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Ports Energy and Carbon Savings

DELIVERABLE 1.3.1: LITERATURE REVIEW ON PORT ENERGY

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1.1 Definitions

General: From https://en.oxforddictionaries.com/definition:

Port:	**"A town or city with a harbour or access to navigable water where ships load or unload".**
Harbour:	**"A place on the coast where ships may moor in shelter, especially one protected from rough water by piers, jetties, and other artificial structures. "**
Marina:	**"A specially designed harbour with moorings for pleasure yachts and small boats".**

Specifically for this project:

Reference system:	**"Part of the port: reference for assessing the feasibility of options to reduce energy consumption and carbon-dioxide emission".**
Boundary:	**"Border between the reference system and the surroundings"**
Pilot:	**"First installed system to reduce energy consumption and carbon emissions"**
Savings:	**"Reduction of fossil fuel energy consumption and related emission of carbon-dioxide, due to technical or non-technical measures within the system boundary"**

1.2 Introduction

This research responses positively to "THE PARIS AGREEMENT". (UNFCCC, 2015) The Agreement aims to respond to the global climate change threat by keeping a global temperature rise. However, the last study published (David G. Victor, 2017), *Nature* found that all major industrialized nations are failing to meet the pledges they made in the Paris Agreement.

In maritime ports and related activities, new environmental issues are constantly emerging and becoming additional competitive factors. Energy consumption and emissions in port sector are increasing the focus of public concern and political attention. This chapter aims to collect background information on best practices relating to carbon neutrality, environmental issues and renewable energy of ports in general.

Ports are strategic geographical locations situated beside oceans, seas, rivers or lakes and can be defined as a harbour or an area that is able to provide shelter to numerous boats and vessels. Ports consist of the dock area, fields, quays, fairways, and land routes. Ports are also related to the port activities, infrastructure such as warehouses, cranes and terminals. (Hippinen & Jaana Federley, 2014).

"Carbon neutrality" was first proposed on "THE PARIS AGREEMENT" (UNFCCC, 2015) in 2015. With rapid expansion of port development, ports around the world form a challenge regarding energy consumption and carbon emission. Carbon pollution urges them to pay extra investment on comprehensive ecological improvement. Actual development varies from port to port with issues, which includes human life, industrial emission, ship transportation and so on. Carbon neutrality refers to achieving less carbon emission or reaching the goal of less carbon footprint by carbon offsetting. Two methods to achieve are balancing a measured amount of carbon emission with an equivalent amount sequestered or buying enough carbon credits. Activities related to them remove carbon dioxide emissions from the surrounding that lead to the reduction on greenhouse gas emissions. (ThorburnNiall, 2008).

1.3 Port energy consumption

The map of fuel consumption in 2000 shows annual near shore fuel consumption pattern around the world (figure 1.1).

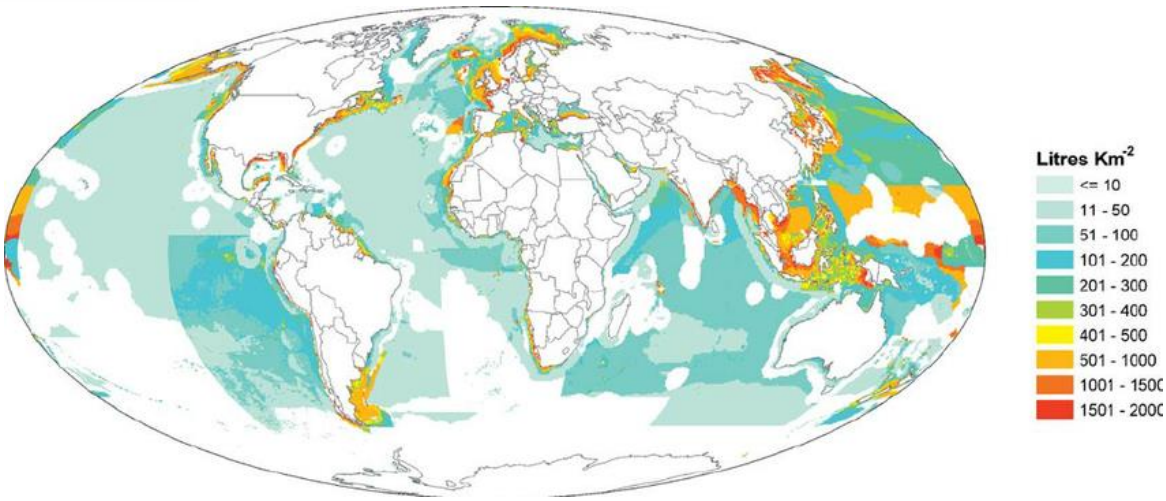

Figure 1 Fuel consumption (Distribution and intensity of fuel consumption by marine fisheries in 2000. Total fuel inputs amount to 50 billion L, with most of this being expended in nearshore fishing grounds of the Northern Hemisphere., 2018)

