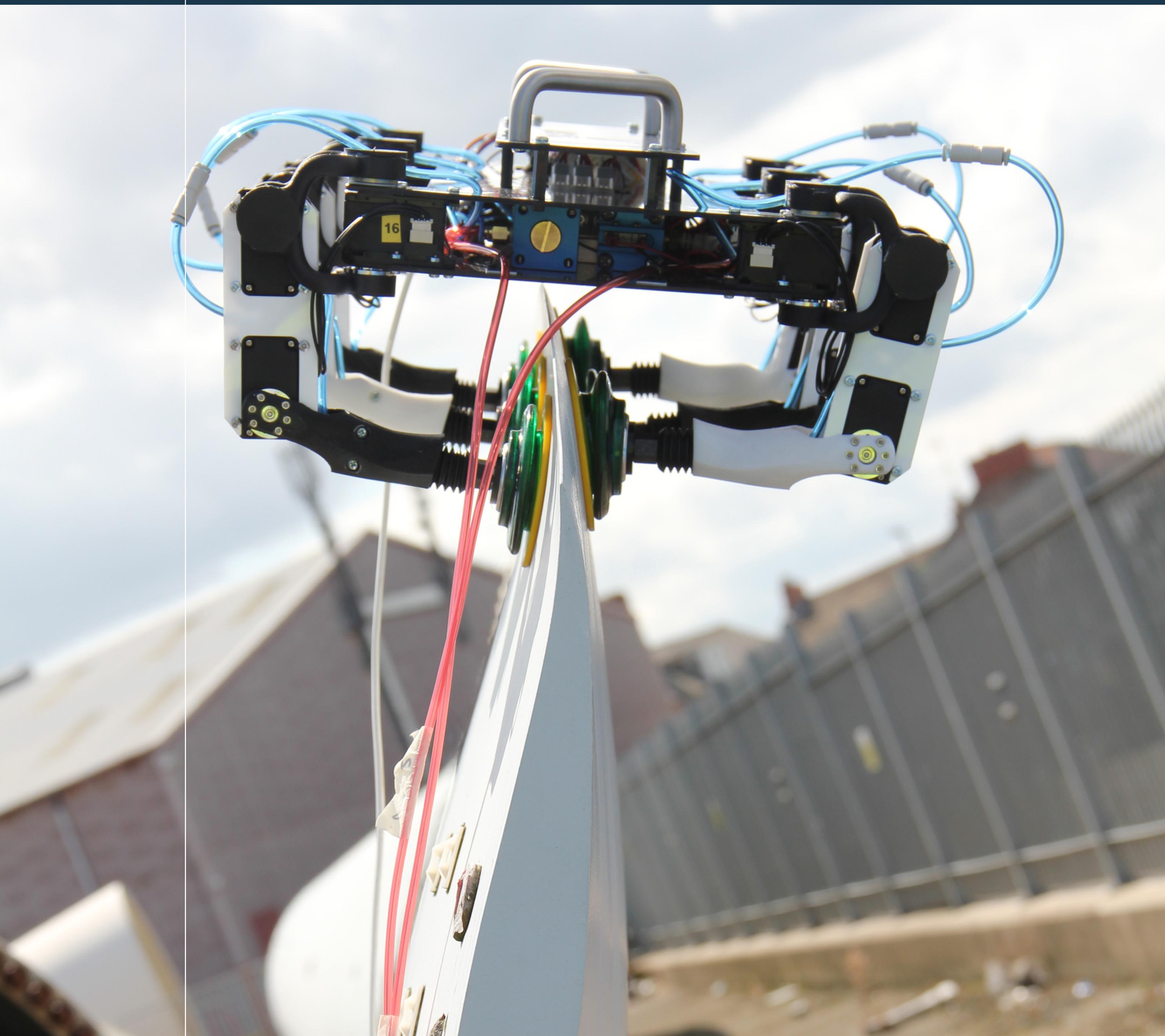
SME GROWTH PLATFORM REPORT

An innovator's guide to

TECHNOLOGY COMMERCIALISATION IN OFFSHORE WIND



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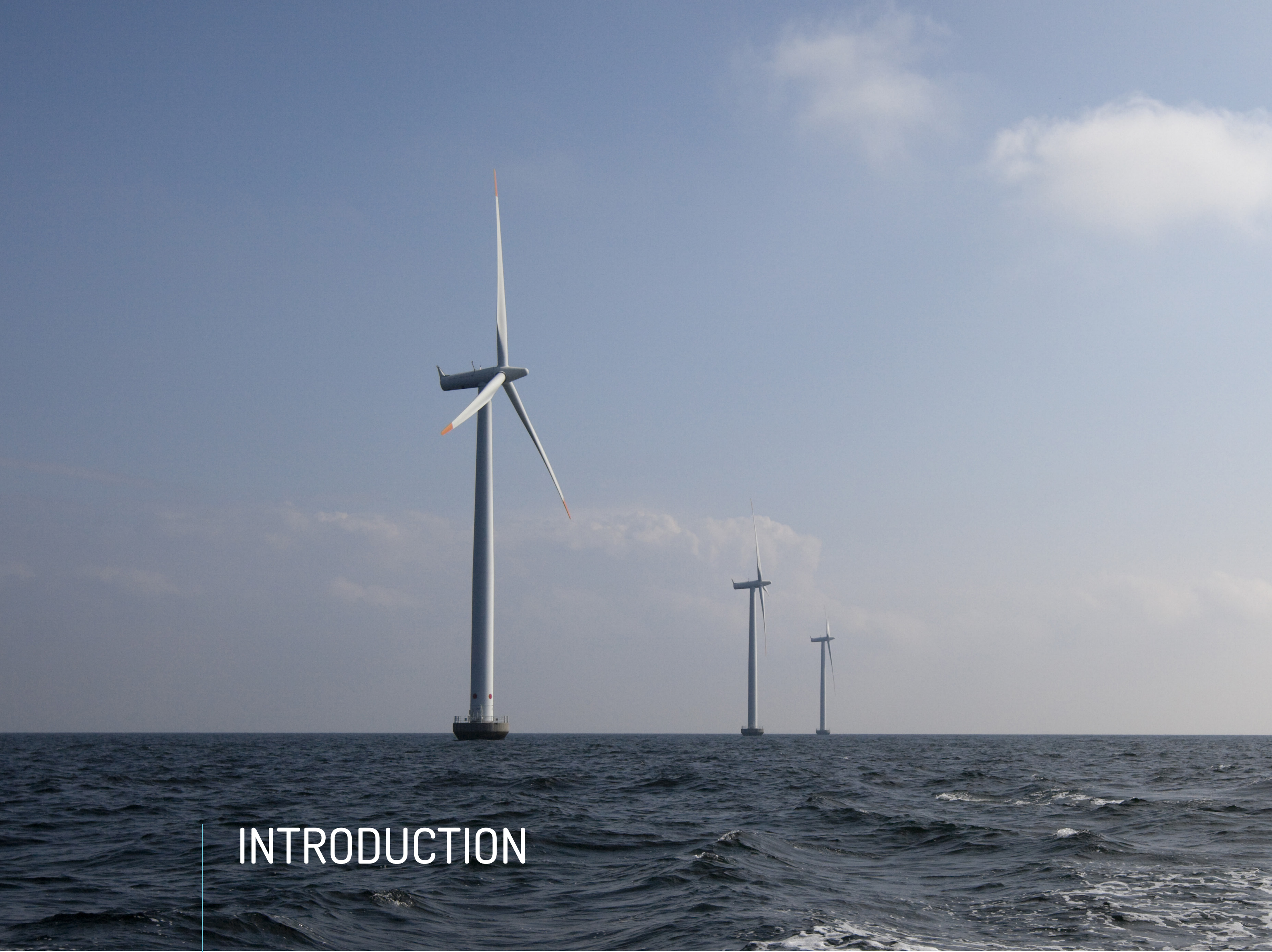
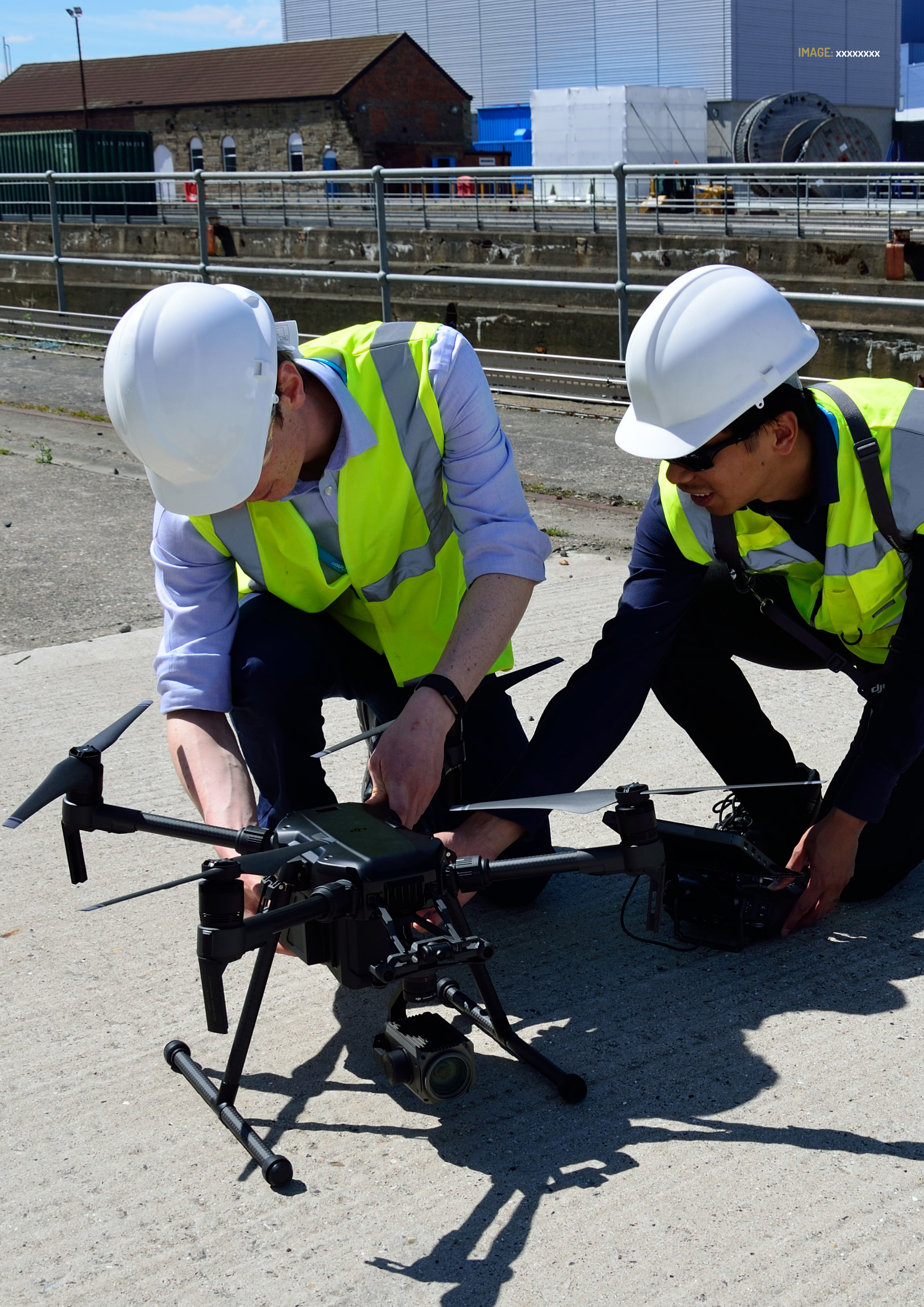


