

SIF Beta Project Registration

Date of Submission

Oct 2023

Project Reference Number

10067856

Project Registration

Project Title

INCENTIVE - Innovative Control and Energy Storage for Ancillary Services in Offshore Wind

Project Reference Number

10067856

Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

Project Start

Jul 2023

Project Duration

15 Months

Nominated Project Contact(s)

Adnan.mahmood@sse.com

Project Budget

£1,122,973.00

Funding Mechanism

SIF Beta - Round 1

SIF Funding

£922,333.00

Strategy Theme

Whole energy systems

Challenge Area

Whole system integration

Lead Sector

Electricity Transmission

Other Related Sectors

Lead Funding Licensee

SSEN - Scottish Hydro Electric Transmission

Funding Licensees

NG ESO - National Grid ESO

Collaborating Networks

National Grid Electricity System Operator

Technology Areas

Fault Current, Fault Management, Low Carbon Generation, Offshore Transmission, System Security, Voltage Control

Summary

SIF Challenge

INCENTIVE is addressing the Whole System Integration innovation challenge by investigating and demonstrating how offshore wind farms (OWF) can provide inertia to the onshore networks.

Aligned to the aims of the innovation challenge, INCENTIVE is:

- Improving the coordination between onshore transmission networks and offshore wind developers, with a view of introducing innovative solutions to the GB energy system.
- Reducing complexity and bureaucracy by developing optimal business models that will be applicable not just for the Beta Phase demonstration but for national roll-out following the completion of the Beta Phase 1 and 2.
- Avoiding duplication by building a common understanding on the INCENTIVE solutions amongst a large consortium with all key stakeholders.
- Reducing complexity and bureaucracy by developing optimal business models that will be applicable not just for the Beta Phase demonstration, but for national roll-out following the completion of the Beta Phase.
- Reducing barriers to market entry for OWFs to provide inertia.

Network Innovation

The fall in inertia in the GB network is inherently a challenge that requires network innovation. INCENTIVE is focused on using OWFs to help stabilise the onshore network. Currently, no OWF is able to provide inertia to onshore networks globally. INCENTIVE will allow a step-change in capability for OWFs across the world, supporting the increase of renewable generation and delivering benefits to consumers.

Evolving from Alpha to Beta

In the Discovery Phase, four innovative INCENTIVE solutions were identified for further study. In the Alpha Phase, the commercial and technical feasibility of these INCENTIVE solutions were investigated, increasing the number of potential sub-options to nine. The Alpha Phase highlighted compelling economic arguments and high-level technical feasibility for the majority of the INCENTIVE solution options.

In particular, the Alpha Phase showed that the three solutions listed below can provide significantly cheaper inertia than current sources, in turn reducing the costs of operating the future energy system and reducing costs for consumers.

OWF with:

- o STATCOM with supercapacitor energy storage and grid forming converter.
- o Battery energy storage system (BESS) with overrated grid forming converter.
- o Synchronous condenser with flywheel.

The Alpha Phase highlighted that these three solutions are of high technical readiness level (TRL) (but low integration readiness level (IRL) and commercial readiness level (CRL)) for demonstration in Beta Phase. The two-stage approach of this project (see question 7) will help investigate this further prior to the demonstration.

As well as finding promising solutions, the Alpha Phase evolved our understanding of the problem to be solved:

- There are technical, regulatory, grid code and market barriers that are inhibiting these solutions (including that offshore wind auction mechanisms require changes)
- There is a radical rethinking required by OWF developers to develop solutions that strengthen the networks: historically this has not been in the remit of OWF developers, and INCENTIVE is providing an opportunity to make this step-change in an industry-wide consortium.
- Engagement with OWF developers and INCENTIVE solutions suppliers has highlighted the need for first-of-a-kind demonstration for these solutions (which will be realised in Stage 2 of the Beta Phase).

The Alpha Phase identified possible sites for detailed feasibility studies in the Beta Phase, with a view of building up to demonstration(s) and also identified possible supplier-specific solutions to include in the Beta Phase demonstrations. The Beta

Phase will build on the work of Alpha to address the remaining challenges stated above, and create a pathway to commercialisation for the INCENTIVE solutions.

Users

In Alpha Phase we identified the following users needs:

- OWF developers and INCENTIVE solution suppliers need to demonstrate the INCENTIVE solutions before they can be rolled out commercially.
- Networks need to understand their role in the implementation of INCENTIVE solutions, and whether they will be capable of owning and operating these assets in the future.
- The ESO needs to understand the technical performance of the INCENTIVE solutions and how they will participate in future markets.
- Consumers need low-cost inertia, and this need will increase in the future as more renewable generation is added to the network.

