D.9.8. FLOTANT Workshops Report

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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

[D.9.8. FLOTANT Workshops Report]

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Abstract

The purpose of this document is summarise the main findings of the workshops performed within the Floating Offshore Wind (FOW) FLOTANT project, covering good practice and the main conclusions identified. Two main workshops (WS) were organised within the project: WS1 on addressing major scientific and technical challenges in main engineering components in the FOW industry in Europe; and WS2 on addressing the techno-economic impact and Levelised Cost of Energy calculation in the FOW industry. WS1 was led by the University of Exeter, and was focused on technical requirements. WS2 was led by the University of Edinburgh and was focused on engaging with stakeholders to identify a suitable baseline to assess potential advantages and disadvantages of new floating offshore wind technologies and projects from a techno-economic perspective.

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1 Introduction

This document is issued as part of the dissemination and communication activities in the FLOTANT project in task 9.4 on 'Communication, Dissemination and Exploitation actions (interpersonal, two-way communication' led by PLOCAN.

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 summarises the main outcomes of the workshops organised as part of the dissemination and communication activities of the project.

Two high-level workshops were performed reaching out to the specialized scientific and industrial experts. Due to the COVID-19 pandemic the organisation of these as part of relevant international events was not possible or strongly constrained. For this reason, alternative communication activities were developed that would allow for fruitful discussions and review of the project results among relevant researchers and developers.

1.1 Purpose of this report

The objective of this report is to summarise the main findings of the workshops performed within the FLOTANT project, covering good practice and main conclusions identified.

1.2 Motivation

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. With these innovations a 60% CapEx reduction and 55% OpEx reduction were predicted, which result in an overall LCoE reduction of 60%, achieving an LCoE by 2030 of 85-95 **€**/MWh. At the time of proposal writing the Carbon Trust report [1] was taken as reference for assessment of these targets, and it was estimated in the techno-economic assessment study reported in D7.1 [2] that they were achieved. However, since the floating offshore wind sector is evolving very quickly, it is important to not only be able to answer if cost reductions are achieved, but also if there is a benefit in introducing the developed innovations in future FOW systems. That is, how improvements achieved with projects such as FLOTANT compare with the development likely to occur in the sector. In a first step towards answering this question, and defining a more systematic method for assessing the value innovations in commercial FOW deployments, it is key to establish a reliable and meaningful baseline, which can be used for the assessment of future projects and technologies.

There is a range of existing information that could be used to define a baseline. A number of reference cases have been defined. In IEA Task 26 [3] an offshore wind baseline was defined based on the average characteristics of projects deployed between 2012 and 2014. This was partly updated in 2018 [4], but it is based on bottom-fixed offshore wind deployments only. Reference turbines and platforms have also been developed within IEA Task 37 [5]–[7] which contain detailed information on reference designs to be used for modelling purposes. Additionally, a number of design studies (e.g. [8]–[10]) have been performed in the past for the optimisation of different components, where reference systems are defined for this purpose. Rules of thumb can be obtained from these studies, such as what is the mooring line length depending on water depth. Finally, there is available information on previous deployments, which to date involves three pre-commercial deployments in Europe (e.g. Hywind Scotland [11], Kincardine [12], or Windfloat Atlantic [13]).

Despite this wide range of information and levels of detail, there are some issues when trying to define a baseline for the assessment of innovations of floating offshore wind technologies. (1) There is not one established technology that can be taken as reference. (2) There are a wide range of assumptions in previous studies in terms of turbine rating, farm size etc. (3) There is a limited amount of historical data given the reduced number of real deployments and the fact that they are pre-commercial and therefore perhaps not representative of future deployments.

To address these issues the goal of this workshop was to engage with stakeholders to identify a suitable baseline. This could be used to assess the potential advantages and disadvantages of new floating offshore wind technologies and projects from a broad techno-economic perspective. That is, we aimed to gather opinions around the questions:

- What are the major Scientific and Technical Challenges?
- What will be considered as a reliable and meaningful comparison?
- How is that information going to be used and processed by different stakeholders?
- What type of metrics may be useful to provide and compare?
- Is there any additional type of analysis that can be performed that will be relevant to a broader range of stakeholders?

1.3 Description of work and role of each partner

The workshops reported here were led by the University of Exeter (UNEXE) and the University of Edinburgh (UEDIN). PLOCAN contributed to the identification and contact of relevant stakeholders, and managed the personal data.

