating approximately 1.2 million kWh annually. • The port of Olympia (Washington) has installed sufficient solar panels on the warehouses to make its buildings energy-neutral and to send surplus energy to the public grid.					
13	Renewable energy: Wind power	R	Wind can be converted into usable electrical energy in wind turbine. The usage of wind energy is especially promising in costal or upland areas. The main challenge of using wind energy in ports is the limited space available. Furthermore, turbines might cause noise and aesthetic pollution. However, wind power can be cost-effective and it does not emit any emissions for the production of energy. To data, there are several wind power plants on port premises. A wind park in the Antwerp port area, for example, consists of 19 wind turbines, producing three megawatts each – enough to furnish the electricity needs of almost 40,000 households. As with all renewable energy options, the technical and economic feasibility is case dependent.	H	H		X	
14	Renewable energy: Hydropower	R	Potential and kinetic energy of flowing water can be tapped to produce electricity or mechanical tasks. There are several techniques of harnessing tidal and wave power. But most of them are not feasible in terminals because of the large area requirement in case of tidal barrage and lagoons, and also because of creation of obstruction within the terminals. Currently, the Port of Dover project is investigating the feasibility of a tidal energy power station, testing smaller scale devices in a commercial location.	H	H		X	
15	Renewable energy: Biogas	R	Biogas is produced by the fermentation of organic substances, which can also serve as renewable energy source. Biogas produces a smaller amount of harmful GHG than fossil fuel and requires only moderate upfront capital costs. However, a biogas plant is a very complex, space-intensive and rather individual facility. One further challenge is that the required substrates and fermentation residue need to be transported. Finally, a biogas plant may also cause unpleasant smell in the port area.	M	H		X	

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
16	Renewable energy: Geothermal	R	The idea of geothermal technology is to use terrestrial heat to generate electric power. Beside the electric power supply, several companies offer systems to use the geothermal energy for heating and cooling buildings. The advantage compared to other renewable energy sources is the permanent access to the energy source. The Ports of Stockholm, for example, partly uses geothermal energy as part of their HVAC systems. Especially the drilling process has a high impact on the necessary capital for these systems. Therefore, the technical and economic feasibility is case dependent.	M	H		X	
17	Renewable energy: Microturbine	R	Microturbines are a relatively new distributed generation technology being used for stationary energy generation applications. They are a type of combustion turbine that produces both heat and electricity on a relatively small scale. Total plant efficiencies as high as 90% are possible Microturbines can be used for several use cases, such as stand-by power, as distributed generation system or for peak shaving purposes. In particular, microturbines offer many potential advantages for distributed power generation as they have a compact size and produce less emissions and waste. Their weakness is their low fuel to electricity efficiency. The technical and economic feasibility for ports is case dependent.	M	M		X	
18	Heavy duty vehicle (HDV) emission control zone	O	One proven means to reduce emissions from external traffic is to tighten emissions standards for vehicles / trucks in the port area, e.g. in the form of EURO V or VI standards. The efforts for implementation are low, however, the standards should not be so strict as to make normal business impossible.	M	M		X	X
19	Alternative HDV cooling concept: Dearman Transport Refrigeration Unit	R	To reduce emissions from cooling units of food supply trucks in the port area, alternative engine concepts can be implemented. One interesting option is the “Dearman Transport Refrigeration Unit” that uses a piston engine powered by liquid nitrogen that generates both cold and power. Depending on energy generation mix used for the production of liquid nitrogen, CO_2 emission reductions in the range of 30-85% are possible while NOx and PM can also be reduced by > 70%. According to manufacturer's specification, the system also has the potential to meet 60dB(A) PIEK with insulation pack. Cost information, however, are not publicly available. Especially high investment, however, can be a pitfall for feasibility.	M	H		X	X

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
20	Alternative HDV cooling concepts: grid connection	R	One further option is to connect the cooling units to the local grid. Again, the CO2 reduction potential depends on the energy generation mix of grid used while air emissions can be totally eliminated.	M	M		X	X
Energy consumer group: ship loading / unloading equipment								
21	Electrification of power train (here: for mobile harbor cranes)	R	Delivering a high level of efficiency and torque, electric motors provide the best platform for an efficient powertrain. Furthermore, the use of electrified equipment can reduce both GHG and air but also noise emissions significantly. Ideally, an advanced level of electrification should go hand in hand with the increasing use of renewable energy to ensure real “emission-free port operations”. According to Kalmar, consumption can be reduced up to 20%. Besides an advantage in consumption the service costs can be reduced to 50% as there are fewer moving parts. Finally, electricity can be recuperated and reused; feedback into terminal grid. The main challenge is the higher investments required.	H	M	X	X	X
22	Energy saving tires	R	Use state of the art “low rolling resistance” tires to save fuel. Promising energy and emission savings are possible since tires account for 20–30% of a vehicle’s fuel consumption. Through the usage of energy saving tires, up to 10% fuel savings possible. This measure is also easy to implement due to the fact that as state-of-the-art tires are slightly more expensive than conventional ones.	L	L	X	X	X
23	Tyre pressure control	O	Proper tire inflation pressure improves energy / fuel economy, reduces braking distance, improves handling, and increases tire life, while underinflation creates overheating and can lead to accidents. There are systems which are fitted directly inside the tire. If the inflation pressure decreases, the tire might be subject to greater strain as it rolls, causing it to heat up, which can damage the tire or even lead to a blowout.	L	L	X	X	X
24	LED floodlights and walkway lights	R	Installing properly designed LED fixtures on port cranes can immediately reduce energy usage, reduce crane maintenance costs and increase operator safety, while moving terminal operators closer to the universal goals of safety, sustainability and profitability. Due to fewer moving parts in LED technology, there will be a significant decrease in service costs.	M	L	X	X	
25	Regenerative drives	R	Regenerative drives recover energy from the cranes lowering and braking motions. This technology can be	M	M	X	X	

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			used for fully electrified cranes or hybrid propelled cranes. In case of the electrified solution the recovered energy will be fed back into the on shore grid. Hybrid propelled cranes store the recovered energy in batteries and use it in following working cycles.					
26	Emission control technologies (ECTs)	R	Cranes can be retrofitted to meet the desired emission standard. Depending on the appropriate application of ECT, ECTs can include a) Diesel oxidation catalyst (DOC); b) Closed Crankcase Ventilation (CCV); c) Diesel particulate filter (DPF); d) Selective catalytic reduction (SCR) and e) Exhaust Gas Recirculation (EGR). Liebherr uses SCR technology for their state-of-the-art Mobile Harbor Cranes. This reduces NOx emissions by 98%. Engines of older models can be retrofitted with exhaust gas after-treatment systems.	M	M		X	X
Energy consumer group: yard operations equipment								
27	Eco-driving lessons	B	Offering employees eco-driving lessons is a suitable means to reduce energy consumption of cargo handling equipment, cranes and vehicles in a port or terminal. The driver training opts for economical driving e.g. driving with foresight and lifting techniques. Field test with container handling equipment showed that drivers could reduce fuel consumption by up to 10% due to the participation in an eco-driving program. This measure has also been proven to be very effective to reduce GHG, noise and air emissions. The eco-driving training can be provided in the form of on-road training or with simulators.	H	L	X	X	X
28	Alternative fuels	R	Instead of diesel, cargo handling equipment can alternatively be fueled with alternative, low-emission fuels. A Tank-to-Wheel CO2e comparison reveals the emissions saving potential: • Diesel fuel: 3.21 kg CO2e/kg diesel • Biodiesel (B100): 0 kg CO2e/kg diesel • Biodiesel (B20): 2.67 kg CO2e/kg diesel • Liquefied Natural Gas (LNG): 3.78 CO2e/kg diesel • Liquefied Petroleum Gas (LPG): 3.1 CO2e/kg diesel • Compressed Natural Gas (CNG): 2.28 CO2e/kg diesel Consequently, emissions can be reduced significantly when switching to alternative fuels. However, biodiesel is slightly more expensive than normal diesel fuel while LNG, LPG and CNG require a specific	M	M		X	X

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			infrastructure on the terminal's premise. The company CASE has developed a wheel loader which is propelled by methane.					
29	Hybrid power train	R	Enables a vehicle to operate equally efficiently on both electrified and non-electrified tracks due to a common propulsion chain. Hybrid (and all-electric) yard hostlers and forklifts operate efficiently under "stop & go" conditions and reduce on-dock emissions. In the Port of Long Beach, three battery-electric hybrid yard hostlers were developed and compared to conventional yard hostlers. The hybrid yard hostlers were able to perform all tasks required in real world use. After addressing mechanical differences, the hybrid system could achieve 12-18% improvement in fuel saving. Business case analysis showed that incentives of just over 17,000 $ per vehicles would be needed to ensure return on investment. As for wheel loaders, Volvo and John Deere have already integrated hybrid wheel loaders to their product lines. In field tests fuel efficiency improved by nearly 50%. In the case of material handlers hybrid solutions exist as well.	M	M	X	X	X
30	Electrification of power train (battery or fuel cell)	R	For full electrification, the combustion engine will no longer be the main source power on the vehicle. An energy storage system like a battery, or a connection to the grid, can support these kinds of solutions for stack-to-stack movements where no grid in-feed is connected. Full electrification can be achieved in various ways. However, operators should expect to make major modifications at the terminal level. The recommended strategy is either to charge the battery/capacitor set at a charging station, although this will mean that more vehicles are needed to replace the machines that are in the charging station. The use of electrified equipment can reduce both GHG and air but also noise emissions significantly. One further advantage of electrified equipment is the possibility to operate indoor and outdoor. However, the electrification of cargo handling equipment not only results in significant capital expenditures but also in considerably operational requirements, mainly due to the battery charging processes and the installation of charging solutions. Fuel-cell powered equipment can reduce the charging time, but safety requirements are high. Regarding the Port of Bar, there are solutions available for full electric forklifts and terminal tractors but not for wheel loaders.	H	M	X	X	X

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			• Electric forklifts: Electric forklifts are available from lift capacities of roughly 1.5 t to 9 t. Capital costs of electric forklifts are estimated to exceed diesel forklifts by about 30%. Operational costs of electric forklifts equal those of diesel forklifts or are even lower if manpower savings for refueling are included. • Electric terminal tractors: Terberg offers a full electric terminal tractor designed for moving trailers in distribution centers, transport depots, airports and also ports. These electrified terminals tractors are, for example, deployed in one of the HHLA´s container terminals.					
31	Emission control technologies (ECTs)	R	See 27	M	M		X	X
32	Energy saving tires	R	See 22	L	L	X	X	X
33	Tyre pressure control	O	See 23	L	L	X	X	X
34	Speed controlling	R	With full speed control, equipment movements are possible at every engine speed. The engine speed is based on the power requirement of the system. The regulator should select the optimal lowest speed compared to the power demand of the movements. Speed controlling can reduce energy consumption by up to 50% depending on the operation and utilization of the equipment.	L	M	X	X	X
35	Speed switching	R	With speed switching, the engine speed is reduced to idle when equipment is not moving, for example from 1800rpm to 750rpm and back in the case of a master controller action. During this idle time, the generator will produce less voltage and less frequency. Speed switching can reduce fuel consumption by up to 25% on average, depending on the operation and utilization of the crane or vehicle.	L	M	X	X	X
Energy consumer group: terminal vehicles								
36	Electrification of power train	R	Delivering a high level of efficiency and torque, electric motors provide the best platform for an efficient powertrain. There are a number of great benefits to electric vehicles (EVs) over conventional petrol/diesel cars. • Owners of an EVs have the advantage of much lower running costs, mainly as a result of the higher engine efficiency	M	M	X	X	X

