GREEN CRUISE PORT ACTION PLAN 2030

Final Report

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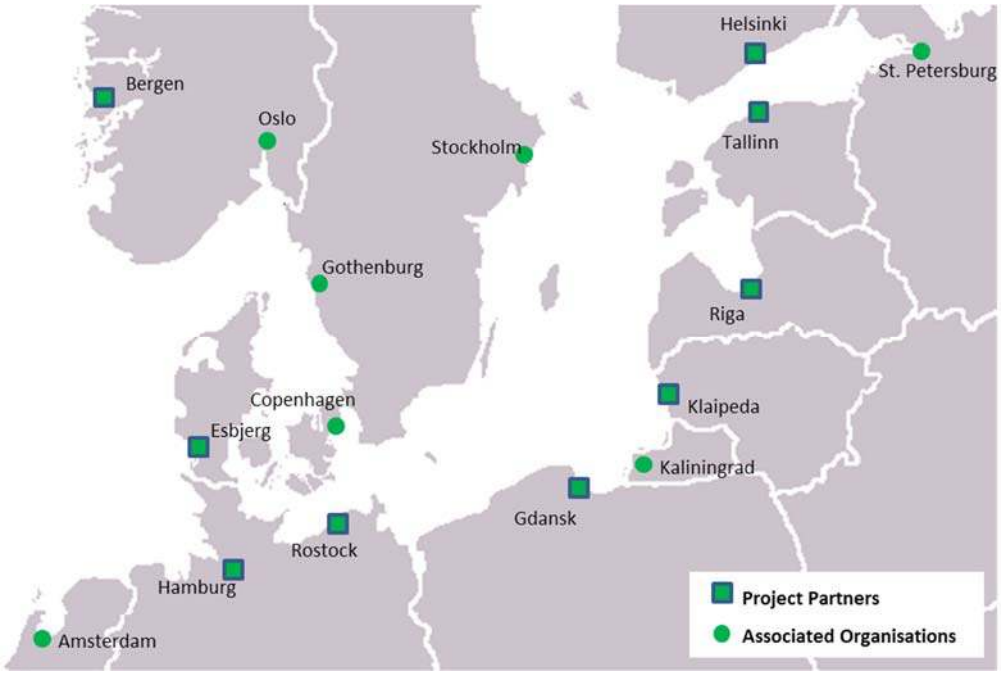

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LIST OF ABBREVIATIONS

Technical Inventory

CCV	Closed Crankcase Ventilation
CHP	Combined heat and power generation plants
CNG	Compressed Natural Gas
CO_2	Carbon dioxide

CO_2e	CO2-equivalent emissions factors
dB	Decibel
DCV	Demand-controlled ventilation
DPF	Diesel particle filer
ECT	Emission control technologies
EGR	Exhaust gas recirculation
EMS	Energy management system
GHG	Greenhouse gas emissions
GT	Gross tonnage
GWP	Global warming potential
H_2	Hydrogen
HFO	Heavy Fuel Oi
HVAC	Heating, ventilation and air condition system
kW	Kilowatt
kWh	Kilowatt hour
LED	Light-emitting diode
LNG	Liquified natural gas
LPG	Liquefied petroleum gas
MDO	Marine diesel oil
MGO	Marine gasoil
NH_3	Ammonia
NO_x	Nitrogen oxide
nZEB	Nearly zero energy building
OPS	Onshore power supply
PM	Particular matter
PV	Solar photovoltaics
SCR	Selective catalytic reduction
SO_x	Sulfur oxides
ULSD	Ultra Low Sulfur Diesel

Others

BSR	Baltic Sea Region
CAPEX	Capital Expenditure
CHE	Cargo handling equipment
CLIA	Cruise Lines International Association
CSI	Clean Shipping Index
ECA	Emission Control Area
EEDI	The Energy Efficiency Design Index
END	Environmental Noise Directive
ESI	Environmental Ship Index
EU MRV	EU Monitoring, Reporting, Verification
EU	European Union
GCP	Green Cruise Port
HELCOM	Baltic Marine Environment Protection Commission
IMO	International Maritime Organization
MARPOL	International Convention for the Prevention of Pollution from Ships
MEPC	IMO Maritime Environment Protection Committee
NABU	Nature and Biodiversity Conservation Union
NSF	No-Special-Fee
OPEX	Operating Expenditure
PRF	Port Reception Facility
SEEMP	Ship Energy Efficiency Management Plan
STS	Ship-to-ship
TTS	Truck-to-ship

EXECUTIVE SUMMARY

Currently, the cruise industry in the Baltic Sea Region (BSR) faces two main challenges. In recent years, the cruise shipping sector in the BSR has grown significantly and it is expected that this growth continues in future. Therefore, the industry has to create the required structural conditions to accommodate the expected increase of both ship calls and number of passengers. As the industry continues to expand, however, this also raises questions and concerns about sustainability and the effect of cruise ships on the environment. In particular, more and more customers see cruise ships as one of the main waste and emission producers of the world seas. Therefore, the cruise industry has to respond to these environmental challenges and try to minimize negative externalities caused by port and vessel operations in cruise ports in the most efficient way.

In order to meet these challenges, a cooperative and coordinated approach by different seaside and landside partners in the BSR is required. Against this background, the "Green Cruise Port" project has been initiated in 2016. The overall goal of the project is to elaborate a multidimensional strategic approach for a sustainable and qualitative future development of cruise shipping in port areas. In the course of the project, several studies and workshops have been carried out by the project partners to gather knowledge on how to reduce port and cruise vessel related emissions in the port area and strengthen the economic effects of cruise tourism.

The Green Cruise Port Action Plan 2030 at hand structured the knowledge generated within the frame of the project – and in other related projects worldwide – in a consistent way. As an output, the Green Cruise Port Action Plan provides concrete and practical information on how to reduce the negative ecological and social impacts of cruise port operations. Consequently, the Green Cruise Port Action Plan will serve as an important tool and source of reference for the project partners and all involved stakeholders, which are striving for a high level of (environmental) sustainability.

As part of the operational planning phase, a comprehensive database has been compiled, containing numerous measures to prevent or minimize ecological damages from port and vessel operations and strengthen the economic effects of cruise tourism. In the following tables, the Top-5 measures of each goal are presented.

Table 1: Top 5 environmental measures

Measure	Area	Emission focus				Evaluation	
		GHG	Air	Noise	Waste	Impact	Efforts
Vessel-related emissions							
On-shore power supply	Ship-port interface	☑	☑	☑		🟢	🟡
LNG bunkering facilities: truck-to-ship	Ship-port interface	☑	☑			🟡	🟢
LNG	Vessel fuels	☑	☑			🟡	🟡
Energy efficiency measures	Vessel	☑	☑			🟢	🟡
Exhaust silencers	Vessel			☑		🟡	🟢
Port-related emissions							
Emission reduction target	Whole port area	☑	☑	☑	☑	🟢	🟢
Obtain “green” energy	Whole port area	☑				🟢	🟢
Eco-driving lessons	Pier & CHE	☑	☑	☑		🟢	🟢
Waste fee reduction	Whole port area				☑	🟢	🟡
LED technology	Terminal building	☑				🟡	🟢

Table 2: Top 5 economic sustainability measures

Measure	Impact on					Evaluation	
	Seaward accessibility	Landward accessibility	Passenger flows	Economic effects	Cruise line behaviour	Impact	Efforts
Provide adequate sign posting		☑				🟢	🟢
Limit number of group sizes of land excursions			☑			🟢	🟢
Bring together local vendors and shipping lines			☑	(☑)	(☑)	🟡	🟢
Establish “Green Port Fees”					☑	🟢	🟢
Extend berth and pier infrastructure	☑					🟢	🔴

1. BACKGROUND

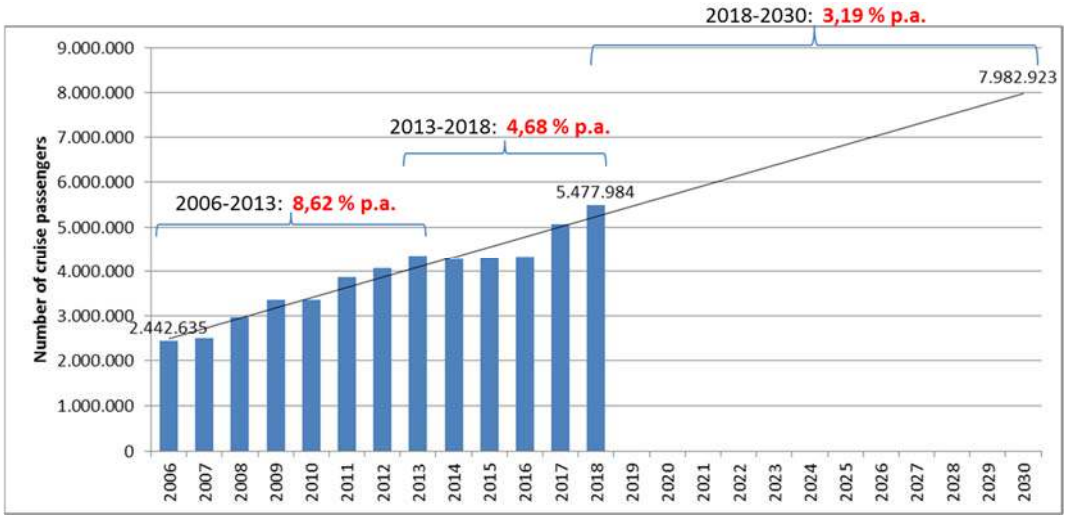
This chapter highlights the relevance of the Green Cruise Port project and the corresponding Green Cruise Port Action Plan, presented in this report.

1.1 Current Challenges in the Cruise Tourism Sector

In recent years, the cruise shipping sector in the Baltic Sea Region (BSR) has grown significantly. From 2000 to 2016, the number of passengers visiting the Cruise Baltic destinations increased by an average annual rate of 9.9%. The most current statistical data of the *Cruise Lines International Association* (CLIA) (Cruise Baltic Market Review, 2017) show that the number of passengers had been reached 4.3 million in 2016 (from 1.1 mill. in 2000). At the same time, the number of calls also increased from 1,453 in 2000 to 2,163 in 2016, representing an average growth of 2.7% per year. The Baltic Sea Region had now become the second largest area for cruise tourism in Europe, after the Mediterranean.

It is expected that the cruise tourism sector in the BSR will continue to grow strongly for up to 7.6 million passengers in 2025, corresponding an average annual growth rate of almost 5% (see Figure 1).

Figure 1: Projection of development of cruise passenger visits in the Baltic Sea until 2025



Source: UNICONSULT, 2013; updated 2018.

It is worth noting that not only the number of passengers and ship calls is expected to grow but also the average dimensions of the current cruise fleet.

Furthermore, many actors in the cruise industry have committed to play an active role in environmental protection and especially intent to tackle climate change. This is particularly important since climate change and insufficient environmental protection could have substantial negative impacts for the industry.

Improving sustainability in the cruise sector is also important in the light of increased customer environmental awareness and increasingly strict environmental regulations (see Section 2.3). In practice, it can be observed that an increasing number of (cruise) port stakeholders (e.g. regulatory authorities) demand a better management of negative externalities caused by port and vessel operations. In particular, the regulation of port areas is becoming ever more stringent in relation to sulfur nitrogen oxides. To sum up, protecting the environmental and improving the level of sustainability will be more and more fundamental for the continued success of the industry.

1.2 Green Cruise Port Project

In order to meet both challenges – accommodating the growth in cruise passengers in the BSR and improving the level of sustainability in the cruise sector – and thus remain competitive in the long term, a cooperative and coordinated approach by different seaside and landside partners on a transnational level in the BSR is required. Against this background, the "Green Cruise Port (GCP) – Sustainable Development of Cruise Port Locations" project had been initiated in 2016. GCP embraces 20 partners, including associated organizations, which represent port authorities, cruise lines, a maritime research institute and a governmental body. Geographically it covers all BSR countries and the neighboring North Sea.

The overall goal of the project is to elaborate a multidimensional strategic approach for a sustainable and qualitative future development of cruise shipping in port areas and wants to encourage investments and procedures for an environmental-friendly cruise port infra- and superstructure in the Baltic Sea Region as well as in smart traffic links to the public transport and supply systems.

To achieve this goal, the Green Cruise Port project concentrated on three content-related work packages (WPs) – note that Work Package 1 is "Overall Project Management and Coordination":

- **WP 2:** Sustainable Energy Supply & Innovative Solutions for Emission Reduction;
- **WP 3:** Smart Cruise Terminal Buildings & Innovative Reception Facilities; and
- **WP 4:** Smart Cruise Port Traffic Solutions & Economic Effects.

The GCP had been implemented from March 2016 to February 2019.

In the course of the projects, several sustainability initiatives of each WP had been examined or even carried out by the project partners. Nevertheless, many challenges persist, and these must be tackled together in a structured way. In particular, the knowledge generated within the frame of the project (mainly in the form of presentations or reports) and in other related projects worldwide needs to be merged in a consistent way to provide a future guideline and framework for a smart cruise port development in the BSR, in the following referred to as "Green Cruise Port Action Plan 2030".

The main goal of the Green Cruise Port Action Plan is to provide information on how to reduce the negative environmental impacts of cruise port operations and to succeed in balancing environmental challenges with economic demands.

1.3 Fundamentals of Green Cruise Port Action Plan 2030

1.3.1 General Information – Green Port Action Plans

The Green (Cruise) Port Action Plan is a comprehensive plan used to address sustainability, and in particular environmental, aspects from (cruise) shipping and (cruise) port operations. Consequently, the Green Cruise Port Action Plan will serve as important tool for the project partners, which are striving for a high level of environmental, social and economic sustainability.

Such a program, as in this case, is generally established and implemented by a port authority with input from local (in particular environmental) regulatory agencies. The program should also be periodically evaluated and revised after the initial implementation to ensure continued applicability. The commitment and the endorsement from the upper level and collaboration from other stakeholders and regulatory agencies are paramount for a successful Green Cruise Port Action Plan. In order to develop a successful plan for an organization, it is important to shape the plan to the organization's needs and according to its capacity to meet those needs. A viable work plan will recognize the extent to which an environmental

action is supported, either directly or indirectly, by an organization's strategic objectives, culture, and human and financial resources. One of the keys to the successful development of an Action Plan is to engage stakeholders throughout the sustainable action planning process, from the initial scoping of the plan through implementation and monitoring.

1.3.2 Overall Goals of Green Cruise Port Action Plan 2030

The Green Cruise Port Action Plan, as developed and presented in this report, will provide a general framework for the partner's sustainability policy in which the most important medium and long-term goals are defined and set out in a basic strategy, where appropriate including concrete measures.

In particular, the Green Cruise Port Action Plan 2030 is designed to support the cruise industry to advance their sustainability practices. In doing so, the Action Plan also presents all Green Cruise Port project partners the opportunity to engage with stakeholders to demonstrate and ensure consideration of the strong potential to provide substantial reductions of greenhouse gas emissions (GHG) and air emissions at a local, regional and global scale.

The Green Cruise Port Action Plan presented in the following two chapters is versatile; its benefits will be seen on different levels (see Figure 2).

Figure 2: Target groups of the Green Cruise Port Action Plan 2030

Source: HPC, 2019.

Overall, the Green Cruise Port Action Plan will support the cruise industry to establish an environment-friendly port operation in accordance with social and

economic aspects. Based on this, many promising potentials are expected to arise for the cruise industry, as illustrated in Figure 3.

Figure 3: Expected results of Action Plan

Source: HPC, 2019.

1.3.3 Focus of Action Plan

It is worth noting that the focus of the Green Cruise Port Action Plan 2030 is on environmental sustainability while economic and social aspects – as part of the whole sustainability concept – will also be considered.

Figure 4: Sustainability dimensions

Source: HPC, 2019.

The focus on environmental issues is due to the fact that most content-related project work packages focus on environmental issues (Figure 4).

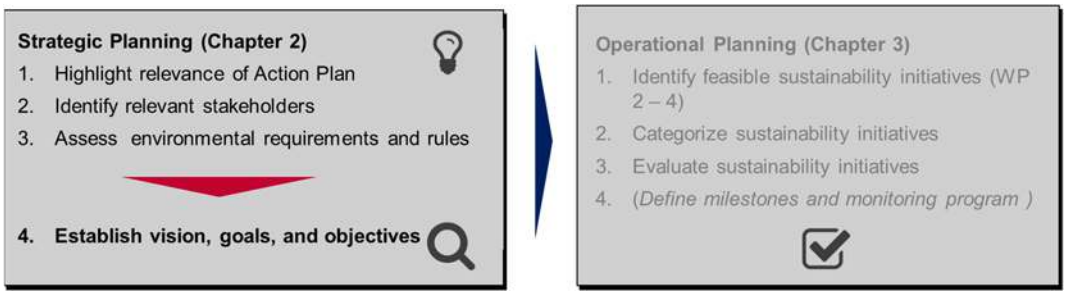
1.3.4 Structure of Green Cruise Port Action Plan 2030 and Procedure for the Development

In general, an effective Green Action Plan should:

- Set up an overarching **sustainability vision**,
- Develop **goals** to identify how the vision will be realized, and
- Develop a **roadmap to achieve all goals.**

This makes clear that a Green Action Plan includes two planning stages (see also Figure 5): the strategic phase that involves the development of a sustainability vision and corresponding goals as well as an operational phase in which concrete measures will be proposed to reach the objectives defined.

Figure 5: Strategic and operational planning phase of Action Plan



Source: HPC, 2019.

Strategic Planning Phase

The Green Cruise Port Action Plan development process starts with the strategic planning phase, which mainly aims to develop the overarching vision as well as a set of goals addressing sustainability issues.

It is worth noting that a Green Cruise Action Plan should also involve specific and quantitative objectives. However, setting concrete, ambitious but also realistic and achievable objectives is a complex and long-term process in which several partners needs to be involved. To set an emission-reduction objective, for example, a detailed emission inventory and forecast must be available. At the same time, the targets should be evaluated from the perspective of the policy context at the local, regional, state and national levels. Moreover, it must be ensured that the targets can really be achieved. The biggest challenge is that several partners from different countries are involved in the Green Cruise Port project, rendering it nearly impossible to set uniform objectives for all partners.

Therefore, the Green Cruise Port Action Plan will not develop concrete objectives but overarching goals that support the vision.

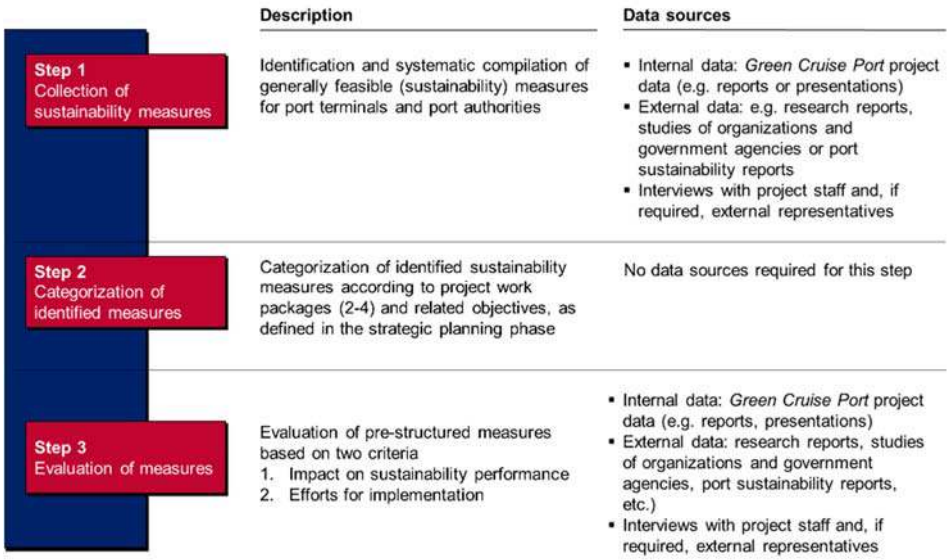
In addition to developing the vision and a set of corresponding goals, the strategic planning phase should also:

- Present the **relevance** for the development of the Action Plan;
- Identify the main **internal** (e.g. agencies for whom the plan is being developed) and **external** (e.g. regional partners) **stakeholders**; and
- Examine all relevant **regulatory requirements and rules**.

Operational Planning Phase

In the subsequent operational planning phase, specific measures for achieving the defined objectives are proposed. Therefore, a broad range of promising measures to improve a cruise port's environmental but also economic and social performance is identified and evaluated. The detailed procedure for providing guidelines in how to improve the level of sustainability of cruise ports will be based upon three steps, illustrated in Figure 6.

