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A Review of Best Practices to Reduce the Environmental Footprint of Port Areas in the Adriatic Region

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***Abstract*— In the past decades, a large number of actions and projects has been carried out to reduce the environmental footprint of port areas, especially in the European Union. This knowledge is a strong basis for future actions and shall be considered by any stakeholder who approaches the topic. In this context, the SUSPORT project involve all major ports in the Italy-Croatia region to build a network for improving ports' environmental sustainability and energy efficiency. The first step is represented by an analysis of the current situation of the port areas and a review of best practices put in place in other port regions, ranging from new technologies to renewable energy sources and new IT systems. In the present work, the applied methodology and the results of the best practices analysis are presented, reporting the main innovations selected by the SUSPORT ports. This collection, together with an analysis of the current status of each SUSPORT port, will be the basis for planning the next actions during the project in the Adriatic area but can be as well applied in other contexts to reduce the environmental footprint in port areas.**

Keywords—Best practices analysis, ports, environmental sustainability, energy efficiency

I. Introduction

Environmental sustainability and energy efficiency represent challenging objectives to be pursued in port areas. In the last decades, increasing attention has been given to these topics, especially in the European context, leading to a large number of actions devoted to reduce the emissions of pollutants and develop new tools and policies to address the environmental impacts of navigation and port operations. Several research and pilot projects have been financed by the European Union through different funding programs, providing a quite strong basis that shall be considered by each stakeholder who approaches the topic.

In this context, the SUSPORT project provides a contribution to the above mentioned challenging objectives. It involves all the main port authorities in the Adriatic region (in particular, in Italy and Croatia), thus, representing a valuable channel to share past experiences and best practices dealing with port environmental sustainability and the improvement of energy efficiency in port areas. However, in order to effectively planning the actions to be carried out in the project area, a benchmark analyses of the state of the art in the SUSPORT ports as well as at a European and international level is required. In the project, such an issue is addressed through a best practice analysis.

The present work reports the results of such an analysis within the wider context related to the preliminary activities constituting the baseline for the pilot actions. Here, a collection of actions, pilot projects and/or experiences is provided dealing with the improvement of environmental sustainability and energy efficiency within the port areas. The collection encompasses all the port operations as well as the environmental policies already put in place by port authorities worldwide. Moreover, the selection has been carried out by focusing on the added value that the best practices can provide to the SUSPORT project to maximise the expected impacts of the pilot actions which will be performed subsequently. Moreover, together with the territorial need assessment carried out by each project partner, the best practices analysis provides a solid basis for carrying out the action plan for enhancing the environmental sustainability and energy efficiency of the ports in the Programme Area.

II. Methodology

In the SUSPORT project, the preliminary phase is devoted to creating the basis for the development of the specific pilot actions planned for the next steps. Two are the main activities carried out in this context: the Best Practices Analysis (BPA) and the Territorial Needs Assessment (TNA).

The BPA is carried out by all the partners of the project. As mentioned, the main aim of the collection is to select the most relevant best practices regarding the enhancement of environmental sustainability and port energy efficiency to improve the information sharing among the project partners and the public audience. The contributions have been collected by means of a template file requesting a description of the selected best practices and the added value for the project area and activities. Each contribution shall deal with technologies, solutions or policies adopted in a specific port or network. No geographical limitations were imposed.

Besides, all the port authorities involved in the project will also define the TNA to assess the baseline required to measure the future outcomes of the pilot actions as well as to ease its implementation. In more detail, the scope of TNA is to assess the state-of-the-art situation in terms of the carbon footprint of the port area. Data related to 2019 will be employed, including both terrestrial and maritime emissions [1,2]. Terrestrial emissions will comprise electric energy, heating, port service vehicles, port operational vehicles, heavy-duty vehicles, railway tractors. Maritime emissions will be decomposed into the ones related to anchored, maneovring and moored ships [3]. This initial status will be the base for the development of