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			• EVs are cheaper to maintain since there are fewer moving parts than a conventional petrol/diesel car • EV you are helping to reduce harmful air pollution and noise from exhaust emissions • If renewable energy is used to recharge the EV, GHG emissions can also avoided (not considering the production process of the EV and the battery) The main challenges of EVs are the long charging times and the higher, short driving range. These drawbacks are practically negligible if the cars are deployed within the port area. Compared to electrified cargo handling equipment, there is already a large number of EVs on the market.					
37	Hybrid power train (plug-in-hybrid)	R	Enables a vehicle to operate equally efficiently on both electrified and non-electrified tracks due to a common propulsion chain that is capable of utilizing both electric and diesel power sources. In diesel-electric trains the diesel engine drives an electric generator. The generated power by the generator is then used to drive an electric motor. Compared to full electric vehicles, the environmental benefits are lower since plug-in-hybrids still required fuel and thus emit local air and GHG emissions.	L	M	X	X	X
Energy consumer group: terminal buildings								
All buildings								
38	Green roof	R	Simply put, a "Green Roof" is constructed by installing a layer of specialized growing medium and specifically selected plants to the top of a traditional roofing system. It can be installed on flat roofs as well as on porch roofs. It requires only small investment and few expenditure; however, the environmental benefits of green roofs are widely recognized: due to the high degree of insulation that they provide, they improve energy efficiency, i.e. reduce cooling electricity demand (on average by 7% on an annual basis)[3], and minimizes heat loss in winter. Furthermore, they reduce the "Urban Heat Island Effect" by absorption (instead of reflection) of UV radiation, and thus contribute to prevention of climate change effects. Storm water run-off is reduced to up to 50%, and storm water is significantly cleaned from pollutants. Further benefits include • Dust prevention, cleaning of the air;	L	M	X	X	

[3] Applying Life Cycle Costing (LCC) to Roofing Investments: A Guide to Using Green Roofs for Healthy Cities GreenSave Calculator, ATHENA Institute, 2007

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			• CO_2-sink and O_2-generation by photosynthesis; • Improved aesthetic views for neighbors; • Improved worker productivity and creativity; • Extended durability of the roof, i.e. less construction waste and less investment in buildings; and • Construction of habitat, i.e. increased biodiversity in the area. Green roofs are already installed in ports, for example in the Port of Portland, which has equipped its 10-story headquarter building with such a green roof and even extended the benefits, e.g. by using the storm water runoff as service water, or the cruise terminal of the Port of Copenhagen.					
39	Regular maintenance of HVAC system	O	Indoor air temperature is regulated by heating, ventilation, and air conditioning (HVAC) systems. They consist of more than 100 components which, if not maintained properly, can degrade energy performance by 30 to 60 %. A well-maintained HVAC system can significantly cut energy costs and extend equipment life; thus, it contributes to less CO2 emissions. Various studies have shown that air conditioning maintenance helps a unit to maintain up to 95% of its original efficiency. Retrofitting old HVAC systems e.g. with thermostats will lead to further energy savings of at least 8 – 10 % for heating and cooling. Another cause of inefficient indoor energy consumption is due to human behavior, as the system is often left switched on for too long, or doors and windows are kept open while the air condition is running. Employees working inside heated or air-conditioned buildings should be made aware of this and act accordingly.	H	L	X	X	
40	LED technology	R	Using LED instead conventional light bulbs can immediately reduce energy usage / emissions but also reduce maintenance costs. While requiring greater initial investment, newer technologies tend to offer longer operational lifetimes, reduced maintenance requirements, and superior performance when compared to many conventional lighting techniques. Furthermore, newer lighting technologies such as LED and LEP, continue to evolve, suggesting that further improvements in safety, operational and environmental performance could be realized with such technologies in the years ahead.	M	L	X	X	
41	Adaptive lighting	O	An adaptive lighting system automatically adjusts its light output and operation to provide targeted light	M	M	X	X	

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			levels based on environmental conditions, user schedules, or other application-specific criteria. An adaptive lighting system can include many different types of products including dimmable lamps and luminaires, occupancy sensors, photocontrols, time clocks, etc. In the Port of Stockholm, for example, energy savings of approx. 35% could be achieved through this measure.					
42	District heating / cooling	O	Instead of each building having its own heating or cooling system, the energy can be delivered to several buildings in a larger area from a central plant. To transport heat efficiently, the district heating distribution infrastructure comprises a network of insulated pipes, delivering heat in the form of hot water, from the generation site to the end user. A change of the heating system from conventional (fossil) to district heating can reduce both GHG and emissions significantly. Usually, district heating is more energy efficient, due to simultaneous production of heat and electricity in combined heat and power generation plants (CHP). Options for district heating (and cooling) are gas, biomass, central solar heating, heat pumps and geothermal heating. In the Port of Stockholm, for example, the CO2e emissions could by decreased from 5,500 to 0.7 tons, mainly because of the switch from oil to district heat. A cooling network is a centralized system that provides chilled water to supply an air conditioning system. In practice, it includes chilled water production and distribution facilities to provide cooling services to all connected buildings.	L	M		X	
43	Seawater source heat pumps	R	Seawater can be used for heating and cooling the premises and producing hot water. • Open water system: seawater is pumped to heat exchangers, brings the energy carrier to the set temperature • Closed loop systems: cold / heat is in a closed pipe that has been installed to the bottom of the sea. This system is very efficient; however, high investments must be made. Open water systems are much easier to realize. Here, it is recommended to use heat pump solutions for both heating and cooling. However, it must be noted that the initial investment is much higher compared to district heating and cooling solutions. Detailed information can be found in the study listed.	M	H		X	

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
44	Insulation		The building envelope is the thermal and mass barrier between the interior and outdoor environment and is one of the primary determinants of how much energy the building consumes and how comfort and indoor air quality are maintained. In fact, approximately 35% of the energy consumed in commercial and residential buildings is used to maintain a comfortable and safe interior environment. Improving insulation is a proven way to reduce both heating and cooling costs. Proper sealants are also a good way to improve the energy efficiency of a warehouse.	H	M	X	X	
Administration building								
45	Nearly zero energy building	R	A nearly zero energy building (also known as nZEB) is a building that has been built in accordance with the best possible construction practices using the technological solutions of energy efficiency and renewable energy. An energy performance indicator is a “specific use of energy”, which reflects an integrated energy use for controlling indoor climate, heating of household water and utilizing appliances and other electrical equipment. It is calculated per square meter of heated area of a building in its typical utilization. To achieve a NZEb, a terminal must not exceed 130 kWh/(m2-y). Energy savings in green buildings typically exceed any cost premiums associated with their design and construction within a reasonable payback period.	H	H	X	X	
46	Demand-controlled ventilation (DCV) system	O	Buildings should be divided into thermal zones with separate controls based on space functions. The radiant heaters should be controlled by timers or occupancy sensors to minimize their operation when areas are unoccupied.	M	M	X	X	
47	Adjusting air temperature	O	Adjusting the desired air temperature closer to the ambient air temperature will save significant amounts of energy consumption; reducing the indoor temperature in summer from 25.6° to 22.2° had been shown to reduce energy consumption by up to 40% on average. This can easily be achieved by retrofitting heating system with thermostats and outdoor sensors.	L	M	X	X	
48	Energy efficiency measures in IT data center	O	Decreasing energy consumption in data centers has become a priority for organizations seeking to reduce their environmental footprint. 50% or more reduction in data center energy consumption without compromising performance or availability is possible. By consolidating multiple, independent servers to a single physical server, for example, those servers can	M	M	X	X	

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			operate more efficiently and reduce energy costs by 10% to 40%.					
Warehouses and workshops								
49	Painting walls white / install windows and skylights	R	Best use of daylight / external venetian blinds with slats and daylight control system. The biggest energy consumers in a warehouses and workshops are lighting and temperature control (heating or cooling). Adoption of a more efficient lighting systems includes best use of daylight by windows and/or skylights and light pipes. In combination with a photo-controlled energy efficient lighting system (e.g. LED or fluorescent lights) that is auto adjusting when the daylight fades, this can lead to energy savings of up to 80%. Lighting and ventilation should everywhere be steered by motion detectors/sensors. Painting of walls in white will reflect the light and is a simple and cost-effective measure to brighten up the warehouse and/or workshop.	M	L	X	X	
50	Install air curtain	R	Open doors provide the largest portal for energy loss in any warehouse. Therefore, the installation of well insulated, high speed doors is recommended to prevent energy escape.	L	L	X	X	
Cold storage								
51	Install air curtains	R	Cold storages consume considerable amounts of energy. Studies have shown that a large part of the cooling is generally lost each time the doors of the cooling section are opened. This increases the energy consumption and operational costs of the refrigeration unit. As a simple measure, the doors are fitted with transparent PVC curtains strips; this decreases the average energy consumption by nearly 20%, while all other factors (number, time and duration of door openings) have remained the same.	M	L	X	X	
52	Provide sufficient perimeter insulation	R	Another measure to reduce the refrigeration load includes sufficient perimeter insulation, in particular between a refrigerated and adjacent unrefrigerated area (including the roof), as well as shading of outside walls, e.g. by trees.	L	M	X	X	
Energy consumer group: terminal lighting								
53	LED lighting	R	The carbon footprint of a terminal building can be improved slightly with moderate efforts by replacing conventional light bulbs by LED lights. While the initial cost of installing LEDs is typically higher than conventional lighting options, energy savings and reduced maintenance can result in a return on investment (ROI), being realized in a relatively short timeframe. Real case scenarios suggest that energy savings can amount to between 55-60%; while	H	L	X	X	

#	Measure	Type[1]	Description	Evaluation[2]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			maintenance costs can fall by up to around 90%. Ports that have introduced newer lighting technologies often report other operational benefits. For example, improved lighting tends to improve safety and result in reduced operator fatigue. New lighting technologies also allow operators to have greater control over how light sources affect the surrounding environment in terms of light pollution, light spill, and glare. Finally, LED lights can be programmed and dimmed to reduce energy consumption and light pollution.					
54	Adaptive lighting system	O	An adaptive lighting system automatically adjusts its light output and operation to provide targeted light levels based on environmental conditions, user schedules, or other application-specific criteria. An adaptive lighting system can include many different types of products including dimmable lamps and luminaires, occupancy sensors, photocontrols, time clocks, communication panels, and wireless communication nodes.	M	M	X	X	

In the previous section, a broad range of possible measures has been identified to:

- reduce port-related energy consumption and mitigate GHG emissions and air pollutions in the port area (main goal 1 and of Action Plan); and
- avoid or reduce ship GHG & air emissions in the port area (main goal 3 of Action Plan)

In addition, these measures have been roughly evaluated using the evaluation framework developed.

