D.7.2. Viability and sensitivity studies on FLOTANT solutions

The University of Edinburgh (UEDIN)

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FLOTANT -Innovative, low cost, low weight and safe floating wind technology optimized for deep water wind sites, has received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreement No.815289

[D7.2: Viability and sensitivity studies on FLOTANT solutions]
Project Acronym: FLOTANT Project Title: Innovative, low cost, low weight and safe floating wind technology optimized for deep water wind sites (FLOTANT). Project Coordinators: Octavio Llinás & Ayoze Castro – The Oceanic Platform of the Canary Islands (PLOCAN) Programme: H2020-LC-SC3-2018 Topic: Developing solutions to reduce the cost and increase performance of renewable technologies Instrument: Research & Innovation Action (RIA)
Deliverable Code: 220531-FLT-D7.2_Viability_v01 Due date: 31/05/2022

DISSEMINATION LEVEL	
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DOCUMENT HISTORY		
Edit./Rev.	Date	Name
Prepared	04/02/2022	Anna Garcia-Teruel (UEDIN)
Checked	17/02/2022	Donald R Noble, PuiWah Wong (UEDIN)
Approved	31/05/2022	Sara Muñoz (COBRA), Alejandro Romero-Filgueira (PLOCAN)

DOCUMENT CHANGES RECORD			
Edit./Rev.	Date	Chapters	Reason for change
UEDIN/01	04/02/2022	Whole Document	Original Version

DISTRIBUTION LIST		
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Acknowledgements

Funding for the FLOTANT project (Grant Agreement No. 815289) was received from the EU Commission as part of the H2020 research and Innovation Programme.

The help and support, in preparing the proposal and executing the project, of the partner institutions is also acknowledged: Plataforma Oceánica de Canarias (ES), The University of Exeter (UK),The University of Edinburgh (UK), AIMPLAS-Asociación de Investigación Materiales Plásticos y Conexas (ES), Rheinisch-Westfaelische Technische Hochschule Aachen (DE), Stichting Maritiem Research Instituut Nederland (NL), Technology From Ideas Limited (IE), Esteyco SA (ES), Innosea (FR), Inea Informatizacija Energetika Avtomatizacija DOO (SI), Transmission Excellence Ltd (UK), Hydro Bond Engineering Limited (UK), FULGOR S.A., Hellenic Cables Industry (EL), Adria Winch DOO (HR), Future Fibres (ES), Cobra Instalaciones y Servicios S.A (ES), Bureau Veritas Marine & Offshore Registre International de Classification de Navires et eePlateformes Offshore (FR).

Abstract

The purpose of this document is to provide techno-economic viability indicators for potential deployments of the FLOTANT technology and perform a sensitivity study of key input parameters used in the techno-economic model. The cost estimates of the FLOTANT deployments and their sensitivity to changes in input parameters are used to assess the viability of potential projects. The considered indicators include: the Levelised Cost of Energy, the Cost of Energy, the Net Present Value, and the Internal Rate of Return. These are calculated for pilot park (60MW) and wind farm (600MW) deployments in Gran Canaria and West of Barra. Analysing the identified key techno-economic indicators taking account of the current cost of electricity in the Canary Islands and the maximum market price set within the fourth round of Contracts for Difference (CfD) for floating offshore wind in the UK, shows that the studied FLOTANT deployments would be viable at all scales at both locations. For the 600MW deployments, this is also true even in the most pessimistic scenario considered in the sensitivity study.

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1 Introduction

This document is issued as part of the work led by the University of Edinburgh (UEDIN) in task 7.1 on 'Cost reduction assessment and LCoE' together with D7.1 'LCOE Techno-economic assessment'[1].

Within the FLOTANT project various innovations in the moorings, cables and platform of a Floating Offshore Wind (FOW) system are investigated, to achieve an innovative, low cost, low weight and safe floating wind technology optimised for deep water sites. This report builds on the results presented in D7.1, where the techno-economic model for the FLOTANT system, and the results quantifying the expected Levelised Cost of Energy (LCoE) were introduced, by performing a sensitivity study around some of the key parameters with an impact on LCoE, and providing other economic indicators, such as the Net Present Value (NPV) and the Internal Rate of Return (IRR) to be able to assess the viability of potential projects. Additionally, a nearer term business case is studied for a medium-sized deployment of 240MW south-east of Gran Canaria.

This work has been undertaken using an economic model developed by the University of Edinburgh (UEDIN), which will be referred to as the FLOTANT Cost model, building on experience developed through UEDIN's work on previous projects.

1.1 Purpose of this report

The objective of this report is to assess more specific advantages and disadvantages of the FLOTANT solutions, based on a more detailed study of the sensitivity of the obtained LCoE estimates, as well as through a viability study considering other techno-economic assessment metrics to evaluate potential project profitability. For these purposes, the obtained results of the expected LCoE, Net Present Value (NPV) and Internal Rate of Return (IRR) for a pilot park and commercial wind farm deployments in the studied locations of West of Barra and Gran Canaria is provided. Additionally, a sensitivity study considering key input parameters of the Cost model developed to assess the FLOTANT technology is performed for the commercial deployment case studies in West of Barra and Gran Canaria. Finally, the Cost model is applied to assess the viability of a medium-sized deployment in Gran Canaria representing a realistic business case.

1.2 Description of work and role of each partner

The work on this report was led by UEDIN with inputs from all partners on the component costs. COBRA provided the model parameters to be investigated in the sensitivity study, as well as the medium-sized deployment case study considered to be realistic in the near future, which is used as a business case.

