Ports Energy and Carbon Savings

Output 4

Decision making tool to select the best mix of low carbon options

Project No. 2S03-009

With the financial support of

Author

NAME [USE TABLE-TITLE]	ORGANISATION [USE TABLE-TITLE]
Dimitar Bozalakov	Ghent University
Lieven Vandevelde	Ghent University

Revision history

REVISION	DATE	AUTHOR	ORGANISATION	DESCRIPTION

Table of contents

Table of figures

Table of figures

No table of figures entries found.

1. Introduction

In this report, a summary of the optimisation tools and method that are developed within PECS project are given. The tool uses as a stepping stone the merit-order principle to rank the energy sources by their electricity cost. The same approach is used to rank the carbon intensity of the low carbon technologies. These data are then used by the cost function of the optimisation tool. The user must enter data in four fields in order for the decision making tool to generate correct outputs. These data are annual energy consumption, electricity cost, desired energy bill reduction and finally available surface for low carbon technologies. Based on this information an optimisation is performed and the output results consists of multiple choices. The user chooses which solution suits his port or marina best, based on the capital expenditure of the plants, electricity bill reduction, return of investment and finally the carbon savings. Finally, the conclusions are drawn in the last section.

2. Description of the general method

In this section, a short summary of the used deliverables, that are an outcome of PECS project is made. The reader is invited to read the full deliverable versions if any further data are needed.

2.1. D1.7.3 and D1.7.4 Optimisation tool and report decision making & energy management

In this report, a detailed description of the developed tool for selecting a mix of green technologies is given. Step-by-step instructions of how to set-up the tool in excels are provided. The purpose of this tool is to give a preliminary results of the potential of carbon savings in the ports of the 2 seas region. Because of the technology development, the cost, system performance and efficiency will vary over the time, which will make the proposed tool less accurate if left with the default values. It also considers only technologies that have high mature level. Innovative technologies or ones with low technology readiness level are disregarded.

2.2. D.1.8.1 Reports about the optimum mix of low carbon options in ports

Deliverable 1.8.1 gives a partner by partner description of the achieved energy cost and carbon savings reduction after performing an optimization by the decision making tool. From the obtained data it was clear that the foreseen surface area was more than enough to achieve the desired energy cost reduction, which was typically between 6 to 20%. An exception is the case of OD Ijmond and its developed LEM platform where a reduction of 122% was achieved. However, the business case for the LEM platform is somehow different from the other ports and marinas participating in the PECS project. This is because of the availability of the rooftop areas of the different users and the main goal of the platform, which is to participate on the energy market. Overall, the results differ from use case to use case.

2.3. D.1.8.2 - Report about the comparison between partners ports regarding the best mix of low carbon options

This deliverable lists the low carbon technologies that ports and marinas can select to achieve their desired energy cost and/or carbon saving reductions. These technologies are predetermined by D 1.7.1 and later embedded in the decision making tool. In addition to that, a short description and these technologies is given as well the motivation of including them in the decision making tool. These deliverable also summarises the results of the ports and marinas that are part of PECS's consortium.

2.4. Improved method and calculation tools to select the best mix of low carbon options in SMS ports

In this report, a description of the optimisation method that is used in the decision making tool is given. The tool uses as a stepping stone the merit-order principle for ranking the energy sources by their electricity cost. The same approach is used to rank the carbon intensity of the low carbon technologies. These data are then used by the cost function of the optimisation tool. The user must enter data in four fields in order for the decision making tool to generate correct outputs. These data are annual energy consumption, electricity cost, desired energy bill reduction and finally available surface for low carbon technologies. Based on this information an optimisation is performed and the output results consists of multiple choices. The user chooses which solution suits his port or marina best, based on the capital expenditure of the plants, electricity bill reduction, return of investment and finally the carbon savings. Some possible future improvements is also included in this report, where features like incorporating existing renewable plants and low carbon technologies, considering photovoltaic thermal and solar thermal technologies and social economic indices are recommended.