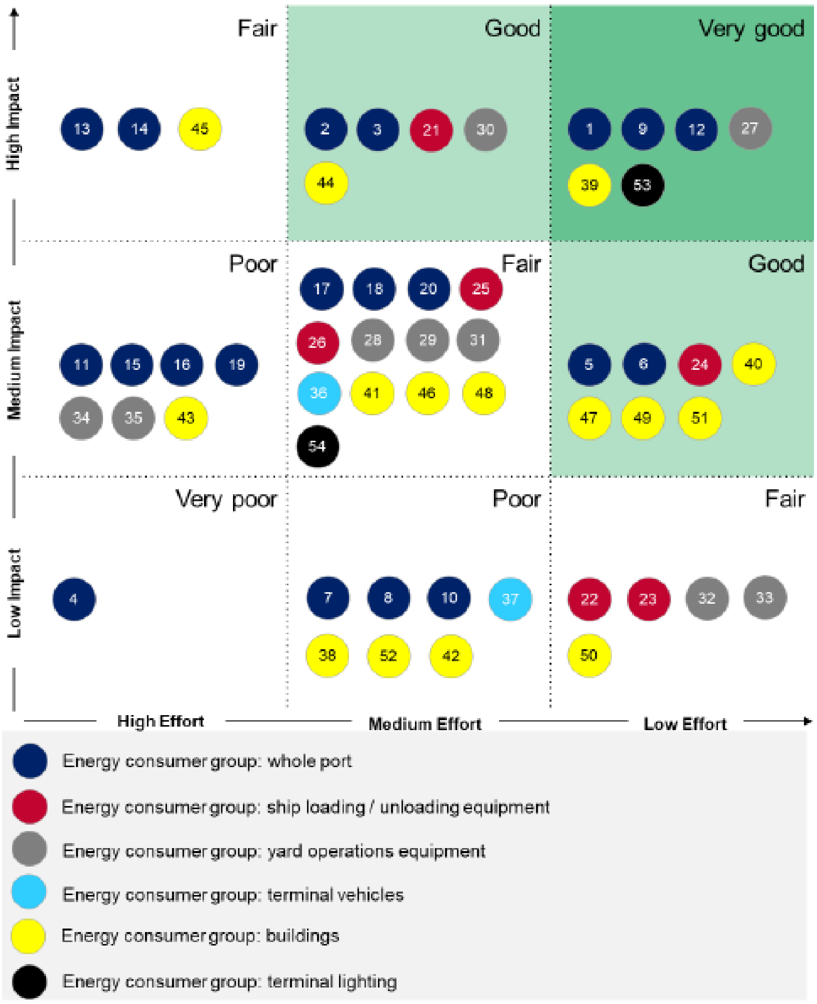

Figure 4: Energy sustainability measures for the Port of Bar to reduce port related emissions and energy consumption (main goal 1&2 of Action Plan)

The Port of Bar not only intends to reduce port-related emissions and energy consumption but also develop solutions on how to reduce ship GHG and air emissions in the port area. In general, there are two main ways on how to achieve this. First, by providing sustainable infrastructure solutions for vessels, e.g., onshore power supply stations. Second, by provide incentives to vessel operators to foster sustainability, e.g., in the form of reduced port fees (green fees). A number of feasible measures to reduce vessel-related emissions in the port area is summarized in the image below.

Table 2: Energy sustainability measures for the Port of Bar to avoid or reduce ship GHG & air emissions in the port area (main goal 3)

#	Measure	Type[4]	Description	Evaluation[5]		Focus		
				Impact	Efforts	Energy cons.	GHG emissions	Air emissions
1	On-shore power supply (OPS)	R	Onshore power (OPS) is one possible technology to avoid GHG, air and noise pollutions from vessel located at berth. This stationary technology allows vessels at berth to use shore power rather than rely on electricity generated by their own (auxiliary) engines that emit GHG and air emissions, affecting local air quality and ultimately the health of both port workers and nearby residents. While local air emissions can nearly be eliminated, the actual GHG emission reduction potential depends on the electricity generation mix of the grid. According to SLR Consulting Australia Pty Ltd (2017), shore-based power, as an alternative to on-ship power, would also result in a noise reduction of up to 10 dB(A). Economic issues are the largest challenge of OPS. First of all, high investment, between 5 and 25 million € per installation, are required to realize OPS in ports, mainly related transformer stations, frequency converters, cable management systems and grid extension. Furthermore, suitable equipment on ships is required, such as connection panel and control systems or on-board transformers, ranging from 300,000 – 1.75 million € per vessel, depending on type and size. Finally, the profitability is strongly dependent on local electricity and fuel prices as well as on the number of calls per year. Mobile facilities are also possible but much more expensive to establish and operate than stationary OPS facilities.	H	H		X	X
2	LNG PowerPac	R	Another innovative solution to reduce a ship's emission at berth can be the so called "LNG PowerPac", developed by Becker Marine Systems. An LNG-fueled generator located in a mobile container allows vessels to switch off their auxiliary engines while the ship is docked. The LNG PowerPac can be placed on the vessel as well as on shore and is capable of delivering power supply of up to 30 MW. The Becker LNG PowerPac weighs 60 tons. Currently the system is tested for container vessels in Hamburg. Compared to conventional marine diesel, an LNG barge emits almost no sulfur and PM. According to manufacturer's specification, the use of	H	M		X	X

[4] O = Operation / R = Resource / B = Behaviour
[5] L = Low / M = Medium / H = HIgh

#	Measure	Type[4]	Description	Evaluation[5]		Focus		
				Impact	Efforts	Energy cons.	GHG emissions	Air emissions
			LNG also results in 20% less CO2 and almost 90% less NOx per ship call. The investment can be broken into the power barge itself and the required onshore distribution (e.g. cable management). Currently, the system is tested for container vessels in Hamburg. First trials show promising results.					
3	Mobile LNG barge	R	Alternatively to OPS, mobile LNG barges can be deployed in ports to reduce a ship's emissions at berth. An LNG barge works like a floating power plant that generates power for vessels using a gas container filled with LNG. In winter, LNG barges can also be used as heat plants. The LNG barge can be designed to provide power to more than one ship at the time. The operation is relatively silent compared to a diesel engine. In addition, compared to conventional marine diesel, an LNG barge emits almost no sulfur and PM. According to manufacturer's specification, the use of LNG also results in 20% less CO2 and almost 90% less NOx per ship call. It is worth noting that the actual GHG emission reduction potential is relatively low due to the emissions of unburnt methane of exhaust gases (methane slip). In addition, the vessel's auxiliary boilers cannot be turned off completely. An LNG barge can be owned and operated by the port authority or by a third party. The investment can be broken into the power barge itself and the required onshore distribution (e.g. cable management). The total investments for this solution are approx. 16 million € of which about 80% are for the barge. Annual operational cost is estimated at around 0.25 million € per year.	H	H		X	X
4	LNG bunkering facilities: truck-to-ship (TTS)	R	To use LNG as fuel for vessels, port authorities or operators need to establish the required LNG infrastructure and superstructure (e.g. bunkering options). The easiest to implement and most flexible solution is direct LNG truck-to-ship option. The mobile facility arrives at a prearranged transfer location and provides hoses that are connected to the truck and to the vessel moored at a dock. Piping manifolds are in place to coordinate fuel delivery from one or more fuel storage tanks. One of the main advantages of truck-to-ship bunkering is the limited investment (approx. 200,000 €/ LNG truck trailer) for operators. The trucks can also be used for LNG distribution for other purposes. The main drawbacks of LNG bunkering by means of TTS	M	L		X	X

#	Measure	Type[4]	Description	Evaluation[5]		Focus		
				Impact	Efforts	Energy cons.	GHG emissions	Air emissions
			bunkering for large consumers is the limited capacity of trucks as well as the slow flow speed. Several design alternatives are possible, each with their specific advantages and disadvantages.					
5	LNG bunkering facilities: shore to ship	R	Vessels arrive at a waterfront facility (tank or small station) designed to deliver LNG as a fuel to the vessel. Fixed hoses and cranes or dedicated bunkering arms may be used to handle the fueling hoses and connect them to the vessels. The transfer usually occurs on a pier or wharf and the LNG will be supplied via truck or vessel. The main advantages of the system are the large bunkering volume and high bunkering flow speed. Furthermore, the system is ready for bunkering when required. In addition, the station can be automatized. However, high investment in tanks and bunker stations are required and sufficient space has to be available in the port. Consequently, this bunkering option is generally a good option for ports with stable, long-term bunkering demand. Several design alternatives are possible, each with their specific advantages and disadvantages.	M	M		X	X
6	LNG bunkering facilities: ship-to-ship (STS)	R	Ship-to-ship bunkering can take place at different locations: along the quayside, at anchor or at sea. Because of size limitations in some ports, only smaller bunkering vessels will be able to operate in the port area. The solution makes it possible to bunker large LNG volumes with a high flow rate without occupying terminal space on land. In addition, compared with other bunkering methods, the flexibility of ship-to-ship bunkering is high with respect to capacity and bunkering location. However, the high investment for bunker vessels are considered to date as the main barrier. Nevertheless, this bunkering option is expected to become the main bunkering method for ships with a bunker demand of over 100 m^3.	M	H		X	X
7	LNG bunkering facilities: local liquefaction plant	R	In principle, it is also possible to establish an LNG production site on a port`s premises. This would reduce the space for storage tanks and could also offer new sources of revenue and competitive advantages. In addition, local production can secure the supply at a shorter delivery time regardless of road conditions, traffic or terminal occupancy. However, the investment for building the plant is very high (approx. 35 million €) and sufficient demand needs to be available to make the plant commercially viable.	M	H		X	X

#	Measure	Type[4]	Description	Evaluation[5]		Focus		
				Impact	Efforts	Energy cons.	GHG emissions	Air emissions
8	Automated mooring systems	R	Automated mooring systems are solutions that allow a quicker mooring with a requirement for only one operator. With such systems, vessel emissions are reduced since mooring operation time is reduced to a few seconds only. Engines can be shut off approximately half an hour earlier. However, the total emission reduction potential is low since emissions from maneuvering operations only represent a small fraction of a vessel's total emissions in ports.	L	H		X	X
9	Ship environmental monitoring system	O	The availability of meaningful data on fuel consumption as well as on emissions of individual ships is central to define suitable energy / emission reduction objectives for vessels in the port area and track progress. If available, corresponding data could be of great value for an ex-ante estimation of the expected environmental impact of a specific incentives scheme. With regard to carbon dioxide, the European Union's MRV Regulation provides an EU-wide legal framework for the monitoring, reporting and verification of the CO2 emissions generated by maritime transportation. Complemented by additional projects on the collection of further records on individual ships' other emissions, a corresponding set of data would not only allow for better benchmarking as well as fine-tuning of indexes and certification programs but would also provide a well-founded and resilient basis for the individual determination of green discounts and rebates.	M	M		X	X
10	Green Port Fees	O	After having defined the desired objectives of the Green Port Fee system having developed an appropriate monitoring system (measure 9), the system should be established in the port. Any port pricing scheme providing environmental incentives should be based on transparent criteria allowing for low administrative complexity, cost-efficient implementation and easy comprehensibility by all stakeholders involved. Linking the grant of discounts and rebates to certifications and scores of existing and acknowledged environmental programs and initiatives, such as the Environmental Ship Index (ESI), the Clean Shipping Index (CSI) or the Green Award, may thereby offer the chance to keep local green port incentive systems easy and transparent while, at the same, time reducing administrative costs for port authorities and ship owners by allocating the certification of a vessel's	H	L	X	X	X

#	Measure	Type[4]	Description	Evaluation[5]		Focus		
				Impact	Efforts	Energy cons.	GHG emissions	Air emissions
			environmental performance to third party organizations.					
11	Slow steaming	O	With lower speeds having a positive effect on fuel consumption and emissions, slow steaming-discounts in port dues may reward vessel operators that voluntarily reduce speed. Applied in the Port of Long Beach, vessel operators participating in the Green Flag-program can thereby earn port fee reductions of up to 25% if they lower speed to 12 knots within a 40 nm zone to the port and 15% if they slow down from 20 nm to the port. Evidence suggests that more than 90% of all vessels comply with the 20 nm speed limit, resulting in reduced emissions in the port area. Given the industry's high degree of time scheduling and generally good on-time performance, corresponding time buffers may thereby be well in-advance plannable into cruise schedules. Moreover, it should be noted that slow steaming in port areas only would probably not require additional ship capacity.	M	M	X	X	X