1.4 Contents

The contents of the present report are organised as follows: **Part I** describes the workshop organised by the University of Exeter on addressing major scientific and technical challenges in main engineering components in the FOW industry in Europe. **Part II** describes the workshop organised by the University of Edinburgh on addressing the techno-economic impact and Levelised Cost of Energy calculation in the FOW industry.

Both parts are organised similarly. **Section 2** introduces the motivation and goal of the workshop. **Section 3** introduces the method used to perform the workshop. **Section 4** describes the main findings achieved through the workshop. **Section 5** summarises the outcomes and the main conclusions.

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Part I – WS1: Addressing major Scientific and Technical Challenges in main engineering components in the FOW Industry in Europe

2 Method

Coordination of on-line workshop about technical developments and demonstrated applications including FLOTANT Dynamic cable, the workshop included the design and test of power cable.

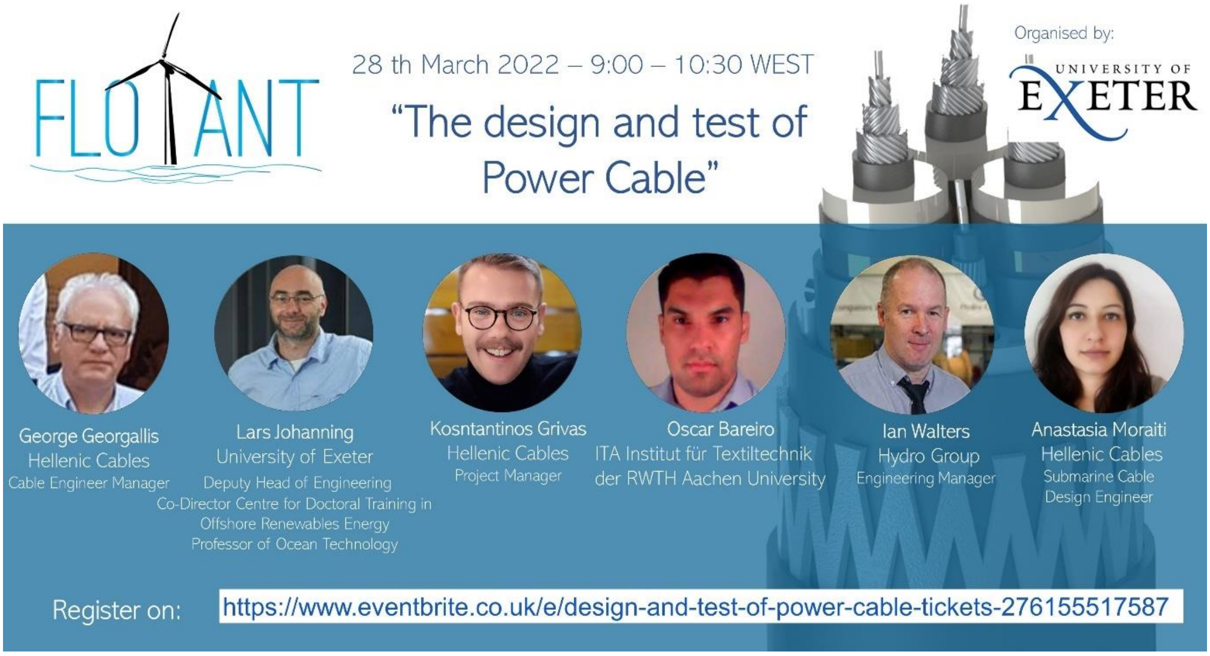

Figure 1. Workshop on "The design and test of power cable.

2.1 Workshop title: "The design and test of power cable"

This workshop produced in fulfilment of FLOTANT Task 5.3 - Power cable performance characterisation. The aim of Task 5.3 is to test the novel power cable components developed within FLOTANT Work Package 3 – Dynamic cable, subsea connectors and export system optimisation in order to increase the understanding of their mechanical properties and fatigue-related effects. In this way, confidence in the effectiveness of the components can be gained, areas of improvement identified, and their commercialisation accelerated.

