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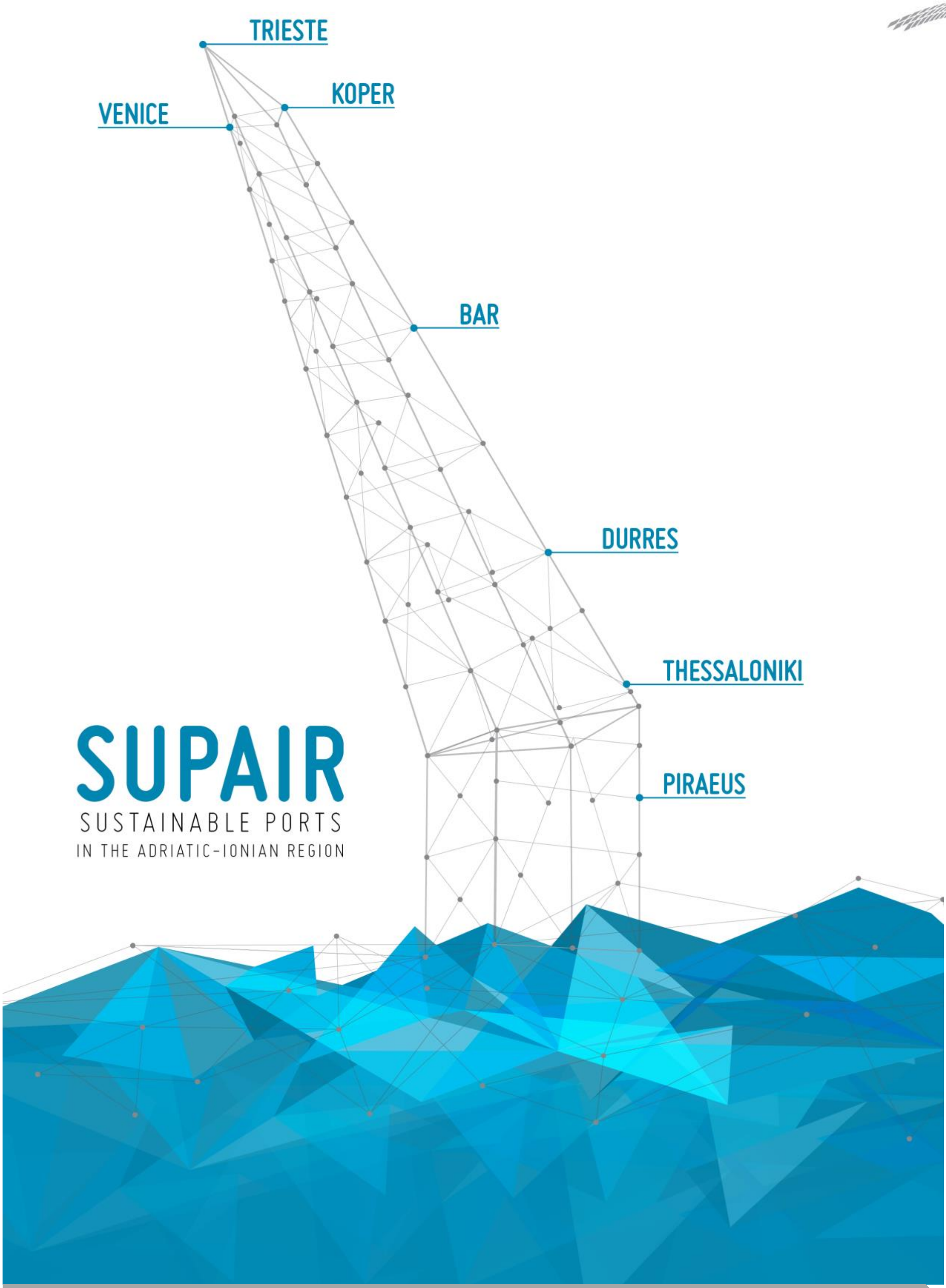

Action Plan for Sustainable and Low-carbon Port of Bar

AUTHOR/INSTITUTION: Dr. Johannes Schmidt / HPC Hamburg Port Consulting GmbH
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Description: *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 Action Plan for sustainable and low carbon Port of Bar at hand that provides detailed and concrete information on how to reduce environmental impacts of port operation in a cost-efficient manner.*

Partner responsible for the deliverable: Port of Bar

Document Author(s): *Dr. Johannes Schmidt (*HPC Hamburg Port Consulting GmbH *)*

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Contents

1. Background

1.1 Current Energy and Environmental Challenges in the Port Sector

During recent years, there has been a fundamental paradigm shift towards increased awareness in the maritime industry worldwide about the role of seaports in the sustainability discourse. For the port industry worldwide, both energy efficiency and the use of renewables have become important topics. There are several reasons for this development, as illustrated in Figure 1 and explained below.

Figure 1: Drivers towards achieving more energy sustainable port operation

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 accounts 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).

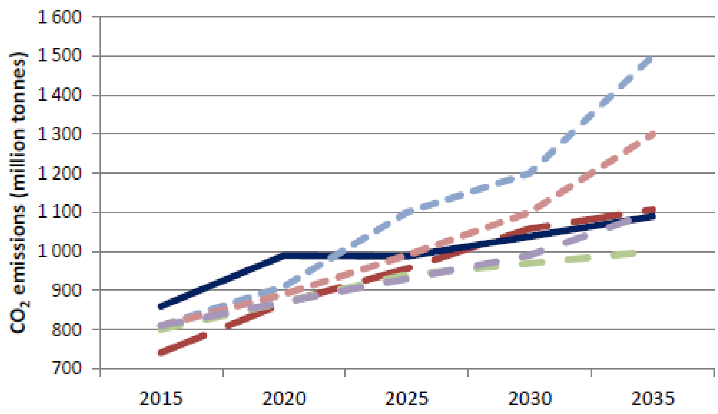

Figure 2: Projections for shipping`s emissions to 2035 (ITF, 2018)

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.

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 with climate change in the Top 10 for the second year in a row (see Figure 3).

Figure 3: Top 10 environmental priorities (ESPO Environmental Report 2018)

1.2 Goals of Green Port Action Plan

The Port of Bar is Montenegro’s main cargo port. At present, there are two operators in the port, namely Port of Bar and Port of Adria, carrying out more than 95% of the country’s maritime transport. The port has promising development potentials (e.g. operative coast length, water depth, connection with railroad and large area for expansion), which gives it great regional status.

Port of Bar is fully aware that ensuring a high level of energy sustainability may help to bring ecological, economic and technological advantages and can be essential for obtaining a leadership position for the port in the long term (see Chapter 1).

> The **overall objective of this "Action Plan for Sustainable and Low-Carbon Port of Bar"**[1] is to show Port of Bar ways for a more efficient use of energy in port operations in order to reduce costs, improve the port`s overall efficiency and increase its environmental performance.
>
> To achieve this goal, the Plan will comprise detailed information on how to reduce the negative environmental impacts of port operation in a cost-efficient manner.

As explained in detail in the next chapter, the Plan will comprise the most important medium and long-term energy sustainability goals for the Port of Bar. Moreover, feasible energy sustainability measures will be identified and evaluated, considering local conditions and the port´s capabilities. Based on this, many promising potentials are expected to arise for the Port of Bar including a sound management of negative externalities caused by port and vessel operations or an improved port's efficiency and productivity.

In order to ensure successful implementation of the Action Plan, stakeholder involvement is required throughout the energy sustainable action planning process. Therefore, the target groups of the Action Plan are also relevant port stakeholders.

The Action Plan's overall objective and purpose, as well as the target groups are summarized in Figure 4.

Figure 4: Objective, purpose & target groups of Action Plan

1.3. Fundamentals of Green Port Action Plan

A Green Port Action Plan is a comprehensive strategy document used to address energy and emissions aspects from shipping and port operations. The overall goal of the Action Plan is to support the Port of Bar in reducing their energy consumption and mitigate their GHG and air emissions in a cost-efficient and sustainable manner.

It is worth noting that the commitment and the endorsement from the upper level and collaboration with other stakeholders and regulatory agencies are paramount for a successful implementation of the

[1] in the following referred to as "Green Port Action Plan"

Green Port Action Plan (see also Section 2.3). In addition, the plan needs to be shaped to the Port of Bar`s individual needs and according to the port`s capabilities and available resources.

1.3.1 Structure of Green Port Action Plan

In general, an effective Green Port Action Plan should set up overarching emission and energy-reduction targets and contains a roadmap to achieve the targets defined. This makes clear that a Green Port Action Plan document includes two main planning stages:

1. **Strategic planning phase:** reveals all relevant background information of the Action Plan but also involves the development of suitable energy sustainability goals; and
2. **Operational planning phase**: involves the identification and evaluation of feasible energy sustainability actions / measures as well as the elaboration of deployment strategies for promising measures.

It is important that the Green Port Action Plan will be enacted in the next phase (implementation phase) and will be assessed and improved in the corresponding final phase (monitoring and improvement phase). However, both phases are entirely within the Port of Bar`s scope of responsibility (see Figure 5 shaded grey) and will thus not be a part of this Action Plan.

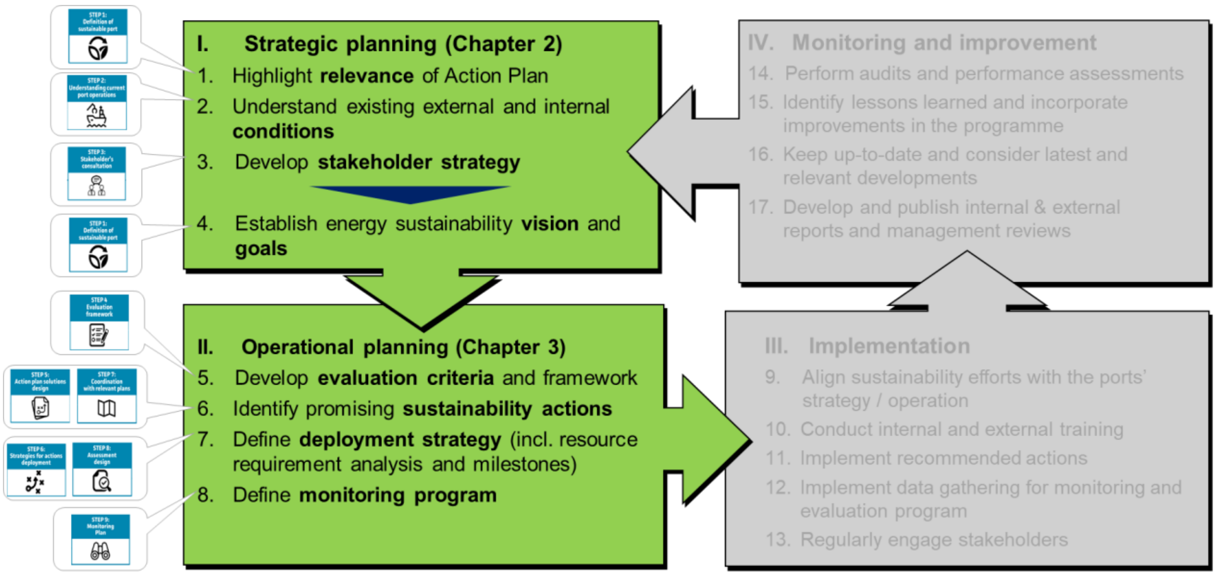

Figure 5: Structure of the Green Port Action Plan document (shaded green)

In the strategic and operational planning phases, all steps listed in the “SUPAIR Guidelines for Sustainable and Low Carbon Ports” are considered, however, in a slightly different order than proposed, as above.

1.3.2 Scope of Green Port Action Plan

The Green Action Plan is designed to assist the Port of Bar in improving its level of energy sustainability in a cost-efficient manner.

It is furthermore important to note that energy sustainability aspects include both, energy efficiency programs, – such as the use of environmentally friendly port technologies, – as well as the usage of renewable energy, – such as solar power– as illustrated in Figure 6.

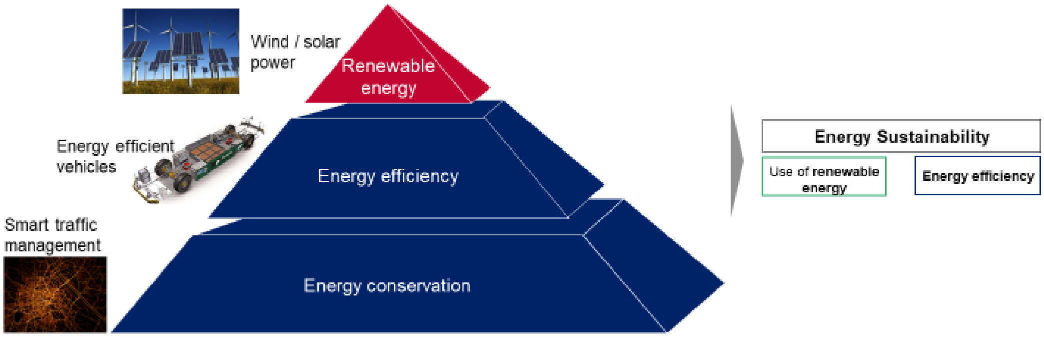

Figure 6: Renewable energy and energy efficiency are said to be the "twin pillars" of sustainable energy policy[2]

Therefore, energy sustainability actions for the Port of Bar (identified in Chapter 3) are designed to decrease energy consumption (oil, diesel, electricity or gas) and mitigate harmful emissions.

For the development of the Green Port Action Plan it is also important to distinguish air and GHG emissions.

- The main problems caused by air emissions that occur close to the ground is their potential to cause direct health effects, such as respiratory diseases. In addition, many air emissions adversely impact vegetation, including forests and agricultural crops. The most important air emissions are Sulfur Oxides (SO_x), Particular Matter (PM) and Nitrogen oxides (NO_x) (for details see Section 2.2.4).
- Greenhouse gas (GHG) emissions refer to a number of gases that have direct effects on climate change / global warming with significant implications for, among others, sea level rise, retreat of glaciers or altered wind, storm and rainfall patterns. Although carbon dioxide (CO_2) is the most influential GHG, there is a growing pressure to consider also other greenhouse gases in particular methane (CH_4) and nitrous oxide (N_2O), most commonly included within CO_2-equivalent (CO_2e) emissions factors (see Section 2.2.3).

Hence, air pollution can be defined as a local phenomenon, while GHG affect the whole of the atmosphere.

Finally, the Green Port Action Plan should address energy sustainability aspects from both shipping and port operation. However, the present Action Plan will focus on port-related aspects that consume energy and cause emissions such as pier and cargo handling equipment or terminal buildings.

- **Pier and cargo handling equipment** in the Port of Bar such as STS cranes;
- **Road (external) traffic** resulting from cargo transport; and
- **Terminal buildings** such as administration buildings and warehouses.

2. Strategic Planning Phase

The Green Port Action Plan development process starts with the strategic planning phase which mainly aims at developing an overall energy sustainability vision and a set of goals addressing energy sustainability issues (Chapter 2.4). In addition to developing goals, this phase

- reveals the relevance of the Plan (Chapter 2.1),

[2] There is a principal difference between energy efficiency and conservation. Energy conservation is any behavior that results in the use of less energy by **reducing a service**. Energy efficiency is defined as using technology that requires less energy to perform the **same function.** Therefore, energy conservation might cut down the level of service.

- examines and presents all relevant conditions in the Port of Bar (Chapter 2.2), and
- identifies the main internal and external stakeholders (Chapter 2.3).

All steps of this phase, that will be included in the Action Plan, are illustrated in Figure 7.

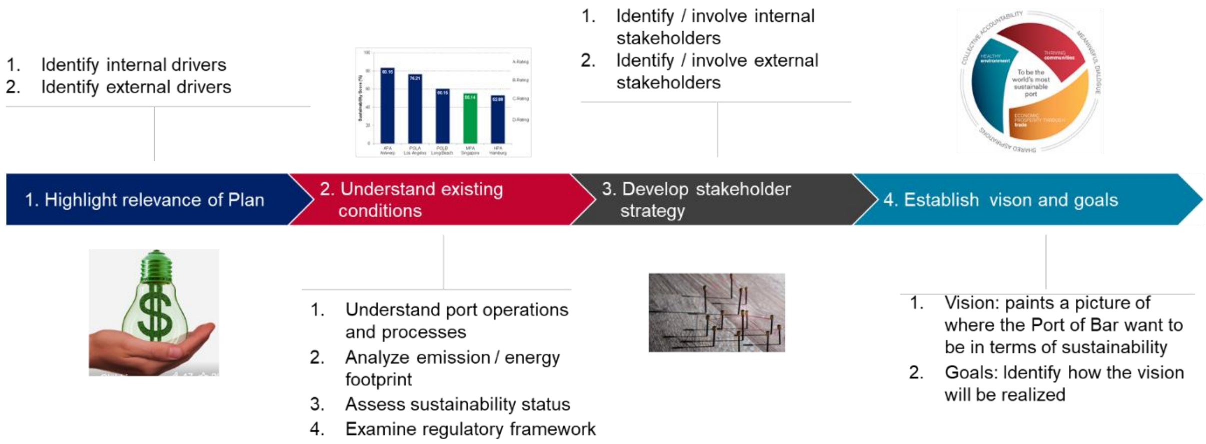

Figure 7: Strategic planning phase of Action Plan

2.1 Relevance of Green Port Action Plan

The relevance for improving the level of energy sustainability in a port (like in the Port of Bar) and thus the relevance for the development of the Green Port Action Plan has already been outlined in detail in Section 1.1. As explained above, the relevance for the Green Port Action Plan arises in particular for the following reasons:

1. Threat of climate change, probably also causing negative consequences for the port sector;
2. Increasing environmental regulatory requirements (international, national and local) and stakeholder demands (e.g. customers and residents); and
3. 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.

2.2 Existing External and Internal Conditions

In this section an exhaustive status analysis is carried out to examine the current external and internal conditions in the Port of Bar affecting the elaboration of the Green Port Action Plan. To this end, the following aspects will be considered:

1. Internal conditions
   a. Port operations, processes and management models (Section 2.2.1)
   b. Port of Bar´s current emission and energy baseline (Section 2.2.2)
2. External conditions
   a. Port of Bar energy / emission performance compared to other, selected ports (Energy Sustainability Benchmark Analysis, Section 2.2.3)
   b. Relevant existing international and national regulatory framework (Section 2.2.4)

Most of the data used for the preparation of the status analysis have been collected within the frame of an on-site visit in Bar and been provided by the Port of Bar.

2.2.1 Port of Bar Operations and Processes

For the elaboration of the Green Port Action Plan, it is required to understand the current port operations in the Port of Bar. Therefore, the Consultant carried out an on-site terminal inspection to compile a detailed overview of the structural equipment and infrastructure conditions on the port, collect energy consumption data and capture the operational processes on the terminals.

The Port of Bar, located south of the city of Bar, was established in 1906 and is the main cargo port in Montenegro. It is located at the entrance of the Adriatic Sea, 976 nautical miles (nm) from the Suez Canal and 1190 nm to Gibraltar. Given its geographic situation (see Figure 8), it has significant competitive advantages over the Northern Adriatic ports. In addition, the Port of Bar is integrated with the Belgrade-Bar railway and road traffic network, making the port an important link of the intermodal transport chain.

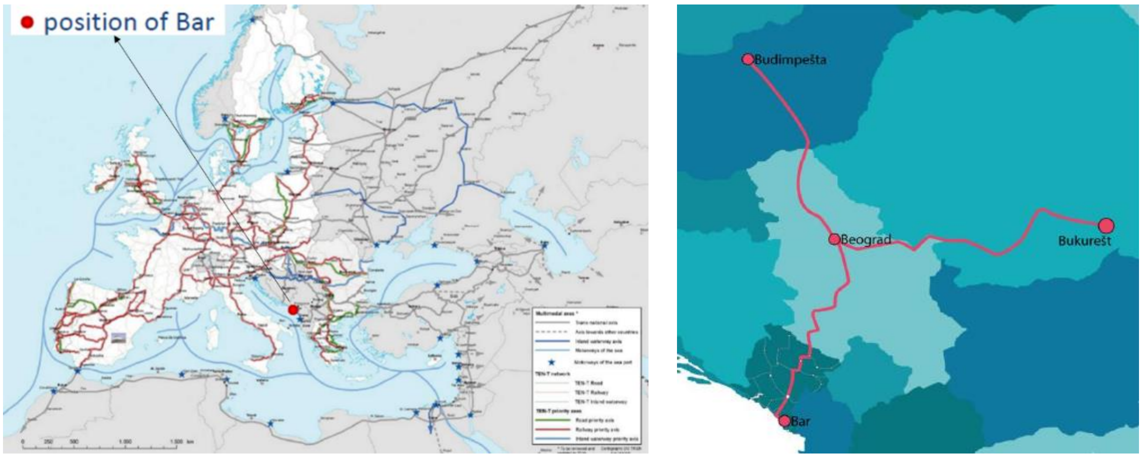

Figure 8: Location of Bar (Source: adapted from 27th RWWG Meeting, Podgorica, 30/06/2017)

Since 2009, there is a further port operator in Bar the “Port of Adria” (see Figure 9). The Port of Adria (Global Ports Holding owns 62.09 % shares in Port of Adria) is a multipurpose port featuring a quay length of 1,440 m with dedicated terminals for container ships, general cargo ships, RoRo and cruise ships. The port covers a total area of 518,790 m^2 with nine berths and has an annual handling capacity of 150,000 TEU and 2.3 million tons of general cargoes.

Figure 9: Port terminal operators in Bar (Source: Port of Bar))

The Port of Bar is a joint stock company, in which the State of Montenegro holds 54% of shares. The current capacity of the Port of Bar is 2.7 million tons per year. It handles different types of cargos; its water depth in the port basin is up to 14m. The main business of the Port of Bar is handling and storage of dry bulk, general cargo, liquid cargo and RoRo. Figure 10 illustrates the cargo handling development in the Port of Bar (excluding RoRo).

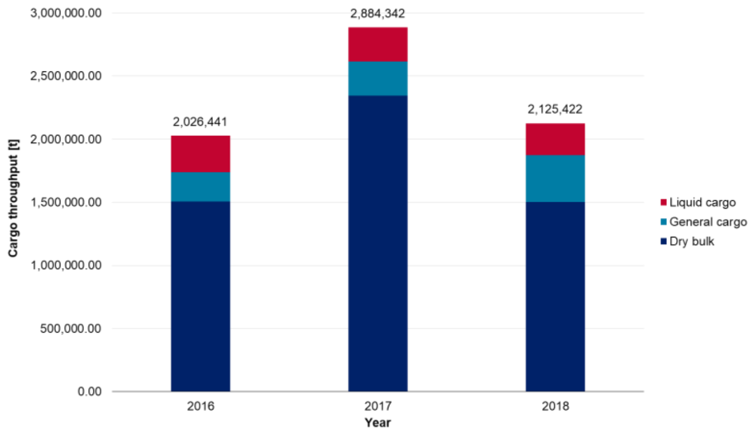

Figure 10: Cargo handling development Port of Bar (Source: data prepared by HPC, 2019)

Given the available capacity of the port, the utilization rate of the Port of Bar capabilities is rather low.