INTRODUCTION

This document is a source of information and guidance for innovators looking to commercialise a product or service and enter the offshore wind market. Bringing a new technology or product into any new market is never straightforward, and presents its own set of challenges and barriers. The offshore wind sector is no exception. Every company needs to find its own path to technology implementation and every path is unique. However, this report provides some basic guidelines for innovators looking at commercialising new technologies and introducing new products into offshore wind in the UK, as well as where to find additional support.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SECTION 1

STEPS TO TECHNOLOGY COMMERCIALISATION IN OFFSHORE WIND

How to manage the steps needed to bring technology into the offshore wind market

1 STEPS TO TECHNOLOGY COMMERCIALISATION IN OFFSHORE WIND

As with most new technologies, when bringing new products into the offshore wind market, development is typically needed across three key areas:

Technology development	Technical steps needed to develop and prove the performance of a technology or product
Commercial preparation	Steps needed to understand the commercial proposition and successfully position the product within the market
Market readiness	Steps required to ensure the market is ready to receive the technology; this may require regulatory change or supporting infrastructure or even steps to address softer barriers such as technology awareness and education

Where good technologies fail to make the transition from idea to product, this can often be due to companies over-focussing on the technology development to the detriment of the commercial and market proposition.

A range of models for product stage gate design, technology and commercial readiness are available to guide companies through the development steps required and many can be found with a quick internet search. In most cases these can be simplified into seven generic steps, linked approximately to technology readiness level (TRL), which are illustrated below.

TRL 1-2	TRL 3	TRL 4	TRL 5-6	TRL 7-8	TRL 9	
Concept Development	Proof of Concept	Design	Testing & Verification	Prototyping	Demonstration	Product Launch
Concept definition & assessment of basic feasibility of technical and commercial proposition	Desk-based verification of initial commercial and technical assumptions	Detailed design and initial lab-based verification of assumptions	Testing of components, systems and system integration	First pre-commercial model operating in representative conditions	Engagement with end user to demonstrate technology in operational environment	Full commercial product issued to market

The figure above highlights the relative effort required at each stage of the process, and the need for early effort on understanding the market and commercial requirements before changing the focus onto technical development during the mid-stages of the process. The level of effort and resource required will vary depending on the technology being brought to market. At the most extreme end, bringing a new offshore wind turbine to market can £100-200 million and typically takes 2-5 years.

Whilst the development process is usually presented as a linear progression it is usually iterative, with design, testing and verification and business model development being carried out throughout the process as the concept and design is refined and optimised. The key activities during the phases are outlined in Section 2.

CHARACTERISTICS OF THE OFFSHORE WIND MARKET THAT MAY AFFECT COMMERCIALISATION

Whilst the steps needed to commercialise innovation in the offshore wind market are similar to other sectors, the offshore wind market has its own unique set of characteristics that can affect the approach and success of technology commercialisation

Notable characteristics include:

Generally low appetite for high levels of technology risk

High cost of failure and large capital cost of equipment mean that developers and, importantly, project investors have low tolerance of technology risk.

High focus on reliability

Both the cost of offshore repairs and the loss of revenue for downtime drive a high focus on reliability.

Strong drive for cost reduction

The success of the industry to date, has, to a large extent, been driven by focussed efforts by the sector to reduce costs, allowing it to compete with other energy technologies. In the UK, the cost of offshore wind has fallen by 32% since 2012, and the focus on cost reduction remains.

Increasingly global market

To date, offshore wind development has mainly taken place in Europe, and consequently is dominated by a European supply chain. Increasingly, the offshore wind sector is becoming a global market with emerging markets in Asia and the US.

The established European suppliers still dominate most global markets; however, most markets have a drive for local content so the local supply chains are developing, particularly for balance of plant, auxiliary systems and O&M.

Limited end users

There are a small number of dominant developers and turbine OEMs who are the key users of new technologies in the sector. In addition, there are relatively few new projects coming on line in the UK each year (1-2). This limits the routes into the sector.

1.1 TECHNICAL DEVELOPMENT

Technical development of new products is likely to require a significant portion, if not the majority, of an innovative SME's funding and resources. The table below summarises the key activities required during technical development. Additional information, including where to get support, can be found in Appendix 2.

Technical Development

Activity / Development Phase	Concept Development	Proof Of Concept	Design	Testing & Verification	Prototyping	Demonstration	Product Launch
Concept Feasibility Assessment & Refinement				●	●	●	
Technical Delivery Plan – Development & Use	●						
Design Specification	●	●				●	●
Component & System Design	●	●					
Lab-Based Verification of Key Elements of Technology		●	●				
System Integration	●	●	●	●	●	●	●
Product Testing & Certification	●			●		●	
Prototyping & Demonstration			●	●	●		

These activities are outlined in more detail in the table below.

Activity

Concept feasibility assessment and refinement

Phases during which effort is required

Concept development	Proof of concept	Design	Testing & Verification	Prototyping	Demonstration	Product launch
■	■					

Technical concept feasibility and refinement typically consists of a desk-based high-level engineering review to identify any fatal flaws that will prevent the technical or commercial delivery of the concept.

During this activity, the concept is refined through technical reviews and top-level design iterations based on simple calculations and modelling, and from input on customer and market requirements.

Innovators should gather the data required to formalise an initial design specification. Technical aspects of the concept should be defined sufficiently for development of the business case and route to market.

Information to should consider:

- Functional and performance requirements
- Customer requirements and constraints
- Key interfaces both internally and with the real world
- Critical component supply
- Consequences of failure

At this stage it is also important to understand and define the technical advantage a product provides over competitors' devices or alternative technologies.

It is also critical that an IP review is carried out to identify any existing IP owned by other organisations that may prevent technology development. This is also a good time to develop a strategy to protect IP that is core to the product. Further details on IP capture and management strategy are given in Section 3.6.

Tip:
The key mistake many companies make at this stage is lack of integration between technical feasibility analysis and customer and market requirements. This should be considered a key driver at all times.

1.1

Activity

Technical delivery plan – development and use

Phases during which effort is required

Concept development	Proof of concept	Design	Testing & Verification	Prototyping	Demonstration	Product launch

A technical delivery plan outlines the steps needed to bring a product to market. The most appropriate approach to a delivery plan depends on the type of technology to be developed and the culture of the company. There are many examples of technology delivery plans online, and extensive information can be found on the various project management styles, from agile scrum-type methods to more traditional goal-focussed methods. Most have the following considerations in common: resource, responsibilities, key tasks, timeframes, and key milestones.

A clear delivery plan is not only vital to ensure team members understand their tasks but is also likely to be required by investors or funders. It will also feed into the key commercial decisions concerning resourcing and investment strategy and can be used to carry out a skills gap analysis. This can in turn be used to drive the recruitment plan and to identify development partners.

Risks associated with the delivery of the plan should be identified and logged in the Programme Risk Register and mitigations should be identified. The risk register should remain a live document and be reviewed regularly.

Tips:

Prevent Scope creep: *the design process is iterative and without control can be infinite. Resist pressure to include just one more upgrade or additional function.*

Don't ignore delivery plans: *it is tempting to put together a project plan for investors and stakeholders and then get back to developing technology. Don't.*

Make delivery plan flexible: *nothing ever goes completely to plan when delivering new technologies.*

Activity

Design specification

Phases during which effort is required

Concept development	Proof of concept	Design	Testing & Verification	Prototyping	Demonstration	Product launch

To progress to detailed design and testing, some degree of lock-down of the overarching design specification will be needed. This is a critical stage in the process needed to prevent scope creep and ensuring a delivery plan stays on track and on budget.

It is unlikely the design specification can be fully locked down at the early stage of the commercialisation process since feedback from the design process, testing and customer engagement should inform refinements in the specification. However, any changes in the technology requirements can be more easily controlled if there is a formal design specification in place.

A comprehensive design specification could include:

- Functional requirements: what does it need to do?
- Performance requirement: how well does it need to do it?
- Test standards, certification, and regulatory constraints
- Load and design life (typically 25 years for a turbine component)
- Operating conditions (e.g. depth, wave height, seabed conditions)
- Safety levels and fault tolerance
- Customer requirements/constraints (e.g. size, weight, transportability, packaging)
- Interfaces with other systems or technologies
- Cost
- Manufacturing, material, or supply chain constraints
- Maintainability
- Condition and performance monitoring requirements

Tips:

A good design specification can ensure alignment across the commercial and technical members of the team, however buy-in from all stakeholders is vital. A 'Design Specification' could equally be termed a 'Product Requirements Specification' to reflect the fact that it should ideally contain commercial requirements as well as those from external stakeholders.

1.1

Activity

Component and system design

Phases during which effort is required

Concept development	Proof of concept	**Design**	**Testing & Verification**	Prototyping	Demonstration	Product launch

During the design phase, detailed engineering activity and modelling is carried out to develop the designs and drawings needed for manufacturing components, systems, and prototypes. Design activities should be based on the Design Specification. There is opportunity for design activities to drive small changes in the Design Specification, but these should be minor and not compromise the focus on customer requirements. Design management is key, comprising a defined series of design reviews with independent peer review and sign-off against achieving agreed objectives. Occasionally, depending on the nature and complexity of the development stage, it may be worth paying for an external 3rd party review.

In many cases, design is a collaborative activity between suppliers and the company. Within SMEs, system and interface design is typically done in-house by the company, but much of the detailed component design may be carried out by suppliers. Close collaboration with suppliers is recommended, but as a minimum they will require detailed design specifications and an understanding of the interface between their component(s) and the system as a whole.

