FLOATECH

D6.4. Final report on the project exploitation initiatives

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FLOATECH
THE FUTURE OF FLOATING WIND TURBINES

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Background: about the FLOATECH project

The FLOATECH project is a Research and Innovation Action funded by the European Union's H2020 programme aiming to increase the technical maturity and the cost competitiveness of floating offshore wind (FOW) energy. This is particularly important because, due to the limitations of available installation sites onshore, offshore wind is becoming crucial to ensure the further growth of the wind energy sector.

The project is implemented by a European consortium of 5 public research institutions with relevant skills in the field of offshore floating wind energy and 3 industrial partners, two of which have been involved in the most recent developments of floating wind systems.

The approach of FLOATECH can be broken down into three actions:

- The development, implementation, and validation of a user-friendly and efficient design engineering tool (named QBlade-Ocean) performing simulations of floating offshore wind turbines with an unseen combination of aerodynamic and hydrodynamic fidelity. The advanced modelling theories will lead to a reduction of the uncertainties in the design process and an increase of turbine efficiency.
- The development of two innovative control techniques (i.e. Active Wave-based feed-forward Control and the Active Wake Mixing) for Floating Wind Turbines and floaters, combining wave prediction and anticipation of induced platform motions. This is expected to improve the performance of each machine and to minimize wake effects in floating wind farms, leading to a net increase in the annual energy production of the farm.
- The economic analysis of these concepts to demonstrate qualitatively and quantitatively the impact of the developed technologies on the Levelized Cost of Energy (LCOE) of FOW technology.

In addition to the technological and economic impacts, the project is expected to have several impacts at societal, environmental and political levels, such as: public acceptance, due to no noise and visibility issues of FOWT; very low impact on biodiversity and wildlife habitat because no piles are needed be to installed into the seabed; the use of less material and space thanks to an environmentally friendly design; the promotion of the installation of FOW in transitional water depths (30-50 meters), as the costs for FOW at those locations will become more competitive compared to the fixed bottom foundations.

Beyond the technological and economic ramifications, the FLOATECH project is poised to instigate a range of impacts at societal, environmental, and political levels.

These include:

- Enhanced Public Acceptance: Floating offshore wind turbines (FOWT) present no noise or visibility concerns, leading to heightened public acceptance.

- Reduced Biodiversity and Wildlife Impact: By obviating the need for piles to be embedded into the seabed, FOWT installations exhibit minimal impact on biodiversity and wildlife habitat.

- Eco-friendly Design: FOWT deployments embrace environmentally friendly designs that necessitate less material and space.

- Promotion of Transitional Water Depths: The project advocates for the installation of FOWT in transitional water depths (30-50 meters), as costs for FOWT in these regions are projected to achieve competitiveness compared to fixed bottom foundations.

In summation, the FLOATECH project endeavours to propel the floating offshore wind sector forward, not only in terms of technological innovation and economic viability but also in fostering positive societal, environmental, and policy outcomes.

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List of acronyms and abbreviations

Acronym / Abbreviation	Meaning / Full text
FOW	Floating Offshore Wind
FOWT	Floating Offshore Wind Turbine
LCOE	Levelized Cost of Energy
LLFVW	Lifting Line Free Vortex Wake
CAPEX	Capital Expenditures
TLP	Tension-leg platform
BEM	Blade Element Momentum model
HAWT	Horizontal Axis Wind Turbine
VAWT	Vertical Axis Wind Turbines
DLL	Dynamic Link Library
KER	Key Exploitatable Results
KO	Knowledge Output

1. INTRODUCTION

The "Final Report on the Project Exploitation Initiatives" serves as a comprehensive report on the strategic actions undertaken to capitalize on the project's outcomes. This deliverable delves into the exploitation initiatives that have been implemented to maximize the impact of the project's result, encompassing a series of activities aimed at ensuring the effective dissemination, utilization, and sustainability of the knowledge and innovations generated.

Creating markets from research results is increasingly viewed as a crucial element in advancing research endeavors. This shift signifies a dynamic evolution where universities and research centers actively collaborate with companies and engage with the non-academic or private sector. FLOATECH, by its very essence, embodies the potential to unlock and capitalize on research results across diverse levels. This potential extends its reach to various types of organizations, including industries, research centers, and other public interest entities. Through these collaborations, FLOATECH aims to generate a ripple effect that not only benefits the involved organizations but ultimately enhances outcomes for the end users. This approach aligns with the contemporary trend of fostering synergies between academia, industry, and public interest entities and a collaborative ecosystem that drives innovation and societal impact.

This deliverable aligns with the stipulations outlined in the Article 28 of the GA: *"each beneficiary must take measures aiming to ensure exploitation of its results (either directly or indirectly, in particular through transfer and licensing) by:*

- *Using them in further research activities*
- *Developing, creating or marketing a product or process*
- *Creating and providing a service*
- *Using them in standardization activities"*

The formulation of the exploitation strategy for the FLOATECH project employed a multifaceted methodology, encompassing a series of activities aimed at supporting the partners in identifying the most effective routes for exploiting the project's results. This methodological approach included the following key activities:

- the identification of Key Exploitable Results
- the involvement of all partners in the Horizon Results Booster ESS seminar,
- the drafting of a market test on specific KERs
- the start of a new Horizon Europe funded project which builds on the project's outcomes: FLOATFARM.

2. MAPPING OF THE PROJET KEY EXPLOITABLE RESULTS

The first concrete initial step regarding the design of the project exploitation process covers the identification of Key Exploitable Results (KERs).

A key exploitable result is a tangible or intangible project output, whatever its form or nature, which has been deemed to be of high priority for project transfer actions: something new that comes out of the project that can be used, has value and is beneficial for the society. This result is selected and considered relevant for its high potential to be "exploited", i.e. to make use and derive benefits down the value chain of a product, process, or solution, or to serve as an important input for policy, further research or education.

