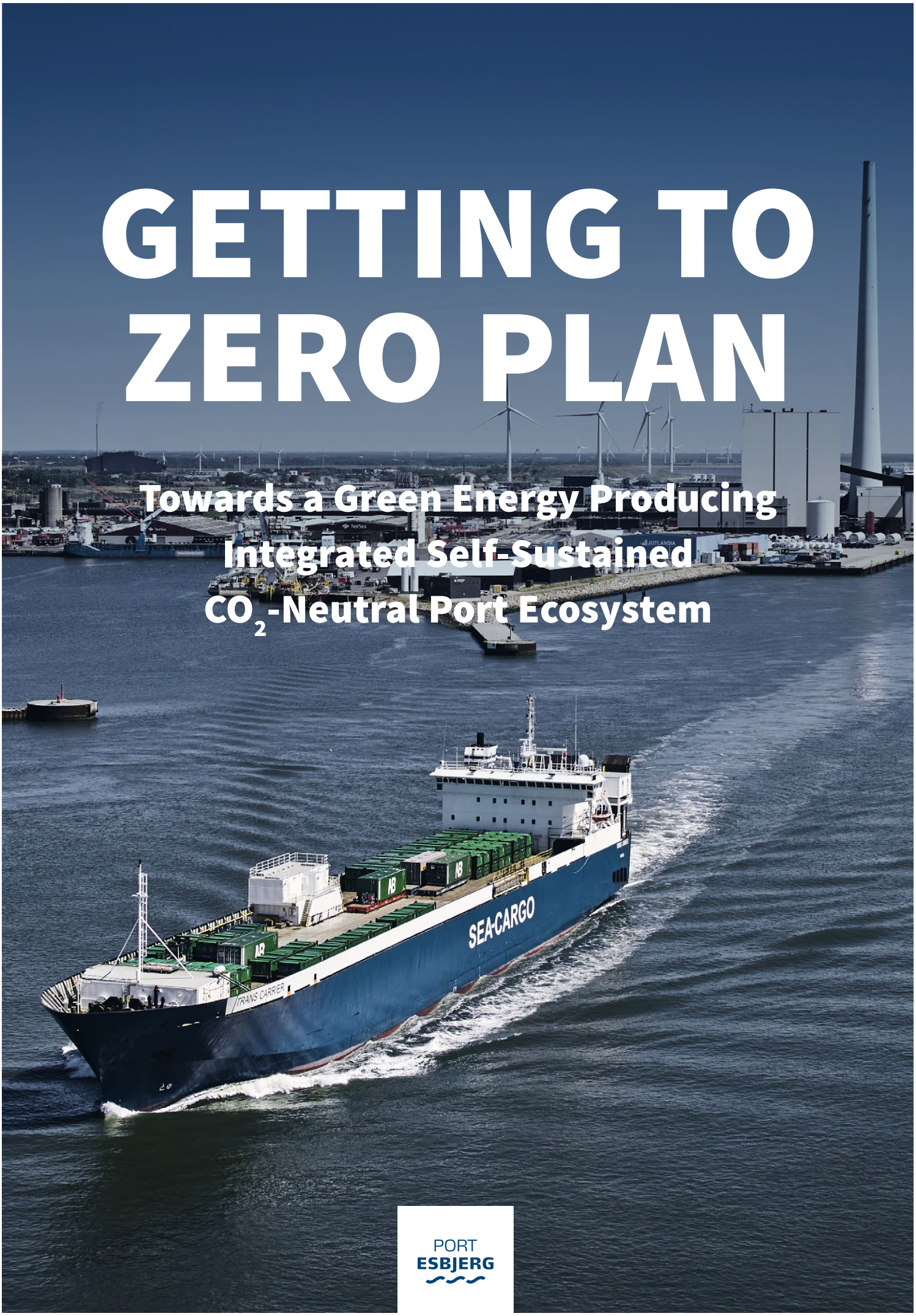
GETTING TO ZERO PLAN

Towards a Green Energy Producing Integrated Self-Sustained CO_2-Neutral Port Ecosystem



PORT
ESBJERG

INTRODUCTION

Port Esbjerg is one of the most influential economic gateways to Jutland. Today, most prominent and successful economic regions are among those that have ports dwelling there. Indeed, this has side effects, as our operations and functions are huge contributors to the Greenhouse Gases (GHG) and other environmental toxicants. Further, many of the non-performing activities, such as idle vessels waiting in port, are the unnecessary operations that are polluting the port-adjacent environment without any tangible contributions.