The rough layout of the Port of Bar is illustrated in Figure 11.

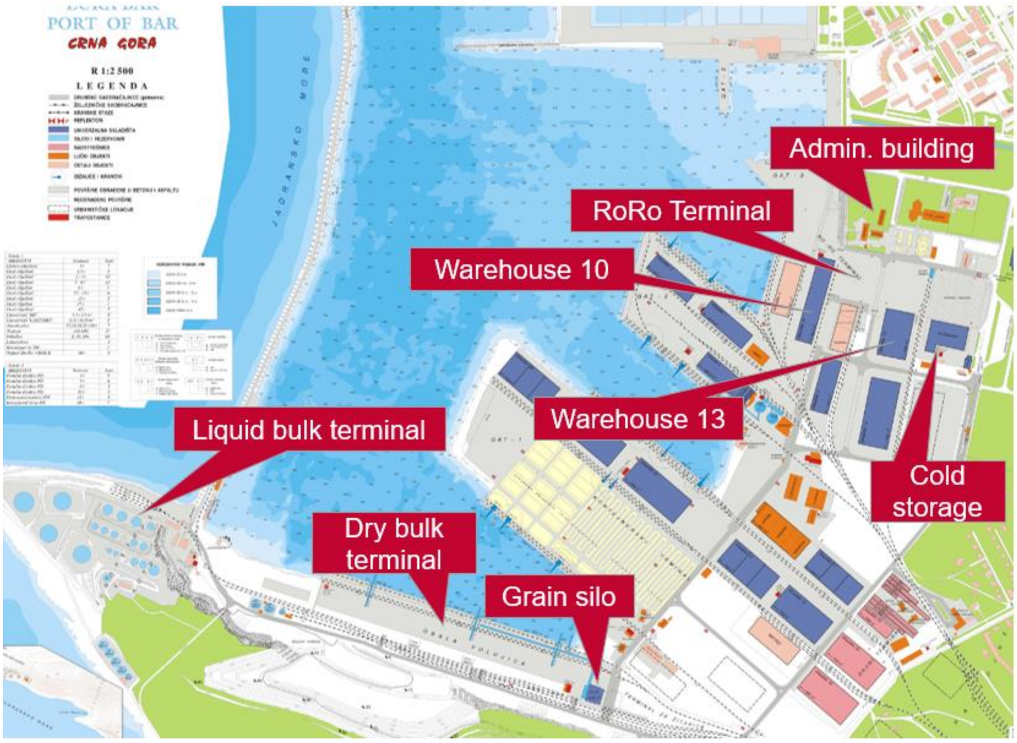

Figure 11: Port of Bar layout (Source: data provided by Port of Bar and prepared by HPC)

It is worth noting that there are currently several development projects in planning. An overview of all development projects can be found in the Port of Bar general presentation..

Port Infrastructure

The infrastructure of the port consists of several berths, as presented and described in Table 1.

Table 1: Infrastructure Port of Bar – Operative quay (Source: Port of Bar homepage)

Type	Length [m]	Depth [m]	Sea level [m]	Type of construction
Quay Volucija	554.4	14	3	Reinforced-concrete structure laid down on pillars
Old quay	280	6.2	2.5	Concrete gravity wall
New petroleum berth	66	13.5	2.5	Dolphin structure on piles
Berth 26 on Pier II/Pier III	239	10.5	3	Reinforced-concrete structure; laid down on pillars
Southern quay of Pier III	136	8.1	3	Reinforced-concrete structure; laid down on pillars
Passenger terminal	332	5.9	2	Concrete gravity wall

In addition, the Port of Bar is also responsible for providing the following port infrastructure:

- Electricity network including substations with different capacities;
- Water supply network (tubes and reservoirs);
- Sewerage systems (several with different diameters);
- Telecommunication infrastructure (e.g. computer network and cable infrastructure); and
- Roads and railway roads.

For the elaboration of the Green Port Action Plan it is of particular importance to consider that the energy infrastructure of the port is based on one system for the entire port. As a consequence of this, it is currently not possible to split the energy consumption between the Port of Bar and Port of Adria. In addition, the Port of Bar is currently not able to allocate energy consumption to specific energy consumer groups of the port (e.g. warehouse, administration buildings or cranes). Usually, this is the responsibility of the local electricity network operator (for details see Section 2.2.2).

Port Superstructure

The superstructure of the Port of Bar, which is of relevance for the Green Port Action Plan (energy consumers), consists of:

1. **Buildings**: administration building, workshop, storage / warehouse and silo;
2. **Terminal lighting**;
3. **Cargo handling equipment**: ship loading and unloading equipment, yard loading / unloading equipment and yard transport equipment; and
4. **Other vehicles**: heavy duty vehicles and light duty vehicles.

An overview of the buildings, located in and operated by the Port of Bar, is given in Table 2 (the location of these buildings is illustrated in Figure 11).

Table 2: Overview – Buildings Port of Bar (Source: data prepared by HPC)

Type	Storage capacity [t]	Storage capacity [m³]	Surface [m²]	Space volume [m³]	Temperature [C°]
1. Grain silo					
-	30,000	n/a	n/a	n/a	-
2. Cold storage					
No 1	n/a	n/a	526.36	3,000.25	0 / -20
No 2	n/a	n/a	1,778.65	10,138.30	0 / +20
3. Reservoir for lube stock					
Base oil	n/a	1.400	-	-	-
4. Open-air warehouses					
Dry bulk	-	-	29,481.29	n/a	-
RoRo	-	-	55,775	n/a	-
RoRo	-	-	20,000	n/a	-
Truck parking	-	-	18,441	n/a	-
5. Closed warehouses					
No 10	-	-	6,300	n/a	-
No 13	-	-	5,982	n/a	-
6. Administration building					
-	-	n/a	1,964	n/a	-

In addition to terminal buildings, terminal lighting consumes energy and causes emissions. In the Port of Bar, terminal floodlights are mainly located in the open area storage (RoRo storage). The following types of lamps are used in the port: sodium, metal halogen, mercury light and LED lights. However, by far the largest share of lights (measured by installed power) are traditional lights, mainly sodium.

In the Port of Bar different type of cargo (dry bulk, liquid bulk, general cargo and RoRo) is handled. Accordingly, different types of cargo handling equipment are used. An overview of the relevant cargo handling equipment deployed in the Port of Bar which is of relevance for the Green Port Action Plan (= energy consumers) is given in Table 3. Please note that detailed information (e.g. number and type of device) cannot be presented as a result of company and operational secrets.

Table 3: Overview – Relevant cargo handling equipment Port of Bar (Source: data prepared by HPC)

Type	Number	Capacity
1. Ship loading and unloading equipment		
Gantry cranes	3	12 t
Mobile crane	1	Up to 60 t
Mobile harbour Crane	1	144t
Grain loading cranes	1	Approx. 300t/h
2. Yard equipment		
Material handler	2	Up to 13 t
Wheel loaders	5	1.5 – 3.5 m³
Skid steer loader	2	0.36 - 0.5 m³
Heavy diesel forklifts	3	12 – 42 t
Medium diesel forklifts	8	2 – 3.5 t
Electric forklifts	2	1.5 – 3 t
RoRo tractors	2	Up to 35 t
Belt conveyer	1	300 t/h

Finally, for the fulfilment of daily business, the Port of Bar owns and operates a small fleet of terminal vehicles. In detail, following five conventional, diesel-fuelled vehicles are used in the port:

- Mercedes Benz Sprinter 308 D 2.1 (Euro V)– 2014
- Skoda Octavia 1.6 tdi – 2014 (Euro V)
- Dacia Logan MVC STORY 1.5dci - 2012 (Euro V)
- Dacia Logan MVC STORY 1.5dci - 2012 (Euro V)
- Dacia Logan MVC STORY 1.5dci - 2012 (Euro V)

2.2.2 Emission / Energy Inventory Port of Bar

In general, a “Baseline Energy Sustainability Inventory” quantifies the amount of energy consumed (e.g. fuel, gas or electricity) and emissions emitted (usually greenhouse gas and air emissions; see Section 1.3.2) by a country, city, company or in this case a port in a baseline year.

There are three main reasons for preparing a Baseline Energy Sustainability Inventory:

1. Based on the knowledge of the current energy use and emission output, it is possible derive concrete, ambitious, but also realistic energy & emission reduction goals for the Port of Bar (Section 2.4);
2. The inventory of the baseline years represents the basis to show any progress or regressions towards the objective defined (e.g. achieved emission reduction over the time); and
3. The inventory allows to identify main energy consumers or emission producers in the Port of Bar. Based on this information, it is possible to prioritize the reduction measures accordingly (“low hanging fruits”, see Chapter 3).

Figure 12 displays the HPC-procedure to prepare an Energy Sustainability Inventory.

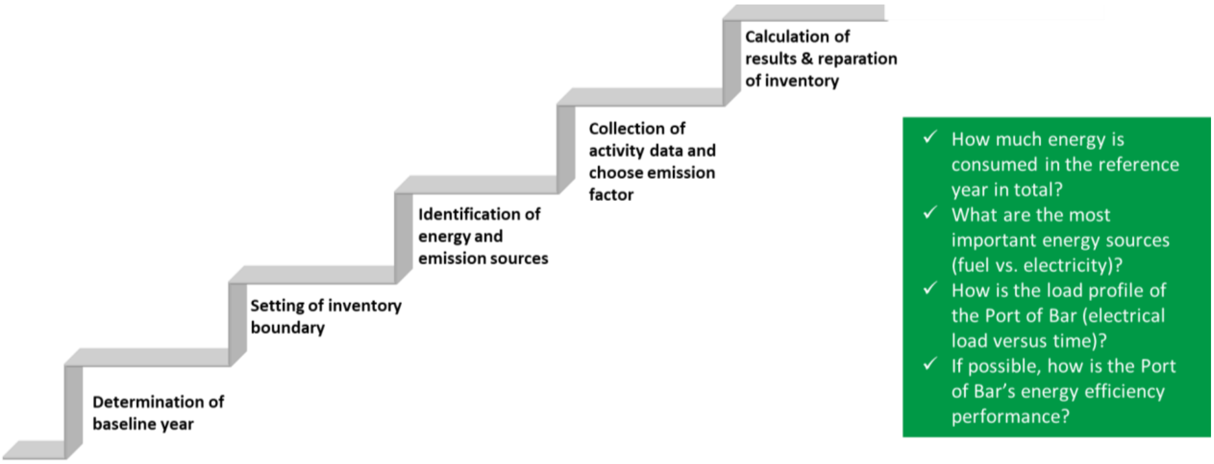

Figure 12: HPC standard procedure for evaluation energy consumption data of ports

In the following, the steps are briefly explained. In addition, the special situation in the Port of Bar is described which has an effect for the preparation of the inventory.

1. **Determination of baseline year:** Baseline year is the year against which the achievements of the emission and emission reductions shall be compared.
   - The baseline year of the Green Port Action Plan for the Port of Bar is 2018, the most current 12-month period for that most data are available.
2. **Setting of inventory boundaries:** These boundaries refer to the coverage and extent that will be considered for the inventory process, i.e. they determine what shall be included and what not.

- Physical boundaries of the Port of Bar used in this assessment include the geographical area within which all of the port's physical assets and infrastructure are located.

3. **Identification of energy and emission sources:** Energy in ports is usually consumed in the form of fuel and electricity by mobile and stationary consumers. The main energy (fuel and electricity) consumers in the Port of Bar are illustrated in Table 4 (see also Section 2.2.1).

Table 4: Energy consumers Port of Bar

Category	Type	Diesel	Electric
Mobile sources			
Ship loading and unloading equipment	Mobile harbour crane (STS)	X	
	Mobile crane	X	
	Gantry cranes		X
	Grain loading crane		X
Yard operations equipment	Diesel forklifts	X	
	Electric forklift		X
	Wheel loader & skid steer loaders	X	
	Material handler	X	
	Terminal tractors	X	
	Conveyor belt		X
Light duty vehicles	Terminal vehicles	X	
Stationary sources			
Administration building			X
Warehouses	Open-air and closed		X
Grain silo			X
Cold storages			X
Terminal lighting			X

4. **Collection of activity (energy consumption) data and determination of emission factor:** activity data mainly details how the consumer operates over time and how much energy is consumed within a specific timeframe. An emission factor provides the means to convert the estimates of energy input into pollutant emission rates that are to be modelled.
   - <u>Fuel consumption data Port of Bar</u>: All fuel consumption data from stationary and mobile sources required for the preparation of the energy inventory is available. For reason of comparability, the fuel consumption is converted to kWh.
   - <u>Electricity consumption data Port of Bar:</u> As briefly explained above, the energy infrastructure of the whole port is based on one supply system since the energy provider only recognizes the Port of Bar as one customer. Thus, it is currently not possible to split the energy consumption between the Port of Bar and Port of Adria. In practice, the total amount of electricity consumed by the Port of Bar is currently based on estimates. Related to this, it is currently also not possible by the Port of Bar to allocate the electricity consumption to specific port energy consumers, such as buildings or cranes. Nevertheless, to make statements about the electricity consumption pattern in the Port of Bar, specific distribution keys have been used in this study. This is possible since the Consultant has detailed information about the energy consumption pattern in other ports, e.g. the typical %-share of administration building's electricity consumption in ports. Based on this information, the distribution keys for all electricity consumers have been developed and used.
   - <u>Emission factor Port of Bar:</u> As explained it Section 1.3.2, it is necessary to distinguish air and greenhouse gas emission. In general, GHG emissions can be reasonably calculated on the basis of the fuel or electricity consumed while air emissions depend on several parameters,

such as the deployed emission control equipment or the state of maintenance of the engine.[3] Since no actual emission test data or detailed source data required (e.g. equipment type or model year) are available, the focus of this inventory is therefore on energy aspects.

5. **Preparation of inventory**: In the final step, calculations are made to answer the following questions:
    - How much energy is consumed in the reference year in total?
    - What are the most important energy sources (fuel vs. electricity)?
    - How is the load profile of the Port of Bar (electrical load versus time)?
    - If possible, how is the Port of Bar's energy efficiency performance?

In the following three sub-sections, the energy inventory is presented, and the main results are discussed. Please note that, as explained above, electricity data are based on estimates.

Total Energy Consumption Port of Bar

In Figure 13, the total energy consumption (fuel and electricity) of the Port of Bar is illustrated.

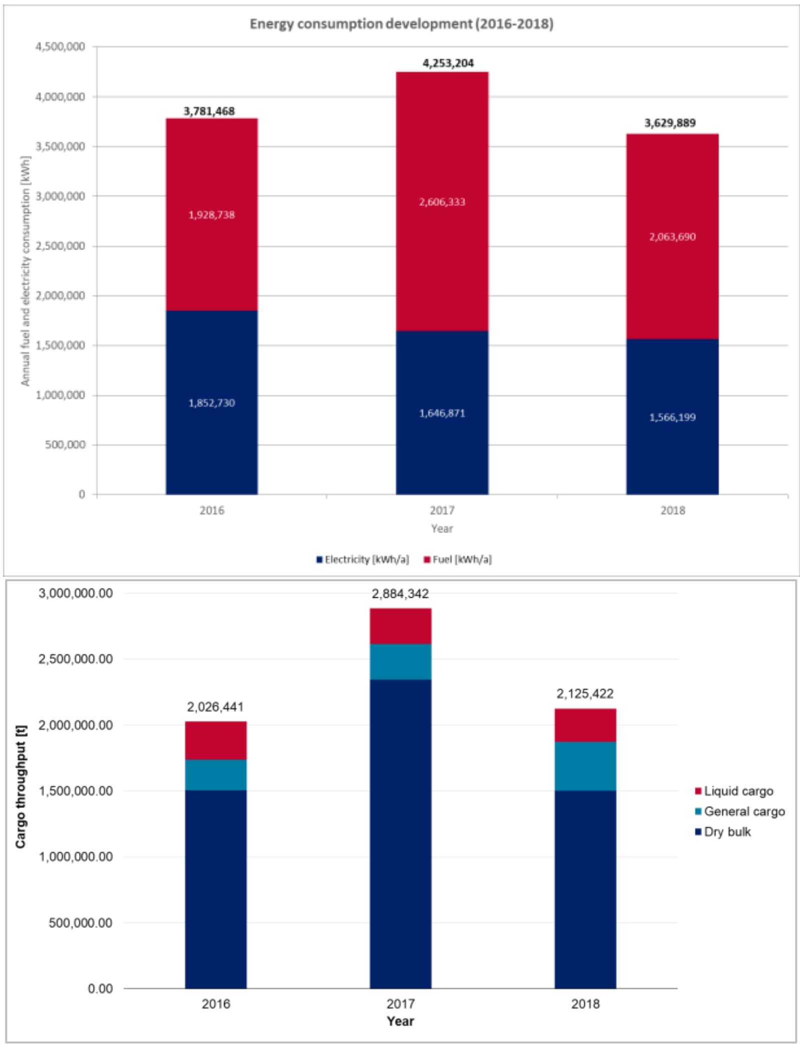

Figure 13: Total energy consumption and cargo throughput Port of Bar[4]

[3] Detailed information can be found in: World Resources Institute (2004): The Greenhouse Gas Protocol

[4] Cargo throughput is counting as total cargo load/unload to/from ships/trucks/trains.

The yearly variations can be explained with the fluctuations of cargo throughput (see right side). Obviously, the energy consumption in ports largely depends on the cargo throughput; the more cargo is handled in a port, the more energy consumption is required (e.g. for transportation and storage of goods). Since the Port of Bar consumes more than 3.5 GWh of energy per year, it can be considered as important energy consumer in Bar. However, compared to other ports, the energy consumption is rather low. For example, the total energy consumption (kWh) of the Port of Venice is about 49 GWh/year.

In Figure 14, the energy consumption per energy consumer in the Port of Bar is presented.

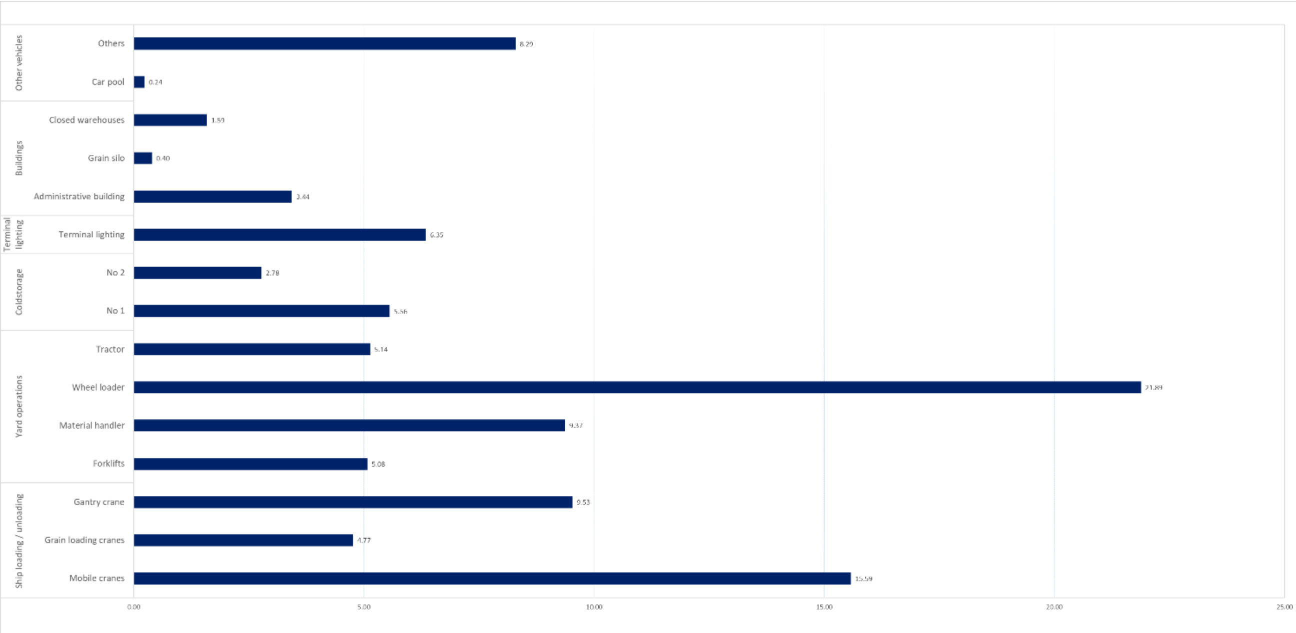

Figure 14: Energy consumption per energy consumer [%]

The following interesting and relevant insights can be drawn:

1. The most important energy consumer group is "yard operations", with a share of more than 40% on total energy consumption, followed by "ship loading / unloading equipment" (share: 30%).
2. With a share of more than 20% on the total energy consumption, the wheel loader is the largest single energy consumer in the Port of Bar.
3. Further important mobile energy consumers are, in descending order, mobile cranes, gantry cranes, material handlers, tractors and forklifts.
4. The most important stationary energy consumers are the terminal lighting and the cold storage 1, followed by the administration building and the cold storage 2.
5. A currently almost negligible energy consumer is the grain silo (which was not in operation in 2018).
6. Almost 10% of the total energy consumption cannot be assigned to any energy consumer.

Based on these findings, the following conclusions can be drawn:

1. For the further preparation of the Action Plan, it is useful to first focus on the port`s main energy consumers and identify energy sustainability measures to these consumers (see Chapter 3)
2. Compared to other ports, the energy consumption of the ship loading / unloading equipment is relatively high. In most terminals, STS (Ship to Shore) and mobile cranes activities consume an

average of around 10% of the total amount of energy used. Therefore, it seems useful to examine this phenomenon in further details.

3. Since almost 10% of the total energy consumption cannot be detected and the electricity consumption could only be estimated, one of the main recommendations of the Action Plan is to implement an Energy Management System to determine exactly how much and how the energy is used in the Port of Bar.

Load Profile Port of Bar

A load profile defines how an energy customer uses its energy over time. It is created by using measurements of a customer's energy use at regular intervals and provides a representation of the Port of Bar. In Figure 15, the monthly energy consumption per ton of cargo handled (general cargo and dry bulk cargo) is presented. The standardization to "energy consumption per ton" is necessary to analyse variations in energy consumption in detail. As explained above, the total energy consumption in a port is largely dependent on the total cargo throughput. In addition, the average monthly temperature is illustrated.