The FLOATECH exploitation plan consists in a strategy describing possible ways to sustain the project's results, by collecting and analysing all the exploitable results of the project.

At the beginning of the project, in the Grant Agreement, FLOATECH partners proposed a roadmap to commercialisation and a preliminary table (Table 1) presenting the expected results of the project, as well as pathways for exploitation and dissemination.

Roadmap to commercialization

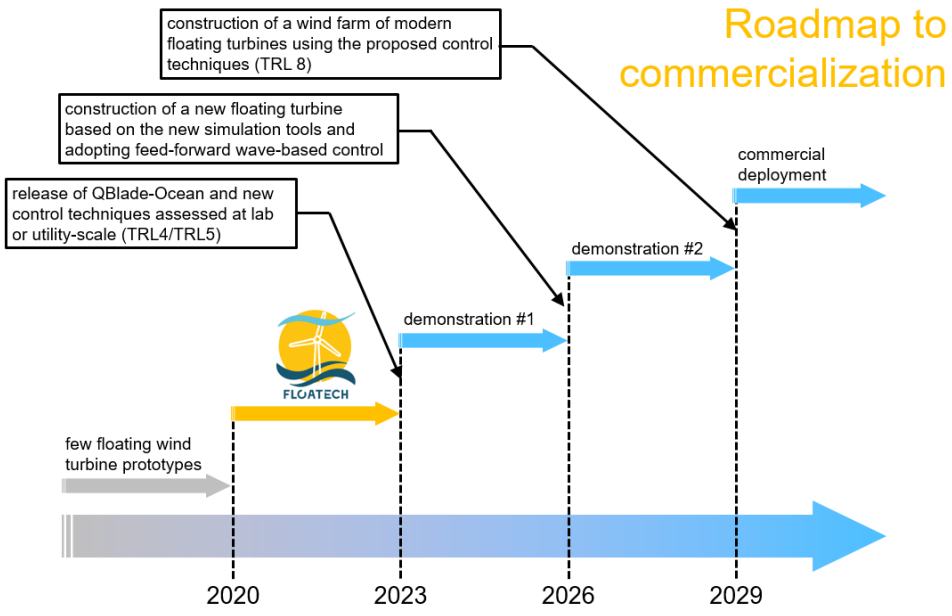
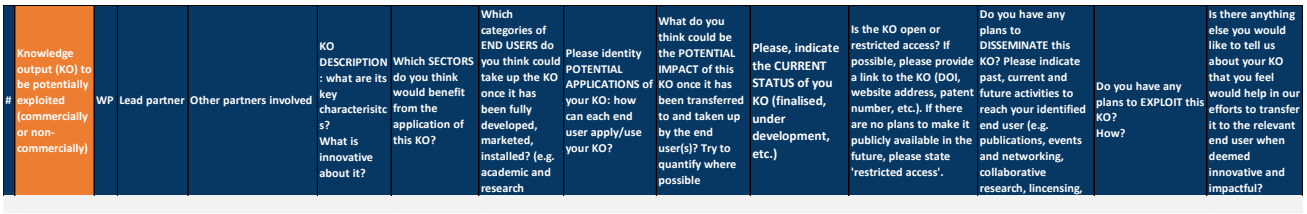


Table 1: List of the results to be exploited commercially or non-commercially identified in the GA

Type of results to be exploited commercially or non-commercially	Owners	Exploitation routes and protection	Potential users	Dissemination to ensure exploitation

Creation of scientific data: wind tunnel measurements of the response of floating wind turbines to the innovative control techniques	Partners ECN, TUD, SAIPEM	Open databases like ZENODO	Basic and applied Researchers, Engineers, Developers websites and Journals	Dissemination in open access, Lectures and courses, Publication through websites and Journals
Full-scale FWT with wave radar system in real environment for validation of control methods	ECN, Ideol, Netxocean	Further commercialisation of the technology (licencing or direct industrial use, creation of patent)	Design engineers, Companies, Researchers	Dissemination in Industrial Conferences, participation to trade fairs
Report/deliverable such as QBlade-Ocean manual	Partners TUB, ECN	Through the publication of scientific papers	Basic/applied Researchers	Participation to Scientific conferences to present the publications
Creation of new services or products: QBlade- Ocean simulation suite; feed-forward, wavebased control system, wake-mixing control technique for wind farms	Consortium	Know how, transfer of knowledge, further commercialisation on via patent Creation of start-ups	PhD students (with the creation of start-ups), postdoctoral researchers, companies in the field of floating wind energy, manufacturers	Support to the young researchers in the creation of start-ups, dissemination to funding agencies to guarantee the further development of the services and products
Techno-Economic assessment to prove the reliability of the technology at large scale	Partners SEAPOWER UNIFI, SAIPEM	Funding of the future research and development	Investment sector (private or public agencies)	Business workshops organised during the project with business stakeholders
Report on cost analysis and positioning of the technology into the energy mix system	Partners SEAPOWER TUB, UNIFI, SAIPEM	Participation and support to EU policies	EU and national Policy makers	Dissemination to policymakers through EU networks and EU associations
Standardization actions: comparison of calculated loads by QBlade-Ocean with available standards and suggestions	Partners TUB, UNIFI	Implementation of standards based on the project technology	The standardization sector	Participation to standardization activities

To go further in the mapping of the Key Exploitable Results and potential exploitable routes, a table was created by Euronovia and sent to project partners in June 2022 (M19) for them to update the list of Knowledge Outputs.