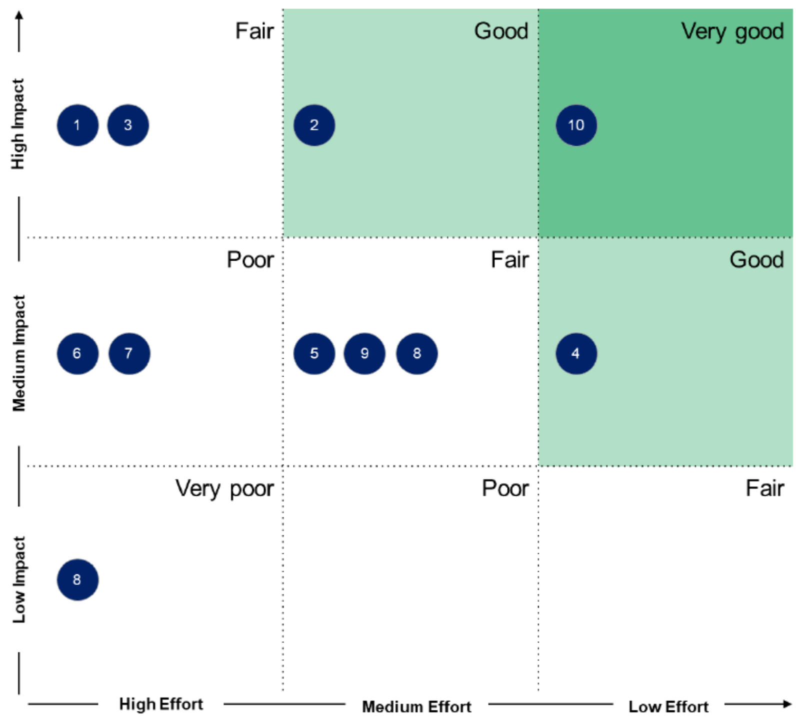

Figure 5: Energy sustainability measures for the Port of Bar to avoid or reduce ship GHG & air emissions in the port area (main goal 3 of Action Plan)

In the Action Plan there are more than 60 potential energy sustainability measures to help reduce both, port and vessel-related emissions and energy consumption in the port area. A more sustainable use of energy in ports is widely recognized as a key component to ensure a future oriented, economically profitable and legally compliant port operation. The need for a more sustainable energy use is especially relevant for ports, which are crucial hubs in the global trading system. The maritime and port sector, however, has not been in the focus of policy makers in terms of environmental aspects for a long time.

4 IMPLEMENTED AND ONGOING IMPLEMENTATION OF GREEN PORT ACTION PLAN MEASURES

4.1 Led technology

Using LED instead conventional light bulbs can immediately reduce energy usage / emissions but also reduce maintenance costs. While requiring greater initial investment, newer technologies tend to offer longer operational lifetimes, reduced maintenance requirements, and superior performance when compared to many conventional lighting techniques. Furthermore, newer lighting technologies such as LED and LEP, continue to evolve, suggesting that further improvements in safety, operational and environmental performance could be realized with such technologies in the years ahead.

These two measures (optimization of HVAC system and LED technology) have been the most promising measures since they have a high energy, sustainable impact and require only low efforts for implementation. Green Port Action Plan analyzed additional measures, but the most of them high effort is needed for the implementation.

LED Terminal Lighting

LED terminal lighting provides a retrofit of all existing floodlights on the terminal from conventional lighting to LED lighting. The advantages of LED compared to conventional lighting are:

- improved lifetime (approximately four times higher than the lifetime of HIDs),
- reduced maintenance cost and
- an increased level of efficiency also resulting in less light pollution.

The increased lifetime and reduced maintenance cost result out of two factors. First, LED lights are solid state light sources therefore they contain less fragile parts like filaments, glass or moving parts. Second is the increased lumen per watt for LED lights (approx. 40 % higher value of lumen per watt compared to HID lights).

Due to the higher lighting efficiency, a factor of 0.6 can be applied to the quantity which is necessary to replace the existing floodlights.

The risk of accidents during lighting-related maintenance should also be considered when reviewing lighting options. Older lamps typically require replacement three or four times a year. The durability of newer technologies reduces maintenance requirements. The longer lifetimes of newer technologies, between 50,000 and 100,000 hours for some units, minimizes replacement requirements and keeps technicians clear of active mobile equipment zones. Furthermore, LED lighting does not require warm-up periods as conventional lighting technologies do. Therefore, LED lights can be programmed and dimmed to further reduce energy consumption and light pollution. The main technical and energy-related characteristics are summarized in following table.

Table 3: LED terminal lighting – Technical data and environmental data

Characteristic	HID	LED
Rated life	2,000-40,000 hours	50,000-100,000 hours
Energy usage	Up to 90% of energy not converted into light	Up to 95% less energy usage than HID
Directionality	Larger radius of light; up to 90% light loss	Control of light minimizes light pollution, light spill and glare
Colour rendering	25% colours not seen accurately	More colour accuracy
Controls	Limited ability to incorporate lighting controls	Allows for simple integration of programming and dimming

Source: PEMA (2016): Lighting Technologies in Ports and Terminals

Related to the energy consumer group, terminal buildings several actions from Green Port Action Plan are considered for the future. Within the SMARTPORT project 73 LED luminaries are installed in the port area (measure 53: LED lighting).

Figure 6: SMARTPORT pilot project – installation of the LED luminaries

4.2 Electric and hybrid vehicles

E-mobility market in Montenegro is at an early stage of development and which offers limited awareness of e-mobility and very limited use of e-vehicles. As far as institutional interest goes, a moderate interest in e-mobility issues prevails. In the segment of services related to the construction and management of publicly available infrastructure for charging electric vehicles, the market is also beginning to develop encouraged by practices from European and neighboring countries and the desire of the entities to be better positioned on the market. Nevertheless, with the goal of faster infrastructure development and the overall concept of e-mobility, the engagement of the state and the public sector in general, as an initiator of infrastructure construction in their respective areas, would be helpful in this market segment.

Implementation of pilot projects as well as certain regulatory shifts would certainly be a positive example and accelerate the development of demand in other segments of the market. As far as Port of Bar is there is a high interest in participating in pilot projects, which include financial assistance for the procurement of electric vehicles, with the aim of familiarizing themselves with technology get in with the e-mobility standards and overall improve energy status in port.

There have been several pilots in that area of implementation and through them Port of Bar has procured the electric vehicle Nissan Leaf through EnerNETMob project (MED Programme) in 2020 making it the first BEV in the car fleet (measure 36: Electrification of power train).

Figure 7: Nissan Leaf (BEV) purchased within the pilot project EnerNETMob

From that point Port of Bar has made efforts to further invest in e mobility and to offer more energy efficient solutions through “green” and optimized transport solutions with low CO_2 emission. Currently, Port of Bar is also implementing project SuMo (Interreg IPA Italy-Albania-Montenegro Programme) and with the financial support of this we have been able to expand the port’s fleet with the hybrid bus for the employees and thus reducing the carbon footprint, efficient using of resources, reducing of GHG emissions while, at the same time, reducing the number of vehicles entering the port area.

The measure considers organization of the Port of Bar internal transport of employees travel within the port area by hybrid bus, in order to reduce the number of vehicles entering the port in order to reduce the traffic, pollution and noise in the port area by promoting the use of common use of low emission vehicles (implemented Measure 7: Employee bus shuttle services).

"Port of Bar" JSC is modernizing its fleet by purchasing the hybrid bus, thus the company is taking a big step forward in further greening the port as the bus will replace the use of hundreds of private cars for transport in the port area. Following the development trends and future changes, which must be in accordance with environmental protection and preservation measures on one hand, and sustainable development of the port on the other, "Port of Bar" JSC is contributing to reduction of greenhouse gases and the negative impact of other air pollutants with the support of the European Union.

For this purpose, the Port of Bar with the support of the SUMO project, purchased a hybrid bus SOLARIS Urbino 12 mild, total length 12 meters. The bus has 29 seats and 72 standing places, it has diesel-electric propulsion, modern air conditioning, three double doors, cameras for monitoring the interior and other modern equipment. The value of the hybrid bus is €277,000.00 and the EU co-financing is €250,000.00. The purchase of the hybrid bus is in accordance with the Action Plan for a sustainable and low-carbon Port of Bar (Green Plan of the Port of Bar).

Figure 8: Hybrid bus from project SuMo

4.3 E - charging station

Within the EnerNETMob project the installation of a fast charger was also carried out. Charger is placed in the port area, in front of the headquarter building which is 300m from the Passenger terminal in the port and about 600m from the city center. The charging stations is EFAPOWER EV-QC45 and it is able to charge all electric vehicles compliant with CHAdeMO charging system and Combined Charging System (CCS) standards (nominal power 50kW at peak; 45kW at continuous). Depending on the battery capacity, EFAPOWER EV-QC45 can charge properly equipped electric vehicles from 0% to 80% in roughly 30 minutes. The battery charging state is displayed on the HMI and the charging cycle finishes by itself or can be interrupted by user command. In addition, there is also AC output CCS – Type 2 (43kVA (or 22kVA)). Due to limitation in cable infrastructure in port the charger is limited to 50 kW in total for both DC & AC outputs. Regarding charging infrastructure, one of the problems we noticed is a lack of infrastructure for the charging points. New charging points need new connections with energy sub stations. Due to this problem, many charging points are not fast charging as they use less expensive infrastructure. We had a similar problem with our pilot - in order to avoid building new power line from the substation to the charger, we have installed a limited charger on 50 kW and we use already existing cable infrastructure.

Figure 9: Fast charger installed in front of headquarter of the Port of Bar

With regard to solutions affecting urban and transport planning, they are yet to be defined with development of electromobility in Montenegro. However, numerous factors have an impact on the selection of the final location for charging station deployment, chief of which are economic and land-related, and in regard to practicality and safety, engineering factors of feasibility are taken into account. From the service availability aspect, charging stations need to be located where there are good traffic connections and a high demand for the service.

Finally, charging station infrastructure is an important element of the whole transport infrastructure and is directly linked with the society's development, therefore it is necessary to take into account social factors as well, and in order to achieve sustainable development, environmental factors need to be taken into account as well. Only if all the aforementioned factors are taken into account, comprehensiveness and rationality of the selection process of charging station locations can be ensured.

5 INITIATIVES IN PLANNING PHASE

5.1 Energy management system (EMS)

EMS allows monitoring, analyzing and controlling building systems and equipment by means of a series of sensors, switches, controls and algorithms. Monitoring individual loads and appliances is required for load control strategies, verification of control response and development and updating of load models. In addition, the monitoring of energy consumption provides the basis for improving energy efficiency, e.g., by detecting wasted energy or identifying the main energy consumers. An EMS is essential designed to improve building energy performance by saving energy and / or reducing peak demand.

An EMS helps ports to establish systemic energy management and to make all energy-related processes more efficient. It facilitates the documentation of all energy consumption and reveal the potential for saving energy. In principle, it is possible to implement an individual EMS or establish the ISO 50001 certification system. The ISO 50001 certification system defines an EMS as a "set of interrelated or interactive elements to establish an energy policy, energy objectives, and processes and procedures to achieve those objectives" (ISO 50001, 2011). In compliance with the ISO 50001 standard, the structure of an EMS can be divided into six phases (see Figure 25) and their related elements.