1.3 Contents

The contents of the present report are organised as follows: **Section 2** presents the current state of the art in floating offshore wind cost assessment and the prevailing assumptions. **Section 3** introduces the method and metrics used to calculate the viability of FLOTANT system deployments. **Section 4** introduces the case studies and assumptions used for the FLOTANT system analysis. **Section 5** shows the obtained results for the viability and sensitivity studies. **Section 6** summarises the results and the main conclusions from this study.

2 Background

Different technologies for Floating Offshore Wind (FOW) systems have been developed and multiple studies exist that aim at comparing the techno-economic advantages and disadvantages of each technology. The aim of these studies is mainly to compare and assess the potential for cost reduction of the different FOW technologies.

A range of cost models to evaluate the economic feasibility of offshore wind projects have been developed in the past decade. They commonly reflect the costs associated to the whole life-cycle of an offshore wind project. This is divided into five phases represented in Figure 1: Development and Consenting (D&C), Production and Acquisition (P&A), Installation and Commissioning (I&C), Operation and Maintenance (O&M) and Decommissioning and Disposal (D&D). Specific costs that have been considered in literature within each of these phases are provided as examples in the figure. This structure has been used for both the Bottom-Fixed Offshore Wind (BFOW) and FOW project analysis. In the production and acquisition phase, costs of all system components are considered separately, which will be different for BFOW and FOW. The main difference will lie in the costs associated with the foundation in BFOW which are often split into the platform, mooring and anchoring systems for FOW projects.

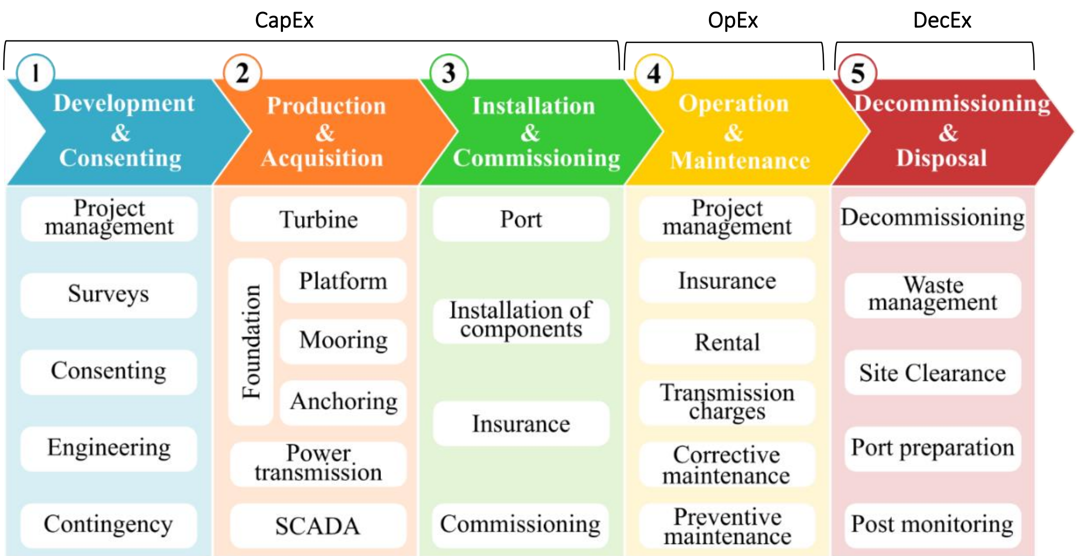

Figure 1: Project phases considered in a Life Cycle Cost Assessment (LCCA) of offshore wind projects [2], with example cost centres.

Capital Expenditures (CapEx) are considered as all expenses incurred in phases 1-3, whereas Operational Expenditures (OpEx) will encompass all expenses associated to phase 4. Decommissioning Expenditures (DecEx) include all expenses occurring in phase 5. Annual Energy Production (AEP) is calculated based on the turbines power curve and a wind speed occurrence distribution, as specified in IEC standard 61400-12-1 [3]. The Capacity Factor (CF) can be calculated from this, which indicates the percentage of power absorbed from the total rated power. To obtain the net AEP, turbine availability and losses need to be additionally considered.

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2.1 Techno-economic viability indicators

The Levelised Cost of Energy (LCoE) is a measure commonly used to compare energy generating technologies, which represents the ratio of the costs incurred over the lifetime of a project in relation to the total energy produced over the operational life. The Levelised Cost of Energy (LCoE) is calculated as shown in equation (1). The Present Value (PV) of the total costs and the energy production (EP) over the lifetime of the project are taken into account. The costs are divided into Capital Expenditures (CapEx), Operational Expenditures (OpEx) and Decommissioning Expenditures (DecEx). The calculation of the PV follows equation (2) where r is the discount rate, n the lifetime in years and t the year in which the expense occurs.

$$\mathrm{LCoE} = \frac{\mathrm{PV(CapEx + OpEx + DecEx)}}{\mathrm{PV(EP)}} \tag{1}$$

$$\mathrm{PV}(x) = \sum_{t=0}^{n} \frac{x_t}{(1+r)^t} \tag{2}$$

The current LCoE for FOW has been assessed to be around 200 €/MWh, and a cost reduction achieving LCoE values of 82 to 106 €/MWh for commercial technologies is envisaged [4]. Recently, developers have been predicting cost reductions of their technologies achieving an LCoE of 60 €/MWh by 2030 [5]. This wide range of the expected cost reductions stems from the different assumptions used in the different studies, such as the capacity and lifetime of the systems or the number of deployed turbines, but also the way in which costs are split between subsystems. A review and discussion of the different studies and assumptions was provided in a FLOTANT preliminary study [6].