During the design phase, the types of analysis and modelling carried out will vary depending on the technology. Specialist tools (CFD, FEA, dynamic and control simulations, etc.) may be needed. **However, some key areas are often overlooked during this phase, including:**

- Sub-systems and system integration, interface control
- FMEA (Failure Modes and Effects Analysis)
- Design risk assessments
- Manufacturability – review of materials and processes, both for prototypes and commercial product
- Serviceability modelling including condition monitoring, diagnostics, and modular equipment design
- Supply chain engagement

Tip:
One of the most common mistakes made during the detailed design process is allowing the design parameters to drift from the Design Specification. To prevent this, it is good practice to carry out regular design reviews, and even external peer reviews, during the design process.

Activity

Lab-based verification of key elements of technology

Phases during which effort is required

Concept development	**Proof of concept**	Design	**Testing & Verification**	Prototyping	Demonstration	Product launch

Laboratory-based small scale testing provides a relatively low-cost way to:

- Provide feedback on initial designs
- Confirm validity of engineering models and extend models' capabilities
- Investigate uncertainties (e.g. behaviour under off-design, fault, or extreme conditions) that are hard to model
- Provide evidence of performance for customers, investors, or certification bodies.

For larger wind farm components, such as blades, testing programmes can take over a year and require a wide range of testing including:

- Structural (sections and whole components)
- Functional
- Material (coupon, beam, coating performance)
- Performance under a range of operating conditions
- Accelerated life testing

Section 2.3 of this report provides a more detailed overview of testing in offshore wind and widely used test standards and typical operating conditions.

Tip:
Test facilities can support you in designing your test programme and ensure you get the best performance out of their equipment.

1.1

Activity

System integration

Phases during which effort is required

Concept development | Proof of concept | Design | Testing & Verification | Prototyping | Demonstration | Product launch

System integration requires assembling all hardware and software developed for the technology into a complete or closely representative system. Broadly, this is putting it all together to make sure it works. This allows testing of interfaces and overall functionality of the technology.

Testing of system integration at this stage can save significant effort and money during the more expensive full testing and verification processes. The nature of this system integration and testing will depend on the nature of the technology being developed.

Tip:
Ensure you have a clear idea of what you want to achieve during system integration testing. A clear aim can allow efficient use of instrumentation, save costs and ensure the opportunity to gather relevant data is not missed.

Activity

Product testing and certification

Phases during which effort is required

Concept development | Proof of concept | Design | Testing & Verification | Prototyping | Demonstration | Product launch

Test, verification and in some cases certification activities should be driven by a detailed Test and Verification Plan, which should be developed and integrated into early programme planning activities.

Whilst test and verification plans can be complex and variable, they all share three key aims to:

- Provide feedback on designs to allow design optimisation
- Verify assumptions in models used during the engineering process
- Provide evidence to reassure customer and investors that the technology is viable

In the commercialisation process presented in this report, testing and verification is shown as one phase, but small-scale testing to inform design choices and to verify assumptions can be carried out throughout the concept development and design phases as well as during the test and verification phase.

Types of testing that are commonly carried out are outlined in section 2.3 of this report but commonly include material testing, accelerated lifecycle testing, failure mechanisms and operation under simulated operational conditions. The time needed to deliver a testing programme is hugely variable depending on the technology, but a large component testing can take up to year.

The level and types of tests carried out will be driven by end-user, customer and investor specifications. These are often provided through a requirement for specific certification (such as a turbine blade, for which DNVGL Type Certification will be needed), or adherence to specific test standards. Alternatively, for more complex novel technology (e.g. turbines or large turbine components) customers may specify a new equipment qualification plan. More information on certification and test standards can be found in section 2.3 of this report.

Tips:
Check early that facilities are available: there can be a waiting list of over a year to access specialist facilities, and in some cases the required facilities might not exist.
Don't underestimate cost and time: for specialist offshore wind testing, this can be high.
Make sure you have enough and the right instrumentation: be clear what you are trying to achieve and plan accordingly
Spend time planning management of data: testing can produce a large amount of data. A solid strategy is needed to produce useful results.

1.1

Activity

Prototyping and demonstration

Phases during which effort is required

Concept development	Proof of concept	Design	Testing & Verification	Prototyping	Demonstration	Product launch

During the prototyping and demonstration phases, the complete system is operated in an environment that is representative of its final operating conditions.

Prototyping typically involves the installation or use of a fully instrumented single device primarily for gathering data on performance and identifying any design tweaks that should be made in the final product. For a wind turbine, the prototype is also used for certification. The operational time required before moving to a full-scale demonstration varies by technology and can be dictated by testing standards. For a wind turbine or large turbine component this is typically 10,000 running hours to ensure system reliability during long term operation. To date wind turbine manufacturers have demonstrated their offshore technology at onshore test sites to reduce costs and allow access. However, some technologies such as novel foundations or subsea inspection tools will need to be prototyped offshore.

Whilst prototyping is focussed on data gathering and ensuring performance meets expectations, demonstration focusses on convincing the customer or end-user that technology is viable and will offer them benefits. In addition, if the technology could have significant impact on the performance of a wind farm, demonstration activities must convince the developers' investors that the product will not negatively impact revenue from the site (often referred to as bankability). Cost of demonstration can, in some cases, be shared with the end user, with the end user paying close to commercial rates for accessing technology but with extended warranty or performance guarantee to mitigate technology risk.

Additional areas for consideration during the prototype and demonstration activities include:

- Supply chain development: during these phases it is important to establish the supply chain that will be able to deliver at full commercial scale. It may be different to the prototype and demonstration. The supply chain can be tested during the delivery of demonstration activities
- Commercial packaging: details such as final appearance, branding, transport tooling and supporting documentation should be developed at this stage
- O&M: service packages and O&M offering should be developed

There is limited availability of sites for full turbine demonstration. Large turbine components will need to be demonstrated in conjunction with wind turbine manufacturer, so buy-in to the new technology is needed at an early stage. For less integrated devices, such as inspection technologies, persuading wind farm owners to give access to test site can also be a challenge. More guidance on accessing demonstration sites is provided in section 2.4 of this report.

Tip:
One of the major barriers to commercialisation of technology into offshore wind is accessing offshore wind demonstration facilities. See section 2.3 for more tips on access facilities for demonstration.

1.1

Activity

Product support and improvement

Phases during which effort is required

Concept development	Proof of concept	Design	Testing & Verification	Prototyping	Demonstration	Product launch
						■

Before the product reaches market, innovators need to be ready and prepared to support early commercial sales, and product support plans and activities should swing into action. This is particularly important during the initial phase of commercial deployment as there are likely to be a range of technical and commercial glitches to be addressed, and this is where reputational damage can arise if this stage is not adequately planned for.

This means:

- Ensuring the technical resources are available to find solutions to any technical issues
- Ensuring resources with the right skills are available, on the ground, to fix any issues, particularly considering the growing number of potentially dispersed customers.
- Working with supply chain to reduce any issues with outsourced component(s)
- Management of customer relationships (customer intimacy and reputation management)
- Ensuring the financing is available to solve any problems or replace parts and cover any warranty claims

This is also a good time to review supply agreements. Once there is some uptake of products, innovators are likely to be able to renegotiate supply agreements as bulk purchasing begins to take effect.

This is also the time to start thinking about product upgrades or additional functionality, so back to the drawing board...

Tip:
Planning for the operational phase may be the last thing on your mind during concept development but it is worth considering as it will significantly affect your financial model and 'investability'.

ROBUST ENGINEERING PROCESS:

As reliability is a key driver for the offshore wind sectors, offshore wind customers will expect that at all stages of delivering the technology to market should be underpinned by a robust engineering process. Not only will this ensure a higher quality product, but it will reassure investors and customers that technology risk is controlled.

A robust engineering process typically includes:

- Good quality management systems – document and version control, QA, reviews, approval authorities, change control process
- A formal defined stage gate design process – clearly documented plan, with a process for design reviews, having clearly defined scopes and gate acceptance criteria
- Clear design specifications – linked to the business and commercial requirements (as well as other stakeholder requirements & constraints)
- Design reviews at different stages – preliminary, critical, freeze, operational etc.
- Links to CAPEX, OPEX and Revenue models – cost modelling should underpin design

1.2 COMMERCIAL PREPARATION

The core elements needed to ensure technology is commercially ready can be summed up in four requirements:

1. Understanding and defining end user requirements
2. Positioning the product in the optimal way, in the right markets
3. Building the route to market
4. Making the technology investable

These can be broken down into key activities which are highlighted in the table below.

Commercial Preparation — Activity / Development Phase	Concept Development	Proof Of Concept	Design	Testing & Verification	Prototyping	Demonstration	Product Launch
Business Plan Development				●	●	●	
Market Review	●						
Customer / End User Identification & Engagement	●	●				●	●
Commercialisation Plan Development	●	●					
IP Protection		●	●				
Programme Management	●	●	●	●	●	●	●
Establish Investment/Funding, If Required	●			●		●	
Establish Manufacturing & Supply Chain			●	●	●		
Warranty Provision Development		●			●	●	
Branding And Marketing						●	●

The tables below provides more detail on the key activities to consider during this process.

Activity

Business plan development

Phases during which effort is required

Concept development | Proof of concept | Design | Testing & Verification | Prototyping | Demonstration | Product launch

A solid business case is the framework on which any technical or commercial development should be established. The business plan should outline what products are to be sold, the target markets, the route market and how the business is expected to operate once the technology reaches the market place.

A typical business plan will pull together many of the areas discussed below including:

- Business and products outline
- Market and competition
- Marketing and sales strategy
- Management and personnel
- Operations strategy
- Expected financial performance
- Route to market
- Delivery programme

Within offshore wind it is important to understand the characteristics and status of target wind farms that are potential customers for your technology. A good source of information for this is 4C Offshore.

Understanding and management of key business risks should form part of the development of any good business plan. Again, a range of templates and guidance for assessing business risks are available online and local business support should be able to assist with generic business risks.

Tip:
Many templates are available online to guide the development of business plan and support is often available from local or regional business support agencies.

1.2

Activity

Market review

Phases during which effort is required

Concept development | Proof of concept | Design | Testing & Verification | Prototyping | Demonstration | Product launch

During early phases, innovators must understand their target market and how their product fits into the offshore wind sector. Particularly:

- How big is the target sub-section of the offshore wind market and how is it structured?
- What are the relevant market trends (e.g. turbine size, depth of water)
- How accessible are the different global offshore wind markets for the technology?
- Are there any disruptive market changes expected?

A product either needs to meet a market need i.e. address a known challenge currently faced by the offshore wind sector or create a market (see market readiness). Identifying the market need is critical to positioning the technology correctly.

