Low Carbon Hydrogen Supply 2 Competition Application Form Stream 2

Proposal Summary

1. Name of Applicant Organisation This should be the lead organisation/co-ordinator for the proposed project
Vattenfall Wind Power Ltd

2. Project Name
Hydrogen Turbine 1

3. To which technology theme(s) are you applying? Please refer to Section 2.3 of the Stream 2 Guidance Notes/ ITT for further information on themes. Select the most applicable theme(s) for your technology.
Zero Carbon Hydrogen Production Solutions

4. Stream 2 Estimated Start Date
* 01/11/2021

5. Stream 2 Demonstration Project Duration (months)
1 39

6. Stream 2 Estimated End Date
* 01/02/2025

7. Stream 2 Total Demonstration Project Costs (£) Please enter the total amount of BEIS funding for Stream 2 that you are applying for excluding VAT.
9993340

8. Please give a brief description of the project. (Maximum 400 words)

Project Hydrogen Turbine 1 (HT1) will be a world-first full scale demonstration of an offshore wind turbine dedicated to Zero-Carbon hydrogen production integrated into the turbine itself. Our innovative solution brings together technologies in a new and challenging environment and demonstrates how to operate them safely.

HT1 consists of hydrogen production equipment: including desalination, electrolysis and associated balance-of-plant closely integrated with the turbine power electronics, physically coupled with the turbine, on an extended platform which will encircle the base of the turbine. All turbine power is dedicated to hydrogen production, and is expected to operate without requiring energy supply from the grid. The hydrogen will be transported to shore via pipeline for processing and delivery to end users.

To accelerate demonstration of the pilot and maximise cost efficiencies, Vattenfall will retrofit an existing 8.8MW turbine within our Aberdeen Bay Offshore Wind Farm (ABOWF), allowing operations to commence by early 2025, two years ahead of other UK proposals.

By selecting ABOWF we will deliver hydrogen into the Aberdeen area and we will be supporting the transition of Oil and Gas to a Renewable Energy Future. Aberdeen has a highly skilled workforce to support the project and benefit from its delivery.

Vattenfall strongly believes that a "deep integration" concept provides the confidence to deliver the lowest cost Zero-Carbon hydrogen when scaled up. The potential for modularity leads to increased volume production and manufacturing efficiencies. Other benefits include reduced energy losses due to integration between power generation and hydrogen production, and replacing electrical transmission with lower cost pipelines to shore.

HT1 is a vital step in Vattenfall’s maturation plan to rapidly scale the concept to GW-size projects by 2030. Our modelling indicates that deploying at such scale will allow Zero-Carbon hydrogen to become cost competitive, without additional support, with fossil based hydrogen when factoring in CO_2 prices. We view this as a pre-requisite for displacing the incumbent hydrogen supply options, and developing a sustainable business and sector growth.

We aim to move with urgency to achieve this and HT1 was specifically conceived with speed of delivery in mind, as evidenced by the scope which focuses on the challenges of physical, electrical and process integration/control, offshore installation, and operation and maintenance. By using existing assets we expedite development time, maximise cost efficiency and provide learnings for the entire offshore wind industry.

9. Please explain why public sector funding is required to take this innovation forward. (Maximum 300 words)

Vattenfall has extensive experience in delivering R&D projects involving public sector funding. R&D, by definition, is often pre-commercial and innovative in its use of technology or application and that is the case with Hydrogen Turbine 1 ("HT1").
A project of the size of HT1 would represent around 75% of Vattenfall’s annual R&D budget and therefore be competing for capital against other Projects being considered. The majority of internal R&D projects focus on small improvements of existing equipment and processes. In contrast, HT1 aims to develop an industrial product, offshore turbine integrated Zero-Carbon hydrogen production. Since HT1 aims to develop a solution available to the entire renewable energy market instead of focusing on results for Vattenfall only, other projects delivering results directly to Vattenfall would be prioritised.
Public Sector funding allows a Private / Public Partnership which will allow the delivery of vital lessons learned to the industry 2 years ahead of similar UK projects and provide a vital stepping-stone in the progression towards delivering Zero-Carbon hydrogen and Net Zero Targets.
Vattenfall has brought together industry stakeholders and key suppliers to support HT1. As can be seen from our direct experience at Aberdeen Bay Offshore Wind Farm ("ABOWF"), Hamburg Hydrogen Bus Refuelling, and HYBRIT low-carbon steel production using hydrogen, we are able to leverage public funding support to accelerate the pace of decarbonisation solutions.
Without the contribution of public sector funding, HT1 will not be able to deliver results in 2025 and this would jeopardise the opportunity for the UK to host the world-first full scale demonstration of a dedicated offshore wind turbine producing Zero-Carbon hydrogen.

Eligibility Criteria

1. Technology Categorisation The technology must be in scope of one of the themes described in Section 2.3 of the Low Carbon Hydrogen Supply 2 Stream 2 ITT.

	Yes	No
Is the technology in scope?	X	

2. Innovation and Technology Readiness This Competition is to support the development of innovative Low Carbon Hydrogen supply solutions. It is to support the development of technologies that are not yet commercial from Technology Readiness Levels (TRLs) 6 to 7 at the start of the projects. (Further information on TRLs can be found in Appendix 1 of the Low Carbon Hydrogen Supply 2 Stream 2 ITT).

	Yes	No
Will your technology / system be at TRL 6 – 7 at the start of the project?	X	

3. Technology Scope The focus of the Competition is to support the development and demonstration of innovative hydrogen supply solutions as detailed in Section 2.3 of the Low Carbon Hydrogen Supply 2 Stream 2 ITT. Exclusions: Funding will not be provided for projects where the technology development focuses on: Upstream energy production (power and fossil fuel extraction) End-use technologies (for example boilers, and other hydrogen appliances) Technologies where the core technology has previously been operated commercially (in UK or Internationally) Power generation from hydrogen (for example fuel cells or CCGT) Gas-grid systems (onshore) Novel CCUS technologies which aren't intrinsically linked in the hydrogen production process

	Yes	No
Does your application exclude costing/budget for any of these technology exclusions (listed above)?	X	

4. Project Status BEIS is unable to fund retrospective work on projects.

	Yes	No
Can you confirm that your application does not seek funding for retrospective work on this project?	X	

5. Additionality Projects can only be funded where evidence can be provided that innovation would not be taken forwards (or would progress at a much slower rate) without public sector funding.

	Yes	No
Can you confirm that this project would not be taken forward (or would progress at a much slower rate) without public sector funding?	X	

6. Contract Size Demonstration (SBRI) contracts for up to £10m per project with a total of £30m across the Stream 2 competition are available, with a maximum of £5m for engineering design. Stream 2 Projects must be completed by 1 February 2025.

	Yes	No
Can you confirm the funding requested from BEIS for your project cost for Stream 2 will be equal to or below £10m with a maximum of £5m for engineering design and is 100% of eligible project costs?	X	

7. Eligible Project Costs SBRI is aimed at organisations working on research and development (R&D) of an innovative process, material, device, product, or service prior to commercialisation. Funding is available for R&D activities only, including related dissemination activity. Projects requesting funding for commercialisation activities are not eligible. The full list of eligible project costs is set out in Appendix 3 and outlined in Section 5 of the Low Carbon Hydrogen Supply 2 Stream 2 ITT. BEIS must fund 100% of eligible project costs, no match or in-kind funding is allowed.

	Yes	No
Can you confirm that requested funding is for eligible costs and BEIS will fund 100% of those costs?	X	

8. Project End Date Projects must be completed and approved by BEIS by 1 February 2025. Projects need to allow time for the BEIS monitoring officer to review the project; this process can take up to a month and should be included in your project plan.

	Yes	No
Can you confirm that the project will meet the specified project end dates?	X	

9. Risk Benefit Sharing The sharing of risks and benefits is an important aspect to the SBRI approach. Projects receive financial support and retain any intellectual property generated, with certain rights of use retained by BEIS. Project outputs are also expected to be shared widely and publicly and project teams are not permitted to include profit in the eligible project costs.

	Yes	No
Do you agree to this approach?	X	

10. Delivering Multiple Projects If project consortium member(s) are part of multiple successful applications, they must be able to deliver on them and they must not have applied for funding for the same piece of work more than once.

	Yes	No
a) If you or your consortium are part of multiple successful applications, would you be able to successfully deliver all projects if necessary?	X	
b) If you or your consortium are part of multiple successful applications, could you please confirm that you have not applied for funding for the same piece of work more than once?	X	

11. Multiple Applications If you intend to submit multiple applications, you must comply with the following limits of entry into the competition: Lead organisations may only enter one application into the Stream 2 competition as the project lead. A technology provider/OEM are limited to one application for a particular technology/solution requiring development.		
	Yes	**No**
a) If you are the lead organisation, as the project lead can you confirm only one application has been submitted for stream 2?	X	
b) If you or your consortium are part of multiple applications, could you confirm that the main technology being developed is different in each application i.e., only one application per particular OEM's technology has been submitted?	X	

12. Prompt Payment For contracts of £5m or more, if you intend to use a supply chain for this contract, you must demonstrate you have effective systems in place to ensure a reliable supply chain. If the application value is over £5m, and you intend to use a supply chain, please complete the document in Appendix 4, Declaration 7 of the Low Carbon Hydrogen Supply 2 Stream 2 ITT.		
	Yes	**No**
If your contract size is greater than £5m, can you demonstrate you have effective systems in place to ensure a reliable supply chain?	X	

Contact and Lead Organisation Details

1. Primary Contact Details

[This information has been redacted]

[This information has been redacted]

[This information has been redacted]

3. The registered address of the Lead Organisation

Address Line 1 5TH FLOOR 70

Address Line 2 ST MARY AXE

Address Line 3 -

Town/City London

Postcode/ Zip Code EC3A 8BE

4. County (If Applicable)

London

5. UK Region (If Applicable)

London

6. Country

United Kingdom

7. Project Location: Is this registered address the location where the main activity of the proposed project will be carried out? You will be asked to provide project location details in the separate BEIS Project Cost Breakdown/ Finance Form.

No

8. Lead Organisation Type

Other (please specify):
Private Limited Company

9. Lead Organisation Size

Large Enterprise

10. Number of employees in Lead Organisation (including directors)

[redacted]

[redacted]

13. Turnover Date (in most recent annual accounts)

* 31/12/2020

14. Balance Sheet Total of Lead Organisation (total assets net of depreciation) Please include the currency of the amount in your response.

[redacted]

[redacted]

19. Lead Organisation Status: a brief introductory description of the company. (Maximum 400 words)

Vattenfall Wind Power Limited (lead) represents the UK branch of Vattenfall AB (parent). Vattenfall AB in turn is the state owned energy company with a clear purpose - to Power Climate Smarter Living for our customers, with an objective to achieve Fossil Free Living Within One Generation. We have been on this journey for several years and are working to achieve this objective across the full value chain: from developing and delivering offshore and onshore windfarms to retail sales of electricity to customers. Furthermore, we collaborate with various industries to support them in their CO2 reduction missions, for example our work on steel with LKAB and SSAB.

Vattenfall conducts research and development (R&D) and technology-based innovation to provide new capabilities to serve our customers better. And Vattenfall considers indirect electrification through fossil-free hydrogen as an important solution to decarbonise the value chains of heavy-emitting industries. Besides the already mentioned collaboration with LKAB and SSAB, Vattenfall is investigating several projects and initiatives across Europe and is a founding member of the initiative AquaVentus, which has the ambition to install 10 GW of offshore hydrogen capacity in the German North Sea until 2030. All of the above demonstrates Vattenfall's commitment to hydrogen and the desire and experience to support our application.

Turning to Vattenfall's business model, Vattenfall finances its operations and investments through a combination of its own generated cash flow and external funding, mainly in the form of corporate bonds. We have a track record of delivering projects on our own and together with partners with the means of our strong financial position. Vattenfall does raise funds through the Green Bond Framework and has issued bonds in 2020, which is reflected in our annual reports.

Vattenfall Wind Power Limited is a 100% subsidiary of Vattenfall AB and as such follows the strategy, vision and operating model of Vattenfall AB. Our business in the UK develops and delivers wind farms as well as solutions to customers in the heat and infrastructure segments. Vattenfall Wind Power Limited has been active in the offshore market – both in terms of recent bids and in terms of farms in operation – and is looking to step into the hydrogen market in the UK.