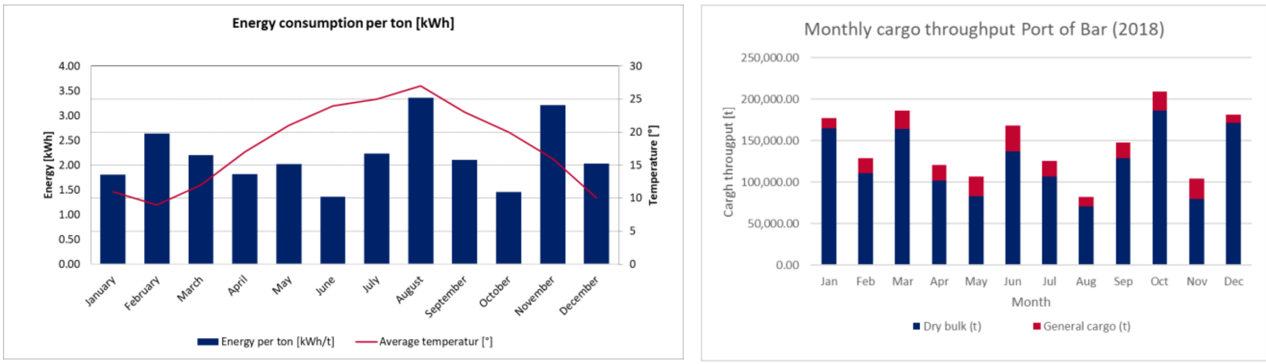

Figure 15: Monthly energy consumption per ton (kWh) / Monthly cargo throughput Port of Bar (2018)[5]

First of all, it can be seen that there are large monthly variations in energy consumption. Generally, however, it is better to have an even energy consumption distribution. For example, electricity grid fees that depend on peak loads can be reduced.

Most variations can be explained with fluctuations in cargo throughput (see Figure 15, right side). In general, the lower (higher) the cargo throughout, the larger (smaller) the influence of the unavoidable fixed energy consumption (e.g. terminal lighting, electricity consumption of administration buildings) per output unit. It can be seen in the figure that there seems to be a correlation between the normalized energy consumption and cargo throughput. Hence, the high standardization energy consumption in August and November as well as the low standardization energy consumption in June and October are caused by these quantity effects.

In addition, the temperature seems to have an effect on the energy consumption. Interestingly, the normalized energy consumption is particularly high in the month August with the highest average temperature. This is probably also because in hot months, an extremely high amount of electricity is required for keeping the temperature in the cold storage on the required level and for cooling down the administration building. This effect can be seen in Figure 16.

[5] Cargo throughput is counting as total cargo load/unload to/from ships/trucks/trains.

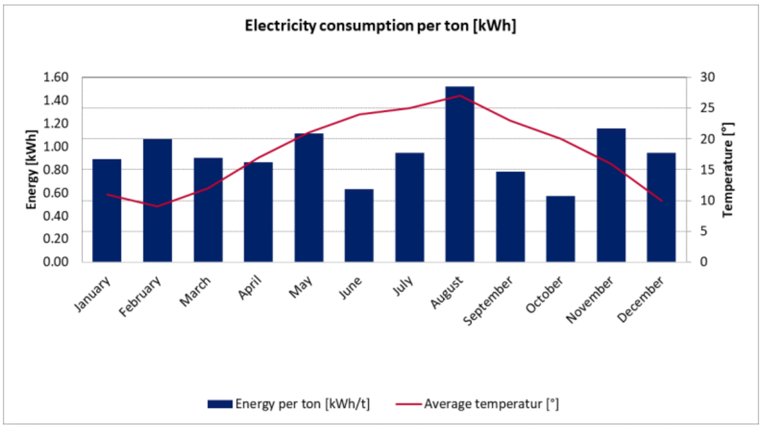

Figure 16: Monthly electricity consumption (kWh) per ton

To further determine the variations in energy consumption, however, an elaborated Energy Management System is required, as explained above.

Nevertheless, the finding that the fixed energy consumers in the Port of Bar seem to have a large proportion on the total energy consumption on the Port of Bar needs to be kept in mind for the identification of energy sustainability measures (Chapter 3).

Analysis of Main Energy Consumers in the Port of Bar

In Figure 17, the monthly energy consumption values of the port`s main energy consumers are illustrated. Note that only fuel / diesel-driven equipment is illustrated since there is no detailed information about electricity consumption available, as explained above.

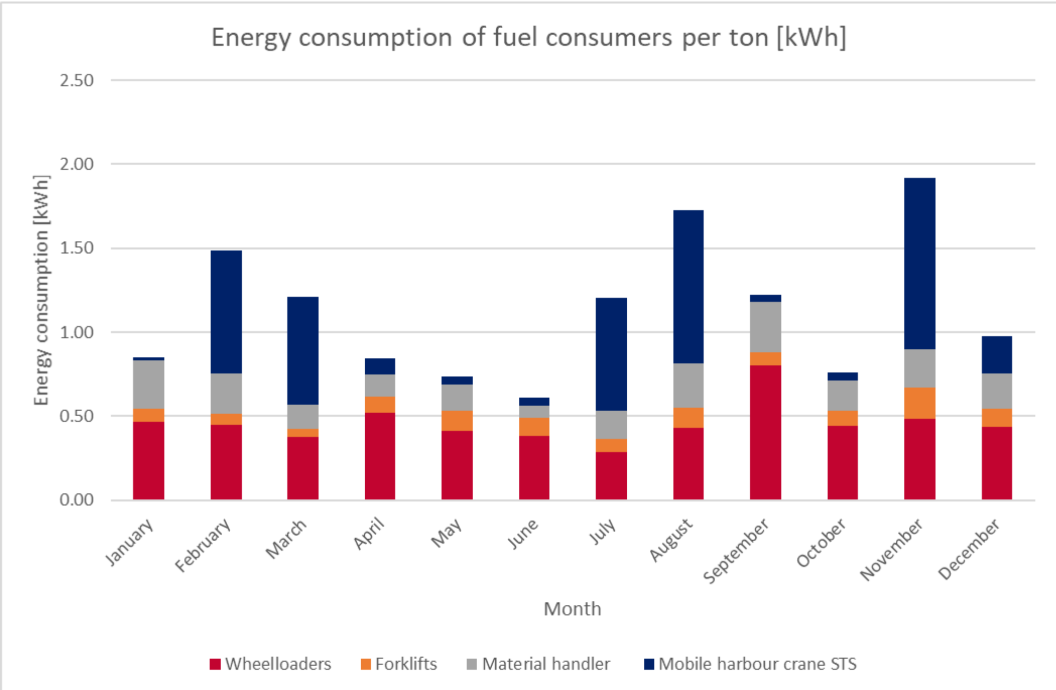

Figure 17: Normalized energy consumption of fuel consumers per ton [kWh]

Particularly noticeable is the large variation in energy consumption of the mobile harbour crane, which is almost zero in some months (e.g. January, June or October). Probably, there have only been few vessels in the port. In addition, the energy consumption of the wheel loaders and forklifts are nearly constant within the reference year. From this it could be deduced that the energy consumption of these equipment is only dependent on a small degree on vessel operations. Compared to other ports, however, the standardized energy consumption of these equipment is quite high[6].

Summary of Key Findings

The following main findings – which are of relevance for the further development of the Action Plan – can be summarized.

1. Currently, no detailed information about the port`s electricity consumption is available. In future, an Energy Management System needs to be installed to at least track electricity consumption.
2. The Port of Bar consumes more than 3.5 GWh energy per year and can thus be considered as important regional energy consumer.
3. The most important mobile energy consumer group is "yard operations" with a share of more than 40% of total energy consumption. It seems useful to first focus on this group to reduce energy consumption and emissions in the Port of Bar.
4. The most important stationary energy sources are the terminal lighting and the cold storage 1, followed by the administration building and the cold storage 2.
5. The normalized energy consumption of most equipment – in particular the cranes, forklifts and the wheel loaders – is relatively high compared to other ports. Hence, there seems to be great potential for improving the level of energy sustainability in the Port of Bar.

2.2.3 Energy Sustainability Status Port of Bar

For the Green Port Action Plan, it appears useful to also prepare a Benchmark Analysis. As the focus of the Green Port Action Plan is on energy-related aspects, the benchmark analysis should also focus on energy sustainability issues. The main goals of an Energy Sustainability Benchmark analysis are to:

- ✓ Assess the project partner's current energy sustainability performance;
- ✓ Reveal gaps or shortcomings regarding energy / emission quality; and
- ✓ Identify the port with the best-in-class energy sustainability performance.

Note that the preparation of a comprehensive Energy Sustainability Benchmark Study would exceed the scope of the study significantly. Detailed data about the energy performance – here: emission output (GHG and air emissions) and energy consumption – of all partners have to be collected and evaluated. The main problem here is that most data are not publicly accessible. Consequently, the status of energy sustainability is assessed by highlighting initiatives of the selected partners with regard to energy issues.

The approach for the preparation of the Energy Sustainability Benchmark Study consists of three essential steps, illustrated in Figure 18.

[6] Please note that detailed information must be treated confidentially.

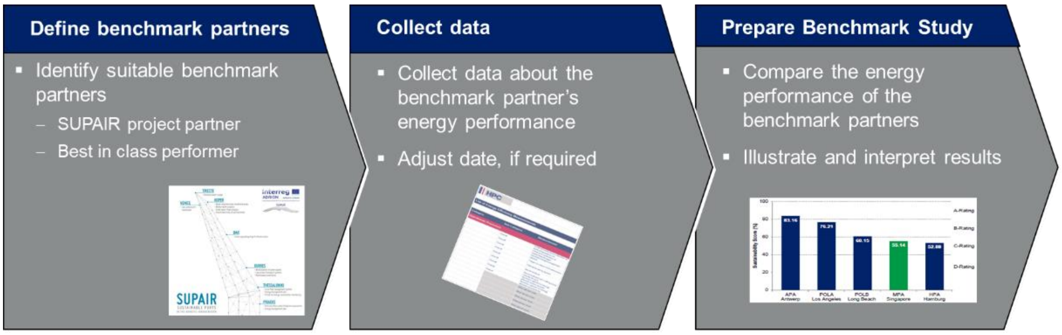

Figure 18: Procedure for Energy Sustainability Benchmark Study

First, two different kinds of benchmark partners will be considered. Due to regional proximity, the main ports in the Adriatic-Ionian region which also participate in the SUPAIR project (namely Trieste, Venice, Koper, Bar, Durres, Thessaloniki and Piraeus). Second, one of the world's leading energy sustainability port operator, the HHLA Hamburger Hafen und Logistik AG, located in Hamburg referred to as "best-practice port". In the second step, data will be collected about the benchmark partner's current energy sustainability status. To this end, it is examined how many of selected "top" energy sustainability measures have already been implemented in the considered ports. Note that these indicatives aim to reduce both the environmental impact of ships located in the port as well as the environmental impact of port facilities. In addition, the focus is on measures which are usually implemented by the port operator and not the port authority. Hence, e.g. the implementation of a smart traffic concept in port or vessel speed reduction programs will not be considered as the port authority usually bears the responsibilities for these measures. Finally, the data will be evaluated, and the corresponding results be illustrated. In Table 5, the corresponding results of the Energy Sustainability Benchmark Analyses are presented.

Table 5: Initiatives of benchmark partners to foster sustainability (☑: implemented; (☑): partly impl.; ×: Not implemented; N/A: No information available)

Selected "top" energy sustainability measures	Bar	Trieste	Venice	Koper	Durres	Thessaloniki	Piraeus	HHLA AG
Environmental Policy	×	☑	☑	☑	×	☑	☑	☑
Certified Environmental Management System	(☑)	☑	☑	☑	×	☑	☑	☑
Definition of objectives for environmental improvement	×	☑	☑	☑	×	☑	☑	☑
Environmental Monitoring Program	×	☑	☑	☑	☑	☑	☑	☑
Renewable energy generation plants	×	×	(☑)	N/A	×	×	×	☑
Onshore power	×	×	×	×	×	×	×	(☑)
Green bunkering facilities (e.g. LNG)	×	×	×	×	×	×	×	×
Green Ship Promotion Programs	×	N/A	☑	N/A	×	×	×	☑
Energetic solutions: terminal buildings[7]	×	N/A	N/A	N/A	×	×	×	☑
Energetic solutions: cargo handling and pier equipment[8]	(☑)	N/A	N/A	☑	N/A	N/A	(☑)	☑
LED terminal lighting	×	N/A	☑	N/A	N/A	N/A	N/A	☑

[7] Energetic solutions for terminal buildings include the usage of LED lighting technologies or the installation of solar panels.

[8] Energetic solutions for cargo handling and pier equipment refer to the usage of alternative fuels (e.g. biofuel) or the electrification of the powertrain.

The table shows that the priority given to environmental protection varies among the ports considered. Most ports have set up an environmental management system that includes the mandatory presentation of an environmental policy and, as a rule, the monitoring of potential environmental impacts. Projects to reduce energy consumption and CO_2 emissions have so far barely been realized in all ports listed in the table above. A brief summary of the key environmental protection measures of each port is given below.

HHLA AG

Energy sustainability enjoys special status within HHLA's sustainability strategy. Terminals near cities need to be planned and run with the environment especially in mind. Organizing eco-efficient transport chains and climate protection are central issues in ecological and energy sustainability. The level of energy sustainability was increased by a variety of projects conducted at the HHLA companies. These include, among others, the deployment of energy-efficient, low-emission machinery and equipment (e.g. electrified automated guided vehicles), the utilization of more renewable energies, the installation of LED lighting equipment including adaptive lighting system or the compensation of unavoidable CO_2 emissions. In addition, the energy management system could be certified according to DIN EN ISO 50001 standard. Finally, an alternative power supply station, the LNG PowerPac, is currently tested in one of the HHLA´s terminals to supply eco-friendly power to container ships at berth. In 2019, it is planned to shape the first totally emission-free container terminal, the HHLA Container Terminal Altenwerder.

Port of Bar

The port operations are largely compliant with Montenegrin environmental and social regulations which have been transposed from applicable EU Directives.[9]In the Port of Bar, up to now only one operator, the Port of Adria JSC, has officially introduced environmental management in form of an Integrated Management System (IMS, certification in September 2018) which includes the Quality Management System (ISO 9001: 2015), Environmental Management System (ISO 14001: 2015) and the Occupational Health and Safety Management System (OHSAS 18001: 2007).

Port of Trieste

The Port Network Authority of the Eastern Adriatic Sea was the first in Italy which obtained a certification on both, a Quality Management System in accordance with ISO 9001 and an Environmental Management System, ISO 14001. [10] . The port participates in a number of regional projects for re-naturation of contaminated industrial sites.[11]

Port of Venice

The North Adriatic Sea Port Authority (NASPA) has developed an environmental vision and is pursuing the "Green Port" philosophy with the implementation of a number of projects and activities. These include enhancing the air quality, protection of the Venetian Lagoon, noise reduction and introduction of energy efficient measures and equipment. In 2011, the Port started developing an environmental management system in accordance with ISO 14001 and has been certified in 2012.

[9] EBRD: Port of Bar Privatization

[10] www.adriaports.com

[11] www.porto.trieste.it

Venice is one of the busiest cruise ports in the Mediterranean, with nearly 500 cruise ship departures and 700,000 cruise passengers per year.[12] Despite this high number of cruise vessels, technical measures (e.g. shore power supply) have not yet been taken to reduce emissions from cruise shipping. However, the port has introduced a voluntary "Venice Blue Flag" agreement in which the sulphur content in the fuel as well as the PM10 and PM2.5 fractions in the exhaust gas have been gradually reduced.[13] Energy saving measures include the adoption of a LED lighting system in the passengers' terminal and another LED system, supported by solar panels, for illuminating 15 km of the main port approach canal, the Malamocco-Marghera Canal.

Port of Koper

In 2000, the Port of Koper was one of the first European and the only Mediterranean port that established an environment management system in accordance with the ISO 14001 standard which applied to all port activities; and in 2010, the port obtained the EMAS (EU Eco-Management and Audit Scheme) certification. Furthermore, the Port of Koper won the ESPO Award on Innovative Environmental Projects in 2014.[14] Also, the port has introduced a comprehensive environmental monitoring program.

The port is about to electrify its handling equipment. This year, five new electric gantry cranes started operation; three electric RMGs have been installed in 2017[15], thus, reducing emission, energy consumption, and noise emissions.

Port of Durres

The Port of Durres has an Environment Directorate which reports directly to the Port Authority. The Directorate is responsible for cleaning and monitoring the land- and waterside port areas.[16]

Port of Thessaloniki

From 2003 till 2014, the Port of Thessaloniki was accredited according to the PERS environmental management standard and it is a member of the EcoPorts network. Since 2015, the port applies an environmental management system in accordance to ISO14001 for all international standard port facilities and processes. The port has established an "Environmental Monitoring Mechanism" which regularly controls all environmental parameters, including sea water and air quality. The monitoring results are posted and are publicly available on the port's webpage.[17]

Port of Piraeus

The Port Authority of Piraeus (PPA SA) has developed an Integrated Quality and Environmental Management System in compliance with the requirements of the ISO 9001:2015 and ISO 14001:2015 standards. PPA SA has also received a PERS (Port Environmental Review System) certification, a port sector specific environmental management standard, developed by EcoPorts.[18] This year, PPA S.A. was honored with an award for the "Environmental Quality Monitoring Programs" by the Centre for Sustainability and Excellence (CSE) in cooperation with the MBA International of the Athens University of Economics and Business.[19] In

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[12] europeforvisitors.com
[13] www.port.venice.it
[14] ESPO European Seaport Organization
[15] www.portseurope.com
[16] www.tenecoport.eu
[17] www.espo.be/news/port-of-the-month-port-of-thessaloniki and www.thpa.gr
[18] www.espo.be
[19] www.olp.gr

order to reduce fuel consumption and emissions, the Port of Piraeus operates twelve all-electric rubber-tyred gantry cranes (RTGs) at the Piraeus Container Terminal (PCT).[20]

Summary of Key Findings

As expected, the HHLA AG located in Hamburg reached the highest ranking and can thus actually be considered as “best-in-class”.

It can also be seen that currently a number of energy sustainability projects have already been and are being carried out in ports of the Adriatic-Ionian region. Thus, a number of "top" energy sustainability measures from the above list have already been covered. However, most of them, such as the outline of an environmental policy or the Environmental Monitoring Programs, are formally included by introducing an Environmental Management System (ISO 14001). As this standard is generally applied to certain business areas only, it does not provide any information about the entire port, as can be seen in the port of Bar, where the operator of Port of Adria can present a certified environmental management system but no information is available e.g. about specific energy consumption.

The comparison of the ports in the Adriatic-Ionian region with the “best-in-class” terminal, however, reveals that there is substantial room for improvement in terms of energy sustainability. Consequently, further environmental and climate protection projects in the Adriatic region should be urgently implemented in future. This applies in particular to the port of Bar, which, compared with other ports in the region, has so far implemented only few measures to enhance climate- and environmental protection and has to make a significant step forward to achieve the status of a “Green Port”.

2.2.4. Regulatory Framework

In the following, the environmental rules and requirements affecting the port industry and thus the Green Port Action Plan are briefly presented. It goes without saying the Port of Bar at least complies with existing environmental regulations. In general, energy issues from regulatory points include the following: air and greenhouse gas (GHG) emission. It is worth noting that GHG, air and noise emissions in ports arise from different sources, i.e. from pier and cargo handling equipment (e.g. forklifts), terminal buildings (e.g. lights), road traffic (e.g. trucks) and ships at berth.

National Environmental Regulations

Montenegro is a potential candidate for EU membership. Thus, most environmental laws are aligned with relevant EU Directives.

National environmental legislation with relevance to the Green Port Action Plan includes:

- The Law on Energy Efficiency (to be implemented since May 1st, 2011) is the legal framework for the development of energy efficiency and rational use of energy in Montenegro; it has been developed in accordance with the requirements of the European Union Directives in the field of energy efficiency. In particular, Article 20 of this Law refers to the obligation of large energy consumers to draw up annual plans for improving their energy efficiency, which are to be submitted to the Ministry of Economy.

[20] worldmaritimenews.com

- The Law on Environment (52/2016): it regulates basic principles of environmental protection and sustainable development, instruments of environmental protection, monitoring, information system, public participation in decision-making in environmental matters, responsibilities, national plans (climate changes, desertification) etc.
- Law on Environmental Impact Assessment (EIA) (75/2018) and Law on Strategic Environmental Impact Assessment (SEIA) (br.080/05 od 28.12.2005, br. 073/10 od10.12.2010, 040/11 od 08.08.2011, 059/11 od 14.12.2001, 052/16 0d 09.08.2016): set out the requirements for undertaking an assessments of potential environmental impacts of public and private projects which are likely to significantly impact the environment, before development consent / construction permit is granted in the form of an approval for project implementation. This law applies to all construction / extension activities also in the port.
- Law on Integrated Pollution Prevention and Control (IPPC) (br. 080/05 od 28.12.2005, br.054/09 od 10.08.2009, 040/11 od 08.08.2011, 042/15 od 29.07.2015, 054/16 od 15.08.2016, 055/18 od 01.08.2018): it regulates conditions and procedures for granting an integrated license, it regulates activities of facilities, surveillance etc.
- Law on Environmental Noise (02/2018): regulates protection against noise in the environment and determines measures for mitigation of harmful effects of the noise on human health.
- Law on Air Protection (43/2015): regulates air quality monitoring, air protection measures, air quality assessment, planning documents for air quality management, inspection and supervision.
- Law on Industrial Emissions (2019).
- Transport Development Strategy of Montenegro (2019).

Environmental matters relating to the port are regulated by the Law on Ports (2008):

- Obligation of Port Authority and the Port Concessionaire to respect international and national laws and regulations, in particular the MARPOL Convention, related to preventing pollution from ships, protection of the sea and coastal areas, as well as civil responsibility for the damage caused by pollution.

In addition to environmental legislation, Montenegro has developed a number of strategic plans and instruments to protect and improve the environment, including:

- Declaration on Montenegro as an Ecological State (1991) which resulted in a series of strategies and bylaws related to prevention of air pollution and climate change.

- National Sustainable Development Strategy (2007) which describes in its chapter 5.2.9 Montenegro's obligation to contribute to climate protection, in particular by reducing CO_2 emissions.

- Strategy for Integrated Management of Coastal Area (2007) which provides a decision-making tool to guide the coastal development process toward sustainability. The environmental segments considered in the Strategy also include air pollution and consequences of climate change (droughts, heavy rains, storm and winds) as well as a vulnerability model for climate change.