The agenda of the event was as follows:

- Hellenic/ University of Exeter: Welcome and project overview
- Hellenic: Novel Power Cable design
- TH Aachen: Optical Fibre sensor integration design
- Hydrogroup: Power cable termination design
- University of Exeter: Power cable testing

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3 Findings

A series of assumptions on material properties, cable geometry and contact definitions have been made, in order to obtain representative stress concentration factors according to the cable model provided and the computational timeframe available. As with any numerical analysis, there are differences between it and real life and the effect of these on the results does need quantifying. Parameters such as contact definition, frictional behavior and simply the computational requirement that large, detailed models have will all contribute; however, on the physical side, manufacturing tolerances can be large, the plastic layers tend to fill much more of the 'gaps' in the cable than the numerical model considers and actual material properties are only indicative and not measured.

Further investigation into the non-linear response of the cable, and the effect of this on the fatigue damage assessment in OrcaFlex should be considered prior to the fatigue testing scheduling. Results from the refined runs will affect the fatigue global analysis and thus the fatigue test plan.

To this end, computational facilities with higher performance capabilities will be required for improved analysis and the longer/more complex geometries due to the high RAM needed to solve the problem. The amount of RAM required is proportional to the mesh size and quality, therefore the initial runs can inform later (more detailed) runs and a good estimate of required RAM can be obtained to inform job submissions.

4 Conclusions

Within this context, the main objective of FLOTANT Task 3.4 (Dynamic Cable local component analysis and fatigue modelling) is to conduct advanced numerical modelling of the novel power cable in order to assess its constituents' performance and reliability characteristics. To this end, a detailed modelling of the power cable to validate the ultimate limit state (ULS) and fatigue limit state (FLS) load conditions initially provided by the global analysis is presented. The local component analysis, simulating the physical phenomena happening in the different sections of the cable under dynamic conditions, is conducted using specialised finite elements method (FEM) software. This kind of analysis is particularly oriented towards the cable integrity and reliability, allowing the prediction of fatigue damage profiles and increasing the understanding of its mechanical and electrical behaviour over the expected lifetime.

The outcomes of this procedure will be integrated with the results from the global analysis, as well as with the outcomes of the experimental testing on the power cable components (detailed in Deliverable 5.6), in order to iteratively assess the fatigue life and validate the cable design.

Part II – WS2: Addressing the Techno-Economic Impact and LCOE calculation in the FOW Industry

5 Method

5.1 Format

Due to the COVID-19 pandemic, the organisation of a face-to-face workshop was not possible, and so an alternative approach to achieve a broad stakeholder engagement was followed. Online focused discussion sessions were organised to get the inputs from different stakeholders on what a baseline should represent to give a reasonable and reliable comparison that is credible and relevant for different stakeholders. The online focused discussion sessions took place with one to two representatives of external organisations in separate sessions for each organisation. One joint session was also organised with FLOTANT partners. To ensure a broader discussion the results were then presented at the Wind Energy Science Conference in May 2021 [14], which also took place online.

To guide the online focused discussion sessions, interviewees were first provided with the background and motivation for the discussion, and then the discussion was guided with the question 'What should a baseline represent?' talking through different aspects of this question as detailed below. Discussions evolved in different directions depending on the stakeholders responses and interests. This was purposely so, since no quantitative assessment of the interviews was sought. The goal was to achieve a better understanding of the different perspectives and their motivations. The different aspects of the key question used to start the discussion were:

(1) Should the baseline be representative of the whole offshore wind sector or specific to floating technologies? (See Figure 2.)