20. Does the lead organisation have a parent company? (If yes you will be asked to provide details)

Yes

Parent Company Details

1. Parent Company Details

Organisation Name	Vattenfall AB
Address Line 1	Evenemangsgatan 13
Address Line 2	-
Address Line 3	-
Town/City	Solna
Postcode/ Zip Code	16992

2. Country

Sweden

3. Number of employees (including directors)

≈20000

4. Company Registration Number

556036-2138

5. Turnover Amount (in most recent annual accounts) Please include the currency of the amount in your response.

[redacted]

[redacted]

8. Balance Sheet Date (total assets net of depreciation)

* 31/12/2020

9. Organisation Maturity

>10 years

Criterion 1: Innovative Low Carbon Hydrogen Supply Approach

Criterion 1: Innovative Low Carbon Hydrogen Supply Approach This criterion will be used to assess the novel approach to Hydrogen Supply in the proposed demonstration project. Applicants should have already determined in outline, that their Hydrogen supply solution is technically feasible and meets, or has the potential to meet, the relevant industrial regulatory requirements, including health and safety and air quality. In their responses under this criterion, applicants are expected to justify that their project is sufficiently proven in terms of technical and regulatory feasibility to warrant funding for their proposed pilot demonstration. In making these justifications, applicants should reference any outputs from their earlier work, identify where further development is needed to confirm feasibility and explain how the pilot demonstration will be designed and executed to provide these confirmations. Highest marks will be awarded to the innovative low carbon hydrogen supply solution that best describes the design and the work expected to be carried out through the project. In the text box below, the applicant should: Describe what is innovative about your solution. Clearly state the aim of the demonstration trials proposed by, for example, stating what levels of performance constitute a successful trial. Describing how and why the demonstration will accelerate the development of low carbon hydrogen. Provide the latest evidenced justification for the technical and regulatory feasibility of the proposed demonstration pilot. This should reference any relevant earlier work, including engineering designs, engineering calculations and the outputs of other feasibility research and recapitulate the innovative nature of the solution. Clearly set out where there is remaining uncertainty about technical and regulatory feasibility and explain how your demonstration pilot will address these uncertainties. (Weighting for Criterion 1 – 5%) (Maximum 2,000 words)

Our submission addresses how Hydrogen Turbine 1 ("HT1") delivers
(A) An innovative Zero-Carbon solution.
(B) The aims of the demonstration and how it accelerates low carbon hydrogen developments.
(C) The justification for technical and regulatory feasibility of the demonstration; and
(D) Any remaining uncertainty around technical or regulatory feasibility and how we will address them.

HT1 provides a full-scale demonstration of an offshore wind turbine dedicated to producing Zero-Carbon hydrogen without relying on grid supply. It involves retrofitting an electrolyser to an existing 8.8MW Vestas wind turbine at Vattenfall's Aberdeen Offshore Wind Farm ("ABOWF"). Our demonstration will be the world's first full-scale offshore hydrogen production turbine delivering two years earlier than comparable UK projects.

[This information has been redacted]
[redacted]

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[This information has been redacted] [redacted]

[redacted]

[redacted]

--- THE AIMS OF THE DEMONSTRATION, INCLUDING PERFORMANCE AND HOW IT ACCELERATES ZERO-CARBON HYDROGEN DEVELOPMENT ---

--- Levels of Performance that Constitute Success ---

The main purpose of HT1 is to demonstrate and de-risk large-scale hydrogen production, proving the concept as a step towards dedicated offshore hydrogen production wind farms through increased technical readiness ("TRL"). The demonstration is a critical stepping-stone in the ramp-up to TRL8, demonstration in an operational environment, from TRL6 today. The paragraphs below describe levels of performance that constitute success for each project phase, discussed in Criterion 5. A summary of previous work around the conceptual design and functional requirements of the technical solution are further detailed in the Appendix.

Work package 1: Technical design.
The aim of the design phase is to verify and de-risk the technical concept through the generation of a detailed design, covering all subsystems and their interfaces. The system design must operate as a hydrogen producing turbine for the duration of the demonstration, all available turbine power output utilised for hydrogen production, with the exception of auxiliary systems, during normal operations. The turbine foundation structural integrity would also be re-evaluated for the new structure. Success would be sign-off on a viable and fully specified detailed design from:
i. Vestas, turbine supplier, and
ii. independent Engineer.

Work package 2: Delivery, Manufacturing, Construction, and Installation.
The aim of this phase is to retrofit power supply equipment, desalination, electrolysis, cooling, safety systems to an existing turbine. Potential turbine modifications include the transformer, Uninterruptible Power Supply, and control systems. Success would be the completion of the construction project based on the development and documentation of procedures, processes and tools to support Zero-Carbon offshore hydrogen technology in:
i. engineering,
ii. procurement,
iii. construction,
iv. manufacturing, and
v. installation.

Work package 3: Integration of Hydrogen Production and Early Operations.
The final phase is to provide tangible proof of Zero-Carbon hydrogen production at an offshore wind turbine in real world conditions. Success criteria include:
i. achievement of TRL 8 for the integrated solution,
ii. all systems to be compliant with applicable Standards and Regulations;
iii. operation of the turbine without any backup power from the grid; and
iv. operation of turbine and hydrogen production equipment autonomously during normal operations.

--- Our demonstration will accelerate Zero-Carbon hydrogen development ---

Our feasibility studies have shown that dedicated offshore hydrogen wind farms integrated at turbine level will deliver Zero-Carbon hydrogen at the lowest cost whilst hybrid farms, generating both power and hydrogen, do not improve project economics. The analysis and methodology regarding the performance and cost of the demonstration are detailed in Criterion 2. Electrical transmission is replaced by hydrogen pipelines connecting to onshore distribution networks and large-scale storage facilities. HT1 will apply our technical development, desk-based feasibility studies and learnings from previous projects, "Deep Purple", discussed below, to deliver the first offshore hydrogen demonstration and on-turbine integration.

The demonstration will provide earlier learnings through the retrofit of an electrolyser to an existing turbine at ABOWF. This allows technology to be demonstrated at significantly lower cost and accelerates the full-scale demonstration timeline in marine conditions by two years compared to other UK demonstrations.

The demonstration accelerates Zero-Carbon hydrogen development, as the Aberdeen region has ambitions to be a centre of excellence for the emerging Zero-Carbon and Low-Carbon hydrogen industries. Aberdeen City Council is supportive and pro-active, as evidenced by creation of the ‘Aberdeen Hydrogen Hub’ initiative, aiming to stimulate demand and coordinate supply.

--- THE JUSTIFICATION FOR THE TECHNICAL AND REGULATORY FEASIBILITY OF THE DEMONSTRATION ---

Our justification for the feasibility of this demonstration centres on:
(1) the TRL of the individual solution components;
(2) the existing turbine; and
(3) our conceptual studies to date.

Relevant detailed early work, including engineering designs, calculations, and outputs of earlier feasibility studies is attached in the Appendix.

Each core component of our Zero-Carbon hydrogen demonstration is commercially available, reducing technical uncertainty. Our solution is based on existing electrolyser, desalination, hydrogen storage and fuel cell technologies and the selected sizes are within the current capacity of those technologies. This allows our demonstration to focus on the specific offshore and integration challenges. The uncertainty lies in combining these technologies both physically (installation, operation, in-situ complications), and computationally (developing the software and controls).

Our approach to retrofit an existing turbine reduces regulatory uncertainty, consents and approvals, and increases deliverability, accelerates delivery and reduces costs relative to a new site. The existing turbine is installed on an innovative jacket foundation, resulting in a simpler retrofit and installation of equipment than for a monopile or floating foundation. The turbine is located at an Award-Winning Innovation Project with key stakeholders explicitly supporting the demonstration, (see Letters of Support in the Supporting Material). Several alternative sites were assessed for the demonstration, and the existing ABOWF has been selected as the optimal site (see Appendix for relevant work regarding site selection).

The previous work we have undertaken to develop a concept and early design reduces technical uncertainty. This includes the "Deep Purple" project, which has completed three phases of conceptual studies and modelling from 2016.

Phase 1 (2016-2017) established the technical feasibility and economic criteria, concluding that hydrogen production offshore was technically feasible and would be commercially viable in the long term.
Phase 2 (2018-2020) developed the concepts and assessing Technical Readiness Levels, and
Phase 3 (2020-2022) is underway, aiming to design and certify components for the pipeline and hydrogen storage sub-sea.

Details of conceptual studies are provided in Criterion 2 and in the accompanying Appendix, and HT1 will utilise this previous ‘proof of concept’ work. HT1 aims to take the concept and complete the world-first large-scale demonstration of a dedicated offshore hydrogen turbine, bringing the technology to TRL8 (demonstration in an operational environment).

--- AREAS OF REMAINING UNCERTAINTY AROUND TECHNICAL AND REGULATORY FEASIBILITY AND HOW WE WILL ADDRESS THESE ---

Remaining uncertainty for HT1 demonstration lies in four key areas. Three of these are technical:
(1) The physical combination of existing components;
(2) System integration to ensure functionality; and
(3) Offshore installation and commissioning of hydrogen production in a marine environment.

There is also Regulatory uncertainty:
(4) Design certification and approvals, environmental and health and safety standards required for operation.

These uncertainties are discussed below, along with details of how the HT1 demonstration project will address these referencing to previous Work Packages ("WP") outlined in Criteria 5 for Technical Design; Manufacturing and Construction; Integration and Early Operations.

1. Physical combination of existing components.

WP1 will provide a technical design and specification for hydrogen producing equipment installed with a turbine and platform to ensure access and functional operational requirements. This design will be validated and tested through WP2 with onshore mock-up of the physical integration of components for safe operation.

2. System integration.
Control system design and safety systems, from WP1, for integrating the hydrogen and turbine will be tested at WP2 before installation and integration with turbine electronics. We will also complete system integration testing prior to delivery at HT1, to ensure compatibility with the control systems.

3. Offshore installation and commissioning.
HT1 will be the world-first installation of turbine integrated hydrogen production at scale in an offshore environment. An installation methodology will be conceived in WP1, including modifications to the platform. WP2 includes preparation for offshore works including commissioning.

4. Regulation.
The innovative nature of the demonstration means there is uncertainty around how Regulation and Policy may develop. To address this, we have a workstream including the Project consenting team, Legal, Stakeholder Engagement, and Public and Regulatory Affairs, to verify any Regulatory restrictions. We have captured Legislative, Regulatory and Policy uncertainties in the Risk Register, see Criterion 5c.

--- IN CONCLUSION ---
We have thoroughly evaluated the technical feasibility of our innovative HT1 solution for Zero-Carbon Hydrogen Supply and have secured the agreement and support of suppliers for components involved in the demonstration. Our key contractors, Technip and Vestas, have signed Letters of Support, providing confidence in the business case and regulatory and technical feasibility for HT1 (see Supporting Information).

Please enter the core content of your response to this criterion in the text box. Applicants who wish to support their response with figures (e.g. illustrations/PFDs/graphs/charts/schematics) may attach these as part of the Referenced Figures single attachment (max. 20MB allowance provided) in the Further Information section of this application form. Applicants must clearly label the figures in the attachment and reference the figures in their response within the text box to ensure they are assessed. Any further text submitted within the Referenced Figures single attachment will not be assessed. Additionally, applicants may use evidence of relevant earlier work (limit to 20 pages), all assumptions / calculations / references to respond to this criterion which should be detailed in the attachment below and will be assessed. To complete this section you may upload evidence of relevant earlier work, all assumptions / calculations / references with your application. Max upload size per file – 20MB Max number of files – 1

- File: HT1 Appendix 1 – Supporting material for C1.pdf - Download

Criterion 2: Performance and Cost Reduction of the Hydrogen Supply Solution

Criterion 2a: Performance of the proposed solution The applicant should provide a detailed explanation of the performance of the proposed hydrogen supply solution and compare it to the current state of the art solution and the applicable counterfactual parameters (see Appendix 2 of the Low Carbon Hydrogen Supply 2 Stream 2 ITT), define the assumptions made and the basis for those assumptions. Describe the impact of different operating conditions, for example if the hydrogen supply solution is operating at a variable throughput. Details of the impact on the efficiency of the process should be presented including impact on OPEX costs, longevity and performance. In the text box below, applicants should: Provide details of the performance and flexibility of the proposed solution at the demonstration site and when rolled-out across multiple, suitable sites in future. Explain how the demonstrator will be used after this project has been completed or indicate the decommissioning strategy. Provide evidence of how and why this solution allows performance benefits when compared to the current state of the art and applicable counterfactual parameters. Provide an explanation of the technical barriers to deployment and description of the plan during the demonstration to overcome/scope-out/understand these barriers better. Provide an overview of any relevant performance validation that has previously been conducted. Applicants should detail the approach of the performance validation process that will be followed during the demonstration phase. Provide an explanation of why it is believed that the hydrogen supply solution will be acceptable to the market in terms of ease of installation and reliability (Weighting for Criterion 2a – 10%) (Maximum 2,000 words)

Hydrogen Turbine 1 ("HT1") will provide vital learnings throughout its demonstration period. With an expected 10-year lifetime for the hydrogen equipment we also believe it will continue to provide lessons after its initial demonstration period.

Dedicated GW-scale offshore hydrogen wind farms will allow the UK to meet is hydrogen, offshore wind and Net-Zero targets. By using an existing asset, we can focus on the performance and impacts of a single hydrogen turbine providing operational data to industry, academia and UK Government. This will drive future lowest cost zero-carbon hydrogen.