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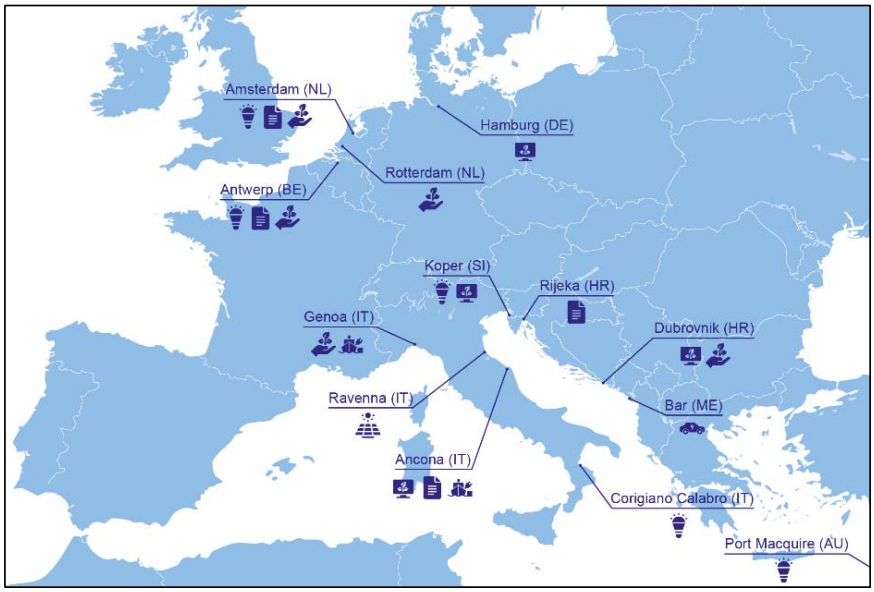

Fig. 1. Selected best practices location

the next steps and the evaluation of project impacts. Besides, to support overall assessment, the involvement of key stakeholders is essential. Hence, TNA will elaborate a complete mapping of the local stakeholders in terms of their relevance. Moreover, actions for their active involvement shall be considered and defined. Finally, a Strengths Weaknesses Opportunities and Threats (SWOT) analysis will be carried out to key internal and external factors perceived as important to achieving project objectives [4]. The TNAs are currently under definition and are here cited to provide the complete framework of the preliminary phase of SUSPORT project.

III. Results of the Best Practices Analysis

A total of 27 best practices have been collected and analyzed. **Errore. L'origine riferimento non è stata trovata.** and Table 1 provide an overview of the results. It can be noticed that most of the best practices are related to European ports. However, also best practices dealing with wider networks have been considered. In detail, the ports involved in the Ecoports initiative and the Adrion region have been considered, since they have a direct impact on the SUSPORT project area.

In the following, a selection of the best practices are described and analyzed, focusing on their impact on the SUSPORT project. The complete set can be fond in the dedicated project deliverable [5].

A. ECO-solutions deployment in the Port of Amsterdam

The Port of Amsterdam [6] is the second largest in the Netherlands in terms of transhipment. It is ranked fourth among European ports and it is considered to be one of the world's most advanced and committed ports in terms of energy efficiency solutions, sustainable energy generation and storage.

In this framework, from the most valuable solutions to be taken as best practice examples, the following solutions have been selected:

- *Energy Port Policy*: adoption of a dedicated Programme for the transformation of the port to a sustainable 'Energy Port'. For instance, smart public lighting on bicycle paths powered by DC was installed as a pilot project (Fig. 2). Moreover, an overall sustainability strategy has been put in place considering shipping, onshore mobility, employment, economic activities, local ecosystem, energy and climate, research and innovation, society, circular economy and safety/security;
- *Installation of solar panels*: with the 100,000 m2 (17 MW) of solar panels installed on port's buildings, the port area is the largest solar farm in the region;
- *"Sustainable energy means business"*: the Port seeks to become an innovative hub for start-ups and companies working in the field of energy efficiency and circular and bio-based maritime economy;
- *Cold ironing*: implementing Cold Ironing solutions lessens the environmental impact on areas surrounding ports, particularly in densely populated areas. The Ports of Amsterdam is a great example where cold ironing has been successfully implemented using locally generated electricity.

The most promising solutions described above in the framework of energy efficiency at the Port of Amsterdam represent valuable references for all SUSPORT project partners as well as for the Italian and Croatian stakeholders.