3. Results of Output 4

In this section, the main results of the optimisation numbers are presented and further analysed. All results are presented on a pilot by pilot case. Furthermore, different key-performance indicators are considered and examined in detail. In total, 5 key-performance indicators are presented, namely Annual energy reduction, Annual cost reduction, Capital expenditure, Return of investment and finally Carbon reduction. All of these categories are further segregated down to individual technology combinations like PVT1 to PVT4 and medium sized wind turbines. More details of the exact technologies behind these abbreviations will be given later on in the report. All results are presented by using bar plots and a side by side comparison between the different pilots can be made. In all pilots except OD Ijmond and Helevoetsluis, there is a combination between solar and wind technologies. The pilot of OD Jimond is based on the LEM platform and it mainly relies on PV technologies. As of the pilot of Helevoetsluis, the medium sized turbines have some negative impacts such as increased noise levels and visual impact, hence the reason of omitting this option.

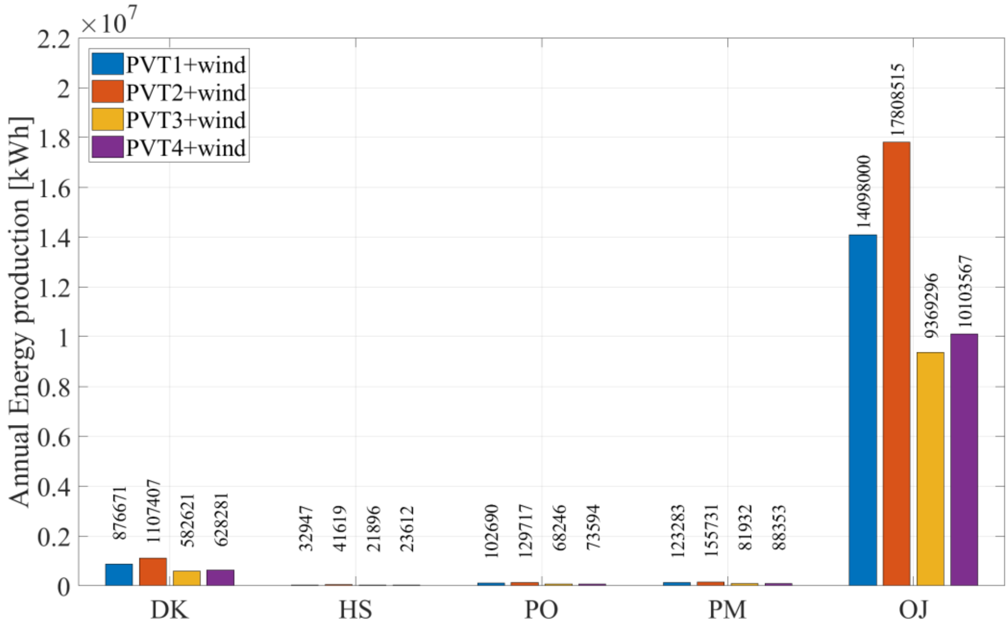

FIGURE 1 ANNUAL ENERGY PRODUCTION OF THE DIFFERENT PHOTOVOLTAIC TECHNOLOGIES AND THEIR COMBINATIONS WITH WIND (DK-DUNKIRK, HS- HELLEVOET SLUIS, PO- PORT OF OSTEND, PM-PORT OF PORTSMOUTH, OD- JIMOND)

In Figure 1, the annual energy reductions of the different pilots are presented. Polycrystalline photovoltaic technology is called PVT1, PVT2 is the monocrystalline variant of the solar panels. PVT3 and PVT4 are Cadmium-Tellurium and Copper-Indium0-Selenium technologies, respectively.

Since the scale of the pilots differs dramatically, the exact numbers are also added on top of each bar that corresponds to an individual technology combination. By looking at the presented data, it can be seen that among all combinations of low carbon technologies, PVT2 gives the greatest annual production reduction. This comes from the fact that this technology is the most efficient one. It is followed by the PVT2, PVT4 and last PVT3. Although the scale of the pilots is different, this trend is observed in all pilot cases.

The annual cost reduction is presented in Figure 2. It is a function of the energy cost per kWh of the different pilots and it depends from a pilot to pilot. More information about the cost of each pilot can be found in *D1.8.1Reports about the optimum mix of low carbon options in ports*. In all pilots, regardless of the power consumption of the pilot, it is obvious that PVT2 provides the highest cost reduction. The same trend is occurring in these data as of in Figure 1. The reason for this trend is again related to the efficiency of each technology. Higher efficiency yields higher power and energy output, which is able to greatly reduce the annual cost.