Compared with figure 1.2 (world major seaport), it turns out that majority of ports area in Europe consume approximately 501 to 1000 litres Km-².

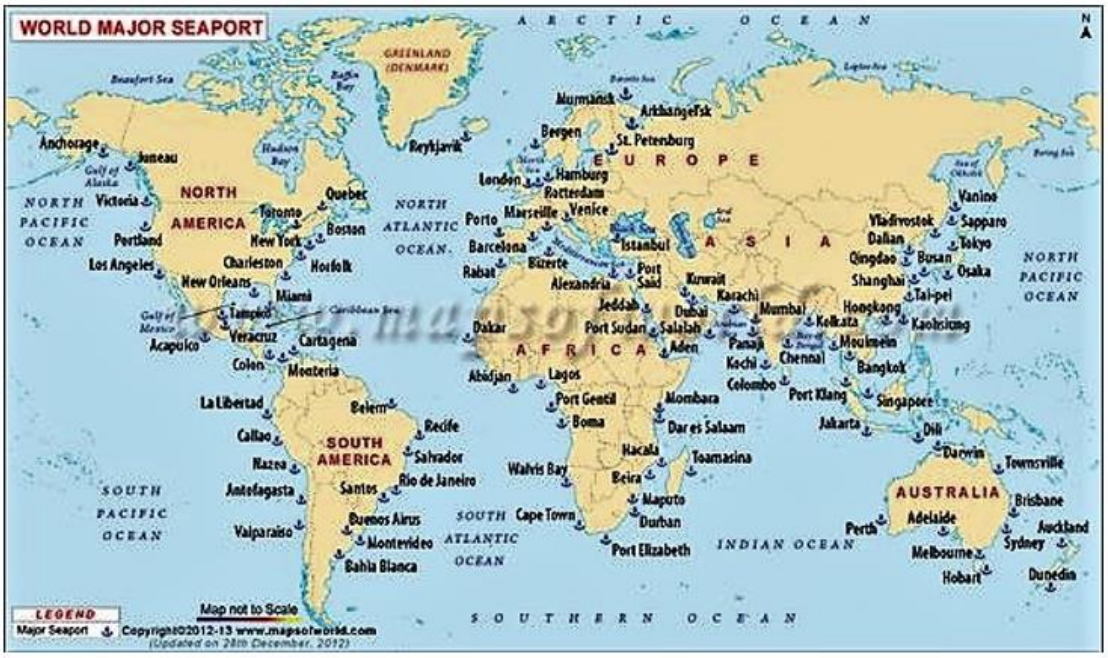

Figure 1.2 World Major Seaport

1.4 Renewable energy

Renewable energy includes solar energy, wind energy, tidal energy, wave energy, and other potential renewables need to be explored. From the end of 2004, worldwide renewable energy capacity grew at rates of 10–60% annually, see table 1.1.

Table 1.1 The consumption of renewable energy of world since 2008 (Ren21, Global status report. 2011, 2011)

Selected renewable energy global indicators	2008	2009	2010	2011	2012	2013	2014	2015	2016
Investment in new renewable capacity (annual) (10^9 USD)[88]	182	178	237	279	256	232	270	285	241
Renewables power capacity (existing) (GWe)	1,140	1,230	1,320	1,360	1,470	1,578	1,712	1,849	2,017
Hydropower capacity (existing) (GWe)	885	915	945	970	990	1,018	1,055	1,064	1,096
Wind power capacity (existing) (GWe)	121	159	198	238	283	319	370	433	487
Solar PV capacity (grid-connected) (GWe)	16	23	40	70	100	138	177	227	303
Solar hot water capacity (existing) (GWth)	130	160	185	232	255	373	406	435	456
Ethanol production (annual) (10^9 litres)	67	76	86	86	83	87	94	98	98.6
Biodiesel production (annual) (10^9 litres)	12	17.8	18.5	21.4	22.5	26	29.7	30	30.8
Countries with policy targets for renewable energy use	79	89	98	118	138	144	164	173	176

1.5 Solar energy

The map below shows the global solar energy potential of the various regions around the world in 2017. According to figure 3, annual solar irradiation of ports area throughout the world ranges from 800 to 2400 kWh/m². There is no doubt that solar energy can be developed significantly among ports area in next few years.