Therefore, to match with the transformation towards sustainable and green future that the world is going through, we must induct innovative methods and approaches that do not only talk about curbing the emissions for a few operations, but rather emphasize on driving the entire port ecosystem towards greener technology and economy. Where, on one hand, the inclusion of green technology abides Port Esbjerg's function and operations with the requirement from the Municipality of Esbjerg, underpinned by the UN's SDGs, the green economy, on the other hand, lays a financial framework for the societies to prosper and progress.

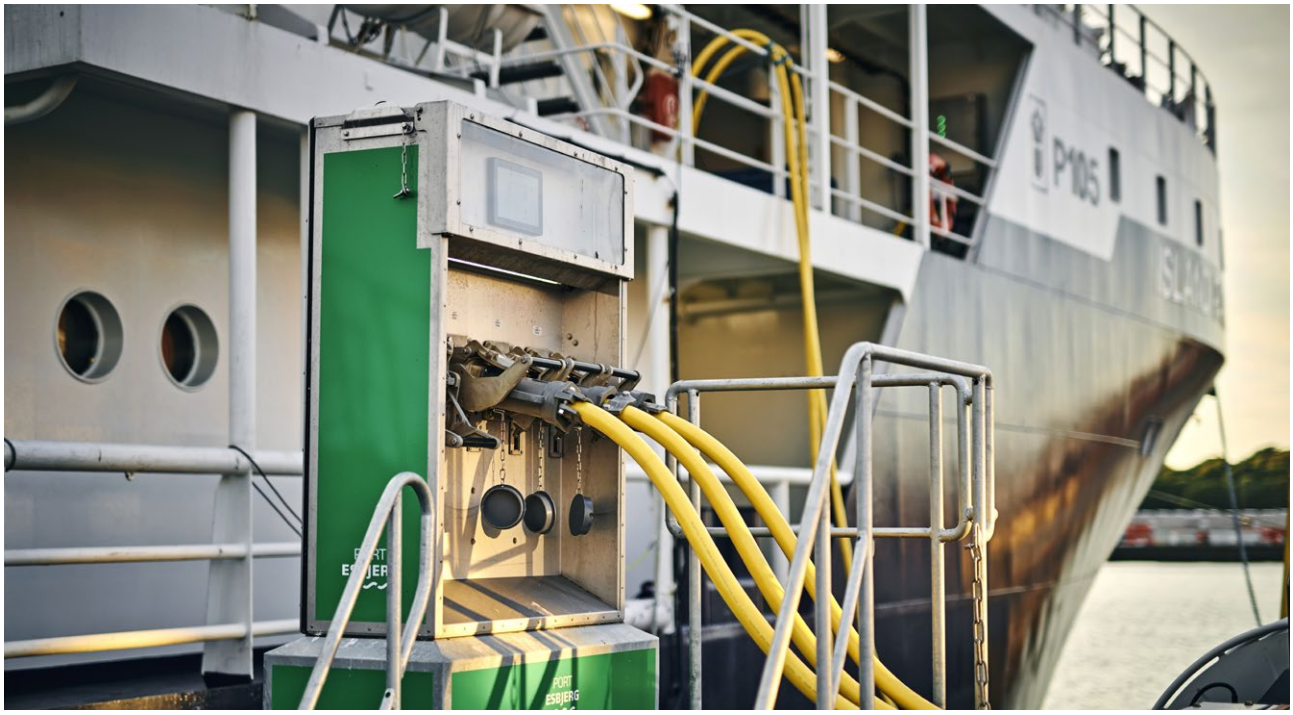
Thus, this plan systematizes the path to carbon neutrality by using the green energy systems available to decarbonize the impact of Port Esbjerg. This depicts the necessity of the Micro Green Energy Grid and the Green Energy Grid, while realizing that Port Esbjerg is a node in a vast network. In this context our commitment towards reducing Green House Gases reaches beyond the port limits.