Figure 6: Approach for identifying sustainability measures

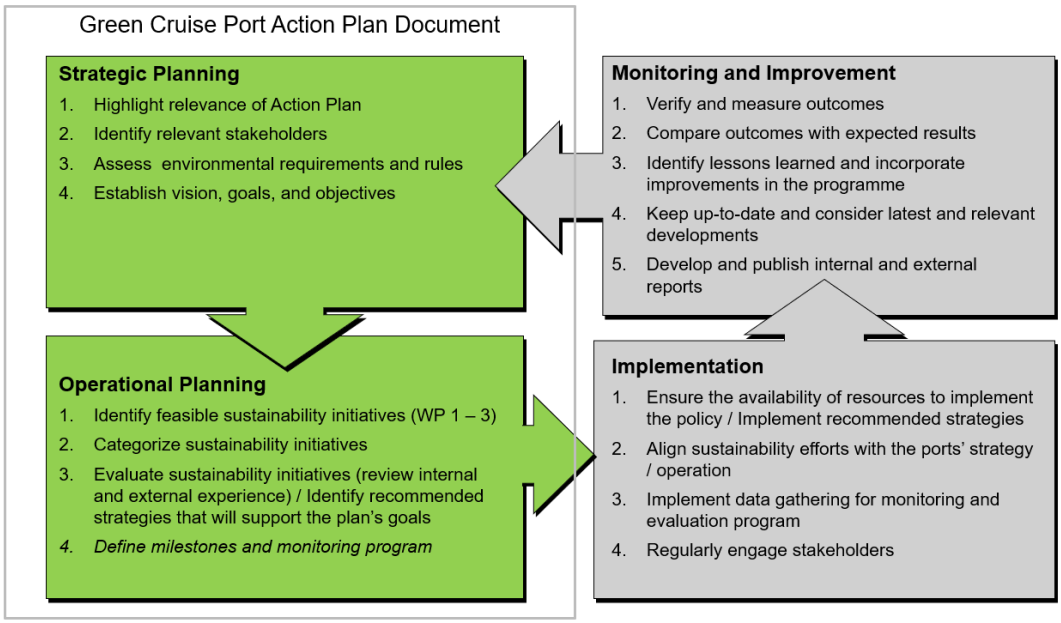


Source: HPC, 2019.

Based on this analysis, the most promising measures, namely those with a high impact to effort ratio, can be identified. For cruise ports it seems sensible to first implement measures with a high impact / effort ratio, i.e. measures having a high impact on sustainability and, at the same time, requiring low effort for implementation. It is worth noting the actual implementation of the plan as well as

all required activities to assess the plan's performance is entirely within the partner's scope of responsibility (shaded grey in Figure 7). Therefore, this document will only consider the phases "Strategic Planning" and "Operational Planning".

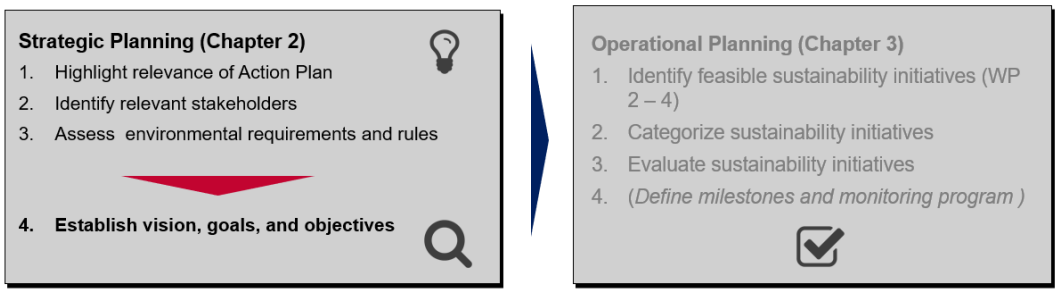
Figure 7: Four phases of Green Cruise Port Action Plan



Source: HPC, 2019.

2. GREEN CRUISE PORT ACTION PLAN 2030 – STRATEGIC PLANNING PHASE

In the Action Plan, the vision and the most important (environmental) sustainability goals are defined (strategic planning phase). In the center of the Action Plan (operational planning phase), a broad range of measures is identified that are suitable to improve the level of environmental sustainability of the project partners.



2.1 Relevance of Green Cruise Port Action Plan

The relevance for the Green Cruise Port project and the resulting Green Cruise Port Action Plan 2030 had already been briefly outlined in Chapter 1.

First of all, the partners not only need to accommodate the expected growth in the number of cruise passengers but also the increasing ship sizes. As the industry continues to expand, this raises questions and concerns about sustainability and the effect of cruise ships on the environment due to the increasing size of the cruise industry.

One of the reasons for this ambitious commitment is that an increasing number of (cruise) port stakeholders – e.g. regulatory authorities or customers – **demand a better management of negative externalities caused by port and vessel operations in (cruise) ports**. Cruise line sustainability has become a concern for environmental groups and governmental agencies due to pollution, sewage, and harm to the seas. One of the consequences of this is that the regulation of port areas is becoming ever more stringent e.g. in relation to sulfur and nitrogen oxides. With regard to greenhouse gas emissions emitted by vessels, it can also be expected that regulations especially in the EU, will become more stringent in the future (see Section 2.3).

One particular challenge in this context that needs to be tackled is that more and more customers see cruise ships as one of the main waste / emission producers of the world seas. This perception could lead to significant image losses in the long term. On the other hand, (cruise) 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. As a positive side effect, cultivating sustainable and green practices may also **improve productivity** by providing a more pleasant work environment for employees. One further reason of the cruise industry for a development towards sustainability is the **threat of climate change** that is regarded as one of the defining challenges of the 21st century. It must be considered that climate change could also have substantial impacts on the cruise industry – e.g. as a result of sea-level rise or sedimentation impacts. It is also worth noting that environmental sustainability has become a promising means **to improve profitability**. For example, significant energy saving potentials can be exploited (e.g. by adopting energy efficient technologies) or unnecessary waste and noise can be efficiently avoided both resulting in potential for cost-savings.

Ensuring a high level of sustainability in cruise ports may thus help to bring ecological, economic and technological / operational advantages and can be essential for obtaining a leadership position for ports (see Figure 8).

Figure 8: Drivers towards achieving more sustainable cruise port operation

Source: HPC, 2019.

2.2 Stakeholders Involved

As explained in Section 1.3 one of the keys to the successful development of the Green Cruise Port Action Plan 2030 is to first identify but also to engage all relevant stakeholders throughout the development process. Among others, this will lend credibility to the Plan. In general, the stakeholders can be defined firstly out of the project partnership, but also from involvement of external stakeholders during the project implementation.

2.2.1 Project Partnership

The project partnership differentiates between full members and associated organizations (see Figure 9).

Figure 9: Overview – Project partnership

GREEN CRUISE PORT Project Partnership	
Full Project Partner	Associated Organization
1. Hamburg Port Authority 2. Freeport of Riga Authority 3. ROSTOCK PORT GmbH 4. Port of Tallinn 5. Port of Helsinki Ltd. 6. Port of Bergen 7. SE Klaipeda State Seaport Authority and 8. Port of Esbjerg 9. Maritime Institute in Gdansk (MIG) and 10. Hamburg Cruise Net e.V. (HCN), former Hamburg Cruise Center e.V.	1. Port of Oslo 2. Ports of Stockholm 3. Copenhagen Malmö Port (CMP) 4. ROSMORPORT Kaliningrad Branch 5. Port of Amsterdam 6. Port of Gothenburg 7. ROSMORPORT North-West Basin Branch St. Petersburg 8. AIDA Cruises 9. TUI Cruises and 10. Free and Hanseatic City of Hamburg Senate Chancellery

Source: HPC, 2019.

Full project partners are entities, which were involved continuously in the project activities. Most of them are port authorities (1-8) in the BSR and neighbouring North Sea area. This group for whom the plan is basically being developed was supplemented by a research institute (9), especially in work package 4, and a non-profit, state-controlled association (10) which represents the perspective and the interests of different landside service providers in the cruise sector and different cruise shipping companies. This group of partners can be understood as internal stakeholders of the Green Cruise Port Action Plan.

Beside the full membership in the project there exists the status of an associated partnership. Entities in such function expressed intention to follow the project

activities and outcomes continuously, to give consultative support and being occasionally a part of project activities. The group of associated organizations shows the engagement of three different stakeholder groups. Again, port authorities (1-7) take over a significant share, but also cruise lines (8-9) and a policy stakeholder on regional level (10) are represented. The members of this group belong to the group of external stakeholders.

2.2.2 Stakeholder Groups

The structure of the partnership defines already five stakeholder groups (a-e), supplemented by furthers external stakeholder groups (f-i) which were involved occasionally during the project implementation:

a) Port Authorities and Terminal Operators;

b) Cruise Lines;

c) Research Institutes;

d) Branch Associations;

e) Policy stakeholders (on regional, national and EU level);

f) Technicians and Engineering Companies;

g) Public Authorities responsible for environmental issues and / or transport (on local, regional or national level);

h) Intergovernmental and international Institutions; and

i) Public and private Transport Companies.

The role of each stakeholder group is described separately in the next paragraphs.

Port authorities and cruise terminal operators

The main stakeholder group of the project activities and the elaborated Green Cruise Port Action Plan 2030 are port authorities and terminal operators respectively. They enhanced their knowledge significantly by studies, participation in workshops and best practice tours in respect to the project work packages.

For further progress in the elaboration of the Action Plan, it is important to understand the different port roles and functions as well as their respective impact and influence on a port's total energy consumption and emission output.

In many **ports** around the world, the landlord model applies, in which the port authority affects the port structure from a mainly political and regulatory perspective (see Figure 9; Full Project Partner 1-2). Port operation is here carried out by private (cruise) companies that lease the required infrastructure from the authority and procure, operate and finance the superstructure 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[1]. Although the port authority is only responsible for a relatively small proportion of a port's total energy consumption, there is a broad range of, mainly indirect, measures to foster sustainability in the whole port area, as explained in Chapter 3. Another commonly used port model is the public service port (see Figure 9; Full Project Partner 3-8). in which the port authority performs the whole range of port related services, in addition of owning the infrastructure. Under this port model, sustainability measures are easier to implement since the port authority also owns and operates the (energy-intensive) superstructure, such as cranes or cargo handling equipment.

Cruise terminal operators are usually profit-oriented, private companies that carry out commercial and operational activities in the port. However, it must be considered that many port authorities involved in the Green Cruise Project fulfil a double role as port authority and terminal operator, as explained above. For the two landlord port authorities, the relevant cruise terminal operators are:

a) CGH Cruise Gate Hamburg GmbH in Hamburg: operates three terminals

b) Riga Passenger Terminal Ltd. in Riga: operates three berths which are dedicated to cruise ships.

Cruise lines

For the successful development and implementation of the Plan, the engagement of cruise lines is essential. This can be explained with the fact that air pollutants and energy consumptions in ports are primarily caused by ships; Gibbs et al. (2014) found that emissions from shipping at berth are approx. ten times greater than those from port's own operations. Even though ships are owned or operated by shipping companies, port authorities and the cruise port terminals can have a significant impact on the reduction of ship emissions and energy consumption in a port (see Section 3). In addition, cruise lines will have to cooperate with terminal operators and port authorities in establishing appropriate port energy infra-and

[1] Only few options exist to directly initiate sustainability measures on relatively energy-intensive cargo handling equipment devices and cranes used in terminals.

superstructure as well as common waste handling standards. The main cruise line operators affecting the Green Cruise Port Action Plan are Aida and TUI Cruise, e.g. they were involved into noise measurement studies in the port of Hamburg. Together with other cruise lines (e.g. MSC Cruises, Royal Caribbean International) they informed in project workshops about technical adaptations of their fleets and expressed their willingness to cooperate more intensively with terminal operators and port authorities in establishing appropriate port energy infra- and superstructure as well as common waste handling standards.

Research institutes

Already in the development but also in the future progress of the implementation of the Green Cruise Port Action Plan support from research institutes will be required. Their analytical skills and scientific know-how helped, for example, to develop respectively recommend standardized solutions or common approaches for a sustainable cruise port development in a determined region. Exemplarily the Maritime Institute in Gdansk as full project partner analyzed common standards in the measurement of economic effects of cruise tourism and elaborated recommendations concerning port dues strategies in order to attract cruise lines with more environmental-friendly ships. Further external input came, for instance, in workshops by presentations or participation in workshop discussions from the KLU Kühne Logistics University, the University of Applied Sciences Wismar, Tallinn University of Technology or the Maritime Academy in Gdynia.

Branch associations

Branch associations, e.g. CLIA Europe, Cruise Baltic or Baltic Port Organization, bundle the interests and can be seen as mouthpiece of their members which are involved into the cruise business. Sometimes they even act as mediating partner in case of contrary opinions between their members. From Green Cruise Port perspective, they were on the one hand competent branch representatives in discussions and on the other hand they can be understood as multiplier of project outcomes / results, informing their members about project findings and challenges and can foster the implementation process of the Green Cruise Port Action Plan.

Policy stakeholders (on regional, national and EU level)

Policy stakeholders have been involved and informed by Green Cruise Port project activities and outcomes about advisable future adaptations towards an innovative and sustainable cruise port infrastructure. For instance, with a better understanding of the economic importance of cruise tourism for the region they

will be much more willing to provide funds for investments in sustainable cruise port infrastructure and superstructure.

Exemplarily, the participation or involvement of the Free and Hanseatic City of Hamburg – Ministry of Economy, Transport and Innovation, the Ministry of Infrastructure Development of the Kaliningrad Region, the Ministry of Tourism of the Government of Kaliningrad Region, the Ministry of Economic Affairs and Communication in Estonia, the Ministry of Environment in Estonia, the Department of Tourism Office of the Marshall of Pomorskie Voivodeship and the Ministry of Economics of Latvia at the workshops in Kaliningrad, Tallinn, Gdansk or Riga can be highlighted. Additionally, the City of Oslo, vice major for Business Development and Public Ownership, welcomed the Green Cruise Port project during a best practice tour to learn about partner's perceptions regarding the future of electric power for cruise ships in ports. Last but not least Merja Kyllönen (MEP), addressed views from the European Parliament in a speech about environmental challenges of the maritime sector in the Baltic Sea to the Green Cruise Port project partnership.

Technicians and engineering companies

Technicians and engineering companies are the planning entities and driving forces for technical solutions directed to a sustainable development of cruise port locations. In several project studies and workshops, e.g. regarding construction / design of terminal buildings, noise measurement, provision of onshore power or LNG bunkering, they brought in their technical know-how, but also enhanced their own knowledge by discussions and experience exchange with Green Cruise Port partners, especially port authorities, terminal operators or cruise lines. Therefore, these companies can also play an active role in the implementation of the Green Cruise Port Action Plan by spreading new gained knowledge about environmental-friendly cruise port infra- and superstructure.

Intergovernmental and international institutions

The most important intergovernmental and international institutions to highlight at this point are the IMO (International Maritime Organization) and HELCOM (Baltic Marine Environment Protection Commission - Helsinki Commission). They set the environmental and legal requirements for more clean shipping in BSR. Thus, they build the base and describe the framework in which the Green Cruise Port Action Plan can be developed and implemented. These entities were not actively involved in the project activities, but their regulations and recommendations had an essential impact on the project activities and the main

outcome, the Green Cruise Port Action Plan. The NABU (Nature and Biodiversity Conservation Union) participated in the opening conference in the project and addressed its requirements and expectations to the project development.

Public and private transport companies

Due to the growing numbers of cruise passengers and growing vessel sizes in the Baltic Sea Region the handling / organization of passenger flows are becoming more and more challenging. The improvement of processes and the organization of the transport system in cruise port locations is a crucial issue. Cruise or ship agents as well as tour operators play an essential role in providing, among other things, transport services for shore excursions as well as for arrival and departure of cruise tourists. Several companies, like Conference & Touring C&T, Sartori & Berger, PWL Port Services, Baste & Lange, H. C. Röver, C&C Port Agency Finland, GAC Finland Oy and others, participated in content-related Green Cruise Port workshops to inform about their services and discuss transport challenges, solutions as well as cooperation between transport means and companies in respect to interoperability. The Green Cruise Action Plan will inform public and private transport companies about the opportunities for their own future business development by fostering a more diversified supply of sustainable traffic links / solutions.

2.3 Environmental Requirements and Rules

In the following, the environmental rules and requirements affecting the cruise industry in the BSR – and thus the Green Cruise Port Action Plan – are briefly presented. Note that country-specific rules and regulations of the project partners will not be examined in detail. It goes without saying the Green Cruise Port project partners at least comply with existing environmental conventions. In general, environmental issues from regulatory points include the following: air and greenhouse gas (GHG) emission, noise, water & sewage as well as waste.

It is worth noting that GHG, air and noise emissions in cruise 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. busses) and cruise ships at berth (see also Section 3.1).

2.3.1 Air Emission Rules and Requirements

It is important to distinguish air and GHG emissions. The main problems caused by air gases occur close to the ground and produce direct health effects, such as

respiratory diseases. GHG refer to a number of gases that have direct effects on climate change / global warming with significant implications for, among others, sea level, retreat of glaciers or rainfall. Hence, air pollution can be (simplified) defined as a local phenomenon, while GHG affect the whole of the atmosphere. Although both air pollution and global warming are different concepts they are related since, inter alia, one factor that is responsible for both phenomena is the extraction and burning of fossil fuels (e.g. in ship or truck engines).

The International Maritime Organization (IMO) regulates international air emissions from ships under Annex VI to the International Convention for the Prevention of Pollution from Ships (MARPOL). 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.

Sulfur Oxides (SO_x)

Sulfur oxides (SO_x) are compounds of sulfur and oxygen molecules. It is a toxic, colourless 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).

Rules and Requirements for Ships

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 in Table 3.

Table 3: 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	
2012	0.1	3.5
2015		
2020		0.5

Source: MARPOL, 2018.

Special fuel quality provisions exist for SO_x ECA (see Figure 10).

Figure 10: The Baltic and North Sea SO_x Emission Control Areas

Source: CR Ocean Engineering

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[2], 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.

Rules and Requirements for Non-Road and Road Vehicles

For non-maritime diesel fuel in the EU, the regulations requires since 2008 that fuel sold in the European Union and several other European countries must contain less than 10 mg/kg[3]. Thus, emissions from those diesel engines are regarded as sulfur free (Ultra Low Sulfur Diesel (ULSD)).

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 micrometres (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).

Rules and Requirements for Ships

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

[2] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32012L0033
[3] EN ISO 20846, EN ISO 20847, EN ISO 2088

indirectly controlled through limitations on the maximum sulphur 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. Consequently, politicians and environmental non-governmental organizations are calling for action on this topic. This is also true for ships, as these may operate close to populated areas or to arctic areas (DNV GL, 2017).

Discussion on reduction of PM from ships at IMO arose from the establishment of a correspondence group during the 10th session of the Bulk Liquids and Gases subcommittee. The outcome of the proceedings is still unclear.

Rules and Requirements for Non-Road and Road Vehicles

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.

Nitrogen oxides (NO_x)

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, such as respiratory problems, cerebrovascular and cardiopulmonary diseases (for details see: Baltic Ports Organization, 2017).

Rules and Requirements for Ships

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 4, NO_x 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 4: 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 NO_x emissions. The ECA in the North and Baltic Sea will be enforced for ships constructed on or after 1 January 2021 or existing ships which "*replace an engine with non-identical engines or install an additional engine*."[4] Tier III limits are expected to reduce NO_x exhaust by 80% in comparison to the present emission level (World Maritime News, 2016).

Rules and Requirements for Non-Road and Road Vehicles

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

- EURO 6d standard limits NO_x emission from diesel fuelled 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 NO_x emission to 400 mg/kWh.

2.3.2 Greenhouse Gas 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 5). 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.

[4] IMO Marine Environment Protection Committee (MEPC 71)

Table 5: 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.

Greenhouse gas quantities are usually documented in the unit of tones, which is also known as metric tons.

Rules and Requirements for Ships

Currently, the whole shipping sector is responsible for only about 2.5% of global GHG emissions. Nevertheless, 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 (IMO, 2015). 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[5]. 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. It provides a specific figure for an individual ship design, expressed in grams of carbon dioxide (CO_2) per a ship's capacity-mile (e.g. tonne mile).
- 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.

[5] See Chapter 4 "Regulations on energy efficiency for ships"

Despite these initiatives, it can be expected that emission regulations for ships, especially in the EU, will become more stringent in future[6]. Partly as a response to this, the IMO Maritime Environment Protection Committee (MEPC) established in 2016 a roadmap for developing a comprehensive IMO strategy on reduction of GHG emissions from ships.

Rules and Requirements for Non-Road and Road Vehicles

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).

2.3.3 Noise Rules and Requirements

Noise pollution has become an increasingly significant environmental issue in many ports (ESPO, 2018). Port noise can be classified as industrial noise and ports authorities are usually mainly responsible for noise emitted from within the port boundaries both on shore and within the water area of the port.