International Regulations and Conventions

Montenegro is party to a number of international conventions; the most important in terms of air emissions and climate change is undoubtedly The Paris Agreement, an agreement within the United Nations Framework Convention on Climate Change (UNFCCC) dealing with greenhouse gas emissions mitigation in order to keep the global temperature rise below 2 °C above pre-industrial levels, and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. With regard to ports and shipping, the International Convention for the Prevention of Pollution from Ships or MARPOL Convention should be mentioned first and foremost. This convention contains six technical annexes, all of which are signed by Montenegro. By this convention, the International Maritime Organization (IMO) regulates international air emissions from ships under Annex VI. In general, two sets of emission and fuel quality requirements are defined here: (1) global requirements, and (2) more stringent requirements applicable to ships in so-called Emission Control Areas (ECA) that include both the Baltic Sea and North Sea. An ECA can be designated for SO_x and PM, or NO_x, or all three types of emissions from ships. The most important international air pollution (No. 1-3) and greenhouse gas (No. 4) are explained in detail below.

1. Sulfur Oxides (SO_x)

Sulfur oxides (SO_x) are compounds of sulfur and oxygen molecules. It is a toxic, colorless gas, which is directly harmful to human health. In addition, it causes adverse impacts to vegetation, including forests and agricultural crops (for details, see Baltic Ports Organization, 2017 and World Bank Group, 1998). SO_x emissions of ships are regulated by MARPOL Annex VI that includes caps on sulfur content of fuel oil to control SO_x emissions and, indirectly, PM emissions. The sulfur limits and implementation dates are listed Table 6.

Table 6: MARPOL Annex VI fuel sulfur limits

Date	Sulfur limit in fuel [% m/m]	
	SO_x ECA	Global
2000	1.5	4.5
2010	1.0	4.5
2012		3.5
2015	0.1	3.5
2020	0.1	0.5

Source: MARPOL, 2018.

In the currently enforced ECAs (i.e. the Baltic and North Sea) vessels are required to use fuels not exceeding 0.1% sulfur. Alternative measures to reduce sulfur emissions (such as the use of scrubbers) are also allowed. Additionally, under the European Directive[21], the allowable fuel sulfur in all European Union and European Economic Area waters will be limited to 0.5% in 2020, consistent with the recently decided global sulfur cap. There is also a 0.1% maximum sulfur cap for fuels used by ships at berth in EU ports (introduced from 1 January 2010).

[21] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32012L0033

2. Particular Matter (PM)

PM is a mixture of solid particles and liquid droplets suspended in the air, many of which are hazardous. Particles less than 10 micrometers (PM_{10}) in diameter pose the greatest health problems while fine particles ($PM_{2.5}$) are the main cause of reduced visibility (dust, smoke or soot) (EPA, 2018).

Although PM can have harmful effects on human health, such as respiratory, cerebrovascular and cardiopulmonary diseases, so far there are no regulations which directly regulate PM emissions from shipping. PM emissions are only indirectly controlled through limitations on the maximum sulfur content allowed in fuels used on board ships or through achievement of equal or superior levels through the use of exhaust gas cleaning systems under MARPOL Annex VI. It should be noted, however, that PM has recently received increasing public attention. This is also true for ships, as these may operate close to populated areas or to arctic areas.

PM emission from on road traffic is regulated by the EURO standards.

- EURO 6d standard limits PM emission from diesel-fuelled cars to 4.5 mg/km.
- EURO VI standard for trucks and busses (> 3.5 t) sets the limit to 10 mg/kWh.
- For off-road machinery, the actual class VI of the 2004/26/EG policy limits PM emission to 25 mg/kWh.

3. Nitrogen oxides (NOx)

Nitrogen oxide refers to a binary compound of oxygen and nitrogen, or a mixture of such compounds. It gets primarily in the air from the burning of fuel. Among others, NO_x forms acid rains and contributes to nutrient pollution in coastal waters. In addition to that, it may cause several health problems.

NO_x emissions of ships are also regulated by MARPOL Annex VI. The NO_x emission limits of Regulation 13 apply to each marine diesel engine with a power output of >130 kW installed on a ship. As presented in Table 7, NOx emission limits are set for diesel engines depending on the engine maximum operating speed (n, rpm). Currently, the Tier II emission limit is effective for engines installed on a ship constructed after 1 January 2011.

Table 7: MARPOL Annex VI NO_x emission limits

Tier	Date	NO_x limit [g/kWh]		
		n < 130	130 ≤ n < 2000	n ≥ 2000
Tier 1	2000	17.0	$45 \cdot n^{-0.2}$	9.8
Tier 2	2011	14,4	$44 \cdot n^{-0.23}$	7.7
Tier 3	2016*	3.4	$9 \cdot n^{-0.2}$	1.96

Source: MARPOL, 2018.

The Tier III standard currently applies only to ships operating in ECA established to limit NOx emissions.

NO_x emission from on **road traffic** is regulated by the EURO standards.

- EURO 6d standard limits NOx emission from diesel fueled cars to 80 mg/km.
- The EURO VI standard for trucks and busses (> 3.5 t) sets the limit to 400 mg/kWh.
- For off-road machinery, the actual class VI of the 2004/26/EG policy limits NOx emission to 400 mg/kWh.

4. Greenhouse Gas (GHG) Emissions Rules and Regulations

Although CO_2 is the most influential GHG, there is a growing pressure to consider other greenhouse gases and their contribution to climate change. In most studies, CO_2, CH_4 and N_2O are the gases most commonly included within transport CO_2-equivalent (CO_2e) emissions factors.

It is important to note that individual greenhouse gases vary in terms of their effectiveness in influencing climate change (see Table 8). To account for this, the gases are rated in comparison to the effectiveness of CO_2, so they can be compared. Each gas has been assigned a CO_2 equivalence (CO_2e) number known as its global warming potential (GWP), with CO_2 being equal to 1.

Table 8: IPCC global warming potential values

Greenhouse gas	Fourth Assessment Report	Fifth Assessment Report
CO_2	1	1
CH_4	25	28
N_2O	298	265

Source: IPCC, 2007 and 2013.

It is expected that shipping emissions will rise considerably in the future. In detail, shipping emissions are predicted to double from 2012–2050 and more than triple over 1990 levels, mainly due to the increased transport demand. Therefore, there is widespread agreement that the shipping sector also needs to reduce GHG emissions in future. As a result of this, in 2011 MARPOL Annex VI also introduced mandatory measures to reduce greenhouse gas emissions in shipping. The mandatory instruments that are intended to ensure energy efficiency standard for ships are:

- The Energy Efficiency Design Index (EEDI): The EEDI is focused on CO_2 and is currently applicable only to new ships. It is a performance-based mechanism that aims at promoting the use of less polluting equipment and engines.
- The Ship Energy Efficiency Management Plan (SEEMP): The SEEMP is an operational measure that establishes a mechanism to improve the energy efficiency of a ship in a cost-effective manner.

Both regulations apply to ships above 400 gross tons and came into force in January 2013. In addition to that, the EU MRV (Monitoring, Reporting, Verification) regulation entered into force on 1 July 2015 that requires ship owners and operators to annually monitor, report and verify CO_2 emissions for vessels larger than 5,000 gross tonnage (GT) calling at any EU port.

Despite these initiatives, it can be expected that emission regulations for ships, especially in the EU, will become more stringent in future[22]. Partly as a response to this, the IMO Maritime Environment Protection

[22] For details see: https://www.eea.europa.eu/articles/aviation-and-shipping-emissions-in-focus

Committee (MEPC) established in 2016 a roadmap for developing a comprehensive IMO strategy on reduction of GHG emissions from ships.

CO_2 emission of new built cars and pickups are regulated by EG Nr. 443/2009 and EG Nr. 510/2011.

- The limit of average fleet emission per carmaker will be gradually reduced from 120 g/km in 2015 to 95 g/km in 2020.

So far, no CO_2 regulations for trucks, busses or off-road machinery exist. However, in May 2018, the European Commission presented a legislative proposal setting the first ever CO_2 emission standards for heavy-duty vehicles in the EU (European Commission, 2018).

2.3 Stakeholder Strategy

As briefly explained above, not only the commitment and the endorsement from the upper management level, but also the collaboration with other stakeholders and regulatory agencies are paramount for a success of the Green Port Action Plan for the Port of Bar. 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 this regard, government support can help to accelerate the commercial viability and technical feasibility of certain, promising measures. In particular, various policies and regulations – e.g. low carbon fuel standards – could support their uptake. Furthermore, a successful stakeholder involvement will lend credibility to the Plan. Ideally, all relevant stakeholders should be engaged throughout the action planning process, from the initial scoping of the plan through implementation and monitoring.

As a consequence of this, a comprehensive stakeholder workshop has been conducted on April 05, 2019 and on April 2018 in the Port of Bar mainly to:

- present the goals and approach of the Green Action Plan;
- collect stakeholder´s needs and requirements; and
- discuss the stakeholder´s role on the project.

Besides the Port of Bar and the project team of HPC Hamburg Port Consulting, members of the Maritime Safety Department (part of the Ministry of Transport), of the Municipality of Bar as well as the representative of the Environmental Inspection / Administration for Inspection Affairs of Montenegro attended the meeting. All information and insights gathered within this workshop are considered for the preparation of the Action Plan and be described in the following sub-section. To this end, a distinction is made between external and internal stakeholders.

2.3.1 Internal Stakeholders

The internal stakeholders are generally employees of the port. All relevant employees have been informed about the intention and the relevance of the Action Plan within the Green Port Action Plan development process. In particular, there has been a close collaboration between a Port of Bar working group responsible for environmental issues and the (HPC) authors of the Action Plan. After the finalization of Green Action Plan, the main results and recommendation of the plan should be presented to all relevant employees to motivate employees engaging in rolling out the plan.

In the next step of the Green Action Planning process (implementation of the plan), it is recommended that an internal port team (or working group) will be selected to steer the development of the plan. This team should consist of employees from the main departments that will be impacted by the plan's recommendations, as determined by the scope of the plan. It is best to work internally at multiple levels, including executives, midlevel managers and front-line employees. It is also recommended to engage the board of directors or equivalent authority to ensure support for the plan. The members of the internal team also will be responsible for engaging employees in other relevant departments at appropriate times throughout plan development and implementation.

2.3.2 External Stakeholder

The external stakeholders related to Green Port Action Plan are mainly:

- regional partners: e.g. port authority, city or government departments of transportation or environmental regulators; and
- advocates: e.g. non-profit organizations, academics and the general and / or affected public.

Usually, one of the most important "Green Port" stakeholder is the Port Authority which can also apply energy sustainability measures in the port area (e.g. smart traffic solutions) and establish the framework conditions for achieving a "green port transformation". In the Port of Bar, the landlord port model applies, in which the Port Authority (located in Kotor) affects the port structure from a mainly political and regulatory perspective. Port operation is carried out by private as well as public companies (terminal operator) that lease the required infrastructure from the authority and procure, operate and finance the superstructure (e.g. cranes and buildings) required. Since port authorities (under the landlord model) do not carry out port operations, their share on a port's total energy consumption is relatively low. Nevertheless, there is a broad range of, mainly indirect, measures to foster energy sustainability in the whole port area, as illustrated in Figure 19.

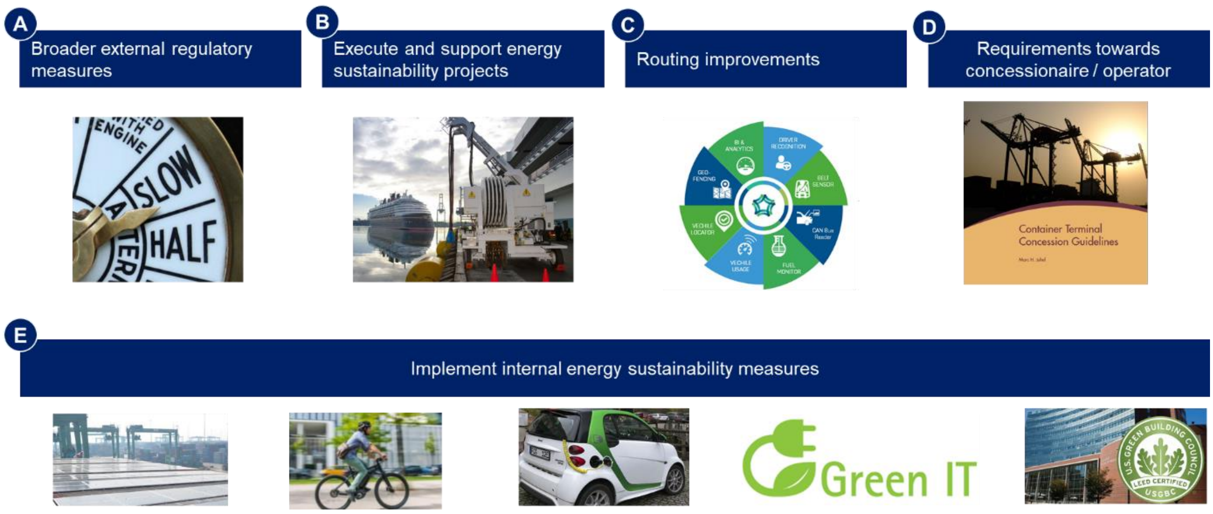

Figure 19: Potential energy sustainability measures for a port authority (Source: HPC, 2019)

In particular, the Port Authority can install certain (green) infrastructure to foster energy sustainability in ports, such as installing shore power supply or liquefied natural gas bunkering facilities. In addition, the Port Authority can provide up-to-date traffic information to the port operators to improve the whole traffic flow in the port area, also resulting in energy / emission savings in the entire port area.

Recommendation 1: As a consequence of this, it is strongly recommended to improve the collaboration between the Port Authority and the port operators in Bar. As explained above, otherwise it will not be possible to exploit the full potential in the Port of Bar´s (energy) sustainability efforts.

Other important regional partners are public authorities responsible for environmental issues and / or transport, intergovernmental and international institutions as well as policy stakeholders. As previously stated, the most important stakeholders have been involved in the Green Port Action Plan development process by participating in a comprehensive stakeholder workshop.

Recommendation 2: Nevertheless, it is strongly recommended to further engage all relevant stakeholders after the finalization of the Action Plan.

For example, these stakeholders should be informed about the project findings. It is also recommended to emphasize the necessity to enact the plan. The more the stakeholders are involved in the whole planning process, the greater the chance that they also support the actual implementation of the plan. It is worth noting that the rough dissemination of the Action Plan´s results is ensured since the Action Plan will be made available on the SUPAIR´s project homepage.

Involving shipping companies in the Action Plan is also an important element of a successful Action Plan since pollutants and energy consumptions in ports are also caused by ships. In addition, shipping lines have to cooperate with terminal operators and port authorities in establishing appropriate port energy infra-and superstructure (e.g. onshore power). Unfortunately, as a result of spatial and temporal borders, the shipping lines have not been involved in the Action Plan development process.

Recommendation 3: Since ships in ports are usually responsible for the largest share of emissions, shipping lines shall also be encouraged to participate more strongly in the “energy sustainability planning process”.

The other set of external stakeholders, advocates for the development and implementation of the plan, include non-profit organizations, academics and the general public. Engaging the advocacy stakeholders should be done in a manner that allows for constructive conversation and debate. These external stakeholders can play a key role in advocating for the necessary coordination, legislation and funding for implementing the recommendations of the Green Action Plan. Therefore, it is also recommended in future to engage these stakeholder groups before enacting the plan in the next step.

Recommendation 4: In particular, local residents shall be informed about the Port of Bar`s environmental efforts. For example, communication campaigns can be carried out by the Port of Bar to ensure and even increase the acceptance of the port operations next to the city centre and thus improve the port-city relationship.

2.4 Energy Sustainability Vision and Goals

Establishing a vision and a corresponding set of goals is critical to the development of the Green Action Plan.

- The vision serves as the guiding principle and paints a picture of where the Port of Bar wants to be in terms of energy sustainability. It has a long-term timeframe.
- The corresponding goals will identify how the vision will be realized and will show in which fields the Port of Bar intents to take actions (see Chapter 3).

In general, goals should be broadly focused and should describe a desired future condition. A set of performance metrics should also be established to track progress toward the goals and objectives (see

Section 3.1.1). One of the main challenges for setting energy sustainability goals for the Port of Bar is that there is no data on actual electricity consumption available (see Sections 2.2.1 and 2.2.2). To set energy-reduction or emission mitigation goals from the baseline year (here: 2018), however, detailed information about the port´s current total energy consumption (fuel and electricity) need to be available. Since this data is not available at the moment, it is currently not possible to define concrete and quantitative objectives, but rather overarching sustainability goals that support the vision.

Energy Sustainability Vision for the Port of Bar

The Port of Bar is one of Montenegro's main cargo ports. The Port is also an important employer, which gives it a great regional status. The Port of Bar is also fully aware that ensuring a high level of energy sustainability may help to bring ecological, economic and technological advantages and can be essential for obtaining a leadership position for the port in the long term. In addition, the Port of Bar is fully aware that an insufficient level of energy sustainability could not only have substantial impacts on nature, society and economy as a whole but also on their operations. Against these challenges, the Green Action Plan project partners pursue the following vision:

> The **overall vision of Green Action Plan for the Port of Bar** is to take a regional leadership role when it comes to energy sustainable performance and continually develop, promote and implement actions to achieve ecologically sound but also profitable port operation.

Inflamed by this vision, the Port of Bar strives to create the necessary conditions to remain competitive in the long term and establish the conditions for growth.

Energy Sustainability Goals for the Port of Bar

To realize the vision established, the Port of Bar pursues three main energy sustainability goals:

- **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.

As explained above, emissions and energy consumption in the port area results from both vessel and port operations. However, the Port of Bar only has an indirect influence on mitigating emissions and reducing energy consumptions from ships in ports, e.g. by providing "green infrastructure" such as onshore power supply stations (for details see Section 3.2). Consequently, the focus of the Green Port Action Plan is on port operations. In Figure 20, the port´s main and sub energy sustainability goals are illustrated and the potentials that are expected to arise from achieving the respective goals are presented.

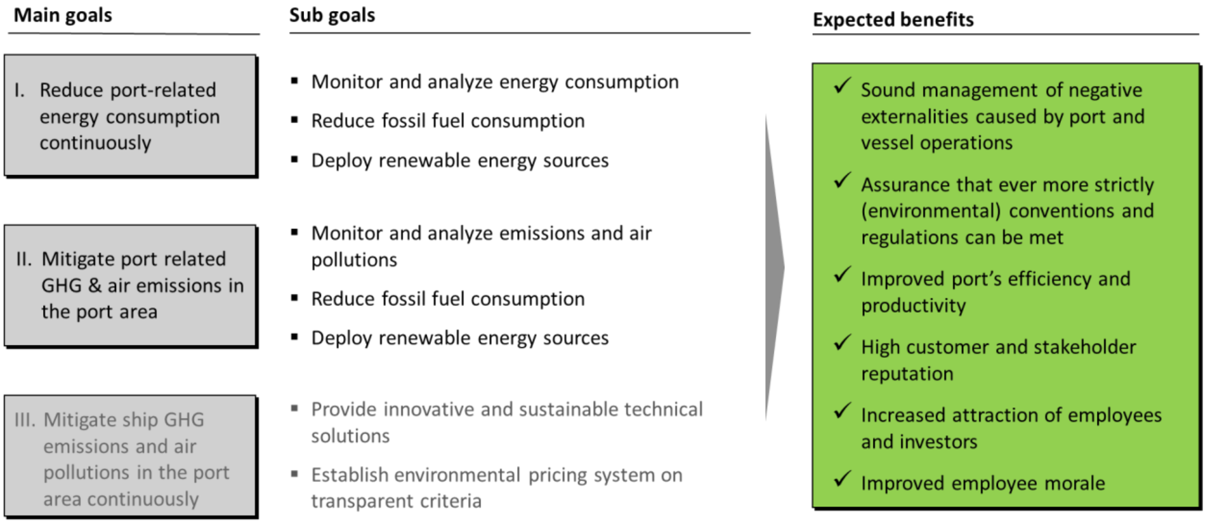

Figure 20: Port of Bar energy sustainability goals

These broader goals are used as overarching guidance of this Green Port Action Plans around which the initiatives / actions for reducing emissions end energy consumption will be organized. The next step of the Green Port Action Plan is to identify feasible and promising actions to reach these goals.

3. Operational Planning Phase

In the operational planning phase, specific measures for achieving the defined objectives are proposed. Therefore, a broad range of promising measures to improve a port's energy sustainability performance is identified and evaluated. All essential steps of this phase are illustrated in Figure 21.

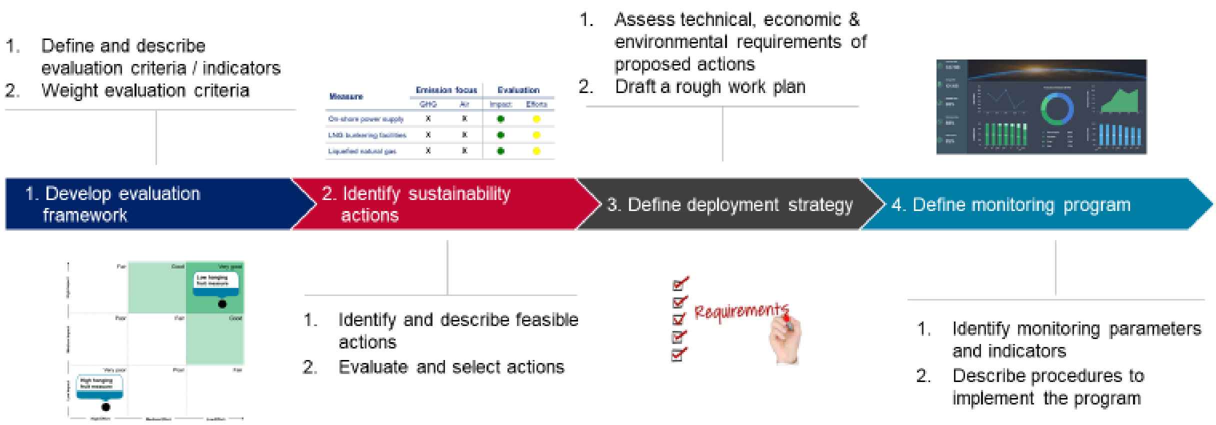

Figure 21: Operational planning phase of Action Plan

In the first step, a generic evaluation framework will be developed in which potential energy sustainability measures will be assessed using several evaluation criteria (Section 3.1). In the next step (Section 3.2), promising energy sustainability measures (or procedures) will be identified for the Port of Bar based on the evaluation framework developed. Afterwards, the most promising energy sustainability measures will be analyzed in detail, taking economic, environmental and technical criteria into account. In addition, a rough work plan will be elaborated for implementing the recommended measures (Section 3.3). Finally, a monitoring program is defined in which several metrics will be established to track and report on successes of these actions (Section 3.4).