This preliminary task allowed the partners to delve into the potential applications and impact of each project outcome and offer a first overview of the work achieved by partners. The following list underlines the 11 Knowledge Outputs identified:

Table 2: List of the Key Exploitable results identified by the FLOATECH partners

No	Name of the KOs	Lead partner
1	**QBlade-Ocean simulation suite**: high order open-source aerohydro-servo-elastic design and simulation tool	TUB
2	**LCOE evaluation tool taking into account control technologies developed within the project**: LCOE evaluation tool using relations for FOW components dimensioning enhanced compared to the scaling laws currently used in most costs' evaluation tools	Seapower
3	**Feed-forward, wave based control system**: new control technique for FOWT	TU Delft
4	**Full-scale FWT with wavebased radar system in real environment for validation of wave prediction system**: installation of a wave radar system mounted on the FWT "ID1-Floatgen" to and aimed to predict motions of the platform, with real time remote wave measurement and validation of the technology.	ECN
5	**Innovative control to enhance wake mixing control in floating wind farms: active wake mixing techniques. Innovation:** Complete new approach to designing floaters to enhance wake mixing by which wind speed can be significantly increased downstream	TU Delft
6	**NEMOH software with full QTF:** active wake mixing techniques. Innovation: Complete new approach to designing floaters to enhance wake mixing by which wind speed can be significantly increased downstream	ECN
7	**Quantification of uncertainty reduction using QBlade-Ocean in comparison to state-of-the-art tools:** detailed analysis of the improvements in terms of accuracy that one can gain using the new software thanks to the more refined representation of some physical phenomena	UNIFI
8	**Creation of scientific data:** Experimental measurements of responses of a scaled floating wind turbine test bench: test bench of a scaled FWT in a hydrodynamic test tank including aerodynamic loads and control (Software In loop method), testing and comparing the innovative control techniques developed in the WP3	ECN

9	**Creation of scientific data:** Full scale experimental measurements of wave fields surrounding a FOWT: dataset aimed at validating deterministic wave prediction techniques	ECN
10	**Economic assessment to prove the effectiveness of FOWs embedding the control technologies developed within the project and their positioning into the energy mix system**	Seapower
11	**Lecture for Master's students on design and simulation of floating wind turbine**	TUB

Following that activity, the focus was on identifying and analysing, among these, potential exploitable results. To do so, the consortium requested the support from the Horizon Results Booster service (Module C).

3. THE HORIZON RESULTS BOOSTER ESS SEMINAR

3.1 FLOATECH'S KER AND COMPETITIVE EDGE

On February 2022 (M14), the FLOATECH consortium reached out the Horizon Results Booster Service to go further in the mapping of the Key Exploitable Results and potential exploitable routes. The service requested was the PDES-C that aims to strengthen the capacity of projects in using their research results enhancing partners' capacity to improve their exploitation strategy. The 3 KERs selected for the discussion during the service were analysed from a viewpoint which is exploitation only and considering how they will be used to generate impact, after the end of the project. This is the market/customer demand or societal needs/user point of view.

The service and the virtual Exploitation Strategy Seminar (ESS) aimed to provide project partners with the opportunity to work on:

1) the identification/grouping of key exploitable results;
2) the first definition of the related use mode;
3) the identification and mapping of risks related to the exploitation;
4) follow-up actions.

The ESS for FLOATECH was organised on the 4th and 6th of October 2022 (M23). The seminar was conducted remotely (online). This decision was made because it was proposed by the experts, and we felt that the outcome of the seminar would not be affected by the online format. In addition, different COVID19 regulations had to be followed in different institutions and countries.

Work was undertaken by partners both prior to and during the ESS seminar in collaboration with the expert. The FLOATECH partners narrowed down the list of identified KOs to three specific Key Exploitable Results that were analysed in detail at the ESS. KER-2 was highlighted as an example during the walk-through session (plenary), whereas KER 1 and 5 were elaborated upon in the group sessions. These three results were chosen since they are considered to be amongst the three most

important outcomes of the project. Moreover, as each is an outcome that depends on the contributions by several beneficiaries, each project partner actively contributed during the ESS.

Table 3: List of the Key Exploitable results selected for ESS Seminar

No	Name of the KER	Description	Lead partner
1	**QBlade-Ocean simulation suite:** high order open-source aerohydro-servo-elastic design and simulation tool	QBlade-Ocean is a simulation suite which enables the fully coupled aero-hydro-servo-elastic simulation of a variety of floating offshore wind turbine architectures. The software is freely available, and the code is open source, providing the wind turbine community with a powerful and easily accessible tool for the simulation and design of wind turbines. The software also has an intuitive graphical user interface, which makes the software furthermore excellent for the teaching of wind turbine physics and design fundamentals.	TUB
2	**LCOE evaluation tool taking into account control technologies developed within the project:** LCOE evaluation tool using relations for FOW components dimensioning enhanced compared to the scaling laws currently used in most costs evaluation tools	LCOE evaluation tool taking into account control technologies developed within the project consists in a methodology for preliminary Levelized Cost of Energy (LCOE) estimation of floating wind turbines. This approach aims to evaluate LCOE accounting for loading estimation, also depending on met-ocean condition of the installation site, obtained from simulation tools such as QBlade-Ocean, in a preliminary simplified sizing of the turbine structures or in a comparison of alternative designs. Such preliminary LCOE estimations can be useful for an assessment of the cost related effects of design choices, particularly when these involve features which have less or no effect on the geometric configuration of the Floating Offshore Wind Turbine (FOWT), but a possibly significant effect on loadings (such as in a change of the control strategy).	Seapower
5	**Innovative control to enhance wake mixing control in floating wind farms: active wake mixing techniques. Innovation:** Complete new approach to designing floaters to enhance wake mixing by which wind speed can be	Within wind farms the interaction between turbines through their wake causes a loss in potential power production for the entire farm. Typically wind farms are designed in such a fashion as to minimize this effect, but these methods are only effective for small wind farms. As wind farms grow these techniques become less effective. Recently active techniques, whereby active control is used, have also shown to have potential in reducing this wake-to-turbine interaction and increasing overall power production. Floating wind turbines potentially offer a large potential in the sense that the fact that they float can be exploited. By either designing the floater and/or controlling it, certain movements can be induced that are shown to significantly aid in reducing the interaction between	TU Delft

	significantly increased downstream	turbines allowing for a higher power production for an otherwise identical wind farm.	