--- How HT1 will be Used after the Demonstration ---

The HT1 demonstration aims to prove and de-risk the innovative solution and will continue to the end of the BEIS Demonstration Study in Q1 2025. Separate to the demonstration, which focuses exclusively on Zero-Carbon hydrogen production at a turbine (see Criterion 1), a pipeline and onshore facilities for hydrogen offtake will be developed.

The full asset lifetime will be based on the lifetime of the electrolyser key components and is expected to be 10 years, after which the turbine will be converted back into electrical export for the remainder of the turbine lifetime. While this will be after the initial BEIS period of funding, an important industry lesson from having an electrolyser in extended service in offshore conditions will be whether exposure to aggressive marine environment affects the asset's lifetime.

Hydrogen will be piped to shore, from the turbine, and transferred to a compressor and pressure vessel storage. We have consulted with Aberdeen Harbour Board's new South Harbour development where it could be used to fuel marine vessels or alternatively Aberdeen City Council's public transport buses. We are currently in early discussions with Shell around the offtake of the hydrogen and have attached a Letter of Support.

--- Performance and Flexibility of the Solution ---

After commissioning, HT1 will operate continuously throughout the demonstration period, subject to the variability of the wind and power from the turbine. The only exception being planned, or unplanned, outages requiring maintenance.

[This information has been redacted] [redacted]

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The flexibility of the hydrogen production system is expected to be in the range 5-125% of the nominal electrolyser load which is based on the historical operation of the wind turbine. See Referenced Figures 1 & 2 for historical data.

The integrated system uses a commercial Polymer Electrolyte Membrane ("PEM") electrolyser stack which has well-established purity specifications, >99.9% expected at 3-4 MPa, increasing to 99.998% with optional de-oxygenation and drying.

HT1, as with all pre-commercial demonstrators, will not produce Zero-Carbon hydrogen at a price that competes with existing fossil-fuelled hydrogen supplies. A successful demonstration will corroborate Vattenfall's belief that offshore integrated turbines have the potential to be the lowest cost hydrogen ("LCoH") production in the UK if industry expectations on cost reductions of equipment are achieved. Further details on the LCoH assumptions are set out in Criterion 2b.

--- Evidence of Performance Benefits when compared to current State-of-the-Art and Applicable Counterfactual Parameters ---

Our Hydrogen production integrated at offshore turbine level (Scenario 1) offers significant performance benefits to the counterfactual, which would be the production of Zero-Carbon hydrogen from offshore wind power transmitted to shore by cable powering electrolysis on land (Scenario 2). As set out in Criterion 2b the LCoH analysis and assumptions compare our proposed approach, deep integration (hydrogen production integrated at turbine level offshore), to the current solution of power producing wind farm with an onshore electrolyser. The key insights are detailed below.

The overall LCoH from a future offshore wind farm with hydrogen production offshore integrated into [redacted] [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

--- Technical Barriers to Deployment and the Management Plan to deal with the Barriers during the Demonstration ---

Throughout the demonstration we will build on learnings within the Zero-Carbon hydrogen production to raise the innovation to TRL 8. This will validate the desktop analysis completed to date, Deep Purple, and deliver the world- first dedicated offshore hydrogen producing turbine.

As described in Criterion 1, the technical barrier to deployment is the combination and integration of existing technologies in an offshore environment, which can be divided into three key challenges:
(1) The physical combination of disparate existing technologies, ensuring operability across PEM electrolyser, desalination, etc;
(2) System integration of the hydrogen equipment and wind turbine for Zero-Carbon hydrogen production in response to intermittent renewables energy; and
(3) the installation and commissioning of hydrogen producing equipment in an offshore marine environment.

Technical Design - Work Package ("WP")1 focuses on these technical uncertainties, that address each of these in turn:
i. A physical design for the footprint of equipment on a modified turbine , with containerised

technologies and extended platform;
ii. Computational system design of controls and safety measures for hydrogen producing equipment software integrated with turbine software; and
iii. an agreed installation and operation plan for HT1.

WP1 will deliver finalised installation designs of equipment and operational efficiency, to minimise operational costs.

Manufacturing and Construction - WP2 will involve onshore system and component testing to reduce uncertainty of the three key challenges described above and understand how to overcome them. The final testing approach will be defined through WP1, but may include, an onshore mock-up of the solution. This would assess the physical combination of disparate technologies identified in challenge #1.

--- Overview of relevant performance validation from previous feasibility studies, and the performance validation process during the demonstration phase ---

To date, we have conducted performance validation through:
i. initial technical concept and economic analysis of integrating hydrogen production offshore, particularly through the Deep Purple project; and
ii. early site-specific analysis and feasibility studies to bring HT1 to ‘proof of concept’ stage.

Further performance validation will be conducted through the demonstration, through:
iii. finalisation of the technical design through WP1; and
iv. testing of innovation components and integration through WP2.

Each performance stage is discussed in detail for completed, 1 & 2, and planned, 3 & 4, validation.
1) Initial analysis. We have conducted a range of initial investigations to determine desktop ‘proof of concept’ for dedicated offshore hydrogen wind farms. These include the Deep Purple project, detailed in the Appendix, which has completed three phases of conceptual studies and modelling from 2016.

Phase 1 (2016-2017) established the technical feasibility and economic criteria, concluding that hydrogen production offshore was technically feasible and would be commercially viable in the long term.
Phase 2 (2018-2020) developed the concepts and assessing Technical Readiness Levels, and
Phase 3 (2020-2022) is underway, aiming to design and certify components for the pipeline and hydrogen storage sub-sea.

2) Early site-specific studies. We have conducted initial conceptual design work to assess the layout feasibility of HT1. Early renderings are included in Appendix 2 Figures 20 & 21.

3) Finalisation of the technical design. We will build on performance validation completed to date through scoping and conceptual studies in WP1. This will involve design of the platform extension and support, turbine and hydrogen integration, and electrical system design. Throughout all of the design, we adhere to our ‘Safety by Design’ process, to understand the key performance challenges, risks and design from the initial technical design phases.

4) Testing. The signed-off technical design from WP1 will be tested in the early stages of WP2. At a high level, we would expect factory acceptance testing by the respective equipment manufacturers. We would then look to perform system integration testing prior to taking the system offshore. The integration testing would focus on validating that the assumptions of the hydrogen production subsystems with the turbine power electronics performing as designed. This would include the following:
- Physical assembly of the system, to the extent possible, at OREC onshore facilities to ensure safe installation, operation , access and maintenance of the physical setup, preferably with the platform extension proposed around the turbine-base to support the equipment.
- Emulating the power interfaces of the turbine and interfacing this with desalination, electrolysers, auxiliary and safety systems. This would allow for validation of control and safety systems, system ramp rates and dynamic response, responses to failure modes, etc.

--- IN CONCLUSION ---

HT1 is a demonstration project that is intended to unlock an offshore green hydrogen production future. The project is not demonstrating the already proven thermochemical or electrochemical process or user acceptance. It is demonstrating the production of hydrogen from existing electrolysis technology in a novel way that has never been tested at scale before. One of the objectives of the demonstrator is to generate processes and learnings to ensure that installation at a commercial scale can be delivered as safely and at as low a cost as is reasonable.

Our initial research with suppliers and offtakers indicates that HT1 will be welcomed by the market for the potential to create significant opportunities for the UK offshore wind market for low cost Zero-Carbon hydrogen for decarbonising 'hard to abate' parts of society and for future export. GW-scale wind farms will for the first time be able to provide Zero-Carbon Hydrogen, in large volumes and at low cost. When combined with storage and implemented across industry, it will allow industry and transport to decarbonise in a way not possible with just renewable electricity.

Please enter the core content of your response to this criterion in the text box. Applicants who wish to support their response with figures (e.g. illustrations/PFDs/graphs/charts/schematics) may attach these as part of the Referenced Figures single attachment (max. 20MB allowance provided) in the Further Information section of this application form. Applicants must clearly label the figures in the attachment and reference the figures in their response within the text box to ensure they are assessed. Any further text submitted within the Referenced Figures single attachment will not be assessed. Additionally, applicants may use evidence of relevant earlier work (limit to 20 pages), all assumptions / calculations / references to respond to this criterion which should be detailed in the attachment below and will be assessed. To complete this section you may upload evidence of relevant earlier work, all assumptions / calculations / references with your application. Max upload size per file – 20MB Max number of files – 1

- File: HT1 Appendix 2 – Supporting material for C2a.pdf - Download

Criterion 2b: Lifetime costs of the proposed solution With reference to relevant prior work, describe the likely lifetime costs of the Hydrogen Supply solution compared with the applicable counterfactual parameters (see Appendix 2 of the Low Carbon Hydrogen Supply 2 Stream 2 ITT) including round-trip efficiency, providing the assumptions made. Costs should be broken down, where possible/relevant, into CAPEX (and financing at IRR 10% where applicable), OPEX (broken down into fuel, maintenance, labour, consumables), carbon cost, for main plant equipment. We also expect a current and estimated future (2035) levelized cost where relevant. Describe how demonstration will firm up these costs. Where applicable, include in this analysis the capture rates, the system benefit costs, the impact on the purity of hydrogen, accessibility to hydrogen and round-trip efficiency. How do these compare against state of the art? Highlight the main uncertainties associated with these cost estimates and explain how the design and execution of your demonstration pilot will address these uncertainties. Applicants should note the following: The applicable technical parameters should match those stated in the counterfactual including the relevant pressures, purities and flow rates. These boundary conditions should be used to develop costs of a counterfactual. If a different set of boundary conditions is more representative for your hydrogen supply technology, this can also be included, in addition, to help support your application, but would require justification. Compare and justify all costs and cost reduction of the proposed system to the current state-of-the-art hydrogen supply solution or closest comparable existing solution. To calculate (and enable us to compare) lifetime costs, bidders should use BEIS's estimates for cost of carbon, electricity and natural gas prices in 2035 (assume these costs and prices do not change). These are provided in in Appendix 2 of the Low Carbon Hydrogen Supply 2 Stream 2 ITT. If a different cost assumption basis is more representative for your hydrogen supply technology, this can also be included, in addition, to help support your application. All units of measurement provided for the analysis should match those stated in the counterfactual. (Weighting for Criterion 2b – 10%) (Maximum 2,000 words)

Hydrogen Turbine 1 ("HT1") will be a world-first full scale demonstration of offshore hydrogen production. We have lifetime projections for Zero-Carbon hydrogen, also known as green, for fossil fuel hydrogen, known as grey, and for fossil fuel hydrogen with carbon capture, known as blue, using widely available data.

Our assessments show that GW-scale dedicated offshore hydrogen wind farms can provide lowest cost hydrogen when compared to onshore hydrogen production from offshore wind farms, the counterfactual.
We also have analysed the Levelised Cost of Hydrogen ("LCoH") when the cost of CO_2 is included in to the overall production costs of low-carbon hydrogen from fossil fuel sources.

--- Overview of Hydrogen Cost Projections ---

[redacted]

[redacted] [redacted]

factors. The long-term benefits

We have

turbines.

environment.

There is limited value

back to DC.

transmission.

As hydrogen

Wind Power ---

Concept 1; and

[redacted]

For both scenarios we have used the following assumptions:
• Commercial wind farm with a capacity of [redacted]
• Commissioning in [redacted]
• [redacted] year plant lifetime (we note that this is longer than the [redacted] year operating lifetime suggested in the BEIS boundary conditions, however we consider this to be more applicable for future offshore wind farms);
• Wind capacity factor of [redacted]

• [redacted] electrical transmission for Concept 1 and [redacted] transmission system for Concept 3
• WACC of [redacted]; inflation rate o[redacted]
• Hydrogen production efficiency of [redacted]

Capital ("CAPEX") and Operational Expenditure ("OPEX") assumptions differ between the two scenarios, as we have estimated costs at a component level.
For (a), we assume a total lifetime CAPEX cost of [redacted] and OPEX of [redacted]; whilst for (b) these are assumed to be [redacted] and [redacted] respectively. CAPEX items are provided below and summarised in Appendix 3 Figure 2.

We have applied common CAPEX assumptions for the following components:
[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted] [redacted] [redacted] [redacted]

[redacted] [redacted] [redacted]

[redacted]

[redacted]

[redacted]

model assumptions are published in the report and are included as Appendix 3 Figure 5.