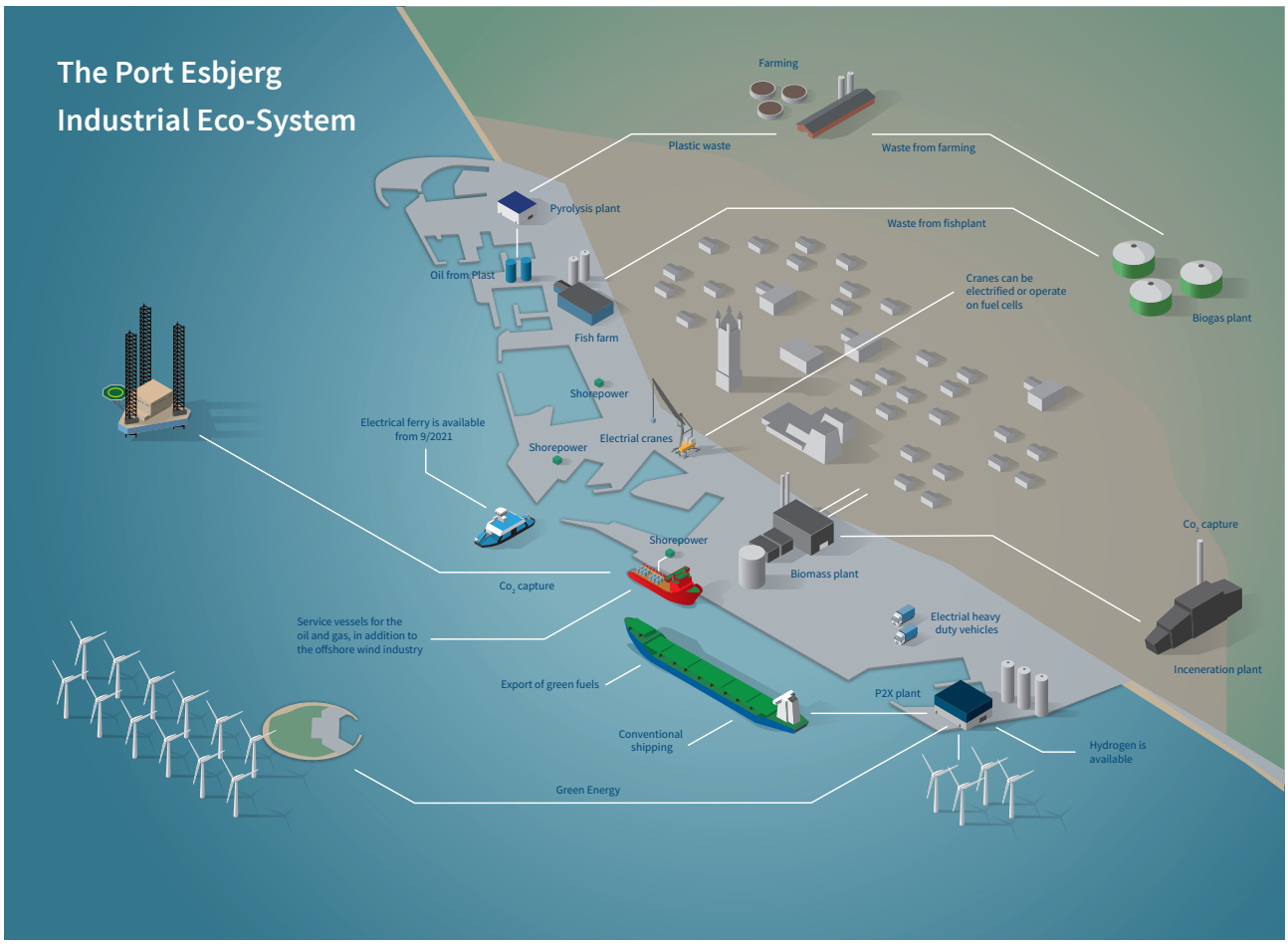
The details of the Green Energy Grid vary with the type of green fuels, but Port Esbjerg has available multiple systems, which are envisaged implemented. Conversely, The Micro Green Energy Grid is a demand-driven system that initially supports the transformers, fuel cells, and generators supplying shore power for the ships in the port. This leads to an immediate and significant leap towards carbon neutrality, but the Micro Green Energy Grid is also instrumental in bunkering of the future shipping operations, thereby providing an integral part in the green transition.

Second, to the impact from the ships, there are all the activities in ports where transport, handling, loading and discharging operations comprise activities that have an impact on the environment in form of carbon emissions and waste from the operations. To impact this, the plan entails digitalization and IoT projects that engage with the actors in the port-ecosystem, to change behaviours for the benefit of the environment and hereunder curb emissions.