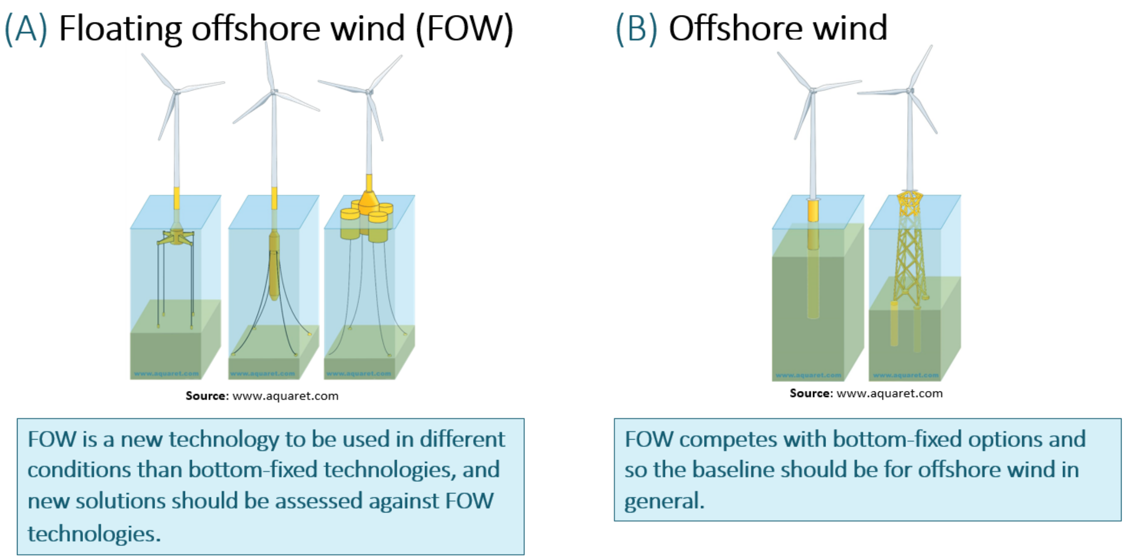

Figure 2: Representation used to discuss question (1).

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(2) Should the baseline be representative of a technology or of a typical project? (See Figure 3.)

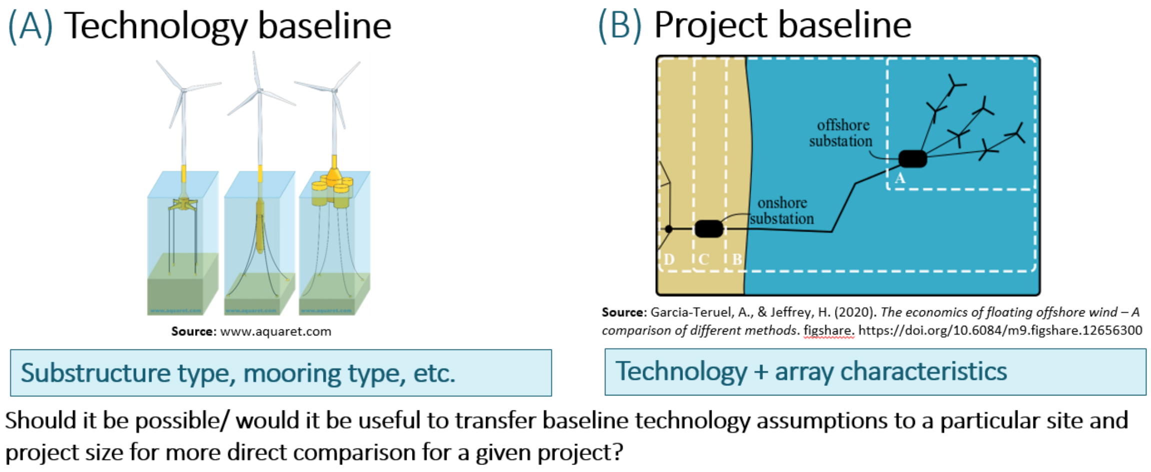

Figure 3: Representation used to discuss question (2).

(3) Should the baseline be based on pre-commercial projects, reference systems or something else? (See Figure 4.)