On the 4th of October 2022, the first workshop focused on several important issues. The session commenced with a focus on the "Objectives of the European Commission," setting the overarching goals of exploitation in context. The following item on the agenda addressed the "Objectives of the seminar".

Subsequently, the discussion shifted to a fundamental question - "What could be considered as an 'exploitable result'?" This exploration aimed to provide clarity on the tangible outcomes. The fifth item, "Presentation of the whole process," offered a comprehensive overview of the procedures involved.

FLOATECH was then examined through an expert's lens in "FLOATECH at a glance: the expert's analysis," shedding light on critical insights. The following item on the agenda focused on the "Identification of the dependencies between the exploitable results," mapping the intricate relationships between different outcomes. Finally, the session "Walked-through the ESS&KM compilation tool," providing a practical understanding of the tool.

On the second day of the ESS seminar that took place on October 6, 2022, the FLOATECH consortium was involved in a series of exercises focusing on KER 1 and KER 5.

Moreover, the session tackled "characterisation, roadmap and use options". The partners went ahead to characterise the outcomes, drafted possible roadmap, and explored different ways of utilising them to increase their impact. Sorting background, foreground knowledge and access rights for each result was the third agenda item which underpinned the aspects of organisation and accessibility. FLOATECH partners were involved in the identification of background and foreground data as well as defining permissions to each outcome to simplify further operations. The workshop then transitioned to "Risk Analysis," where participants collectively assessed potential risks associated with the outcomes and devised strategies to mitigate them effectively.

3.2 RECOMMENDATIONS FROM THE EXPERT

Three KERs were considered for analysis during the ESS seminar and the discussion proved highly participative, with active contributions from all partners. The seminar helped FLOATECH partners to focus on project results and their exploitation routes, including the possibility of internal use of KERs.

Also, regarding the planning towards the Exploitation plan, the expert provided 6 recommendations:

- Keep it flexible enough and in line with the economic, environmental, societal and legal context in which the project has been set up;
- Use the lean canvas to better define early adopters, current solutions, unique value propositions and commercialisation channels for further information);
- Identify KPIs and milestones to define a roadmap, with all the activities needed to pave the way for use of the selected KERs;

- Take into consideration the time and resources needed for implementing the next steps after the end of the project, considering that most of the partners have guidelines and procedures for spin-offs, joint ventures, licencing that require time;
- Consider consistency among the selected route to market, competition, early adopters, proposed exploitation actions and the expected impact of the project;
- Highlight the value chain dimension of the project and make sure this is considered to find the best set up in terms of future collaboration as partnership and as individual entities.

In terms of Monitoring Risk Analysis, the expert advised a proactive approach, suggesting that addressing risks at the individual Partner level first will enhance the impact of mitigation actions.

Regarding IP ownership and partnerships for exploitation, the expert highlighted the need for prompt agreement among joint owners of Key Exploitable Results (KERs). This agreement delineated the terms of ownership and protection, aligning with the intellectual contributions to the results' development. The expert recommended the signing of bilateral or multilateral Memorandum of Understanding (MoU) agreements.

The complete report from the expert, including methodology and information gathered from project partners on KERs, is available upon request to Euronovia.

4. MARKET STUDY

As stated in the Grant Agreement (GA), the identification of market opportunities for exploitable results involves the conduct of a test market study. To kickstart this comprehensive examination, a meeting on FLOATECH Exploitation strategy was organised on January 17, 2023, to define the scope of the market study.

The partners selected KER 1 and KER 5 for a thorough analysis within the market study. The consortium agreed on the following key elements to be included in the market study:

- Quantitative and qualitative analysis of the market and the various customer segments
- Information on market competitors
- Economic environment in terms of entry barriers and regulation
- Market gaps and future trends

Following the seminar, Key Wind Energy GmbH, a technical consulting firm in the field of wind energy was selected to conduct the market study.

The complete market study is available upon request to Euronovia.

4.1 OBJECTIVE OF THE MARKET ANALYSIS AND METHODOLOGY

The objective of the market analysis conducted by Key Wind Energy GmbH was to provide a comprehensive understanding of the dynamic floating offshore market. The primary focus was on active projects and companies offering services related to floating offshore structures. The analysis

delves into two key categories: companies overseeing wind farms with floating structures and those introducing innovative concepts for floating turbine substructures.

To achieve this analysis, the methodology employed began with a short overview of the current floating offshore market, examining its state of the art and ongoing projects. This involved an exploration of market stakeholders, an overview of current trends, and an assessment of existing challenges, particularly focusing on the profitability of floating offshore projects.

The analysis then transitioned to an analysis of the KER 1, QBlade-Ocean, including its value proposition, competitors, and an evaluation of its strengths, weaknesses, and opportunities. The study also tried to identify potential groups of interest.

The analysis extended to the KER 5, innovative control enhancing wake mixing in floating wind farms, which involved presenting the value proposition of this innovative control approach, examining the current projects and potential customers in the market.