Finally, the plan connects with the activities in Port Esbjerg, which are the transport network in the hinterland and the activities supporting the oil, gas and offshore wind operations in the North Sea. Here, the mode of transport and the control of the transport make a considerable impact, which is changed through systems of information and knowledge sharing.

The plan commences describing the basis for the carbon emission, then proceeds to describe the port-ecosysten, which forms basis for the Micro Green Energy Grid, the network engagement and the Green Energy Grid that together are envisaged to reach carbon neutrality. The impact is therefore measurable, and specific and the knowledge gained is usable.



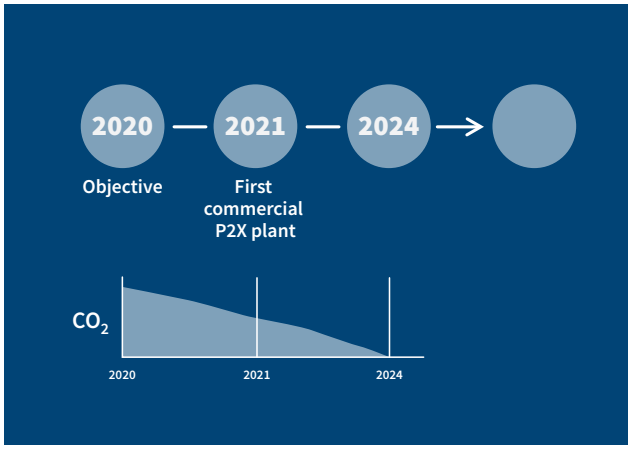


PORT ECOSYSTEM

This plan's excellence is reflected in its title, which says, 'Towards a Green Energy Producing Integrated Self-Sustained CO_2-Neutral Port Ecosystem'. It is a leap that we shall make towards a green fuel driven self-sustained port. The title conveys our definition of a Green Port Ecosystem that will be pursued, and each term in the title expresses the key elements that we will focus on in our journey towards carbon neutrality.

According to our definition of the Green Port Ecosystem, which is portrayed for Port Esbjerg below, the port must have the ability to accommodate and cater of all kinds of green fuels to power its shore requirements, must be able to reverse toxicants and eliminate CO_2 from the environment, and must be able to make its functions and operations energy efficient. Hence, our plans juxtapose the green energy, digital intelligence, toxicant reversal, and green economy frameworks and systems under an umbrella. The Getting to Zero Plan's intention is (a) to investigate and find methods and approaches that can curb the toxicant emissions of the port operations and shift the paradigm to a self-sustainable level, (b) to evaluate and showcase the socio-techno-economic impact of the findings by implementing them on most critical shore functions, and (c) to endorse the achievements by creating living labs. Port Esbjerg has these attributes, which allow for seamless connection with its industrial ecosystem.

The Getting to Zero Plan leapfrogs the conventional path by connecting to the green industrial ecosystem available within the spatial cluster of the port and hinterland, and thereby benefits from the steps taken by the wider society towards the green transition.



BASIS FOR THE GETTING TO ZERO PLAN

The impact of Port Esbjerg was calculated with the basis year 2018 and here it was notes that the carbon emissions exceeded hundred thousand tons per year. Most where from the ships calling the port. In addition, the cargo operations by crane and other handling also provided a significant contribution. These activities are under direct influence of Port Esbjerg and are therefore referred to as primary impacts. Here, the establishment of the Micro Green Energy Grid allows for shore power to ships, cranes and handling equipment, while the Green Energy Grid shall provide the future fuels to the ships.

Conversely, one of the culprits in the emission of Green House Gases is the incineration of waste from the ships, wherefore Port Esbjerg has developed its own waste management system, albeit significant volumes still need to be incinerated. The possibility to reverse the toxicants from the port operations therefore forms part of the Getting to Zero Plan.