3.1 Evaluation Criteria and Framework

In this section, an evaluation framework is developed. The overall goal of this framework is to assess all applicable “green” measures (see Section 3.2) comprehensively that contribute to achieve the energy sustainability goals defined in the previous section.

The first step of the proposed evaluation approach is the identification of suitable evaluation criteria for all measures. In order to derive criteria which are applicable to energy sustainability measures for the Port of Bar, all criteria have been aggregated into two main groups:

1. **Energy sustainability potential**: evaluates the quality of a measure with regard to its potential for reducing local air pollutants and greenhouse gas emissions as well as to reduce the total amount of fossil energy consumed the port.
    - The higher the resulting specific emission mitigation / energy saving potential of a measure, the higher the resulting impact.
        - The energy saving potential is assessed based on the expected total energy savings that result from the application of a certain measures (form: low – medium – high).
        - The emission mitigation potential is assessed based on the expected amount of emissions that can be saved through the implementation of a measure (form: low – medium – high). It should be remembered that two different kinds of emissions have to be considered: GHG and air pollutants (see Section 2.2.3). At this point of the Action Plan, however, both kinds of emissions are considered together. The emission saving potential will be assessed separately and in quantitative terms only for pre-selected (promising) measures.
    - Measures that contribute to reducing various kinds of emissions and energy consumption at the same time get a higher rating than measures that only contribute to reducing emissions or energy consumption. For example, air emissions can be reduced through selective catalytic reduction technologies but no GHG and energy saving potentials can be generated. By contrast, air and GHG emissions can be mitigated and energy savings be achieved through onshore power technologies. Accordingly, this measure would achieve a higher rating.
2. **Efforts for implementation**: this criterion relates to financial and operational efforts.
    - The sub-criterion “operational efforts” mainly comprises the estimated time it will take for this action to be implemented (short, medium or long term) and the resources (e.g. staff and material) required to implement a certain measure.
    - The sub-criterion “financial efforts” comprises the necessary CAPEX for the implementation of a measures (low, medium, high) as well as the estimated payback period.
        - Both sub-criteria, financial and operational efforts, will be merged by transforming both aspects in the following form: low – medium – high.
    - Measures that are relatively simple efforts to implement and amortize quickly achieve a higher rating than measures that can only be implemented with great expense and effort and have a long or even no payback period.

The most promising measures are those with a high impact / effort ratio, namely having a high impact on energy sustainability and, at the same time, requiring low effort for implementation (so called “low hanging fruits”). The quality evaluation scores are clustered into five categories – ranging from very good to very poor (see Figure 22). Applying this evaluation framework will help to prioritize potential energy sustainability measures. Based on the evaluation criteria, it is 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. In Section 3.3, these selected measures will be assessed in detail.

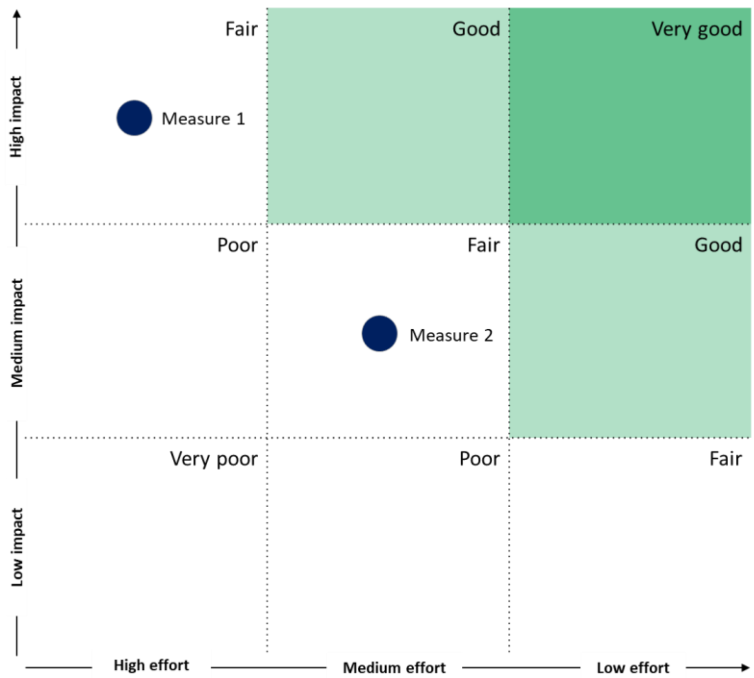

Figure 22: Energy sustainability evaluation framework

For the evaluation of measures, the local conditions and specific requirement of the Port of Bar have been analyzed and considered. In particular, the information gathered through the preparation of the emission / energy inventory (Section 2.2.2) must be considered in which the most important energy consumers in the Port of Bar have been identified. This is because the energy sustainability impact of a measure (e.g. electrification of terminal vehicles) depends on the share of the respective energy consumer in the overall energy consumption in the port. The more important the respective energy consumer, the better the energy sustainability impact of a measure. In addition, local conditions have to be considered for the evaluation of the "efforts for implementation". Regarding the provision of onshore power supply stations, for example, space constraints and financial restriction in the Port of Bar play an important role.

Summary and Overview of Evaluation Framework

In the following table, the evaluation framework including all evaluation criteria is summarized.

Table 9: Overview – Evaluation framework

Main evaluation criteria	Score	Sub-criteria	Description
Energy sustainability impact	Low / Medium / High	Energy saving potential	Expected fuel and energy savings [kWh / year]
		Emission saving potential	Expected GHG and air emission savings [tons/ year]
Efforts for implementation	Low / Medium / High	Financial aspects	Expected CAPEX, OPEX and payback period
		Operational efforts	Time and resources required

To sum up this evaluation scheme allows to analyze how, and to which extent a certain measure contributes to the achievement of the energy sustainability goals of the Port of Bar (evaluation criteria: energy sustainability impact). However, to avoid negative impacts on the port´s profitability and thus achieve a "cost-efficient green port transformation" financial and operational effects will also be estimated (evaluation criteria: efforts for implementation).

3.2 Sustainability Actions for the Port of Bar

3.2.1 Classification Scheme for Energy Sustainability Measures

All potential energy sustainability measures identified for the Port of Bar will be structured according to two main categories. This way, they are structured along the type of measure that needs to be taken (category 1, organizational categories) and the area in which the measure is applied (category 2, energy consumer clusters).

1. **Category 1 – port organizational aspects**: the clustering of energy sustainability measures according to operation (process-related), resource (technology-related) and behavior (-related) aspects allows for a first rough classification.
    a. Operation: measures to reduce energy consumption by improving processes in the whole port (e.g. extended gate hours).
    b. Resource: measures to decrease energy consumption by applying state-of-the-art and energy efficient technology (fully electric cargo handling equipment) as well as measures to reduce carbon emissions through the use of renewable energy sources equipment (e.g. solar power plants or wind turbines).
    c. Behavior: measures to promote the environmentally friendly behavior of employees (e.g. offering employees eco-driving lessons).
2. **Category 2 – energy consumer clusters:** in order to further structure the measures, all measures identified are clustered according to energy consumer clusters (see Section 2.2.2).
    a. Whole port;
    b. Ship loading and unloading equipment (e.g. mobile harbor crane);
    c. Yard operations equipment (e.g. forklift);
    d. Light duty vehicles;
    e. Buildings (administration building, warehouses grain silo and cold storages); and
    f. Terminal lighting.

At this point, it should be recalled that the most important energy consumer group in the Port of Bar is "yard operations" while the largest single energy consumer is the wheel loader with a share of more than 20% on the total energy consumption. For details, please see Section 2.2.2.

3.2.2 Overview – Energy Sustainability Measures for the Port of Bar

A number of feasible measures to reduce the Port of Bar`s port related emissions and energy consumption (main goal 1 and 2 of Green Port Action Plan) is summarized in the following table.

Table 10: Energy sustainability measures for the Port of Bar to reducer port relate emissions and energy consumption (main goal 1 and 2)

#	Measure	Type[23]	Description	Evaluation[24]		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 an EMS, it is highly recommended to create an energy management department or to appoint an energy manager. For example, 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 means 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
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

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

#	Measure	Type[23]	Description	Evaluation[24]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
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, 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.	H	L		X	
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-	H	H		X	

#	Measure	Type[23]	Description	Evaluation[24]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			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.					
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	
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

#	Measure	Type[23]	Description	Evaluation[24]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
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
20	Alternative HDV cooling concepts: grid connection	R	One further option is to connect the cooling units to the local grid. Again, the CO_2 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 are possible. This measure is also easy to implement due to the fact that state-of-the-art tires are slightly more expensive than conventional ones.	L	L	X	X	X
23	Tire 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 used for fully electrified cranes or hybrid propelled cranes. In case of the electrified solution the recovered energy	M	M	X	X	

#	Measure	Type[23]	Description	Evaluation[24]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			will be fed back into the onshore 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 CO_2e comparison reveals the emissions saving potential: • Diesel fuel: 3.21 kg CO_2e/kg diesel • Biodiesel (B100): 0 kg CO_2e/kg diesel • Biodiesel (B20): 2.67 kg CO_2e/kg diesel • Liquefied Natural Gas (LNG): 3.78 CO_2e/kg diesel • Liquefied Petroleum Gas (LPG): 3.1 CO_2e/kg diesel • Compressed Natural Gas (CNG): 2.28 CO_2e/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 infrastructure on the terminal’s premise. The company CASE has developed a wheel loader which is propelled by methane.	M	M		X	X
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	M	M	X	X	X

#	Measure	Type[23]	Description	Evaluation[24]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			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.					
30	Electrification of power train (battery or fuel cell)	R	Full electrification can be achieved in two mayor ways. Both solutions have in common that they use an electric motor as powertrain. A battery electric vehicle (BEV) is a type of electric vehicle that uses chemical energy stored in rechargeable battery packs. A fuel cell vehicle is a type of electric vehicle which uses a fuel cell, instead of a battery, to power its on-board electric motor. Currently, it seems that battery electric vehicles will probably win the race, mainly because of the much better degree of energy efficiency compared to fuel cell vehicles. Usually a fuel cell car consumes 2.4 times more energy than a battery electric car, because electrolysis and storage of hydrogen is much less efficient than using electricity to directly load a battery. Operators should expect to make major modifications at the terminal level when using (battery) electric vehicles. 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 considerable 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. • 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.	H	M	X	X	X
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

#	Measure	Type[23]	Description	Evaluation[24]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
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 • EVs are cheaper to maintain since there are fewer moving parts than in a conventional petrol/diesel car • EV 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 be avoided (not considering the production process of the EV and the battery) The main challenges of EVs are the long charging times and the short driving range with one battery charge. 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.	M	M	X	X	X
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	L	M	X	X	

#	Measure	Type[23]	Description	Evaluation[24]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			efficiency, i.e. reduce cooling electricity demand (on average by 7% on an annual basis)[25], 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; • 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	Optimization 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 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.	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 levels based on environmental conditions, user schedules, or other application-specific criteria. An adaptive lighting	M	M	X	X	

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

#	Measure	Type[23]	Description	Evaluation[24]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			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 CO_2e 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	
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	H	H	X	X	

#	Measure	Type[23]	Description	Evaluation[24]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			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.					
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 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.	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 operate more efficiently and reduce energy costs by 10% to 40%.	M	M	X	X	
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	M	L	X	X	

#	Measure	Type[23]	Description	Evaluation[24]		Focus		
				Impact	Efforts	Energy	GHG emi.	Air emi.
			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.					
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 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.	H	L	X	X	
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	

As explained in Section 2.4, the Port of Bar not only intends to reduce port-related emissions and energy consumption (Table 10) 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 providing incentives to vessel operators to foster sustainability, e.g. in the form of reduced port fees (green fees). In Table 11, a number of feasible measures to reduce vessel-related emissions in the port area is summarized.

Many environmental measures currently applied for vessels refer to the use of LNG. Therefore, the fundamentals of LNG as fuel for vessels are briefly presented. LNG is formed when natural gas is cooled to -162 ºC, which shrinks the volume of the gas 600 times. In its liquid state, LNG is not explosive and does not ignite and can reduce air pollution considerably. Using a gas-only engine can reduce SOx emissions and PM by almost 100% compared to conventional fuel oil. The technical solution often includes a dual-fuel engine that can run on either LNG or fuel oil. The CO_2 mitigation potential of LNG is proven to be substantial with CO_2 reduction which ranges between 5-30% compared to the heavy fuel oil. However, handling and combustion of LNG involves the release of unburnt methane, also referred as methane slip, which can diminish its overall environmental advantages depending on the volume of the methane emissions. Some reports therefore assume LNG to be rather a potential interim solution in order to reach low carbon ship transports. In addition, refitting an LNG or dual-fuel engine or boiler is highly cost demanding since substantial modifications of the whole system are necessary. It is also important to consider that the profitability of LNG for cruise ships depends upon future LNG and fuel prices. In future, a small part of LNG can also be produced by anaerobic digestion or gasification of biomass (Bio-LNG).

Table 11: 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[26]	Description	Evaluation[27]		Focus		
				Impact	Efforts	Energy cons.	GHG emissions	Air emissions
1	On-shore power supply (OPS)	R	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.	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. 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	H	M		X	X

[26] O = Operation / R = Resource / B = Behaviour

[27] L = Low / M = Medium / H = HIgh

#	Measure	Type[26]	Description	Evaluation[27]		Focus		
				Impact	Efforts	Energy cons.	GHG emissions	Air emissions
			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 CO_2 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 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.	M	L		X	X
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	M	M		X	X

#	Measure	Type[26]	Description	Evaluation[27]		Focus		
				Impact	Efforts	Energy cons.	GHG emissions	Air emissions
			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.					
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
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 CO_2 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-	H	L	X	X	X

#	Measure	Type[26]	Description	Evaluation[27]		Focus		
				Impact	Efforts	Energy cons.	GHG emissions	Air emissions
			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 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

3.2.3 Evaluation of Measures

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 in Section 3.1. In the following figures, all identified and pre-evaluated measures are presented, and the most promising ones are selected for further consideration.

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

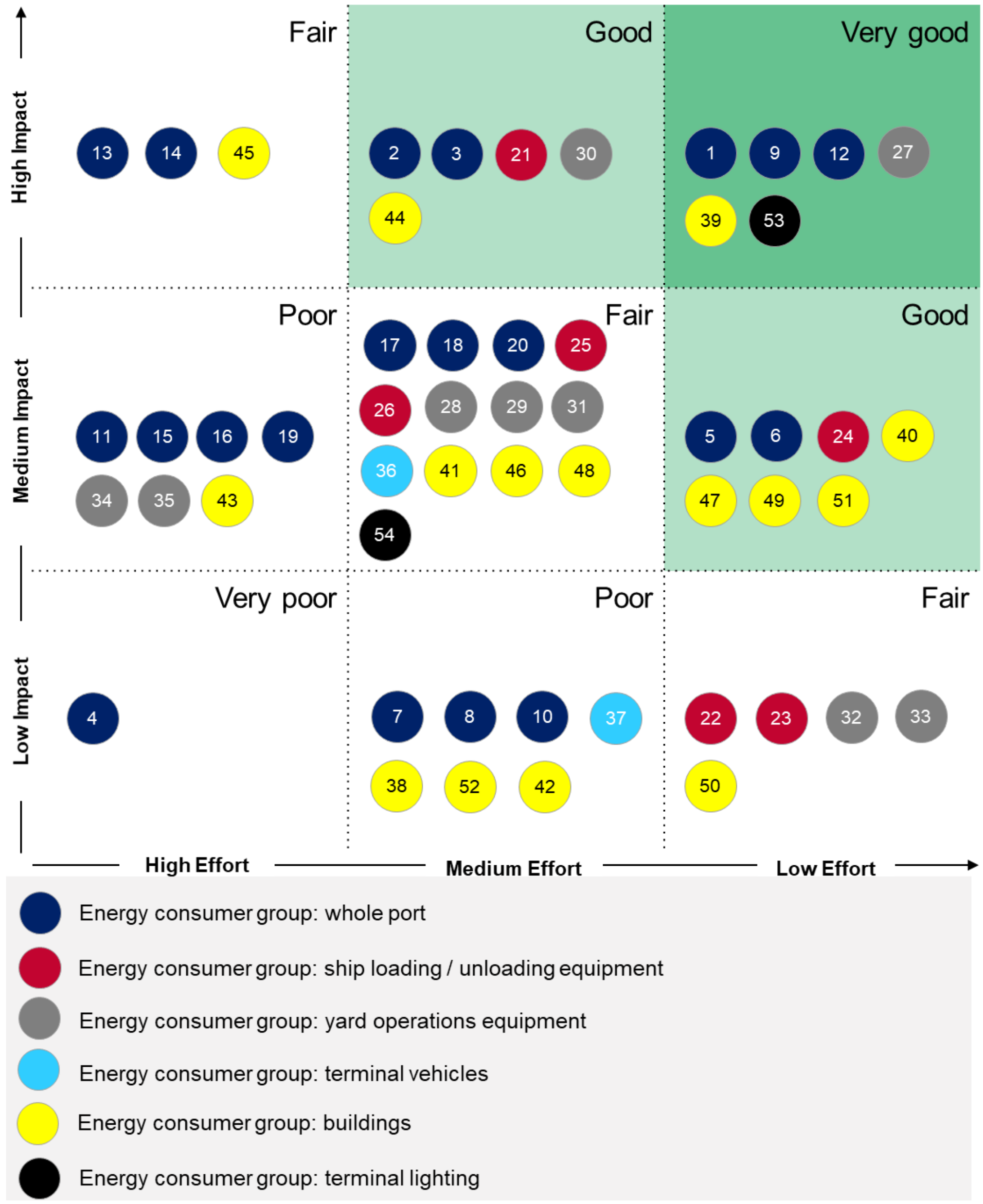

Figure 23: Energy sustainability measures for the Port of Bar to reduce port related emissions and energy consumption

Whole port		**Terminal vehicles**	
1	**Energy / emission target**	36	Electrification of power train
2	**Energy management system (EMS)**	37	Hybrid power train (plug-in-hybrid)
3	Energy audits	**Buildings**	
4	Smart grid applications	All buildings	
5	Employee suggestion system	38	Green roof
6	Employee environment training	**39**	**Optimization of HVAC system**
7	Employee bus shuttle services	40	LED technology
8	Bicycles for commuting purposes	41	Adaptive lighting
9	**Obtain “green” energy**	42	District heating / cooling
10	Bundling of power	43	Seawater source heat pumps
11	Cross-company use of waste heat	44	Insulation
12	**Renewable energy: Solar photovoltaics**	Administration building	
13	Renewable energy: Wind power	45	Nearly zero energy building
14	Renewable energy: Hydropower	46	Demand-controlled ventilation (DCV) system
15	Renewable energy: Biogas	47	Adjusting air temperature
16	Renewable energy: Geothermal	48	Energy efficiency measures in IT data center
17	Renewable energy: Microturbine	Warehouses and Storages	
18	HDV emission control zone	49	Painting walls white / install windows and skylights
19	HDV cooling concept: Dearman	50	Install air curtain
20	HDV cooling concepts: grid connection	**Cold storage**	
Ship loading / unloading equipment		51	Install air curtains
21	**Electrification of power train**	52	Provide sufficient perimeter insulation
22	Energy saving tires	**Terminal lighting**	
23	Tyre pressure control	**53**	**LED lighting**
24	LED floodlights and walkway lights	54	Adaptive lighting system
25	Regenerative drives		
26	Emission control technologies (ECTs)		
Yard operations equipment			
27	**Eco-driving lessons**		
28	Alternative fuels		
29	Hybrid power train		
30	**Electrification of power train**		
31	Emission control technologies (ECTs)		
32	Energy saving tires		
33	Tyre pressure control		
34	Speed controlling		
35	Speed switching		

The measures marked in green and bold are the most promising measure since they have a high energy sustainability impact and require only low efforts for implementation. In Section 3.3 these “low-hanging fruit” measures are considered in further detail. The other measures marked in green also seem to be promising for the Port of Bar, however, to a lesser extent.

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)

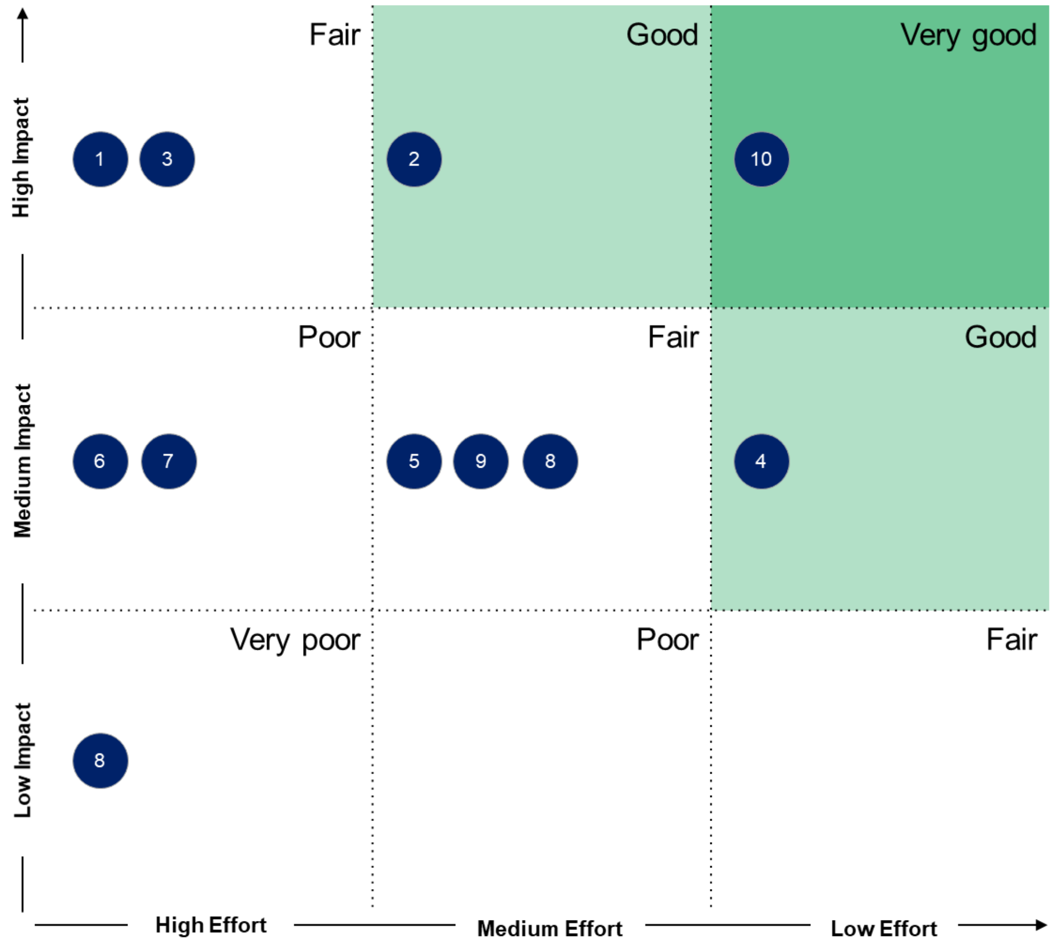

Figure 24: Energy sustainability measures for the Port of Bar to avoid or reduce ship GHG & air emissions in the port area

1	On-shore power supply (OPS)	7	LNG bunkering facilities: local liquefaction plant
2	LNG PowerPac	8	Automated mooring systems
3	Mobile LNG barge	9	Ship environmental monitoring system
4	LNG bunkering facilities: truck-to-ship (TTS)	**10**	**Green Port Fees**
5	LNG bunkering facilities: shore to ship	11	Slow steaming
6	LNG bunkering facilities: ship-to-ship (STS)		

Again, the measures marked in green and bold are the most promising measures and will be considered in further detail in the next section. As there is only one measure with a very high potential, the other promising measures (marked in green) will also be discussed.