The LCoE of 600MW deployments of FLOTANT technology by 2030 was estimated to be between 73.05 and 92.99 €/MWh in D7.1 [1]. In that deliverable, it was therefore shown that the cost reduction targets as set-out in the Grant Agreement were achieved. These are in line with the SET-Plan targets for deep water deployments of 90 €/MWh by 2030 [7], which have been recently updated to a range of 62-106 €/MWh by 2030 [8], and seem to be a reasonable expectation within the cost range estimated in the literature.

As previously discussed in FLOTANT preliminary studies [6], [9] and in the literature [10], additional metrics can be used to assess the viability of renewable energy projects.

1. *Cost of Energy (CoE)* is calculated as the LCoE but without accounting for any type of discounting, and so is equivalent to considering a 0% discount rate. As shown in [2], the discount rate and investment schedule (i.e. when each of the costs occur) are highly project dependent and have a large impact on the final cost estimates. A definition of a 'risk levy' associated to different floating offshore wind technologies represented within the discount rate is also subject to large uncertainties. Including discounting might, therefore, introduce additional unnecessary uncertainty when comparing the suitability of different technologies (rather than projects).

2. *Net Present Value (NPV)* of all cash flows considers the sale of produced electricity at the market price. The NPV value represents the profitability of a project, where a positive value means the project is profitable. It is understood as the equivalent of the PV when taking into account both:

inflows – such as the revenue from selling the generated electricity, and outflows – such as all of the costs considered in the PV calculation.

$$NPV(x) = \sum_{t=0}^{n} \frac{Cash\ flows_t}{(1+r)^t} \quad (3)$$

3. *Internal Rate of Return (IRR)* is a measure of project profitability. It is defined as the discount rate that makes the NPV of all cash flows equal to zero. IRR is calculated in an iterative process that approximates equation (4).

$$NPV(x) = \sum_{t=0}^{n} \frac{Cash\ flows_t}{(1+\mathrm{IRR})^t} = 0 \quad (4)$$

In summary, the NPV and IRR measures complement the LCoE values by providing additional insights into project profitability. The CoE helps to provide increased transparency in the obtained cost values. It may be more suitable when comparing innovative technologies with the goal of selecting the best designs, rather than when comparing different possible project deployments of a specific technology.

3 Method

To analyse the viability of FLOTANT technology deployments, a Life Cycle Cost Assessment was performed. A Cost model was implemented in Python based on equations (1) – (4), where cost contributions over the whole lifecycle of the project as shown in Figure 1 were considered.

To perform this analysis, inputs from other partners and WPs were used. For instance, net Annual Energy Production is obtained with the help of the O&M model developed by the University of Exeter (UNEXE) and described in D6.4 [11]. Farm availability is an output of that model, and it accounts for downtime due to faults and repair options depending on weather windows. The O&M costs provided by the model only consider corrective maintenance costs (i.e. they do not consider planned maintenance, or other fixed O&M costs). To avoid underestimating the O&M costs impacts, an assumption based on COBRA's experience was used for the overall OpEx. Additionally, Transmission Excellence (TX) developed an inter-array* cable layout optimiser within the project [12] to provide improved estimates of the required balance of plant components. An overview of the used inputs and the interactions with the O&M model and the inter-array cable layout optimiser is provided in Figure 2. Components costs are provided by all partners for their respective components. Other project costs, for example, development and installation costs, are provided by COBRA for the FLOTANT project. The models are described in further detail in D7.1[1].

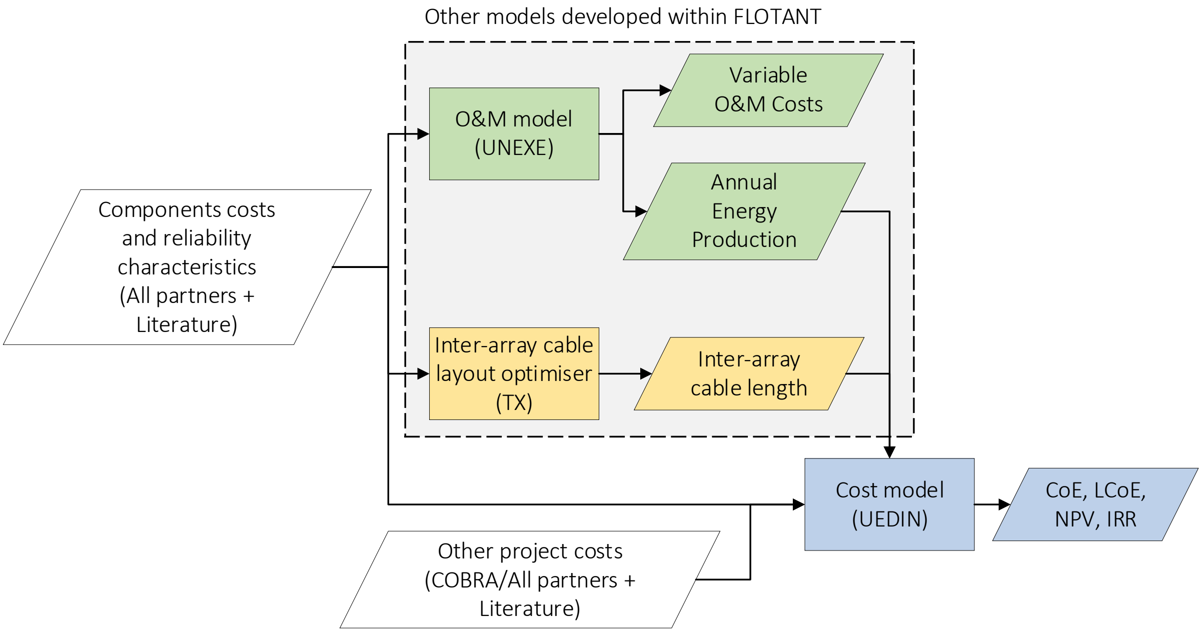

Figure 2: Overview of cost model inputs and interactions with other models developed by FLOTANT partners.