--- Cost Uncertainties and how We will Address these ---

There are a range of cost uncertainties that have been used to calculate the LCoH described above. A key aim of the demonstration is to generate industry insights and actual costs for dedicated offshore hydrogen wind farms. The demonstration will enable greater certainty of the costs for the technical design; manufacturing and installation; and early operations work packages. Each of these is discussed in turn.
(1) The technical design phase will allow us to confirm CAPEX costs for the hydrogen production components through the determination of the optimal fuel cell / battery sizes. Our 'Safety by Design' approach involving experts in installation, commissioning and operation into the design stage, will also allow us to firm up component and asset installation and operating costs and will form the basis of our operational control plan. This will provide confidence in our view of ongoing OPEX costs at HT1.
(2) The manufacturing, testing and commissioning phase will involve early component and solution testing, following which the solution will be deployed offshore at ABOWF. The solution testing will allow us to identify any further cost savings across the different technologies, optimising our offshore deployment and installation costs. As described in Criterion 1, HT1 will be a world-first for a dedicated offshore hydrogen wind turbine, and HT1 will confirm the costs associated with offshore installation.
(3) The early HT1 operations phase will be key to determine OPEX costs in practice, and compare these to the OPEX costs for an offshore wind farm dedicated to electricity production. We will assess cost performance in real 'wind-following' conditions, allowing us to understand OPEX costs at dedicated hydrogen turbines.

There are expected to be cost improvements for HT1 compared to the counterfactual of onshore hydrogen production from offshore wind turbines, which will drive further commercial benefits that we foresee with GW-scale integrated hydrogen projects.

The proportion of transmission costs of overall CAPEX costs at offshore wind farms is expected to increase as offshore wind build-out in the UK continues with larger turbines further away from shore and transmission distances increase. There is potential to connect multiple offshore hydrogen wind farms to reduce pipeline costs. For example, a single 90cm diameter pipeline could transport the Zero-Carbon hydrogen from 7-10GW of combined offshore wind farm capacity, providing further cost reduction per project.

--- IN CONCLUSION ---

The HT1 project will be a world-first demonstration of dedicated offshore hydrogen production at a turbine. Allowing us to firm up our understanding of the CAPEX and OPEX costs associated with Zero-Carbon hydrogen production at a dedicated offshore turbine. This provides the first step towards the goal of dedicated hydrogen production at offshore wind farms, which will unlock further cost reductions in future and deliver on UK Net-Zero targets.

Please enter the core content of your response to this criterion in the text box. Applicants who wish to support their response with figures (e.g. illustrations/PFDs/graphs/charts/schematics) may attach these as part of the Referenced Figures single attachment (max. 20MB allowance provided) in the Further Information section of this application form. Applicants must clearly label the figures in the attachment and reference the figures in their response within the text box to ensure they are assessed. Any further text submitted within the Referenced Figures single attachment will not be assessed. Additionally, applicants may use evidence of relevant earlier work (limit to 20 pages), all assumptions / calculations / references to respond to this criterion which should be detailed in the attachment below and will be assessed. To complete this section you may upload evidence of relevant earlier work, all assumptions / calculations / references with your application. Max upload size per file – 20MB Max number of files – 1

- File: HT1 Appendix 3 – Supporting material for C2b.pdf - Download

Criterion 3: Social Value

Criterion 3a: Short term development plan. In the text box below, the applicant should provide a summary of the short-term development plan that comprehensively appraise the outstanding technical challenges of the solution and its commercial benefits and risks relative to the applicable counterfactual parameters. In the response, please cover the following: Present the plan for further development, commercialisation and exploitation of the hydrogen supply solution. What are the main technical and commercial challenges and risks to getting the solution to market; and how will you overcome them? A summary of the business plan must be presented that highlights the route to market and estimated time to secure market share. Applicants who wish to support their response with figures (e.g. illustrations/PFDs/graphs/charts/schematics) may attach these as part of the Referenced Figures single attachment (max. 20MB allowance provided) in the Further Information section of this application form. Applicants must clearly label the figures in the attachment and reference the figures in their response within the text box to ensure they are assessed. Any further text submitted within the Referenced Figures single attachment will not be assessed. (Weighting for Criterion 3a – 5%) (Maximum 1,000 words)

We have a detailed short-term development plan for Hydrogen Turbine 1 ("HT1"), considering:
(A) future commercialisation and exploitation of dedicated offshore hydrogen production turbines;
(B) the main technical and commercial challenges to getting the solution to market; and
(C) a summary of the business plan.

--- Development Plan for Commercialisation and Exploitation of our Zero-Carbon Hydrogen Supply Solution ---

A number of studies have shown that UK offshore wind will be the backbone of the hydrogen economy in Europe and Vattenfall is a market leader in offshore hydrogen development, building on its 3.6 GW of installed wind capacity, 3.2 GW under construction and 4 GW in an advanced stage of development. Offshore wind farms dedicated to hydrogen production will be a large part of Vattenfall's future portfolio and the ambition is to enable the development of at least 1,5GW of integrated hydrogen wind farms by 2030 at the latest.

We believe that cost competitive Zero-Carbon hydrogen can be achieved by 2030 by combining scale, standardisation and innovation in dedicated offshore hydrogen wind farms, and have identified five steps needed to mature integrated hydrogen turbines towards large scale deployment:
(1) Technical design and engineering of dedicated offshore hydrogen wind turbines;
(2) Onshore component and systems testing;
(3) Initial offshore demonstration at Aberdeen Bay Offshore Wind Farm ("ABOWF");
(4) Offshore clusters as part of larger farms; and
(5) Entire offshore wind farms dedicated to hydrogen production.

These steps aim to gradually increase technical complexity, building on learnings to increase scale whilst managing risk and driving down uncertainty. This approach will systematically qualify the technical solution for large scale deployment, whilst maintaining investment in the process of rapidly progressing towards the required levels of economic attractiveness. The steps also provide the opportunity to allow consolidation of learnings and build-up of capability and expertise in how to design, construct and operate such assets across the industry for 2030 delivery.

The HT1 project delivers stages 1-3 listed above:
• finalisation of technical design (Work Package ("WP")1 referenced in Criteria 1);
• testing, installation and construction (WP2); and
• integration and early operations to provide a first full-scale demonstration of a turbine dedicated to producing hydrogen offshore (WP3).

It will be a critical stepping-stone for further development and commercialisation by raising the TRL of the solution. Vattenfall's commercialisation plan following the successful demonstration of HT1 is to install 100 MW integrated turbines at Hollandse Kust West by 2026 and a dedicated wind farm of 1 GW by 2030 , details of which are described in Referenced Figure 6.

--- Technical and Commercial Challenges ---

Innovative designs are, by definition, immature and face commercial challenges as well as technical risk. Below we outline the key challenges that will need to be addressed to scale from HT1 to a hydrogen cluster and ultimately to entire offshore wind farms dedicated to hydrogen production.

Technical challenges associated with scaling up hydrogen production at offshore wind farms include the complexity of installing hydrogen production equipment offshore, and the risk that this could delay delivery and commissioning of new build wind farms. As HT1 involves the retrofit of an electrolyser to an existing turbine, it allows learnings from testing in WP2, to be two years earlier than comparable UK demonstrations. We will ensure component functionality and successful integration across both operability, physical operation of components in the determined configuration, and system integration. These can be leveraged in future developments to reduce the risk of delays from integrating hydrogen producing equipment on a new-build offshore wind farm.

A further technical challenge in getting the solution to market is the risk that the innovation impacts the operation of the wind farm. HT1 is confined to a single turbine and does not interact or interfere with the remainder of ABOWF reducing this risk. A key deliverable from WP3 would be the operations and maintenance learnings from the demonstration. Any observed challenges can be considered for further deployment and operation of hydrogen production at offshore clusters and ultimately dedicated offshore hydrogen farms.

There is also a commercial challenge around offtake. Although the project is pre-commercial and therefore is not expected to make a positive return, offtake of the hydrogen produced at HT1 is still required. Our current plan for offtake is discussed in more detail below as part of our wider business plan.

--- Business Plan ---

To compensate for part of HT1s costs, Zero-Carbon hydrogen will be sold to offtakers in the vicinity of Aberdeen, providing revenues from the hydrogen. Internal analysis has indicated that hydrogen from HT1 will be eligible for RTFCs from the Department of Transport, which will provide additional . Current scope boundaries include outsourcing of the distribution of the hydrogen with Shell as interested party, a Letter of Support from Shell has been included in the Further Information.

After commissioning of HT1, Vattenfall expects turbine suppliers, including Vestas, to make the developed product available to the market. Hydrogen producing turbines will then be deployed at offshore wind farms by Vattenfall as well as by other developers. This is the next big step in sustainability, enabling molecule based industry to become renewable.

Vattenfall is an early mover and sector leader in hydrogen and power-to-gas industry, and is already highly engaged in hydrogen initiatives, see Referenced Figure 3. Until 2030, we expect the Zero-Carbon hydrogen market to be driven by regional hubs, with offtakers and production in proximity spurred by favourable Local Regulation, see Referenced Figure 2.

--- IN CONCLUSION ---

Vattenfall is planning dedicated offshore hydrogen wind farms or large-scale sections of a wind farm across its Portfolio. Our pipeline of projects is presented in Referenced Figures 3, 5 & 6 and expect an accumulated 1.5 GW of dedicated Zero-Carbon hydrogen production in operation or construction by 2030. Our plans are to scale this further in to GW-scale dedicated offshore hydrogen wind farms in the 2030s. HT1 is a critical step in the maturation of the solution and accelerates commercial deployment by 2 years, enabling a number of projects to be in operation by 2030.

Criterion 3b: Long term development plan. In the text box below, the applicant should provide a summary of the longer term development plan that highlights the route to market and estimated time to secure market share including highlighting the key challenges to achieving commercialisation at scale (assuming there is a demand for bulk low carbon hydrogen), timescales, build rate, and estimated development costs, UK job creation and development of a supply chain to develop a future hydrogen economy. In the response, please cover the following: Discuss the timescales and development costs and any potential supply chain constraints to support a future hydrogen economy particularly focusing on the UK 2030 hydrogen ambition and 590 TWh by 2050 (based on National Grid's Future Energy Scenarios). This should include potential cost savings through learning by doing, UK job creation, the development of a supply chain to meet future demand, air quality impacts (NOx, amines, particulates etc.) and carbon (CO2eq) savings across the economy (direct or indirect). Where possible, please separate emissions into Scopes 1 and 2 (direct and indirect), UK and international, and for theme 1 (Low Carbon Hydrogen Production) please include upstream emissions from natural gas (please see details in Appendix 2 of the Low Carbon Hydrogen Supply 2 Stream 2 ITT). The applicant should also detail the potential wider environmental impact (local and global) from the roll out of the proposed hydrogen supply solution and limitations in the supply of rare materials, and how they could be mitigated. With reference to the response against Criteria 5 (Project Delivery) how will these be mitigated? Route to market and market potential of the proposed solution discussing the alternatives and the competitive advantage, highlighting future innovations and learning rates and how the hydrogen supply solution could reduce the costs of achieving net zero. Explain how the demonstration will accelerate the development of low carbon hydrogen economy in the UK. Applicants who wish to support their response with figures (e.g. illustrations/PFDs/graphs/charts/schematics) may attach these as part of the Referenced Figures single attachment (max. 20MB allowance provided) in the Further Information section of this application form. Applicants must clearly label the figures in the attachment and reference the figures in their response within the text box to ensure they are assessed. Any further text submitted within the Referenced Figures single attachment will not be assessed. (Weighting for Criterion 3b – 10%) (Maximum 2,000 words)

Hydrogen Turbine 1 ("HT1") is innovative in being the world-first full scale demonstration of offshore zero-carbon hydrogen supply, using existing technologies in novel ways.

The learnings from HT1 both in its initial phase to Q1 2025 and its potential over the lifetime of the hydrogen equipment will be a catalyst to further long-term developments.

Vattenfall envisages GW-scale dedicated offshore hydrogen wind farms, and HT1 being a dedicated single turbine will allow focused study on any potential impacts and how they might then be mitigated at scale.

HT1 is expected to be the first step in a new UK market for offshore hydrogen production using the skills from the existing Oil and Gas industry, offshore wind and emerging hydrogen manufacturing base. All these can be found in UK and position it well for the future.

By utilising our existing asset at Aberdeen Bay Offshore wind farm ("ABOWF") we will be able to reduce risk, cost and time to deliver 2 years ahead of similar UK Projects. We will also leverage our existing supply chain, creating new highly-skilled sustainable roles.

--- Market Context – Supporting a Future Hydrogen Economy ---

Zero-Carbon hydrogen is a critical lever in meeting the UK's Net Zero 2050 target, and there is potential for the UK to lead the development and supply chain for integrated Zero-Carbon hydrogen generation. Vattenfall have a long-term Zero-Carbon hydrogen development plan that considers the UK market as a primary driver and the likely challenges and opportunities to arise in the development of a hydrogen economy, see Vattenfall Hydrogen Strategy in Appendix 4 Figures 1-4.