3.3 Deployment Strategy

A Green Port Action Plan cannot be successful if it cannot be implemented. Therefore, in this section, a rough implementation plan will be developed to answer the following questions for each pre-selected measure, identified in the previous section:

1. Which resources are required for the implementation and what are the effects on existing port processes?

The technical assessment is supposed to create a brief understanding of the functional benefits and limitations of each measure. This approach outlines the complexity of a measure and how it affects the terminal layout, due to possible infrastructural adjustments. Furthermore, the capacity of measures is estimated which already sketches possible benefits and limitations.

2. What are the ecological advantages associated with the implementation of a measure?

To quantify the environmental (energy sustainability) impacts of a measure, the amount of fuel (diesel), electricity and / or emissions that can be saved or avoided through the implementation of a measure is estimated.

3. What are the costs associated with the implementation and what are the economic consequences over the entire service life of a measure?

The economic aspects of each measure are assessed by estimating necessary capital expenditures (CAPEX) to implement a measure and analyzing the effects on operational expenditures (OPEX). If possible, a total cost of ownership (TCO) analysis is conducted. A TCO analysis implies that all costs associated with the acquisition, use, and maintenance of an item are to be considered in evaluating that item and not just the purchase price. Performing a TCO analysis is strongly recommended for energy sustainability measures. Many energy sustainability measures (e.g. LED lighting vs. traditional lighting or electric cargo handling equipment vs. diesel-fueled cargo handling equipment) are related to higher upfront costs. Considering the whole life cycle, however, many measures often have a clear economic advantage since significant operational benefits (e.g. lower energy costs) can be achieved. Due to data constraints, however, it is not possible to perform a TCO for each measure in this Action Plan.

While some “complex” measures such as LNG PowerPac or Solar Photovoltaics require a separate consideration (technical, environmental and economic) there are several “simply to implement measures” such as obtaining green energy or employee suggestion system that will be considered together.

3.3.1 Technical, Environmental and Economic Assessment

3.3.1.1 Energy / Emission Reduction Goals

As laid out in detail in Section 2.4, it is of upmost importance to establish energy / emission reduction goals. These goals should be established through a collaborative process involving both, internal stakeholder (e.g. employees) as well as external stakeholders (e.g. municipality). Involving regional partners in developing the goals can help ensure regional coordination and cooperation in implementing the final plan. In addition, the energy / emission reduction goals should follow the SMART concept:

1. **S**pecific: well-defined, focused, detailed and concrete
2. **M**easurable: kWh, time, money, %, etc.
3. **A**chievable: feasible, actionable
4. **R**ealistic: in the context of the resources that can be made available
5. **T**ime-Bound: defined deadline

In practice, a potential SMART emission reduction objective could be: cut greenhouse gas emissions (GHG) by 40 percent by 2025, by 55 percent by 2028 and up to 75 percent in 2030, compared to 2017. As explained above, in the first step the current energy / emission output from the Port of Bar needs to be determined by installing all required measurement equipment (=energy management system). The economic and environmental aspects of this measure are not quantifiable since this measure can rather be considered as pre-condition for shaping a sustainable port. Based on the energy / emission reduction goals, respective measures should be implemented.

3.3.1.2 Energy Management System (EMS)

Technical and Environmental Assessment

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 (see Section 2.2.2). 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.

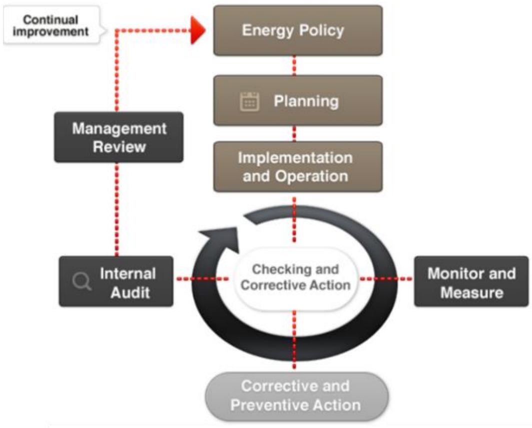

Figure 25: Phases of an EMS implementation (bureauveritas.com)

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). Detailed information can be found e.g. in Boile et al. (2016): *Developing a Port Energy Management Plan: Issues, Challenges, and Prospects.*

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.

Economic Assessment

In the Port of Koper, the implementation of an EMS in the fruit terminal lead to energy savings in the amount of 250 MWh which also results in significant cost-saving potentials. The installation costs (including monitoring and communication systems) was €65,000. According to the Port of Koper, the payback period of this measure was 3.5 years. It can be assumed that these values can be transferred to the Port of Bar.

Recommendation

Although the efforts for implementing this measure should not be underestimated it is strongly recommended to deploy an EMS in the Port of Bar. 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.

3.3.1.3 Obtaining Green Energy

Technical, Environmental and Economic Assessment

One measure with a high impact on reducing GHG and air emissions that is also relatively easy to implement for ports is obtaining green energy from energy producers. It is important to note that the actual emission reduction potential depends on the currently used energy mix of the port. Moreover, the additional cost of procuring pure renewable energy may vary considerably from country to country.

Montenegro's electricity needs are mainly met by the 225 MW lignite power plant at Pljevlja, the 307 MW Perucica and the 342 MW Piva hydropower plants. In 2016, approx. half (51%) of the electricity consumed in Montenegro was generation from renewable (mainly hydropower) sources.

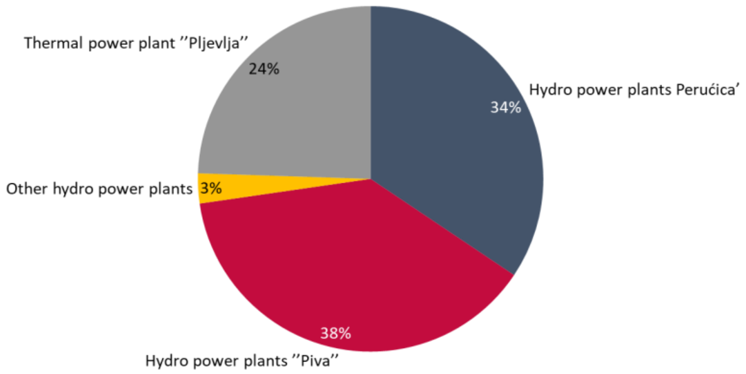

Figure 26: Montenegro`s 2016 share of installed capacities of power plants in the total capacity (data from. Montenegro Energy Regulatory Agency (2016): Report in the Energy Sector of Montenegro in 2016

Considerable attention is paid to the research and use of other energy resources, in the part of renewable (solar, wind, biomass, etc.), and activities on the exploration of hydrocarbons in the offshore zone of Montenegro have been intensified.[28]

According to the Port of Bar´s information, there is only one electricity providers in Bar. Hence, it is hardly possible to procure pure green energy. Even if no renewable energy can be procured, however, 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. Carbon offsets are measured in tons of carbon dioxide equivalent (CO_2e) and usually represent six primary categories of the greenhouse gases: carbon dioxide, methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons, and sulfur hexafluoride. One carbon offset represents the reduction of one ton of carbon dioxide or its equivalent in other greenhouse gases. There are several carbon offset providers available, for details see https://www.endscarbonoffsets.com/directory/. Worldwide, the range of carbon

[28] For details see: Montenegro Energy Regulatory Agency (2016): Report in the Energy Sector of Montenegro in 2016

offset prices in the voluntary offset market can be anywhere from $0.10 per ton to $44.80 per ton. A 2016 study conducted by Forest Trends' Ecosystem Marketplace reported that the average price of a carbon offset is about 3€ per ton of carbon dioxide equivalent.

Recommendation

To sum up, it is recommended to apply this measure – at least to a certain extent – since it is a quite easy to implement energy sustainability measures. It must be kept in mind that the focus should always be to directly reduce energy consumption and avoid emissions in the port area. Only if emissions cannot be avoided – e.g. since there are not economically viable and feasible solutions available – carbon offsetting can be justified.

3.3.1.4 Solar Photovoltaics

Technical and Environmental Assessment

This technology converts solar radiation into electric energy. The energy generated can be used by the port itself or be fed into the local grid.

Figure 27: 9.5 MW solar energy generation facility at Jurong Port (Source: porttechnology.org)

In terms of ease of installation and maintenance, solar power is clearly the most convenient way to generate renewable electric energy and thus most suited for ports / terminals. 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 results from a trial in the Port of Rotterdam showed that a single STS equipped with solar panels can produce around 16 MWh energy per year in the Netherland.

A solar photovoltaic system consists of solar photovoltaic modules, an inverted rectifier and an assembly system. 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.

The emission mitigation potential depends upon the carbon intensity of the grid energy currently used in a port. The lower the share of electricity produced in a country or region, the larger the environmental benefits of using own renewable energy generation plants. Assuming a country with 100% renewables, having own renewable energy generation would not result to further positive environmental impacts. As seen in Figure 28, renewable energy-based electricity generation in Montenegro reached more than 40% in 2014 making the country to one of the top countries for renewable energy. Therefore, the total environmental impact of installing solar photovoltaic modules in the Port of Bar is rather medium. It must be mentioned that, in contrast to most other countries, the share did not further increase in Montenegro by 2017.[29]

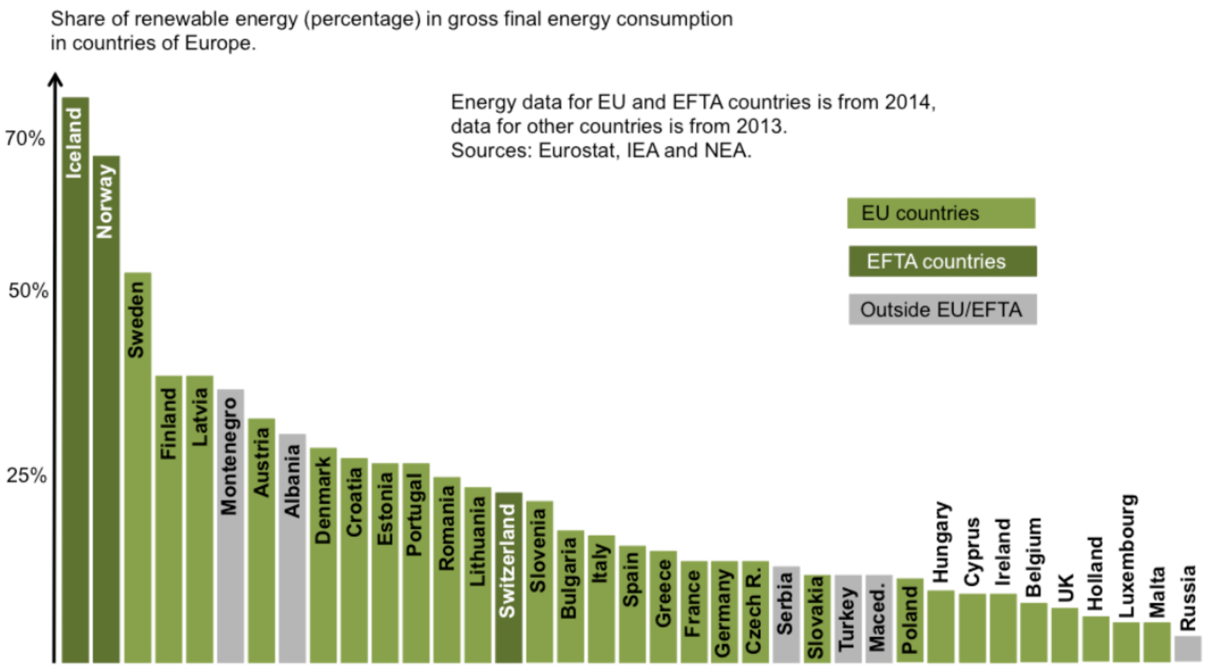

Figure 28: Share of renewable energy (percentage) in gross final energy consumption of each country within the EU and EFTA (Source: The Independent Icelandic and Northern Energy Portal, 2018)

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.

An overview of possible components of a photovoltaic system is given in Figure 29.

[29] https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=t2020_31&language=en

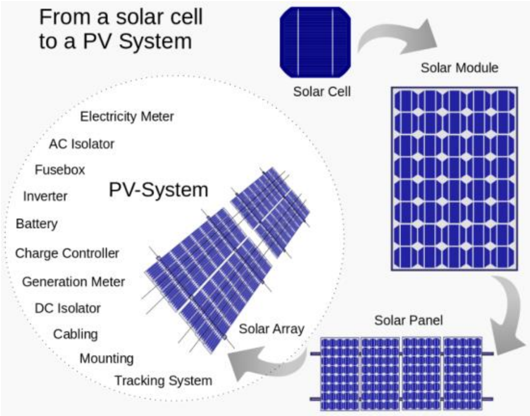

Figure 29: Possible components of a photovoltaic system (wikipedia.org)

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). As benchmark: a photovoltaic system at the Container Terminal Tollerort in Hamburg (area: 0.6 km^2) mainly installed at roofs on selected terminals buildings produced 117,370 kWh of CO_2-free electricity in 2018.

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 corresponding results of the TCO analysis are illustrated in Figure 30.

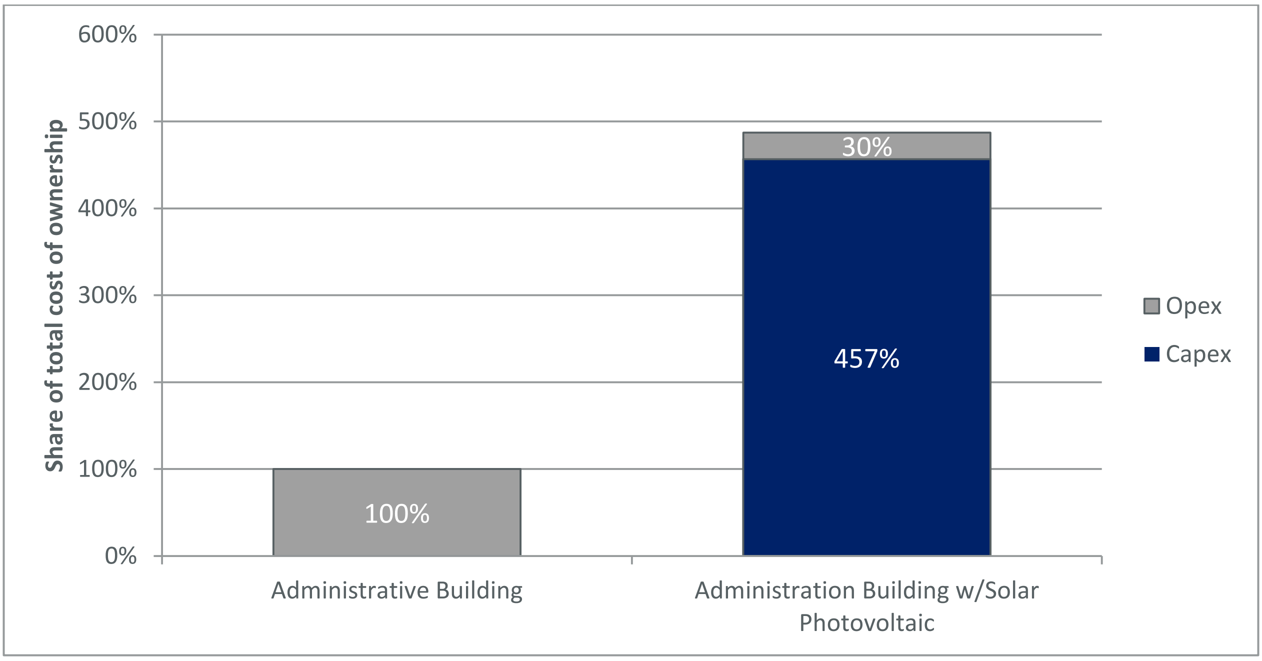

Figure 30: Capex and opex for solar photovoltaic

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 (see Figure 31). 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.

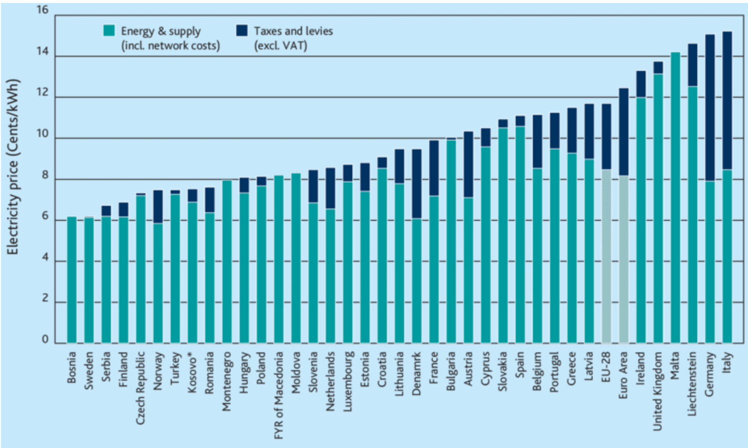

Figure 31: Electricity price for industrial consumers with a consumption of 0.5-2 GWh in Europe (Source: https://www.researchgate.net/figure/Electricity-price-for-industrial-consumers-with-a-consumption-of-05-2-GWh-in-Europe_fig9_322796409 [accessed 10 July 2019])

Recommendation

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.

3.3.1.5 Electrification of Power Train

Technical and Environmental Assessment

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. In this Action Plan, it is not possible to make valid statements about the most appropriate technology.

For the Port of Bar, 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 CO_2 emissions. Assuming that the required energy is generated from renewable energy sources, this measure has a considerable positive environmental impact. According to the Consultant´s information, the mobile harbor crane manufacturer has already submitted an offer for the electrification of the diesel-driven mobile harbor crane in the Port of Bar. 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. A small diesel engine or energy storage system is needed to drive the crane without grid connection to another area. Alternatively, a bus-bar connection can be deployed. The bus-bar installation included a pantograph and a connection box, however, is quite challenging and space-intensive. Protection measures must also be taken to prevent trucks from driving into the bus-bar construction.

It is also, with only reasonable effort, possible to replace the **diesel-driven terminal vehicle fleet** by battery-electric vehicles. However, since the terminal vehicles consumed less than 300 liters of fuel in 2018, this measure is of less importance.

Although the **wheel loaders, skid steer loaders and material handlers** are the largest energy consumers in the Port of Bar (see Section 2.2.3) it is hardly possible to electrify this type of mobile equipment. This is because the required energy for operating these equipment devices is too high. Currently, some smaller electrified wheel loader is available, however, with limited operational capability (operation time with one battery charge < 3h).

The total and maximum CO_2 emissions saving potentials per year that result from a full electrification of the forklift fleet and the electrification of the mobile harbor crane is illustrated in Figure 32.

[30] The burning of 1 kg diesel fuel emits 2.67 kg CO_2

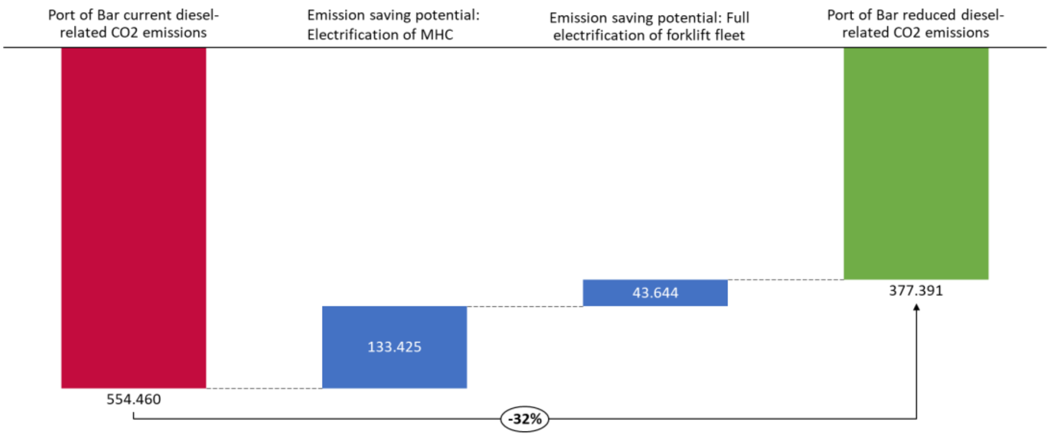

Figure 32: Annual CO_2 emission saving potential for the Port of Bar – Electrification of cargo handling equipment

To sum up, this measure is technically feasible and has a considerable positive impact on improving the level of energy sustainability in the Port of Bar. As explained above, the focus should be in the first step on the (further) electrification of the forklift fleet and on the electrification of the mobile harbor crane.

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. This would exceed the scope of this Action Plan and should be analyzed in a separate step.

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 250,000 – 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. It is highly recommended to request detailed information about the expected energy saving potentials and performing a TCO analysis before implementing this measure.

Recommendation

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. After having clarified the expected energy saving potentials from the manufacturer, this measure should also be implemented.

In future, the terminal vehicles should also be replaced by battery-electric vehicles. However, as a result of the currently rather low energy consumption of the terminal vehicles, the other measures should be treated with higher priority.

3.3.1.6 Eco-Driving Lessons

Technical, Environmental and Economic Assessment

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. At the EUROGATE Container Terminal in Bremerhaven, for example, average fuel savings of 7% per operating hour were achieved in test drives with the help of eco-driving in straddle carriers without increasing the time required for the tasks. At the Port of Trelleborg eco-driving training is mandatory for personnel who operate heavy machinery and has been shown to reduce fuel consumption by approximately 0.4 l per hour. The port has also enforced a speed reduction for terminal tractors together with a rpm regulation which has further reduced the amount of fuel used and the risk of accidents. Other positive effects of reduced speed and eco-driving are lower stress levels and improved control. If one transfers these results to the Port of Bar (assumption: 7% fuel savings after having established eco-driving), it becomes clear the energy / emission saving potential is considerable. As illustrated in Figure 33, more than 10,000 liters of diesel, corresponding to more than 26,000 kg CO_2 emissions can be saved. Note that only diesel consumers could be analyzed since no detailed electricity data are available.