More specifically, the described best practices could be taken into consideration while exploring eco-solutions and energy efficiency measures, such as:

- energy Policy;
- solar panels installation and smart grids;
- sustainable energy and innovation start-ups;
- on-shore power supply and generation of electricity from renewables.

TABLE I. COMPLETE LIST OF THE BEST PRACTICES COLLECTED AND ANALYSED DURING SUSPORT PROJECT.

Best Practice	Location
Port of Amsterdam smart public lighting on DC	Amsterdam (NL)
ECO-solutions deployment in the Ports of Amsterdam	Amsterdam (NL)
Overall sustainability strategy	Amsterdam (NL)
Port Authority-CNR agreement to reuse the former Fincantieri building	Ancona (IT)
PIA – Progetto Inquinamento Ancona	Ancona (IT)
Ancona Blue Agreement	Ancona (IT)
Onshore power supply	Ancona (IT)
Analysis of energy consumption	Ancona (IT)
Interact City in the Port of Antwerp	Antwerp (BE)
ECO-solutions deployment in the Ports of Antwerp	Antwerp (BE)
Overall sustainability strategy	Antwerp (BE)
Electric vehicles for Port of Bar	Bar (ME)
Public lighting in the port of Corigliano Calabro	Corigliano Calabro (IT)
ECO measuring station by Dubrovnik Port Authority	Dubrovnik (HR)
Alterenergy project	Dubrovnik-Neretva Region (HR)
Green initiatives	Genoa (IT)
Cold ironing in the port of Genoa	Genoa (IT)
Advanced technology solutions for the port operations and management	Hamburg (DE)
Introducing high-efficiency lighting technologies	Koper (SI)
Monitoring can bring savings	Koper (SI)
LED Street Upgrade	Port Macquire-Hastings (AU)
Photovoltaic system on the roof of the Port of Ravenna Authority headquarters	Ravenna (IT)
Low Carbon Transport Plan	Rijeka (HR)
Carbon footprint and sustainable initiatives	Rotterdam (NL)
Ecoports network - UE	
Ports in Adrion Region - UE	

Fig. 2. DC powered lighting system in the port of Amsterdam

B. ECO-solutions deployment in the Port of Ancona

The Port of Ancona [7] has put in place several environmental actions, agreements and policies in the latest year by involving a large set of stakeholders, including public bodies, shipping companies and the local shipyard.

Regarding the environmental policies, the following actions have been implemented recently:

- *Reuse the former Fincantieri building*: the building located in the ancient harbour will be the new headquarters of the Institute for Biological Resources and Marine Biotechnologies of the National Research Council. The building will be refitted to reduce the energy consumption, thus, giving an example of smart reuse of existing structures on a historical waterfront;
- *Environmental awareness*: the port authority is committed along with the municipality to improving knowledge on the exposure of the population to allergenic pollens and their potential interaction with pollutants atmospheric agents such as fine dust;
- *Ancona Blue Agreement*: the port authority established an agreement with the main shipping companies to anticipate the entering into force of international rules regarding the sulphur content in marine fuels. This represents a good example of local cooperation between the public bodies and the maritime operators to reduce maritime emissions coming from port operations.

Moreover, the authority is also committed to enabling cold ironing. In this context, a pilot project has been carried out at the Fincantieri shipyard, where the outfitting quay has been equipped to provide electric power to the ships under construction. This solution avoids running the onboard generators during all the outfitting phase.

C. ECO-solutions deployment in the Port of Antwerp

The port of Antwerp [8] houses the Europe's largest integrated fuel and chemicals cluster, which is associated with high energy intensity and emissions of greenhouse gases. Despite these characteristics, the port community is considered worldwide as one of the most advanced in energy efficiency and has taken successfully energy optimization related measures in past years while investing in renewable energy. From the most relevant solutions implemented in this framework, the following measures have been selected:

- *Energy Plans and "The Blue Gate Antwerp project"*: the Port promoted a specific framework for energy plans dedicated to businesses operating in the port area. Furthermore, the Port of Antwerp itself is reinvesting its share of the income yielded by the generation of energy from renewables via dedicated fund for energy named "The Blue Gate Antwerp project";
- *ECLUSE*: Ecluse (Fig. 3) is a steam network created by the Port that supplies the heat from six incinerator facilities in the form of steam to the nearby port companies;
- *PortXL and start-up Enervalis* – smarter decisions about energy management: with this project, the Port of Antwerp aims to introduce and support innovative technologies on to the port sustainability platform, such as the case of Enervalis, a start-up offering software that allows making smarter decisions about energy management;
- *Mobility*: The promotion of sustainable transport methods within the port is one of the priorities in which

the port is committed, including the promotion of a dedicated policy fostering the use of sustainable transport methods and the reduction in the number of home/work trips by private cars.