An analysis of key competitors and competitive technologies is also important in market positioning. As well as the obvious places to check what competitors are doing; online, conferences and patent searches, it is also worth looking at the projects the research councils and Innovate UK have supported over the last few years. These are available on the **UKRI Gateway Website**.

Tip:
In addition to gathering general industry intelligence, reviewing industry competitions such as the ORE Catapult Innovation Challenge and the Carbon Trust's Offshore Wind Accelerator, can highlight critical industry needs as they are often specified and driven by issues raised by developer groups.

Activity

Customer / end user identification & engagement

Phases during which effort is required

Concept development | Proof of concept | Design | Testing & Verification | Prototyping | Demonstration | Product launch

During the Concept Development and Proof of Concept phases, customer requirements need to be understood. An understanding of customer requirements should drive the technical and commercial specifications for technology development. Once the product is ready for demonstration and launch, the majority of an innovator's effort is required to raise the awareness of potential customers. Whilst not essential, feedback on the design or concept is valuable at any stage of project development.

Identification, and in particular accessing, end users can be one of the most challenging aspects of bring a new technology to market. Many of the potential customers and end-users in offshore wind sector are large organisations i.e. Developers, Turbine OEMs, or large O&M providers. This can make them difficult to access. It is important that innovators, not only identify their target organisations, but also consider which part of the company they are targeting as route in and how to approach them. This will usually be driven not only by the end-users within the organisation but also the maturity of the technology. For example, talking to a procurement representative at a conference is unlikely to be a successful route to find a collaborative R&D partner.

Timing of engagement is also critical. Procurement and R&D technologies will often be linked to specific wind farm development milestone or turbine model's development programmes. Databases such as **Crown Estate Offshore Wind Project Portfolio** and **Renewables UK Offshore Wind Database** can provide updates on the key projects that are upcoming. A range of subscription wind energy news services can also provide up to date news on UK projects.

If directly approaching end users is not proving successful, consider some alternative ways to engage such as:

- **Collaborative R&D programmes:** these can provide a framework for working together at low risk to the end user, particularly if there is third party funding
- **Technology competitions:** These are often driven by end-users who establish competitions and monitor the results
- **Engagement with enabling organisations:** The Catapult network and regional support agencies often have access to end users and can on occasion facilitate introductions
- **Supplier events:** These are typically run by the procurements teams in large companies so are likely to be more relevant once the product is close to market.

Tip:
It is worth identifying where the end-users have strategic alliances with or show a strong preference towards key suppliers, for example the developer Ørsted has typically used Siemens turbines for offshore development. The end user, usually the developer, may be different from the customer who is often the system integrator i.e. the turbine manufacturer, O&M contractor or infrastructure fabricator or their supply chain.

1.2

Activity

Commercialisation plan development

Phases during which effort is required

There are a range of models by which technology can be brought to market and these need to be considered as they will affect the business case, programme, and funding strategy. These are discussed in more in section 2.1 of this report but can be broadly categorised as:

- Service model: Provision of a service to customers based around use of the technology / product
- Direct sales: Provision of the technology as a product to a customer
- Licencing: Sale of a licence for the technology to a third party who then offers a product or service to the customer
- Divestment of company or technology: Selling the company or all rights to the technology to a third party

Which route to take depends on the technology, the ambitions of the business owners, the investment needed to bring to commercial stability and the level of integration with end-user activities.

See section 2.1 for more information.

Tip:
Where possible, talk to your customers. They may have a preference on how to access your technology and should steer your decision on commercialisation models

Activity

IP protection

Phases during which effort is required

Intellectual Property (IP) is the ideas, know-how and inventions within the company and the team.

Having a strong IP strategy is critical for technology companies for three reasons:

1. To prevent a business's competitors from bringing their ideas and developed products to the market
2. To ensure the business is not infringing other companies existing IP.
3. To ensure the company have access to the IP owned by other organisations that is needed to develop the product

Traditionally IP strategies were based around formally protecting IP through patent, trademarks and copyrights, which can be registered with relevant authorities. However, in a fast-evolving market place, this approach can be slow and expensive, so lighter touch IP strategies are often more appropriate.

More information on IP protection strategies is provided in section 2.6 of this report.

Tip:
Patenting may not be the best option to protect your IP. Seriously consider the cost/benefit of applying for a patent before progressing.

1.2

Activity

Programme management

Phases during which effort is required

Concept development	Proof of concept	Design	Testing & Verification	Prototyping	Demonstration	Product launch

Good program management should integrate both the technical delivery plan and the commercial and market elements of commercialisation. This allows the control of the product delivery time and scope and allows resource planning. Depending on the technology and company culture a range of tools are available for programme management. More information on tools and processes for programme management is available from a range of sources online.

Common mistakes that are made during technology commercialisation programme planning include:

- An inability to lock-down concept or design. There are always improvements that can made to technologies but sometimes getting a product to market is more important than having the optimal design. Repeated unplanned design iterations will lead to overspend and delays in programme delivery
- Underestimation of the time and resource needed to bring new staff on board
- Lack of consideration of investors' agendas: Understanding investors critical timelines or internal milestones can ensure maintenance of good relationships with investor throughout he commercialisation process.
- Complete focus on the immediate next step: Whilst it is important to focus efforts in getting over the next barrier, don't ignore the phases ahead. Some activities can take months or more, such as:
  - o Accessing offshore wind farm or turbine for demonstration (typically 6-12 months)
  - o Accessing more specialist testing facilities (typically 6 months-year for large blade or drive train testing)
  - o Applying for grant funding (Typically Innovate UK funding 3-6 months, European funding 6-9 month)

As part of Programme management, risks to the delivery programme need to be identified and managed. This is typically carried out through a programme risk register. Templates for these are available online.

The overall programme plan should also feed into a skill and resource requirement analysis that will shape the recruitment and partnering strategy.

Tip:
In addition to gathering general industry intelligence, reviewing industry competitions such as the ORE Catapult Innovation Challenge and the Carbon Trust's Offshore Wind Accelerator, can highlight critical industry needs as they are often specified and driven by issues raised by developer groups.

Activity

Establish investment/funding, if required

Phases during which effort is required

Concept development	Proof of concept	Design	Testing & Verification	Prototyping	Demonstration	Product launch

A wide range of funding options are available and are suitable for technologies at different levels of maturity.

Even if the benefits of the technology are evident, steps need to be taken to become investor ready. Many of the steps needed are part of good general technology commercialisation practice. Investors will want information that provides them with evidence that the business has adequately considered and covered key elements of technology development, financial modelling, and route to market. In most cases, they are less interested in the technology itself than the business case and the company capability.

More in information on finance and funding options and becoming investor ready is provided in ORE Catapult's 'An Innovators Guide to Finance and Funding in Offshore Wind'.

Tip:
Ideal investors bring more to a company than pure finance. Often investors can provide technical support or facilitate access to markets. This is something to consider when choosing the best funding options.

1.2

Activity

Establish manufacturing and supply chain

Phases during which effort is required

Concept development | Proof of concept | **Design** | **Testing & Verification** | **Prototyping** | Demonstration | Product launch

Once the basic concept and early design is established the manufacturing and supply chain strategy should be considered. Most companies have two strategies, one for the prototype and demonstration and one for full commercial production. Both need to be considered early in the technology commercialisation process.

Decisions on manufacturing strategy are complex but areas that drive these decisions include:

- Company's preferred role (integrated manufacturer, assembler, or distributer)
- Competencies within the company
- Commercial model and investor exit strategy
- Supply chain readiness
- Development partners and IP access
- Cost of developing facilities
- Location of customers
- Local market requirements
- Grant access tied to local job creation

Other key considerations when choosing suppliers during technology commercialisation should include:

- Scaling opportunity: Can the suppliers ability to scale to full production capacity
- Dual sources: Ideally, a company should not be reliant on one manufacturer for key components
- Access to IP: Ensure the company has access to critical IP from collaborative development programmes and can take designs etc to other suppliers

It should be noted that in many countries, including the UK, there is a requirement for local content in offshore wind farms. It is worth highlighting any UK activities to customers as local manufacturer can, in some cases, provide a competitive advantage.

In most regions support and funding is available for establishing facilities through regional development agency infrastructure and job creation funds.

Tip:
The supply chain should also be considered during the design phase. This is often parked as a consideration for later in the commercialisation process, but it is not unusual for a company to reach prototype phase to discover critical components are not available, are very expensive or are limited to one supplier. This can force late stage design changes and cause associated costs and programme delays.

1.2

Activity

Warranty provision development

Phases during which effort is required

Concept development	Proof of concept	Design	Testing & Verification	Prototyping	Demonstration	Product launch

For some technologies, for example large turbine components, customers will expect a warranty. The terms of the warranty offering are a commercial decision, primarily driven by customer expectations but other key considerations when deciding on a warranty position are:

- Industry standard offering
- Warranties provided by your supply chain
- The cost of worst case serial failure (and associated contingency provision)
- What the company need to offer as a remedy to issues arising, for example, will on-site repairs be offered or is it necessary to bring the product back to shore for repairs

Tip:
Investors will expect to see warranty provision clearly outlined in the financial models and product cost analysis.

Activity

Branding and marketing

Phases during which effort is required

Concept development	Proof of concept	Design	Testing & Verification	Prototyping	Demonstration	Product launch

The market review, customer identification and business plan should provide a clear positioning of a product in the offshore wind market. This should drive a company's branding and marketing.

Any marketing and branding should clearly identify the key benefits and unique selling points of a technology and should be presented in language that aligns with the needs of customer in the offshore wind sector.

In addition to social media, more traditional marketing routes such as conferences and journals can also be effective, if somewhat more expensive. There is a vast array available. For companies new to the sector, it is worth talking to someone in the sector to understand which the best events are to attend or journals to publish in. Local or regional support agencies may be able to offer support to attend events.

Tip:
Ideal investors bring more to a company than pure finance. Often investors can provide technical support or facilitate access to markets. This is something to consider when choosing the best funding options.

1.3 MARKET READINESS

In addition to making sure a technology is ready for market, it is also necessary to make sure the market is ready for the technology. In some cases, where there is a clear market pull, minimal effort is required. However, if the product requires significant changes in the market infrastructure, the business developing the technology may need to drive this. Key areas to consider are:

- Regulatory barriers
- Supply chain capability
- Skills availability
- Stakeholder acceptance

Key activities in that a technology developer can undertake to ensure the market is ready for their technology are illustrated in the table below.