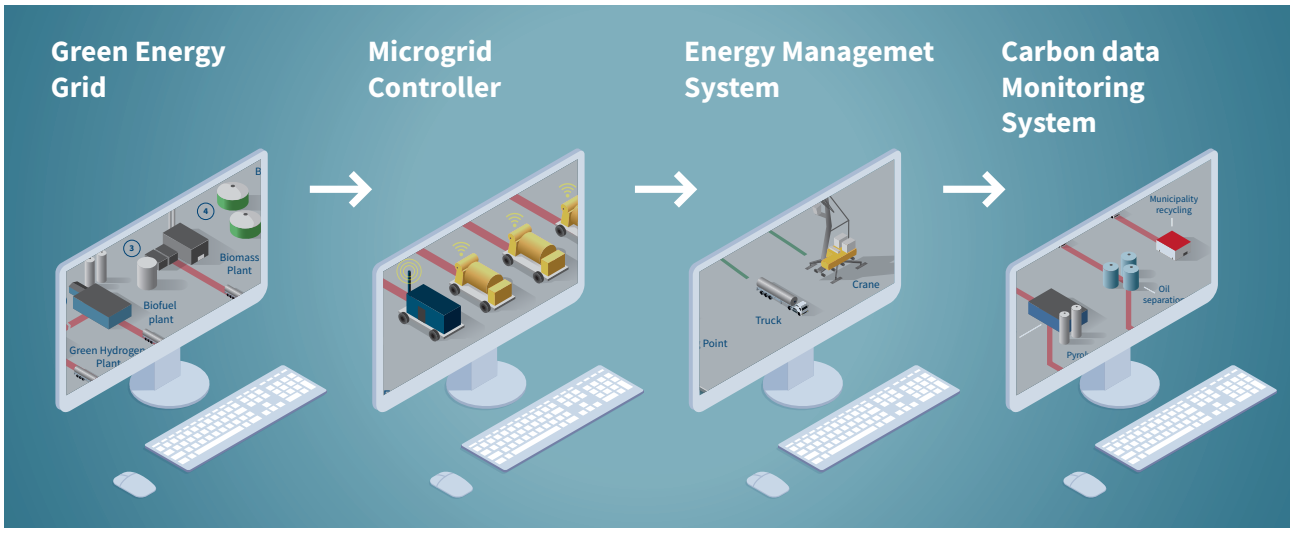
Finally, there is also activities to outwit our direct influence. E.g. thousand trucks that each day enter or leave the port, while also more than seven thousand people commute to the port every day. This contributes to the carbon emissions, albeit we have no direct control on changing these modes of transport. Consequently, we have developed Port Societal Systems that influence the behavior of decision-makers and thereby nudge the change that will support our transition towards carbon neutrality.

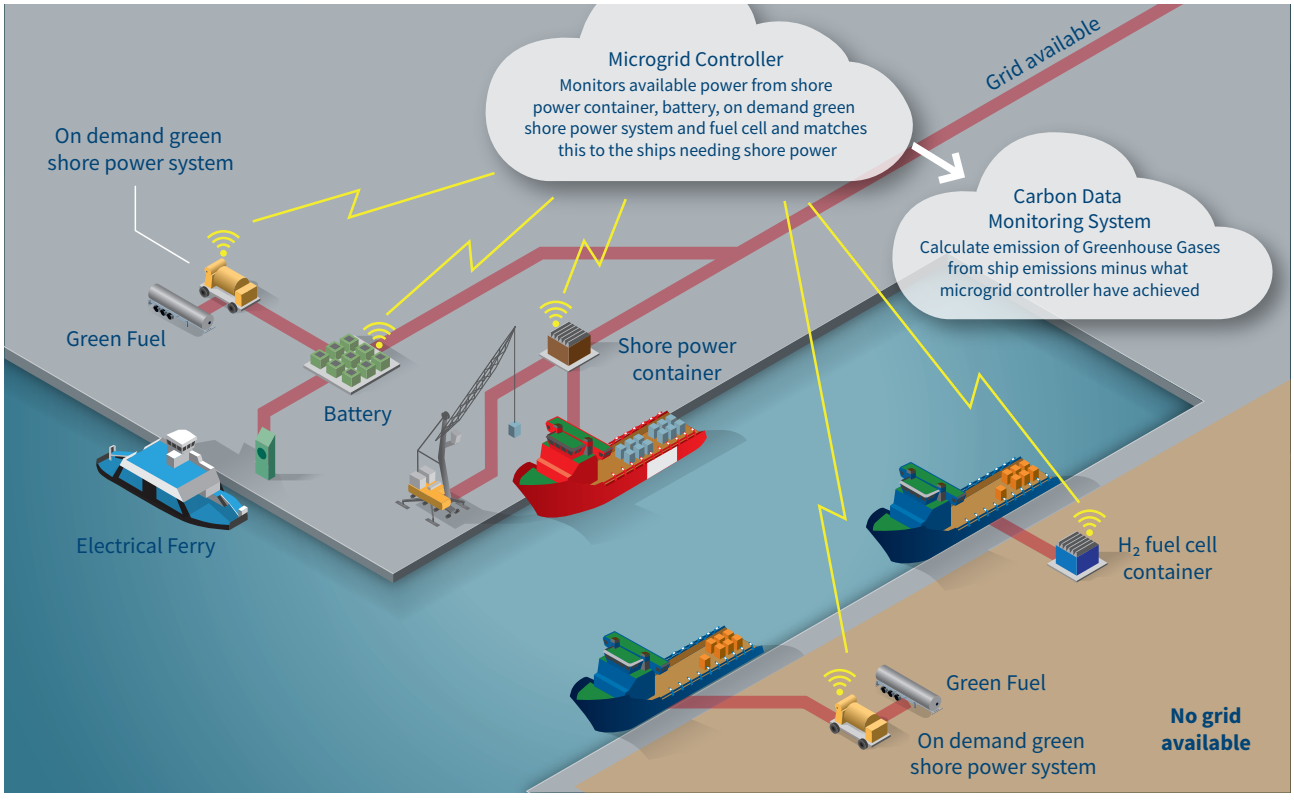
CONTROL	ACTIVITY	ANNUAL CO_2
Direct control	General cargo ships	6,029
Direct control	RoRo and car carriers	799
Direct control	Oil and gas service ships	65,058
Direct control	Offshore wind service ships	12,269
Direct control	Fishing ships (shorepower already established)	0
Direct control	Tank ships (wet bulk)	1,096
Direct control	Ferry traffic	9,037
Direct control	Port dredger	130
Direct control	Forklifts	104
Direct control	Reach stackers	34
Direct control	Cranes	4,938
Direct control	Other port moving materiel	334
Direct control	Waste incinerated	9,000
No direct control	Trucks	3,012
Total CO_2 emission (tons)		**112,841**
	CO_2 Reduced Through the Plan	
Saved by biodiesel generator		5,201
Saved by biogas generator		5,201
Saved by fuel cells		3,334
Saved by transformers		60,013
Residual w/o engaging in the social ecosystem		**39,092**
Saved by trimodal simulator		37,303
Saved by car pooling		1,000
Saved by collaboration with the heliport		579
Saved by coordinating crew change		200
Residual after changed behaviors		**0**