Fig. 3. ECLUSE network in the port of Antwerp

D. ECO-solutions deployment in the Port of Genoa

The Port Authority of Genoa [9] carried out several actions to improve energy efficiency and environmental sustainability. They include:

- the employment of *alternative energy sources*, such as LNG and biomass, for heating and cooling buildings;
- the installation of a 120 kW *photovoltaic system* on the West Terminal roof of Savona's Palacrociere Cruise Teminal;
- the replacement of traditional lights with *energy-saving lights* (LEDs);
- the provision of *shoreside electrical power* to the Genoa Prà basin to reduce pollutant emissions, improve energy efficiency and noise reduction impact;
- the introduction of a *cold ironing* system which provides shoreside electrical power to vessels at berth whilst the main and auxiliary engines are switched off, leading to a reduction of CO2 emissions in the Vado Ligure basin.

E. Advanced technological solutions for the port operations and management

The Port of Hamburg [10] is testing the implementation and realisation of 5G and network slicing in a real-world operational environment, with the aim at getting hands-on experience with the capabilities of the new communication system, and to explore the arising possibilities for improving the port's operations and processes.

The focus of the implemented applications is on improving the traffic and infrastructure control as well as the environmental monitoring within the port area. For example, traffic lights are connected to the central traffic control and steering system using a wireless connection, which is clearly faster and cheaper to install compared to a fixed line. This approach would also allow the integration of temporary traffic lights at construction sites.

Environmental measurements collected from sensors – partially installed on mobile barges roaming within the port –

Fig. 4. Mobile structure for ships' cold ironing in the port of Genoa (Source: Port System Authority of the Western Ligurian Sea)

are meant to be processed in real-time. In addition, Augmented Reality-based applications are planned to help maintenance teams controlling the infrastructure to create a safer environment.

Applications that are part of testing are: (1) traffic lights, which are connected with the central traffic control through the 5G mobile communications, (2) environmental sensors installed on Hamburg Port Authority ships providing real-time data, (3) VR- and AR-goggles, which can support engineers to test constructions and studies in the port area.

The pilot testing is a part of the project 5G-MoNArch (5G Mobile Network Architecture) as a research project funded by the European Commission within the Horizon 2020 Framework Programme.

F. Carbon Footprint and Sustainable Initiatives in the Port of Rotterdam

Rotterdam Port Authority [11] has listed a strong reduction of CO2 emissions since 2011 among its goals with an initiative called CO2-Neutral Sin. The policy, on one hand, encourages port operators to report carbon footprint while, on the other hand, allows the deployment of measures to reduce its CO2 emissions, such as using renewable energy, saving fossil fuel for the patrol ships and lending energy cars for the employees. The remaining emissions are compensated for by means of Gold Emission Allowances purchases.

Among the main initiatives, the followings can be highlighted:

- *Carbon capture and storage*: the port Authority cooperates with many partners to study the construction of a pipeline in the port area allowing private companies to catch the CO2 and transfer it into the empty gas fields in the North Sea;
- *Portshuttle*: a rail shuttle system to transfer containers in the port area, which is operational 24/24 and 7/7. It allows transport operators and logistics service providers to optimize freight flows and the whole logistics system inside Rotterdam, thus, representing a good example of efficient use of the existing railway line;
- *Portbase for the information planning and exchange*: the Port Community System is used for logistics

planning and information exchange among different modes of transport.;