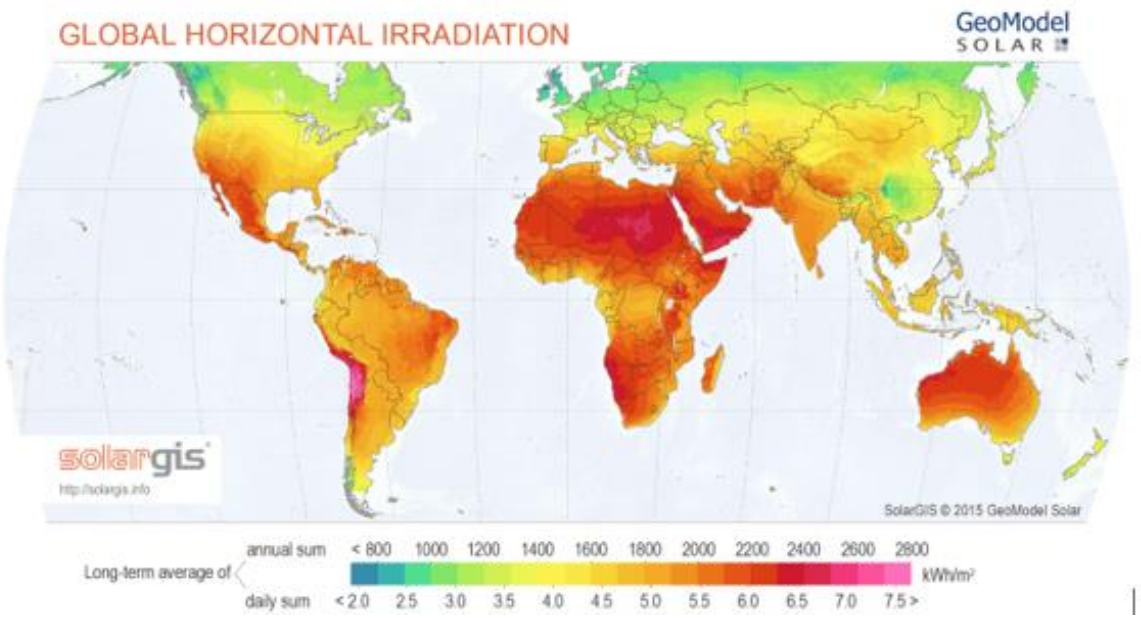

Figure 1.3 Global horizontal irradiation (World Solar PV Energy Potential Maps, 2018)

1.6 Wind energy

The wind map (figure 1.4) can be used to evaluates deviations in global wind conditions in 2018 from the historical norm on an annual basis. Depending on the figure 1.4 showing the exact location of major seaports all over the world, average wind speed anomaly among all ports approximately ranges from +6/+9 to +12/+15. Potential of wind power of general ports is predicted to be substantial.