The widespread deployment of offshore Zero-Carbon hydrogen production requires the development of the UK hydrogen supply chain, storage, and UK hydrogen offtake market. Current global supply chains for electrolysers and fuel cells must ramp up significantly to meet projected demand; there are, however, plans in place for the development of giga-factories in the UK. Large scale offtake is also needed to develop hand-in-hand with supply, and the entire value chain must be considered for successful roll-out of low carbon hydrogen projects. Early signs are promising with innovative plans for Aberdeen Hydrogen Hub and UK's first hydrogen town by 2030. UK Government initiatives, such as this Low Carbon Supply are being developed in parallel to demand, such as the Green Distilleries. Coordination of supply and demand through Policy and by Industry will allow the potential for Low Carbon hydrogen to deliver on UK Net Zero targets.

We fully expect that the development of the UK industry for Zero-Carbon hydrogen production at dedicated offshore wind farms will create local jobs and a tangible economic benefit. The IRENA jobs database (2020) indicates that the UK currently ranks 5th in the world for wind employment, after China, Germany, the USA, and India. Developing a globally leading offshore wind hydrogen production industry is a key strategic lever to enable the UK to maintain and further its leading status in the offshore wind industry.

Research from Oxford Brookes University showed that up to 50 full time equivalent ("FTE") local jobs will be created from operations activities at ABOWF, realised through local contracts with suppliers and onward spending in the community. The same research also highlights that ABOWF could generate £100m for the region over 20 years, see Appendix 4, Figure 6

The development of a world-first hydrogen producing turbine at ABOWF will facilitate the development of UK capability and expertise in offshore hydrogen, as well as establishing an innovative supply chain. These specialist skills and supply chains developed could be a blueprint for wider prospects for future hydrogen-producing offshore wind in the UK and provide and for export opportunities for both technology and skills.

At Vattenfall, our approach is to proactively facilitate local supply chains to gear up and deliver enhanced local job opportunities and economic development. The benefit of enabling a low carbon hydrogen economy in Aberdeen is recognised by the city council, who published an Aberdeen Hydrogen Strategy in 2015 and have an innovative solution for a regional Hydrogen Hub developed in 2021. Our commitment to developing Zero-Carbon supply chains, and our approach to local development projects, is detailed in the EIC insight report article, "Developers as facilitators of supply chain conversations", depicted in Appendix 4 Figure 5.

--- Environmental Impact of the Proposed Supply Solution and Mitigation ---

For a large scale roll out of dedicated offshore hydrogen wind farm, the environmental impacts are expected to be largely similar to those of a current offshore wind farm. Consideration of the constituent parts of a hydrogen wind farm are set out below.

Assuming offshore electrolysers are largely integrated at the turbines bases, the infrastructure in terms of scale and form will not lead to any materially different environmental impacts. The process of desalination and electrolysis will produce heat and introduces a new risk in comparison to a traditional offshore wind turbine. Natural cooling will be used and we are also investigating if there are complimentary opportunities to use this heat.

Discharge of excess water from desalination will have an elevated salinity compared to the surrounding seawater. This will need to be assessed as saline discharges to the marine environment may have impacts on benthic fauna, plankton and fish as well as impacts on water quality. The higher saline excess water will be denser than ambient seawater and will have a tendency to sink, however as the volume discharged will be widely distributed over a large area, it is not expected to lead to significant environmental impacts.

Pipeline installation will lead to broadly similar impacts as cable installation, although it may be possible to reduce the extent of these impacts as fewer pipelines are needed than export cables. The effect of damage to the pipeline will need to be assessed although with safety systems in place, the worst-case volume of hydrogen leaked into the marine environment would be unlikely to cause significant environmental effects.

Our large operational and development portfolio, Appendix 4 Figure 7, is evidence of successful delivery of Environmental Impact Assessments and high-quality Environmental Statements. Our Environment and Sustainability Team Provides project environmental support, advice and consulting services and ensures compliance with Policy and Regulations, including relevant UK and EU legislation such as Habitat Regulations Assessment and Water Framework Directive. Our inclusive approach enhances the robustness and sustainability of decision-making, as potential impacts are avoided and reduced through embedded mitigation.

Vattenfall's Sustainable Supply Chain team has also conducted independent research studies into sustainability concerns surrounding the supply of rare earth elements ("REE"), critical raw materials ("CRM") and conflict minerals which have been used to inform the development of hydrogen supply chains.

The specific type of electrolyser proposed at HT1 is currently under review, however it is expected that while the REE requirement is limited for hydrogen production projects, a supply of CRM such as nickel, cobalt, lithium and platinum may be required. Vattenfall applies the Organisation for Economic Co-operation and Development Due Diligence Guidance and expects its suppliers to do the same.

--- Route-to-Market and Market Potential of the Proposed Solution ---

We believe that dedicated offshore hydrogen wind farms will be the main production of Zero-Carbon hydrogen in the UK in the longer term given the high wind capacity factors and the anticipated reduction in capital costs over time. Hydrogen has the potential to be an enabler of greater amounts of renewable energy into the constrained grid; utilising otherwise curtailed power and facilitating the development of offshore wind projects that would not be considered economic. In this context, integrated hydrogen turbines have the potential to be the main source of all hydrogen production in the UK by 2050.

As an Energy producer, we do not plan to commercialise the technology but instead deploy it at our own developments and sell the hydrogen to end users. Our integrated turbine strategy has a number of competitive advantages:
• Turbine-level integration of electrolysis reduces losses and provides lowest cost power (<21 GBP/MWh);
• high electrolyser utilisation (4500+ FLH) due to load-following;
• lower cost and improved efficiency through transmission via pipelines; and
• less turbine components so reducing component failure.

This singular focus on deep integration means cost reductions can be achieved earlier than competitors but requires us to move quickly with our commercialisation plans.

We consider ourselves to be facilitators of supply chain development and we will engage with SMEs local to our development projects and seek opportunities to collaborate to the benefit of all stakeholders and local communities.

--- How the Demonstration will Accelerate the Low Carbon Hydrogen Economy ---

We expect that HT1 will be the world-first full scale demonstration of a dedicated offshore wind turbine producing Zero-Carbon hydrogen. This will accelerate the development of the low carbon hydrogen sector, through the development of industry competencies in the design and delivery of HT1. It will build on the mature UK offshore wind industry, supporting intentions for the UK to become a global leader in the development of a low carbon hydrogen economy.

Today, Zero-Carbon Hydrogen is not available commercially at high volumes, which is problematic for fossil-based industry wishing to decarbonise their operations. The availability of high volumes of Zero-Carbon Hydrogen at commercially competitive rates, will enable an effective decarbonisation, leveraging the existing skills and capabilities of the Oil & Gas workforce. All the separate building blocks of the solution are technically feasible, what remains is the demonstration of the integrated system offshore to kickstart investment into GW-sized offshore windfarms, providing renewable feedstock for UK industry and fuel for transport.

Alternative methods of decarbonisation such as direct electrification or co-located electrolysers require significant expansion of the UK's national electricity grid, a costly endeavour with long lead times.

Integration of renewable electricity generation is also associated with balancing costs, which exceeded 1 billion GBP in the period from 2018-2019 and has increased to 1.25 billion GBP in 2019/2020 according to "Review of GB energy system operation", published January 2021. Contrary to grid-connected offshore wind farms, hydrogen dedicated wind farms would not require compensation for curtailment.

The nature of HT1 as a demonstration as a retrofit of an existing turbine at ABOWF will allow the innovation to achieve an accelerated timeline, demonstrating the technology at scale in marine conditions but not requiring the full development of a new offshore turbine, two years ahead of other UK projects. As the ABOWF site is also an innovation centre, we therefore expect a simplified development process and stakeholder engagement.

The Scottish Government's Hydrogen Policy Statement (Dec 2020) describes the opportunity for Zero-Carbon hydrogen production from offshore wind to overcome regional grid constraints, develop high value jobs in communities close to offshore wind resources, often remote rural locations, and create an export industry to the rest of the UK and Europe. There are also notable synergies and opportunities with the existing Oil and Gas and infrastructure industry in the Aberdeen region where ABOWF is located.

As dedicated offshore hydrogen production can produce hydrogen independently of a transmission grid, the location of a farm dedicated to hydrogen production can be placed in locations with the highest load factor without concerns for grid availability and electrical transmission constraints.

--- IN CONCLUSION ---

HT1 will deliver a world-first full-scale demonstration of low cost, high volume, Zero-Carbon 2 years ahead of other UK projects.

By using our existing assets at ABOWF, leveraging our existing supply chain and providing high-skilled sustainable roles, HT1 will provide vital learnings on how this can then be replicated and expanded to develop a zero-carbon hydrogen supply economy for UK-and beyond.

By using on an existing single turbine, we reduce the technological risk and focus the industry learnings on the application of hydrogen production in an offshore environment.

Criterion 3c: Knowledge dissemination strategy. In the text box below, the applicant should explain the current plans for taking the knowledge and experiences arising from the demonstration pilot and ensuring that these are effectively communicated and shared within the relevant stakeholders. Applicants who wish to support their response with figures (e.g. illustrations/PFDs/graphs/charts/schematics) may attach these as part of the Referenced Figures single attachment (max. 20MB allowance provided) in the Further Information section of this application form. Applicants must clearly label the figures in the attachment and reference the figures in their response within the text box to ensure they are assessed. Any further text submitted within the Referenced Figures single attachment will not be assessed. (Weighting for Criterion 3c – 5%) (Maximum 1,000 words)

At Vattenfall, we recognise that driving rapid progress in the energy transition will require the cooperation of the entire energy industry, across the private and public sectors and academia. To deploy zero-carbon hydrogen production at scale, developments in testing, piloting and commercialising the technologies, will result in driving cost reductions. This will be possible if technologies are adopted widely and economies of scale achieved. Broad dissemination of research findings from HT1 will be essential to obtaining full value from the innovation demonstration.

We have developed a strategy to ensure a broad dissemination of Hydrogen Turbine ("HT1") findings to drive faster progress and adoption. The strategy rests on three key pillars:
(A) Broad Stakeholder Engagement Plan – a structured approach to reach out to audiences with the right information, at the right time and engagement context;
(B) Prompt and proactive communication of research results – we will disseminate findings widely through a range of channels; and
(C) Access to intellectual property – we will make Vattenfall's patents that stem from the innovation testing available on a free to use licence.

Each of these pillars is described in detail below.

--- Broader Stakeholder Engagement ---

We have conducted an analysis of the different stakeholder groups to whom the innovations are likely to be relevant and their respective communication needs, including UK and Scottish Governments, Aberdeen City and Aberdeenshire County Councils, BEIS and other Government departments; Industry participants; Academia; Interest groups; and the public. A summary of engagement objectives, stakeholder communication requirements, and relevant engagement forums for engagement are provided for each stakeholder group in Referenced Figures 11 & 12. Key milestones include:
(1) Press release announcing the demonstration, subject to award funding, to raise awareness of the project and highlight the expected outcomes;
(2) HT1 website to document objectives, overall plan and to highlight results;
(3) Completion of onshore testing to disseminate findings from Work Package 2 (Onshore works); and
(4) Early operations findings from Work Package 3 (Early operations and Maintenance).

Our plan includes other forms of ongoing dissemination:
Webinars – Approximately every 6 months digital engagement with an update on the latest results from the demonstration depending on its phase. Invitations will be broadly distributed, and a recording made available. Specific sessions will be tailored to a scientific audience along with separate ones designed for policymaker/regulator audiences.

Website updates – In addition to major announcements publication of reports and deliverables, the website will be updated on an ongoing basis, expected to be minimum quarterly, with latest progress updates and news on the demonstration.

Social media – Vattenfall has active social media feeds - LinkedIn, Twitter and Instagram will feature regular news and updates regarding the progress of the demonstration.

--- Communication of Research Results ---

Vattenfall intends to be transparent with all research findings emerging from the demonstration and to disseminate them widely in peer-reviewed journals and academic conferences. Vattenfall often submits
abstracts to the major conferences attended by a wide variety of experts in the field. This allows not only
rapid dissemination of information, but also exchange and discussion with other experts in the field and
the potential seeding of future collaborations.

Conferences will be a key communication channel for knowledge sharing within the industry. We have outlined key conferences for innovation sharing as All-Energy, Wind Europe, Offshore Energy Conference,
and The Hydrogen Technology Show with proposed focus areas in Referenced Figure 11.

Despite not being part of HT1, learnings obtained from the design and operation of the pipeline and onshore facilities will also be disseminated.

--- Access to Intellectual Property ---

Vattenfall fully expects that the demonstration will prove a number of novel and useful applications that would be eligible for protection under Intellectual Property ("IP") laws for which Patents could be registered. We aspire for our Open & Active IP strategy to create an environment, which allows us a freedom to operate and stimulate activity in zero-carbon hydrogen supply across the industry. To fulfil these objectives, we intend to pursue:

(a) An open IP strategy that Vattenfall patents stemming from the innovation testing will be published, and
available to license to interested parties on a free to use basis. We see this as mutually beneficial to Vattenfall and the industry and we will also seek collaborations where the IP will be placed in the Joint Ventures. We will encourage other parties to follow our lead and make any consequent innovations free to
use on a licence basis. Our pledge on knowledge dissemination is set out in Referenced Figure 10.