CAPEX is another important aspect of any investment in renewable technologies. The results regarding the capital expenditure are presented in Figure 3. Due to the different scale of the pilots and the potential for installing low carbon technologies, the CAPEX varies significantly. The largest CAPEX's are observed in the case of OD-Ijmond for all low carbon technologies and the lowest in the case of Helevoetsluis. Despite these variations, the a similar trend to Figure 1 and Figure 2 is observed as well. Investment in PVT2 relates to the highest CAPEX of all, followed by PVT1, PVT4 and finally PVT3. The manufacturing process of the monocrystalline PV panels is very energy intensive, hence the higher cost is higher.

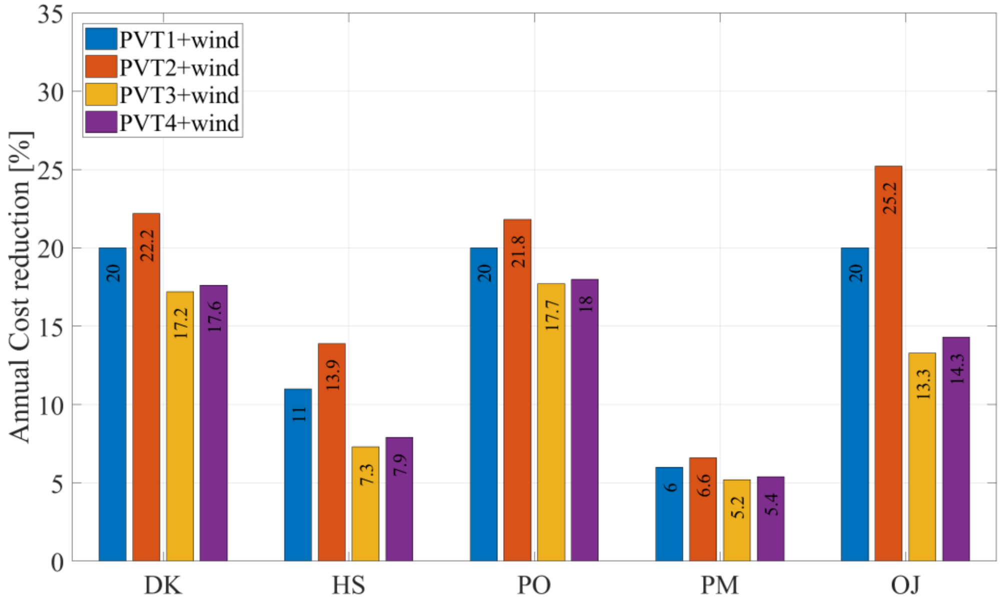

FIGURE 2 ANNUAL COST REDUCTION OF THE DIFFERENT PHOTOVOLTAIC TECHNOLOGIES AND THEIR COMBINATIONS WITH WIND (DK-DUNKIRK, HS- HELLEVOET SLUIS, PO- PORT OF OSTEND, PM-PORT OF PORTSMOUTH, OD - JIMOND)