The techno-economic viability indicators are calculated based on equations (1) to (4). The IRR is obtained with the corresponding function ('irr') available in the 'numpy' package [13]. Further considerations not represented through these equations, include: 1) the representation of the annual

* Inter-array cables refer to those between turbines within the array, also termed intra-array cables.

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degradation of the energy production, which has been estimated to have a significant impact on LCoE [14]; and 2) the consideration of nominal prices.

All calculations are performed in terms of nominal prices, which are the actual prices paid when purchasing goods, as opposed to the real prices where the impact of inflation is removed. A nominal prices approach is used here because these are easier to interpret, and this is the common approach used in the industry. This only means that the nominal WACC ($\mathbf{WACC_{nominal}}$) is used in combination with nominal prices. That is, inflation is considered on all costs and production occurring after year 0 through the inflation rate $\boldsymbol{i}$. The resulting LCoE value is the same, as when applying a real WACC ($\mathbf{WACC_{real}}$) value, calculated from the nominal WACC value according to the Fisher's rule represented in equation (5), and not applying inflation on the costs and production occurring after year 0. The WACC is calculated from the weighted average cost of debt and equity after taxes.

$$\mathrm{WACC_{real}} = \frac{1 + \mathrm{WACC_{nominal}}}{1 + i} \tag{5}$$

4 Case studies and assumptions

4.1 Case studies

The FLOTANT technologies have been developed considering two potential deployment sites that represent the two different ends of the range of expected deployment conditions the technologies should be suitable for, i.e the Canary Islands (South-East of Gran Canaria) and Scotland (West of Barra) The main characteristics of these two sites and the corresponding design characteristics of the FLOTANT technology are summarised in Table 1.

Table 1: Overview of site details and main characteristics of the case studies.

Location	Canary Islands – South East of Gran Canaria	Scotland – West of Barra
Electricity price [€/MWh]	124.08 [15]	65.25 [16]
Water depth [m]	250	100
Distance to connection point [km]	10	19
Distance to O&M port [km]	17.7	19
Soil type	Mainly sand	Rock soil (basalt)
FLOTANT design characteristics		
Mooring	4 lines - Mooring spring + fibre rope + chain	5 lines - Mooring spring + mooring chain
Anchors	4 Deadweight anchors (2429t per anchor)	5 Deadweight anchors (5095t per anchor)
Cables	Al core + carbon fibre armour	Al core + galvanised steel double armour
Cost of fabricated steel [€/m^3]	5000-8000	6000-9500
Cost of fabricated concrete [€/m^3]	500-600	600-700

Two points along the technology development path are considered: a pilot park deployment (5×12MW) and a large farm (50×12MW) deployment. This allows to consider learning effects in the cost estimates along these development stages. For context, to align the technology development stages with a realistic timeframe, the pilot park deployment is assumed to take place by 2025 and the first commercial deployment by 2030. Given the lead times for the development and deployment of an offshore wind project of 5 to 10 years, this is considered a reasonable assumption. As in D7.1 [1], it is, assumed that costs provided by the partners represent the costs of the components today, and that sustained cost reductions take place until 2030. An additional case considering the cost of the technology after the first commercial-farm deployment (Commercial wind farm (II)) is also reported. An overview of the considered development stages is provided in Table 2.

Table 2: Considered development stages.

Development stage	Year	Number of turbines	Total capacity [MW]	Previously installed capacity [MW]
Pilot park	2025	5	60	12
Commercial wind farm (I)	2030	50	600	60
Commercial wind farm (II)	After 2030	50	600	660

4.2 Sensitivity study parameters

A number of parameters are identified to have an impact on the techno-economic assessment results, where a sensitivity study is required, and are listed in Table 3. Baseline values highlighted in grey are used for the calculation of the viability indicators. For the sensitivity study, the baseline values are used, and only one parameter value is changed at a time.

Table 3: Input parameter values considered for the sensitivity study. The baseline case parameter values are highlighted in grey.

Parameter	Values considered in sensitivity study					
$WACC_{nominal}$ [%]	4	6	8	10	12	
Inflation rate [%]			1	2	3	
Operational time [years]			20	25	27	30
Annual degradation [%]			0	0.50	0.65	0.80
DecEx [% of CapEx]			0	3	6	10
CapEx – sensitivity around mean value [%]		-10	-5	0	5	10
AEP– sensitivity around mean value [%]			-5	0	5	
OpEx– sensitivity around mean value [%]			-5	0	5	

Additionally, pessimistic and optimistic cases are represented to assess the full range of possible outcomes. Four cases are considered in total, cases representing pessimistic (-) and optimistic (+) assumptions in the CapEx and OpEx assumptions only, and cases representing pessimistic (- -) and optimistic (++) assumptions across all parameters considered for the sensitivity study, as summarised in Table 4. The combination of parameter values was defined by COBRA.

Table 4: Combination of input parameter values used to represent pessimistic and optimistic cases. The baseline case parameter values are highlighted in grey.