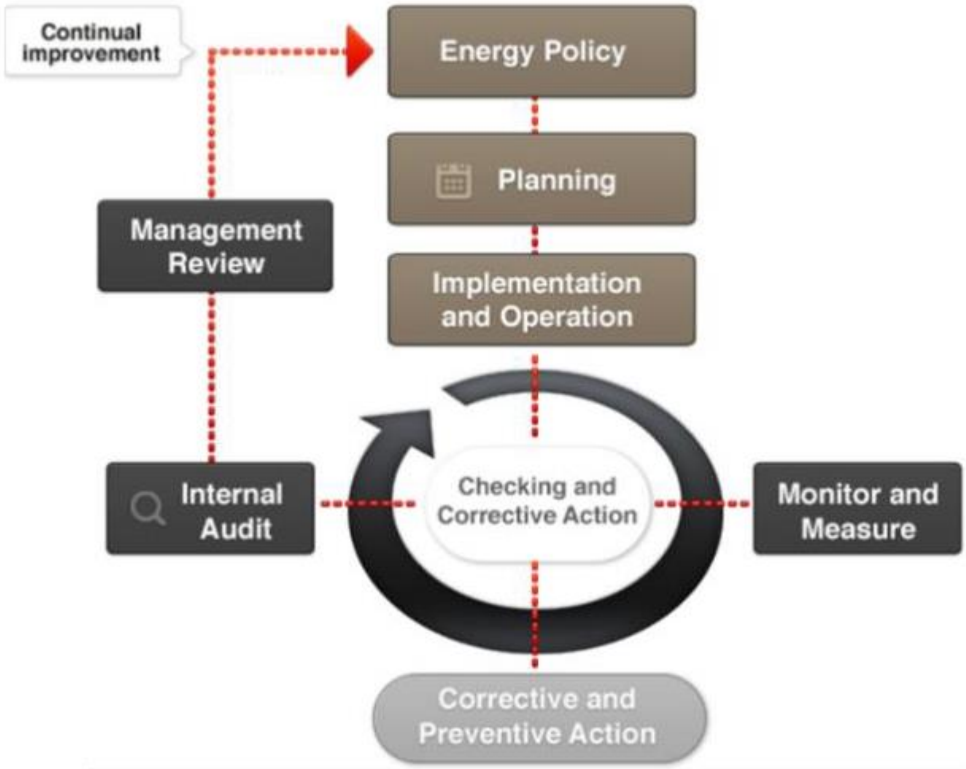

Figure 10: Phases of an EMS implementation (bureauveritas.com)

One central component of an EMS for a port is an energy mapping and consumption tool to map energy consumption to specific blocks (e.g., cranes or buildings) and processes (e.g., operations or support functions). A properly designed EMS can help to detect energy waste and improve energy efficiency (up to 15% over the terminal as a whole), however, investments in ICT systems must be made and employees need to be trained. In general, it can be considered as one of the most important enablers of a sustainable port which may also result in large energy savings.

5.2 Electrification of Power Train

Fully electric equipment decreases noise levels and enables zero emissions at the point of use. Electric power in mobile equipment is a relatively new development, but electric drives are a highly mature and commoditized technology. For the Port of Bar, the following equipment can be electrified:

1. Ship loading and unloading equipment: mobile harbour crane (STS) and mobile crane
2. Yard operations equipment: diesel forklifts, wheel loader & skid steer loaders, material handler and terminal tractors
3. Light duty vehicles: terminal vehicles

For all electric equipment it must be considered that, from a regional perspective, the production of emissions is shifted to power plants, if no renewable energy sources are used.

In addition, for the deployment of mobile electrified equipment a suitable charging infrastructure has to be installed on the terminal´s premise. Here, several alternatives are available ranging from battery swapping stations to inductive (wireless) charging spots.

It seems particularly promising to further electrify the existing fleet of forklifts. Due to the absence of exhaust gas emissions electric forklifts are – in contrast to diesel-driven forklifts – allowed to operate in confined spaces. They can be used indoor and outdoor, which is a key advantage in cargo handling. Currently, electric forklifts are available from lift capacities of roughly 1.5 to 18 tons. There is a large number of different manufacturers available, the most suited electric forklift has to be identified in a separate step. Regarding the maximum emission saving potential of this measures, more than 160,000 liters of diesel – corresponding to approx. 430,000 kg CO_2 emissions 30 – can be saved per year, assuming that the full fleet is electrified, and the energy is generated from renewable energy sources.

Likewise, the electrification of the currently diesel-driven mobile harbor crane has a large environmental and energy saving potential. In 2017, the mobile harbor crane consumed almost 50,000 liters of diesel – corresponding to approx. 133,500 kg CO2 emissions. Assuming that the required energy is generated from renewable energy sources, this measure has a considerable positive environmental impact. For a cable reel option, the mobile harbor crane must be installed with both a reel and a high voltage transformer. However, hardly any additional infrastructure is need in the stacking area. In the middle, at the start or end of the stack, a grid connection is needed. A small floor duct is required to protect the cable from being driven over by the crane. Due to the fixed connection, the cable must be unplugged to allow the crane to leave an area.

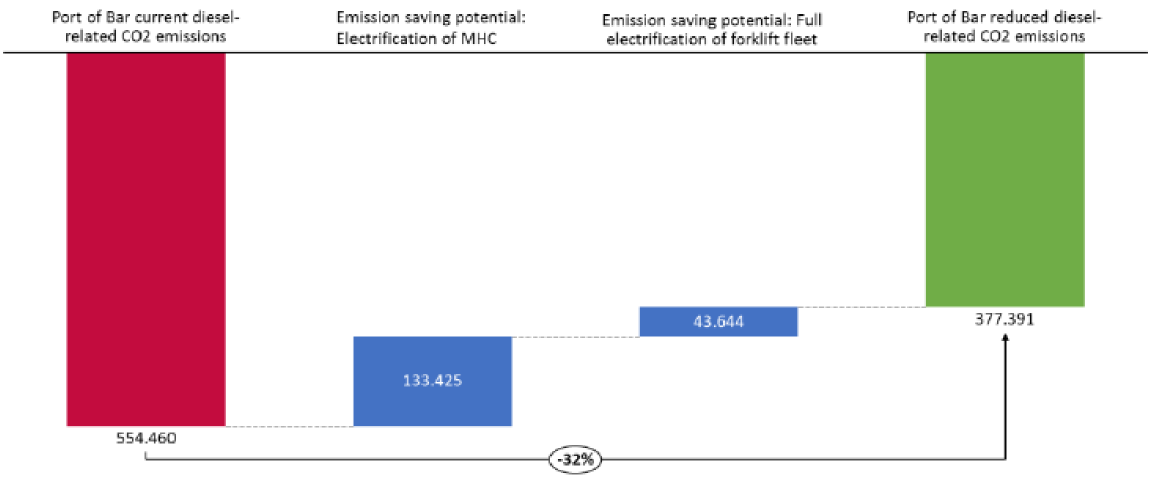

Figure 11: Annual CO_2 emission saving potential (electrification of cargo handling equipment in the port)

Economic Assessment

Capital costs of electric forklifts are estimated to exceed diesel forklifts by about 30%. Operational costs of electric forklifts equal those of diesel forklifts or are even lower if manpower savings for refueling are included. For a comprehensive economic assessment, the capital and operational cost of the required charging infrastructure also needs to be considered.

Likewise, the electrification of the mobile harbor crane requires a separate consideration, in particular analyzing technical requirements in detail. The retrofitting costs are in the range of approx. 300,000 euros. As a result of the higher hoist drive efficiency of electrified mobile cranes, however, the operating (energy consumption) costs of electrified mobile harbor cranes are low compared to diesel-fueled solutions. Additionally, electricity can be recuperated and reused. According to manufacturer specification, electrified solutions consume up to 30% less fuel.

The electrification of forklifts is an established and well-suited solutions for ports to improve the level of energy sustainability with modest effort and in a cost-effective manner. Therefore, it is highly recommended to further electrify the existing forklift fleet. Likewise, the electrification of the currently diesel-fueled mobile harbor crane seems to be a promising measure in environmental and economic terms. In future, the terminal vehicles should also be replaced by battery-electric vehicles.

5.3 Solar photovoltaics

In terms of ease of installation and maintenance, PV is clearly the most convenient way to generate renewable electric energy. Many projects have been implemented in ports. In 2014, for example, a large solar panel park was opened on the roof of the RDM Scheepsbouwloods in the Port of Rotterdam and solar panels have also been installed on cold storage facilities. It is worth noting that sufficient space needs to be available (which is usually the case on warehouse roofs) and the technical and economic feasibility is case dependent.

The special advantages of solar power compared to other renewable energy sources are its low maintenance requirements, the limited space requirements, the direct energy production and the economic feasibility. To prevent a disturbance of daily port operation, the required solar modules should be installed on a terminal's roofs, e.g., on warehouses or administration buildings. It is also possible to install solar panels on STS cranes.

The amount of solar photovoltaic modules and the assembly system depends on the size of the area where the system shall be installed. Furthermore, the possible energy output of the system depends on their size but also on solar radiation or existing building design. As a rule of thumb, to generate one kW power output, eight square meters of solar photovoltaics have to be installed. It must also be considered that solar energy is an intermittent renewable energy resource, meaning it is not continuously available for conversion into electricity and outside direct control. Thus, it can only be used as additional energy generation source in a port. Ideally, the solar power is equipped with an additional (battery) storage system.

To estimate the energy generation output from photovoltaic systems in the Port of Bar, detailed analysis needs to be performed including an assessment of suitable locations considering prevailing conditions (e.g., load bearing capacity of roofs).

Economic Assessment

The roof of the administrative building in the Port of Bar has a surface of 1,752 square meters. However, not the whole surface area can be used, therefore it is assumed that an area of 1,300 square meters can be used for solar photovoltaics. This results in a power output of 162.5 kW. The costs for solar photovoltaics modules range from 750 to 1,500 euros. The annual maintenance costs per kW range from 1-3% of the capital expenditures. The generated energy is capable to cover the total consumption of the administrative building.

The threat of climate change requires reducing greenhouse gas emissions rapidly which requires adopting green technology, like rooftop solar panels and electric cars, at accelerating rates. On top of the green benefits, both solar panels and electric vehicles are likely to save money over time. It's possible that institutions with big parking lots could take economic advantage of both. For that reason, Port of Bar is in planning phase of covering the parking lot in front of administrative building with solar photovoltaics. In the same parking lot, the fast charger is installed.