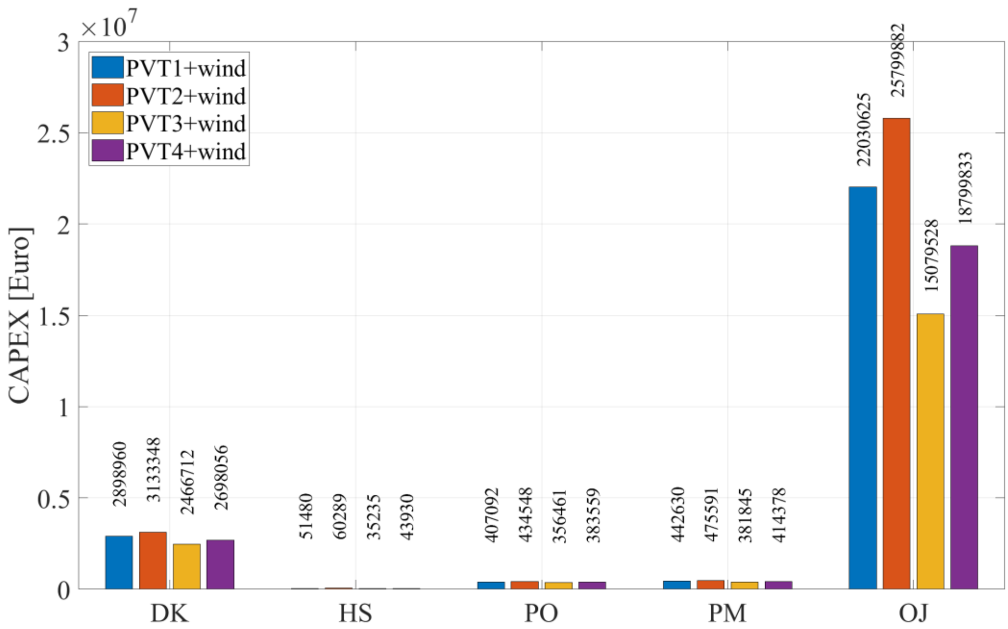

FIGURE 3 CAPITAL EXPENDITURE OF THE DIFFERENT PHOTOVOLTAIC TECHNOLOGIES AND THEIR COMBINATIONS WITH WIND (DK-DUNKIRK, HS- HELLEVOET SLUIS, PO- PORT OF OSTEND, PM-PORT OF PORTSMOUTH, OD - JIMOND)

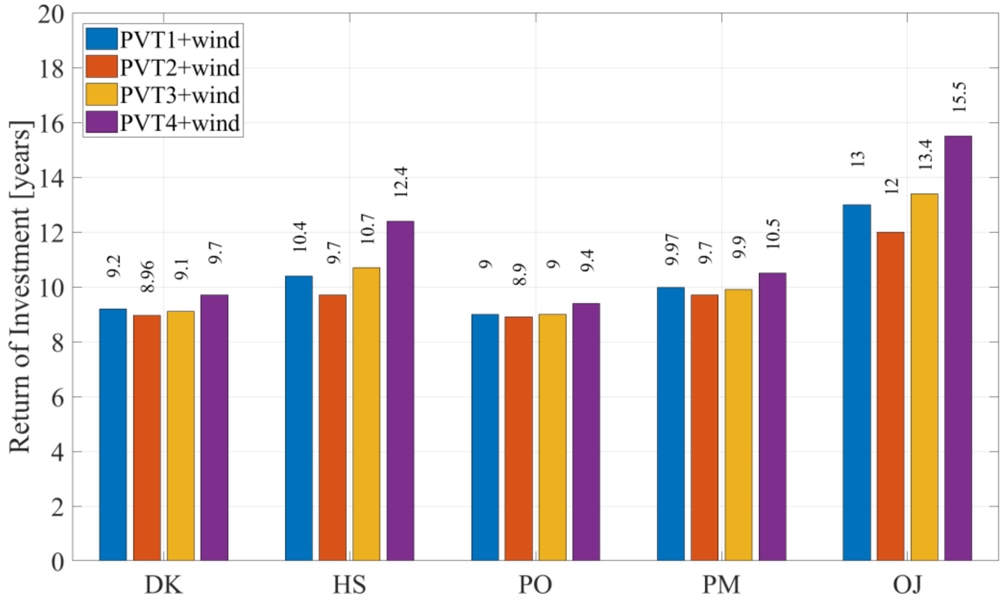

FIGURE 4 RETURN OF INVESTMENTS OF THE DIFFERENT PHOTOVOLTAIC TECHNOLOGIES AND THEIR COMBINATIONS WITH WIND (DK-DUNKIRK, HS- HELLEVOET SLUIS, PO- PORT OF OSTEND, PM-PORT OF PORTSMOUTH, OD - JIMOND)