On 18 July 2002, the Directive 2002/49/EC (Environmental Noise Directive - END) entered into force which can be considered main factor contributing to the ports increased focus on noise issues. The aim of the Directive is "*to achieve a high level of health and environmental protection…*", among others, *by "avoiding, preventing or reducing on a prioritized basis the harmful effects, including annoyance, due to exposure to environmental noise.*". To reach this goal the following actions shall be implemented progressively:

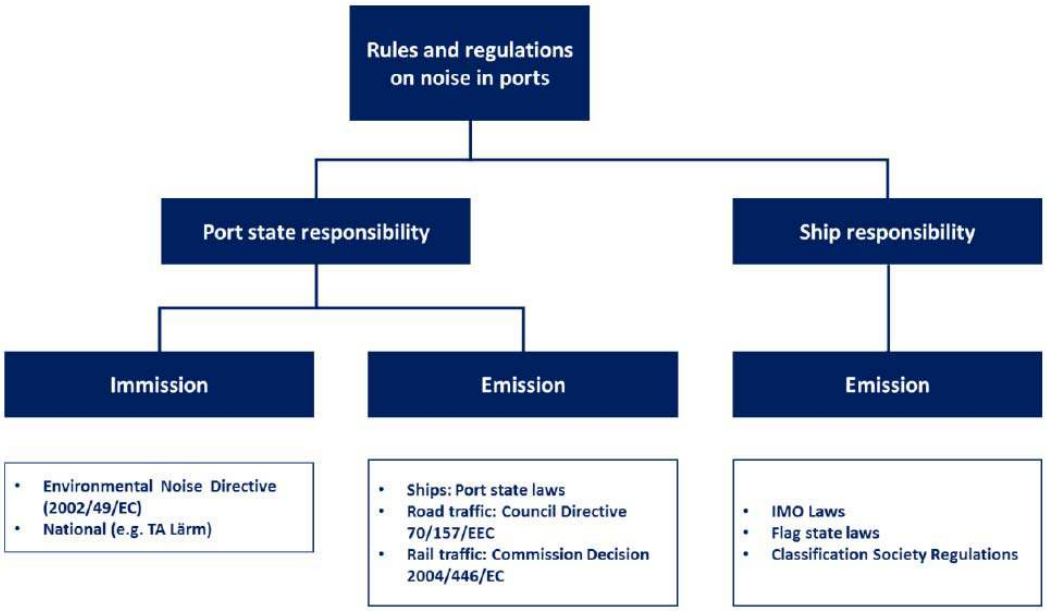
- *Determine the exposure to environmental noise, through noise mapping, by methods of assessment common to the Member States;*
- *Ensure that information on environmental noise and its effects is made available to the public; and*
- *Adopt action plans by the Member States, based upon noise-mapping results, with a view to preventing and reducing environmental noise (…)*

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

The Directive 2002/49EC applies to environmental noise to which humans are exposed in particular, hence also for ports near residential areas. Vessels can be considered as the most challenging noise source in ports. Until now, however, noise emitting from vessels is not regulated internationally. In the SOLAS regulations of the IMO[7], there are rules set about noise on board of ships, but no regulations are present for noise emissions to the surrounding area. As a result of this, noise emissions from maritime traffic are only regulated on the national level through the environmental permits of ports. Finding uniform and international rules for vessel noise requires a common basis which does not exists for the moment. Therefor the international project Neptunes (*N*oise *E*xploration *P*rogram *T*o *U*nderstand *N*oise *E*mitted by *S*eagoing *S*hips) developed a measurement protocol, a classification for noise emitted from seagoing vessels and a best practice guide. In addition, a noise label was developed and will be integrated in the Environmental Ship Index (ESI) of the World Port Sustainability Program of the IAPH.

A summary of regulations concerning noise in ports is compiled in Figure 11.

Figure 11: Rules and regulations on noise in ports



Source: Green Cruise Port, 2018g.

[7] Code on Noise Levels of Board Ships

2.3.4 Wastewater Discharge Rules and Requirements

The discharge of raw sewage into the sea can create a health hazard. In addition, sewage can lead to oxygen depletion and can be an obvious visual pollution in coastal areas – this is a particular challenge for tourist areas.

Therefore, MARPOL Annex IV also contains a set of regulations pertaining to the discharge of sewage into the sea from ships including:

- Regulations regarding the ships' equipment and systems for the control of sewage discharge;
- The provision of port reception facilities for sewage (see next section); and
- Requirements for survey and certification.

As such, the regulations prohibit dumping of untreated sewage into the sea within a specified distance of shore. Detailed descriptions of the requirements can be found in MARPOL Annex IV "Prevention of Pollution by Sewage from Ships".

It is worth noting that in July 2011, the IMO designated the Baltic Sea as a special area for sewage from passenger ships. The decision entered into force on 1 January 2013 and introduced the following relevant requirements:

- *The discharge of sewage from passenger ships within a Special Area is generally be prohibited under the new regulations, except when the ship has in operation an approved sewage treatment plant which has been certified.*
- *The sewage treatment plant installed on a passenger ship intending to discharge sewage effluent in Special Areas should additionally meet the nitrogen and phosphorus removal standard (…)*

The discharge requirements for Special Areas in regulation IV for the Baltic Sea Special Area shall take effect on 1 June 2019, for new passenger ships and on 1 June 2021 for existing passenger ships (see MEPC.275(69)). CLIA has set more stringent policies for its members, setting a standard for no discharge of untreated sewage anywhere. Detailed information can be found in "Waste Management Best Practices and Procedures".[8]

[8] https://cruising.org/about-the-industry/regulatory/industry-policies/environmental-protection/waste-management

2.3.5 Waste Management Rules and Regulations

An adequate waste management in cruise ports is crucial for minimizing negative environmental impacts of the cruise industry. In addition, the steadily rising number of cruise passengers also leads to larger quantities of waste produced.

According to MARPOL 73/78 and the EU Directive 2005/59/EC ports are obliged to provide adequate port reception facilities which must be adequate to meet the needs of ships using the port, without causing undue delay. The EU Port Reception Facility (PRF) Directive also requires:

- Vessels to land the waste they produce during voyages to and between EU ports to port reception facilities;
- Ports to develop waste handling plans; and
- Vessels to pay a mandatory fee for landing this waste and to notify the port of what waste it has in advance of arriving in port[9].

The most important IMO regulation concerning waste can be found in MARPOL Annex V[10] that states that all plastics and other garbage produced from ships are prohibited to be discharged in the sea. In addition, ships must have a garbage record-keeping book onboard.

Some ports in the BSR (e.g. Port of Helsinki) also follow the "No-Special-Fee" (NSF) system even before the EU Directive 2005/59/EC. The system, developed Helsinki Commission (HELCOM) in 1998, is defined as "*a charging system where the cost of reception, handling and disposal of ship-generated waste…is included in the harbor fee or otherwise charged to the ship irrespective of whether waste are delivered or not*"[11]. Hence, the waste management fee imposed on a ship should be independent of the volume of the wastes delivered to the port reception facilities.

2.4 Vision and Goals of Plan

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

[9] The mandatory fee ensures that a ship can land its waste and that waste is not discharged into the sea, however, the amount and type of wastes that can be delivered in each port vary.
[10] Pollution by Garbage from Ships
[11] HELCOM Recommendation 28E/10

- The vision will paint a picture of where the partners want to be in terms of sustainability and has a long-term timeframe (Section 2.4.1);
- The corresponding goals will identity how the vision will be realized; the goals developed will be mostly qualitative (Section 2.4.2); and
- Based on the goals developed, specific measures will be suggested in the next planning phase (operational phase) to achieve the objectives (Chapter 3).

2.4.1 Overall Vision

The cruise shipping sector in the BSR has grown significantly in recent years and the industry (and project partners) intends to grow further in the future. In order to create the necessary conditions for a further growth in the long term, however, the cruise industry must not only expand its capacities but especially respond to sustainability challenges. This is especially important in the light of climate change, an increasing public awareness of environmental responsibilities and increasingly strict environmental regulations (see Section 2.3). Against these challenges, the Green Cruise Port project partners pursue the following vision:

Decouple growth in the BSR cruise port industry from negative sustainability, and especially environmental, impacts that result from port and vessel operations.

This demonstrates clearly the project partners are fully aware that an insufficient level of sustainability could not only have substantial impacts on nature, society and economy as a whole but also on their operations. Consequently, the partners are seeking to anticipate and respond proactively to these challenges.

It is important to note that the project partners recognize that sustainability does not only include environmental but also social and economic aspects. Therefore, the partners not only commit to protect the environment but also the health and safety of their employees and customers while also to operate profitably in the long term. Nevertheless, the project partners committed to initially focus on the protection of environment within the frame of the project and the Action Plan.

Inflamed by the vision, the project partners are striving to take a leadership role in sustainability and create the necessary conditions to remain competitive in the long term and establish the conditions for growth.

2.4.2 Goals of Action Plan

To realize the vision defined, the project partners pursued two concrete main objectives that contribute in shaping the conditions for further growth in the cruise (port) industry in the BSR:

Goal 1: Ensure to meet growing sustainability requirements and reduce negative externalities caused by port and vessel operations in cruise ports.

Goal 2: Accommodate the projected growth in the number of cruise passengers as well as the steady increase in vessel size in the long term and strengthen sustainable economic effects.

Within the frame of the project, three corresponding work packages have been defined and performed to reach these strategic goals (see Figure 12).

Figure 12: Overall goals of Green Cruise Port Action Plan[12]

Source: HPC, 2019.

As explained in Section 1.2, each work packaged defined and performed within the frame of the project contributed in different ways to the achievement of the project goals. In the following, the respective objectives of each WP (2-4) are presented.

[12] WP 1is project management and administration.

2.4.2.1 WP 2 – Sustainable Energy Supply & Innovative Solutions for Emission Reduction

WP 2 of the Green Cruise Port project directly contributes to the achievement of the first overall project goal. In detail, various initiatives have been executed to identify measures in how to reduce or avoid harmful emissions caused by cruise vessel in ports, inter alia, by providing environmentally-friendly and innovative port supra- and infrastructure. As revealed in detail in Section 2.3, different kinds of emission need to be distinguished. Consequently, the following sub-goals have been pursued.

Avoid or reduce cruise ship GHG and air emissions in ports

Climate change has recently received more attention in the shipping sector, partly due to the fact that shipping is one of the fastest growing sectors in terms of GHG emissions (see Section 2.3.1). Alike, the contribution of ships and port operations to air pollution in port cities has become more important (see Section 2.3.2). In many cities, ships are now among the largest sources of air pollution. Because of these facts, WP 2 places a strong focus on reducing or even avoiding both GHG and air emissions emitted by vessels in ports.

Avoid or reduce ship noise emissions in ports

Noise has become a highly discussed issue when it comes to cargo handling and shipping operations in port areas. One of the reasons is that noise can be directly noticed by residents of port surrounding neighbourhoods[13]. Although some noise may be unavoidable, it can often be controlled using improved work practices. Against this background, another main goal of WP 2 is to find measures in order to reduce or even avoid noise emissions emitted by vessels in cruise ports.

2.4.2.2 WP 3 – Smart Cruise Terminal Buildings & Innovative Reception Facilities

Like the previous work package, this WP also directly contributes to the project's first main goal. Contrary to WP 2, however, this WP focuses on measures to reduce emissions emitted by cruise terminal buildings (including cargo handling equipment) and not by vessels. To provide another valuable contribution to sustainable development of the cruise sector in the BSR, the following two objectives are being pursued in this WP.

[13] For details see Section 2.3

Increase recycling rate of cruise port terminals / Improve waste management

Analogous to the increase of passenger numbers, the amount of waste being produced on board cruise ships is rising. On average one cruise passenger generates over 1 kg of solid waste per day (Svaetichin, 2016). The cruise ship is responsible to minimizing the production of waste and the proper sorting on board. In general, the disposal of waste should always be the last option and waste should always be recycled, if possible. Against this background, one of this WP's main goals is to increase the recycling rate of cruise port terminals and improve the waste management system.

Reduce energy consumption / emissions from terminal operations

Energy efficiency is becoming more interesting for ports and terminals as they realize that substantial energy savings and thus cost-saving potentials can be obtained, e.g. through rationalization of operation or adoption of new technologies; improving energy efficiency is also the easiest way to reduce GHG emissions and air pollutions. Further, terminals and ports can also produce electricity generated from renewable energy sources itself to reduce emissions but also energy costs. Consequently, WP 3 also tries to find innovative ways to reduce a (cruise) terminal's energy consumption and emission levels in a cost-efficient manner, without restricting operational performance.

2.4.2.3 WP 4 – Smart Cruise Port Traffic Solutions & Economic Effects

The cruise industry is among the foremost drivers of growth in the tourism sector and has experienced strong increases in recent years. In 2017, CLIA operated more than 449 ships with another 27 expected to debut in 2018. With ship sizes also being on the rise, it is projected that the number of global ocean cruise passengers will surpass the 27 million mark in 2018, compared to 18 million in 2009. During the year 2017, around 11.3% of the industry's bed capacity was thereby assigned to the Baltic Sea market and European regions other than the Mediterranean (CLIA, 2017). The stated numbers give an impression of the challenges and opportunities arising from the cruise industry's development for ports of call and cruise destinations worldwide. With regard to sustainability and with the cruise sector representing an increasingly important economic factor for many destination cities and regions globally, these go far beyond issues directly related to ship handling and cruise terminals operations in the port areas. While increasing ship sizes are new nautical requirements regarding seaside access, it is the growing number of cruise passengers per call that demands new solutions

regarding land side access of terminal sites, passenger mobility and management of passenger flows. To tackle these challenges and strengthen sustainable economic effects of cruise tourism in destination cities and regions five objectives (sub-goals) are being pursued in this WP. Note that all of this WP`s objectives directly contribute in different ways to the achievement of the project's second main goal.

Provide solutions for nautical challenges and for a sustainable seaside access of cruise terminals

In recent years, new-build cruise ships have frequently defined new standards with regard to ship size and passenger capacity. These developments, in turn, come along with new requirements specifications regarding cruise port infrastructure and cruise terminal operations. While landside infrastructure has to accommodate for larger numbers of passengers, seaside access and nautical requirements at terminal locations must be designed in order to allow for safe navigation of very large cruise ships. While some cruise ports may have to adapt existing nautical infrastructures, such as yard basins, to allow for larger vessel sizes, new developments of adequate berthing places may be required elsewhere. In light of these challenges, WP 4 aims to identify solutions for a sustainable development of adequate seaside access to cruise terminals.

Improve landside accessibility of cruise terminals & Provide solutions for sustainable public transport to and from the cruise terminals

In view of more frequent cruise ship calls, rising passenger numbers and new cruise terminals that are not always located in direct walking distance to city centers or tourist sights, landside access for cruise terminals becomes an ever more important aspect. Different challenges may thereby apply depending on the port of call: while cruise ports serving the change-over of passengers are faced with growing requirements on transport links with airports and rail stations, focused information and reliable transport services for cruise passengers that do not take part in organized excursions are needed in stopover destinations. In both cases, capable links of cruise terminals to the landside traffic infrastructure and coordinated logistics services are required. WP 4 thus addresses these requirements and provides sustainable approaches to transport solutions and smart traffic links for landside access of cruise terminals.

Manage the growing passenger flows from cruise port operations & Provide solutions for sustainable mobility in cruise port cities

Cruise passenger flows constitute an increasingly important aspect not only for smaller or medium-size destinations. Growing numbers in cruise ship visits along with increases in ship sizes do thereby not only induce landside traffic but can also lead to other bottlenecks that may have a negative impact on the quality of stay. Large numbers of tourists visiting certain sights at the same time can cause tourism crowding that does not only impair the visitors' experience but may also lead to waning support for cruise tourism among the local public. Hence, project work within WP 4 aims to develop and propose applicable solutions and approaches for a coordinated management of passenger flows in destination regions.

Demonstrate positive economic effects from cruise tourism

The cruise industry contributes significantly to economic development both on local as well as on regional and national levels. As for the year 2016 the industry's worldwide output is estimated at around USD 126 billion, with more than 1.0 million jobs and USD 41.1 billion in wages and salaries depending on the cruise sector (CLIA, 2017). Although cruise tourism differs from traditional tourism in the way that production factors can be sourced from various countries, a significant part of the economic value added usually remains within destination cities and regions, e.g. through tourist expenditures and the purchase of supplies by cruise lines. While different studies provide estimates on the sector's regional economic effect on port cities and destinations in the Baltic Sea and beyond, results can vary due to different methodological approaches employed. Based on the objective of substantiated and comparable results, another project work in WP 4 aims at the development of common standards for the measurement of economic effects by cruise tourism.

Change cruise line behaviour towards a greener port stay

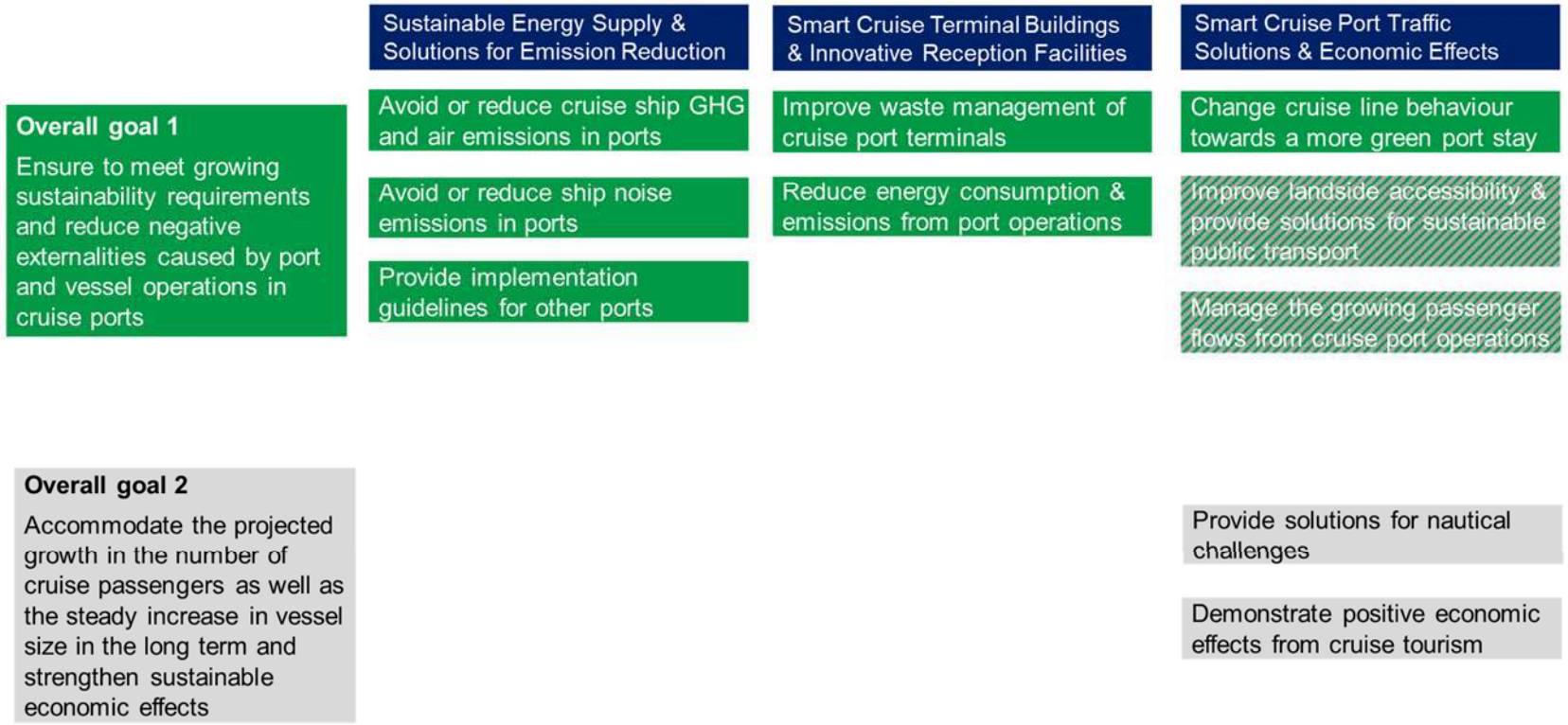
Being among the drivers of recent growth in the tourism sector, the cruise industry does not only help to raise the level of awareness for certain tourist destinations but also contributes to regional economic development. At the same time, the cruise sector can also pose an environmental burden on port cities. In order to mitigate the environmental impact, the Green Cruise Port project also focused on the identification, development and adaptation of organizational and technical measures for sustainable cruise tourism in the BSR and beyond. While some actions are technically feasible, they may be subject to investments or financial expenses on part of the cruise lines. In ports throughout the world, differentiated

port dues and green port fees are thereby used as a market-based mechanism to incentivize cruise lines to adapt sustainable technologies and use green port facilities. In order to strengthening these efforts, WP 4 also aims to provide common a guideline for the sustainable configuration of port tariff systems.

2.4.2.4 Summary – Goals per Project Work Package

As presented in Figure 13, each of the three work packages' defined goals directly contributes to achieve the ambitious but achievable main goals of the Action Plan.

Figure 13: Goals per project work package and contribution to overall goals of Action Plan[14]



Source: HPC, 2019.

[14] Note that the green and gray shaded sub-goals contribute to both of the Action Plan's overall goals.

3. GREEN CRUISE PORT ACTION PLAN 2030 – OPERATIONAL PLANNING

As part of the strategic planning phase of the Action Plan (Chapter 2), the overall sustainability vision of the partner had been presented and corresponding goals been developed. In this chapter, specific measures on how to improve the level of (environmental) sustainability of cruise ports – and thus achieve the long-term objectives defined – are proposed.

3.1 Emission Sources in Cruise Port

In the following three sections, a broad range of promising measures to especially improve the port's environmental but also economic and social performance is identified and evaluated, using a structured approach (see Section 1.3.4).