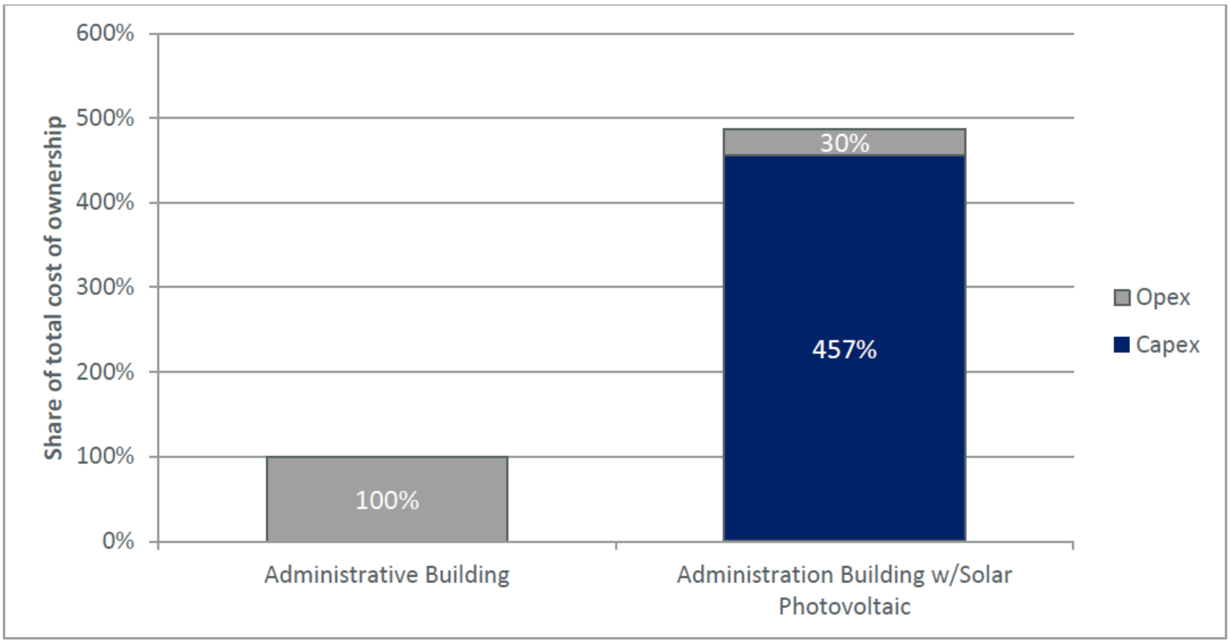

Figure 12: Capex and opex for solar photovoltaic

When considering the results, it can be seen that the significant higher capital expenditures (purchase and installation of the system) cannot be compensated over the whole lifetime. The negative economic results can also be explained with the fact that electricity procurement costs are quite cheap in Bar. Since the electricity prices in Montenegro are quite low, it is hardly possible to operate renewable self-energy production systems in a cost-efficient manner at the moment.

As revealed, solar power is clearly the most convenient way to generate renewable electric energy and thus most suited for ports / terminals. Although detailed technical analysis needs to be performed, the feasibility of this measure can probably be assured. In economic terms, however, this measure displays negative results. Therefore, this measure should only be implemented if other benefits (environmental or social) justify an investment.

5.4 Adaptive lighting system

An adaptive lighting system automatically adjusts its light output and operation to provide targeted light levels based on environmental conditions, user schedules, or other application-specific criteria. An adaptive lighting system can include many different types of products including dimmable lamps and luminaires, occupancy sensors, photocontrols, time clocks, communication panels, and wireless communication nodes.

5.5 LED lighting

Further implementation of the LED lighting in port areas, warehouses, etc. and changes of all old lighting lamps in the port.

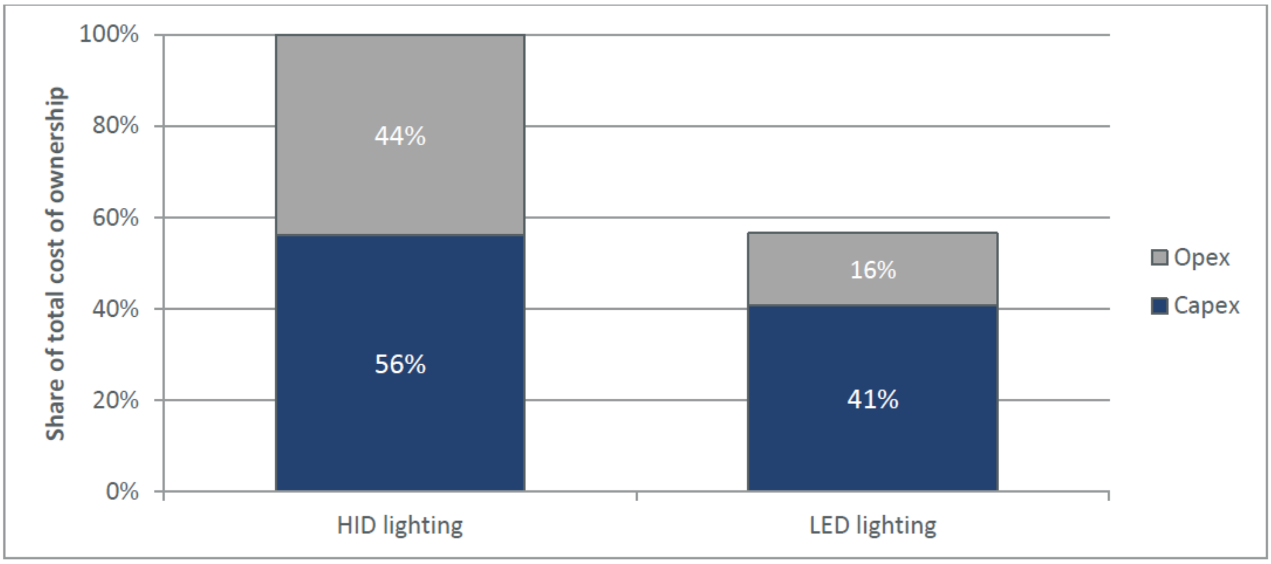

Figure 13: TCO analysis for LED terminal lighting in 15 years period

Following measures are related to the buildings as an energy consumer group.

5.6 Nearly zero energy building

A nearly zero energy building (also known as nZEB) is a building that has been built in accordance with the best possible construction practices using the technological solutions of energy efficiency and renewable energy. An energy performance indicator is a “specific use of energy”, which reflects an integrated energy use for controlling indoor climate, heating of household water and utilizing appliances and other electrical equipment. It is calculated per square meter of heated area of a building in its typical utilization. To achieve a nZEB, a terminal must not exceed 130 kWh/(m2-y). Energy savings in green buildings typically exceed any cost premiums associated with their design and construction within a reasonable payback period.

5.7 Optimization of HVAC system

Indoor air temperature is regulated by heating, ventilation, and air conditioning (HVAC) systems. They consist of more than 100 components which, if not maintained properly, can degrade energy performance by 30 to 60 %. A well-maintained HVAC system can significantly cut energy costs and extend equipment life; thus, it contributes to less CO_2 emissions. Various studies have shown that air conditioning maintenance helps a unit to maintain up to 95% of its original efficiency. Retrofitting old HVAC systems e.g., with thermostats will lead to further energy savings of at least 8 – 10 % for heating and cooling. Another cause of inefficient indoor energy consumption is due to human behavior, as the system is often left switched on for too long, or doors and windows are kept open while the air condition is running. Employees working inside heated or air-conditioned buildings should be made aware of this and act accordingly.

The following sub-measures could be realized.

1. **Regular maintenance of the HVAC system serves to keep the equipment running efficiently to maximize HVAC energy efficiency**. Changing clogged air filters, for example, is a basic measure to prevent steady increase in HVAC energy consumption. A neglected system loses up to 5% efficiency each year that it goes without air conditioning maintenance. Further benefits are fewer and less costly repairs or an extension of equipment lifetime.
2. **Adjusting the desired air temperature closer to the ambient air temperature will save significant amounts of energy consumption**, i.e., the room temperature should not be cooled down excessively. Generally, it can be said that 1 degree higher room temperature means approximately 4 % less power requirement for cooling.
3. **Buildings should ideally also be divided into thermal zones with separate controls based on space functions**. The radiant heaters should be controlled by timers or occupancy sensors to minimize their operation when areas are unoccupied. It is advisable to control the units of the terminal's demand-based ventilation based on the content of carbon dioxide and room air temperature.

Especially, sub-measure 1 and 2 are easy to realize with almost no capital requirements. For the sub-measure 3, the space functions need to be analyzed and technical equipment be installed (no cost estimated can be give since the buildings need to be inspected in detail). It is highly recommended to optimize the existing HVAC system(s) in the Port since the building´s energy consumption can be reduced considerably with moderate efforts.

5.8 Air curtains

The measures that could be implemented easily but also seems to have a proven energy sustainability impact is the installation of air curtains in front of the doors of the cold storage´s chambers. Air curtains create an invisible barrier across a doorway and provide an effective seal between two temperature zones. They can stop refrigerated air escaping from a cold store. In particular, the combination of storage doors and air curtain provides high energy savings. By eliminating the need to frequently open and close fast acting roller doors, service and maintenance costs can also be reduced as can repair expenses from collisions. Air curtains can also improve safety in a logistics operation. Unlike plastic slat curtains, an air curtain provides unhindered visibility allowing people and vehicles to travel through a doorway clearly seeing what is on the other side. Powerful models can blast around 7,000m³/h of air from every 1m length of air curtain and are capable of sealing doorways up to 10m high when mounted above.

The costs per piece are in the range of 5,000 € (for large commercial and industrial doors 5-6m). Considerably less expensive are plastic slat curtains which, however, are less effective (see Figure 9).

Figure 14: Air curtain and plastic slat curtain used in cold storages

Tests are showing that a correctly installed air curtain significantly can reduce the energy losses in an open door between 70–85%. Temperature recordings for air curtain in a cold storage can show an increase of between 4°C and 10°C every time a cold store door is opened. This can be improved to 1°C with an air curtain, which results in reducing heat loss by up to 90%.

5.9 Adaptive lighting

An adaptive lighting system automatically adjusts its light output and operation to provide targeted light levels based on environmental conditions, user schedules, or other application-specific criteria. An adaptive lighting system can include many different types of products including dimmable lamps and luminaires, occupancy sensors, photocontrols, time clocks, etc.

5.10 District heating/cooling

Instead of each building having its own heating or cooling system, the energy can be delivered to several buildings in a larger area from a central plant. To transport heat efficiently, the district heating distribution infrastructure comprises a network of insulated pipes, delivering heat in the form of hot water, from the generation site to the end user. A change of the heating system from conventional (fossil) to district heating can reduce both GHG and emissions significantly. Usually, district heating is more energy efficient, due to simultaneous production of heat and electricity in combined heat and power generation plants (CHP). Options for district heating (and cooling) are gas, biomass, central solar heating, heat pumps and geothermal heating. A cooling network is a centralized system that provides chilled water to supply an air conditioning system. In practice, it includes chilled water production and distribution facilities to provide cooling services to all connected buildings.

5.11 Seawater source heat pumps

Seawater can be used for heating and cooling the premises and producing hot water. Open water system: seawater is pumped to heat exchangers, brings the energy carrier to the set temperature Closed loop systems: cold / heat is in a closed pipe that has been installed to the bottom of the sea. This system is very efficient; however, high investments must be made. Open water systems are much easier to realize. Here, it is recommended to use heat pump solutions for both heating and cooling. However, it must be noted that the initial investment is much higher compared to district heating and cooling solutions.

5.12 Insulation

The building envelope is the thermal and mass barrier between the interior and outdoor environment and is one of the primary determinants of how much energy the building consumes and how comfort and indoor air quality are maintained. In fact, approximately 35% of the energy consumed in commercial and residential buildings is used to maintain a comfortable and safe interior environment. Improving insulation is a proven way to reduce both heating and cooling costs. Proper sealants are also a good way to improve the energy efficiency of a warehouse.

5.13 Demand-controlled ventilation

Buildings should be divided into thermal zones with separate controls based on space functions. The radiant heaters should be controlled by timers or occupancy sensors to minimize their operation when areas are unoccupied.

5.14 Adjusting air temperature

Adjusting the desired air temperature closer to the ambient air temperature will save significant amounts of energy consumption; reducing the indoor temperature in summer from 26° to 22° had been shown to reduce energy consumption by up to 40% on average. This can easily be achieved by retrofitting heating system with thermostats and outdoor sensors.