(b) An active IP strategy and file patents for novel applications we identify. This is primarily to ensure an open playing field, while avoiding the risk of subsequent patent applications by others restricting our ability
to deploy or benefit from the innovations.

There are a number of potential areas that could yield patentable results, across structural and system innovations. Structural innovations include external structures on the individual wind turbine towers, whilst

system innovations include system controls for variable production of hydrogen in response to real-time
wind conditions.

--- IN CONCLUSION ---

HT1 offers a unique opportunity to be the world-first demonstration Project in the UK and provide valuable
learnings that will be shared with the industry, academia and BEIS on zero-carbon Hydrogen Supply. For
its full potential to support future decarbonisation of the hard-to-abate areas of society knowledge will be
shared widely.

HT1 will be a vital step in achieve the UK Government ambitions for 5GW of hydrogen production and 40GW of offshore wind by 2030. As a catalyst for further developments and innovations, HT1 will showcase
zero-carbon hydrogen supply and deliver towards UK Net-Zero targets.

Criterion 4: Project financing

To complete this section please upload a completed BEIS Project Cost Breakdown/ Finance Form for Stream 2 here. Max upload size per file - 5MB Max number of files - 1

- File: HT1 Appendix 4 - Cost file .xlsx - Download

In the text box below, the applicant should: Provide justification of costs and ensure all costs are eligible. Applicants who wish to support their response with figures (e.g. illustrations/PFDs/graphs/charts/schematics) may attach these as part of the Referenced Figures single attachment (max. 20MB allowance provided) in the Further Information section of this application form. Applicants must clearly label the figures in the attachment and reference the figures in their response within the text box to ensure they are assessed. Any further text submitted within the Referenced Figures single attachment will not be assessed. (Weighting for Criterion 4a – 10%) (Maximum 1,000 words)

As described in the response to previous Criteria, the aim of the Hydrogen Turbine 1 ("HT1") innovation demonstration is to prove, and de-risk dedicated offshore zero carbon hydrogen production at a turbine within the existing Aberdeen Bay Offshore Wind Farm ("ABOWF"). Outside of the boundaries of the innovation project, which focuses exclusively on zero-carbon hydrogen production at HT1, a transmission pipeline and onshore facilities will be developed for the transport and offtake of the hydrogen. The Finance Form represents 100% of the costs that are required for the HT1 demonstration and is not reflective of any costs for material or labour relating to activities associated with the pipeline or shore-side developments.

The total funding request is for £9,993,340. Below we have taken each category of project costs, as defined in the Finance Form, and set out the methodology for calculating the given amount. Note that [redacted]

[redacted]

specified per department. The hourly rates have been assumed alongside a resource profile described below, to calculate the total labour cost. All calculations assume 220 working days annually and 40 hours per week. Please see the Cost Breakdown Form for costs per role, listed below:

Project Manager
Project Management Officer
Risk Manager
Technical Project Manager

System Design Modeller
Turbine Hydrogen Integration Engineer/PM
Hydrogen Platform Engineer/PM
Electrical and Metering Engineer/PM
Control Solutions Engineer/PM
SCADA Engineer/PM
Principal Engineer - Electrical
Principal Engineer - Process
O&M Design Engineer/PM
O&M Manager
Offshore Logistics Engineer/PM
Geoscience Specialist/PM
Consents Manager
Public and Regulatory Affairs Manager
Legal Support
Quality Officer
Insurance Manager
Turbine-Hydrogen Category Manager
Offshore Transmission and Logistics Category Manager
Head of Procurement
Turbine-Hydrogen Commercial Contract Manager
Offshore Transmission and Logistics Commercial Contract Manager
SCADA Commercial Contract Manager
Security Officer
Planner
HSE Manager
Environmental and Sustainability Specialist
Construction Manager
Construction Engineer
Commissioning Manager
Jack-up Operations Manager
Certification Engineer
Site Manager
H&S Specialist
Turbine Service Technician
Hydrogen Service Technician

--- Material Costs ---

Costs have been provided for materials expected to be consumed during the demonstration, based on resources required to modify the existing turbine to accommodate hydrogen producing equipment. These are described below.

[redacted]

[redacted]

steel. [redacted]

[redacted]

[redacted] [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

capacity.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

ongoing.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Criterion 4b: Value for money to HM Government In the text box below, the applicant should describe why the proposal represents good value for money for HM Government. The answer should explain the following: How the availability of public funding makes a material difference to the actuality and pace of moving the solution towards commercialisation, and Qualify and quantify the savings that are being passed on to HM Government to reflect the asymmetric balance of risks and benefits accruing to the project consortium and HM Government. Applicants who wish to support their response with figures (e.g. illustrations/PFDs/graphs/charts/schematics) may attach these as part of the Referenced Figures single attachment (max. 20MB allowance provided) in the Further Information section of this application form. Applicants must clearly label the figures in the attachment and reference the figures in their response within the text box to ensure they are assessed. Any further text submitted within the Referenced Figures single attachment will not be assessed. (Weighting for Criterion 4b – 15%) (Maximum 1,500 words)

For any innovation project that requires public funding, it is vital to demonstrate that such funding provides benefits to industry, academia and/or Government. Hydrogen Turbine 1 ("HT1") delivers in all areas.

While we make use of an existing asset to reduce risk, time and cost to both Vattenfall and the

[redacted]

solution.

targets.

[redacted]

• batteries,

[redacted]

Given that HT1 is pre-

are available.

This includes a

The

organisations.

risk and reward.

A direct

[redacted]

centre for innovation in offshore wind, HT1 would not be possible without ABOWF. Other examples include a seven-digit EUR sum for the Hamburg Hydrogen Bus Refuelling, the HYBRIT project, which combined 50m GBP of investment from the Swedish Energy Agency with 90m GBP of investment from joint venture partners to demonstrate low-carbon steel production using hydrogen. Details of the HYBRIT project are provided in Referenced Figure 14 & 15.

--- Savings Passed to HM Government ---

HT1 provides value to HM Government across a range of parameters, including savings driven by the demonstration benefitting as a retrofit onto an existing turbine, the definition of project boundaries and costs, and the expertise of the proposed team. In addition HT1 will be the world-first dedicated offshore hydrogen production turbine delivering learnings 2 years ahead of other UK demonstrations. These are detailed below.

--- The Retrofit of an Existing Turbine at ABOWF drives Lower Development Costs and Accelerated Timeline, using Established Relationships ---

The retrofit of an existing turbine offers substantial cost reductions compared to the alternative of demonstrating the technology at new-build offshore wind turbines. The development cost of ABOWF [redacted]

Floating foundation is still innovative and
ABOWF therefore

HT1's location at an innovation hub, ABOWF,

[redacted] [redacted]

As detailed above, HT1 involves innovative hydrogen production at the turbine itself. Outside of project boundaries, a pipeline and onshore facilities are used to transport the hydrogen to storage and offtake. This is not included in the BEIS funding request.

--- HT1 Costs assume Significant Residual Value of 87.5% for Capital Equipment, including the Electrolyser and Associated Zero-Carbon Hydrogen Production Assets ---

By focusing HT1 funding on technical and project-specific resources, and applying a residual value methodology for capital equipment that accounts for the 10 year lifetime of the hydrogen assets, the project offers significant value for money to HM Government. The project costs reflected in Criteria 4a are driven by the engineering team required to design and execute the world-first offshore integrated hydrogen turbine.

--- HT1 will Benefit from the Expertise from Vattenfall and Key Suppliers, as well as Design Works done to Date ---

As detailed in Criteria 2, we have conducted design works, technical and economic analysis of the benefits of offshore hydrogen production, early site-specific analysis and conceptual studies to bring HT1 to the current 'proof of concept' stage. We have collaborated with key suppliers, including Vestas the turbine manufacturer at ABOWF and TechnipFMC provider of offshore works and subsea engineering services. The HT1 project team will benefit from the combined experience not just at Vattenfall but also key supplier organisations. The project will also be able to leverage insights from feasibility studies being undertaken by others in zero-carbon hydrogen production.

--- Synergies with Government Targets for 5GW of Hydrogen Production, 40GW of Offshore Wind by 2030 and achieve Net Zero by 2050 ---

There are synergies between the UK's globally leading status as a hub for the development and deployment of offshore wind, and the requirement for low cost zero-carbon hydrogen production. Our feasibility analysis and conceptual studies conducted to date have shown that offshore hydrogen production at turbine level is the lowest cost configuration, see Criteria 2. HT1 would develop industry competencies in the design and delivery of this solution, providing HM Government an opportunity to leverage the existing offshore wind industry in the UK and become a global leader in the development of zero-carbon hydrogen offshore.

Low cost zero-carbon hydrogen at scale presents the Government with an opportunity to accelerate the decarbonisation of hard-to-abate sectors with truly zero-carbon hydrogen that is produced within the UK rather than imported from other regions of low-cost renewable resource.

The development of low carbon hydrogen supply chains will build on the mature hydrocarbon, offshore wind development, O&M and subsea engineering industries present in the UK. As a result of HT1 taking place in the UK, these industries are well positioned to fill the competency gaps that exist in the areas of technical design, manufacture, and O&M capabilities for dedicated hydrogen turbines.

The development of zero-carbon hydrogen production at offshore wind turbines represents a significant benefit to local communities around Aberdeen. The Scottish Government's Assessment for Hydrogen (December 2020) identified the benefits of leveraging offshore wind for hydrogen production for the region, across supply chains, grid constraint alleviation, and high value job creation.

--- IN CONCLUSION ---

HT1 offers a unique opportunity for UK Government to participate in a world-first full scale demonstration of a dedicated offshore wind turbine producing zero-carbon hydrogen.

Utilising an existing asset, we reduce, risk, costs and time for both parties, delivering results two years ahead of similar UK projects. This will provide key learnings for the industry, academia and Government and accelerate zero-carbon supply and opportunities to deliver towards Net-Zero targets.

Criterion 5: Project delivery

To complete this section please upload a completed Gantt chart (or Outline Project plan) and Key Work Packages with your application. Key Work Package document not to exceed 6 pages. Max upload size per file - 10MB Max number of files - 2

- File: HT1 Appendix 6 - Gantt charts.pdf - Download
- File: HT1 Appendix 5 – Key Work Packages.pdf - Download

In the text box below, applicants are expected to: Explain how the project team, if involved in multiple Hydrogen Supply 2 applications will ensure they have sufficient capacity to deliver multiple projects. Applicants who wish to support their response with figures (e.g. illustrations/PFDs/graphs/charts/schematics) may attach these as part of the Referenced Figures single attachment (max. 20MB allowance provided) in the Further Information section of this application form. Applicants must clearly label the figures in the attachment and reference the figures in their response within the text box to ensure they are assessed. Any further text submitted within the Referenced Figures single attachment will not be assessed. (Weighting for Criterion 5a – 15%) (Maximum 500 words)

The Vattenfall Hydrogen Turbine 1 ("HT1") project team is not involved in multiple Hydrogen Supply 2 applications.

Vattenfall is setup as a Matrix organisation. Within that Matrix organisation there are various Departments involved in HT1. Vattenfall also uses the Portfolio approach in its Projects to utilise the leverage effect. Portfolio approach can be summarised in a way that one Department, called "Roadmaps" is responsible for the early development phase of the Project with the goal to standardise the way of working in Projects.

Another Department, called "Project Delivery" is responsible for the execution of HT1 and the final preparation for the handover to the O&M Department. By doing so, Vattenfall ensures that learning and knowledge is transferred directly into the preparation for the next Project. It also means that the Team members are not exclusively working on HT1 allowing cross-project learnings to occur.

The Resource Plan and costs are calculated by having the Roadmaps Team working with the Project Delivery team around the Final-Investment-Decision to ensure that preparations for HT1 are in place for execution. There is constant knowledge exchange between these two Departments to ensure that lessons learnt, and knowledge transfer is ensured. Towards the end of the Construction and Commissioning phase the handover to the O&M Department is prepared. O&M, within Vattenfall, is responsible for the Operation and Maintenance of the Project for the design lifetime.

The strong involvement of the Roadmaps from the beginning – Work Package 1 – is matched by the ramping up from the Project Delivery Department with focus on Manufacturing, Construction and Commissioning for Work Package 2 and Work Package 3.

During the Work Package 1, the technical feasibility is developed and further matured until the final Product can be implemented for HT1. The overlap between the Work Package 1 and Work Package 2 shows the transition period between the Roadmaps and the Project Delivery Departments, ensuring that all technical design assumptions from the Roadmaps are being transferred into the delivery phase.

The transition from the Roadmaps, Project Delivery and finally to O&M is identified in the Organisation charts, see Appendix 8. The involvement of the Contractors is highlighted by two boxes for the leading roles but behind that there are various other people in the respective organisations from Vestas and TechnipFMC. Lastly, a clear ramp-up on the O&M Organisation is shown to also indicate the demand of people for the Operational phase.