As explained in the previous chapter, the focus of the Green Cruise Port project is on environmental aspects. Hence, most measures suggested are designed to mitigate the environmental impact of cruise port operations, primarily by reducing emissions in the port area. In doing so, it should be considered that there are various emission sources in (cruise) ports. GHG, air and noise emissions from a cruise terminal typical arise from:

- **Cruise ships at berth:** emissions from ships in ports mainly result from[15] (World Ports Climate Initiative, 2010);
  - Auxiliary power systems that provide electrical demands during ship operations,
  - Auxiliary boilers which produce hot water and steam for use in the engine room and for crew and passenger amenities and
  - Ventilation systems (only noise).
- **Pier and cargo handling equipment**: in cruise ports, cargo and luggage handling is usually conducted by a small number of forklifts and mobile cranes (both mainly diesel-driven);
- **Road (external) traffic:** resulting from passenger arrival and departure as well as cargo supply (among others tank trucks); and

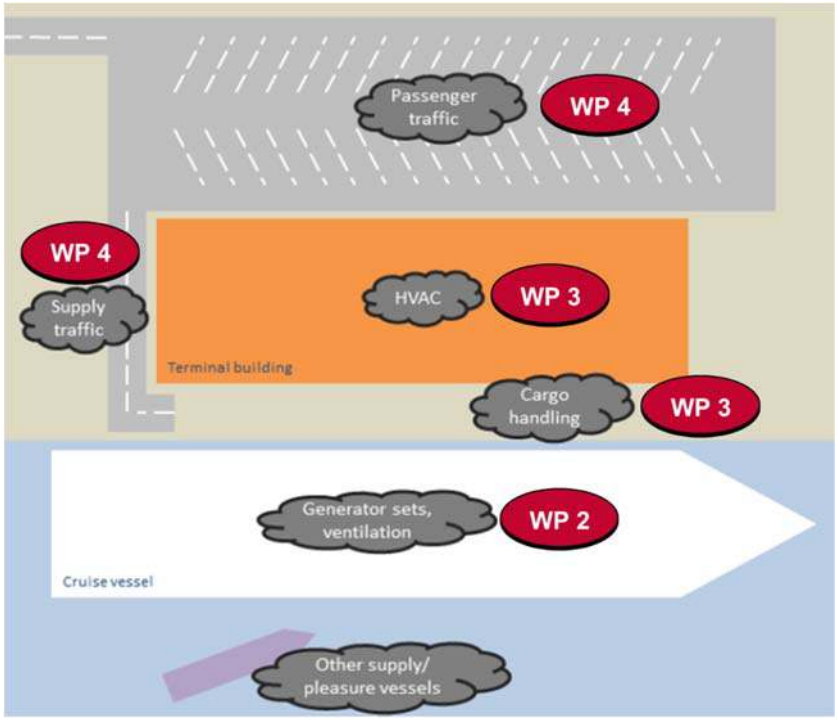
[15] Note that propulsion engines are usually switched off during hotelling (ship is either docked at a berth or anchored).

- **Terminal buildings**: the major energy user of a cruise terminal is usually the heating, ventilation and air condition system (HVAC).

It is important to note that in "Green Cruise Port, 2018g", it was found that air and GHG emissions of the cruise terminal itself are comparably low in contrast to the cruise ship at berth. On the other side, noise emissions from cruise ships are already very low due to noise restrictions on deck for the comfort of passengers. As a result of the large amount of emission sources, the Green Cruise Port project had been subdivided into several WPs, each with a focus on individual emissions sources (see also Figure 14):

- **WP 2** aimed to reduce emissions that result from **vessel operation**;
- **WP 3** concentrated on measures to reduce emissions that result from **terminal buildings** as well as **pier and cargo handling equipment**; and
- **WP 4** reveals measures to reduce emissions that result from **supply and passenger traffic.**

Figure 14: Emission sources of a typical cruise terminal and connection to project WPs[16]



Source: Green Cruise Port, 2018g.

[16] WP 1is project management and administration.

3.2 WP 2: Sustainable Energy Supply & Innovative Solutions for Emission Reduction

3.2.1 Collection of Measures

As reveled in the previous section, sustainability issues in cruise ports have to be addressed on two different areas, on the water side (vessel operation) and on the land side (port operation). Within the frame of the Green Cruise Port project, WP 2 aimed to reduce or mitigate emissions and waste from cruise vessels in cruise ports (see also Section 2.4.2).

As part of the project, a broad range of detailed studies and workshops on this issue have been carried out. One study published by Bergen og Omland Havnevesen and DNV GL comprised the business cases for establishing onshore power supply (OPS) for selected cruise ports. The analysis shows that all ports have a substantial need for investment support to cover the running costs for OPS – both in the shore to grid and LNG-power-barge case (Green Cruise Port, 2018a). Another study of this WP, carried out by the HPA and DW-ShipConsult, identified the different emission sources in a cruise terminal. It was found out, for example, that the cruise ship at berth is by far the largest air and GHG (not noise) emissions source on the terminal. In addition, diverse emission mitigation measures have been identified and evaluated (Green Cruise Port, 2017g). In another interesting study published within this WP, LNG as an alternative fuel for maritime vessels had been assessed, inter alia, by examining LNG supply chain and bunkering options and creating several business cases. A detailed comparison of differing bunkering models for ports had also been compiled (Green Cruise Port, 2017e). Two further studies of this WP provided valuable insights on noise emissions that result from vessel and port operations (Green Cruise Port, 2018d and Green Cruise Port, 2018q). In addition, a broad range of project-related workshops on this issue have been performed in the course of the project.

In the following section, the resulting (sustainability) measures identified are compiled and described. In order to gain an even more comprehensive overview, also external studies and publications are considered in the analysis. To this end, scientific publications (e.g. Gibbs et al., 2014: *The role of sea ports in end-to-end maritime transport chain emissions)* other project reports (e.g. Swiftly Green, 2015), manufacturers' brochures (e.g. from Becker Marine System) as well studies published by renowned institutions (like the “World Ports Climate Initiative”) have been considered.

3.2.2 Categorization of Measures

Based on the workshops held and concept studies elaborated during the Green Cruise Port project as well as taking further secondary sources into account, a total of 23 measures have been identified for the scope of work package WP 2. The measures that are summarized in Table 6 below have in common that they support the overall objectives of work package WP 2 (see Section 2.4.2). In the following, the derived measures are thereby categorized according to the aforementioned objectives.

Table 6: Overview of measures – Sustainable Energy Supply & Innovative Solutions for Emission Reduction

#	Action	Description	Responsibility	Source
Objective: Avoid or reduce ship GHG and air emissions in ports				
		Ship-port interface		
1	On-shore power supply (OPS)	Onshore power (OPS) is one possible technology to avoid GHG, air and noise pollutions from (cruise) 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,	Port authority or terminal operator(s)*	Green Cruise Port, 2018a; DNV GL, 2017; HPA, 2018; SLR, 2017

#	Action	Description	Responsibility	Source
		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.		
2	LNG PowerPac	Another innovative solution to reduce a cruise ship's emission at berth can be the so called "LNG PowerPac", developed by Becker Marine Systems. An LNG-fueled generator located in a mobile container allows vessels to switch off their auxiliary engines while the ship is docked. The LNG PowerPac can be placed on the vessel as well as on shore and is capable of delivering power supply of up to 30 MW. The Becker LNG PowerPac weighs 60 tons. Currently the system is tested for container vessels in Hamburg. The emission reduction potential is similar to the mobile LNG barge solution.	Port authority or terminal operator(s)*	Green Cruise Port, 2018e; Becker Marine System, 2018
3	LNG bunkering facilities: truck-to-ship (TTS)	To use LNG as fuel for vessels (see "Alternative Fuels" below), 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 (see Green Cruise Port, 2018e).	Port authority or terminal operator(s)*	Green Cruise Port, 2018e; WPCI, 2018
4	LNG bunkering facilities: shore to ship	Vessels arrive at a waterfront facility (tank or small station) designed to deliver LNG as a fuel to the vessel. Fixed hoses and cranes or dedicated bunkering arms may be used to handle the fueling hoses and connect them to the vessels. The transfer usually occurs on a pier or wharf and the LNG will be supplied via truck or vessel. The main advantages of the system are the large bunkering volume and high bunkering flow speed. Furthermore, the	Port authority or terminal operator(s)*	Green Cruise Port, 2018e; WPCI, 2018

#	Action	Description	Responsibility	Source
		system is ready for bunkering when required. In addition, the station can be automatized. However, high investment in tanks and bunker stations are required and sufficient space has to be available in the port. Consequently, this bunkering option is generally a good option for ports with stable, long-term bunkering demand. Several design alternatives are possible, each with their specific advantages and disadvantages (see Green Cruise Port, 2018e).		
5	LNG bunkering facilities: ship-to-ship (STS)	Ship-to-ship bunkering can take place at different locations: along the quayside, at anchor or at sea. Because of size limitations in some ports, only smaller bunkering vessels will be able to operate in the port area. The solution makes it possible to bunker large LNG volumes with a high flow rate without occupying terminal space on land. In addition, compared with other bunkering methods, the flexibility of ship-to-ship bunkering is high with respect to capacity and bunkering location. However, the high investment for bunker vessels are considered to date as the main barrier. Nevertheless, this bunkering option is expected to become the main bunkering method for ships with a bunker demand of over 100 m^3.	Port authority or terminal operator(s)*	Green Cruise Port, 2018e; WPCI, 2018
6	LNG bunkering facilities: local liquefaction plant	In principle, it is also possible to establish an LNG production site on a port`s premises. This would reduce the space for storage tanks and could also offer new sources of revenue and competitive advantages. In addition, local production can secure the supply at a shorter delivery time regardless of road conditions, traffic or terminal occupancy. However, the investment for building the plant is very high (according to the Green Cruise Port Study listed approx. 35 million €) and sufficient demand needs to be available to make the plant commercially viable.	Port authority or terminal operator(s)*	Green Cruise Port, 2018e; WPCI, 2018
7	Mobile LNG barge	Alternatively to OPS, mobile LNG barges can be deployed in ports to reduce a cruise 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 cruise ship at the time. The operation is relatively silent compared to a diesel engine. In addition,	Port authority or terminal operator(s)*	Green Cruise Port, 2018e; Becker Marine System, 2018; Anderson et al.

#	Action	Description	Responsibility	Source
		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 NO_x 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. In a comprehensive study conducted within the frame of the Green Cruise Port project (Green Cruise Port, 2018a), it was found that the mobile LNG barge is probably the economic more viable solution compared to OPS.		2015
8	Automated mooring systems	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.	Port authority or terminal operator(s)*	Gibbs, 2014
Exhaust gas treatment systems				
9	Diesel particle filer (DPF)	This is the devise used at the back of diesel engines on the exhaust gases path to trap the particulates and prevent them from leaving the engines. Through the installation of DPF in vessels, PM and black carbon can almost be eliminated while noise can also be reduced significantly by up to 30 dB. Further emission reductions can be achieved by combining DPF with SCR systems (see below). To use DPF, however, low sulfur fuels needs to be used. The main challenges of DPF are the huge investment and additional maintenance costs that range from 100-160 €/kW as well as the resulting higher fuel consumption of up to 5%. Furthermore, according to the CLIA, there are no ultra-fine particular filters currently on the	Cruise lines	Green Cruise Port, 2018g; IMO, 2016

#	Action	Description	Responsibility	Source
		market befitting of cruise ships.		
10	Selective catalytic reduction system (SCR)	SCR is a well-known and efficient technology for significant reduction of NO_x emissions (up to 95%) from exhaust gas. As the name implies, SCR converts NO_x back to N_2 (nitrogen gas) and O_2 (oxygen). Using SRC systems, even the strictest IMO Tier III standards can be fulfilled. This can have a high impact on the NOx depositions in natural preservation areas many miles away from the ship, especially since the NOx is emitted at great heights and the high temperature of the exhaust gases. Through SCR system noise can also be reduced; typical noise reductions are in the range of 8-10dB. The technology update can be implemented relatively easy. In addition, the retrofit costs are manageable, ranging from about 15-110 €/kW. However, it has to be considered that the system has to be replaced regularly (approx. after 4 years). In addition, OPEX are expected to increase, mainly as a result of increasing fuel costs (approx. + 7-10%).	Cruise lines	Green Cruise Port, 2018g; Fathom, 2018
11	Scrubber systems	Scrubber systems are an established technology to remove harmful particles and residues from a ship`s exhaust gas. Since this system lowers the temperature of the exhaust fumes, they cannot be combined with SCR systems without further treatment. Using scrubber systems on ships allows for significant reduction of SOx (up to 90%) and PM (up to 80%) emissions. Scrubber systems are especially promising since IMO and SECA regulations can be met thereby even using (cheap) high sulfur content fuels. In addition, scrubber systems show good noise reduction capabilities of up to 30 dB. The main challenge of scrubber systems is the high investment required. Investment range from 200-400 €/kW and up to 20 million € for a complete cruise ship retrofit. In addition, operating costs will also increase as a result of additional fuel and maintenance costs (approx. + 4 €/ MWh). • There are different scrubber types: wet scrubbers and dry scrubber systems. Wet scrubbers use the alkalinity of (sea) water to bind SOx and to cool down the exhaust gas. The amount of needed water increases with the sulphur content of the fuel and also with the exhaust flow rate and temperature.	Cruise lines	Green Cruise Port, 2018g; Walter, 2012; Fung et al., 2014

#	Action	Description	Responsibility	Source
		• Open-loop wet scrubbers use seawater for cooling and scrubbing of exhaust gas. The processed seawater can be discharged back to sea after water treatment according to MEPC.184(59) while particulate matter of various chemical nature from the fuel remain in a form of sludge on board. Currently, there is uncertainty about the cumulative effects of scrubber water discharge. There is no uniform European standard, but in several ports and coastal areas the operation of open-loop system is already forbidden to protect the marine environment. Restrictions or even prohibitions of open-loop scrubbers may be predestined. • Closed-loop scrubbers use fresh water added with sodium hydroxide that is reprocessed on board in a closed water loop. The sodium hydroxide infusion maintains a certain alkalinity level. Like open-loop systems, sludge is produced and must be discharged on land. The sludge is classified as hazardous waste, similar to oil sludge disposal, and contains toxic substances. Closed-loop systems require more installation space than open-loop systems due to increased system complexity. Closed-loop scrubbers are attractive for vessels that operate in areas where the discharge of wash water is forbidden. Besides, in seas with high amount of brackish water like the Baltic Sea the alkalinity of seawater can be too low for efficient open-loop scrubber operation. • In dry scrubbers the exhaust gas is pushed through a reservoir of calcium hydroxide granulate, which reacts with the SOx of the exhaust gas to gypsum. This technology is widely used in onshore applications but did not win recognition in maritime applications by now.		
		Alternative fuels		
12	LNG	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 SO_x 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	Cruise lines	Green Cruise Port, 2018g; IMO, 2016; Bouman et al., 2017; Verbeek, 2013;

#	Action	Description	Responsibility	Source
		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 (see Section 2.3.2).[17] 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). First trials show promising results.		CLEANSHIP 2013
13	Advanced biofuels	Biofuels are produced from organic material (e.g. plant materials and animal waste) trough contemporary biological processes. While traditional biofuels include unprocessed biomass (e.g. fuelwood), advanced biofuels are produced by extracting biofuels from materials such as wood, crops and waste material. The biomass conversion can result in fuel in solid, liquid, or gas form. Advanced biofuels offer a high potential in reducing CO_2 emissions in the range of 25-100%, depending on the quality, type and the way it is processed. Further, biofuels lead to significantly reduced emissions of SO_x. Using technical complex measures, it is possible to use marine biofuels that are compatible with existing marine engines. There is also the possibility of blending biofuels with conventional marine diesel. One of the main challenges is that the availability of biofuels for the transport sector is limited. The market entry for biofuels in the marine sector is therefore most favorable on-board of smaller vessels for coastal waters. The cost of biofuels is also higher than the cost of fossil fuels and is expected to remain so in the medium term. Further weaknesses of biofuels are concerns	Cruise lines	IEA Bioenenergy, 2017

[17] According to Verbeek, the GHG mitigation potential will be loosed if the methane slip is higher than 5.8 kg/kWh. Manufacturers claim that efficient engines can emit less than 1 g/kWh while others might have emissions close to 6 g/kWh (Verbeek, 2013).

#	Action	Description	Responsibility	Source
		about storage and oxidation stability of the fuel and the lack of long-term fuel testing for marine biofuels. Nevertheless, various ships are already running on advanced biofuels.		
14	Ammonia (NH_3)	Similar to H_2, ammonia can be an interesting fuel option for vessels. However, research is still in its infancy so that it is not possible to make qualified statements about the real economic and technical feasibility. The main challenges are that the production of ammonia to date relies on fossil fuels and the significant higher fuel prices compared to HFO.	Cruise lines	ITF, 2018
15	Electric / hybrid propulsion	Theoretically, it is also possible to deploy electric / hybrid propulsion systems on cruise ships. The advantages of electric propulsion systems are its high efficiency, resulting in significant fuel savings (even for hybrid systems up to 40%). Furthermore, local air and noise emissions can almost fully be eliminated. Producers of a Norwegian electric car ferry report a reduction of CO_2 emissions by 95% and operating cost by 80%. However, electric (full and hybrid) vessel has been estimated to be the least profitable technology compared to alternative fuel options. This is mainly because high battery costs. Furthermore, the low energy density of current available battery systems would make it necessary to have immense quantities of battery packs on-board to provide sufficient range (especially for cruise ships). Finally, recharging the battery systems would require specific extremely powerful infrastructure (charging systems) in ports.	Cruise lines	ITF, 2018
16	Hydrogen (H_2)	H_2 can also be a viable alternative fuel in future since it emits zero CO_2, SO_X and only negligible amounts of NO_X. However, the use of hydrogen as a replacement for conventional diesel fuel still requires research and development, particularly to make it commercially viable. Furthermore, safety issues, especially for cruise vessels, remain a main challenge.	Cruise lines	ITF, 2018
17	Methanol	Methanol could be one of the future marine fuels that can be – similar to LNG – be used in marine duel-fuel engines. Its advantages compared with LNG include its better storage and distribution capabilities since it is liquid at room temperature. Methanol is also convenient because it is available worldwide and requires only minor modifications to ships and	Cruise lines	ITF, 2018; FCBI energy, 2015

#	Action	Description	Responsibility	Source
		bunkering infrastructure. Installation costs of a small methanol bunkering unit have been estimated at around 400,000 €; a bunker vessel can be converted for approx. 1.5 million €. Today, most of the methanol is produced from natural gas. It has a total CO_2 emission reduction potential of approx. 25% compared to HFO. In addition, methanol has an emission reduction potential of 99% for SO_x, 60% for NO_x and 95% for PM. Methanol thus also meets the SECA and NECA emission requirements without any exhaust treatment. The usage of renewable energy sources for the production of methanol even enables a further reduction of GHG emissions. One challenge is the higher methanol prices compared to HFO. Expansion in methanol manufacturing capacity, however, could downward pressure on costs, making methanol even more cost-competitive. In Sweden, a pilot project was launched to convert a RoPax vessel into a methanol-powered vessel and to provide the bunkering facilities in ports. Although the conversion cost 22 million €, the vessel operator expects significant cost reductions of around two-thirds of the total cost of ownership.		
		Energy efficiency measures		
18	Energy efficiency measures	Improving energy efficiency via technological measures is the aim of the global regulation on the energy efficiency of ship (see Section 2.3.2). There is a wide range of technical measures available used to increase the energy efficiency of a ship including • Light materials and slender design; • Propulsion improvement devices; • Bulbous bow; • Air lubrication and hull surface; and • Heat recovery. Slender hull designs, for example, can reduce the overall propulsion requirements of a ship; compared to standard designs fuel consumption savings of up to 15% are possible. A detailed description of these possible technical measures can be found in ITF, 2018. In addition, LED lighting can be applied for on-board applications. In 2015, Costa Cruises	Cruise lines	Green Cruise Port, 2018g; ITF, 2018

#	Action	Description	Responsibility	Source
		upgraded ten of its ships with LED driven lighting, resulting in a 60% reduction of energy used for lighting per ship.		
Objective: Avoid or reduce ship noise emissions in ports				
19	Exhaust silencers	Exhaust silencers, such as absorption silencers or resonator silencer, can be used to reduce exhaust noise from cruise ships. The needed noise attenuation of a silencer should be determined by thorough calculations taking the type of engine, design of the exhaust stack, external noise limits and other relevant factors into consideration. Ideally, noise abatements of up to 20dB for selected frequencies are possible. Due to the complex interaction with ship design, cost estimations of silencers are highly case dependent. However, a rough estimation of typical capital costs for each main exhaust silencer (absorption type) of a 300 m cruise ship with 4 generator sets amounts up to 80,000 €.	Cruise lines	ETB 2018; Green Cruise Port, 2018d
20	Noise reduction of ventilation systems	In ports, on-board fans are usually operated continuously. Standard methods for reducing noise from ventilation systems onboard a ship include • primary measures: e.g. optimal system design or ensure of good inflow); and • secondary measures: e.g. usage of silencers or improvement of fan rooms (adding mineral wool to fan rooms for example) An overview of suitable measures for ventilation system noise mitigation can be found in the Green Cruise Port project study listed. It is worth noting that all noise reduction measures for fans are subject to trade-offs. Besides costs, especially the space requirements must be considered for the selection of measures. While silencers can be retrofitted with relatively little efforts, other measures (e.g. exchange of fan units) are considerably more complex.	Cruise lines	Green Cruise Port, 2018d

Source: HPC, 2019.

3.2.3 Evaluation of Measures

In the previous section, a broad range of possible measures for reducing the negative environmental effects (GHG, air and noise emissions) caused by cruise ships in ports have been identified. In the following, these measures will be evaluated on the basis of two main criteria.