5.15 Energy efficiency measures in IT data centre

Decreasing energy consumption in data centers has become a priority for organizations seeking to reduce their environmental footprint. 50% or more reduction in data center energy consumption without compromising performance or availability is possible. By consolidating multiple, independent servers to a single physical server, for example, those servers can operate more efficiently and reduce energy costs by 10% to 40%.

5.16 Green roof

“Green Roof” is constructed by installing a layer of specialized growing medium and specifically selected plants to the top of a traditional roofing system. It can be installed on flat roofs as well as on porch roofs. It requires only small investment and few expenditures; however, the environmental benefits of green roofs are widely recognized: due to the high degree of insulation that they provide, they improve energy efficiency, i.e., reduce cooling electricity demand (on average by 7% on an annual basis), and minimizes heat loss in winter. Furthermore, they reduce the “Urban Heat Island Effect” by absorption (instead of reflection) of UV radiation, and thus contribute to prevention of climate change effects. Storm water run-off is reduced to up to 50%, and storm water is significantly cleaned from pollutants.

6 LONG TERMS INITIATIVES

6.1 LNG facilities

Several different options related to the LNG are also analyzed in the Green Port Action Plan.

LNG bunkering facilities: truck-to-ship (TTS)

To use LNG as fuel for vessels, port authorities or operators need to establish the required LNG infrastructure and superstructure (e.g., bunkering options). The easiest to implement and most flexible solution is direct LNG truck-to-ship option. The mobile facility arrives at a prearranged transfer location and provides hoses that are connected to the truck and to the vessel moored at a dock. Piping manifolds are in place to coordinate fuel delivery from one or more fuel storage tanks. One of the main advantages of truck-to-ship bunkering is the limited investment (approx. 200,000 €/ LNG truck trailer) for operators. The trucks can also be used for LNG distribution for other purposes. The main drawbacks of LNG bunkering by means of TTS bunkering for large consumers is the limited capacity of trucks as well as the slow flow speed. Several design alternatives are possible, each with their specific advantages and disadvantages.

LNG bunkering facilities: shore to ship

Vessels arrive at a waterfront facility (tank or small station) designed to deliver LNG as a fuel to the vessel. Fixed hoses and cranes or dedicated bunkering arms may be used to handle the fueling hoses and connect them to the vessels. The transfer usually occurs on a pier or wharf and the LNG will be supplied via truck or vessel. The main advantages of the system are the large bunkering volume and high bunkering flow speed. Furthermore, the system is ready for bunkering when required. In addition, the station can be automatized. However, high investment in tanks and bunker stations are required and sufficient space has to be available in the port. Consequently, this bunkering option is generally a good option for ports with stable, long-term bunkering demand. Several design alternatives are possible, each with their specific advantages and disadvantages.

LNG bunkering facilities: ship- to-ship (STS)

Ship-to-ship bunkering can take place at different locations: along the quayside, at anchor or at sea. Because of size limitations in some ports, only smaller bunkering vessels will be able to operate in the port area. The solution makes it possible to bunker large LNG volumes with a high flow rate without occupying terminal space on land. In addition, compared with other bunkering methods, the flexibility of ship-to-ship bunkering is high with respect to capacity and bunkering location. However, the high investment for bunker vessels are considered to date as the main barrier. Nevertheless, this bunkering option is expected to become the main bunkering method for ships with a bunker demand of over 100 m^3.

LNG bunkering facilities: local liquefaction plant

In principle, it is also possible to establish an LNG production site on a port`s premises. This would reduce the space for storage tanks and could also offer new sources of revenue and competitive advantages. In addition, local production can secure the supply at a shorter delivery time regardless of road conditions, traffic or terminal occupancy. However, the investment for building the plant is very high (approx. 35 million €) and sufficient demand needs to be available to make the plant commercially viable.

6.2 On-shore power supply (OPS)

Port of Bar analyzed the development of the onshore power supply (cold ironing) in the Green Port Action Plan: Onshore power supply (OPS) is one possible technology to avoid GHG, air and noise pollutions from vessel located at berth. This stationary technology allows vessels at berth to use shore power rather than rely on electricity generated by their own (auxiliary) engines that emit GHG and air emissions, affecting local air quality and ultimately the health of both, port workers and nearby residents. While local air emissions can nearly be eliminated, the actual GHG emission reduction potential depends on the electricity generation mix of the grid. According to SLR Consulting Australia Pty Ltd (2017), shore-based power, as an alternative to on-ship power, would also result in a noise reduction of up to 10 dB(A). Economic issues are the largest challenge of OPS. First of all, high investment, between 5 and 25 million € per installation, are required to realize OPS in ports, mainly related transformer stations, frequency converters, cable management systems and grid extension. Furthermore, suitable equipment on ships is required, such as connection panel and control systems or on-board transformers, ranging from 300,000 – 1.75 million € per vessel, depending on type and size. Finally, the profitability is strongly dependent on local electricity and fuel prices as well as on the number of calls per year. Mobile facilities are also possible but much more expensive to establish and operate than stationary OPS facilities.

6.3 LNG PowerPac

As high investments are needed for the installation of the OPS, Green Port Action Plan analyzed alternative and innovative solutions:

Another innovative solution to reduce a ship's emission at berth can be the so called "LNG PowerPac", developed by Becker Marine Systems. An LNG-fueled generator located in a mobile container allows vessels to switch off their auxiliary engines while the ship is docked. The LNG PowerPac can be placed on the vessel as well as on shore and is capable of delivering power supply of up to 30 MW. The Becker LNG PowerPac weighs 60 tons. Compared to conventional marine diesel, an LNG barge emits almost no sulfur and PM. According to manufacturer's specification, the use of LNG also results in 20% less CO_2 and almost 90% less NOx per ship call. The investment can be broken into the power barge itself and the required onshore distribution (e.g., cable management). Currently, the system is tested for container vessels in Hamburg. First trials show promising results.

The handling procedure is illustrated in Figure 15 and described below.

Figure 15: Becker LNG PowerPac (source: www.becker-marine-systems.com)

The LNG PowerPac is a measure to mitigate various emissions from vessels during their port stay. This offers vessel operators an alternative to the conventional energy generation by diesel-generators or onshore power supply. Compared to onshore-power supply, the LNG PowerPac solution is much easier to implement and requires less investment, however, the emission mitigation potential is probably lower. This is because the burning of LNG still emits a certain amount of emissions.

The LNG PowerPac consists of two containers which are stacked atop each other. One container contains a gas-propelled generator which is able to produce a power output of up to 1.5 MW. Atop the gas generator, there is a second container which contains a tank that supplies the gas generator with LNG. The tank has a capacity of 8.2 tons of LNG, sufficient to provide energy for approx. 30 hrs. The LNG PowerPac weighs around 60 tons including the LNG storage.

Once a container ship is moored, the first step is to place the PowerPac on board via the port terminal's loading equipment (e.g. such as gantry cranes). Alternatively, the PowerPac can be stored at the quay, as close as possible to the vessel's connection point. It has to be mentioned that the currently available PowerPac can only be used for vessels with a voltage of 6,600 V and a frequency of 60 Hertz.

From a technical standpoint, the implementation of the LNG PowerPac requires moderate effort. It is a quickly implemented with a delivery time of eight months and requires no infrastructure investments. Due to its flexibility, this solution is particularly suitable for smaller ports.

Economic Assessment

The approximate capital expenditures for the LNG PowerPac to generate 1.5 MW are approx. 2 million euros. To provide large vessels with energy, however, two PowerPacs are required. According to the manufacturer, the maintenance costs are 3% of the expenditures per year. Additionally, there are loan costs and costs for the procurement of LNG. The price for a ton of LNG varies and depends in last years. The required investment is comparable to onshore power supply, but the operating costs are much lower.

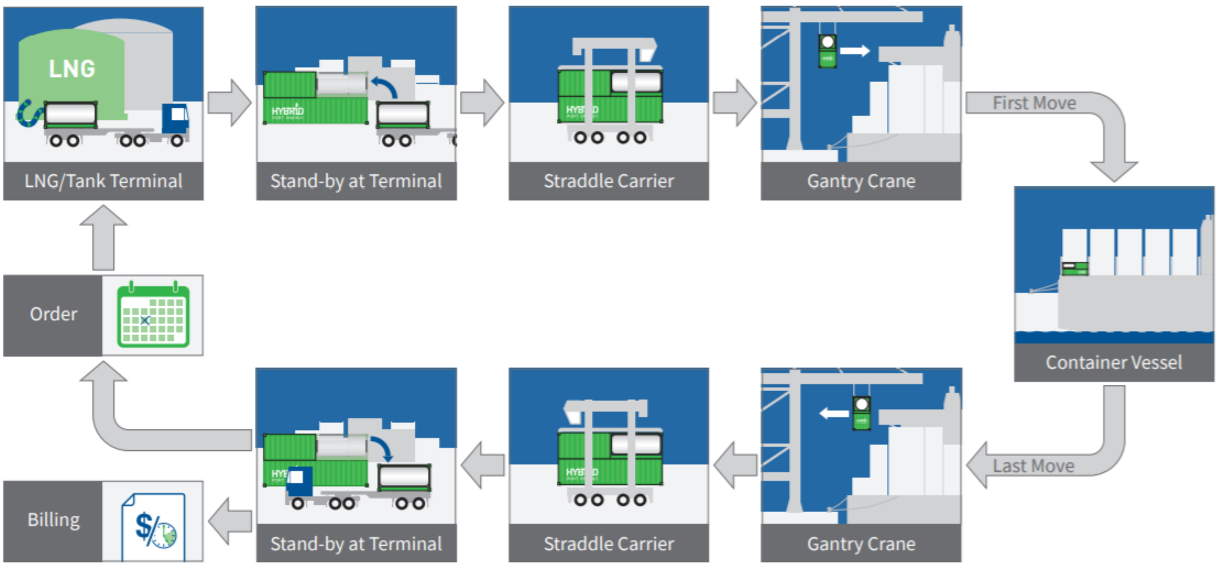

Figure 16: Becker LNG PowerPac: handling procedure (Source: www.becker-marine-systems.com)

For the Port of Bar, the LNG PowerPac is probably the superior solution to reduce vessel-related emissions in the port compared to onshore power supply. Through this measure, a large proportion of the vessel-related emissions can be saved. It needs to be considered, however, that large investment (up to 4 million euros) are required only to purchase the required PowerPacs. In addition, it is also uncertain whether the vessel operators are willing to accept a price premium for using the LNG PowerPac. Accordingly, this measure is of subordinate importance for the Port of Bar.

Table 4: LNG PowerPac – Technical and environmental data

Technical key facts		**Environmental key facts**	
Characteristic	Value	Type of emission	Mitigation potential[33]
Dimension	2*40 ft container	CO_2	-22%
Capacity	8,2 t LNG (28-30 hrs operation)	NO_x	-98%
Power output	1.500 KWel / 60 Hz / 6.6 kV	SO_x	-100%
Weight	60 t	PM	-100%

Source: becker-marine-systems.com.

6.4 Small-scale Terminal for Bunkering and Regasification of LNG

One energy sustainability measure which has not been identified as priority measures (see Section 3.2 Sustainability Actions for the Port of Bar which will nevertheless be analyzed is “LNG bunkering facilities: shore to ship”. This is because there are currently concrete plans to provide this kind of LNG bunkering facility in Bar (see technical assessment).