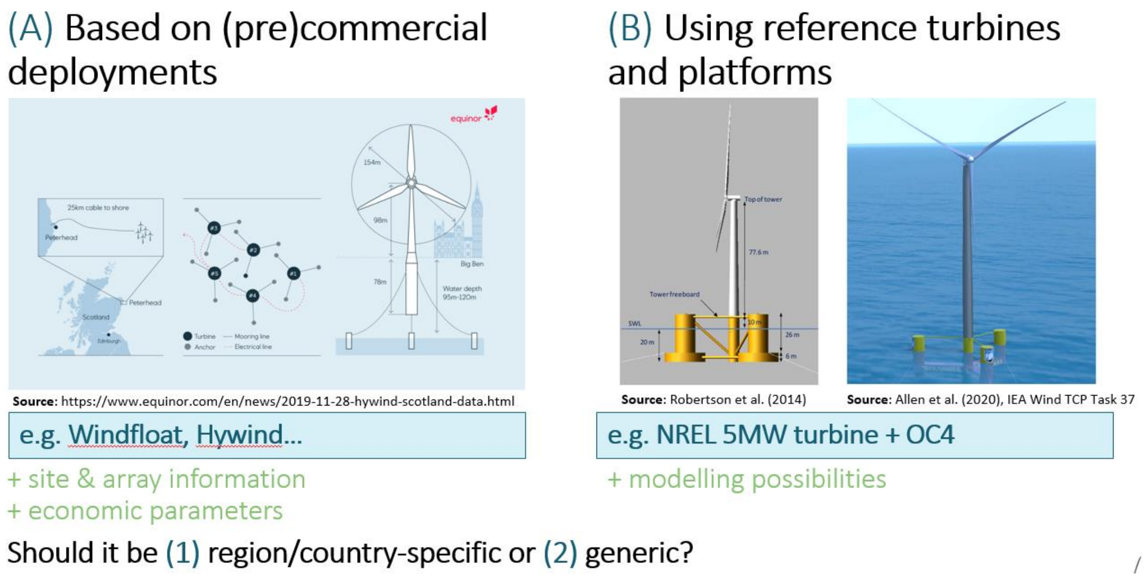

Figure 4: Representation used to discuss question (3).

(4) What would you find particularly important to be defined in a FOW baseline regarding relevant characteristics and parameters? (See Figure 5.)

(5) What is the best way to ensure that baselines are kept up-to-date and who is best placed/ is a trusted organisation to do this?

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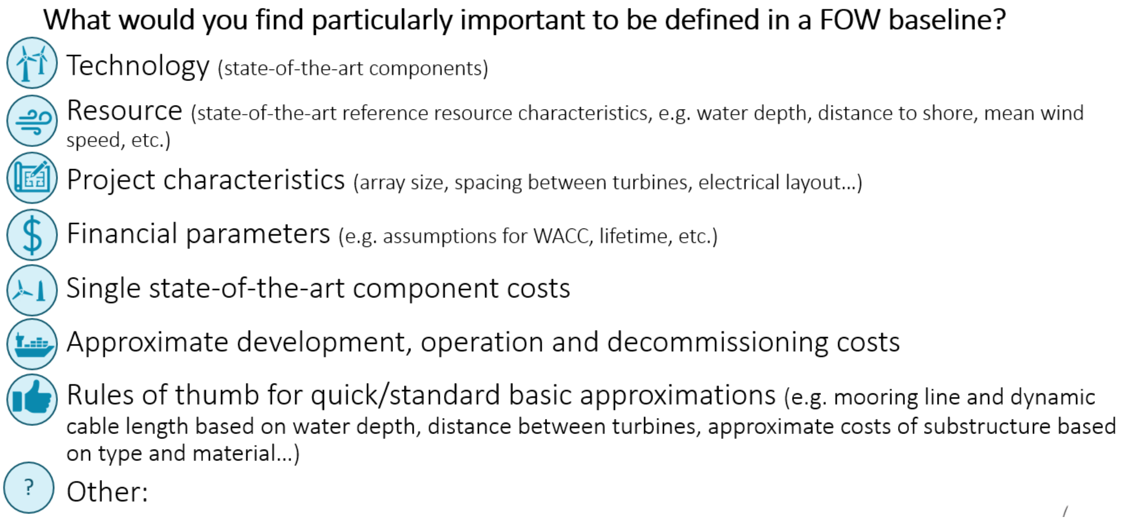

Figure 5: Representation used to discuss question (4).

5.2 Participants

A number of stakeholders were interviewed covering a broad representation of the sector, including: utility companies & project developers, technology developers, consultancies & innovation groups, funding agencies & collaboration initiatives, trade associations, investment companies and universities.

Following anonymity requests, a non-exhaustive list of the participants' organisations includes:

- SSE
- Simply Blue Energy
- COBRA
- TFI
- FULGOR
- ESTEYCO
- ORE Catapult
- Carbon Trust
- Innosea
- Scottish Enterprise
- Wave Energy Scotland (WES)
- Spanish Wind Energy Association (AEE)
- Greenbackers Investment Capital
- Danish Technical University (DTU)
- The University of Edinburgh

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6 Findings

As a results of the discussion a number of factors were identified to be key to define a suitable baseline on a case-by-case basis. These are:

1. the **primary goal** of the study
2. the **stage of development** of the technology
3. the **available information**
4. the **scope** of the study
5. the **relevant metrics depending on level of detail**

It was also found that in an ideal case, where all information and resources were available, the baseline would

1. enable technology comparison but also tell a story in terms of how it compares to other more mature technologies;
2. vary by development stage;
3. represent the best available commercial solution and be updated regularly;
4. be location specific and potentially typology specific;
5. allow LCoE comparison but also include other parameters that provide some further insights for specific deployments.