	Pessimistic		Optimistic	
Parameters	(- -)	(-)	(+)	(++)
$WACC_{nominal}$ [%]	12	10	10	4
Inflation rate [%]	3	2	2	1
Operational time [years]	20	25	25	30
Annual degradation [%]	0.80	0.50	0.50	0.50
DecEx [% of CapEx]	10	3	3	0
CapEx – sensitivity around mean value [%]	10	5	-5	-10
AEP– sensitivity around mean value [%]	5	0	0	-5
OpEx– sensitivity around mean value [%]	5	5	-5	-5

Overall, based on the input parameter values defined above and considering the optimistic and pessimistic cases, a total of 35 cases were considered for the sensitivity study.

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4.3 Business case

As mentioned before, a medium-sized deployment of 240MW in the Gran Canaria site is considered as a near-future realistic business case. The design and technology characteristics of this case agree with those used in D7.1 [1] and are summarised in Table 1. The availability values obtained for the 60MW and the 600MW deployment were very similar (see Table 7 in Results section 0), and so the same availability as for the 600MW deployment is assumed here, resulting in a net capacity factor of 61.55%.

The main difference in the 240MW deployment is associated with the electrical array layout. For this purpose, an array of 20 turbines was considered. This was defined based on the 600MW array layout and using the set of turbines closest to the 'collection point'. Since the outcome of the array layout optimiser is that an offshore substation is not required, no actual collection point is considered here. However, this is defined as the point from which dynamic cables will meet and turn into static export cables that will follow a similar path to the onshore connection point. The outcome of the electrical array-layout optimiser is shown in Figure 3. A total of two cable cross-sections (CS1 and CS2) is found to be optimal within the farm, and three export cables (CS2) of 10 km each are used. The main characteristics of the electrical array layout are summarised in Table 5.

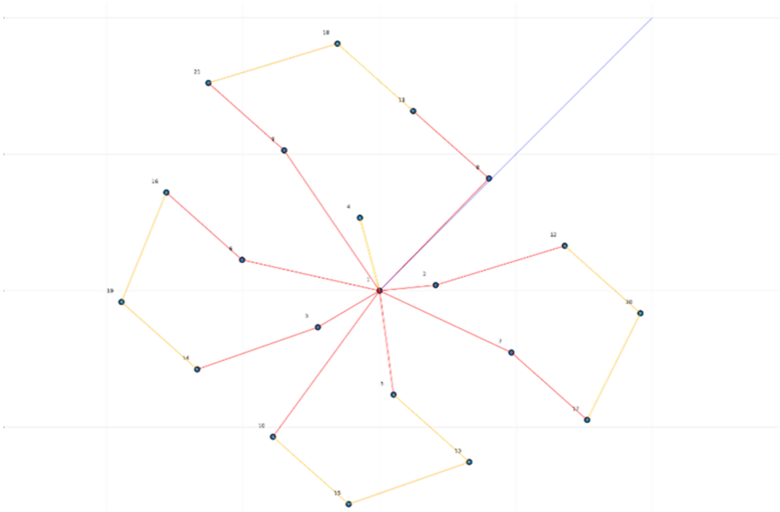

Figure 3: Optimised electrical array layout for a 240MW wind farm deployment. Cables represented in yellow have CS1, cables represented in red have CS2, and blue line represents the export cable (CS2).

Table 5: Electrical array layout characteristics for 240MW wind farm deployment.

Inter-array	
Cable CS1 [mm^2]	150
Cable CS2 [mm^2]	300
Length of CS1 [km]	8.5
Length of CS2 [km]	12.4
Total Length [km]	20.9
Number of cable ends	51
Export	
Cable CS2	300
Number of cables	3
Length of CS2 [km]	10
Total Length [km]	30

Regarding the investment timeline, the 600MW case study had been assumed to be deployed in three phases, in which the first two phases represented 240MW deployments each. The investment timeline for the 240MW case is, therefore, defined analogously to the first deployment phase of the 600MW case. This is shown in Table 6.

Table 6: Investment timeline as percentage distribution of each phase costs for the 240MW deployment case.

Phase \ Year	0	1	2	3	4-26	27	28	29
D&C	50%	30%	20%	–	–	–	–	–
P&A	–	80%	20%	–	–	–	–	–
I&C	–	40%	60%	–	–	–	–	–
O&M	–	–	–	100%	100%	100%	–	–
D&D	–	–	–	–	–	–	70%	30%

5 Results

The results obtained for the viability and sensitivity studies are presented in this section. Firstly, the techno-economic viability indicators for 60 and 600MW deployments in the two locations of Gran Canaria and West of Barra are introduced in sub-section 5.1. Secondly, the results of the sensitivity study on the obtained LCoE and NPV values for the 600MW deployments at the two locations are discussed in sub-section 5.2. Finally, the results of the techno-economic assessment of the 240MW business case in Gran Canaria are shown in sub-section 5.3.

5.1 Techno-economic viability

The obtained techno-economic viability indicators when using all the previously specified assumptions are provided for the two studied sites. An overview of the results obtained for deployments in Gran Canaria is provided in Table 7, and for West of Barra in Table 8Table 8.

Table 7: Overview of results of the techno-economic study for Gran Canaria, considering different stages of deployment.

Parameter \ Farm size		Pilot park 60 MW	Farm (I) 600 MW	Farm (II) after 660 MW
Net capacity factor	%	61.53	61.55	61.55
CapEx/MW (incl. DecEx)	k€/MW	3,955	2,936	2,480
CapEx/MW (excl. DecEx)	k€/MW	3,840	2,851	2,407
OpEx/year/MW	€/MW/year	88,000	88,000	88,000
LCoE	€/MWh	93.21	73.05	64.38
CoE	€/MWh	49.16	41.25	37.58
NPV	m€	87.89	1328.08	1553.75
IRR	%	11.84	16.45	19.31

Table 8: Overview of results of the techno-economic study for West of Barra, considering different stages of deployment.