4.2 KEY FINDINGS AND INSIGHTS RELATED TO MARKET TRENDS AND OPPORTUNITIES

As mentioned, the market study began with an examination of the current state of the floating offshore market, revealing how it is characterized by constant evolution, with ongoing efforts to achieve the ideal design concept. Four predominant concepts have emerged in recent years, each with distinct advantages and disadvantages: **Spar** involves a large vertical cylinder anchored to the seabed, providing exceptional stability but with complex construction and installation. **Semisubmersible** feature multiple hulls, offering excellent stability and substantial deck space, but their design and construction can be complex. **Tension-leg platforms (TLPs)** are buoyant platforms tethered to the seabed, delivering superior stability and motion control, suitable for deepwater applications. **Barge platforms** are cost-effective and versatile but may exhibit less stability.

The study revealed that the market, with over 40 concepts in research and development, remains dynamic. Ongoing trends focus on efficiency enhancement and cost reduction. However, these innovations may pose challenges for streamlined regulations in the floating offshore market compared to conventional designs.

The market study underlined interesting data with conservative estimates that project approximately 26% annual growth until 2035, while more optimistic scenarios suggest rates as high as 42.4% until 2030 or even 56.6% until 2029. The market value estimations span from 15.64 billion USD in 2029 to 114.62 billion USD in 2035. Europe is expected to be a dominant player in the market, with the potential for a significant floating wind capacity of around 4000 GW. This dominance is reinforced by Europe representing about 80% of all offshore wind resources, particularly in depths exceeding 60m.

With countries under increasing pressure to accelerate their efforts in meeting green energy goals (USA, United Kingdom, Norway, France, Japan, South Korea, and Taiwan) there arises a heightened necessity for new technologies and greater investments in novel electricity production methods. With approximately 80% of wind capacity situated in regions where sea depths exceed 60 meters,

the floating wind energy sector is poised to gain significance in the coming years. This sector holds the potential to yield higher profits compared to existing onshore and offshore markets.

The market study offers an examination of current companies within the floating wind market, a distinct focus is placed on distinguishing between those involved in wind turbine manufacturing and those concentrated on project planning, construction, and certification. Notable companies in this domain include Equinor, Principle Power, RWE, and Korea Floating Wind, each contributing to the advancement and innovation in the floating offshore wind market. The prevailing trend suggests hesitancy among major companies to develop entirely new horizontal turbines for the next generation of commercially viable floating offshore parks. Finally, the market study underlines the potential for a new avenue in turbine production specific to floating offshore applications could arise if the integration of floating control systems gains traction. However, this would require addressing core challenges, primarily profitability and substructure design.

As the dynamic nature of the floating offshore market creates opportunities for various players to emerge as key leaders in the coming years, the analysis of market trends leads to the identification of challenges and risks faced by the market. These challenges include:

- The presence of high financial costs and the associated issues.
- The elevated Levelized Cost of Electricity (LCOE), ranging from approximately €150-200/MWh in 2021, which diminishes the attractiveness of investments aimed at streamlining support structures.
- The lack of accessible data, creating barriers to risk appraisal and eroding investor confidence, thereby hindering the expansion of the market.

4.3 KEY FINDINGS AND INSIGHTS RELATED TO KER 1 AND KER 5

Regarding KER 1, the market study highlights the **value proposition** of QBlade-Ocean which centers around its accessibility to a wide audience, practicality for both novice and experienced professionals, and its adaptability to meet the needs of advanced users in the dynamic field of wind turbine design.

Moreover, the market currently provides numerous software alternatives with functionalities akin to QBlade. Certain competitors had already incorporated floating offshore systems prior to the introduction of QBlade-Ocean:

- Ashes
- OpenFAST
- OrcaFlex,
- DeepLines Wind
- HAWC2

Table 4: Shared complementaries between market providers (from the market study)

Software/Criteria	Open-Source/access	Free-Version	Programming knowledge	Most probable target group
QBlade	Yes – open access	Yes – limited features	Not necessary but helpful	Research and academia
Ashes	No	No	No – but helpful	Industry
OpenFast	Yes – open source	Yes	Yes – necessary for usage	Industry and academia/research
OrcaFlex	No	No	No – but helpful	Industry
HAWC2	No	Yes	Required to some extension due to interface	Industry and academia/research

Table 5: Streghts, weaknesses and opportunities of KER 1

Strengths	Weaknesses	Opportunities
Open-Source Flexibility	Uncertainties in Offshore and Floating Turbine Calculations	Interest from Certification Bodies
User-Friendly Interface		
Advocacy Potential		
Accurate Load Calculations		
Credibility and Validation		
Extensive Validation for Onshore Turbines		Collaboration with Academia
Promising Offshore and Floating Turbine Results		
Optimized LLFVW Method		
Support for Wind Farm Layout Analysis		

Regarding KER 5, the market study focuses on two elements: value proposition and market potential (current projects and potential customers).

KER 5's value proposition relies in wake losses mitigation. Wake losses, induced by rotational trails, can significantly reduce wind farm efficiency, estimating up to a 20% efficiency loss in larger offshore farms. Implementing control mechanisms to mitigate wake losses has the potential to increase power generation downstream of wakes, thereby lowering overall energy production costs. The market study reveals that no large-scale implementation of downward wake optimization control mechanisms has been achieved, presenting a valuable opportunity for innovation.