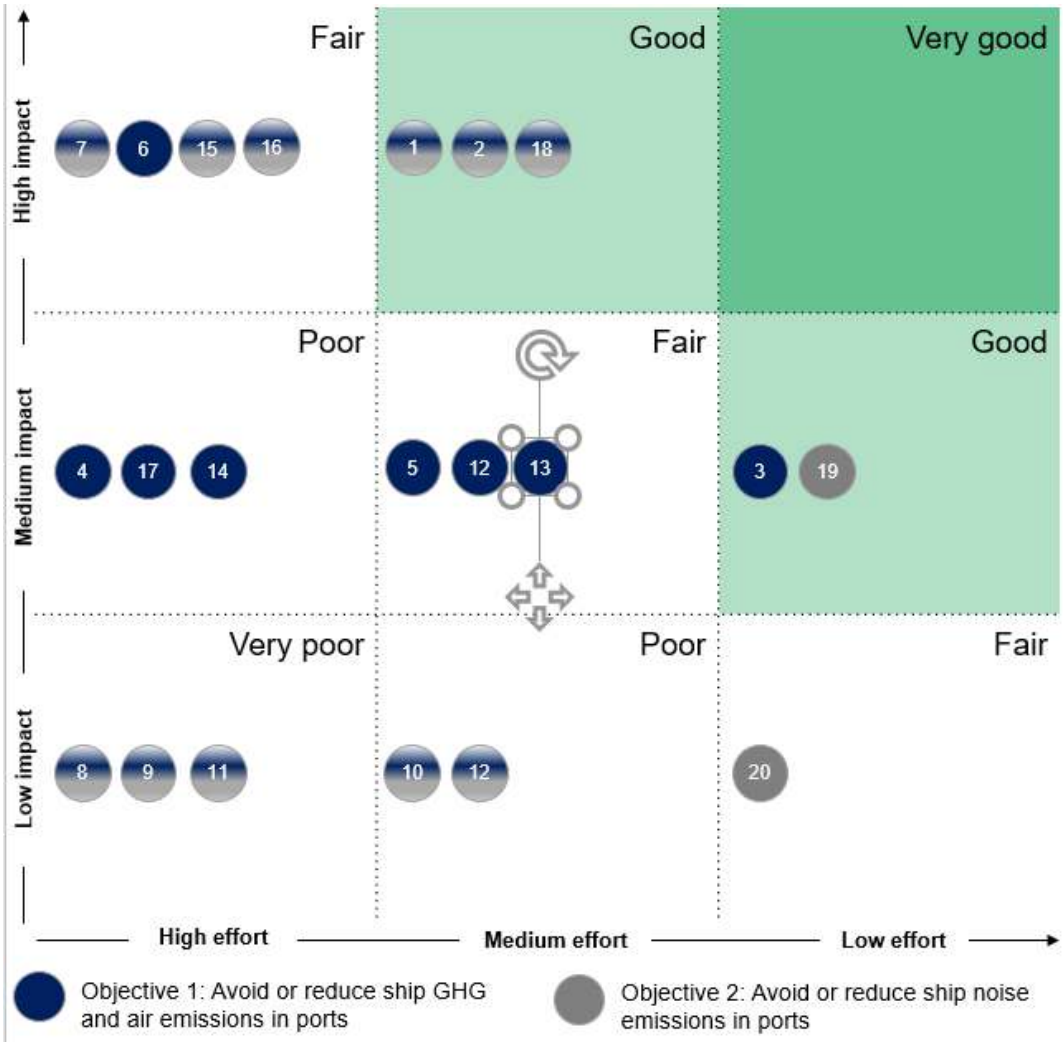
1. **Impact on environmental sustainability**: this criterion relates to the quality of a measure with regard to their potential on reducing local air pollutants, greenhouse gas and noise emissions in a (cruise) port.
   - The higher the resulting specific emission mitigation potential of a measure, the higher the resulting impact (e.g. in terms of noise).
   - Measures that contribute to reducing various kind of emissions (e.g. reduction at GHG, air and noise emissions through onshore power supply) get a higher rating that measures that only contribute to reducing one kind of emission (e.g. NO_x reduction through SCR on vessels).
2. **Efforts for implementation**: this criterion relates to capital and operational expenditure as well as operational efforts, i.e. time and resources required to implement a certain measure.
   - Measures that are relatively simple efforts to implement (e.g. exhaust silencers) achieve a higher rating than measures that can only implemented with great expense and effort (e.g. mobile LNG barge).

The most promising measures are those with a high impact / effort ratio, namely having a high impact on environmental 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 15). The allocation of measures to these defined clusters enables to prioritize them and to make recommendations (see Section 4).

It is worth noting that it is quite difficult to make general statements about the impact / effort of a specific measure. Regarding the emission saving potential of a measure, for example, the decision whether to focus on GHG, air pollutants, noise or all is dependent upon several factors. For ports next to residential areas (e.g. the Ports of Hamburg or Tallinn), local air pollutants play a much greater role than for ports that are located outside residential areas. In addition, the actual emission saving potential of a measure is highly case dependent. For example, the actual GHG emission reduction potential from onshore power supply depends upon the energy generation mix of the local grid. One of the main challenges in estimating

the total efforts for implementing sustainability measures in a port is to adequately assess the resulting procedural efforts, in particular technical and human capacities required or any necessary redesign of process chains. Likewise, for some ports it is almost impossible to provide stationary LNG bunkering facilities as a result of space constraints. Nevertheless, the evaluation scheme developed gives important hints for cruise ports and cruise lines.

Figure 15: Evaluation of measures – WP 2



Source: HPC, 2019.

Objective 1: Avoid or reduce ship GHG and air emissions in ports

Ship-port interface

1. On-shore power supply (OPS)
2. LNG PowerPac
3. LNG bunkering facilities: truck-to-ship (TTS)
4. LNG bunkering facilities: shore to ship
5. LNG bunkering facilities: ship- to-ship (STS)
6. LNG bunkering facilities: local liquefaction plant
7. Mobile LNG barge
8. Automated mooring Systems

Exhaust gas treatment systems

9. Diesel particle filer (DPF)
10. Selective catalytic reduction system (SCR)
11. Scrubber systems

Alternative fuels

12. LNG
13. Advanced biofuels
14. Ammonia (NH_3)
15. Electric / hybrid propulsion
16. Hydrogen (H_2)
17. Methanol

Energy efficiency measures

18. Energy efficiency measures

Objective 2: Avoid or reduce ship noise emissions in ports

19. Exhaust silencers
20. Noise reduction of ventilation systems

Further measures: 1, 2, 3, 7, 8, 9, 10, 11, 15, 16, 18

It is interesting to note that there are no "low-hanging fruit" measures. In Chapter 4, the most promising measures will be further explained, and specific recommendations be derived.

3.3 WP 3: Smart Cruise Terminal Buildings & Innovative Reception Facilities

3.3.1 Collection of Measures

It should be recalled that sustainability issues in cruise ports have to be addressed on two different areas, on the water side (vessel operation) and on the land side (port operation) While the previous section identified and evaluated measures to reduce emissions caused by cruise vessel, this section places the focus on measures to reduce or mitigate emissions and waste caused by port operation.

Within the Green Cruise Port project's WP 3, a broad range of studies had been carried out on this issue. In a study published by the Port of Tallinn and SWECO, the possibilities of implementing sustainable, in particular energy efficient and emission-free, solutions at cruise terminals had been investigated. The authors derived important recommendations on how to build, establish and operate a sustainable cruise terminal building (Green Cruise Port, 2017f). In another study, carried out by the Port of Helsinki and ECOBIO, the cost efficiency of the Port Reception Facility (PRF) in a specific port had been assessed and future possibilities for changes in the PRF both from an economical and environmental point of view had been analyzed (Green Cruise Port, 2017b). In two other Green Cruise Port studies, already mentioned in the previous section, the emission sources (GHG, air and noise) of cruise terminals were identified and several mitigation measures to reduce both water-side and land-side emissions in cruise ports been proposed (Green Cruise Port, 2018d; Green Cruise Port, 2018g). In

addition, a broad range of project-related workshops on this issue have been performed in the course of the project.

In the following section, the resulting (sustainability) measures identified are compiled and described. In order to gain an even more comprehensive overview, also external studies and publications are considered in the analysis. To this end, scientific publications other project reports manufacturers' brochures as well studies published by renowned institutions have been considered.

3.3.2 Categorization of Measures

Table 7: Overview of measures – Smart Cruise Terminal Buildings & Innovative Reception Facilities

#	Action	Description	Responsibility	Source
Objective: Improve waste management of cruise port terminals				
1	Integrated waste management	Since waste disposal companies in individual cruise ports in the BSR have varying capabilities of handling different types of waste, their resources can be combined to optimize the disposal or recycling at adequate reception facilities in a regional waste management plan. This would require cruise ships to specifically organize their waste sorting and disposal with regard to the specific reception possibilities of the receiving port and help the individual waste management provider to optimize its transport capacities and reception facilities.	Port Authority shipping lines and waste facilities	Green Cruise Ports 2017b; Zuin et al 2009;
2	Standardized waste notification form	To create transparency and predictability in the waste handling in the participating ports, a standardized waste notification form can be established for cruise ships to pre-announce the amount and the type of waste they intend to dispose. In order to provide the cruise ships and operators with a single list format, the ports are required to agree on standardized categories of waste types for the vessels to sort the waste accordingly on board.	Port authorities or terminal operator(s)*	Green Cruise Ports, 2017b; Svaetichin, 2016
3	Waste fee reduction for sorted waste / sewage disposal	As an alternative to measure 1, reduced waste fee can be offered for vessels which sort the waste on board, as practiced in the Port of Tallinn or the Ports of Stockholm. This would encourage shipping lines to introduce a sorting system on board (if not already in place) and increase the effectivity of the resource disposition of the waste disposal companies. A variation of this approach is followed by the Port of Helsinki where vessels are granted a 20% fee reduction for waste disposal if they also dispose of their wastewater.	Port authority or terminal operator(s)*	Green Cruise Ports, 2017b; Svaetichin, 2016
4	No-Special-Fee System	Copenhagen Malmö Port, Port of Tallinn, Port of Helsinki and the Ports of Stockholm and Nynäshamn have implemented different “No-Special-Fee” systems for the reception of waste,	Port authority or terminal	Svaetichin, 2016

#	Action	Description	Responsibility	Source
		which includes the waste handling costs in the regular port fees. The intention behind this concept is to generate a more balanced distribution of waste between the participating ports instead of leaving the port with the lowest fees to deal with the bulk of ship generated waste.	operator(s)*	
5	Standardized scrubber waste handling	As a result of the implementation of the Sulphur Directive ((EU) 2016/802)), the scrubber waste (as the waste product of the exhaust gas purification of the equipped cruise vessels) is becoming a new important faction of waste. At present, there is no standardized handling approach. With regard to a unified waste management, the ports should have to come to an agreement on the means of dealing with this type of waste, ideally comprising an incentive for the use of scrubbing technology. To facilitate this, scrubber waste could be included in a “No-Fee System”, as already practiced in the Port of Tallinn.	Port authority or terminal operator(s)*	Svaetichin, 2016
6	Wastewater pipelines to municipal sewerage	The installation of wastewater pipeline connections in the cruise terminal piers, directly connected to the municipal sewerage systems, like in the Port of Helsinki, the Ports of Stockholm, and the Port of Tallinn, would fasten the process of discharging and eliminate the need for costly and comparatively inefficient transport by truck. For this purpose, the Port of Tallinn, for example, has recently invested 2 million Euro to connect the port’s sewage pipeline to the city wastewater network, thereby increasing the reception capacity per hour by 1,000%. As an additional effect this would also further reduce the operations-related emissions otherwise generated by the utilization of the sewage trucks. For the realization of this measure, it must be considered that additional wastewater bunkering facilities must be installed. This is required since, it is in most ports, it is not possible to feed the whole and large amount of wastewater from vessels in the municipal sewerage systems at once.	Port authority or terminal operator(s)*	Svaetichin, 2016
Objective: Reduce energy consumption / emissions from terminal operations				
Whole port area				

#	Action	Description	Responsibility	Source
7	Noise barrier	In case the emission levels of noise emitting equipment on the pier and at the terminal area cannot be attenuated sufficiently, noise barriers are an option to reduce at least immission impact at selected locations. They impede sound radiation from source to receiver, as they block the direct propagation of sound. They can be fitted with noise damping material to reduce reflection at the barrier. In dependence of frequency, practical maximum noise reductions of 25 dB can be achieved. The placement of noise barriers is case dependent. Typically, the terminal building itself acts as a noise barrier to the pier area. A parking lot for noisy machinery, such as cooling aggregates of supply trucks, can be installed below the roof of the terminal and surrounded by noise barriers.	Port authority or terminal operator(s)*	Green Cruise Port, 2018d
8	Certified energy management system (EMS)	Implementing an EMS to monitor, quantify and control overall energy consumption. To introduce a certified EMS, it is highly recommended to create an energy management department or to appoint an energy manager. The Port of Koper could reduce their energy consumption by more than 10% through the implementation of an EMS.	Port authority or terminal operator(s)*	Pavlic, 2014
9	Energy audits	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. cruise 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.	Port authority or terminal operator(s)*	U.S. DOE, 2011
10	Employee suggestion system	Another 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.	Port authority or terminal operator(s)*	HPC database
11	Employee environment training	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.	Port authority or terminal operator(s)*	HPC database

#	Action	Description	Responsibility	Source
12	Employee bus shuttle services	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.	Port authority or terminal operator(s)*	HPC database
13	Obtain “green” energy	Instead of producing renewable energy on-site, green energy can also usually be procured from an energy producer. In general, this is an easy to implement measure to improve the eco-balance of a port. The additional costs depend on local conditions.	Port authority or terminal operator(s)*	HPC database
14	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.	Port authority or terminal operator(s)*	HPC database
15	Renewable energy: Solar photovoltaics (PV)	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 (e.g. on roofs) and the technical and economic feasibility is case dependent. So far, no project has been conducted in cruise ports.	Port authority or terminal operator(s)*	Green Efforts, 2014
16	Renewable energy: Wind power	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 (cruise) ports is the limited space available. Furthermore, turbines might cause noise and aesthetic pollution. However, wind power can be cost-effective (mainly as a result of the very low operating costs) 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.	Port authority or terminal operator(s)*	Green Efforts, 2014

#	Action	Description	Responsibility	Source
17	Renewable energy: Hydropower	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.	Port authority or terminal operator(s)*	Green Efforts, 2014
18	Renewable energy: Biogas	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. Hence, biogas plants appear unsuitable in cruise ports.	Port authority or terminal operator(s)*	HPC database
19	Renewable energy: Geothermal	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.	Port authority or terminal operator(s)*	Green Efforts, 2013
20	Renewable energy: Microturbine	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	Port authority or terminal operator(s)*	University of California, 2016

#	Action	Description	Responsibility	Source
		less emissions and waste. Their weakness is their low fuel to electricity efficiency. The technical and economic feasibility for cruise ports is case dependent.		
21	Target to reduce emissions	After setting an appropriate emission baseline and prioritizing pollutants, a team should set up an emission target in terms of percentage of emission baseline in a given year. 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.	Port authority or terminal operator(s)*	ACEE, 2010
22	Smart grid applications	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.	Port authority or terminal operator(s)*	Green Efforts, 2014
Terminal buildings				
It is important to consider that a cruise terminal building is different compared to a residential or typical non-residential building. Its special characteristics are (Green Cruise Port, 2017f): • The irregular utilization of the building (e.g. high season vs. off-season); • The influence of maritime climate (e.g. higher average temperature in autumn); and • The special architectural solutions (e.g. large proportion of glass facades) These special characteristics must be considered when improving a cruise terminal's level of sustainability.				
23	Building design	The shape of a building affects its use of energy; the more compact the building and the smaller the area of the envelope per volume unit, the lower the need of heat energy. For the optimal design of a terminal, several construction criteria must be considered, such as • envelope of the building (e.g. massiveness of exterior wall) or • doors and windows of the buildings (proportion of glass facade). Valuable construction guidelines can be found in the Green Cruise Port study listed.		Green Cruise Port, 2017f

#	Action	Description	Responsibility	Source
24	District heating / cooling	Instead of each building having its own heating or cooling system, the energy can be delivered to several buildings in a larger area from a central plant. To transport heat efficiently, the district heating distribution infrastructure comprises a network of insulated pipes, delivering heat in the form of hot water, from the generation site to the end user. A change of the heating system from conventional (fossil) to district heating can reduce both GHG and emissions significantly. Usually district heating is more energy efficient, due to simultaneous production of heat and electricity in combined heat and power generation plants (CHP). Options for district heating (and cooling) are gas, biomass, central solar heating, heat pumps and geothermal heating. 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.	Port authority or terminal operator(s)*	Green Cruise Port, 2017f; Green Cruise Port, 2018g
25	Green roof	The building has a green roof that cleans the air, reduces the load of rainwater, and decreases the temperature of the roof. Similar green areas are situated around the building as well for the purposes of cleaning the air and rainwater (cleaned seawater is directed into the sea).		Green Cruise Port, 2017f
26	Indoor temperature adaption / Demand-controlled ventilation (DCV) system	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. In addition, adjusting room temperature closer to the ambient temperature results in significant energy / emission saving potentials; reducing the indoor temperature in winter from 25.6° to 22.2° had been shown to reduce energy consumption by up to 40% on average (Green Cruise Port, 2017f).	Port authority or terminal operator(s)*	Green Cruise Port, 2017f; Rosone, 2016
27	LED technology	Using LED instead conventional light bulbs can immediately reduce energy usage / emissions but also reduce maintenance costs. While requiring greater initial investment, newer	Port authority or terminal	Green Cruise Port, 2017f;

#	Action	Description	Responsibility	Source
		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.	operator(s)*	PEMA, 2018
28	Nearly zero energy building	A nearly zero energy building (also known as nZEB) is a building that has been built in accordance with the best possible construction practices using the technological solutions of energy efficiency and renewable energy. An energy performance indicator is a “specific use of energy”, which reflects an integrated energy use for controlling indoor climate, heating of household water and utilizing appliances and other electrical equipment. It is calculated per square meter of heated area of a building in its typical utilization. To achieve a NZEb, a terminal must not exceed 130 kWh/(m^2-y). Energy savings in green buildings typically exceed any cost premiums associated with their design and construction within a reasonable payback period.	Port authority or terminal operator(s)*	Green Cruise Port, 2017f; USGBC, 2015
29	Noise treatment systems for luggage boxes	On cruise terminals, the transport of luggage from the pier onto the cruise ship is generally carried out with luggage boxes for cranes. There are principally two methods available to reduce radiated airborne noise: • Reduction of excitation force in the frequency range of structural response. This is possible by elastic feet to prolong impact time; and • Reduction of structural response by application of additional damping, for example constrained layer damping. Both technologies are very simple to install and naturally come along with only minor capital costs. No operating and maintenance costs apply.	Port authority or terminal operator(s)*	Green Cruise Port, 2018d
30	Seawater source heat pumps	Seawater can be used for heating and cooling the premises and producing hot water. • Open water system: seawater is pumped to heat exchangers, brings the energy carrier to the set temperature • Closed loop systems: cold / heat is in a closed pipe that has been installed to the bottom of the sea. This system is very efficient; however, high investments must be made.		Green Cruise Port, 2017f

#	Action	Description	Responsibility	Source
		According to a Green Cruise Port Study, 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.		
31	Adaptive lighting	An adaptive lighting system automatically adjusts its light output and operation to provide targeted light levels based on environmental conditions, user schedules, or other application-specific criteria. An adaptive lighting system can include many different types of products including dimmable lamps and luminaires, occupancy sensors, photocontrols, time clocks, etc. In the Port of Stockholm, for example, energy savings of approx. 35% could be achieved through this measure.	Port authority or terminal operator(s)*	California Lighting Technology Center, 2015
32	Energy efficiency measures in IT data center	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%. An overview of applicable energy efficiency measures in IT data centers can be found in Energy Star, 2015.	Port authority or terminal operator(s)*	Energy Star, 2015
33	Regular maintenance of HVAC system	HVAC operation can easily be optimized by regular maintenance. Changing clogged air filters, for example, is a basic measure to prevent steady increase in HVAC energy consumption.	Port authority or terminal operator(s)*	Rosone, 2016
Cargo and pier handling equipment				
34	Automatized and electrified luggage handling	Automatized and electrified luggage handling has the potential to further reduce emissions at the cruise terminal, for example, by reducing the number of forklifts needed for cargo handling. Literature in this field is still scarce, but knowledge of airport luggage handling procedures may be transferred to cruise terminal operations.	Port authority or terminal operator(s)*	Green Cruise Port, 2018g
35	Electrification	Delivering a high level of efficiency and torque, electric motors provide the best platform for an	Port authority	Green Cruise

#	Action	Description	Responsibility	Source
	of power train (battery or fuel cell)	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”. One further advantage of electrified equipment is the possibility to operate indoor and outdoor. However, the electrification of cargo handling equipment, such as forklifts, not only results in significant capital expenditures (approx. +30% compared to conventional equipment) but also in considerably operational requirements, mainly due to the battery charging processes and the installation of charging solutions. Fuel-cell powered equipment can reduce the charging time, but safety requirements are high.	or terminal operator(s)*	Port, 2018g
36	Alternative fuels	Instead of diesel, cargo handling equipment can alternatively be fuelled with alternative, low-emission fuels. A Tank-to-Wheel CO_2e[18] 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. An appropriate interim solution to achieve an emission-free transport system could be CNG. CNG burns cleaner than petroleum-based products due to its lower carbon content. Compared to petrol or diesel, CNG vehicles emit 40% less of nitrous oxide, 90% less of	Port authority or terminal operator(s)*	Standard EN 16258; IMO, 2016

[18] Emissions only associated with vehicle operation

#	Action	Description	Responsibility	Source
		hydrocarbons, 80% less of carbon monoxide, and 25% less of carbon dioxide. Further, noise level of CNG engine is much lower than that of diesel. Despite its advantages, the use of natural gas vehicles faces several limitations, including fuel storage and infrastructure available for delivery and distribution at fuelling stations. Furthermore, CNG today mostly comes from non-renewable sources. Nevertheless, it can be supplied or produced from renewable sources.		
37	Auto idle locks	Reduce idling emissions by using idle-reduction technologies that include automatic shut down and start up systems. In conjunction with speed reduction and other measures, the implementation of auto idle locks resulted in an annual decrease of 5-10% in fuel consumption at the Port of Trelleborg.	Port authority or terminal operator(s)*	Swiftly Green, 2015
38	Eco-driving lessons	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. According to Mark et al. (2015), field test with buses showed that drivers could reduce fuel consumption by up to 15% 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.	Port authority or terminal operator(s)*	Swiftly Green, 2015; Mark et al., 2015
39	Emission control technologies (ECTs)	Cargo handling equipment 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). Regarding diesel particulate filters for forklifts for example, retrofit costs for are manageable (3,000-7,000 €) while PM can be reduced by more than 90% according to the manufacturer's specification. Further details about the emission reduction potential are presented in the sources.	Port authority or terminal operator(s)*	IMO, 2016; GenCat, 2017
40	Energy saving tires	Use state of the art “low rolling resistance” tires to save fuel. Promising energy and emission savings are possible since tires account for 20–30% of a vehicle’s fuel consumption. Through the usage of energy saving tires, up to 10% fuel savings possible. This measure is also easy to	Port authority or terminal operator(s)*	ENERGYWISE, 2016

#	Action	Description	Responsibility	Source
		implement due to the fact that as state-of-the-art tires are slightly more expensive than conventional ones.		
41	Hybrid power-train	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.	Port authority or terminal operator(s)*	CALSTART, 2012
External traffic				
42	Emission control zones	One proven means to reduce emissions from external traffic is to further 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.	Port authority or terminal operator(s)*	Green Cruise Port, 2018g
43	Alternative cooling concepts: Dearman Transport Refrigeration Unit	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 NO_x 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.	Port authority or terminal operator(s)*	Dearman Technology Centre, 2017
44	Alternative	One further option is to connect the cooling units to the local grid. Again, the CO_2 reduction	Port authority	HPC

#	Action	Description	Responsibility	Source
	cooling concepts: Grid connection	potential depends on the energy generation mix of grid used while air emissions can be totally eliminated.	or terminal operator(s)*	database
45	Alternative cooling concepts: Local warehouse	To reduce emissions from cooling units of trucks, it is also possible to install and provide a refrigerated warehouse on the port's premise. This not only results in GHG emissions reductions but especially in a reduction of local air emissions. However, the constructions costs are high while space needs to be available.	Port authority or terminal operator(s)*	HPC database
* Depending on port management model				

Source: HPC, 2019.