To complete this section on Project Team please upload a completed CV package and Organogram here. Max upload size per file - 20MB Max number of files - 2

- File: HT1 Appendix 7 - CV Package.pdf - Download
- File: HT1 Appendix 8 - Organogram.pdf - Download

In the text box below: The applicant should present their proposed governance arrangements between the partners to ensure effective project delivery The applicant should list any external parties responsible for delivering goods or services worth more than 10% of the total project value and explain how they will ensure that these parts of the project do not give rise to delays in the delivery of the project. The applicant should provide details of the relevant skills, qualifications and experience of main project team members, including descriptions and evidence of previous relevant work carried out. Include brief details of relevant team member previous projects, including the date, location, client and project size. Applicants who wish to support their response with figures (e.g. illustrations/PFDs/graphs/charts/schematics) may attach these as part of the Referenced Figures single attachment (max. 20MB allowance provided) in the Further Information section of this application form. Applicants must clearly label the figures in the attachment and reference the figures in their response within the text box to ensure they are assessed. Any further text submitted within the Referenced Figures single attachment will not be assessed. (Weighting for Criterion 5b – 10%) (Maximum 3,000 words)

Vattenfall Wind Power Ltd ("Vattenfall"), is an established renewable energy developer with a wealth of in-house knowledge and expertise in delivering Offshore wind farms. Hydrogen Turbine 1 ("HT1"), in retrofitting hydrogen production to an existing 8.8MW turbine within our Aberdeen Bay Offshore Wind Farm ("ABOWF"), will use the existing site information and our pioneering engineering talent to deliver a world-first demonstration Project in the UK.

We have well-proven internal Governance that has successfully delivered >2.6GW of offshore wind energy, bringing together, Partners, novel technology and innovative solutions as demonstrated in ABOWF itself, a European site for deploying innovative solutions. With over 1,000 personnel directly working on the consenting, construction, installation and operation of Offshore assets, we can call upon a wide range of skills within the Project Team. We will use the established Vattenfall Sequential Project Model to coordinate key suppliers, Stakeholders, and the Project Team to ensure that all phases of the Project deliver a safe, reliable and efficient solution.

--- Proposed Team and Governance Arrangements ---

Vattenfall, as the lead organisation, will lead HT1 through all phases, supported by key suppliers. There are no Partner organisations involved in the demonstration. Vattenfall has well established Engineering delivery departments with over 700 employees and a further 3,000 working in Offshore Wind throughout all phases of Projects.

The Team Profile evolves as the Project moves through different phases. An HT1 Team Organogram has been provided for each Work Package (see Appendix) depicting the changing personnel profile required to meet skills and competencies for each phase. The key roles are outlined below alongside the planned governance arrangements.

--- Project Governance ---

Project Governance will follow Vattenfall’s Sequential Project Management Model ("VSPM"). This sets the Plans, processes, procedures and Tollgates to be followed by all Projects, regardless of size. This includes, amongst others:
• Periodic Assurance reviews from Business Governance, external from the Project team;
• Regular Project Steering Group and Project Review Board meetings, which set mandates for the Project Team and monitor deliverables versus objectives
• Processes such as Health & Safety and Project Management Plans that provide guidance to the Project Team on successfully delivering a safe and reliable Project.
• Tollgates which bring together the above items and provide a hold/confirmation point for Projects to ensure compliance with VSPM requirements, before allowing the Project to progress to the next phase.

While the Project Governance is led by Vattenfall, our Key Suppliers will also be involved in feeding into our processes including the reporting of non-conformities, acceptance tests and Handover phases. They are active participants in the various phases of Project HT1.

--- Project Skills and Supplier involvement required in each Phase ---

Technical design – Work Package 1 ("WP1")
The core skills and competencies that the project team requires in WP1 are:
- Engineering and technical design capabilities, to deliver the technical design. This will be performed in-house led by the Technical Project Manager;
- Risk and valuation refine and actively mitigate key project risks and dependencies, e.g. the dependency on pipeline development and offtake agreements;
- Operational considerations for Day 1 Readiness, to ensure that the technical design is fit for purpose and to align with Vattenfall’s ‘Safety by Design’ principles;
- Experts and central functions, to support HT1 with HSE, Legal, Accounting, Commercial, Procurement, and other such support; and
- Project Management and Planning, to ensure HT1 adheres to Vattenfall best practice in terms of Project status and direction.

As a key supplier, input from Vestas will ensure that the design is fit for purpose and can integrate in a safe, reliable, and robust manner throughout the later Work Packages. Vestas are expecting to provide a Turbine Engineer and Project Manager to ensure that the electrolyser equipment integrates with the existing turbine for all phases of the Project.

Delivery, Manufacturing, Construction and Testing – Work Package 2 ("WP2"):
A wider range of suppliers and sub-contracts will be required under WP2, compared with WP1. Vattenfall will coordinate across the key suppliers, e.g. Vestas, TechnipFMC, and sub-contractors, e.g. local providers in Aberdeen, and engage with the relevant stakeholders, e.g. Councils and end users.

The core skills and competencies that the project team requires are:
- Commercial competencies, including procurement and risk, which will be provided by Vattenfall's Commercial team, led by the Commercial Project Manager;
- Technical expertise to execute the design from WP1, to be led by the Technical Project Manager, and will include Site Management to engage with ABOWF and local stakeholders;
- Environment and HSSE to ensure that all applicable standards are met and certifications received;
- Project management and planning, including project admin, to ensure that the project is actively managing the plan and achieving the demonstration goals;
- Public Regulatory Affairs to ensure that the design is executed in a means fully compliant with all legal and regulatory requirements.

Commissioning and Early Operations – Work Package 3 ("WP3")
As per WP1 and WP2, Vattenfall will lead the HT1 demonstration through commissioning and early operations, with the input of a range of key suppliers.

The core skills and competencies that the project team will require in WP3 are:
- Operations expertise, as we expect that during this phase, we will have two dedicated hydrogen distribution operators, specifically monitoring the operations of the HT1 demonstration, in addition to the operations team running the ABOWF;
- Maintenance, provided by a team encompassing Vattenfall service technicians and Vestas sub-contracted service management that will ensure HT1 is adequately maintained during the course of commissioning and early operations. We will train local employees to give them unique offshore hydrogen O&M skills and capabilities,
- Logistics, to ensure that commissioning logistics are coordinated and smooth throughout WP3;
- Project management and planning, to ensure that deadlines are met and that demonstration goals are achieved, including knowledge dissemination and publication of scientific findings as the demonstration comes to an end.

--- Key Suppliers Responsible for Delivering Goods or Services of >10% of Total Project Value ---

Below we outline the key suppliers, Vestas and TechnipFMC, contribution to HT1, describing the organisation and their role. We also detail how Vattenfall will ensure that Project timescales are met.

Our Key Suppliers are Market Leaders in their Fields.
Vestas manufactures and services wind turbines and is the manufacturer of the existing turbines used on the ABOWF. Vestas is a natural collaborator in the realisation of HT1, given the requirement for structural, electrical and mechanical integration of hydrogen production with the existing turbine systems. Due to comprehensive knowledge of the turbine and moves to build up a broader Power-to-X business including dedicated hydrogen turbines, Vestas is in a strong position to augment the existing systems with the hydrogen related additions in a safe, reliable and robust manner. HT1 provides an early opportunity to develop a technical concept which could grow into a significant new business for Vestas and the wider turbine industry and will be the first to demonstrate the concept offshore at full scale.

Vestas' role as a key supplier will evolve across all three Work Packages. Vestas will input into the technical design in WP1, and will support WP2 with engineering services, manufacturing, procurement, and installation. Through WP3, Vestas will support with commissioning and operation, dependent on requirements. Vestas are conducting early feasibility studies into hydrogen innovation in addition to HT1 as the technical concept has the potential to represent a significant future market opportunity. These committed man-hours are not included in the Bid Costs Form provided in our response to Criteria 2a. We reaffirm the requirement for innovation funding to perform an in-situ demonstration of the Zero-Carbon hydrogen production innovation and refer to our response to Criterion 1 and 4 for the additionality of HT1 and the benefit of public funding to accelerate the solution towards commercial delivery.

TechnipFMC is a leader in Engineering, Procurement, Construction and Installation of offshore structures and subsea solutions including pipelines, and hence is a key contributor in the realisation of HT1. The retrofitting an existing structure with a platform to support hydrogen production equipment requires comprehensive knowledge of offshore structures and subsea installations. TechnipFMC is in a strong position to augment the existing systems with the hydrogen-related additions in a safe, reliable and robust manner.

TechnipFMC is also pursuing feasibility studies to establish the key requirements for hydrogen production at offshore wind farms. Due to the innovative nature of the technology and the potential for this to become a significant business opportunity for TechnipFMC in the future. Those costs have not been included in the Bid Costs Form submitted as part of the Finance Form in Criteria 4.

--- We have Established a Collaborative Way of Working with Key Suppliers, Maximising Communication to Minimise Delivery Risk ---

Vattenfall is currently in the process of signing Letter of Intent documents with key suppliers; Vestas and TechnipFMC. We have also attached Letter of Support documents from each key supplier to demonstrate their commitment to and support for HT1.

We will ensure that key suppliers do not delay the delivery of HT1, by contracting with a small number of close collaborators, Vestas and TechnipFMC, and establishing a collaborative way of working across all parties and sub-contractors. We envisage that the Vattenfall Project Manager will liaise with nominated Project Managers from each key supplier to manage input and track progress against the Vattenfall Project Plan for HT1.

--- Details of Relevant Skills and Experience of Key Team Members ---

A representative selection of team members with different capabilities and skills has been selected in our response to this section. A CV package is attached in an Appendix to this criterion, covering the project team members listed below.

The selected team members and their roles are:
Project Manager, [redacted]
Technical Project Manager, [redacted]
Construction Manager, [redacted]
Commissioning Manager, [redacted]
H&S Manager, [redacted]
Stakeholder Engagement Manager, [redacted]
Public & Regulatory Affairs, [redacted]
Risk Manager [redacted]

--- Key Responsibilities in each Phase ---

--- Project Delivery ---

Required capabilities and related activities for the duration of the project are project steering via clear project management and governance processes, supported by robust scheduling, planning and quality management. This is led by the Project Director and supported by the Project Management Officer ("PMO"), Project Planner, Risk Manager and Quality Officer.

The PMO will manage Project Governance process for optimal Project maturation. The Project Director and PMO create an overview of timeline, budget and staffing. This is adapted into an Integrated Project Management Plan, which is an overall guide to deliver the Project. This document is regularly updated to ensure all team members have a full view of key activities. The PMO plans and prepares for Project Steering Groups, Project Review Boards and Tollgates. At each Tollgate the Project undergoes a Value Assurance Review, for which the PMO will compile data and create a plan for discharge of actions.

The Project Planner develops and manages a detailed Project schedule. This includes all phases, products, packages, interdependencies, float, risks of delay and mitigation. Monthly updates measure actual progress against plan and shared with suppliers to mitigate programme risk.

The Risk Manager implements and oversees implementation of Risk Management Processes. Risk analyses are conducted continuously, and clear mitigation plans developed by Team members. At Project initiation the Project Director creates a register of Project risks and opportunities. Risk owners are then assigned to develop mitigation plans. On bid award a Risk and Opportunity register will be formalised and provides a basis for monthly risk reports. The Risk Manager coordinates the identification and management of risks and opportunities, updating the Register and ensuring controls are identified and implemented.

The Quality Officer is responsible for Quality Assurance ("QA") and Quality Control ("QC"), through management of clear processes and systems. Vattenfall's Quality Management System is ISO9001 certified. We have established QA procedures to ensure that all suppliers comply with our quality requirements and adopted ISO standards. The Quality Officer is supported by the Project Director, and Technical Engineers to define the Project Quality Strategy and Quality Plan at Project initiation. Pre-qualification questionnaires and invitation to tender documents are produced and issued to suppliers, where applicable. Returned tenders are evaluated and scored to shortlist preferred suppliers. Audit and validation of shortlisted suppliers takes place to ensure they can meet our requirements. The final step is bilateral negotiation of contract terms.

QC starts during the establishment phase and continues until operational handover. The QC procedure requires regular monitoring and auditing of supplier performance, system components and services to ensure compliance with agreed standards. The suppliers input into our Wind Inspection Tool for quality, non-conformities and observations across HT1. This is managed by the Quality Officer by audit, and inspection throughout manufacturing, construction and handover to O&M.

--- Health & Safety ---

The benchmark for HT1 is zero accidents, injuries, or work-related ill health. We use our ISO45001 Certified Management System and in-house interactive tool to target continuous improvement and regular review of our Health, Safety & Environment ("HSE") processes, procedures, and documentation.

This is led by the H&S Manager and standards monitored with the Project Director and includes in-depth training for the entire team. Setting the highest H&S standards via use of certified management systems, strict enforcement of H&S policies and regulations, monitoring, recording/analysis of incidents, performance, and strong risk management ensures high levels of H&S compliance.