THE MICRO GREEN ELECTRICITY GRID

The Micro Green Electricity Grid aims to be able to deliver green shore power to the ships in the port, as this is considered the initial steps towards carbon neutrality. A grid is available in most of the port that allows delivery on certified green power, but as most ships operate on 60 Hz compared to the 50 Hz available, there is a need for transformers. Conversely, there are areas in the port where no grid exits, and here several solutions is planned for delivering shore power, comprising fuels cells for use of hydrogen, biodiesel and biogas generators.

The delivery of power needs to be controlled and coincide with the ships calling the port, wherefore the Microgrid Controller is planned to perform this function, while the Power Management System controls the delivery and the Carbon Data Monitoring System (already in operation) calculates the CO_2 emission, as illustrated below.





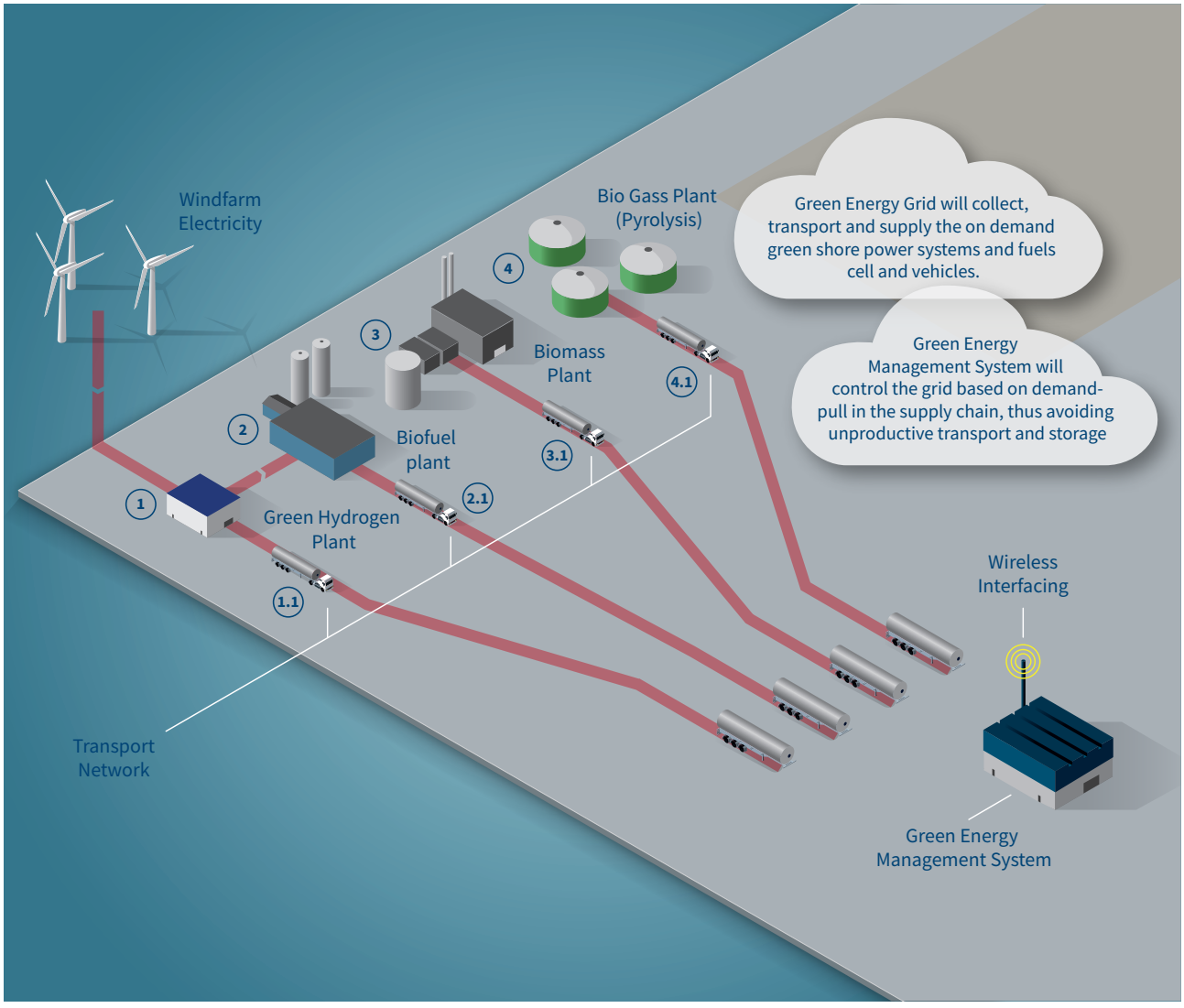
THE GREEN ENERGY GRID

Shipping is imperative for the European economy and ports are an integrated part hereof. In 2013, the European Commission (COM 295) made the report on ports as engines of growth, and this portrayed the vital socio-economic perspective of ports. Same applies to the green transformation of shipping, where the availability and distribution of green fuels is the solution to the future environmental shipping.

The future fuels of shipping are envisaged as e-fuels, such as ammonia or methanol and hydrogen. The delivery of these green fuels requires Port Esbjerg to plan for this, while further enhancement of the project allows for bunkering ships.

Conversely, we also expect that biodiesel, biogas and pyrolysis fuels will play a role in future fuels. These fuels require collection of waste stream, which is considered in the toxic reversal plans. This allows for collection of various waste streams that can be used to produce these fuels, which again is depending on the activities in the hinterland.