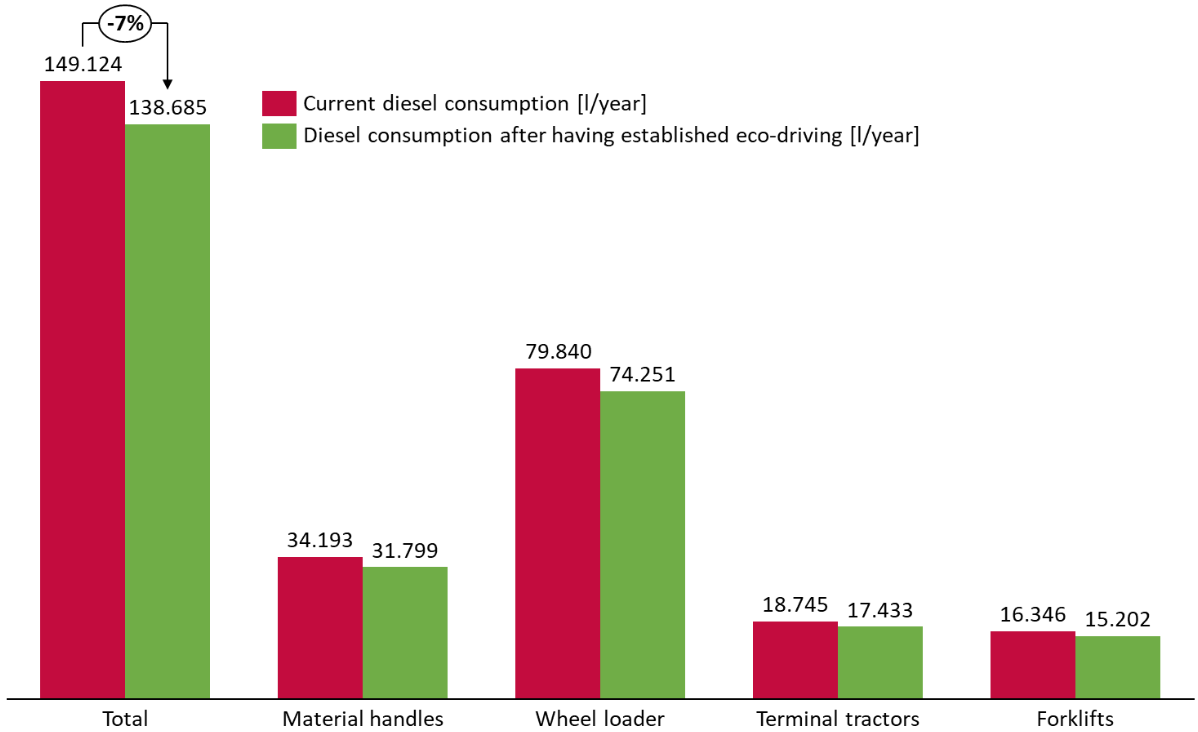

Figure 33: Annual expected fuel savings that results from offering eco-driving lessons in the Port of Bar

Recommendation

It is highly recommended to apply this measure since the ecological impacts are large and the implementation efforts are low. The eco-driving training can be provided in the form of on-road training or with simulators. Accordingly, the costs of implementing this measure are relatively low while significant cost-saving potentials in the form of reduced energy costs are expected to arise.

3.3.1.7 Optimization of HVAC system

Technical, Environmental and Economic Assessment

Usually, the major energy user of a port`s administration building is the heating, ventilation and air condition system (HVAC). Therefore, it is highly recommended to optimize a terminal's HVAC system. Typically, HVAC systems are electric driven and the most common heating energy sources are oil, gas, district heating or electricity. 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. Various studies have shown that air conditioning maintenance helps a unit to maintain up to 95% of its original efficiency. On the other hand, 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[31].
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. In the Action Plan, no cost estimated can be give since the buildings need to be inspected in detail.

Recommendation

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.

3.3.1.8 LED Terminal Lighting

Technical and Environmental Assessment

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).

[31] Bürogebäude - viel sparen mit weniger Strom, Bayerisches Landesamt für Umweltschutz, 2004

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 Table 12.

Table 12: 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

The carbon footprint of a terminal building can be improved slightly with moderate efforts by replacing conventional light bulbs by LED lights. Since no detailed electricity consumption from the Port of Bar are available, it is not possible to estimate the actual energy and emission saving potential. However, many operators that use LED lighting on port handling equipment have reported reductions in energy usage associated with lighting of up to 95 %.

Economic Assessment

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

The capital expenditures for LED lights are driven by the number of installments. At Port of Bar, there are 48 floodlight posts with eight lights each. Based on HPC expertise, a factor of 0.6 to retrofit the terminal lighting is applied, 230 LED lights thus replace the existing HID lighting system.

The capital expenditures for a single LED light are approx. 1.5 times higher than for conventional lighting. The maintenance costs for conventional lighting is between 5 and 10 % per year, whereas the maintenance costs for LED lighting are usually below 1%. The corresponding results of a TCO analysis for conventional and LED terminal lighting systems in the Port of Bar are displayed in Figure 34.

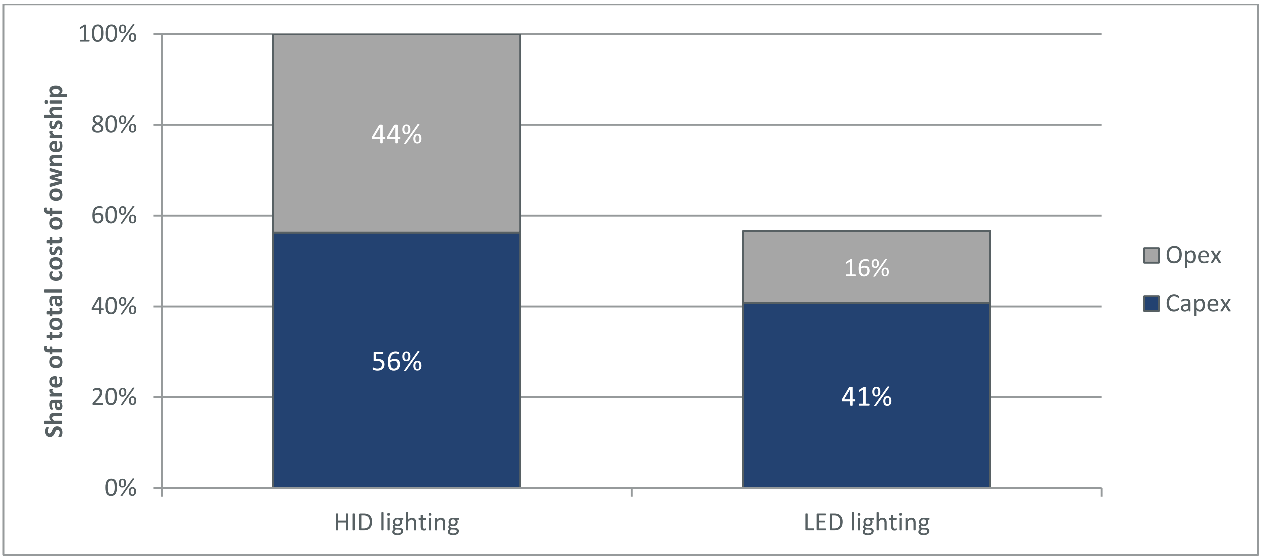

Figure 34: TCO analysis for LED terminal lighting[32]

It can be clearly seen that, considering the whole lifecycle, significant cost-savings are expected to arise due to the lower operating (energy) costs as well as the lower number of required LED lights compared to conventional (HID) lights.

Recommendation

To sum up, this measure is relatively easy to implement, results in large energy savings and also has positive economic effects for the Port of Bar. Therefore, it is strongly recommended to implement this measure in the Port of Bar.

3.3.1.9 LNG PowerPac

Technical and Environmental Assessment

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 (see Section 3.2.2).

Figure 35: Becker LNG PowerPac (Source: www.becker-marine-systems.com)

[32] Period under review = 15 years

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.

The handling procedure is illustrated in Figure 36 and described below.

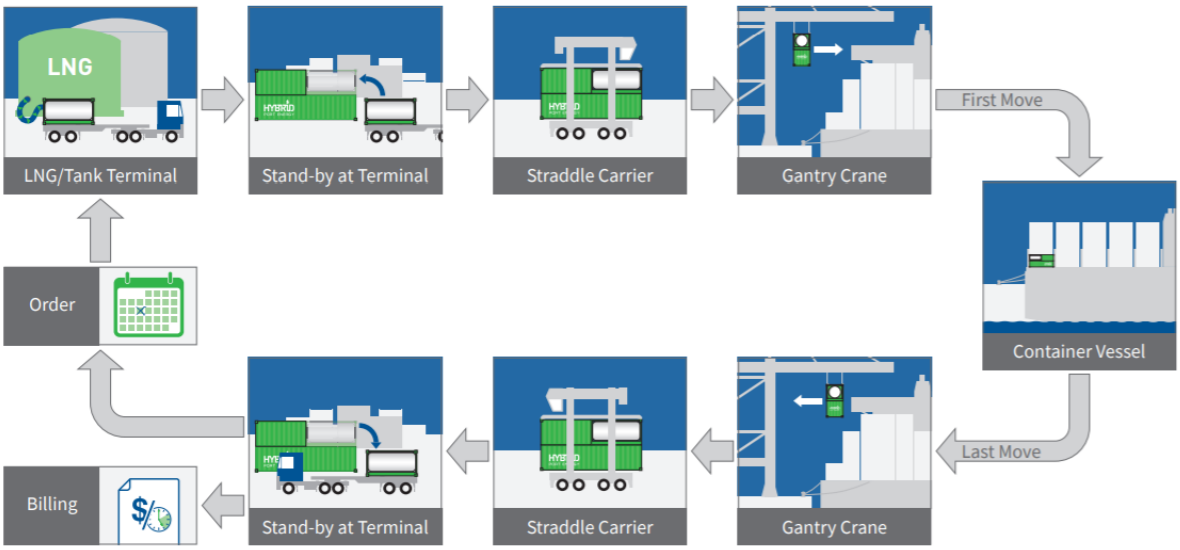

Figure 36: Becker LNG PowerPac: handling procedure (Source: www.becker-marine-systems.com)

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.

Table 13: 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.

[33] Compared to MGO 0.1

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 upon the location. In Europe the price per ton LNG is between 600 and 800 euros. The required investment is comparable to onshore power supply, but the operating costs are much lower.

Recommendation

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.

3.3.1.10 Green Port Fees

Technical, Environmental and Economic Assessment

There have been a number of voluntary award schemes developed to encourage vessels to be more environmentally friendly through incentives based on port dues. One possibility is the introduction of green fees or 'green passports', providing a right of entry and reduced port fees to those vessels meeting environmental requirements.

In most cases this means that the cleanest ships get a deduction of the regular port fee, either a fixed amount or a proportional deduction (e.g. a 10% rebate on the port fee). As most port fees are somehow related to ship size, the deductions could be considered more or less proportional to ship size. Some ports apply different charging schemes according to the type of vessel. Green port fees are in practice linked to green ship indexes (e.g. Environmental Ship Index (ESI), the Clean Shipping Index (CSI) or the Green Award), use of alternative fuels and energy and vessel speed. A comprehensive description about the different options of Green Port Fees can be found here.[34] The existence of environmentally related port pricing system is mainly aimed at the areas with high levels of air pollution. Today, 28 of the 100 world's largest ports in terms of total cargo volume handled offer incentives for environmentally friendly ships, a new report released by the International Transport Forum (ITF) shows.[35]

Table 14: Global top 100 ports with environmental port fees (Source: International Transport Forum, 2018: Reducing Shipping Greenhouse Gas Emissions)

Europe	Asia	Americas	Africa
Rotterdam (Netherlands)	Singapore	Los Angeles (US)	Durban (South Africa)
Antwerp (Belgium)	Shenzhen (China)	Long Beach (US)	Richard's Bay (South
Amsterdam (Netherlands)	Hong Kong (China)	New York/New Jersey (US)	Africa)

[34] COGEA, (2017), "Study on differentiated port infrastructure charges to promote environmentally friendly maritime transport activities and sustainable transportation", COGEA, Glintt, Vrije Universiteit Brussel, KLU. Study for European Commission

[35] ITF (2018b), "Reducing Shipping GHG Emissions: Lessons from Port-based incentives", International Transport Forum, OECD Publishing, Paris.

Europe	Asia	Americas	Africa
Hamburg (Germany)	Busan (South Korea)	Vancouver (Canada)	
Bremerhaven (Germany)	Ulsan (South Korea)	Montreal (Canada)	
Le Havre (France)	Tokyo (Japan)	Buenos Aires (Argentina)	
Zeebrugge (Belgium)	Yokohama (Japan)		
Sines (Portugal)	Nagoya (Japan)		
Valencia (Spain)	Kitakyushu (Japan)		
London (UK)	Ashdod (Israel)		
Bergen (Norway)			

Since pricing is a very complex processing and there would not be a uniformed system that suits all the ports, ports have to consider whether to introduce the green port dues. Cooperation and coordination between ports and ship owners as well as between (competing) ports is essential for implementing Green Port Fees. When environmental charging schemes are designed, they should be simple to understand and to implement, clearly state the goals to be achieved, and be monitored throughout their implementation. The availability of meaningful data on fuel consumption as well as on emissions of individual ships is central to the ex-post evaluation of environmental incentive schemes. 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 CO_2 emissions generated by maritime transportation.

The Port of Rotterdam, for example, applies differentiated port tariffs based on ship environmental performance. The port does not produce data on the impact of the scheme in terms of emissions reduction. However, the port reports that in 2013 and 2014 ESI certified ships represented 19% and 21% of total calls, while ships that got rebates (i.e. with a score equal to or higher than 31) were around 7% of total calls[36]. Furthermore, environmental charging may also carry positive implications in terms of image (which could ultimately yield economic benefits) for both ports and ship owner.

However, the impact of differentiated port dues may be limited for a number of reasons. Port dues represent only a very small part of the total port costs of ships and the core decisions affecting the green performance of the ship are in the design/purchasing phase.

Recommendation

Green Port Fees are a proven and effective regulatory solution to reduce negative environmental externalities linked to shipping inside the port area. From a commercial and marketing point of view, this measure contributes to a sustainable Port of Bar image. In contrast to any technical measures – in particular onshore power or LNG PowerPacs – this measure is significant less resource intensive and could be implemented very quickly. However, it is of upmost importance to ensure that no competitive disadvantage arises. Neighboring ports not implementing these schemes leading to competitive disadvantage for the Port of Bar from a cost perspective. Therefore, this measure should only be implemented in collaboration with both vessel operator and competitive ports.

3.3.1.11 *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.

<u>*Technical and Environmental Assessment*</u>

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 (see Figure 37).

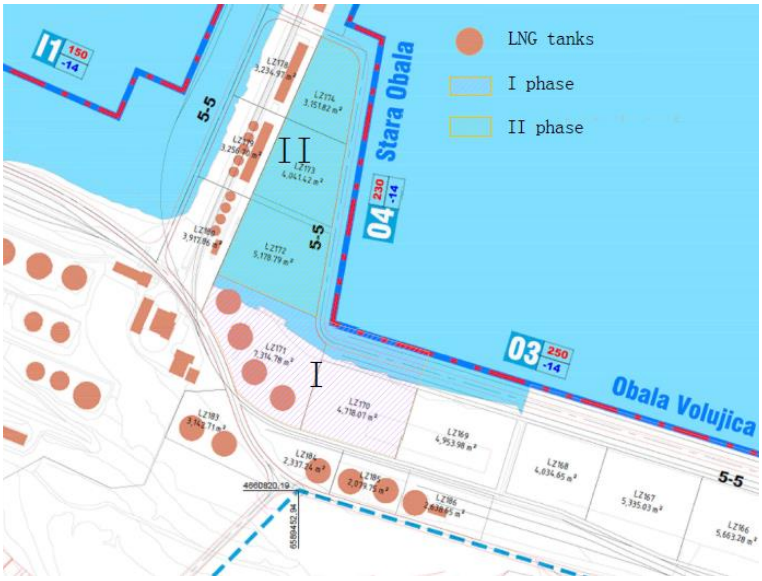

Figure 37: Planned terminal for liquid gas LNG in the Port of Bar (Source: Port of Bar)

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[37] – are:

Table 15: 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

It is hardly possible to estimate the environmental impacts of this measures. As explained in Section 3.2.3, the CO_2 mitigation potential of LNG ranges between 5-30% compared to the heavy fuel oil. Using a gas-only engine can also reduce SOx emissions and PM by almost 100% compared to conventional fuel oil. However, handling and combustion of LNG involves the release of unburnt methane, also referred as methane slip, which can diminish its overall environmental advantages. To estimate the environmental benefits for the Port of Bar, detailed fuel consumption data from the vessels operating in the port area over a certain timeframe (usually one year) are required. Based on this information, the emission mitigation potential can be calculated. However, such data are not available.

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.

[37] Truck-to-Ship, Container-to-Ship, Ship-to-Tank or Ship-to-Ship

- **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 Action Plan and should be done in a separate step.

Recommendation
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.

3.3.1.12 Other Measures

In the following, further promising measure identified in Section 3.2 are briefly explained. In contrast to the above-mentioned measures, these measures rather have a low impact on the port´s level of energy sustainability and are also relatively easy to implement.

One suitable way to involve employees into the process of striving towards energy sustainability is to introduce an **environmental employee suggestion system**. In general, an employee suggestion system is described as a formalized mechanism that encourages employees to contribute constructive ideas for improving the organization in which they work. It can also be designed with a focus on energy / environmental aspects. An environmental employee suggestion system will elicit environmental suggestions from employees, classify them, and dispatch them to the “experts” for evaluation. After this, the suggestion might be adopted, in which case the suggestion may well be rewarded. The reward may range from a certificate to a reward commensurate with the energy / emissions savings generated by the suggestion. Awards for bringing in ideas with a high impact on energy sustainability can further promote participation and increase employees’ motivation. This measure could be implemented virtually immediately. It is only necessary to determine experts that evaluate the measures and design a proper incentive system.

Switching to LED lighting in the port´s terminal buildings is a promising way to become more energy efficient and reducing energy usage and costs up to 80%. The general environmental and economic benefits of LED lighting compared to conventional lighting technologies has been presented in detail in Section 3.3.8 (measure: LED terminal lighting). Using LED lighting in offices may also lead to positive effects influencing human energy, mood, vitality and work performance. Studies in US and Europe have revealed that by simply switching to LED lighting and providing a better light environment can increase work performance by at least 3%. For the implementation of this measures it must be considered that LED probably lead to cost savings over time, however, LED bulbs are more expensive up front.

People factor plays an energetic role in creating and sustaining environmental orientation of organizations and thus also ports. Shaping and reshaping behaviors of employees, environmental management related knowledge, skills and attitude development, creating environment-friendly innovative behaviors and knowledge based eco-innovations are possible through people. Hence, **environmental employee training** is a suitable way to improve a port´s environmental performance. Employee environmental training is a systematic process to improve the environmental knowledge, skills and attitudes of employees in order to achieve the environmental goals of the organization. It can be said that without proper environmental training, it is impossible for an organization to achieve its environmental goals. Research has suggested that environmental training improve the employee's motivation towards eco initiatives and environmental performance of organization. Obtaining management commitment is the critical first step in developing a successful training program. Commitment from management will ensure that the training will have impact throughout the organization. To ensure that the training program will have measurable results, objectives must be established prior to the start of the training. It is possible to perform the training internally (e.g. by internal environmental experts) or externally. For the latter, companies offering environmental employee training are available. The efforts of implementing this measure are very low while the impacts can be high. Ideally, a long-term mind shift for sustainability transformation can achieved through this measure.

The final 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 38).

Figure 38: 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%.

Finally, the existing **tires of the cargo handling equipment can be improved** in terms of environmental and operational aspects. First of all, energy saving tires should be used in future, resulting in energy savings of up to 10%. Additional, regular tire pressure controls should be performed since 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.

3.3.2 Work Plan

In this part of the Action Plan, recommendations are provided as to which energy sustainability actions should actually be enacted. In addition, recommendations about the implementing sequence are given, considering a 5-year period. It is worth mentioning that this information should only serve as a rough guideline. This is because 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).

To select the most promising measures for the Port of Bar, the following evaluation criteria have been used (see Sections and 3.2):

1. **Environmental / energy sustainability impact**: emissions and energy efficiency;
2. **Efforts for implementation (technical assessment)**: operational efforts and required resources; and
3. **Economic impacts**: CAPEX, OPEX and ROI.

The procedure to select the high-priority (top) measures for the Port of Bar and determine the implementation sequence is as follows:

1. **High priority measures**: medium to high energy sustainability impact / low efforts for implementation / high commercial viability assured OR measures that are a pre-requisite for other measures (e.g. energy management system)
2. **Medium priority measures**: at least medium energy sustainability impact / not worse than medium efforts for implementation / at least: acceptable commercial viability
3. **Low priority (optional) measures**: all remaining measures with a high energy sustainability impact

In Table 16, all shortlisted measures that have been evaluated in detail in the previous section are listed.