Market Readiness — Activity / Development Phase	Concept Development	Proof Of Concept	Design	Testing & Verification	Prototyping	Demonstration	Product Launch
Address Regulatory Barriers	●	●	●		●		
Build Supply Chain			●	●	●	●	
Develop Skill Base Required		●				●	●
Ensure Stakeholder Acceptance		●				●	●

Activity

Address regulatory barriers

Phases during which effort is required

Concept development | Proof of concept | Design | Testing & Verification | Prototyping | Demonstration | Product launch

If a technology represents a significant change to the state of the art, there is a risk that there may be some regulatory barriers. For many technologies, this area presents little concern but it is worth reviewing the regulatory landscape for the technology during the concept development phase.

Some areas of regulation to consider are:

- Health and safety
- Aviation safety
- Maritime operations
- Environmental impact
- Grid compliance

If any regulatory barriers are identified there are three steps that can be taken:

1. The first step is to determine if design or operational procedures changes can be made that allow the technology to overcome the regulatory barriers
2. If this is not possible, engagement with the relevant authorities will be required. Regulatory stakeholders will often take a conservative approach to new technology due to lack of data and may invoke a 'Precautionary Principle'. Some regulatory barriers can be overcome through provision of more information on technology, for example, thorough bird monitoring or noise recording during prototyping.
3. If stakeholders are still not willing or able to relax regulatory barriers significant lobbying will be needed.

The regulatory conditions for offshore wind are relatively stable and no major changes are expected but it is worth monitoring through industry news channels.

Two other potential areas that may need to be managed in order to prevent impractical requirements on technology deployment are:

- **Inappropriate or lack of certification and test standards:** If the technology is very novel there may not be relevant existing certification and test standards. This can be barrier to end-user adoption and financing. If this is the case, early engagement with the certification bodies is essential to work with them to develop new standard or adapt existing standards. In some cases standards can be adapted from other sectors e.g. leading-edge erosions testing standards are adapted from those used in helicopters
- **Rochdale Envelopes:** When wind farms are consented, the consent includes certain specification such as; tip height, nacelle height, distance between turbines and number of turbines. Changing a Rochdale envelope is expensive for the developers so any technology they adopt will need to fit within that envelope, for instance, it may limit the uptake of a new blade technology or turbine concept on a site.

Tip:
A basic regulatory landscape review during the concept phase will allow a technology developer to develop a plan to ensure there are no regulatory barriers to demonstration and market entry.

1.3

Activity

Build supply chain

Phases during which effort is required

Concept development	Proof of concept	Design	Testing & Verification	Prototyping	Demonstration	Product launch

If a technology requires specific and new components, there is a risk that there may not be any suppliers than can currently provide them or the cost may be prohibitive. This should be identified early during the concept phase.

If high-risk critical components are identified, there are two options; either

- Alter the design to one that does not rely on difficult to obtain components; or
- Work with a supplier to assist them in developing the capabilities needed to supply components.

Unfortunately, if major effort is needed by the supplier, they may be reluctant to put in the investment of time and resource for one start-up (who is probably perceived as high risk and low volume). This can become a significant barrier to deployment.

Even if the supplier is prepared to make the changes required, it is likely to that the company will have to absorb at least some of the costs either up-front or through the component costs.

In this situation, there are a few activities that can help alleviate supply chain barriers:

- Identify the supply chain risks early; this gives time to sort them out
- Engage with regional development agencies; they may be able to provide support and act as facilitator
- Talk to competitors; They may have a similar issue. Suppliers may be more willing to make the required investment if two companies approach them
- Develop a strong business plan: Suppliers will want reassurance that if they make an investment, there is a long-term business for them.

Tip:
An early review of critical and bespoke components during the concept development phase can identify any risks in the supply chain, which can be managed. This can prevent the need for costly redesign or programme delays at a later stage.

Consider collaboration

Significant changes may be needed to regulations, stakeholder mind-set or a skill and supply chain infrastructure, to create a viable market for an innovative product. Innovators should consider collaboration with competitors by; for instance:

- Either joining or if necessary, creating a lobbying group,
- Co-developing training courses; or
- Co-development of the supply chain

A good example of this is the floating wind sector, where ten of the key companies involved in floating wind joined together to form 'Friends of Floating Wind', a group aimed at removing the barriers to floating wind deployment.

1.3

Activity

Develop skill base required

Phases during which effort is required

Concept development	Proof of concept	Design	Testing & Verification	Prototyping	Demonstration	Product launch

Specific skills may be needed both internally, in the supply chain and in wider industry. As a technology pioneer, innovators may need to put steps in place to ensure the relevant skills are available.

Areas where additional skills may be needed include:
- Supply chain
- Own manufacturing and assembling facilities
- Own teams for deployment and use / provision of service
- Within customers/operators
- Internal or external maintenance and servicing crews.

Developing training programmes may need to be considered. This can be done in conjunction with an existing training provider.

Tip:
Support is often available from regional development agencies for retraining and development of training programmes.

Activity

Ensure stakeholder acceptance

Phases during which effort is required

Concept development	Proof of concept	Design	Testing & Verification	Prototyping	Demonstration	Product launch

Ensuring stakeholder acceptance of a technology is critical for ensuring both investment during the technology development phase and market uptake. For new technologies coming into the offshore wind market there are two key steps to stakeholder acceptance.

Stakeholders need to be convinced that the technology:
- Is coming to market and need to be considered.
- Does what the company says it does.
- Will have minimal negative impact on their operations.

Key stakeholders in offshore wind include:
- End Users: Ultimately, in offshore wind, this is likely to be developers.
- Customers: For most technologies, this is likely to be the tier 1,2&3 suppliers.
- Investors.
- Regulators: Health & Safety Executive, Civil Aviation Authorities (CAA), MCA, Ofgem.
- Developer investors: Many offshore wind farms are owned or partially owned by financial investors, adoption of new technology adds risk to their investment.
- Consenting statutory stakeholders: including the environmental protection bodies, CAA and MoD. Whilst generally cooperative, consenting statutory stakeholders can be risk adverse when addressing significant changes in the offshore wind industry due to the relative immaturity of the sector and the resulting lack of impact data.
- Certification and testing standards.
- Regulators: if regulatory change is needed.
- Public: In some cases, buy-in from the public can raise the profile and general acceptability of a technology.

Tip:
In many cases, stakeholders care more about is the impact of the technology on their operations than the technology itself. Focusing on this creates the best chance of bringing stakeholders on-board.

SECTION 2

KEY CONSIDERATIONS

Key consideration when bringing technology to market in offshore wind

IMAGE: Courtesy of EDF Energy Renewables

2.1 COMMERCIALISATION MODELS

When considering the route to market, it is vital for a business to consider their commercial model: how will the new technology get into the marketplace? Early consideration of this can drive the company structure, IP strategy, route to market, and investment strategy. It can also demonstrate to investors what the end goal of commercialisation looks like.

The best outcome at the end of a commercialisation process may not be direct sales. Other models may provide higher revenues or provide solutions to overcoming some of the key barriers to market entry, such as the cost of manufacturing facilities.

Considerations when choosing a commercial model:

- Company strengths and culture
- Willingness / capability to accept commercial and technical risks
- Funding and resources required to bring technology to market vs funding and resources available
- Constraints on time to market
- The company's ability to directly access target market.
- Customer preference for accessing technology.

In simple terms, there are four commonly used commercialisation models that can be considered:

1 Service model	2 Direct sales	3 Technology licencing	4 Sale of company or technology
Offering a service that is supported by the new technology, for example; provision of sub-sea inspection service based around a novel ROV concept; or Leasing of technology and operators to end-users, for example, supply and maintenance of novel on-turbine power sources during installation phase.	Direct sale of technology to customer, potentially with follow-up service or operating contract, for example, supply of novel in-turbine lifting system directly to turbine OEMs.	Licencing to a third party the IP required to use a technology. This can be on an exclusive or non-exclusive basis. Income from the technology is then achieved through a royalty, period use fees, one-off payment, or success fees. For example: • Licencing the design of a novel blade lightning system to a blade supplier, or: • Licensing a turbine design concept to new entrant OEM	Full exit from managing a technology through selling either the IP or the company to an organisation who is looking to bring the technology to market, incorporate the technology into their own product or offer a service based on the technology.
Advantages			
• Often highest revenue option • Long term potential revenue stream • Clear commercial proposition to end user • Unlikely to require significant effort for end user to adopt	• Clear commercial proposition • Likely to lead to larger and/or long-term contracts e.g. supply to whole wind farms or full production run of turbine models	• Avoidance of the high cost and risk of establishing manufacturing and technology deployment. • Licensee may be in a much stronger position to bring the technology to market • No long-term commitment, relieves resources for development of next technology.	• No long-term commitment. Frees up resource for development of other technologies • No long-term exposure to technology and market risks
Disadvantages			
• High CAPEX and ongoing operational cost and resource requirements • Requires highest level of commercial and technical risk adoption by development company • Potentially short-term/ small contracts	• Relatively high level of development cost and resource required. Some ongoing resource requirements • Relatively high of level of commercial and technical risk	• Reduced revenue • For contracts based on royalties or success fees, companies are still sharing commercial risk with licensee but have reduced control over key risks	• No ongoing revenue streams • Companies do acquire IP and companies in order prevent commercialisation, so the invention may never reach the market • No learning from technology deployment that can feed into future product development.

Decreasing level of ongoing commitment →

2.2 DEMONSTRATING THE BENEFITS TO END USERS

All potential customers in offshore wind will have different requirements depending on their role in the industry value chain and company priorities. However, the criteria used when assessing the attractiveness of a new technology or service are common across most offshore wind end users. An ability to clearly define the benefits of a technology or service using these common terms will maximise a business's ability to sell.

Fundamentally, a product or service will need to provide a financial benefit to the customer through increasing direct revenue, reduced costs, or reduced risk exposure, regardless of the customer's position in the offshore wind life cycle.

Understanding the customer

Analysis of key benefits, whilst essential for positioning the technology, should not replace efforts to understanding potential customers. Every customer is different.

Aspects of customers to investigate include:
- Key challenges facing the company
- Current related technology use
- Current and target markets (geographical and market segment)
- Existing partnerships
- Company structure
- Company culture and decision-making process
- Technology risk appetite
- Key individuals within the organisation.

KEY BENEFIT 1: INCREASING REVENUE

A technology or service can increase direct revenue from a wind farm by:

- Extending turbine operation life: either through extending the turbine design life, or through de-risking the operation of turbines and other offshore wind hardware past the end of their design life
- Increasing energy capture by the turbine: through improvements in rotor design and control systems or increasing efficiency of the drive train
- Reducing turbine downtime: through improvements in reliability and reducing the downtime needed for operation and maintenance (O&M) activities

KEY BENEFIT 2: REDUCING COSTS

There two key mechanisms by which a technology can reduce the costs of generating electricity using offshore wind: reductions in CAPEX (initial capital cost of installing a wind farm), and reductions in OPEX (cost of operating a wind farm). The mechanisms for reducing these costs are illustrated below.