Most of the existing LNG terminals in Europe were developed to inject the imported gas into the transmission and distribution grid. As a consequence of the increasing focus on environmental concerns and in general oversupply and low margins, many of these terminals implemented services enabling new market possibilities such as:

1. reload (break-bulk) LNG from terminal into vessels,
2. transshipment in which LNG is transferred from one vessel to the next,
3. bunkering of bunker barges or LNG-fueled ships and
4. truck / rail loading where LNG is loaded in smaller quantities.

In principle, it is also possible to establish own production of LNG or even CO_2 neutral liquefied biogas (LBG) using an own liquefaction plant. The benefit from a local liquefaction plant is the limited need for establishing large storage. However, demand has to be rather large in order to recapture the investment in the liquefaction facility. In addition, a liquefaction facility involves some additional safety regulations, which require more space. Therefore, this option does not seem to be suitable for the Port of Bar.

The Port of Bar considers installing a small-scale terminal for bunkering and regasification of LNG in which the LNG will be delivered with ships. From the terminal it will be possible to fuel semi-trailers or bunker ships with LNG. In addition, regasification of the LNG will enable delivery of gas to a local gas grid or industrial consumers.

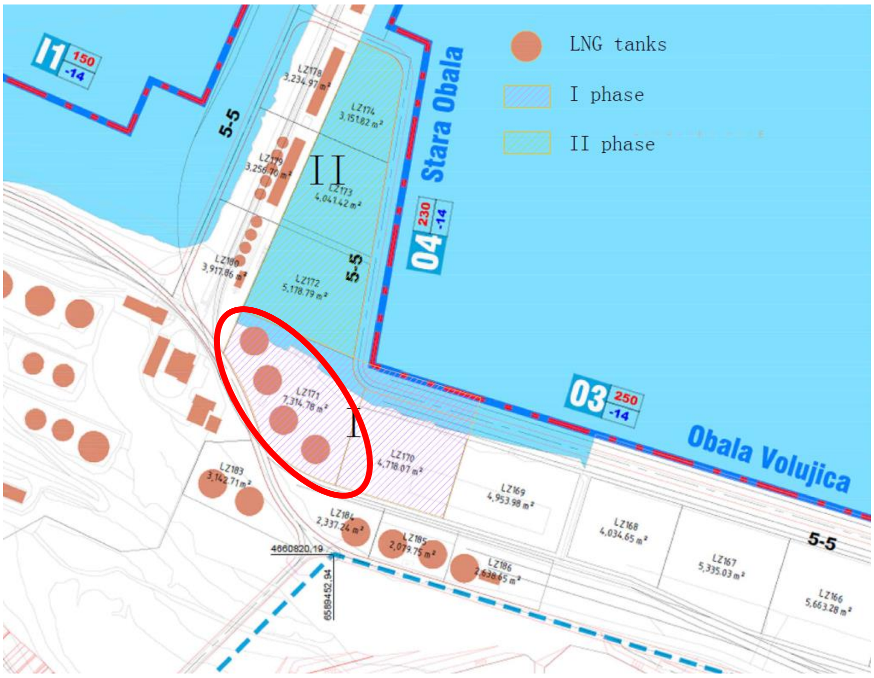

Figure 17: Planned terminal for liquid gas LNG in the Port of Bar

In the port area, in accordance with spatial plan 7.314,78 m^2 are dedicated for the 4 LNG tanks.

According to the port´s information, the "terminal for liquid natural gas LNG (at the root of the Old Quay and the Volujica Quay) of 2.0 ha in the first phase, covers more than 1,200 m^3 - 5,000 m^3 of volume, the capacity of the terminal is 10,000 m^3 in the first phase and another 10,000 m^3, in the second phase; system for receiving, loading/unloading of ships; network of pipelines and pumps; technical and security service and accompanying activities; evacuation route, administrative and business facilities".

The main characteristics of a small-scale terminal for bunkering and regasification – compared to other LNG terminal infrastructure bunkering alternatives are:

Table 5: Technical assessment of LNG terminal (adapted from Port of Esbjerg (2017): Sustainable Energy Supply & innovative Solutions for Emission Reduction "Green bunkering of cruise vessels with sustainable fuel options)

Characteristics	Definition	Assessment
Flexibility	Ability to change location within a short amount of time	Low
Safety	A solution with a higher level of safety will have gas detectors, fire detectors and temperature sensors installed	High
Automation	No permanent staff required	Medium
LNG Volume	The amount of available LNG to be transferred during a bunkering process	High
Flow-speed	Illustrates how quick a certain amount of LNG can be delivered to the customer	High
Require EIA	Environmental Impact Assessment will be required	Yes
Investment	Amount of capital required for the realisation	High
Operational costs	Price for operating the system	High

Economic Assessment

To make valid statements about the business case, the following elements need to be considered:

- **Market demand and potential**: this involves analyzing the potential in the LNG vessel market and other market areas such as offshore supply.
- **LNG prices and price development**: the price towards the end client of the LNG comprises the gas price, trader margin, the terminal feed, logistics costs and bunker fee. Recently, lower oil prices have made the change to LNG less attractive for the shipping companies and instead they often rely on scrubbers.
- **Business model and operating model**: it has to be determined who is responsible for operating the LNG terminals.
- **Investment:** required capital expenditures to realize the LNG terminal.
- **Operational costs:** staff costs, energy costs, maintenance costs, etc.
- **Regulatory requirements**: this part is considering the different safety regulations related to the different bunkering options.

Preparing a business case for this measure, considering all elements listed above, would significantly exceed the scope of this document and should be done in a separate step. A permanent bunkering supply from a local terminal is a huge investment that requires a large volume and an elaborated strategic planning. Due to the large investments, certainty of demand is re pre-requisite for a viable economic solution. Matters are complicated since there are currently little signs that LNG will be a relevant fuel option for general cargo vessels and tankers. On the contrary, a large part of new cruise ships is equipped with LNG technology and market for LNG has a relatively high potential in the future.

It is also essential that economic advantages must be presented to the ship-owners, because they are now also considering alternatives such as electric propulsion, hybrids and hydrogen. Finally, there are different cheaper and more flexible technical solutions with lower capacity. Such solutions should be introduced if demand is low. Therefore, this measure should only be implemented if the sufficient demand is available and the business plan shows positive outcomes.

7 CONCLUSION AND NEXT STEPS

A more sustainable use of energy in ports is widely recognized as a key component to ensure a future-oriented, economically profitable and legally compliant port operation. The need for a more sustainable energy use is especially relevant for ports, which are crucial hubs in the global trading system. The maritime and port sector, however, has not been in the focus of policy makers in terms of environmental aspects for a long time. Therefore, only few ports have started to significantly reduce air and GHG emissions so far. Like all other sectors, however, port operation should achieve a reduction in emissions as soon as possible, as stated in the Paris Agreement from the United Nations Framework Convention on Climate Change (UNFCCC).

The Port of Bar has recognized the signs of the times early and started its "green port transformation". The overall goal is to ensure an energy efficient and largely emission-free port operation to reduce costs, improve the port´s overall efficiency and increase its environmental performance. One essential part of the port´s overall "energy sustainability strategy" is the Green Port Action Plan at hand that provides detailed and concrete information on how to reduce environmental impacts of port operation in a cost-efficient manner. In the centre of the Action Plan, a large number (> 70) of potential energy sustainability measures have been identified and pre-evaluated that are suitable to reduce both, port and vessel-related emissions and energy consumption in the port area.

The implementation phase includes putting into place the (proposed) measures and associated data-gathering programs to evaluate performance over time.

In addition, the following aspects need to be considered in future for a successful implementation of the Green Port Action Plan:

1. Before actually selecting and implementing measures, it is suggested to first define specific and ambitious but also realistic and achievable sustainability / emission reduction targets.
2. For the definition of energy sustainability goals, it is required to actually measure the energy consumption in the port. In the Port of Bar, however, this is currently not possible for electricity. Therefore, it is strongly recommended to install all measurement devices required to actually measure electricity consumption, ideally using an energy management system. In addition, it is useful to install several metering points in the port to measure electricity consumption per "port energy consumer".
3. The evaluation of measures rather provides a general assessment of their expected effort and impact. It is strongly recommended to assess measures for each individual case as their impact and effort is strongly case dependent (e.g., as a result of prevailing space restrictions).
4. Government interventions can help to accelerate the commercial viability and technical feasibility of certain, promising measures. Therefore, it is recommended to identify and participate in suitable funding programs since many measures are currently not cost-efficient (e.g., onshore power).
5. One of the keys to the successful development of the Green Port Action Plan is to further engage all relevant stakeholders throughout the implementation and monitoring of the actions. The port sector cannot operate in isolation from its local, city or municipality institutions, and neither can it conduct its business without integrating its efforts with

responsible agencies, government institutions and industrial organizations. In particular, the collaboration with the port authority could be strengthened.

6. Cooperation and coordination between ports and ship owners is essential for implementing many promising measures in practice. For example, for the success of onshore power or LNG PowerPacs, ports need to agree on certain standards. In addition, the introduction of Green Port Fees or Waste Fee Reduction programs need to be coordinated between (competing) ports.
7. Information about opportunities to improve the level of sustainability in ports should be more available, not only to other ports but also to the public and other relevant stakeholders.

To sum up, although the Green Port Action Plan provides valuable insights in how to achieve a sustainable port operation, further efforts are needed. In particular, the suggested measures need to be implemented under consideration of the references listed above.

8 FIGURES INDEX

Figure 1: Drivers towards achieving more energy sustainable port operation 4
Figure 2: Potential energy sustainability measures for a port authority (Source: HPC, 2019) 5
Figure 3: Port of Bar energy sustainability goals 7
Figure 4: Energy sustainability measures for the Port of Bar to reduce port related emissions and energy consumption (main goal 1&2 of Action Plan).. 22
Figure 5: Energy sustainability measures for the Port of Bar to avoid or reduce ship GHG & air emissions in the port area (main goal 3 of Action Plan) 27
Figure 6: SMARTPORT pilot project – installation of the LED luminaries 30
Figure 7: Nissan Leaf (BEV) purchased within the pilot project EnerNETMob 31
Figure 8: Hybrid bus from project SuMo 32
Figure 9: Fast charger installed in front of headquarter of the Port of Bar 33
Figure 10: Phases of an EMS implementation (bureauveritas.com) 35
Figure 11: Annual CO_2 emission saving potential (electrification of cargo handling equipment in the port) 36
Figure 12: Capex and opex for solar photovoltaic 38
Figure 13: TCO analysis for LED terminal lighting in 15 years period 39
Figure 14: Air curtain and plastic slat curtain used in cold storages 41
Figure 15: Becker LNG PowerPac (source: www.becker-marine-systems.com) 44
Figure 16: Becker LNG PowerPac: handling procedure (Source: www.becker-marine-systems.com) 45
Figure 17: Planned terminal for liquid gas LNG in the Port of Bar 47

9 TABLES INDEX

Table 1: Energy sustainability measures for the Port of Bar to reduce port related emissions and energy consumption (main goal 1 and 2) 8
Table 2: Energy sustainability measures for the Port of Bar to avoid or reduce ship GHG & air emissions in the port area (main goal 3) 23
Table 3: LED terminal lighting – Technical data and environmental data 30
Table 4: LNG PowerPac – Technical and environmental data 46
Table 5: Technical assessment of LNG terminal (adapted from Port of Esbjerg (2017): Sustainable Energy Supply & innovative Solutions for Emission Reduction "Green bunkering of cruise vessels with sustainable fuel options) 47

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