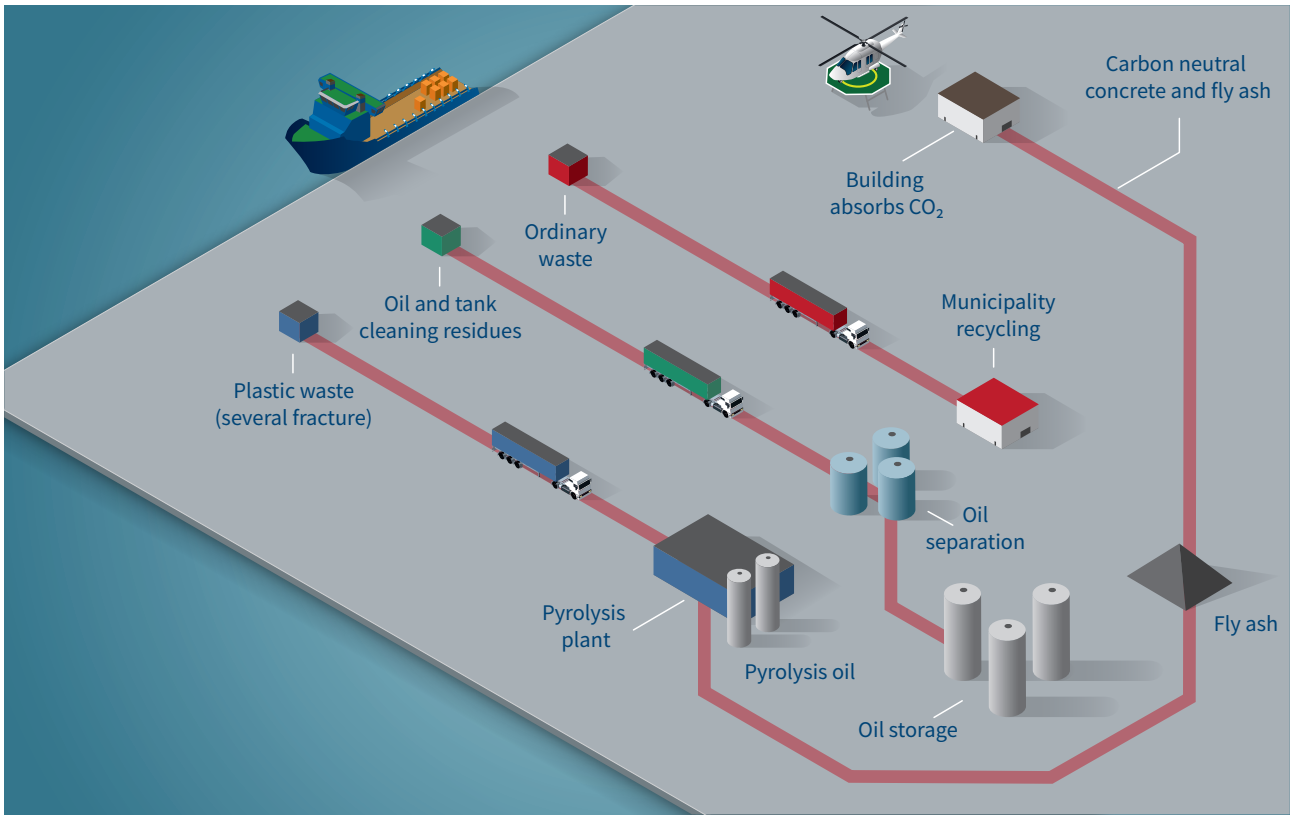
In sum, the Getting to Zero Plan aims to achieve carbon neutrality in the port based on immediate effects using green fuels and developing green energy. This methodology is the axiom for the port to integrate in the green transformation. The Green Energy Grid aims to be able to deliver green fuels to the ships in the port. This will be performed on demand, wherefore integration of port system into a Green Energy Management System is planned, as illustrated below.



TOXIC REVERSAL SYSTEM

This is a novel idea to be launched at Port Esbjerg, which aims at collocating various detoxificating systems. Under one umbrella. Through these plans, we shall show the big impact of the incremental steps that we take by realizing and integrating waste collection with future recycling and reuse. The waste from ships is segregated into solid and fluid waste streams, where the following has been performed:

- Port Fluid Waste Treatment System for reuse of fuels
- Plastic waste segregations system



PORT SOCIETAL SYSTEMS

This concept behind the port societal system is to create platforms that will allow better informed decisions to the benefit of the green transition. This requires collaboration between the various parties and in this context minimizing carbon footprint is considered by ensuring that cargo is transported to the port in the most carbon-friendly way available. And resources are shared were beneficial.

Cargo departing Port Esbjerg is destined to all over the world, but is mostly arriving from Europe via ship, rail or road, and to select the route that contributes least carbon emission requires simulation of available routes. This is performed with the Trimodal Simulator being developed. This allows freight forwarders to report that the most beneficial route has been considered and thereby to achieve rebate on the cargo dues.

The other societal system is the Portal Port Esbjerg, which was developed to create a common platform for sharing of resources. The system does this by mapping the workflows and thereby visualizes the value chain, while it allows the various parties to connect with each other and thereby obtain synergies, when resources are shared.

PORT ESBJERG
Hulvejen 1 · DK-6700 Esbjerg
Phone +45 76 12 40 00
adm@portesbjerg.dk · www.portesbjerg.dk

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