Reducing CAPEX	Reducing OPEX
Reduce costs of: • Gaining consent (or reduction in consenting risks) • Wind farm hardware manufacturing costs • Transport and installation of wind farm hardware	• Improve reliability of wind farm components • Optimising O&M strategy • Reduce cost of planned O&M activities • Reduce cost of unplanned O&M activities

When assessing the overall direct financial impact of technology in offshore wind, the financial levers are commonly combined into one metric: Levelised Cost of Energy.

2.2

LEVELISED COST OF ENERGY (LCOE)

LCoE is a widely recognised metric that allows the cost of generating a MW of electricity to be calculated. By understanding the impact of a technology on the elements within LCoE calculations, it is possible to assess the impact of adoption of a new technology onto the revenue from a wind farm. LCoE amortises capital expenditure (CAPEX) and operation expenditure (OPEX) by unit of energy generated over the revenue generated by the wind farm during its lifetime. A tool for calculating LCoE, produced by the Danish Energy Agency, can be found **online**.

Lowering the LCoE can be achieved by increasing energy production, decreasing CAPEX or OPEX or reducing the cost of capital.

KEY BENEFIT 3: REDUCING HS&E AND REPUTATIONAL RISK

When communicating the benefits of a technology and service, it is also worth considering if the product can add indirect value to a company by reducing the risks of a health, safety, and environment (HS&E) incident, or by reducing a company's reputational damage in other ways.

- HS&E: Companies have an obligation to prevent HS&E incidents. In addition, health and safety or environmental incident can cause significant direct or indirect costs for a company, including fines from regulators, turbine down-time and remediation costs. Companies may be willing to accept the cost of new or more expensive solutions that reduce the probability and / or impact of HS&E events.
- Reputation: Additional damage to reputation can be cause by issues such as low reliability, high profile failures, causing public inconvenience, poor operational procedures, and poor corporate social responsibility management. There is a value to a product, if it can be demonstrated that it can help protect end user reputation.

COST OF INTRODUCTION AND "HASSLE FACTOR":

In additional to demonstrating benefits to users, it is also important to demonstrate that there will minimal cost and hassle in adopting the technology.

Whether it is introducing new technology during the manufacturing process or operational phase, the impact of the introduction needs to be understood, considering questions such as:

- Does the technology require a significant change to manufacturing processes?
- Is reinvestment in facilities needed?
- Would it require a significant amount of re-engineering in an operational asset and associated costs?
- Will personnel require additional training in new processes?

Innovators may also be looking to change long-standing construction or operational philosophies within organisations where the hassle factor of a change management process should not be underestimated.

Customers may also be reluctant to introduce new technology if it will invalidate their hard-won track record that is based around a different technology concept.

2.3 TESTING, VERIFICATION AND CERTIFICATION

Early consideration of test, verification and in some cases certification requirements is important. These should ideally be captured in a test and verification plan during the concept development phases of the commercialisation process. Areas to consider during the testing planning phase include:

- Requirement for testing: The exact activities within testing programmes are driven by a combination of test standards, customer, or end-user requirements. Investors will expect evidence that industry standards are being followed but are unlikely to have their own requirements
- Requirements for certifications
- Facilities required: When designing a test programme, ensure the facilities are available (and affordable) to deliver it. Innovators may be required to develop bespoke test facilities
- Costs: Testing can be very expensive, particularly those that simulate operating conditions or require specialist equipment
- Timeframe: Some tests such as accelerated life tests can take several months to perform. In addition, for specialist facilities, there can be a waiting list of up to a year
- Partnering/ subcontracting: If specialist facilities or competencies are required, collaboration with a testing organisation may be required for test design and delivery e.g. Catapult network, NPL
- Manufacturing process testing: Innovative manufacturing process will need to be tested at this stage.
- Ongoing quality control testing: Innovator should consider the need for in-house testing during commercial manufacture

OVERVIEW OF TESTING REQUIREMENTS

Testing requirements are driven by a combination of:

1. Certification requirements
2. 3rd party standards (e.g. national and international and certifications – BS EN, ISO, IEC, ASME, ASTM etc)
3. CE marking requirements
4. Internal company testing requirements
5. Expectations of customers

In general, it is the designer/manufacturer's responsibility to identify the required standards under items 1 to 5 above and ensure conformance. Many organisations will already be aware of the relevant design and testing standards through working in the industry, however online searches of the various standards organisations (BS EN, ISO, ASME, ASTM, API etc.) or specialist consultancy support can help identify what is required.

The testing and certification requirements vary enormously depending on the type of technology and its role within an offshore wind farm. For example, small individual components such as sensors and non-safety-critical equipment such as in-service monitoring equipment are likely only to need to meet CE marking requirements to allow incorporation into a wind turbine.

Larger systems such as a pitch or yaw systems, power electrical systems, or a novel foundation or floating platform concept will require an extensive laboratory and in-field testing under an agreed equipment qualification programme in accordance with the Type Certification or Project Certification standards (see below). For highly novel equipment, there are dedicated standards for qualification programmes such as DNVGL-RP-A203-Qualification of New Technology which (though non-mandatory) could be applied and would assist in achieving certification.

CERTIFICATION

Certification is probably the area that newcomers to the offshore wind industry are likely to be least familiar with, and the next section outlines the requirements and responsibilities. There are two types of certification:

- Type Certification: covering turbines and turbine components
- Project Certification for the Balance of Plant (BoP): covering foundations, cables, joints & substations

2.3 TYPE CERTIFICATION

Type Certification is an almost universal requirement. It is the turbine OEM's responsibility to achieve Type Certification for their product via a recognised Certification Authority. The predominant European Turbine Type Certification authority is DNVGL, who set out the scope of Type certification in two Service Specifications (SEs):

- **DNVLGL -SE-074**
- **DNV-SE-0441**

These Service Specifications set out the scope and required standards (design, manufacture & testing) which the turbine OEM is expected to meet, and the OEMs pass these requirements on to turbine suppliers of components and systems. The document hierarchy is illustrated in the figure below: the top-level standards are usually the DNVGL Design Standards (STs) and the supporting DNVGL – Recommended Practices (RPs), Guidance Notes (GNs) and Technical Notes (TNs). The design standards in turn specify the acceptable IEC and ISO standards, which then reference down to a range of Component Design and Testing standards. There is usually some choice in the selection of the detailed standards.

TURBINES – DOCUMENT HISTORY

DNVGL – TYPE CERTIFICATION SERVICE SPECIFICATIONS

DNVGL-SE-074 "Type and Component Certification of Wind Turbines according to IEC"

DNV-SE-0441 "Type and Component Certification of Wind Turbines"

DNVGL – **Design Standards** (STs)
DNVGL – **Recommended Practices** (RPs)

IEC Standards
ISO / EN ISO Standards

Component Design & Test Standards:

• ASTM • ASME • DIN / VDDI
• API • NORSOK

Part of the certification procedure is for the Certifying Authority to audit the Quality Management System (QMS) of the turbine OEM, and the OEM will in turn audit the QMS of suppliers. Some suppliers achieve independent accreditation of their QMS from the Certification Authority to ease the process, although this is not usually done until the product is reasonably mature.

The Certification process includes independent inspection and witnessing of all aspects of the manufacturing process, including Type Qualification tests and Factory Acceptance Tests (FATs); suppliers of key safety-critical and performance-critical equipment to turbine OEMs can expect to be subject to similar audit and inspection requirements as the OEMs.

For an SME, the main point about Type Certification is to be aware of the scope and standards, to be fully prepared in understanding the Certification Authority's requirements, and to be willing to co-operate fully with the turbine OEM and the Authority. If the certification requirements for a particular component or subsystem are unclear, early engagement with the Certification Authority and/or a target turbine OEM customer is recommended.

PROJECT CERTIFICATION

Balance of Plant (BoP) equipment is project- and site-specific and cannot therefore be generically Type Certified. The BoP scope usually includes:

- Turbine Foundations and piling
- Array & export cables
- Offshore substation foundations & topsides

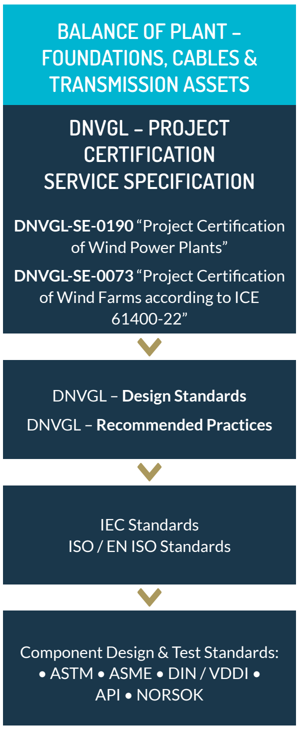
And may include:

- Installation
- Operations & maintenance

BoP comes under Project Certification rules. Project Certification is non-mandatory in Europe (except in Germany), but is usually carried out on most projects for insurance purposes. It is the project owners responsibility to secure Project Certification. As per Type Certification, DNVGL has two Service Specification for Project Certification:

- DNVGL-SE-0073 "Project Certification of Wind Farms according to IEC 61400-22"
- DNVGL-SE-0190 "Project Certification of Wind Power Plants"

2.3



Unlike Type Certification, however, there are many more organisations who undertake Project Certification, including for example (in Europe) Lloyds Register and Bureau Veritas.

The document hierarchy is similar to that for Type Certification, as illustrated in the figure. From a BoP supplier's perspective, the process is like Type Certification in terms of QMS audit, with some additional requirements:

- Cables and joints are usually bespoke designs for projects, and subject to independently witnessed FAT and Type Qualification testing, in accordance with industry practice and recognised standards.
- For structures (foundations, floating platforms & OSS topsides), installation process/equipment and cable routes, the designer will be expected to submit the following to the Certifying Authority as a minimum:
  - o a comprehensive Design Basis containing loads data, ground conditions, metocean and other information to Factory inspections of structures will typically include audits and inspection of weld procedures and welder qualifications, fabrication quality, NDT, paintwork quality etc.
  - o a set of design calculations, drawing and full suite of technical specifications.

CE APPROVAL & MARKING

The letters 'CE' appear on many products that are traded on the single market in the European Economic Area (EEA). The CE mark is required for many products.

By placing the CE marking on a product a manufacturer is declaring, on their sole responsibility, conformity with all the legal requirements to achieve CE marking. The manufacturer is thus ensuring validity for that product to be sold throughout the EEA. The manufacturer usually self-administers the CE approval process. Guidance on what products require the marking, the applicable standards for checking, and the governance rules for the process can be found at www.gov.uk/guidance/ce-marking.