Regarding the KER's market potential, the Siemens Gamesa's Wake Adept project, implemented in 2019, showcased the feasibility of active wake control, claiming up to a 1% increase in annual energy production for offshore wind farms. The ongoing "Wake Effect" project in 2021, in collaboration with TU Delft, explores the implementation of active wake mixing and wake steering methods. The Wake Mixing Method holds promising potential to revolutionize wind turbine efficiency and reduce wake losses. With ongoing projects and limited publicized initiatives from competitors, this innovative approach presents a unique market opportunity. Its potential customers are listed below:

- Manufacturing Companies: The innovative control method proposed in the FLOATECH project could be immensely valuable for turbine manufacturers, offering mutual benefits by incorporating design changes to optimize wake mixing.
- Wind farm operators stand to gain significantly from wake mixing control technologies. Higher margins for power generation and reduced maintenance due to decreased loads on turbine structures make them a key customer group.
- Policy makers and regulatory bodies are potential stakeholders, as control techniques contribute to the overall sustainability, efficiency, and environmental impact of offshore wind energy.
- Research institutions and academia are valuable benefactors. The findings from this innovative control system contribute to the knowledge base, providing insights into technical feasibility, performance, and optimization of wake mixing control in floating wind farms.

5. KNOWLEDGE MANAGEMENT AND IPR ISSUES

As part of the project, a Consortium Agreement has been signed to address all relevant issues related to IPRs and the results generated during the project (access rights to background and foreground necessary for the execution of the Project, rules for dissemination and use of own knowledge, etc).

The Consortium Agreement (CA) complements the rules of the Grant Agreement. In the Consortium Agreement, information on the following items is detailed:

- Which knowledge the consortium will exchange?
- Under which conditions?
- Who will be the owner of the results?
- What happens in cases of joint ownership?
- Who (and how) will exploit the results?
- Who (and how) will disseminate the results?
- How is the consortium protecting confidential information?

As a rule, IPR is the property of those partners who have contributed to get the knowledge. The degree of ownership will depend on the degree of contribution to the IPR. This applies if it does not violate national legislation, specific agreements for scientific publication, and specific agreements among partners regarding ownership of IPR. Partners, that have jointly carried out work generating foreground and where their respective share of work cannot be ascertained, shall have joint ownership of that foreground, and may establish appropriate joint ownership agreements or license agreements.

During the ESS Seminar, the IPR roadmap was identified by the partners for KER 1, 2 and 5.

Table 6: IPR Roadmap identified during the ESS Seminar

No	Name of the KER	Targeted audience	First users	Availability	IPR this result is based on	IPR these results produced
1	QBlade-Ocean simulation suite	University level teaching, research and wind turbine design & certification	The general public and research community as well as established WT manufacturers and consultants	It is already available on qblade.org	The copyright of the complete QBlade code is owned by D. Marten, main developer of QBlade	The copyright of the public source-code of QB-Ocean
2	LCOE evaluation tool taking into account control technologies developed within the project	Universities: Professors and students in Engineering and Economy on Energy related topics; Research: Academic and Research community, especially researchers in Economy and Engineering of the floating offshore wind energy field; Industrial: Companies in the field of offshore wind energy (during the predesign phases, single component and control strategy development); Policy makers: Control authorities involved in the definition of the offshore wind energy	University Professors and Students during lectures and master degree and PhD theses (for example, Mechanical and Energy Engineering of University of Naples "Federico II").	End of the WP5 (September 2023)	None	None

		regulatory policy.				
5	Innovative control to enhance wake mixing control in floating wind farms	Companies that design floating substructures developing floating wind solutions might be considered among interested parties. Alternatively, the technology can also be deployed in wind farms by wind farm operators. Finally, it can also be used as education to showcase the concept of co-design (through e.g. assignment or lectures).	Academia. Given the highly academic nature of the KER, it is likely that further research will be done with the results which, down the line, might end up with other targeted users.	At the end of the FLOATECH project (31-12-2023), a report should be available.	IPR related to the Helix wake mixing methodology.	There is a patent that covers, in general basis, the idea to design controllers and floating turbines such that they enhance wake-mixing. This patent is property of the TU Delft.

In the aftermath of the ESS Seminar, a strategic focus on Intellectual Property (IP) protection has been employed to safeguard and manage the dissemination of key exploitable results (KERs). This section outlines the specific steps taken for each KER, emphasizing the varying approaches and considerations for IP protection.

Regarding **KER 1**, the QBlade software and its source code is distributed publicly under the Academic Public License (https://qblade.org/assets/APL.txt), which allows QBlade (and its source code) to be used in a non-commercial setting. Recognizing the diverse needs of different users, particularly in the commercial sector, we have also developed a specialized commercial license. This commercial license differs from the public one in a significant aspect: it provides access to additional functionalities (not developed in the context of FLOATECH) while keeping its source code proprietary. This approach not only facilitates broader usage of QBlade across various sectors but also ensures the protection of intellectual property, balancing openness in academia with the commercial interests of users.

Regarding **KER 2**, no restriction has been applied to the dissemination of the results and no IPR action has been explicitly undertaken. The description of the model development procedure, which is the main result of the work, is reported in three FLOATECH deliverables released in the public domain and available from the FLOATECH website. The spreadsheet tool can be released to interested researchers or developers on request.

For **KER 3** no restrictions have been applied.

KER 4 falls in the expertise area of the Open-C Foundation the largest European offshore testing centre entirely dedicated to floating wind turbines and renewable marine energies that gathers 10 public and private founders (Ifremer, Centrale Nantes, ITE France Énergies Marines, EDF, RTE, TotalEnergies, Technip Energies, Valorem, Valeco, Énergie de la Lune).

Regarding **KER 5**, all research data used in a published work is openly available. It is published on the 4TU repository with each paper having a DOI linking to the specific data set. The idea itself of using platform motion to enhance wake mixing is patented by TU Delft. The patent can be found under patent number WO2022240292A1.

Regarding **KER 6**, NEMOH v3.0 is an open-source software that is released under the GNU GPL v3.0 License. The main features are recapped here: https://www.gnu.org/licenses/quick-guide-gplv3.en.html. The IP is own 100% by ECN (different authors of the code), which guarantees a straightforward management of licensing, exploitation, etc. In terms of availability, the code is freely accessible on the gitlab.com platform: https://gitlab.com/lheea/Nemoh.