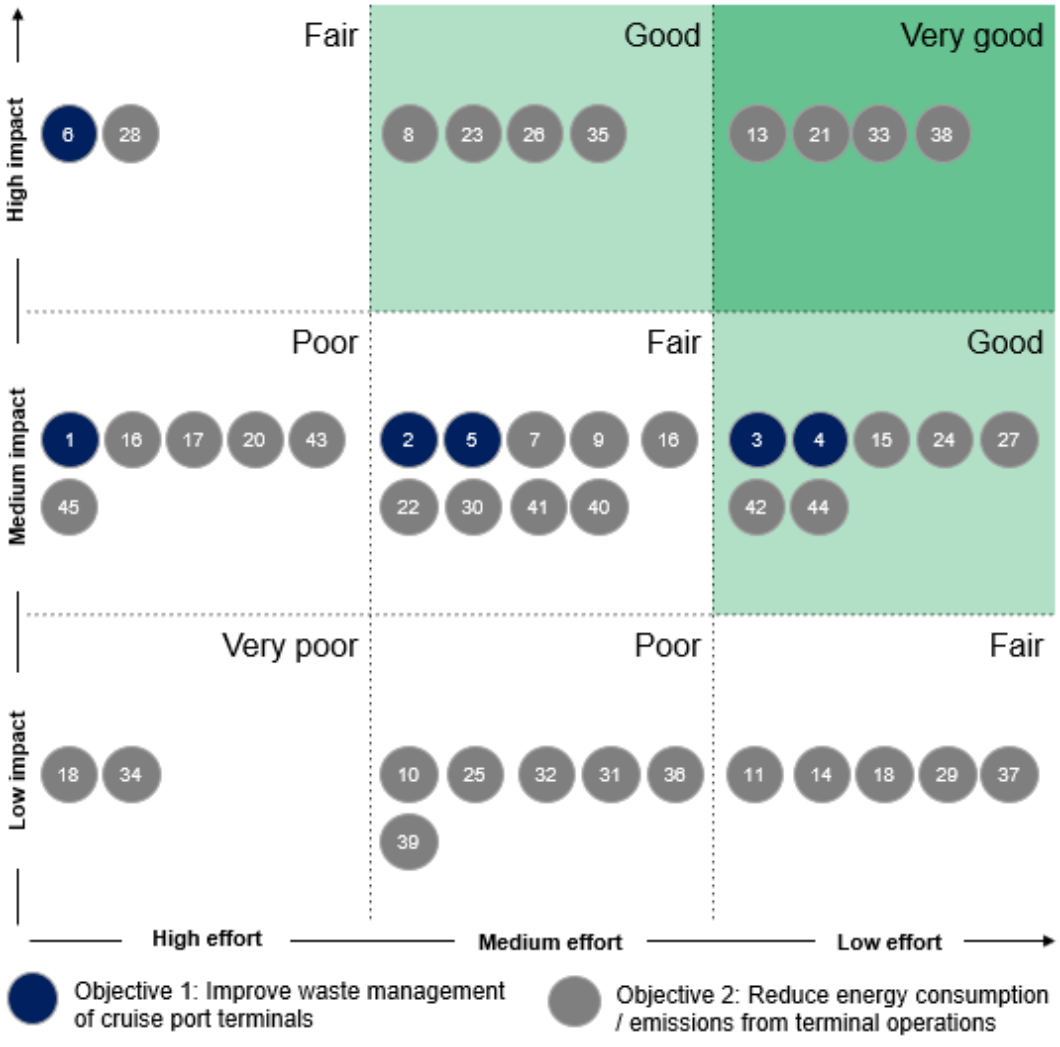
3.3.3 Evaluation of Measures

The previous primarily revealed a broad range of possible measures for reducing the negative environmental effects (GHG, air and noise emissions) caused by port operation in cruise ports. Analog to Section 3.2.3, all environmental measures will be evaluated on the basis of two main criteria:

1. **Impact on environmental sustainability**: emission saving potential
2. **Efforts for implementation**: capital and operational expenditure as well as operational efforts

The resulting evaluation scheme is presented in Figure 16 while the most promising measures are presented in more detail in see Section 4.

Figure 16: Evaluation of measures – WP 3



Source: HPC, 2019.

Objective 1: Improve waste management of cruise port terminals

1. Integrated waste management
2. Standardized waste notification form
3. Waste fee reduction for sorted waste / sewage disposal
4. No-Special- Fee System
5. Standardized scrubber waste handling
6. Wastewater pipelines to municipal sewerage

Objective 2: Reduce energy consumption / emissions from terminal operations

Whole port area

7. Noise barrier
8. Certified energy management system (EMS)
9. Energy audits
10. Employee suggestion system
11. Employee environment training
12. Employee bus shuttle services
13. Obtain “green” energy
14. Provision of bicycles for commuting purposes
15. Renewable energy: Solar photovoltaics (PV)
16. Renewable energy: Wind power
17. Renewable energy: Hydropower
18. Renewable energy: Biogas
19. Renewable energy: Geothermal
20. Renewable energy: Microturbine
21. Target to reduce emissions
22. Smart grid applications

Terminal building

23. Building design
24. District heating / cooling
25. Green roof
26. Indoor temperature adaption / Demand-controlled ventilation (DCV) system
27. LED technology
28. Nearly zero energy building
29. Noise treatment systems for luggage boxes
30. Seawater source heat pumps
31. Adaptive lighting
32. Energy efficiency measures in IT data center
33. Regular maintenance of HVAC system

Cargo and pier handling equipment

34. Automatized and electrified luggage handling
35. Electrification of power train (battery or fuel cell)
36. Alternative fuels
37. Auto idle locks
38. Eco-driving lessons
39. Emission control technologies (ECTs)
40. Energy saving tires
41. Hybrid power-train

External traffic

42. Emission control zones
43. Alternative cooling concepts: Dearman Transport Refrigeration Unit
44. Alternative cooling concepts: Grid connection
45. Alternative cooling concepts: Local warehouse

3.4 WP 4: Smart Cruise Port Traffic Solutions & Economic Effects

3.4.1 Collection of Measures

Within the overall set-up of the Green Cruise Port project, WP 2 and WP 3 put emphasis on sustainability options addressing organizational and technical issues with regard to cruise vessel equipment and cruise terminal facilities. Both work packages have in common, that they focus primarily on the port premises, in particular the ships' berths and cruise terminals. Extending the area of action, WP 4 includes actions and measures supporting the development of sustainable cruise tourism in port cities beyond the terminal area and port boundaries. In particular, project work focused on the measurement of economic effects by cruise tourism and incentives for green port stays by green port fees as well as cruise passenger flow management in port cities, smart traffic links for cruise terminals and sustainable seaside accessibility of berthing sites.

Input for the subsequent collection of measures comes, on the one hand, from the scope of work covered by work package WP 4 of the Green Cruise Port project. In this regard, a total of four expert workshops were held in Rostock, Gdansk, Riga and Klaipeda. These workshops offered well received platforms for professional exchange between stakeholders from both inside and outside the Green Cruise Port partnership. Insights and findings from the WP 4 workshops are documented in the corresponding workshop reports (Green Cruise Port, 2017a; Green Cruise Port, 2017d; Green Cruise Port, 2018f; Green Cruise Port, 2018p). Moreover, four corresponding concept studies supplemented by two additional case-/sub-studies were elaborated during the course of project work. Focusing on maritime and landside traffic challenges of future cruise ship size developments (Green Cruise Port, 2018b; Green Cruise Port, 2018s), smart traffic links in cruise port cities (Green Cruise Port, 2014; Green Cruise Port, 2018c; Green Cruise Port, 2018h) and common standards in the measurement of economic effects by cruise tourism (Green Cruise Port, 2017e; Green Cruise Port, 2018r) as well as green port due strategies and incentives (Green Cruise Port, 2018j).

In addition, further secondary sources have been taken into consideration while deriving the following measures, recommendations and actions. Among others these include third party studies on seaside terminal accessibility, cruise passenger behavior, as well as on differentiated port infrastructure charges providing incentives for environmental-friendly maritime transport. Reports by industry associations provided further sources of information.

3.4.2 Categorization of Measures

Based on the workshops held and concept studies elaborated during the Green Cruise Port project as well as taking further secondary sources into account, a total of 41 measures have been identified for the scope of work package WP 4. The measures, summarized Table 8, have in common that they support the overall objectives of work package WP 4, which are identified and described in Section 2.4.2 of this report. In the following, the derived measures are thereby categorized according to the aforementioned objectives.

Table 8: Overview of measures – Smart Cruise Port Traffic Solutions & Economic Effects

#	Action	Description	Responsibility	Source
Objective: Provide solutions for nautical challenges / Improve seaward accessibility				
1	Extend berth and pier infrastructure	A workshop on maritime and landside traffic challenges of cruise ports in the Baltic Sea Region revealed that all represented cruise ports are able to meet today's requirements of cruise vessel operators. The seaward infrastructure is sufficient in all cruise ports. Four of five ports are able to accommodate vessels with a length up to 300m. However, there is a need for infrastructure improvements to accommodate future cruise vessels. If the existing infrastructure cannot accommodate larger vessels or if the existing infrastructure will not be able to do so in the future, an extension of the length and depth of piers and berths would allow accommodating larger cruise vessels.	Port authority or terminal operator(s)*	Green Cruise Port, 2017a
2	Extendable and retractable floating pier	If the water depth at piers is insufficient, an extendable and retractable floating pier to moor as well as charge and discharge vessels would allow accommodating larger cruise vessels. Such a floating passenger bridge has been put in place at the port of Nynäshamn in Sweden. It must, however, be said that in port locations with a great tidal range, such as in ports along the North Sea, a floating pier must be	Port authority or terminal operator(s)*	Green Cruise Port, 2017a

#	Action	Description	Responsibility	Source
		able to compensate for large differences in water levels. An assessment revealed that this would require a sophisticated construction and would considerably raise the costs.		
3	Limit number of vessels and passengers	If the seaward infra- and superstructure is limited and cannot be extended, a limitation in the number of vessels and passengers according to capacity availability would limit the load on and requirements to infra- and superstructure.	Port authority or terminal operator(s)*	Green Cruise Port, 2017a
* Depending on port management model				
Objective: Improve landside accessibility & provide solutions for sustainable public transport				
4	Build train, tram or metro stations	An analysis of 27 cruise ports in the BSR indicated that private vehicle transport is the most important mode of passenger transport in arrivals and departure at cruise ports. Public transport options are not as developed as they should be. A higher share of public passenger transport in arrivals and departure at turnaround ports would, however, contribute to higher sustainability of cruise port operations. In the case of an insufficient public transport system, the provision of train, tram or metro stations as well as installation of ticket selling stations could improve arrival and departure passenger traffic flows between, on the one hand, cruise terminals and, on the other hand, the city center, central station, airport and external parking lots.	Port authority or terminal operator(s) & municipality*	Green Cruise Port, 2014; Green Cruise Port, 2018g
5	Provide bicycle lanes	For transit calls, the provision of bicycle lanes or an extension thereof, ideally two lanes, from piers to cities and bicycle rental stations could improve arrival and departure passenger traffic flows.	Port authority or terminal operator(s) & municipality*	Green Cruise Port, 2014
6	Provide bus shuttle services	For transit calls, the provision of bus shuttle services could improve arrival and departure passenger traffic flows to and from the city center of the cruise port location. For turnaround calls, a bus shuttle from and to external parking lots could improve the arrival and departure of cruise guests to the terminal.	Port authority or terminal operator(s) &municipality*	Green Cruise Port, 2014; Green Cruise Port, 2018g

#	Action	Description	Responsibility	Source
7	Provide a separate lane for park and ride	For turnaround calls and ports, separate lanes for, on the one hand, park and ride service vehicle traffic and, on the other hand, private vehicle traffic at cruise terminals, could improve arrival and departure passenger traffic flow.	Port authority or terminal operator(s) & municipality*	Green Cruise Port, 2014
8	Offer airport or station check-in at cruise terminals	For turnaround calls and ports, the provision of an airport or (central) station check-in at cruise terminals for both passenger transport and luggage handling between cruise terminals and airports could improve arrival and departure passenger traffic flows. An airport check-in has been implemented at the cruise port of Copenhagen. The cruise passengers have the option to check through their luggage from the cabin of the vessel to their final destination.	Cruise terminal operator(s), cruise shipping line(s) & airline(s)	Green Cruise Port, 2014; Green Cruise Port, 2018g
9	Increase terminal capacity by means of multipurpose terminal buildings and tent facilities	At terminals which suffer from a lack of capacity for arrivals and departures of passengers, a multipurpose terminal building and tent facilities, which can not only be used for cruise tourism but also for other purposes outside the cruise season, could improve arrival and departure passenger traffic flows. At the port of Copenhagen, terminal buildings are used as exhibition halls and event locations.	Port authority or terminal operator(s)*	Green Cruise Port, 2014
10	Bundle supply and disposal transports	The bundling of supply and disposal deliveries between logistics centers outside the city center and cruise vessels could reduce the traffic volume and, eventually, improve delivery and collection of goods.	Cruise lines & logistics providers	Green Cruise Port, 2018c
11	Improve information exchange between all stakeholders	An increase in information exchange between all relevant stakeholders at a cruise terminal and port location, for instance by means of IT systems, could improve coordination and, in turn, improve arrivals and departures as well as deliveries and collection of goods. These stakeholders may include cruise vessel operators, terminal operators for both passenger and luggage handling, transport operators for deliveries and pick-up / collection as well as passenger transport operators.	Cruise vessel operator, terminal operator(s) & transport operators	Green Cruise Port, 2014; Green Cruise Port, 2018c
12	Provide adequate	The provision of adequate sign posting, including road signs and car-park routing	Port authority or	Green Cruise

#	Action	Description	Responsibility	Source
	sign posting to and from the terminals	systems, could improve arrivals and departures of private vehicles and busses as well as deliveries and collection of goods.	port operator(s) & municipality*	Port, 2014; Green Cruise Port, 2017a
13	Provide better information about tour busses	The provision of better information about tour busses and their tours could allow a facilitated allocation of passengers to busses.	Bus operators, terminal operators & cruise lines	Green Cruise Port, 2017a
14	Separate passenger traffic flows	A separation of passenger traffic flows from service traffic flows could increase the safety of terminal operations.	Terminal operator(s)	Green Cruise Port, 2017a
15	Separate handling and service areas of different vessels	A separation of handling and service areas of different vessels could help to avoid a passenger mix and, thereby, ensure reliable terminal operations.	Terminal operator(s)	Green Cruise Port, 2017a
16	Organize terminals check-in & check-out operations	The organization of terminals and terminals operations in such a way that – even in the case of a short port time and larger cruise vessels – check-in and check-out can be organized at the same time.	Terminal operator(s)	Green Cruise Port, 2017a
* Depending on port management model				
Objective: Manage the growing passenger flows from cruise port operations				
17	Limit of cruise vessel calls and / or passengers	To mitigate the negative effects from cruise tourism, some ports have limited the number of vessels calls or passengers. The absolute limitation either refers to the number of vessels and passengers for a certain period or length of stay. An absolute limitation in the numbers appears to yield positive effects for the destination. At a port of analysis, the limitation of vessels and passengers turned out to lead to positive effects from the view of passengers, the local tourist industry as well as from the perspective of the cruise shipping line. Whilst some shipping lines changed their routes and called on another day, some guests visited the port on another occasion. Interesting to point out is that this cruise port location has	Municipality & terminal operator(s)	Green Cruise Port, 2018c

#	Action	Description	Responsibility	Source
		been ranked as the number one in “non-crowded” cruise port of all cruise port locations in that country. At a port of analysis, an envisioned limitation by means of pricing through port fees according to capacity utilization did not bring the expected positive effect. It should also be mentioned that at a port of analysis, the overall number of cruise tourists does not represent a problem. What causes bottlenecks at this port of analysis is that cruise tourists show up in large numbers simultaneously within a spatially limited location. The load exceeds the local capacity and causes temporary bottlenecks.		
18	Equalize cruise vessels and passengers spatially or temporarily	Instead of a limitation of cruise vessel calls and cruise guests, a spatial or temporal equalization of calls and guests could contribute to the sustainability of a cruise port. A spatial or temporal equalization of calls could be achieved by means of a refusal of inquiries, capacity utilization-based pricing and cooperation of ports. With regard to the spatial equalization, it is important to point out that this option is less desirable if this leads to a loss of cruise vessel calls and a loss in revenues and profit. Spatial equalization is able to play to its strengths and can be implemented more easily, if calls at separately operated ports are aligned to each other and all participating port benefit. However, it must be clarified as to whether such agreements fall within the scope of a ban on cartels. Of those measures, only cooperation of regional ports has been realized. However, it is still too early to make definitive statements on the results.	Municipality & terminal operator(s)	Green Cruise Port, 2018c
19	Attract visitors to surrounding areas	An option to reduce the load on cruise port locations is to attract more visitors to surrounding areas of the cruise port location and, thereby, achieve a higher spatial equalization. This requires, on the one hand, a greater choice of activities in surrounding areas, and, on the other hand, more intensive marketing of surrounding areas. For instance, the provision of an application for mobile devices could make visitors aware of points of interest in surrounding areas. However, since the point of	Local tourism service agency	Green Cruise Port, 2018c

#	Action	Description	Responsibility	Source
		interest is often the city center itself, there are still doubts about the success of these measures. At a port of analysis, an app for mobile devices has been implemented to make visitors aware of points of interest in surrounding areas. The early results turned out to be dissatisfying; this may, however, change overtime. At another port of analysis, an audio online and offline mobile app with information on the cruise port city, a City Guide recommended and implemented. The application provides visitors with information on sights, activities and mobility (See Klaipeda Audio Guide in app stores).		
20	Monitor and control the number of visitors	The monitoring and controlling of the number of tourists in certain districts of cruise port cities could help to control the overall number of visitors. Conducted pilot projects include measures, such as surveillance cameras to measure the number of visitors, mobile phone position data to monitor traffic flows, a slot booking for busses to control the effects from drop-offs as well an application for mobile devices in order to encourage traffic equalization.	Municipality, local tourism service agencies and tour operators	Green Cruise Port, 2018c
21	Limit number of group sizes of land excursions	The limitation of group size, limitation of number of busses and allowable time, e.g. a slot system for busses and individual attractions, could lead to a higher spatial equalization of visitors. A study on tourism crowding points out that the impact the cruise guests have on the cruise port location not only depends on the number of passengers, but also on the structure of passengers. The structure may range from largely children up to passengers at an average age of 77. This has an effect on the impact of this measure. With regard to a specific cruise port location, is was stated that tourism crowding does not represent a fundamental, ubiquitous problem. There still seems to be room for further growth in that specific cruise port location. However, the solution will be to better equalize the number of visitors throughout the city.	Municipality, local tourism service agencies & tour operators	Green Cruise Port, 2018c
22	Hold regular	At a port of analysis, in spring and autumn, an annual meeting with members of the	Municipality,	Green Cruise