Parameter \ Farm size		Pilot park 60 MW	Farm (I) 600 MW	Farm (II) after 660 MW
Net capacity factor	MWh	54.43	54.51	54.51
CapEx/MW (incl. DecEx)	k€/MW	4,665	3,426	2,903
CapEx/MW (excl. DecEx)	k€/MW	4,529	3,326	2,819
OpEx /year/MW	€/MW/year	88,000	88,000	88,000
LCoE	€/MWh	120.83	92.99	81.79
CoE	€/MWh	61.98	55.18	51.01
NPV	m€	-140.00	-123.19	-639.28
IRR	%	0.58	1.70	3.15

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As it can be seen from these results, and as previously discussed in D7.1 [1] the LCoE target set in the Grant Agreement of 85 to 95 €/MWh by 2030 is achieved in the studied cases at both deployment sites with the 600MW deployments.

If looking at the NPV results, positive NPV values are achieved in all cases considered for deployments in Gran Canaria, whereas negative NPV values are obtained in West of Barra. If the NPV is positive the project is economically viable and profitable. That is, based on this measure only deployments in Gran Canaria would be profitable with the considered assumptions. If looking at the IRR values, values higher than the assumed real WACC of 7.8% are obtained in Gran Canaria, but relatively low values lower than the assumed WACC are obtained in West of Barra. For the project to be profitable the IRR needs to at least be as high as the real WACC. This means, that also based on this measure only deployments in Gran Canaria would be profitable with the considered assumptions.

It should be noted, that both NPV and IRR depend on the assumed electricity price. For Gran Canaria, both the LCoE is lower and the considered average electricity price higher than in West of Barra. In Gran Canaria, the electricity price of 124.08 $€_{2019}$/MWh [15] is higher than the LCoE estimates for all development stages and, therefore, the NPV is positive in all cases. In West of Barra on the other hand, the assumed electricity price of 65.25 $€_{2019}$/MWh [16] is lower than the LCoE in all cases. For this reason the NPV is negative. This assumption was based on the prices achieved in the third CfD round in the UK for offshore wind [16]. However, for the fourth CfD round bottom-fixed offshore wind has been assigned a separate pot (Pot 3) from more innovative technologies such as floating offshore wind (Pot 2). Additionally, within Pot 2, floating offshore wind has been allocated a minimum amount of investment. Based on this, the offered market price would be higher than that achieved by bottom-fixed technologies. The NPV becomes larger than 0, when the electricity price reaches the respective LCoE values. At the time of writing the fourth CfD allocation round is ongoing, and the maximum tariff for floating offshore wind is set to 122 $£_{2012}$/MWh, approximately 165.5 $€_{2019}$/MWh. This tariff would therefore make all considered deployments of the FLOTANT technology in West of Barra viable.

In general terms, due to the relatively high electricity prices of island regions, such as the Canary Islands, a deployment in such regions or in locations of similar characteristics can be expected to be more profitable.

5.2 Sensitivity study

The sensitivity study is performed for the techno-economic indicators obtained for the commercial 600MW deployment in the two considered locations of Gran Canaria and West of Barra. The impacts on the estimated LCoE and NPV values of the variations in the input parameters as detailed in section 4.2, are shown in Figure 4 and Figure 5, respectively. The variations in input parameters are represented as percentage differences in these figures to facilitate comparison of their impacts. The impacts of the optimistic and pessimistic cases are shown as horizontal lines since multiple input parameters were varied simultaneously to simulate these cases.