Regarding **KER 7**, a high-quality open-source DATASETS for public use has been developed:

- Design Load Case Database for Code-to-Code Comparison
  - https://zenodo.org/records/8383686 (OC4, SOFTWIND and HEXAFLOAT FOWTs)
- Aero-hydro-elastic model definition of three FOWT concepts
  - https://zenodo.org/records/8337539 (OC5 FOWT)
  - https://zenodo.org/records/8337433 (SOFTWIND FOWT)
  - https://zenodo.org/records/7037256 (HEXAFLOAT FOWT, restricted access)
- An Open-Source Procedure to Derive Met-Ocean Conditions for the Simulation of Floating Wind Turbines
  - https://zenodo.org/records/10102696

Regarding **KER 8**, the database is online on Zenodo (open data), at least in parts; the rest should follow in the coming months (after the end of the project), as soon as we have published the papers in partnership with TU Delft. This will be done with full consent of both parts LHEEA and TUDelft.

Regarding **KER 9**, the field trials were merely a demonstration effort. No new IP was generated.

Regarding **KER 10**, as of KER 2, no restriction has been applied to the dissemination of the results and no IPR action has been explicitly undertaken.

Regarding **KER 11**, QBlade has been, and continues to be, used to introduce interested students to the field of wind turbine blade design, certification and load simulation through the master's course Design and Simulation of Wind Turbines.

6. WHAT'S NEXT

6.1 THE EXPLOITATION STRATEGY OF THE FLOATECH KERS

This section delves into the strategic avenues for the exploitation of FLOATECH's KERs. The exploitation strategy outlined encompasses a diverse set of approaches tailored to each specific KER.

Regarding **KER 1**, following the conclusion of the project, our strategy for the exploitation of QBlade involves a dual approach, primarily facilitated through our dedicated website, https://qblade.org. Firstly, the website serves as the central platform for distributing the free academic version of QBlade, known as QBlade-CE. This version is tailored for academic and research purposes, allowing educators, students, and researchers to access and utilize QBlade's capabilities without any cost. In addition to the academic version, we are actively engaging with the commercial sector by offering QBlade-EE, a proprietary version of the software. This version is available under various commercial licenses, catering to the diverse needs of industry professionals. The commercial licenses not only provide access to the advanced features of QBlade-EE but also include comprehensive consulting support. This support is designed to assist commercial users in effectively integrating QBlade into their specific projects and workflows, ensuring they derive maximum benefit from the software. Through this bifurcated approach, we aim to maximize the reach and impact of QBlade. By offering a free version for academic use and a licensed, feature-rich version for commercial applications, we are able to support a wide range of users, from researchers advancing the field of wind turbine technology to industry professionals seeking to optimize their designs and operations.

Regarding **KER 2**, the developed model has been used to set up an LCOE estimation tool, implemented using a spreadsheet, which takes as input the main configuration (geometry), performance (power curve and loads) and operating environmental data (wind statistical distribution) of a floating wind turbine. A potential interested audience has been identified, encompassing a broad range of areas: academic (both for educational and research purposes), industrial researchers, policy makers. The first steps in the exploitation strategy will be oriented to the development of scientific publications (not already undertaken during the project due to the fact that the tool development work was extended close to the end of the project duration). Further exploitation activities will include the application of the developed procedure and tool to specific case studies for model validation and improvement.

Regarding **KER 3**, part of the results obtained will be used as validation of the new developments of QBlade especially in the FLOATFARM project (the follow-up project of FLOATECH starting in January 2024).

Regarding **KER 4**, the Open C Foundation will most likely used this fundamental and technological research in sea trials as they play a major role in experimental development. They enable prototypes to be validated in real-life conditions, as well as pre-industrial tests.

Regarding **KER 5**, as of yet there is no clear plan regarding the exploitation of KER5 after the project aside from continuing the research in FLOATFARM. It could potentially be featured in different research projects.

Regarding **KER 6**, the open-source release of NEMOHv3.0 will ensure a possible large broadcast of the software and the necessary interactions with the users. It is expected that it becomes a standard tool for the description of 1st and 2nd order hydrodynamic loads on fixed and offshore structures in design offices or R&D departments. Hopefully, the open-source release will motivate further developments of the software by the community through possible collaborative projects.

Regarding **KER 7**, the validation and quantification of the overall accuracy of QBlade-Ocean represents the key enabler for the software itself. It will allow considering the software as a ready-to-use instrument for the analysis of floating wind turbines.

Regarding **KER 8**, the data collected during the project will be exploited during future studies such as the validation on numerical models that may be developed at LHEEA by PhD students and for the papers we are preparing for publication.

Regarding **KER 9**, the aim is to proceed in our efforts to both improve the wave prediction algorithms and to understand better the conditions at which deterministic wave prediction is successful. i.e. further research/development

Regarding **KER 10**, the LCOE estimation tool, developed throughout WP5, has been applied to a floating turbine configuration to estimate the effectiveness of the two novel control technologies developed in the project (Active Wave Control and Active Wake Mixing). The performed economic assessment of the new technologies offer a possibility for a direct exploitation in orienting the further development of the control strategies, highlighting the strengths and the possible improvement areas.

Regarding **KER 11**, the lectures will most likely evolve with the extension of QBlade-Ocean. An additional course could potentially be structured around the added complexity that floating offshore wind presents.

6.2 HORIZON RESULTS PLATFORM

After the end of the project, the results will be uploaded to the Horizon Results Platform which represents a strategic step to maximize the impact of the FLOATECH project by ensuring compliance, sharing knowledge, fostering collaboration, and promoting the broader utilization of the project's outcomes. A template was created and shared with partners by Euronovia to collect information on KERs to be uploaded on the platform.