- *Sustainable logistics chains*: in order to ensure more efficient IT-based ship navigation, the use of electric cranes and transition fuels such as the LNG is promoted. Such fuels would then perspectively be replaced by hydrogen and synthetic fuels in the long term;
- *Free emission short trips to/from the port by 2040*: to reach such a goal, three conditions would be be met, namely the availability of alternative fuels and its distribution grid, the conversion of truck engines (also by means of pilot projects) and a policy of incentive provisions for alternative fuels;
- *Container transport with e-truck in the whole port*: the Port Authority commissioned a feasibility study on containers being transported by electric of hydrogen-powered trucks. It assessed that in 2024 the purchase of a battery truck might be cheaper than a traditional diesel truck considering the truck entire life cycle. While hydrogen-fueled trucks might be more advantageous in 2030, even in the battery truck might still be the cheapest. However, infrastructure optimization for the use of the electric truck is deemed to be necessary.

G. Ecoports network - UE

EcoPorts is the main environmental initiative for the European port sector. It was initiated by a number of proactive ports in 1997 and has been fully integrated into the European Sea Ports Organisation (ESPO) since 2011. The overarching principle of EcoPorts is to raise awareness on environmental protection through cooperation and sharing of knowledge between ports and improve environmental management [12]. In this framework several initiatives have been put in place, providing also different tools devoted to assess and improve the port sustainability. These tools can be applied by all the ports within and also outside the Ecoports network. Here, two of these tools are analysed:

- *Self Diagnosis Method*: the Self Diagnosis Method (SDA) is a tool which is configured as a checklist supporting a port authority in identifying the main environmental risks affecting the port area. Moreover, it allows the comparison of the specific port environmental performances with the European average in order to improve their environmental management and policies by prioritising future actions. Within the EcoPorts initiative, experts review the SDA and can provide customised advice and recommendations according to port main priorities to ensure sustainable development;
- *Port Environmental Review System*: the port of Rotterdam defined a tool to assess the sustainability performance of a port by considering several sustainability issues. The system, named Port Environmental Review System (PERS), has been developed in line with ESPO recommendations concerning port sustainability and it is now part of the tools provided by EcoPorts Initiative. The PERS incorporates the current recognised environmental management standards, such as ISO 14001. A wide range of sustainability issues is addressed by PERS including noise, air and water quality, waste treatment, problems connected to dredging operations and disposal, bunkering operations, dust, pollution due to ships and port operations, port energy consumption, the interaction between the port and the local community and with the port and the habitat/ecosystem with special attention to climate change. The PERS can help port authorities in facing environmental challenges and improving their environmental management. Ports from EcoPorts network can apply to obtain a PERS certificate independently reviewed by Lloyd's Register and valid for two years. The PERS, initially implemented for the Rotterdam port, is now a flexible and user-friendly tool applicable to other contexts (ports with different infrastructures, terminals, location, etc.).

IV. Conclusions

The main outcomes of the best practices analysis carried out within the SUSPORT project have been presented and discussed. The analysis provides an overview of the actions that can be carried out to improve environmental sustainability and the environmental efficiency of port operations. The importance of an overall environmental policy has been highlighted by several virtuous examples available mostly in northern Europe. In particular, some big ports such as Rotterdam, Antwerp and Amsterdam show that environmental impacts can be effectively tackled and indeed reduced in port areas through proper planning, even with increasing port traffic.

Besides, several shreds of evidence show that the objectives can be achieved by applying a mix of new technologies (e.g. the replacement of public lighting system, electric cars, cold ironing), renewable energy sources (e.g. photovoltaic panels) and IT systems. In this context, also monitoring devices and data analysis play a key role: they allow the control of the air/water quality and the main sources of pollution (e.g. maritime and road traffic inside the port), thus, feeding better action plans.

In conclusion, it shall be noted that the current best practices analyses mostly deal with the European context, which is the most familiar context for the project partners but also where the environmental issues are more considered by the administrations in the international scenario. The analysis does not provide a comprehensive discussion on sustainability issues in the port enviroment, which is out of the scope of SUSPORT project. Rather, it presents a valuable collection of real-life examples that can be directly applied in the Programme Area as well as in other geographical contexts. Hence, it is expected that sharing information about sustainability among the project partners and local stakeholders can help in planning the next steps of the project to maximise its impact in each specific local context.

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