#	Action	Description	Responsibility	Source
	meeting with relevant stakeholders	city, the cruise port company, the airport, the local tourism service agency takes place in order to coordinate the entirely of activities and services. The study points out that it is of particular importance, that the port company provides the other stakeholders with information. This allows for further coordination among stakeholders and services. A regular meeting with relevant stakeholders could allow to coordinate the entirely of activities and services better.	cruise terminal operator(s), airport company & local tourism service agency	Port, 2018c
23	Carry out infrastructure amendments	The realization of infrastructure amendments at infrastructure bottlenecks could reduce the load of the number of tourists on the city center. At a port of analysis, infrastructure amendments would reduce to load of the number of tourists on the city center. However, due to the World Heritage status of the city center, the recommended change of the infrastructure cannot be realized. Likewise, due to the large size of tourist groups, bottlenecks typically come into existence at infrastructures, such as bridges and narrow sidewalks / lanes. However, this infrastructure can often not be extended or not to the necessary extent. Nonetheless, what could possibly be done is a relocation of bus stops to different locations.	Municipality	Green Cruise Port, 2018c
24	Carry out communication campaigns	Communication campaigns could include campaigns that aim at visitors to be behaved in a considerate and respectful manner as well as campaigns that aim at residents and the local population to recognize the importance of visitors and enhance the reputation of cruise tourism. Moreover, a communication campaign could also include recommendations to non-cruise guests to avoid a cruise port location during peak periods.	Municipality, local tourism service agency, visitors & residents	Green Cruise Port, 2018c
25	Bring together vendors of local products and shipping companies	Events where producers and sellers of local products as well as shipping companies meet in order to increase the sale of local products and services could raise the acceptance of cruise tourists by locals.	Local producers, tourism service agency, terminal operator(s) &	Green Cruise Port, 2018c

#	Action	Description	Responsibility	Source
	meet		shipping lines	
Objective: Demonstrate positive economic effects from cruise tourism				
26	Apply common standards for economic impact studies	With regard to the cruise sector's contribution to the local economy, a general differentiation can be made between passenger, crew and ship expenditures. Economic impact assessments of cruise tourism in port cities can thereby help to identify such positive economic impacts and should be based on shared standards and common indicators in order to ease clarity of calculations and ensure comparability between studies. Tourist and cruise line expenditures in cruise destination regions do thereby constitute direct effects to the local economy that increase the value added and contribute to the generation of jobs in the region. Based on the direct beneficiaries' demand for inputs, input-output-models allow for the calculation of indirect economic benefits in terms of value added, jobs and income generated in upstream sectors of the economy, thus spreading the effect of cruise tourism into other economic sectors. Based on the spending of those employees who are directly or indirectly employed as a result of the local cruise business, further induced effects on output, value added and employment can be calculated which are, inter alia, concentrated in the retailing and consumer good sectors, residential housing as well as personal and health services. Personal earning multipliers can thereby be used to calculate corresponding effects.	Municipality, port authority, tourism boards & cruise destination associations	Green Cruise Port, 2017d; Green Cruise Port, 2017e
27	Define common set of indicators for benchmarking	Whereas the application of shared standards may facilitate the elaboration and understanding of economic impact assessments, benchmarking may further help in the proper assessment of the industry's local impact as well as of measures and actions related to cruise tourism. A common set of indicators may not only focus on the tourism sector but on the destination as a whole. While some measures may be optional, all should be clearly defined. Apart from economic issues, also socio-	Municipality, port authority, tourism boards & cruise destination associations	Green Cruise Port, 2017d; Green Cruise Port, 2017e

#	Action	Description	Responsibility	Source
		cultural and environmental factors as well as governance and external chances and threats should thereby be considered.		
28	Base cost benefit on cruise tourism's wider impact	Besides the consideration of business aspects, potentially negative economic impacts of cruise tourism have to be managed, inter alia, including noise levels, waste, water, air quality, and energy efficiency. Respective cost benefit analysis should be based on adequate standards and cruise ship charges as well as passenger fees may be adapted to cover the total costs of port operations.	Municipalities & port authority	Green Cruise Port, 2017d; Green Cruise Port, 2017e
29	Create policy framework for intra-regional cooperation	Cruise destinations should engage in cooperation with other involved stakeholders from the region as well as cruise lines in order to develop a comprehensive policy framework for sustainable cruise tourism within the context of a destination's long-term operations capacity. By taking joint actions against a rundown, overcrowding and a loss of the destination's original authenticity as well as potential unwanted social impacts, a sustainable and lasting development of cruise tourism shall be ensured, thus safeguarding a maximum economic benefit to the destination city and the region.	Municipality, port authority & tourism boards	Green Cruise Port, 2017d; Green Cruise Port, 2017e
Objective: Change cruise line behaviour towards a greener port stay				
30	Set clear goal on what to achieve with green port dues	Prior to the introduction of green port dues or any economic incentive for more environmentally-friendly port stays, ports should set goals regarding the anticipated effects of the to-be-introduced environmental charging system. The ex-ante establishment of clear objectives is thereby, inter alia, necessary in order allow for benchmarking and later evaluation of a charging scheme and as a substantive basis for any potential future adjustments to the green port incentives. Given the fact that ports often operate in complex and integrated urban environments, the elaboration and formulation of such anticipated goals may thereby be done in close cooperation in between the port administrations and the respective local and	Municipality & port authority	Green Cruise Port 2018f; Green Cruise Port 2018j; COGEA et al. 2017

#	Action	Description	Responsibility	Source
		regional authorities.		
31	Consider the cruise sector's specific characteristics	Environmental incentive schemes are currently applied in various ports throughout the BSR and beyond and mainly contain differentiated charges in form of discounts or rebates on the applicable port tariffs, e.g. depending on a vessel's environmental performance. While several green discount schemes equally apply for general cargo shipping as well as the cruise sector, the latter has specific characteristics that should be considered when implementing corresponding charging systems. In particular, the cruise sector would particularly benefit from a more consistent approach on reductions on port dues as well as waste collection fees in all ports throughout an operating area. Compared to other sectors of the shipping industry, cruise lines may also take a higher marketing benefit from environmental certification.	Municipality & port authority	Green Cruise Port, 2018f; Green Cruise Port, 2018e
32	Monitor and analyze data on cruise ships calling at the port	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. 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.	Multinational institutions, central governments, municipalities & port authority	Green Cruise Port 2018f; Green Cruise Port 2018j; COGEA et al. 2017
33	Establish	After having defined the desired objectives of the Green Port Fee system (measure	Port authority	Green Cruise

#	Action	Description	Responsibility	Source
	environmental pricing system on transparent criteria	30) under consideration of the cruise sector`s specific characteristics (measure 31) and development of an appropriate monitoring system (measure 32), the system should be established in a cruise port. Any port pricing scheme providing environmental incentives should be based on transparent criteria allowing for low administrative complexity, cost-efficient implementation and easy comprehensibility by all stakeholders involved. Linking the grant of discounts and rebates to certifications and scores of existing and acknowledged environmental programs and initiatives, such as the Environmental Ship Index (ESI), the Clean Shipping Index (CSI) or the Green Award, may thereby offer the chance to keep local green port incentive systems easy and transparent while, at the same, time reducing administrative costs for port authorities and ship owners by allocating the certification of a vessel's environmental performance to third party organizations.		Port 2018f; Green Cruise Port 2018j; COGEA et al. 2017
34	Incentivize voluntary adoption of stringent standards and procedures	Recent research suggests that incentive schemes granting rebates to vessels that exceed given IMO standards on a voluntary basis can result in notable reductions of CO_2 emissions, even if only a small share of the fleet is eligible. Moreover, port incentive schemes may support the voluntary compliance of procedures that reduce external effects and that are not necessarily bound to the deployment of new ships. 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 cruise industry's high degree of time scheduling and generally good on-time performance, corresponding time buffers may thereby be well in-advance	Port authority	Green Cruise Port 2018f; Green Cruise Port 2018j; COGEA et al. 2017; Gibbs et al. 2014

#	Action	Description	Responsibility	Source
		plannable into cruise schedules. Moreover, it should be noted that slow steaming in port areas only would probably not require additional ship capacity.		
35	Try to define common criteria for environmental charges	While a sheer top-down approach with any too stringent and centralized provisions may fail to consider the individual ports' specifics, a coordinated proceeding (e.g. on the EU level) may yet improve the effectiveness of green port incentives and environmental charging schemes. Ship owners may, inter alia, benefit from the application of EU-wide common standards on classification criteria for vessels while port administrations and operators may, at the same time, maintain their autonomy on the determination of the ports' individual tariffs and the specific designs of their respective incentive schemes. A register of common conditions and independent certification programs entitling for environmental rebates may support the creation of a level playing field between ports while offering ship owners a portfolio of different options that bring access to discounts and rebates.	Multinational institutions, central government, port authority & environmental certification initiatives	Green Cruise Port 2018f; Green Cruise Port 2018j; COGEA et al. 2017
36	Base incentivizing charges on wider environmental benefits	While it is important to know the costs related to port infrastructure provision and port operation, potential costs incurring from the introduction of green port dues and economic environmental incentives should be assessed in the context of their wider environmental benefits. If rebates or discounts linked to a green charging scheme result in a loss of revenue on the port operator's side, it could thus be balanced by local public authorities considering the scheme's overall environmental benefits, such as improvements in air quality. Any potential compensation mechanism would thereby reflect the general principle that the costs incurred by green port incentive schemes which provide benefits to the overall community should be borne accordingly.	Central governments, municipality & port authorities	Green Cruise Port 2018f; Green Cruise Port 2018j; COGEA et al. 2017
37	Establish a common platform for	As illustrated above, any port charging scheme providing environmental incentives may not be seen as a static but should rather undergo continuous monitoring. In	Multinational institutions, central	Green Cruise Port 2018f;

#	Action	Description	Responsibility	Source
	collection of insights on green incentive schemes	this regard, both a scheme's actual performance as well as external developments, such as technological progress, may result in revisions and adaptions of applicable discounts and rebates. With current research showing that many port authorities and operators are still in a learning phase, it appears recommendable to establish a neutral platform that collects learning insights and allows for periodic discussions on new developments and best practice examples on green incentive schemes. By involving various stakeholders (e.g. cruise lines) such a platform could not only foster the diffusion of experiences made by individual ports, but also be of benefit for the overall and industrywide acceptance of environmental charging schemes while at the same time serving the implementation of new emission-reducing technologies and processes in cruise ports.	government, municipality, port authority & cruise lines	Green Cruise Port 2018j; COGEA et al. 2017

Source: HPC, 2019.

3.4.3 Evaluation of Measures

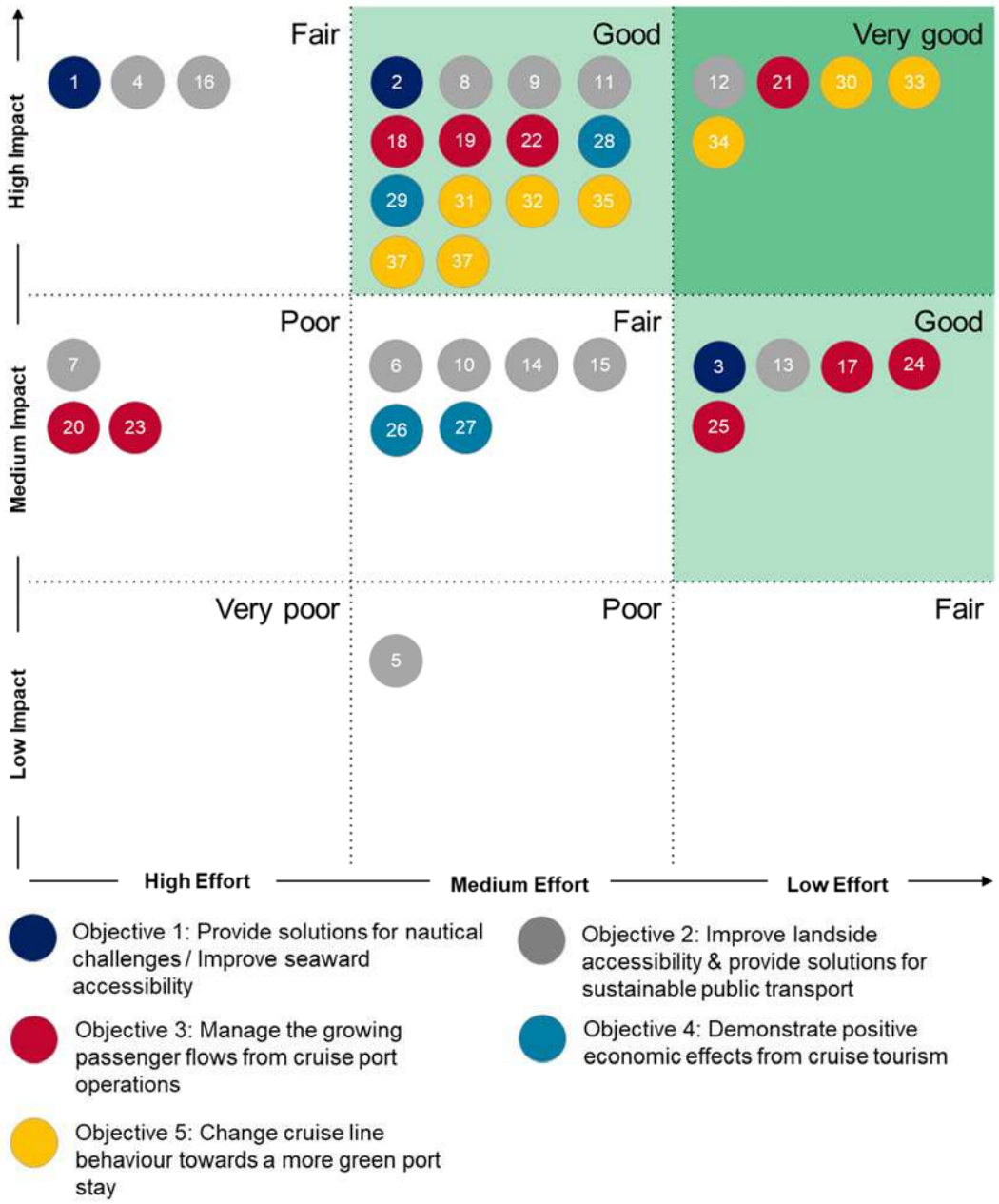
While the previous two work packages focused on environmental aspects of cruise tourism in the port areas, WP 4 aimed to strengthen sustainable economic effects of cruise tourism in destination areas outside the terminal and port boundaries.

Due to the multidimensional nature of the work package´s objectives, the corresponding measures identified in the previous section vary by required efforts as well as their expected overall impact. For the evaluation of these measures, the following two criteria – similar to the previous two WPs – are defined:

1. **Impact on economic sustainability**: this criterion describes the suitability of proposed measures to contribute to a smooth seaside and landside cruise terminal access as well as improved cruise traffic flows in destination regions. Moreover, it relates to the suitability of the corresponding measures to improve the documentation of economic effects caused by cruise tourism and to provide incentives for green port stays by cruise vessels.
2. **Efforts for implementation**: this criterion relates to capital and operational expenditure as well as operational efforts, i.e. time and resources required to implement a certain measure.

In order to evaluate their complexity and effectiveness, Figure 17 below provides a graphical classification of the individual measures in terms of their expected impact on the WP's objectives as well as the efforts required for their implementation.

Figure 17: Evaluation of measures – WP 4



Source: HPC, 2019.

Objective 1: Provide solutions for nautical challenges / Improve seaward accessibility

1. Extend berth and pier infrastructure
2. Extendable and retractable floating pier
3. Limit number of vessels and passengers

Objective 2: Improve landside accessibility & provide solutions for sustainable public transport

4. Build train, tram or metro stations

5. Provide bicycle lanes
6. Provide bus shuttle services
7. Provide a separate lane for park and ride services as well as private vehicle traffic
8. Offer airport or station check-in at cruise terminals
9. Increase terminal capacity by means of multipurpose terminal buildings
10. Bundle supply and disposal transports
11. Improve information exchange between all stakeholders
12. Provide adequate sign posting to and from the terminals
13. Provide better information about tour busses
14. Separate passenger traffic flows
15. Separate handling and service areas of different vessels
16. Organize terminals check-in & check-out operations

Objective 3: Manage the growing passenger flows from cruise port operations

17. Limit of cruise vessel calls and / or passengers
18. Equalize cruise vessels and passengers spatially
19. Attract visitors to surrounding areas
20. Monitor certain districts of the cruise port location to control the number of visitors according the maximum carrying capacity
21. Limit number of group sizes of land excursions
22. Hold regular meeting with relevant stakeholders
23. Carry out infrastructure amendments
24. Carry out communication campaigns
25. Bring together vendors of local products and shipping companies

Objective 4: Demonstrate positive economic effects from cruise tourism

26. Apply common standards for economic impact studies
27. Define common set of indicators for benchmarking
28. Base cost benefit on cruise tourism's wider impact
29. Create policy framework for intra-regional cooperation

Objective 5: Change cruise line behaviour towards a greener stay

30. Set clear goal on what to achieve with green port dues
31. Consider the cruise sector's specific characteristics
32. Monitor and analyze data on cruise ships calling at the port
33. Establish environmental pricing system
34. Incentivize voluntary adoption of stringent standards and procedures
35. Try to define common criteria for environmental charges
36. Base incentivizing charges on wider environmental benefits
37. Establish a common platform for collection of insights on green incentive schemes

While measures, such as the provision of extended berth and pier infrastructures as well as tram or metro access, are assumed to have a high impact on an enhanced terminal accessibility, they are most likely subject to high implementation efforts and construction cost, thus resulting in a fair overall score.

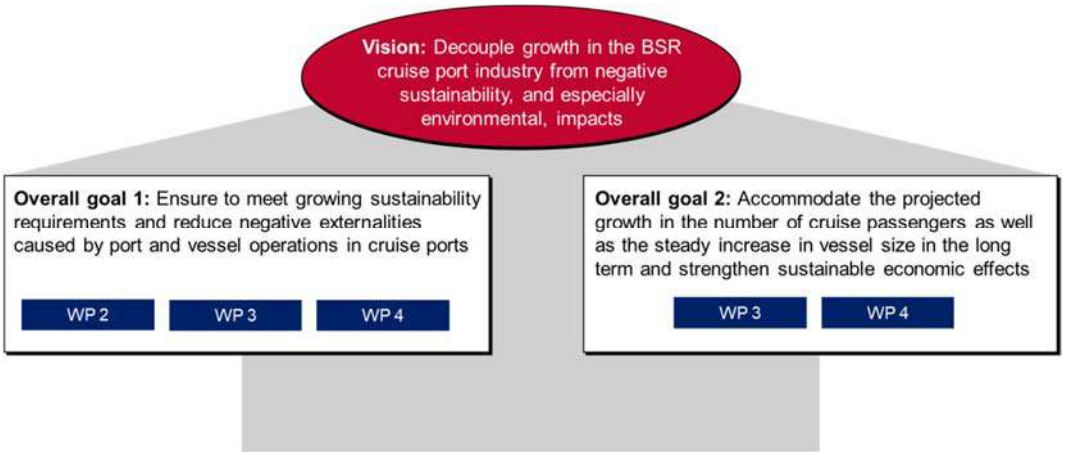
The same score is thereby achieved by a number of measures that are expected to yield a medium impact with medium efforts assumed for their implementation. Among others, these include the optimization of processes on passenger and service management at cruise terminals as well as smaller infrastructural measures, such as the provision of adequate maneuvering areas for busses and service trucks. Moreover, a number of measures focusing on methodological issues regarding the documentation of the sector's regional economic benefits fall in this category.

By contrast, a fair amount of measures with an expected high impact on the corresponding objectives in combination with medium efforts anticipated for their implementation are assigned a good score. Among others, these include measures on smaller infra- and superstructures (e.g. floating passenger bridge) as well as a better interconnectivity between cruise terminals, public transportation and air transport (e.g. airport check-in). In addition, measures aiming at a better intra- and interregional cooperation as well as the implementation and improvement of green charging schemes frequently receive a good or even very good score.

In Section 4, the most promising measures are presented in detail.

4. GUIDELINES FOR PROJECT STAKEHOLDERS

The Green Cruise Port Action Plan 2030 at hand aims to support the cruise port industry turn environmental challenges into opportunities. This section presents and discusses the most promising measures to achieve the ambitious sustainability goals defined in the most efficient manner.



As part of the Green Cruise Port project, various studies and workshops have been carried out to gather knowledge on how to reduce port and cruise vessel related emissions in the port area and foster the level of economic sustainability. To complement these knowledge, also external studies and publications have been considered in the Action Plan. Based on this approach, a comprehensive database had been compiled, containing numerous measures to prevent or minimize ecological damages from port and vessel operations and strengthen economic effects of cruise tourism (see Section 3.2 – 3.4). In the following sub-sections, the most promising measures identified are presented. For the evaluation of measures, not only the sustainability impact of a measure (e.g. in terms of emission reduction potential) but also the effort for implementation had been assessed.