Further thoughts on each of the identified factors are summarised in sub-section 6.1, and the best way to ensure that a baseline would be kept relevant and up-to-date in sub-section 6.2.

6.1 Important factors that define a suitable baseline

6.1.1 Primary goal

The primary goal in the use of a baseline was found to be (1) to assess impact of technology innovations but also (2) to provide a high-level characterisation of the state-of-the-art of the sector (e.g. efficiency, costs, etc.).

In the first case, a floating offshore wind baseline would be used and so floating offshore technologies should be compared against floating offshore wind technologies. However, to achieve the second goal apart from having a representation of the floating offshore wind state-of-the-art, it was mentioned that parallels to bottom-fixed offshore wind should be drawn. This could be in the form of high-level production efficiency and cost comparison with the state of the art in BFOW, as well as with the cost reduction trajectories experienced in BFOW technologies. This higher level context can also provide further advantages, such as enabling government decisions on technology support, allowing lobbying organisations to demonstrate technology progress & potential, and identifying innovation and supply chain requirements.

For future studies of innovative FOW technologies this means that further context can be provided by including a high-level comparison to the costs of BFOW. Furthermore, the expected cost reductions estimated for floating offshore wind can also be compared with the experienced cost reductions in bottom-fixed offshore wind technologies to demonstrate the cost reduction potential and increase investor confidence.

6.1.2 Development stage

A further idea that was raised during the discussions was that what is used as a baseline will depend on the development stage of the technology being assessed.

So for example, when developing a new FOW technology, the comparison will need to be external, because no previous versions of that technology exist that it can be compared to. In cases where technologies are developed up to TRL5, the best approach may be to use a generic baseline that represents the sector state-of-the-art.

However, when reaching pre-commercial stage, previous versions of the same technology will exist. Once a technology is chosen for further development and design optimisation, it tends to be compared to previous versions of itself.

Finally, once commercial stage is reached, the technology may still be optimised for specific deployments or for further general improvements. In that case, the comparison would still be made with respect to a previous version of itself. However, at this point most actors would take a set strike price (for example in a bidding process) as the comparison target, since it represents the goal to be achieved and to be compared against to finally get a return for the electricity generated.

6.1.3 Available information

The workshops revealed a wide range of conflicting opinions on what data a baseline should be based on. However, a number of criteria to inform this choice were mentioned in the workshops, including: data availability, data reliability, the contemporariness or time validity of the data, and how representative the data were of real deployments. The discussed concepts are summarised in Table 1, where the advantages and disadvantages of different information sources were qualitatively assessed based on the criteria identified. The table does not represent an exhaustive comparison but a summary of the ideas arising from the discussions.

There was a general agreement that a baseline to be used to make design choices or to provide a high-level picture, should be forward-looking. That is, it should be based on planned future deployments with turbines with ratings larger than 10 MW and farms larger than 200 MW, rather than looking back at pre-commercial deployments. Pre-commercial deployments were generally considered to become quickly outdated and to represent one-off deployments with smaller turbines which may not be representative of real deployments.

Table 1: Advantages and disadvantages of using different sources of information to define a baseline.

Criteria \ Information sources	Pre-commercial deployments	Reference turbines and platforms	Other generic standard cases	Current technology considered for future deployments
Data availability	Partially available	No cost or operations data	High level only	Little information available
Data reliability	Existing deployments	Well accepted	Variable	Plans may change
Contemporariness/ Time validity	Quickly outdated	If updated	If updated	Found to be representative
Representative of real deployments	One-off deployments with smaller turbines	Assuming turbines ≥10MW	Assuming turbines ≥10MW	Found to be representative
Conflicts due to commercial interests	Partners may be involved	None	None	Partners may be involved

6.1.4 Scope

In terms of scope, there was also a general agreement that a baseline to be used to make design or technology choices should be **location specific**, where two options were highlighted:

1. to use a specific location
2. to define a range of conditions that would be representative of the conditions that can be expected in locations where FOW could be deployed.