Table 16: Summary – Evaluation of shortlisted measures

Measure	Energy sustainability assessment	Efforts for implementation (technical assessment)	Economic assessment	Final evaluation
Energy / Emission Reduction goals	No direct energy or emission reduction potential: measure necessary prerequisite for improving the level of energy sustainability	Low: mainly coordination & collaboration with stakeholders	Probably cost-effective: almost no implementation costs but goals have to be realistic	Top priority energy sustainability measure
Energy management system	No direct energy or emission reduction potential: measure necessary prerequisite for establishing other measures	Medium: Mainly set-up of ICT systems	Cost-effective: installation costs low (≈ 65,000€) / probably short payback period	Top priority energy sustainability measure
Obtaining green energy / carbon offsetting	High: 100% renewable electricity is possible	Low: investing in environmental projects (carbon offsetting) / switching electricity provider not possible for Port of Bar	Overall cost increase: average price of a carbon offset is about 3€/kg CO_2	Medium priority energy sustainability measure
Solar photovoltaics	Medium: share of renewable energy in gross final consumption in Montenegro is relatively high (approx. 40%)	Medium: planning, installation and maintenance of overall system	Probably not cost-effective: electricity prices in Montenegro are quite low	Low priority (optional) measure
Electrification of power train (forklift fleet and mobile harbor crane)	High: maximum emission saving potential approx. 180,000 kg CO_2e per year	Medium-high: procuring e-forklift fleet, installing charging infrastructure and retrofit mobile harbor crane	Probably cost-effective: e-cargo handling equipment approx. 30% more expensive operating costs much lower	Top priority energy sustainability measure
Eco-driving lessons	High: average fuel savings of 7% can be expected	Low: offering training courses once a year	Cost-effective: causes almost no additional costs / significant savings of energy can be achieved	Top priority energy sustainability measure
Optimization of HVAC system	Medium: significant energy saving potential for building are possible / buildings rather a small port energy consumer	Low: regular maintenance / adjusting the desired air temperature / realizing thermal zones with separate controls	Probably cost-effective: low implementation costs / certain savings of energy can be achieved	Medium priority energy sustainability measure
LED terminal lighting	High: reduction in energy usage of up to 95% is possible / terminal lights are a large port energy consumer	Low: replacing conventional lights by LED lights / lower operational efforts (less maintenance) can be expected	Cost-effective: total cost-saving potential over the total lifetime approx. 40%	Top priority energy sustainability measure
LNG PowerPac	Tend to be very high but not quantifiable for the Port of Bar	High-medium: procuring PowerPacs and additional equipment / establishing (complex) handling processes	Probably not cost-effective: high initial costs and also high energy costs	Low priority (optional) measures
Green Port Fees	Tend to be very high but not quantifiable for the Port of Bar	Low: mainly coordination & collaboration with stakeholders and other competing ports	Ideally cost-neutral	Medium priority energy sustainability measure
Small scale LNG terminal	Tend to be medium but not quantifiable for the Port of Bar	High: planning and building of a completely new terminal is a complex and sophisticated task	Probably not cost-effective: huge investment / demand probably not sufficient	Low priority (optional) measures
Environmental employee training	Tend to be high but not quantifiable for the Port of Bar	Low: offering training courses once a year	Cost-effective: causes almost no additional costs / savings of energy can be achieved	Top priority energy sustainability measure

Switching to LED lighting in the port´s terminal buildings	Medium: reduction in energy usage of up to 95% is possible / terminal buildings medium energy consumer	Low: replacing conventional lights by LED lights	Cost-effective: total cost-saving potential over the total lifetime approx. 40%	Medium priority energy sustainability measure
Environmental employee suggestion system	Tend to be medium but not quantifiable for the Port of Bar	Low: establishing reward system and select experts that evaluate suggestions	Cost-effective: causes almost no additional costs / certain savings of energy can be achieved	Medium priority energy sustainability measure
Installation of air curtains	Medium-high: energy costs of cold storages can be reduced significantly	Low: procuring, installing and maintaining devices	Probably cost-effective: low implementation costs (5,000 €/ piece) / certain savings of energy can be achieved	Top priority energy sustainability measure
Optimization of tires (energy saving tires and regular pressure controls)	Medium: reduction in energy usage of up to 10% is possible	Low: procuring energy saving tires and performing regular pressure monitoring	Probably cost-effective: energy saving tires are more expensive but certain energy savings can be achieved	Medium priority energy sustainability measure

Based on the detailed evaluation of potential energy sustainability measures, the implementation plan illustrated in Figure 39 is proposed. For the implementation plan, the following points need to be pointed out:

- The measures “energy / emission reduction goals” and “implementing an energy management system” are prerequisites for other measures (as explained above) and should thus be implemented first
- “Eco-driving lessons” and “environmental employee trainings” should be carried out on a regular basis (ideally once a year)
- Both measures, “solar photovoltaics” and “LNG PowerPac” should only be implemented after a careful examination of economic and operational aspects
- It is not recommended to build a “small scale LNG terminal” since investment are huge, and it is questionable whether there is sufficient demand

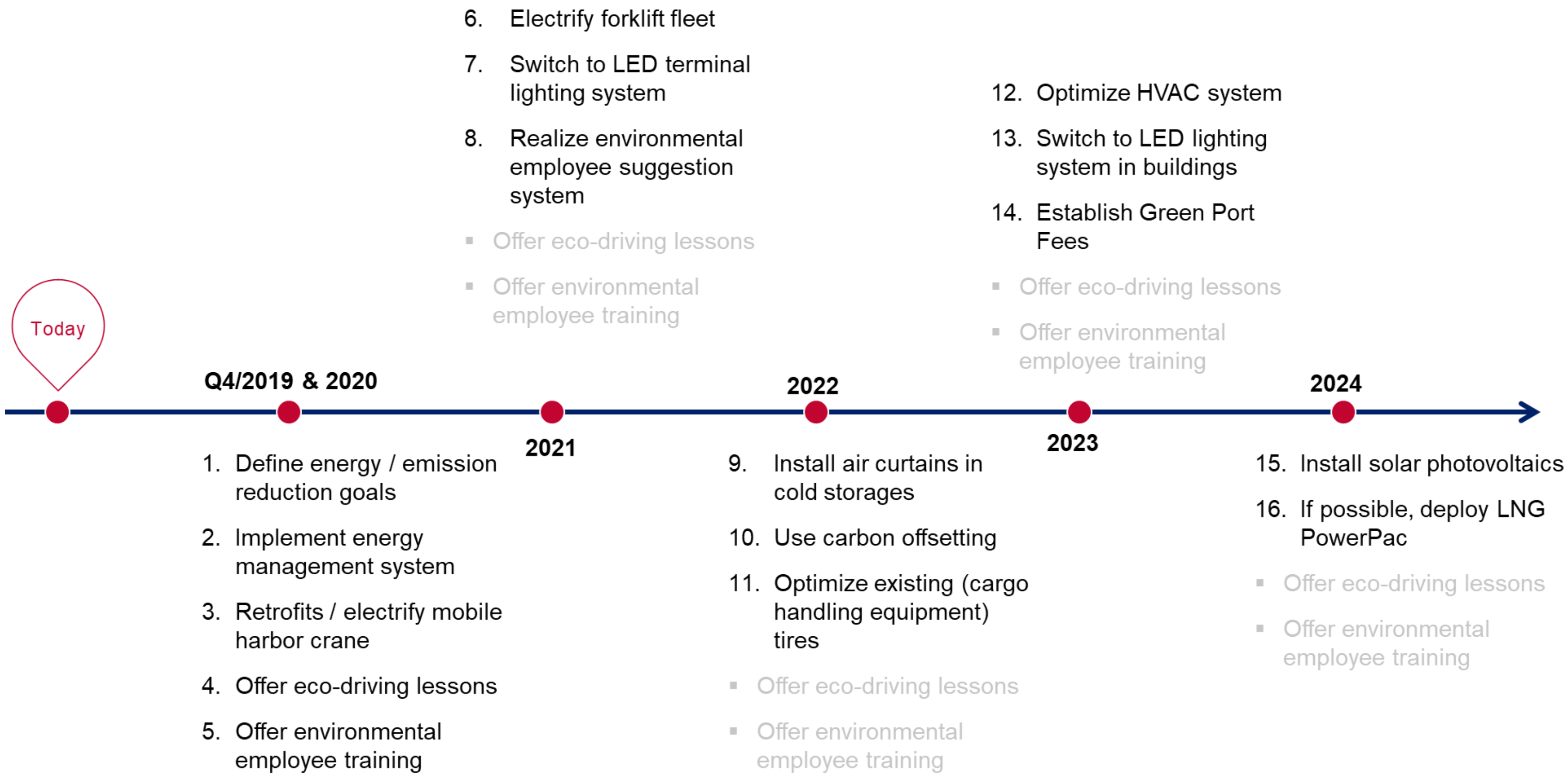

Figure 39: Energy sustainability measures implementation plan

3.4 Monitoring Program

Once a Green Port Action Plan has been proposed in the port (see previous section), an effective monitoring process should be envisaged to track the impacts and effects of proposed actions over time. Regular stakeholder meetings should be held at the port premises to discuss monitoring results. In this section, the most important steps to establish a monitoring program will be presented.

A monitoring program is also the main tool to track the port's progress on meeting the vision and goals of the Green Port Action Plan. To this end, energy sustainability indicators or metrics are needed in order to assess the progress and performance (Step 1 and 2). One of the most important steps of the monitoring program is to establish feedback loops to assess and improve performance. In particular, the monitoring results should be used to deploy possible corrective actions when needed (Step 3). In addition, current developments probably affecting the Green Port Action Plan should be considered (Step 4). Finally, it is also recommended to publish period progress reports (at least annually) using the metrics or indicators established (Step 5).

3.4.1 Preliminary Step – Preparation

In a preliminary step, the Port of Bar should dedicate the necessary resources and establish procedures to implement the monitoring program. This involves identifying the appropriate staff to coordinate the monitoring program and establishing the processes and procedures for collecting the necessary data. As this are internal processes, no detailed recommendation can be provided. However, a preferable option is to dedicate staff that are responsible for environmental issues.

3.4.2 Step 1 – Establish (Performance) Metrics

It is important to establish energy sustainability metrics or indicators, in order to track and report on successes of various initiatives and on the progress toward meeting specific targets and goals. It must generally be ensured that the monitoring plan is based on meaningful performance measures for which the port can collect the necessary data.

In some cases, the targets established in the Green Port Action Plan lend themselves as metrics. As described in detail in the previous sections, it has not been possible to define specific energy sustainability (energy efficiency / emission reduction) goals for the Port of Bar since no detailed electricity consumption data are available. Therefore, it has been recommended to implement an energy management system and then define specific, achievable but also ambitious energy / emission reduction goals. Consequently, the first and most important metrics are energy and emission reduction targets (which have to be defined in future by the Port of Bar), illustrated in Table 17.

It is recommended to define normalized energy / emission reduction targets that sets the port´s energy and emission goals relative to some sort of economic output (here: amount of cargo [tons] handled per year). Contrary to absolute targets, this allows to set energy and emissions reduction targets while accounting for positive or negative business growth.

Table 17: Energy sustainability targets / main performance metrics

Sustainability issue	Unit	Explanation / Steps	Exemplary target
Overall level of energy efficiency	kWh/ton of cargo handled per year	1. Record the yearly energy consumption data and convert these into unified value → kWh 2. Calculate annual cargo throughput 3. Determine the average, annual energy consumption per ton of cargo handled 4. Define the energy efficiency goal from a baseline year	Reduce energy consumption by 40% by 2025, by 55% by 2028 and up to 75% in 2030, compared 2017
Port-related greenhouse gas emissions	CO_2e / ton of cargo handled per year	1. Collect fuel, electricity and gas consumption data 2. Determine the energy-specific CO_2 emission factor 3. Calculate annual cargo throughput 4. Determine the average, annual GHG emissions per ton of cargo handled 5. Define the GHG emission reduction goal from a baseline year	Cut greenhouse gas emissions by 40% by 2025, by 55% by 2028 and up to 75 % in 2030, compared 2017
Port-related air emissions	SO_x, PM and NO_X / ton of cargo handled per year	1. Collect fuel, electricity and gas consumption data 2. Determine the energy-specific air emission factor 3. Calculate annual cargo throughput 4. Determine the average, annual air emissions per ton of cargo handled 5. Define the air emission reduction goal from a baseline year	Cut air gas emissions by 40% by 2025, by 55% by 2028 and up to 75% in 2030, compared 2017

Based on these metrics, it is possible to track continuously progress and, if necessary, take corrective actions, e.g. if it does not look likely that the targets will be achieved.

In addition to these main performance metrics, it is also recommended to establish a set of energy efficiency sub-metrics (key performance indicators [KPI]), among others, to identify potential weak points (underperforming port areas). In addition, these KPIs can be used as reference values to compare the Port of Bar´s energy sustainability performance with those of other ports. A list of potential sub-metric that can be used by the Port of Bar is summarized in Table 18.

Table 18: Energy efficiency performance metrics

Port energy consumer	Energy source		Sub energy sustainability metric / Key performance indicators	
	Diesel	Electricity	Unit	Reference value
Ship loading and unloading equipment	X	X	kWh/ton/annum	• Average annual energy consumption per type of equipment [kWh] • Amount of cargo handled per type of equipment [tons]
Yard operations equipment	X	X	kWh/ton/annum	• Average annual energy consumption per type of equipment [kWh] • Amount of cargo handled per type of equipment [tons]
Light duty vehicles	X		kWh/100 km	• Average annual energy consumption of vehicles [kWh] • Total distance driven in the reference year [km]
Administration building		X	kWh/m^2/annum	• Annual electricity consumption of building [kWh] • Size of building in square meter [m^2]
Warehouses		X	kWh/m^2/annum	• Annual electricity consumption of building [kWh] • Size of building in square meter [m^2]
Grain silo		X	kWh/ton/annum	• Amount of cargo handled in silo [tons] • Size of building in square meter [m^2]
Cold storages		X	kWh/t/annum	• Amount of cargo handled in cold storage [tons] • Size of building in square meter [m^2]
Terminal lighting		X	kWh/m^2/annum	• Annual electricity consumption of lighting system [kWh] • Size of terminal area in square meter [m^2]

These key performance indicators can be used to determine the current state of energy sustainability of each port energy consumer class.

3.4.3 Step 2 – Collect and Evaluate Data

In the next step, all relevant data (see Table 17 and Table 18) to compile the energy sustainability metrics need to be collected. The most important are:

- **Fuel consumption per port consumer**: the preferred method of determining the amount of fuel combusted is to gather data from fuel receipts or purchase records;
- **Electricity consumption per port consumer**: gathered from electricity bills or measurements on site (ideally, all processed data will be provided from the energy management system;
- **Emission factor:** this element provides the means to convert the estimates of energy output or fuel consumption into the pollutant emission rates that are to be modelled;
- **Weight of cargo handled per port energy consumer**: refers to the actual weight of the cargo carried during the same measurement period in which the fuel and electricity is measured; and
- **Sizes of total area and per building**.

Fuel / electricity specific emission factors serve to convert the amount of fuel (in liters or kg) or electricity (in kWh) into emissions produced. Generally, emission factors can differ significantly, depending on the method of calculation, geographic coverage and the scope of the emissions counted. In principle, one can decide to use a fuel-specific emission factor that is suitable for a particular region (domestic emissions factor) where the transportation service is fulfilled or international emission factors. For example, if the source of fuel is unknown, it appears sensible to use an international emission factor.

It is recommended to use domestic emission factors. As this is not always possible, suitable international emission factors will be presented in the following.

Table 19: Diesel emission factors (Source: GLEC Framework for Logistics Emission Methodologies)

Fuel type	TTW CO2e emission factor (kg CO_2e/kg fuel)[38]	WTW CO_2e emission factor (kg CO_2e/kg fuel)[39]
Diesel	2.67	3.24

Tank-to-Wheel emissions factors would lead to incomplete or inaccurate emission factors since the factors related to fuel extraction, processing and distribution are not captured. Therefore, it is recommended to use a Well-to-Wheel approach.

If fuel quantities are available, total emissions would be calculated one by one for each fuel type as:

$$CO_2\text{e emissions} = \Sigma Energy\ consumption\ (kg) \times Emission\ factor\ \left(\frac{\text{kg CO2e}}{\text{kg fuel}}\right)$$

Electricity production is considered to include the conversion of fuel within the power plant, and the distribution of electricity. As the emission factor may differ significantly from region to region (depending upon the energy generation mixture) it is required to use a local emission factor that reflects the average emissions intensity of the grids on which the energy consumption occurs (see Table 20).

[38] Direct emissions (tank-to-wheel / TTW): direct emissions from the combustion of fuels or electricity that mainly result from the vehicle / vessel operation.

[39] Indirect emissions (well-to-tank / WTT): indirect emissions caused by the production of power and fuels for the fulfilment of the logistics processes (energy provision, production and distribution).

Table 20: Electricity emission factors for Montenegro (Source: GLEC Framework for Logistics Emission Methodologies)

Source 1: WTW CO_2e emission factor (kg CO2e/kWh)[40]	Source 2: WTW CO_2e emission factor (kg CO2e/kWh)[41]
0.521	0.623

After having collected all required data, the metrics shall be calculated, and the results be evaluated. In particular, it must be regularly reviewed whether the defined long-term energy sustainability objectives can actually be achieved. If not, required (additional) actions are required.

3.4.4 Step 3 – Keep Up-to-Date and Consider Relevant Developments

This step is often neglected, however, is of particular importance for the long-term success of the Green Port Action Plan. In this step, all external developments, probably affecting the energy sustainability planning process over time will be analyzed. For example, if there are environmental regulations changes (e.g. stricter emission standards), all potential impacts for the Green Port Action Plan need to be assessed. If required, corrective and preventative actions (Step 4) must be taken and the Action Plan be modified.

Updating the Green Port Action Plan follows a new planning process to developing initiatives for new or existing focus areas. If a new plan is not in order or appropriate, an updated appendix with new or revised strategies can be added to the original Green Port Action Plan.

It is recommended to regularly consider four main factors, potentially influencing the Green Port Action Plan over time and analyze the potential influence on the plan (see Figure 40).

Political–legal factors
- National (environmental) regulatory frameworks
- International (environmental) regulatory frameworks
- Taxes and subsidies

Technological factors
- Availability of new technologies
- Process reorganization
- Standards

Market development
- Overall growth rate / port revenues
- Customer expectations for eco-friendly port services
- Energy prices
- LNG demand as fuel for vessels

Ecological factors
- Changes in the ecological situation
- Condition of port´s territory and workplace

Figure 40: Main factors potentially influencing the Green Port Action Plan over time

Each of these points may have a considerable impact on the Green Port Action Plan. For example, if there is an unexpected and strong increase in demand for LNG as fuel for vessels (factor: market development), providing LNG bunkering facilities could be an interesting option. Contrary, if it becomes apparent that the port faces financial difficulties (e.g. as a result of a recession) energy sustainability investment could be postponed (factor: market development). Likewise, if there are superior and new energy efficiency or renewable energy technologies available, it is strongly recommended to examine the feasibility (ecological

[40] IFEU Heidelberg
[41] Eurostat

factors). Finally, stricter environmental laws (political-legal factors) could have a considerable impact on the Green Port Action Plan. For example, many US states decided to mandate shore side electricity to ships that seeks to cut the majority of their emissions while in ports. Similar environmental rules in Europe or Montenegro could force the Port of Bar and other ports providing the respective infrastructure.

3.4.5 Step 4 – Identify Lessons Learned and Incorporate Improvements

Building on the results of the energy sustainability metrics calculated (Step 1 and 2), and after having reviewed all current factors that may have an impact on the Green Port Action Plan (Step 3), lessons learned, and after-action reviews should be implemented to provide valuable information about both positive and negative performance. Frequently, these activities yield insights into internal best management practices and successful operating models that can be further leveraged across the port.

In this step, it is also required to initialize corrective and preventative actions, and to promote continual improvement. Corrective and preventative actions are always required when there is a risk that goals cannot be achieved under the current circumstances. For example, if the defined overall emission reduction targets are bound to fail, additional energy sustainability measures should be implemented (see Section 3.2.3). The energy sustainability key performance indicators defined (Step 2) are an effective tool to identify potential weak points (priority areas).

The value of this step is not simply in the individual management review but more the institution's commitment to create a culture of environmental excellence using these reviews as a starting point. By leveraging past successes and overcoming performance deficiencies through periodic review and recalibration of Green Port planning and strategic goals, organizations can more effectively promote and integrate climate action to ensure ongoing mission value.

3.4.6 Step 5 – Develop and Progress Reports and Involve Stakeholders

It is recommended to publish two kind of energy sustainability progress reports: one internal (management) report and one external (stakeholder) report. A regular reporting process highlights local achievements while also helping to identify issues and opportunities to adapt existing approaches. Reporting may also stimulate accountability, promotes healthy competition among peer organizations, and feeds program momentum. In addition, best-in-class reporting (e.g. considering other ports participating in the SUPAIR project) emphasize transparency. Dissemination of results, achievements and challenges met in the implementation of measures may also help other ports in improving its level of energy sustainability. Finally, if goals and targets are being achieved, it is recommended to publish via issue press releases.

In the external progress report, an overview of initiated actions (implemented measures) should be given and the main metrics be presented. In addition, the next steps could be introduced. For the internal report, more information is required. In particular, economic aspects are of particular importance. In addition, potential difficulties and recommended countermeasures should be discussed. As explained in Section 2.3. the collaboration with stakeholders and regulatory agencies is paramount for a success of the Green Port Action Plan for the Port of Bar. Therefore, the port stakeholders shall also be regularly informed (e.g. in the form of external reports or in the form of workshops) about the progress of the port's energy sustainability efforts. In addition, regular stakeholder meetings should be held at the port premises to discuss monitoring results.

4. 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. In addition, the 15 most promising measures have been evaluated in detail, considering technical, economic and environmental aspects (see Table 21) and a work plan including a recommended timetable for the implementation has been proposed.

Table 21: Summary - Top energy sustainability measures for the Port of Bar

Measure	Energy sustainability assessment	Efforts for implementation	Economic assessment	Final evaluation
Energy / Emission Reduction goals	No direct reduction potential	Low	Probably cost-effective	Top priority
Energy management system	No direct reduction potential	Medium	Cost-effective measure	Top priority
Carbon offsetting	High	Low	Overall cost increase	Medium priority
Solar photovoltaics	Medium	Medium	Probably not cost-effective	Low priority
Electrification of power train (forklifts & mobile harbor crane)	High	Medium-high	Probably cost-effective	Top priority
Eco-driving lessons	High	Low	Cost-effective	Top priority
Optimization of HVAC system	Medium	Low	Probably cost-effective	Medium priority
LED terminal lighting	High	Low	Cost-effective	Top priority
LNG PowerPac	Tend to be very high	High-medium	Probably not cost-effective	Low priority
Green Port Fees	Tend to be very high	Low	Ideally cost-neutral	Medium priority
Small scale LNG terminal	Tend to be very high	High	Probably not cost-effective	Low priority
Environmental employee training	Tend to be very high	Low	Cost-effective	Top priority
Switching to LED lighting in the port´s terminal buildings	Medium	Low	Cost-effective	Medium priority
Environmental employee suggestion system	Tend to be very high	Low	Cost-effective	Medium priority
Installation of air curtains	Medium-high	Low	Probably cost-effective	Top priority
Optimization of tires	Medium	Low	Probably cost-effective	Medium priority

Even after this comprehensive study, open questions need to be addressed in the future by the Port of Bar. First of all, recommended energy sustainability measures actually need to be implemented by the Port of Bar. The implementation phase includes putting into place the (proposed) measures and associated datagathering programs to evaluate performance over time. With regard to the monitoring program, the Green Port Action Plan also includes detailed recommendation for the design and implementation.

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. Ideally, the project partners should work together with other ports and stakeholders and define common targets (all aspects on how to define goals can be found in the Action Plan).
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 2030 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.