Upon award, an HSE Plan covering responsibility and an HSE Activity Plan to continually monitor deliverables, Regulatory compliance, and updates to HSE Legislation. Vattenfall will enforce safety requirements and assess contractor HSE plans throughout HT1. HSE training Inspections and safety walks will be scheduled with suppliers and sub-contractors. Full H&S induction training will be provided to all team members as soon as practical.
To manage HSE risk, the H&S Manager, along with the Risk Manager, organise Hazard Identification & Risk Assessment workshops throughout HT1. This will include reviewing and signoff contractor Risk Assessment Method Statement through all phases of HT1.

--- Environment ---

By selecting ABOWF, an existing offshore wind farm, we have already a wealth of information about the proposed HT1 environment and potential impacts, and can call on staff who are experienced and knowledgeable about the site in order to deliver to programme.

On bid award we will develop an Environmental Plan for HT1 that sets the survey requirements, licences and consents that might be needed to operate. Our team can call upon consultants to support in the production of surveys to back up comprehensive Environmental Impact and Habitat Regulations Assessments in compliance with all relevant legislation, e.g. the Water Framework Directive.

--- Stakeholder Engagement ---

Stakeholder engagement activities are mapped, planned, and integrated from the outset. This is led by the Stakeholder Engagement Manager, supported by the Local Liaison Officer, Consents Manager, Environmental Specialists, and Public & Regulatory Affairs Manager. All five of these roles play an important part in drafting the stakeholder engagement and communication strategy to detail the needs of all interested parties. It accounts for local socio-economic and political context and engagement methods to optimise stakeholder involvement on Project decisions. The Stakeholder Engagement team is closely involved in consenting and risk mitigation. They engage local media to ensure a steady flow of Project updates to the public. Engagement continues throughout construction to ensure local stakeholders can raise opportunities or concerns to the Project team.

From bid award PRA lobbies for Policy and Regulatory frameworks to support investment in combining Green Hydrogen with Offshore Wind. They work with national governments to unlock barriers to planning, and assists in defining investment plans supporting low-cost electricity production. PRA advise the Project team on Policy and Regulation, ensuring requirements are understood and inform decision-making.

--- Technical Expertise ---

The technical deliverables associated with HT1 are managed by the Technical Project Manager. This role coordinates the engineering, design, construction, and operational specialists to deliver the project solution. Vattenfall have over 700 engineering and design personnel working on offshore wind, including integrating hydrogen production with turbines.

They also interface with Procurement, H&S, Environmental, and Business Controlling. This ensures all technical aspects are incorporated into the standards and procedures to provide a safe, reliable, and cost-efficient Project.

Specifically, at HT1, there will be a requirement to coordinate the aspects of the turbine, foundation, and the installation of the hydrogen production equipment. They will also coordinate the technical elements that are not within the scope of HT1, pipeline and onshore facilities, upon which the Project depends.

Hydrogen production integrated with offshore wind is a new concept that needs to mature and establish capabilities. Vattenfall is driving a maturation plan with the potential to deploy dedicated offshore hydrogen wind farms by 2027. We are building in-house hydrogen capabilities with technical expertise in hydrogen production and gas transmission systems and rapid development of hydrogen skills to meet HT1 Project Schedule.

The turbine and the foundation function together as a structural unit. Therefore, the role of the Turbine and Foundation Engineers is key to ensuring continued safety and performance of the turbine and foundation. It will be necessary to work closely with the Hydrogen Engineers and Commissioning Manager to develop the engineering design, installation method and operational procedures. We have over 300 personnel working in installation and operational phases of our offshore wind and this is expected to triple by 2027.

The technical experts are supported by a number of Staff functions who specialise in areas such as GIS, Geotechnical, Environmental Scientists. The Technical Project Manager brings their skill sets into the Project at the appropriate time, providing dedicated resource in producing design documents, seabed assessments and Impact assessments such as the discharge of excess water from desalination into the surrounding seawater

--- IN CONCLUSION ---

Vattenfall as an experienced and reputable offshore developer has the existing capability and skills to successfully deliver HT1 in a safe, reliable and timely manner. HT1 will be the world-first demonstration Project in the UK and provide valuable learnings to the industry and BEIS on delivering on Zero-Carbon Hydrogen Supply.

Criterion 5c: Risk Assessment The applicant should provide a detailed risk register to outline the key project risks and risk mitigation techniques for the project (in the interests of thoroughness, we encourage you to think about risks and structure your risk assessment according to whether the risks are, or relate to: technical, legislative/regulatory, environmental, policy, economic, commercial, financial or project management). The risk register should include: Description of risk; cause of risk; risk owner; overall risk rating (probability x impact), mitigation action, and residual risk after mitigation action. Description of any contingency planning. Applicants should attach a risk assessment table to this criterion, which will be assessed. (Weighting for Criterion 5c – 5%) To complete this section please upload a completed Risk Register for Stream 2 here. Max upload size per file - 10MB Max number of files - 1

- File: HT1 Appendix 9 - Risk Register.xlsx - Download

Collaborative Application

Is this a collaborative application? If yes you will be asked to provide contact and organisation details for each partner.

No

Additional Information

The answer to the following question will only be taken into account once the application has been fully assessed to ensure projects are not double funded. Have you applied, or are you planning to apply, for any other government funding for this project?
No

Programme Performance Indicators and Benefits

How would you describe the nature of your innovation project?
Product Development
Process Development

State how many FTE jobs could be retained in your organisation as a result of participation in this project? (enter a number)
20

State how many FTE jobs could be created in your organisation as a result of participation in this project? (enter a number)
10

What is the number of Partner Organisations supported to deliver the project? (enter a number)
0

Will the project be conducting consumer trials?
No

Technology Readiness Level at Project Start

	1	2	3	4	5	6	7	8	9
						X			

Expected Technology Readiness Level at Project Close

	1	2	3	4	5	6	7	8	9
								X	

What do you think are the current market barriers to the commercial exploitation of your innovation? Please select all that apply.

Accessing UK based markets/customers

Capital intensive demonstration phases

Further technical, scientific or engineering challenges

Lack of clarity on Government policy

Lack of industry standards

Large incumbent firms using proven technology

UK Government regulations

The Low Carbon Hydrogen Supply 2 Competition will aim to realise the following benefits. Please select which benefits your innovation could potentially contribute to. This is not a scored section.

	Yes	No
Supply Chain Development Help support the growth of 'clean growth' supply chain companies in key technology and engineering sectors.	X	
Export Opportunities Support development of domestic and export markets. Multiple countries are developing hydrogen strategies, which have low carbon hydrogen production targets of multiple GWs. A recent update to the Energy Innovation Needs Assessment (EINA) estimates that by 2050 an active UK hydrogen economy could generate a GVA of £11.7bn and support 100,000 jobs from both domestic and export markets. Without support for innovation projects the hydrogen economy is unlikely to achieve this market share.	X	
Policy Insights Provide insight into costs, performance and what is required to remove technology and market barriers to deploying hydrogen supply solutions.	X	
Spillover Benefits Result in knowledge spillovers, where discoveries made from advancing your innovation could enable developments in other sectors. The projects could also provide wider benefits supporting the development of a hydrogen economy.	X	
Green Jobs Increase number of jobs working on 'building back better' in the UK.	X	
Carbon Savings Increase carbon savings through improved efficiencies, greater capture rates or through enabling greater applicability for hydrogen to decarbonise the energy system.	X	
Reduced Costs Increase and de-risk the range of products on the market which could enable greater competition.	X	

Public Description of the Project

The public description of the project should be a brief non-confidential description of the project that BEIS may use in online or printed publications. Please describe the project objectives, key deliverables and the expected project benefits. (Maximum 400 words)

Project Hydrogen Turbine 1 (HT1) will be a world-first full scale demonstration of an offshore wind turbine dedicated to Zero-Carbon hydrogen production integrated into the turbine itself. Our innovative solution brings together technologies in a new and challenging environment and demonstrates how to operate them safely.

HT1 consists of hydrogen production equipment: including desalination, electrolysis and associated balance-of-plant closely integrated with the turbine power electronics, physically coupled with the turbine, on an extended platform which will encircle the base of the turbine. All turbine power is dedicated to hydrogen production, and is expected to operate without requiring energy supply from the grid. The hydrogen will be transported to shore via pipeline for processing and delivery to end users.

To accelerate demonstration of the pilot and maximise cost efficiencies, Vattenfall will retrofit an existing 8.8MW turbine within our Aberdeen Bay Offshore Wind Farm (ABOWF), allowing operations to commence by early 2025, two years ahead of other UK proposals.

By selecting ABOWF we will deliver hydrogen into the Aberdeen area and we will be supporting the transition of Oil and Gas to a Renewable Energy Future. Aberdeen has a highly skilled workforce to support the project and benefit from its delivery.

Vattenfall strongly believes that a "deep integration" concept provides the confidence to deliver the lowest cost Zero-Carbon hydrogen when scaled up. The potential for modularity leads to increased volume production and manufacturing efficiencies. Other benefits include reduced energy losses due to integration between power generation and hydrogen production, and replacing electrical transmission with lower cost gas pipelines to shore.

HT1 is a vital step in Vattenfall's plan to rapidly scale the concept to GW-size projects by 2030. Our modelling indicates that deploying at such scale will allow Zero-Carbon hydrogen to become cost competitive, without additional support, with fossil based hydrogen when factoring in CO_2 prices. We view this as a pre-requisite for displacing the incumbent hydrogen supply options, and developing a sustainable business and sector growth.

We aim to move with urgency to achieve this and HT1 was specifically conceived with speed of delivery in mind, as evidenced by the scope which focuses on the challenges of physical, electrical and process integration/control, offshore installation, and operation and maintenance. By using existing assets we will expedite development time, maximise cost efficiency and provide learnings for the entire offshore wind industry.

Further Information

Referenced Figures (will be assessed) The applicant's response must be entered in the text box(es) where provided in the Assessment Criteria section. Applicants who wish to support their responses with figures (e.g. illustrations/PFDs/graphs/charts/schematics) may attach these here as part of the Referenced Figures single attachment (max. 20MB allowance provided). Applicants must clearly label the figures in the attachment and reference the figures in their response within the text box to ensure they are assessed. Any further text submitted within this attachment will not be assessed. To complete this section, you may upload referenced figures here Max upload size per file – 20MB Max number of files – 1

- File: HT1 Appendix 10 - Referenced Figures.pdf - Download

Supporting Information Additional letters of support or other supporting information can also be submitted here before you submit your online application form, where they add background/ supporting information (this could include but not limited to relevant papers, assumptions/ calculations to back up the assertions made in the application) to the application. However, the assessment will be based on the information directly written in the online application; you should not assume that any additional information will be cross-referenced or reviewed as part of the selection process. Applicants may upload up to 4 such attachments (max. 20MB per attachment). Upload further information documents here. Max upload size per file - 20MB Max number of files - 4

- File: HySupply2_HT1_Vestas_Letter_of_Support.pdf - Download
- File: Hysupply2_HT1_TechnipFMC_Letter_of_Support.pdf - Download
- File: HySupply2_HT1_OREC_Letter_of_Support.pdf - Download
- File: HySupply2_HT1_Shell_Letter of Support_July2021.pdf - Download

Declaration Forms

To complete your application, you must download, complete and sign where relevant and upload the following documents using the 'choose file' option below. Statement of non-collusion Form of Tender Conflict of Interest form Standard Selection Questionnaire Code of Practice GDPR Assurance Questionnaire Prompt Payment If convenient you can use e-signature to sign the documents. Max upload size per file - 5MB Max number of files - 7

- File: HT1 Declaration 1.pdf - Download
- File: HT1 Declaration 2.pdf - Download
- File: HT1 Declaration 3.pdf - Download
- File: HT1 Declaration 4.pdf - Download
- File: HT1 Declaration 5.pdf - Download
- File: HT1 Declaration 6.pdf - Download
- File: HT1 Declaration 7_inc._Annex_A_&_Evidence.pdf - Download

Application Form Checklist

As well as the completion of this Application Form please check that, if required, you have provided the following information.

	Yes	No
Organogram	X	
CV package	X	
Stream 2 Gantt Chart or Outline Project Plan	X	
Stream 2 Key Work Packages	X	
Stream 2 Risk Register	X	
Project Cost Breakdown / Finance Form	X	
Declarations	X	
Attached supporting documentation ***Clearly Referenced***	X	

Signatory Page

Enter details below	
Name of Organisation	Vattenfall Wind Power Limited
Signature ***Please insert name***	[redacted]
Position in Organisation	[redacted]
Date (DD/MM/YYYY)	27-08-2021

Do you give BEIS permission to contact you/your organisation in relation to your application and to provide updates on its progress. We may also share with you further details on the Low Carbon Hydrogen Supply 2 competition when available? Consent is required for the application to be submitted.
Yes