The following KERs were selected by the partners to be promoted on this platform, since these are considered to be the most promising ones:

- **KER#1 Q-Blade simulation tool** is a publicly distributed simulation suite that brings value to the scientific community through advanced simulation capabilities. In addition, it has an intuitive GUI that allows young researchers and students to easily access wind turbine simulations
- **KER#5 Active wake mixing techniques** are innovative solutions that have the potential to increase the AEP of existing wind farms. The first analysis shows that it is feasible and opens the door for further research to analyse the strategy also from a load analysis perspective.
- **KER#6 NEMOH v.3** is also an open-source simulation that now has the ability to calculate quadratic transfer functions, allowing researchers to more accurately simulate and analyse structures without the need for commercial use.

6.3 THE FLOATFARM PROJECT

Building on the outcomes of FLOATECH, a new project running from January 2024 until December 2027 is receiving funding under Horizon Europe: FLOATFARM will ensure the proper exploitation of the FLOATECH results, bringing the technologies developed within FLOATECH to the next level of technological readiness, complementing them with a significant number of new concepts, innovations, and methods, to make FOW enter a new phase of industrial maturity.

Indeed, several KERs of the FLOATECH project will be used in the FLOATFARM project:

- **KER 1:** QBlade will be directly applied in several technical work packages of FLOATFARM. QBlade will be used in WP1 to generate a novel wind turbine reference design, incorporating several key technologies investigated in FLOATECH and FLOATFARM. WP2 sees QBlade performing dual functions. Firstly, it generates essential loading data for UGE's advanced structural modelling tool, for higher order structural analysis. Secondly, QBlade is instrumental in simulating various shared mooring concepts for Floating Offshore Wind Turbines (FOWTs). In WP3, QBlade's functionality receives an upgrade through the integration of a novel higher-order aerodynamic tool. This enhancement significantly boosts its capability to model complex turbine wake interactions in wind park settings. Additionally, QBlade in WP3 is used for refining the control solutions, namely the helix and wave feed-forward methods, developed in FLOATECH. WP4 involves a critical validation process, where the shared mooring simulations from QBlade are rigorously tested against experimental tank measurements. This step ensures the reliability and accuracy of the simulation data. Lastly, WP7 integrates QBlade into the WEIS optimization framework, enabling a co-design functionality. This integration is a cornerstone for all other WPs utilizing QBlade, ensuring a cohesive and streamlined exploitation of the software across the FLOATFARM project.

- **KER 2:** Furthermore, a direct exploitation of the developed model is related to the continuation and extension of the work to be carried out within the EU funded FLOATFARM project, which will include a work package dedicated to economic assessment analyses and to the improvement of the developed LCOE model, aiming at its integration in an overall floating turbine optimization framework.

- **KER 3**: The wind tunnel data that was generated for KER3 will be used to compare results from QBlade in FLOATFARM (WP3). Furthermore, the ideas presented in FLOATECH are further expanded on in FLOATFARM.

- **KER 5:** Active wake mixing techniques will be further researched in the framework of the FLOATFARM project.

- **KER 6:** In FLOATFARM, it is expected that all hydrodynamic databases at use in QBlade-Ocean will be obtained thanks to NEMOH v3.0. It includes first-order as well as second-order hydrodynamic description of the floaters.

- **KER 7**: QBlade-Ocean is now ready and fully validated. It will represent the key element for most of the analyses in FLOATFARM and will be included in the MDAO framework to harmonize the key innovations that will be developed.

- **KER 9:** In FLOATFARM we will make the step from validating wave prediction towards validating motion response. We have the objective to learn which factors are driving the accuracy of deterministic prediction since we will have the rare opportunity to compare wave prediction (from FLOATECH) with motion response prediction (from FLOATFARM), and therefore will be able to address the effect of the response model separately from the effect of the wave initialization and prediction model.

- **KER 10**: Moreover, the results of the analysis will be used as a basis for new applications and improvements for the development of the introduced control techniques, in in the framework of the FLOATFARM project to be continued in the upcoming FLOATFARM program; furthermore, the results of the study will provide a background for the FLOATFARM activities dedicated to the improvement of the LCOE model itself.

Some KERs won't be exploited in the framework of the FLOATFARM project, it is the case for KER 4, 8 and 11.

In addition, FLOATFARM will pay special attention towards decreasing the negative environmental impacts on marine life and to enhancing the public acceptability of FOW farms. With FLOATFARM, nine additional partners (3 academic and 6 industrial partners) have joined the FLOATECH consortium: Universiteit Gent (UGE), Danmarks Tekniske Universitet (DTU), Sofresid Engineering, Sowento, Innosea, Consiglio Nazionale delle Ricerche (CNR), BlueOASIS, France Energie Marines (FEM), Hagnesia.

7. CONCLUSION

In conclusion, the execution of exploitation initiatives throughout the project adhered to the stipulations outlined in the Grant Agreement. Over the entire duration of the project, each partner demonstrated commitment and contribution to the implementation of the methodology designed for identifying exploitation initiatives.

Numerous activities were undertaken, and a diverse array of tools was developed to actively engage partners in the identification of project outcomes. The enthusiastic participation of all project partners in the exploitation efforts demonstrates a shared dedication to ensuring the sustained impact and relevance of the project results. As the project draws to a close, the commitment of all partners to continue the exploitation activities in strict accordance with the terms laid out in the Grant Agreement solidifies the foundation for a seamless transition from project implementation to long-term impact and applicability.

All project partners successfully delineated comprehensive plans for the post-project exploitation of results, with a particular focus on integration within the broader scope of the FLOATFARM project. This underscores a collective willingness to sustain the project's results and emphasizes a strategic intent to leverage the accomplishments of FLOATECH.