The equipment likely to be relevant for offshore wind farms is anything where safety from hazards must be demonstrated, including:

- Electromagnetic compatibility
- Lifts
- Low voltage electrical equipment
- Machinery
- Measuring instruments
- Noise emission in the environment
- Personal protective equipment
- Pressure equipment
- Radio and telecommunications
- Terminal equipment
- Simple pressure vessels

VESSELS AND O&M ACCESS EQUIPMENT

Vessels and on-board access equipment to foundations are subject to Ship Classification Rules and maritime legislation. It is assumed that manufacturers in this field would not be developing new products from scratch and would already be aware of the design and classification standards; therefore, no further discussion is presented here.

2.4 WHERE CAN AN INNOVATOR DO TESTING AND DEMONSTRATION?

For most offshore wind technologies, the types of test facility required can broadly be split into four categories and can be mapped onto the commercialisation phases as illustrated below:

	TRL 1-2	TRL 3	TRL 4	TRL 5-6	TRL 7-8	TRL 9	
	Concept Development	Proof of Concept	Design	Testing & Verification	Prototyping	Demonstration	Product Launch
Testing Labs	●	●	●	●			
Component Test Centre				●			
Test Turbines				●	●	●	
Demonstration Projects						●	

Very few SMEs or technology start-ups have extensive in-house testing and demonstration facilities. Most, therefore, need to look externally for access to facilities. There are three main ways an SME can access the facilities they require:

- Through development partners such as suppliers
- Through accessing public facilities
- By developing their own facilities.

Extensive information on open access offshore wind testing facilities and how to access them is available on the ORE Catapult Renewable Energy Facilities website. An overview of some key testing facilities in the UK is provided below.

TESTING LABS

There is a wide range of lab-based testing facilities in the UK. Many of the open access testing labs are based in universities but can be accessed when not being used for research or as part of collaborative research projects.

Some sit within larger open access R&D centres such as the High Value Manufacturing Catapult (HVMC) and National Physical Labs (NPL) and some in privately owned R&D centres, that can be accessed as part of commercial R&D contracts. Some notable UK test labs suitable for offshore wind technology development:

Materials	National Composite Centre (NCC), Advanced Forming Research Centre, various university labs, TWI
Structural and Fatigue	Energy Technology Centre, TWI
Manufacturing Process	Advanced Manufacturing Research Centre, NCC
Offshore Environmental	ORE Catapult (LE Erosion), TWI
Test Tanks	FloWave, Wave Basin
Wind Tunnels	17 wind tunnels in the UK are coordinated by the National Wind Tunnel Facility.
Condition Monitoring Systems	IVHM
Electrical Systems	ORE Catapult, University of Manchester
Lighting Testing	Cobham Lightning Testing Facilities. Cardiff High Voltage Laboratory and Lightning Laboratory

Support in identifying and accessing testing labs is available from organisations such as the KTN, Energy Technology Partnership (ETP) and the Catapult Network.

2.4 COMPONENT TEST CENTRES

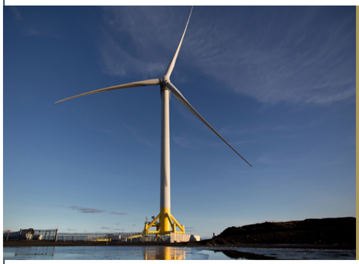
There is a limited number of large offshore wind component testing centres in the UK. Typically, these facilities have structural, functional, or accelerated life testing for full scale or scale model components. Notably, the ORE Catapult Blyth offers a world-class testing facility that specialises in offshore wind. More details of this are highlighted in the overview below. Some notable UK offshore wind component testing facilities:

Energy Technology Centre	The Energy Technology Centre's test facilities are focused on the testing of low carbon technology, including wind and marine power systems. Test facilities include a wind tunnel (17 m/s max speed), small scale structural testing, and a drivetrain test facility.
Ore Catapult -Blyth	ORE Catapult owns and operates a range of testing equipment, specifically for the use of businesses in the offshore wind and marine energy sector. These include blade and drivetrain testing rigs, electrical equipment, an anemometry platform, and subsea docks.
Power Network Demonstration Centre	PNDC is a leading test facility for embedded electrical systems and software. The system electrically resembles a low voltage distribution network.
National HVDC Centre	The National HVDC Centre is a simulation facility for HVDC systems. The aim of the centre is to assist technologies which will improve the feasibility and operation of HVDC transmission systems.

In addition to specific component testing facilities, various docks are available for sub-sea or access system testing. Docks and quaysides that actively promote their facilities for offshore wind testing include Falmouth, Ilfracombe, Methil, Pembroke, Portland, and Workington.

ACCESSIBLE TEST TURBINES

One open access turbine is currently installed in the UK. This turbine provides an opportunity for technology developers to access the turbine systems to test new technologies.



Levenmouth Demonstration Turbine (LDC)

LDC is the only open access offshore wind test turbine in the UK. It is a 7 MW offshore wind turbine, owned and operated by ORE Catapult. It is located in Fife, Scotland. It is situated near shore and is accessible via a bridge from the shore.

The turbine is available to provide an on-turbine test bed for research and product testing and demonstration. To date, it has been used for testing:

- O&M processes and systems
- Turbine control systems
- Aeroelastic development
- Condition monitoring

For more information on the LDC see the LDC website or talk to the ORE Catapult.

The National Offshore Wind Turbine Test facility (NOWTTF) at Hunterston is the UK's only onshore test facility for offshore wind turbines. However, it is not openly accessible to third parties. It is operated by SSE and Scottish Enterprise and consists of two test turbines and one site that is currently unoccupied. They are primarily used for development of turbine technology by the OEMs present on the site (Siemens-Gamesa).

CASE STUDY

LIMPET Technologies

ORE Catapult provides LIMPET Technologies the opportunity to validate their technology
The LIMPET personnel transfer system is a novel design that enables safe crew transfer in wave heights up to 3m. **This increases accessibility to far-offshore installations from 50% of the year to 80%.**

ORE Catapult has provided LIMPET with access to the Levenmouth Demonstration turbine, allowing the company to move their system out of the lab and into the offshore sector. This vital step allowed LIMPET technologies the opportunity to test their system offshore, validating and proving their lab-based concept, but without the financial or safety risks associated with real-world deployment. This has opened up doors to demonstrate their system at the Gwynt y Mor wind farm.

For more information see www.backingthegamechangers.com/success-stories/limpet-technology

2.4 DEMONSTRATION PROJECTS AND TEST SITES

In mainland Europe there are test sites where pads are developed with grid connection and relevant infrastructure for prototype turbines to be installed. The Ørsterlid National Test Centre in Denmark is a prominent example of such a facility. There are no offshore wind scale open-access test sites in the UK but there is a smaller facility operated by TUV-NEL at Myers Hill in Scotland where turbines up to 500 kW can be tested. In some cases, this may be useful for scale model testing of a full turbine system.

For full scale turbine and BOP demonstration, three large offshore wind demonstration projects have been built in the UK in the last five years. Commercial developers have developed these sites to demonstrate offshore wind technology before wider deployment. **The three key projects developed in the UK are:**

- European Offshore Wind Deployment Centre (EOWDC)
- Blyth Offshore Demonstrator
- Hywind Pilot Park

Whilst innovative technologies were incorporated in these sites during design and installation, they now operate primarily as commercial wind farms and are not easily accessible for new technology testing. There are no demonstration sites currently tendering for innovate suppliers. It is possible that there will be further demonstration sites built in the UK, particularly considering the move towards larger turbines (up to 12 MW) and expected developments in electrical infrastructure.

In addition to open access test and demonstration facilities, it may be possible to engage with a developer to access to a commercial offshore wind farm, or some of its data. In most cases, this is only possible for testing technologies that are unlikely to interfere with the commercial operation of the wind farm and have a low risk of causing damage, for example a sub-sea inspection technique or O&M drones.

However, persuading a wind farm operator to grant access to the wind farm or their data can be a significant challenge. **Some areas to address to improve the chances of getting access are:**

- **Get operator buy-in for the technology:** Operators will only be interested in engaging with organisations that provide technology that saves them money or solves a challenge. Effort is needed to sell the technology to them.
- **Demonstrate competency:** Turbines and their infrastructure are highly valuable assets. If a developer picks up any hint that a team might not be competent to operate around them, they won't allow them access to the turbine or their data.
- **Ensure team members have the relevant qualifications:** Every site operator has a strict list of qualifications technicians will need before accessing turbines. Ensuring employees have these will need to be part of the delivery plan.
- **Be flexible:** There is likely to be a limited window of opportunity for accessing a wind farm (often during a summer O&M campaign), make sure this is understood and built into the delivery plan.
- **Try an indirect route:** Sometimes a direct approach doesn't work. If not, consider
    - Inviting developers in as part of a funded collaborative R&D project;
    - Using enablers such as ORE Catapult who have existing relationships with the turbine operators; or
    - Entering industry innovation competitions, which are often driven by the wind farm operators and may open dialogue for access to their wind farms.

2.5 HS&E

Safety is not something that can be bolted on once a product works. When managed poorly, safety can add significant cost, delays or even cancellation. This is because late consideration of safety may identify significant late phase design changes, which are disproportionally expensive. When done well, it can significantly add value to the design of a product or service, being a significant market differentiator and embedding resilience in the design.

As an SME or start-up, safety considerations will fall into two broad areas:

- **Occupational Safety**: Safety of a business's own operations, facilities, and staff (occupational safety)
- **Operational Safety:** Safety of a product or service during all stages of the product / service lifecycle; development, deployment, operation, and retirement.

The process for identifying and reducing risks associated with operations / product or service is broadly similar for both these areas. The goal should be a closed loop process that identifies, reduces, monitors, and iterates. This is what is called the 'Plan, Do, Check, Act' cycle by the Health and Safety Executive (HS Executive). This is often seen as 'just common sense' and it is, just done systematically and consistently.

For innovators approaching safety management for the first time, or who are concerned that they might need to, these are the broad outline activities that should be undertaken to clarify their current position (NB this does not need to be a 'formal' process):

1. Properly describe the operation / product or service in context
2. Identify the associated risks
3. Reduce the risks (to As Low as Reasonably Practicable – ALARP)
4. Record decisions in an initial risk assessment

Based on the above initial assessment, how much rigour and effort to expend to provide safety assurance will need to be considered; the relevant regulatory regimes and the size of the organisations will drive this. Organisations larger than 5 people are expected by the HSE to have a formalised written safety policy according to governmental health and safety acts.