Experience

The consortium contains partners with all the necessary experience and capabilities to address the above needs:

- **SSENT** has the technical expertise to conduct the necessary technical assessments of the INCENTIVE solutions.
- **NGESO** has the expertise to provide insights on market access and grid code compliance.
- **University of Strathclyde** has experience in developing and assessing innovative control solutions for use on the GB network.
- **Carbon Trust** (representing 10 leading OWF developers, and with assistance from Frazer-Nash Consultancy (FNC), has the commercial and technical knowledge to develop business models to ensure commercial roll out, and the developers have the capability to conduct the Beta Phase demonstration.

An Advisory Panel of INCENTIVE solution suppliers has also been set up to ensure their expertise contributes to the Beta Phase.

Project Description

Problem

The energy contained in generators at power stations and industrial facilities provides inertia as they rotate at the same frequency as the electricity grid.

Inertia in the GB electricity network is falling. Without novel solutions, adding additional renewable generation capacity will become increasingly challenging and could increase the operating cost of the GB network system and consumers bills. Historically, renewable generators have not treated system inertia as their problem as it has been high. However, we are already seeing renewable generation curtailed due to low system inertia.

Solution

INCENTIVE will investigate and demonstrate how offshore wind farms (OWF) can provide inertia to the onshore networks. This will provide grid stability and reliability at a lower cost, and reduce the need for additional infrastructure by co-developing and co-locating inertia services with OWFs. OWFs providing inertia to the onshore network is not an incremental innovation, but a step-change in thinking that could be replicated globally.

INCENTIVE will investigate OWFs with:

1. STATCOM with supercapacitor energy storage and grid forming converter.
2. Battery energy storage system (BESS) with overrated grid forming converter.
3. Synchronous condenser with flywheel.

These solutions have never been trialled in conjunction with an offshore windfarm before, making this a first-of-its-kind project.

The Project brings together OWF developers, technology suppliers, NGESO and Ofgem, to help build a cross-industry understanding of the INCENTIVE solutions.

Approach

As agreed with UKRI, INCENTIVE will be delivered over two stages:

- Stage 1 (this application) - build on the Alpha Phase to deliver concept selection and a site selection for the installation of a pilot project.
- Stage 2 (subject to site and technology selection) - take the project through Front End Engineering Design and the Financial Investment Decision to install the pilot project. Stage 2 will be applied for under Beta Round 2.

This approach will deliver better value for GB consumers by reducing the potential of project failure and ensuring consumers money is spent confidently.

Benefits

INCENTIVE will deliver benefits over and above those achievable through existing programmes (i.e. The Stability Pathfinder). These include:

- Introduction of design alterations to requisite or already-planned assets to provide inertia.
- Capturing cost savings by building inertia provision alongside building OWFs. For example, sharing network, access and planning considerations.
- Accelerating the connection of renewable assets by proactively addressing inertia at the outset
- Driving down market prices by creating a liquid market for inertia services.

Preceding Projects

10024879 - INCENTIVE - Innovative Control and Energy Storage for Ancillary Services in Offshore Wind

10037143 - INCENTIVE – Innovative control and energy storage for ancillary services in offshore wind

Third Party Collaborators

The Carbon Trust

University of Strathclyde

Nominated Contact Email Address(es)

transmissioninnovation@sse.com

Project Description And Benefits

Applicants Location

- Scottish Hydro Electric (SHE) Transmission Plc ("SSENT") – PH1 3GH
- National Grid Electricity System Operator Limited ("NGESO") – WC2N 5EH
- University of Strathclyde ("Strathclyde") – G1 1XQ
- The Carbon Trust - EH3 8EG

The location of the Stage 2 demonstration project will be confirmed in Beta Phase Stage 1. The offshore windfarm developers in the consortium have put forward the following potential sites. These will be studied in Stage 1, and the site(s) to continue to the Stage 2 demonstration will be selected based on the outcomes of Stage 1.

- Onshore substation of the Awel y Môr offshore wind farm, which is planned for construction ~2025-2027, and which has been put forward by RWE
- Onshore substation of the Mona offshore wind farm, which is planned for construction ~2026-2028, and which has been put forward by EnBW
- Onshore substation of the Morgan offshore wind farm, which is planned for construction ~2026-2028, and which has been put forward by EnBW
- Onshore substation of the Hornsea 3 offshore wind farm, which is planned for construction ~2025-2027, and which has been put forward by Orsted

Project Short Description

INCENTIVE is investigating and demonstrating how offshore wind farms can provide stability to the onshore networks, through a range of novel solutions located at the onshore substation of offshore wind farms.