In terms of which **typology** (i.e. class of FOW platform) should be used as a baseline, different types of comparison for design and technology choices were suggested, as shown in **¡Error! No se encuentra el origen de la referencia.**. If developing a new technology, the first step was suggested to be to compare to a baseline of the same typology. To then understand if the technology performed better than other typologies, it should be compared to baselines representing other typologies. Finally, the final goal would be to compare to the best available commercial solution, which for FOW to-date would be difficult to define. Overall, moving along these different steps results in an increasing level of difficulty to obtain reliable data, and therefore also a decreasing level of detail expected in the comparison.

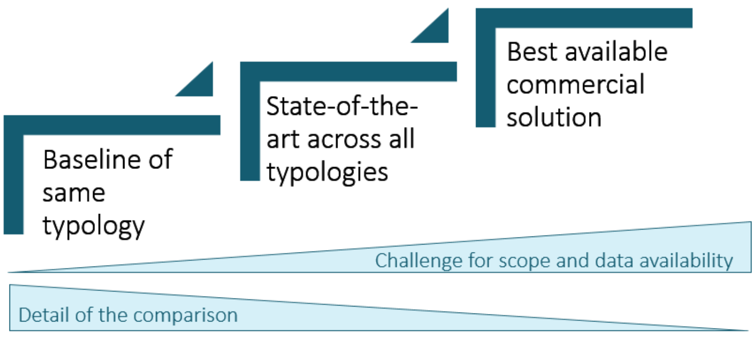

Figure 6: Different steps in the comparison of a novel technology, resulting in different scope of the comparison.

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6.1.5 Relevant metrics depending on the level of detail

In terms of the level of detail of the comparison, there was a common agreement on LCoE being the key metric to be used for comparison.

However a number of other metrics were suggested, such as the motion response or the mooring line footprint, which can be used to assess the suitability of a solution for a specific deployment. The selection of these metrics will have an impact on:

- **Turbine requirements**, as would be the motion response, and the turbine inclination and acceleration
- **Manufacturability and infrastructure requirements** as would be the platform dimensions, weights and materials, or the modularity of the solution
- **Deployment site restrictions** as would be the mooring line footprint

So providing this additional information can provide further insights relevant to a wider range of stakeholders.

6.2 How to keep it up-to-date

The requirements of an organisation responsible for keeping the baseline up to date were also discussed. The general answer was that for it to be a trusted organisation it should be an international, independent, prestigious organisation(s) with no technology-specific interests, and with the ability to update the baseline regularly. Some of the suggested organisation were IEA, IRENA, and NREL.

Useful information to be recorded as part of the baseline would be: (1) generic baselines (for 4 typologies for defined site classes), and (2) a data base of previous projects characteristics (e.g. what was built, what it costed, conditions, suppliers, etc.).

7 Conclusions

The main conclusion drawn from the focussed discussion sessions on what would be a suitable baseline for floating offshore wind, was that there is not one solution that fits all cases. What a suitable baseline looks like will depend on the primary goal and scope of the study, the stage of development of the technology, the available information, and the level of detail required for the comparison. Taking into account the listed factors and the considerations summarised here can support finding a suitable baseline for a given project. Further insights and perspective can be provided for a wider range of stakeholders with small additional effort by considering some of the ideas presented here.

For the FLOTANT project, the cost reduction targets were defined at the proposal stage with the information available at that time. For this reason, those values were used for the assessment of the FLOTANT technologies against the project targets in D7.1 [2]. Additionally, costs were compared with the target electricity prices in the deployment locations in the FLOTANT viability study in D7.2 [15]. The considered deployment scenarios to evaluate the FLOTANT technology are in line with the conclusions drawn here. That is, planned future deployments with turbines with ratings larger than 10 MW and farms larger than 200 MW were considered. However, based on these discussions in future studies of similar characteristics to FLOTANT (i.e. innovative technology development) it could be beneficial to establish a baseline technology so that the performance of the innovative technology and the baseline technology can be compared in more detail under the same deployment conditions. Based on these discussions, this would involve multiple comparison steps, where first a suitable baseline technology to compare the FLOTANT system to would be a floating system using a barge or semi-submersible design for the floater. In a second step, it would be compared with baseline technologies representing other floater designs, such as a spar and a tension leg platform. Finally, if information on the best performing technology in the market was available, it would also be compared against it.

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