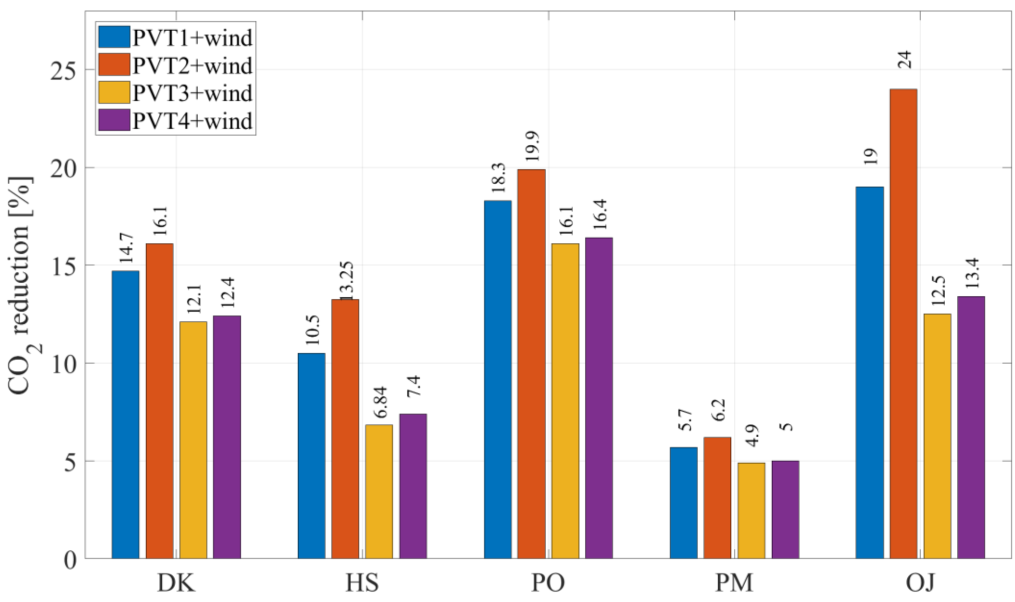

FIGURE 5 CO_2 REDUCTION WHEN DIFFERENT PHOTOVOLTAIC TECHNOLOGIES AND THEIR COMBINATIONS WITH WIND ARE USED (DK-DUNKIRK, HS- HELLEVOET SLUIS, PO- PORT OF OSTEND, PM-PORT OF PORTSMOUTH, OD - JIMOND)

By looking at Figure 4, it can be seen that the return of investment varies between the pilot partners and it is dependent of the scale of the renewable energy plant size. Overall, return of investment is in between 9 to 12 years after the installation but it is faster for PVT2 compared to the other technologies.

As of the carbon reduction, all ports manage to reduce their carbon emissions at a different level depending on the scale of the installed low carbon technologies related to their electricity consumption from the national energy mix of the respective country. The results of the carbon reduction are presented in Figure 5 in percent (relative values).

The PECS pilot consortium is very diverse and use case scenarios are very different. The small marinas have different requirements and priorities compared to small and medium sized ports. Due to their small energy consumption, they can reach net carbon neutrality very easily only with one carbon saving technology. Big and medium sized ports like Portsmouth and Port of Ostend, must use at least two low carbon technologies in order to achieve significant reduction of the their energy cost and carbon emissions or eventually net carbon neutrality. Big ports like port of Dunkirk will need more than two technologies to reach net carbon neutrality. Besides the used carbon saving technologies suggested by the optimisation tool, other non-energy production technologies like heating and cooling, lighting, active demand side management, etc. could help to achieve significant carbon reductions and potentially net carbon neutrality.

4. Conclusions

In summary, the integration of the proposed PV and WT technologies is able to reach the desired energy reduction set by the ports. The user is offered four options different PV technologies in combination with the wind turbines. If the user does not need solar or wind energy it simply places zero available surface for this technology. The tool is based on the economic aspects of the low carbon technologies, but the environmental aspect is also concerned in the second part of the Solution section of the tool. With the tool developed in the framework of PECS, the user is guided to make the best possible decision to invest in low carbon technologies and to apprehend the significance of incorporating these technologies in the future development of the ports and marinas.

5. References

[1] Dimitar Bozalakov, Lieven Vandevelde, “D 1.7.1 - Report on decision making tools,” Report, Ghent, 2019.

[2] Dimitar Bozalakov, Lieven Vandevelde, “D 1.7.4 - Optimisation tool and report decision making & energy management,” Report, Ghent, 2019.

[3] Dimitar Bozalakov, Lieven Vandevelde, “D1.8.1-Reports about the optimum mix of low carbon options in ports,” Report, Gent, 2021.

[4] Dimitar Bozalakov, Lieven Vandevelde, “D 1.8.2 - Report about the comparison between partners ports regarding the best mix of low carbon options,” Report, Ghent, 2021.

[5] Dimitar Bozalakov, Lieven Vandevelde, “Improved method and calculation tools to select the best mix of low carbon options in SMS ports,” Report, Ghent, 2021.