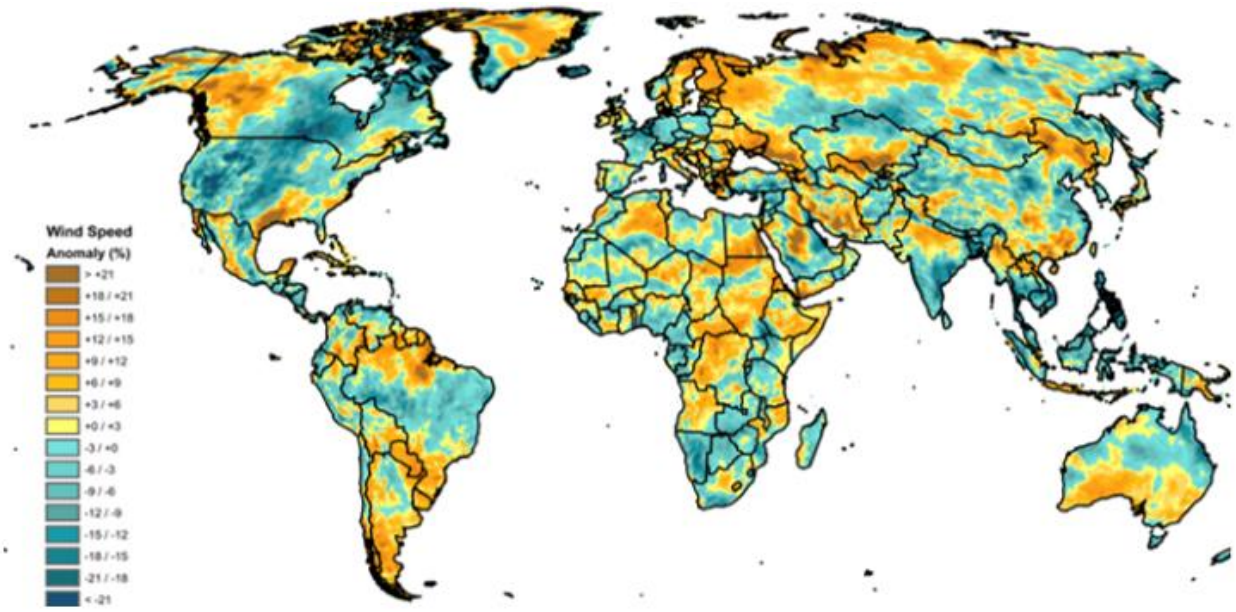

Figure 1.4 Global Wind Map (AWS Truepower releases Q4 2017 Wind Trends Bulletin, 2018)

1.7 Tidal energy

The map (figure 1.5) clarifies that not all ports can exploit tidal energy and ports in the north like North America, Australia, west Europe and South America have greater potential to use this renewable energy.

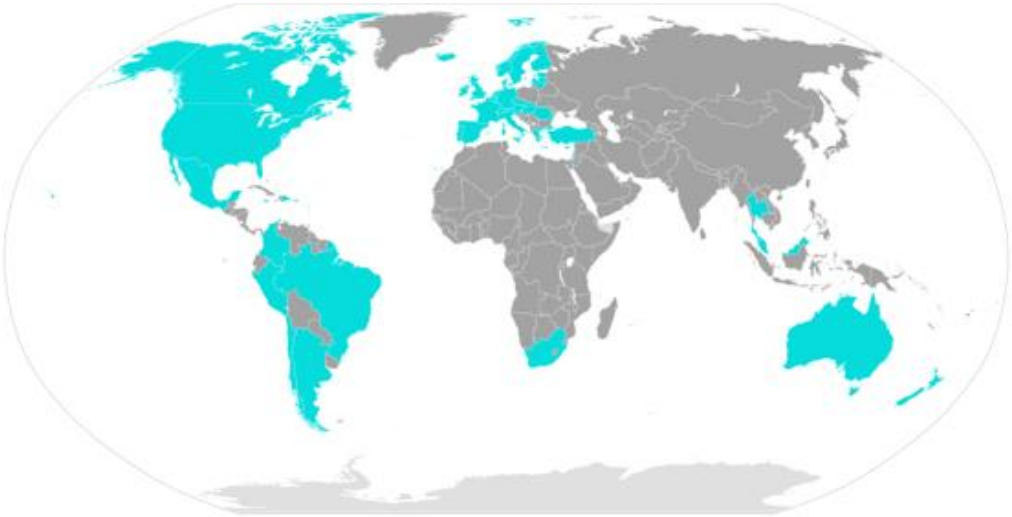

Figure 1.5 Availability of Tidal in the World (Availability of Tidal in the World.svg, 2018)

1.8 Wave energy

From the wave height map below, it turns out that most ports areas own certain amount of wave height ranges from 1.5 m to 3m. According to the figure 8, it illustrates the relationship between wave energy. During the calculation of wave parameters, the wave power will reach over 3.1 MWh/m while energy period is between 11s and 12s. It is predicable that wave energy have greater potential in the foresee future and port can benefit a lots from it.