Innovation Justification

State of the art

INCENTIVE will maintain the UK's global leadership in offshore wind integration. Building OWFs that provide inertia to the grid is highly ambitious and doing so would be a world-first. Having OWFs provide inertia to the onshore network is not an incremental innovation but a step-change in thinking that could be replicated globally. SIF is the ideal mechanism to bring together the wide cross-industry consortium to perform the necessary innovation.

Regarding state of the art, inertia has historically been an inherent characteristic of the electricity system due to large numbers of synchronous (typically fossil fuel) generators. Due to increased renewable penetration, inertia levels are falling. If this fall is not arrested, it will prevent further renewable generation being added to the network; indeed, in GB renewable generation is already being curtailed due to low inertia. To begin to address this, ESO has launched a trial stability market (Stability Pathfinder) to procure inertia and other stability services. In this trial market, technology solutions (including BESS and synchronous condensers) have been procured by ESO to provide stability.

How INCENTIVE is innovative

At present, OWFs and other renewable generators do not provide inertia to the grid. Whilst BESS and synchronous condensers are known to be able to provide inertia, the combination of an OWF with a BESS or synchronous condenser has not been demonstrated to provide inertia, and there are significant technical and commercial risks in the combination of the assets. Further still, a STATCOM with supercapacitor storage has not been demonstrated to provide inertia anywhere on the network (standalone or in conjunction with an OWF).

Whilst early stability markets are being trialled (Stability Pathfinder), the incentive for OWF developers to participate in these markets has not been addressed directly. OWF developers' main business focus is to develop OWFs to sell power to consumers, not to

provide / sell stability services to the ESO. OWF developers are in a highly competitive space and always focus on developing the most cost effective OWFs as quickly as possible. OWF developers are privately financed and so naturally tend to seek the lowest risk, best-known solutions to ensure private investors provide finance to the developments. Any innovation that increases the risk profile of a £multi-billion privately financed asset will require a strong business case to be implemented.

Going above incremental innovation

All of these factors mean that pushing through inertia-providing OWFs to commercialisation is a highly ambitious innovation. It is not just an incremental innovation, but INCENTIVE is leading a step-change in thinking. Further, with The Department for Energy Security and Net Zero's (DESNZ) Holistic Network Design, it is clear that DESNZ wishes OWF developers to take a stronger role in developing the future offshore network. Projects like INCENTIVE, which includes GB networks and most major OWF developers, can nurture the collaboration between networks and OWF developers to deliver optimal future network solutions.

From the Alpha Phase, we have survey data from many OWF developers and INCENTIVE solution suppliers who indicate that demonstration of INCENTIVE solutions is required before they can be commercialised.

IRL and CRL estimations

Raising the IRL and CRL of the INCENTIVE solutions is core to the INCENTIVE project's aim to bring INCENTIVE solutions to BAU implementation.

Through the work conducted in Discovery and Alpha, the integration readiness of the INCENTIVE solutions has been raised from IRL 1 to IRL 3. Upon completion of the Beta Stage 1 tasks, we will raise this to around IRL 4-6, and then end Beta Stage 2 at IRL 7.

Through the work conducted in Discovery and Alpha, the commercial readiness of the INCENTIVE solutions has been raised from CRL 1 to CRL 4. Upon completion of the Beta Stage 1 tasks, we will raise this to around CRL 5-6, and then end Beta Stage 2 at CRL 7-8.

Funding source

INCENTIVE cannot be funded elsewhere in the price control or be considered as part of BAU due to the level of risk and ambition.

Furthermore, it is likely that assets will not form part of a transmission owner's regulated asset base, as they will belong to OFTO/OWF operator.

Competitive markets

INCENTIVE does not undermine the development of competitive markets, as it seeks to increase competition of future stability markets but provides additional sources of inertia for NGESO to procure.

Counterfactual solutions and approaches

Regarding counterfactual solutions, INCENTIVE was scoped to deliberately consider all possible innovative ways that OWFs can provide inertia, and to compare those against existing approaches for increasing system inertia (running CCGTs out of merit and the Stability Pathfinder results). Some innovative ways have been dropped from consideration due to low TRL. However, the three main options will be continued into the Beta Phase.