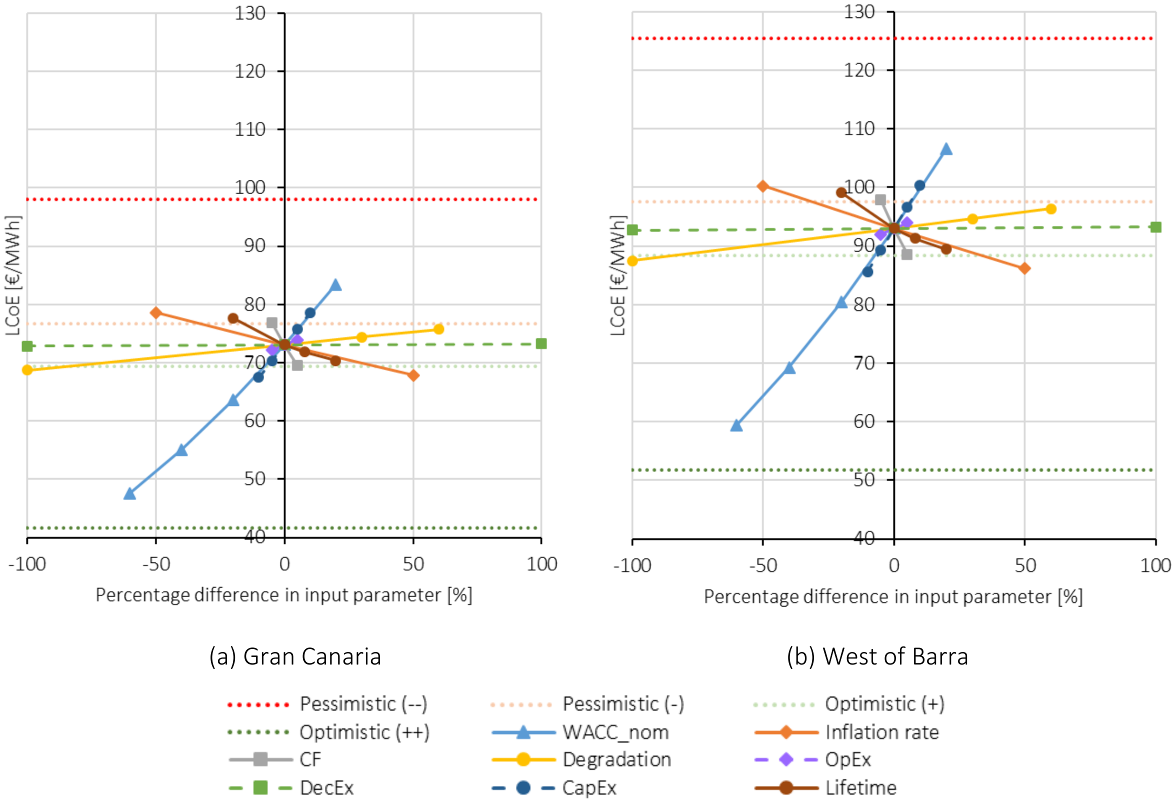

Figure 4: Sensitivity of estimated LCoE to variation in input parameters for a 600MW deployment (a) in Gran Canaria and (b) in West of Barra. Pessimistic and optimistic cases are represented as horizontal lines, since multiple input parameters were varied simultaneously in those cases.

As it can be observed from these figures, the impact of the studied input parameters to LCoE and NPV is the opposite. That is, where the increase in an input parameter results in an increase in LCoE, it results in a decrease in NPV. This is because for the same electricity price, if the cost of generation per MWh increases, the net revenue per MWh decreases.

Both LCoE and NPV are most sensitive to the nominal WACC (WACC_nom), the capacity factor (CF), and changes in overall CapEx. Changes in these parameters show the highest curve steepness. This agrees with previous results found in the literature [2], [17], where discount rate (influenced by the nominal WACC) and the energy produced (influenced by the CF) were found to have some of the largest impacts on the estimated cost indicators.

Both LCoE and NPV are least sensitive to variations in DecEx and annual degradation of the energy production. These are also the most uncertain parameters, i.e. where the largest percentage difference (±100% and -100% to +60%) in the input values was considered reasonable based on COBRA's input. DecEx has a very small contribution to LCoE and NPV, due to these expenditures occurring at the end of the project lifetime, and therefore having a comparatively low present value. The annual degradation is a very small value, with the baseline case considering 0.5% annual degradation, so that small variations in the absolute value are represented through large percentage differences. This means, however, that the impact of this input parameter is not negligible. Together with the CF it influences the total amount of energy produced, which as mentioned previously has a large impact estimated cost indicators.

For the value ranges considered to be realistic here, the largest sensitivity of the results is to the assumed nominal WACC values for both LCoE and NPV. For LCoE this is followed by the variations in CapEx. This is because CapEx investment takes place in the first years of the project where discounting has a smaller impact, and therefore these costs have a higher overall impact on the results. For NPV the nominal WACC as the most sensitive parameter. In the West of Barra case, this is followed by the variations in CapEx, whereas in the Gran Canaria case it is followed by inflation rate. The larger impact of inflation rate in the Gran Canaria case, is because this parameter affects the value of electricity sold over the farm lifetime. Electricity is sold at a higher price in the Gran Canaria case, so that the changes in absolute revenue values due to the inflation rate have a higher impact on the overall result.

Following from the discussion in the previous section on the expected cost of electricity in the two locations under study, the 600MW deployments would still be viable even in the most pessimistic case, where LCoE values of 98.1 and 125.5€/MWh would be achieved in Gran Canaria, and West of Barra, respectively.