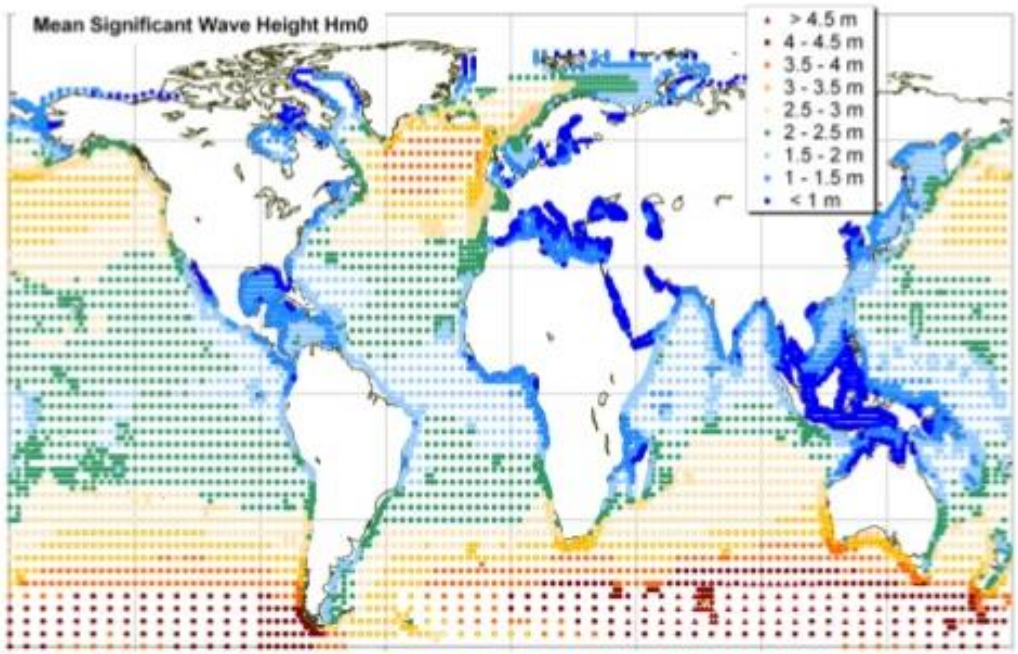

Figure 1.6 World wave height (Bivariate distribution of energy (MWh/m) for sea states defined by wave height and energy period , 2018)

1.9 Existing methods to assess the potential of renewables

Since the (r)evolution of renewable energy sources, various tool have been developed to assess the potential, to name (Bozalakov, 2018)

1. HOMER (Hybrid Optimization of Multiple Energy Resources) is the developer and distributor of the HOMER software, a standard for optimizing microgrid and distributed energy resource designs. HOMER combines engineering and economics into one model, allowing users to determine least-cost options. Two option are offered
    - Pro - The tool for optimizing microgrid design
    - Grid - A tool for optimizing the value of behind-the-meter, distributed generation systems
2. NREL developed energy analysis data and tools to assess, analyze, and optimize renewable energy and energy efficiency technologies. Various data-sets and tools are available. One of the models is SAM (System Advisor Model) which is a performance and financial model designed to facilitate decision making for people involved in the renewable energy industry
3. SKELION is a graphical tool for the design solar thermal or solar photovoltaic installations starting from a 3d model. Residential installations or ground mount power plants can be designed using Sketchup and Google Earth.
4. HYBRID2 software package is a tool to perform performance and economic analysis on a wide variety of hybrid power systems. It is is a probabilistic/time series computer model, using time series data for loads, wind speed, solar insolation, temperature and the power system designed or selected by the user, to predict the performance of the hybrid power system. Variations in wind speed and in load within

each time step are factored into the performance predictions. The code does not consider short term system fluctuations caused by system dynamics or component transients

After evaluation the existing tools show to powerful, but requiring a level of details that is not always available. As an alternative, in deliverable D.1.3.2 and D.1.3.3 a more straightforward approach is adopted for the assessment of renewable energy.

1.10 Conclusions

This literature research report shows that:

1. Port in general, due to their strategic position at the border between land and seas and oceans, display a considerable energy consumption.
2. At present all most the total energy usage is fossil fuel related, and therefore constitutes a considerable contribution to greenhouse gas emissions.
3. Also due to their strategic position, ports have access to renewable energy sources from water (seas and oceans) and land. In particular: energy from the sum (electrical and thermal), wind, tidal and wave.

This report mostly has a qualitative basis. In project deliverable "1.3.2: Draft method to determine potentials of renewable energy sources in SMS ports" quantitative figures will be provided for port energy consumption and the potential of renewable energy sources.