Impacts and benefits

System stability services are critical to supporting increasing volumes of non-synchronous renewable generation. The current provision is through redispatch of synchronous generation, which carries significant financial and environmental costs, and the development of new, standalone assets procured through Stability Pathfinder (SP). Published figures suggest that the £1.3bn contract cost from SP3 could deliver benefits of £14.9bn between 2025 and 2035.

INCENTIVE will deliver benefits over and above those achievable through SP by developing generation and network assets with in-built stability provision. Benefits include:

- Introducing design alterations to requisite/planned assets to enhance stability service provision for only marginal cost increases.
- Capturing co-development cost savings, e.g. in shared network, access, and planning considerations
- Potential acceleration in connection of renewable assets by proactively addressing stability at the outset.

- Creating a more liquid market for stability services, potentially driving down market prices in the long-term.

The CBA is based on a system capacity of 250 MVA, consistent with a 750MW offshore windfarm. The counterfactual is the cost of procuring similar levels of stability services via a SP tender. The benefits are the system-wide savings that would accrue to both the network operator and asset owner, with apportionment between these parties dependent on the nature and liquidity of future stability markets.

STATCOMs with supercapacitor energy storage – Impacts and Benefits

Cost Savings

Adding supercapacitor energy storage and grid forming converter to a conventional STATCOM would carry a lifetime cost of £7.85m and would deliver stability services that would cost an estimated £32.4m to procure via SP – a cost reduction of 75%. GB has a pipeline of up to 68GW of offshore wind. Assuming 50% will be AC-connected via a STATCOM, widespread adoption of the STATCOM with supercapacitors could meet around 5% of GB inertia needs and in doing so deliver savings of around £1.0bn over 30 years compared to SP procurement.

New-to-market products, processes, and services

This is a new technology, requiring large-scale demonstration before BAU adoption. The positive economic case is clear-cut, but the commercial case requires clarification owing to:

- Regulatory complexities related to ownership.
- Route-to-market concerns resulting from the relatively small amounts of stability offered at each location.

BESS

Cost Savings

There are multiple design and operating variables to consider when assessing the economic case for BESS (e.g. stacking of multiple services which can alter the optimal battery output from day to day). Alpha deliverable 2.6 models this in detail.

The benefits of uprating power converters to provide additional operating headroom, and hence additional capacity for inertia, are clear: A stand-alone 250 MW battery requires a 263 MVA converter to be grid code compliant and can deliver stability services with a lifetime SP procurement cost of £298m. Uprating this to 353 MVA would cost ~£5.9m. Assuming an 80:20 split between delivery of active power and delivery of stability services (actual split would be operational decision for battery asset owner), the uprated system would deliver 2.9 times more inertia. The lifetime SP procurement cost for this extra inertia is ~£195m.

New-to-market products, processes, and services

BESS is a maturing technology with the capability to provide stability services yet to be proven at scale. Areas of uncertainty needing to be resolved include:

- Testing and compliance of these systems to advance maturity.
- The technical benefits of oversizing converters needs further testing.
- Longer term commercial uncertainties exist around the future stability market and how batteries could contribute to these over different time scales.
- Co-location with offshore wind point-of-connection is novel use-case, which may bring Grid Code/STC and commercial implications.

Synchronous Condenser with Flywheel

Cost Savings

This is the most technologically mature option, although installation with a flywheel is less common. A flywheel may be added to a synchronous condenser for around £4m. In return, the inertia delivered by a 250 MVA installation increases by 1.25 GVAs. This extra inertia would cost £113m to procure via SP, over the asset lifetime. This is partly offset by increased energy losses.

New-to-market products, processes and services

There are outstanding questions about the impact on grid stability and connection should these systems be deployed at the point of onshore connection of offshore windfarms.

New to market products and services

All INCENTIVE solutions will be new to market products, providing new, low-cost inertia services to the ESO.

Carbon reductions – direct or indirect (MTCO₂e)

SP solutions provide significant improvement over redispatch of fossil synchronous generation, however the dominant SP solution is synchronous condenser-based and therefore suffers power losses of 1-3%. INCENTIVE STATCOM and BESS solutions do not experience these losses, thereby delivering additional environmental benefit. Switching away from a 250 MVA synchronous condenser potentially saves 178 ktCO₂ over a 30-year lifetime.

We will demonstrate each concept and potential returns in Stage 2 of the Beta Phase so that investors have the confidence to invest in scaling up the service.

Project Plans And Milestones

Project Plans, Milestones & Risks

Full Project Plan has been included in the Project Management Template.