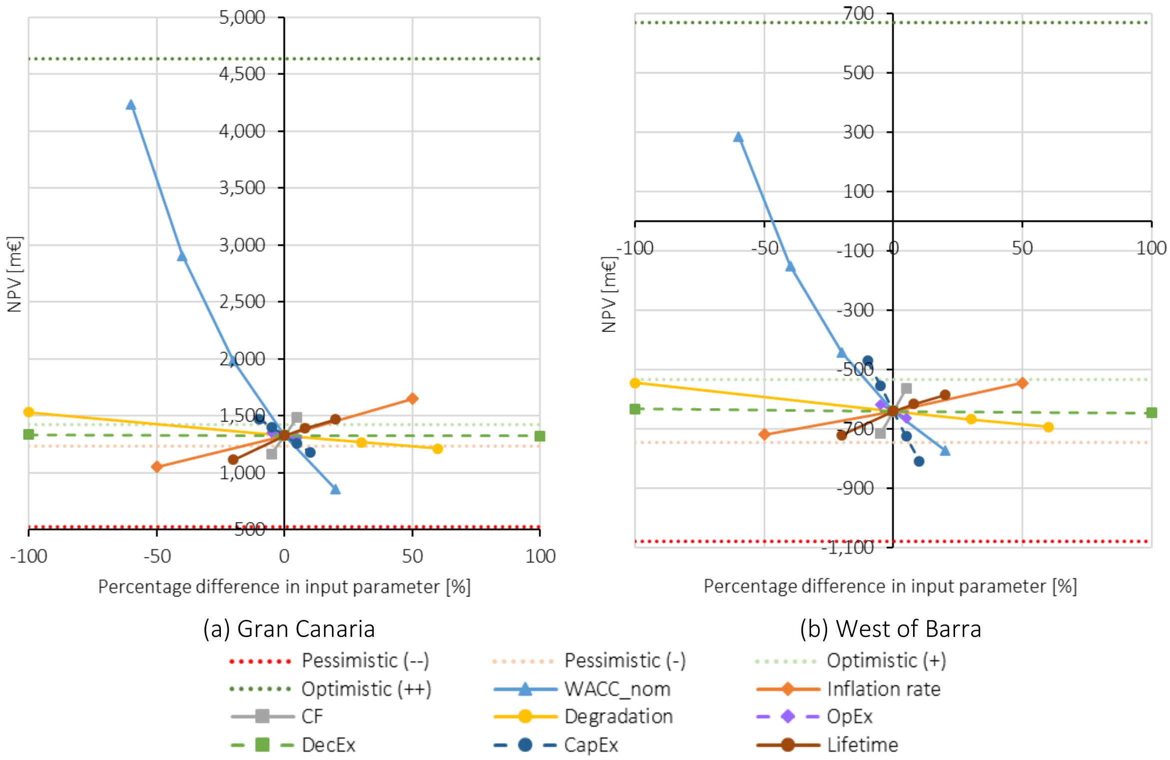

Figure 5: Sensitivity of estimated NPV to variation in input parameters for a 600MW deployment (a) in Gran Canaria and (b) in West of Barra. Pessimistic and optimistic cases are represented as horizontal lines, since multiple input parameters were varied simultaneously in those cases.

5.3 Business case

The techno-economic indicators obtained for a 240MW deployment in the Gran Canaria site are summarised in Table 9. As it can be seen from these values, LCoE, CoE and IRR, are very similar to the results obtained for a 600MW deployment in the same location. That is, the project is equally viable from a techno-economic perspective. Differences in these values stem from the difference in the power transmission infrastructure assumed to be required. The NPV representing the profitability of the

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project is about 44.2% that of the 600MW deployment. That is, a deployment of 40% of the rated capacity achieves 44.2% of the profitability, and so this smaller deployment could be overall more profitable.

The distribution of the LCoE contributions over the different project phases, as well as the distribution of the CapEx contributions across different components was discussed in detail in D7.1 [1]. An overview is provided here for context in Figure 6. As observed before, the Production and Acquisition (P&A) phase has the highest contribution to LCoE. Within that the substructure followed by the turbine have the highest cost contributions.

Table 9: Overview of results of the techno-economic viability study for Gran Canaria, considering a 240MW farm deployment.

Parameter \ Farm size		Farm 240 MW
Net capacity factor	%	61.55
CapEx/MW (incl. DecEx)	k€/MW	2940.61
CapEx/MW (excl. DecEx)	k€/MW	2854.96
OpEx/year/MW	€/MW/year	88,000
LCoE	€/MWh	72.60
CoE	€/MWh	41.04
NPV	m€	586.48
IRR	%	16.62

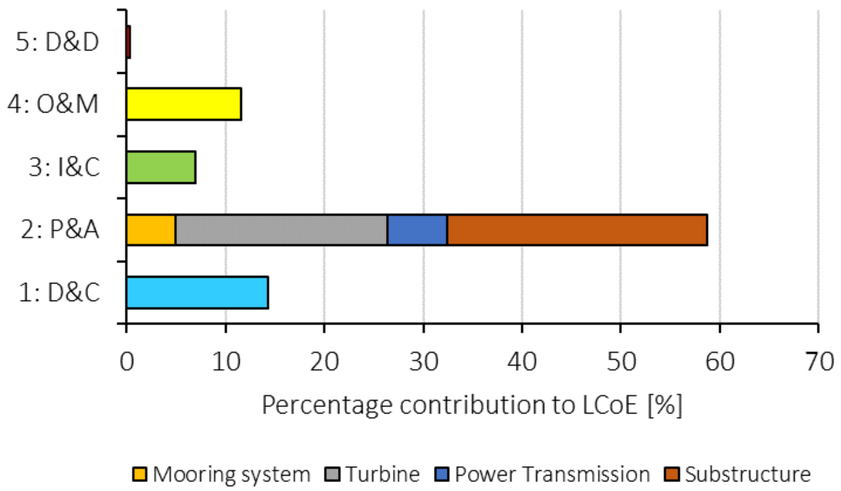

Figure 6: Contribution of different projects phases to LCoE, with further breakdown of the contribution of the main subsystems to the Production and Acquisition Phase (P&A).

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6 Conclusions

The goal of this study is to assess the FLOTANT solutions, based on a more detailed study of the sensitivity of the obtained techno-economic viability indicators. The study was performed for different deployments of the FLOTANT system, considering two different locations with different design requirements (Gran Canaria and West of Barra), as well as different scales of deployment (60MW pilot park and 600MW farm). A sensitivity study of the results obtained for the 600MW farm was performed. Analysing the identified key techno-economic indicators taking account of the current cost of electricity in the Canary Islands and the estimated market price for floating offshore wind within the fourth round of Contracts for Difference (CfD) in the UK, shows that the studied FLOTANT deployments would be viable at all scales at both locations. For the 600MW deployments, this is also true even in the most pessimistic scenario considered in the sensitivity study. A 240MW deployment in the Gran Canaria site is studied as a realistic business case, which results in a Levelised Cost of Energy (LCoE) of 72.6 €/MWh, a positive Net Present Value (NPV) and an Internal Rate of Return (IRR) of 16.62%, which is higher than the range of discount rate values considered in the sensitivity study.

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