Businesses should consider the following actions to develop and deliver an HS&E management system:

1. Nominate an individual who will take responsibility for implementing and enforcing HS&E
2. Get independent safety advice. A short period of input from a Suitably Qualified and Experienced (SQEP) person or organisation can help to clarify what really needs to be focused on at the various stages of development
3. Formalise the safety system as an integrated part of the management system; it is not a separate activity. It should drive and help to inform design and business decisions. It should cover more than just the 'bits of kit' but also the required training and maintenance activities. It should focus on taking actions/design decisions

Some additional guidance can be found at:

- HS Executive Introductory Guide Plan, Do, Check, Act
- HS Executive Write a Safety Policy
- HS Executive Example Risk Assessments

> **"Nobody deliberately designs an unsafe product or service. However, safety considerations can be lost in the struggle to just manage the design process, or only really properly considered late in the development process once a product or service is working, to meet regulatory requirements or in the worst case following a serious incident or accident."**
>
> – ARC consulting

2.6 INTELLECTUAL PROPERTY

Intellectual Property (IP) is defined as 'the intangible property that is the result of creativity'. During technology commercialisation the term 'IP' is usually used to refer to concepts, designs, processes, and other know-how that has been developed or is being used during the development process and during commercial operation.

In the early stage of the offshore wind industry, the sector took a highly aggressive, protective stance towards IP. As the industry has matured, a more collaborative open approach has been adopted in order to ensure the continued market development.

Understanding the IP landscape and protecting IP is important because:

- It prevents infringement of existing IP owned by other companies and having to undertake expensive legal battle or late stage design changes.
- It prevents competitors from using a business's invention
- It creates value in a company that can be used to leverage investment and can be sold or licencing as an asset.

The table below highlights the key types of IP that need management:

	Type of IP	What is it?	What Should Innovators do About it?
External IP	**Existing external IP**	Existing, current patents, trademarks and copyright owned by other organisations that may block an innovator's ability to deliver their product.	Carry out a patent search or get a specialist IP organisation to do it. If patents are identified that overlap with a business's technology, there are two options: • Try to licence the IP – though this is not always possible and may be expensive • Make design changes to ensure they are no longer infringing the existing IP.
External IP	**IP owned by development partners and suppliers**	Background or foreground IP, that is needed to commercialise a technology which is owned by their supplier or development partners, for example, a supplier may own the IP on material that is needed for customers design.	Issues can arise if suppliers or development partners own IP that is critical to delivery of a technology. This can mean a business is tied to one supplier. In an ideal world, once in commercial production, a business should negotiate for the rights to take the IP and designs to additional suppliers. There is likely to be a cost to this.
External IP	**Jointly-owned foreground IP**	IP which is owned by more than one company and therefore both companies have the rights to use. Joint-IP is often created within collaborative R&D projects.	Good management of jointly owned IP starts with a solid collaboration agreement at the start of any project. This agreement should: • Set out the background IP that the partners are bringing to the project • Ensure the business has freedom to use the IP in the target market segments and regions • Ideally, a business would have the freedom to use the IP with a range different suppliers and later development partners • Prevent partners from taking co-owned IP to competitors
Internal IP	**Internal background IP**	IP that currently exists within the company that will be used in this product.	Whilst no pro-active management of internal background IP is needed, it is worth understanding what, of the company's background IP, is likely to be needed, and ensure it is properly protected for new applications.
Internal IP	**Internal foreground IP**	New IP that is developed during the technology development project.	It is important that new IP is both identified and protected. There are range of strategies for this. These are discussed below.

IP can cover a range of company activities: Many technology developers consider patenting their technology concept or design, but fewer consider other aspects of their company activities. Consider protecting anything that may add value to company.

1. Manufacturing process
2. Customer built test rig design and processes
3. O&M process and tools
4. Support documentation
5. Branding and marketing tools

2.6 IP should be developed in conjunction with an IP specialist. If IP management capability does not exist within the organisation, getting support from a law firm specialising in IP protection should be considered. IP strategies can be broadly split into three categories and most organisation will use a mixture. These are summarised below.

Protect it	Stay ahead	Hide it
Formal protection of IP through patents, copyright etc.	Move fast and stay ahead, make sure that even if IP is copied, the business is already onto the next development	Don't tell the world what the business is doing, keep it quiet in other technology or inside the business's facilities

When is the Strategy Suitable?

Protect it	Stay ahead	Hide it
• When protection of core technology is required to ensure freedom to operate • When there is high cost of technology development and a relatively slow route to market (e.g. large turbine component) • When reverse engineering the core technology is straightforward • When the cost of having IP copied is more than the cost of protecting it.	• Technology, such as control software or battery chemistry that has fast design iterations • When end-user requirements are changing fast, leading to a limited useful life of technology.	• When the working of the technology is unlikely to be accessible to anyone outside the team • When just knowing about the technology under development could significantly help competitors to increase their competitive position • When reverse engineering the technology would be near impossible • When cost of protecting IP is prohibitive.

There are six key areas that should be considered when developing IP strategy:

- Operational geography
- Cost of protection vs risk
- Ability to maintain IP secrecy
- Time to market vs time to patent
- Commercialisation model
- Development partners.

The roles are outlined in more detail in Appendix 1.

SECTION 3

ADDITIONAL SUPPORT

Where to find
additional support

3.1 HOW CAN ORE CATAPULT SUPPORT?

Engineering support	Technical support in key knowledge areas of blades, drive trains, electrical infrastructure, operations and maintenance, and foundations and substructures
Funding application support	Strong partner is providing support in identifying funding opportunities and writing applications. See the Innovators Guide to Finance and Funding for more details
Test design and testing	Assets include 50m and 100m blade testing, 15MW wind turbine nacelle testing, offshore anemometry platform, electrical and materials laboratories, and the 7MW demonstration turbine
Market knowledge	Market intelligence, business modelling and commercialisation support (see the Innovator's guide to the Offshore Wind Market)
Access to stakeholders and partners	Technology assessments and benchmarking to provide confidence to investors. Facilitating collaborations between industries and/or academia

3.2 OTHER RELEVANT SUPPORT AGENCIES

Free or subsidised support is available to innovators in the UK from a range of public sector bodies. Below we highlight seven of the key support agencies that innovators in the offshore wind industry should consider.

Support agency	Areas
ORE Catapult	ORE Catapult is the UK's leading technology innovation and research centre for offshore renewable energy. ORE Catapult can assist with research, innovation, and testing
Regional development Agencies	Regional development agencies directly assist businesses through providing commercial support. Some may also help businesses receive technical support through partnership programmes with technical experts. **Scotland** – Scottish Enterprise, Highlands & Islands Enterprise, and Business Gateway **England** – Local Enterprise Partnerships **Wales** – Business Wales **Northern Ireland** – Invest NI and Enterprise NI
Offshore Wind Support Programmes	Scottish Enterprise's Offshore Wind Expert Support offers technical and commercial support from industry experts to business based in Scotland. Green Port Hull and SCORE provide similar opportunities for companies based in England
Carbon Trust (incl. OWA)	The Carbon Trust set up the Offshore Wind Accelerator with key industry partners to decrease the cost of offshore wind. OWA runs collaborative research and innovation programmes and competitions. SMEs can benefit from access to future customers and demonstration sites
Innovate UK	Innovate UK are the UK's public body for promoting economic growth through innovation. They also part fund and lead the Knowledge Transfer Network (KTN) and Catapult Centres, including the Offshore Renewable Energy Catapult
Knowledge Transfer Network	The KTN aims to help UK businesses find new opportunities through hosting events, arranging Special Interest Groups, and providing insight in to support available from public sector bodies

The following organisations can also provide support to SMEs developing new technologies in the offshore wind sector with more specialist support. Some offer industry specific support, whereas others provide support in areas such as IP protection and university collaboration.

- **Knowledge Transfer Partnership**
- **Energy Technology Partnership**
- **Catapult Network**
- **Offshore Wind Innovation Hub**
- **Offshore Innovation Exchange**
- **Enterprise Europe Network**
- **European IPR Helpdesk**
- **ESPRC Impact Accelerator Accounts** (see individual University websites)

3.2

APPENDIX 1. CONSIDERATIONS WHEN DEVELOPING YOUR IP STRATEGY FOR OFFSHORE WIND

1 GEOGRAPHY

Patents and other IP protection is geographically specific. Most countries have their own IP protection system and there are some regional IP protection systems in Europe, Africa and the Arab States. Alternatively, the World Intellectual Property Office has a Patent Cooperation Treaty (PCT). An application filed under PCT will cover many countries. Organisations should consider getting protection to cover any country or region they intend to supply to or operate in, although there are significant costs associated with this.

Be aware patents are more enforceable in some countries than others and therefore the value vs cost of protection needs to be considered in these regions.

2 COST

Getting patents on IP is expensive. UK Patent Application filing usually costs £3-5k. For covering all major markets costs can be as much £25,000 per patent.

Once background checks have been carried out and the application is accepted, there is an additional cost to proceed. It can cost around £3-4k to process a patent in the UK and up to £12k across the major European markets

During the following years there is also likely to be additional costs of dealing with objections to the patent. It can typically cost around £4-8k to deal with these objections.

Over a period of 6 years, it is not unusual to have spent around £40,000 securing patent protection in a selection of major European countries and the USA. There are also ongoing annual renewal fees in many countries *(Source; Dehns – The Financial Realities of IP Protection 2017)*

3 SECRECY

Three aspects of secrecy should be considered:

1 | **How easy is it to copy my technology?**
If the IP sits within software embedded in a complex system and would be difficult to reverse engineer, it may not need protection.

2 | **Manufacturing and supply strategy**
If manufacturing externally or using external suppliers for core components, a company is likely to need to share detailed information on their technology. Whilst Non-Disclosure Agreements will provide some protection, it can be challenging to control inventions once they have left the core team.

3 | **While patents protect IP, they also allow visibility of the technology.**
If IP can be kept secret e.g., a process within a company's own factories, this is often a better option.

4 TIME

It usually takes around 4 years for a patent to be issued in the UK. In the US the average time is just under 3 years. Patents in the UK are typically issued for 20 years.

In a fast-moving sector, or for technologies with quick technology development turnaround, patenting may simply take too long. Technology will have moved on rendering the patent virtually worthless. Businesses should question whether paying for 20 years of protection is required.

However, if there is IP that will form the ongoing basis of a business's core technology, patenting may be worth the time and expense.

5 COMMERCIALISATION MODELS

Businesses that want to licence or sell IP as part of their commercialisation strategy will need to protect it. Unprotected IP is worthless in this context.

6 DEVELOPMENT PARTNERS

The terms of collaboration agreements with development partners may dictate how IP is managed (see table above)

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