4.1 Overall Sustainability Goal 1

Ensure to Meet Growing Sustainability Requirements and Reduce Negative Externalities caused by Port and Vessel Operations in Cruise Ports

Promising measures to reduce shipping emissions and waste in ports

Although most ship-related GHG, air and noise emissions take place at sea, the most directly noticeable part of shipping emissions takes place in port areas and

port-cities. It is here that shipping emissions have the most direct health impacts. Furthermore, shipping emissions in ports can represent a substantial share of total emissions in the port-city. This highlights the importance of environmental and social requirements for cruise lines.

An overview of the most promising environmental-friendly measures for cruise vessels in ports is presented in Table 9[19]. It is suggested to, at least, evaluate the implementation of the measures suggested.

Table 9: Top environmental measures for cruise vessels

Measure	Area	Emission focus			Evaluation	
		GHG	Air	Noise	Impact	Efforts for Implementation
On-shore power supply	Ship-port interface	☑	☑	☑	🟢	🟡
LNG PowerPac	Ship-port interface	☑	☑	☑	🟢	🟡
LNG bunkering facilities: truck-to-ship	Ship-port interface	☑	☑		🟡	🟢
LNG	Vessel fuels	☑	☑		🟡	🟡
Energy efficiency measures	Vessel	☑	☑		🟢	🟡
Exhaust silencers	Vessel			☑	🟡	🟢

Source: HPC, 2019.

One of the most promising measures for reducing cruise vessels' emissions in the port area is **on-shore power supply (OPS)**. While local air emissions can nearly be eliminated, the actual GHG emission reduction potential depends on the electricity generation mix of the grid. Field tests in the Port of Hamburg with a cruise vessel that was located 12 hours at berth have shown that OPS can save 71% of SO_x and PM_{10}, 89% of NO_x and 71% of CO_2 emissions in comparison to the use of MDO / MGO. In addition, noise emissions can be reduced considerably, in the range of 10 dB(A). The main challenges when introducing cold ironing are power availability, the lack of technical standardisation of connectors and capital requirements. In a comprehensive study conducted within

[19] The most promising measures are those with a high impact/effort ratio, namely having a high impact on environmental sustainability and, at the same time, requiring low effort for implementation

the frame of the Green Cruise Port project (Green Cruise Port, 2018a), it was found that the establishment of OPS in the selected ports would require net public investment in the range of 9-32 million €.

Alternatively to OPS, a **mobile LNG Power Pac** can be deployed in ports to reduce a cruise ship's emissions at berth. An 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 (according to the manufacturer's specification). 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 NO_x per ship call. The investment can be broken into the power barge itself and the required onshore distribution (e.g. cable management). Currently, the system is tested for container vessels in Hamburg. First trials show promising results.

LNG as vessel fuel is an appropriate interim solution for achieving an emission-free vessel operation. The LNG fleet has grown exponentially since the early 2000s and the fleet is expected to double and grow by another 123 vessels in the next years (ITF, 2018). 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, the total emissions of CO_2-equivalents are not necessarily in favor of LNG as marine fuel because of the release of unburnt methane. This so-called "methane slip" occurs during the handling and combustion process as well as during the bunkering phase. It is also important to consider that the profitability of LNG for cruise ships depends upon future LNG and fuel prices. Currently, fuel prices are cheap, hampering the economic implementation of LNG for vessels. LNG might see a growing uptake in the short and medium term as part of industry efforts to mitigate CO_2 emissions. However, considering the negative impacts of LNGs (methane slip) and the relative CO_2 advantages of other cleaner alternative fuels (e.g. electric propulsion or hydrogen) LNG might not be the most attractive long-term solution. For a part of the ferry market, for example, it has turned out that electric power can be a relevant solution for many shipping companies.

For the widespread usage of LNG, ports also need to provide **LNG infrastructure and bunkering** possibilities. A comprehensive study carried out within the frame of the Green Cruise Port project (Green Cruise Port, 2018ea) compared alternative LNG infrastructure and bunkering possibilities. The authors identified the "truck-based solution" as suitable way to provide LNG for vessels. A truck-based solution is basically one (or more) trucks, which can be used to supply small amounts of LNG directly to the ship without permanently installed

equipment. It can be combined with more trucks supplying LNG at the same time. The truck-based solution only requires moderate investment and is relatively easy to apply and operate. The costs of permanent solutions are significantly higher and safety regulations are tighter from these installations. Hence, before choosing the permanent solutions, demand should be rather high. In addition, enough space must be available on the port's premise to install stationary solutions. However, it is important to note that logistics cost of the truck-based solution can be high, depending on the distance between terminal and end-customer, and the bunkering volume and speed is rather low. Finally, the presence of truck and bunker processes may impact other quayside activities like passenger handling.

Another promising environmental measure – with a focus on noise emissions – is the installation of **exhaust silencers** on vessels. In Green Cruise Port, 2018d, it was found that in most cases, the ignition frequency of the generator engines is dominant in the exhaust gas noise[20]. To reduce this noise, one suitable solution is to apply a resonator type silencer at the exhaust gas pipe. This silencer can be installed during a regular port call and is estimated to cost between 10,000 € and 20,000 € including installation. It is worth noting that OPS is even more suitable to reduce exhaust gas noise for a vessel located at berth. However, not each port can be equipped with such a system. In addition, the noise emissions during maneuvering cannot be reduced through OPS. It is noteworthy that in modern cruise ships, the described noise attenuation measure is already in widespread use.

Promising measures to reduce port-related emissions and waste

Not only the cruise vessel but also the port itself causes GHG, air and noise emissions as well as waste in the port area. As revealed in Section 3.1, these derive from three main sources:

- Pier & cargo handling equipment (CHE);
- Road (external) traffic; and
- Terminal buildings.

Table 10 reveals the most promising measures to reduce these port-related emissions and waste in cruise ports. Again, for the evaluation two criteria have been considered: the impact on reducing emissions and waste as well as the efforts for implementing a measure (for details see Section 3.3).

[20] Long-term monitoring was carried out at six positions over the period of one year.

Table 10: Top environmental measures for cruise ports

Measure	Area	Emission focus				Evaluation	
		GHG	Air	Noise	Waste	Impact	Efforts for Implementation
Target to reduce emissions	Whole port area	☑	☑			🟢	🟢
Obtain “green” energy	Whole port area	☑	☑			🟢	🟢
HVAC system optimization	Terminal building	☑	☑	☑		🟢	🟢
Eco-driving lessons	Pier & CHE	☑	☑	☑		🟢	🟢
Electrification	Pier & CHE	☑	☑	☑		🟢	🟡
Waste fee reduction	Whole port area				☑	🟢	🟡
LED technology	Terminal building	☑				🟡	🟢
Solar photovoltaic	Whole port area	☑				🟡	🟢

Source: HPC, 2019.

After setting an appropriate emission baseline and prioritising pollutants, a team should set up an **emission target** in terms of percentage of emission baseline in a given year. Goals help measure progress towards a target, making energy efficiency and emission mitigation efforts more tangible and yielding quantifiable results. Energy and emission saving goals also spur innovation and can help motivate employees and shareholders engaging in energy efficiency and environmental-friendly measures. The efforts for implementation are moderate; however, the goal must be realistic. To set an emission-reduction objective, for example, a detailed emission inventory and forecast must be available. Nevertheless, it is strongly recommended to define concrete emission reduction targets in future.

One further measure with a high impact on reducing GHG and air emissions that is also relatively easy to implement for (cruise) 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. Nevertheless, this measure is considered to be very promising for improving the carbon footprint of a port. 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.

Offering employees in cruise ports **eco-driving lessons** is a suitable mean to reduce energy consumption, but also GHG, air and noise emissions, of cargo handling equipment, cranes and vehicles. Previous field tests in other ports showed promising results. At the EUROGATE Container Terminal in Bremerhaven, for example, average fuel savings of 7% per operating hour were achieved with the help of eco-driving in straddle carriers without increasing the time required for the tasks (ESPO, 2014). Other positive effects of reduced speed and eco-driving are lower stress levels and improved control (Swiftly Green, 2015). **An electrification of the existing cargo handling and vehicle fleet** also offers significant future potential for a terminal operator since battery-powered vehicles require up to 30% less fuel compared to conventional designs. In addition, local GHG and air emissions can be eliminated, and engine noise be reduced significantly. However, operators should expect to make major modifications at the terminal level. This is mainly because of the extensive battery charging times, necessary employee training activities and the planning, installation and operation of a charging infrastructure on the premise. Finally, battery-powered vehicles are still much more expensive than conventional ones.

As revealed in Section 3.1, the major energy user of a cruise terminal is usually the heating, ventilation and air condition system (HVAC). Therefore, it is highly recommended to **optimize a terminal's HVAC system**.

- *Regular maintenance of the HVAC system* serves to keep the equipment running efficiently to maximize HVAC energy efficiency. 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.
- A*djusting the desired air temperature closer to the ambient air temperature* will save significant amounts of energy consumption; reducing the indoor temperature in summer from 25.6° to 22.2° had been shown to reduce energy consumption by up to 40% on average.
- B*uildings 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 (CO_2) and room air temperature (Green Cruise Port, 2017f).

To improve the waste management of cruise port terminals, **reduced waste fee** can be offered for vessels which sort the waste on board. This would encourage shipping lines to introduce a sorting system on board (if not already in place) and increase the effectivity of the resource disposition of the waste disposal companies. A variation of this approach is followed by the Port of Helsinki where vessels are granted a 20% fee reduction for waste disposal if they also dispose of their wastewater. The implementation of a sorting system on board is very much depending on the design and the spatial capacities of the different types of vessels. While new build cruise ships usually have a waste sorting system implemented in their initial design and can therefore easily comply with the requirements of this measure, older vessels may have difficulties to implement such a system due to lack of storage capacity for different types of waste. The attempt of a reduced port fee in case of wastewater disposal, however, requires no implementation effort on the part of the cruise vessels. This measure would result in improved planning opportunities for the waste disposal companies since they would be able to organize their transport resources according to the individual amounts and types of waste.

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 realised 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.

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 cruise port terminals. The carbon footprint of a cruise port terminal can be reduced by using the thus generated “carbon-free” energy. 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 cruise

port operation, the required solar modules should be installed on a terminal's roof. Excess energy generated can be feed into the grid and thus contribute to the steady supply of renewable energy of the whole region. However, it is important to note that the feasibility of using solar power depends very much upon local conditions (e.g. electricity prices, solar radiation or existing building design).

4.2 Overall Sustainability Goal 2

Accommodate the projected growth in the number of cruise passengers as well as the steady increase in vessel size in the long term and strengthen sustainable economic effects

As part of the Green Cruise Port project, various studies and workshops have been carried out to gather knowledge on how to:

- Improve the seaward and landward accessibility;
- Develop solutions for sustainable public transport to manage the growing passenger flows; and
- Demonstrate the positive economic effects from cruise tourism and to change cruise line behavior.

In the preparation of the Action Plan, both internal project results as well as external studies and publications have been considered. Based on this approach, a comprehensive database has been compiled, containing numerous measures to improve the level of economic sustainability of cruise tourism. In the following, the most promising measures (for detail, see Section 3.4) are presented. Both the estimated impact as well as the effort to put these actions into practice have been considered to recommend effective and efficient actions.

Table 11: Top economic sustainability measures for the cruise sector

Measure	Impact on					Evaluation	
	Seaward accessibility	Landward accessibility	Passenger flows	Economic effects	Cruise line behaviour	Impact	Efforts for Implementation
Provide adequate sign posting		☑				●	●
Limit number of group sizes of land excursions			☑			●	●

Measure	Impact on					Evaluation	
	Seaward accessibility	Landward accessibility	Passenger flows	Economic effects	Cruise line behaviour	Impact	Efforts for Implementation
Hold regular meeting with relevant stakeholders			☑			🟢	🟡
Bring together local vendors and shipping lines			☑	(☑)	(☑)	🟡	🟢
Establish “Green Port Fees”					☑	🟢	🟢
Incentivize voluntary adoption of stringent standards					☑	🟢	🟢
Extend berth and pier infrastructure	☑					🟢	🔴

Source: HPC, 2019.

One of the most promising measures to improve the landward accessibility for passenger, cargo and service traffic to and from the cruise terminal, is the provision of **adequate sign posting for vehicles.** This is because the expected impact on traffic flows is high whilst the expected effort of implementation is low. Even though this measure will not reduce the total number of vehicles, it can help to reduce the duration of stay and, especially during peak times, allow for smoother inbound and outbound traffic flows.

High numbers of visitors at the same time and same location place high demands on the capacity of existing infrastructure and impair passenger traffic flows in cruise port locations. Whilst infrastructural measures may lead to an improvement, these measures may either be difficult to realize or undesirable in a specific location. For this reason, a **limitation of the number of people within a group** can help to reduce the load on infrastructure and allow for a smoothening of pedestrian traffic flows. A limitation in the number of people could be achieved directly by setting a limit to group size or by setting a limit to the duration of stay, respectively by limiting the number of people at specific locations. It must, however, be point out that a reduction of group sizes would reduce the number of passengers that can take part in an activity / excursion. To ensure that – despite a reduction of the capacity of specific activities / excursions – there is still a sufficient offering for passengers to leave the cruise vessel, additional activities must be offered.

The high volume of passenger and cargo traffic during peak times could also well be addressed by a better provision and coordination of services provided by the

various stakeholders. Cruise terminal operators, the municipality, public and private transport operators as well as local tourism agencies could **exchange information and coordinate their activities better** on a regular and frequent basis. The expected impact can be high; due to the number of different stakeholders and services to be coordinated, the necessary expected effort for implementation is fair.

A promising measure to increase the acceptance of cruise tourism by residents and the local population are **events where vendors of local products and services meet with cruise shipping lines** in order to assess the opportunities for product and service placements and sales. Whilst the impact on the acceptance of cruise tourism is expected to be fair, the effort for implementation is expected to be low.

An **environmental pricing** by means of port dues should be done on the basis of clear and well-defined criteria. In order to limit the effort of classifying vessels according to environmental criteria, certifications and scores of existing and acknowledged environmental programs and initiatives may be used. A consistent approach on green port incentives for the cruise sector would support the industry's own efforts while, at the same, time being neutral to competition between destinations. The impact is expected to be high; the effort for implementation is expected to be low. For the successful implementation, the objectives of the environmental pricing scheme should be clearly defined. Environmental pricing would set a market price for allegedly costless goods and services and allow for an active regulation.

Another measure that promises a high impact on sustainability and low effort for implementation is the **creation of incentives for voluntary adoption of more stringent standards and procedures** as part of green pricing schemes. Granting rebates to vessels that exceed current IMO standards on a voluntary basis can thereby result in notable emission reductions, even if only implemented by a small share of the fleet. Moreover, financial incentives may be used to promote the voluntary application of emission reducing procedures such as slow steaming in port areas. A higher adoption of more stringent standards and procedures would reduce negative externalities.

If the existing infrastructure cannot accommodate larger vessels or if the existing infrastructure will not be able to do so in the future, **an extension of the length and depth of piers and berth**s would allow accommodating larger cruise vessels. Although this measure requires a high expected effort for implementation, the expected impact is at the same time high. For this reason, an extension of berth

and pier infrastructure is regarded as an important measure that should be considered.

5. CONCLUSION AND NEXT STEPS

Achieving a high level of sustainability can be considered as the key prerequisite for a further growth of the cruise industry worldwide. As laid out in detail in this report, reducing the negative environmental impacts of cruise port operation is especially important in the light of increased customer environmental awareness and increasingly strict environmental regulations.

The project partners of the Green Cruise Port project (see Section 1.2) are thus fully aware that fostering sustainability and reducing the negative environmental impacts of cruise port operations is essential to continue the success story of the cruise sector. The goal of the Action Plan was therefore to assist the Green Cruise Port project partners and other involved stakeholders in improving both their environmental and economic sustainability, thus achieving a "green cruise port transformation". To this end, a broad range of measures was identified and evaluated that can be implemented to:

- ✓ Meet growing sustainability requirements and reduce negative externalities caused by port and vessel operations in cruise ports; and
- ✓ Accommodate the projected growth in the number of cruise passengers but also the steady increase in vessel size in the long term and strengthen sustainable economic effects.

For the identification of potential measures, studies and workshops carried out within the frame of the Green Cruise Port project but also external studies have been considered; more than 100 measures have been thus compiled and prioritised.

Even after this comprehensive study, open questions need to be addressed in the future. First of all, the Action Plan should be periodically evaluated and adjusted to the current market environment and technical innovations (e.g. emission-free port technology). In addition, it is of paramount importance to consider that the actual implementation of the plan is entirely within the partner's scope of responsibility. The implementation phase includes putting into place the (proposed) measures and associated data-gathering programs to evaluate performance over time. Important to note here is that each organization may have its own formal processes in place through which it must implement the plan.

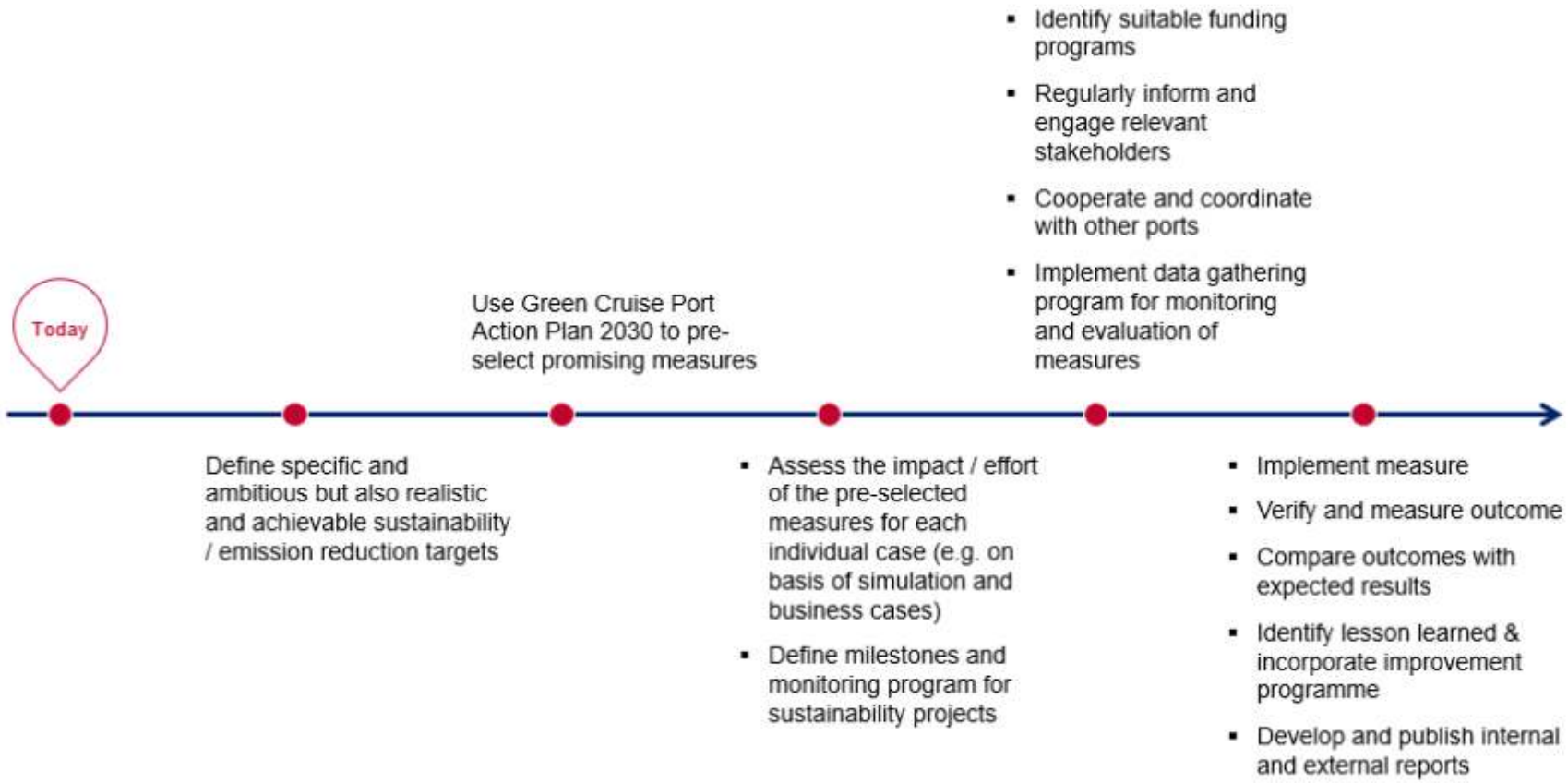
In addition, the following aspects need to be considered in future for a successful implementation of the Green Cruise Port Action Plan:

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** (see Sections 2.4 and 4). Ideally, the project partners should work together and define common targets.
2. 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).
3. **Government interventions** 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. Further, financial institutions could **develop green finance programs** to stimulate sustainable cruise tourism. It is thus recommended to further promote the project partners' sustainability efforts, if required.
   - While some measures (e.g. installing LED lights) can be implemented by the port itself, other ecologically promising solutions still require funding as these are not economically viable for the port (e.g. OSP) of cruise line.
4. One of the keys to the successful development the Green Cruise 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.
5. **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, 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.
6. **Information** about opportunities to improve the level of sustainability in cruise 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 Cruise Port Action Plan 2030 provides valuable insights in how to achieve a sustainable cruise port operation, further efforts are needed. In particular, the suggested measures need to be implemented under

consideration of the references listed above. An overview about the recommended next steps, after the publication of the Action Plan, is highlighted in Figure 18.

Figure 18: Recommended next steps for the project partners



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