The Beta Phase of INCENTIVE will be delivered over two stages. This application is for Stage 1 funding only. In line with UKRI guidance, for Stage 2, INCENTIVE will apply to the next Beta Phase (mid-2024) at the end of Stage 1.

This approach has been selected for the following reasons:

- INCENTIVE is problem-oriented, rather than solution-oriented. The Discovery and Alpha Phases took an ambitious open-minded approach to solving the difficult problem of falling system inertia. Whilst we have compelling evidence that INCENTIVE solutions benefit the GB consumer, we are not yet at a stage to definitively scope out a full-scale demonstration. We have been unable to go from solution discovery to a fully scoped solution in 8 months of work, and we do not think this is unreasonable.
- A staged approach will deliver better value for the GB consumer by reducing the chances of project failure and ensuring consumers' money is spent confidently. Based on the Alpha Phase results, we could have selected one INCENTIVE solution and scoped a large capital expenditure demonstration project; however, we are not yet at the stage to select the optimal INCENTIVE solution, and therefore would like more evidence to ensure such a large expenditure project will be the best spend of GB consumer money. This approach has been backed by the OWF developers, who highlighted that they believe it is too early to select an INCENTIVE solution for demonstration.
- OWF developers are providing funding to INCENTIVE. Private companies will only provide finance for work that is definitively scoped. To gain their investment into the project, a staged approach is the best process to follow.

Stage 1 will build on the generic (i.e. non-site-specific and non-supplier-specific) technical and commercial work conducted in Alpha, and conduct site- and supplier-specific studies. The aim of Stage 1 is to prove feasibility of INCENTIVE solutions and unlock investment (public and private) in a demonstration for Stage 2.

Stage 1 will deliver five work packages, as detailed in the project appendix.

WP1: Project Management

Lead resource: SSENT and Carbon Trust

Aim:

- Ensure timely and effective project delivery.

Deliverables / Milestones success criteria:

- Efficient and timely delivery and completion of the project.

WP2 – Business Model Development

Lead resource: Carbon Trust and Frazer-Nash

Aim:

- Devise non-site-specific business models for the three most promising INCENTIVE solutions identified in the Alpha Phase.
- Seek clarity on regulation, grid code and revenue mechanisms.
- Devise site-specific business model for Stage 2 demonstration.

Key deliverables:

- A workable business model for INCENTIVE solutions (non-site-specific).

- Clarity on regulation, grid code and revenue mechanisms.
- Final business model for Stage 2 demonstration (technology and site-specific).

WP3: Technical Assessment

Lead resource: SSENT and Strathclyde

Aim:

- Obtain access to suitable models.
- Develop a comprehensive understanding of technical performance of INCENTIVE solutions, at a non-site-specific level and also at a more detailed, site-specific level for the specific Stage 2 demonstration site.

Key deliverables:

- Suitable models for the simulation models received from INCENTIVE solution suppliers.
- Supplier-specific modelling completed (at a non-site-specific level).
- Supplier-specific modelling completed (at a more detailed, site-specific level for Stage 2 demonstration site).

WP4: Site Selection

Lead resource: Carbon Trust

Aim:

- Shortlist sites for Stage 2 demonstration
- Understand practical benefits and issues of conducting Stage 2 demonstration.
- Select site(s) for Stage 2 demonstration.

Key deliverables

- Site selection for detailed study in Stage 1.
- Site selection for demonstration in Stage 2.

WP5: Stage 2 Scoping

Lead resource: Carbon Trust

Aim:

- Identify need for further work in Stage 2.
- Select technology and demonstration methodology for Stage 2.
- Produce detailed scope of work for Stage 2.
- Reach FID for Stage 2.

Key deliverables:

- Stage 2 scope is defined.
- Stage 2 financing agreed.

A full Risk Register has been included in the Project Management Template. These risks will be continuously reviewed, updated and managed. The main risks are:

- Lack of suitable demonstration site – the mitigation for this is ongoing through strong engagement with OWF developer partners in the project. We already have four sites confirmed for feasibility study, which has reduced this risk already. WP4 of Stage 1 will seek to reduce this risk further.
- Lack of supplier input (particularly their models) – the mitigation for this is ongoing through strong engagement with suppliers and the creation of the Advisory Panel. At the time of application, we already have five suppliers confirmed on the Advisory Panel. WP3 of Stage 1 will seek to reduce this risk further.
- Technical and commercial feasibility not shown in Stage 1 – on the basis of Alpha Phase results, this risk has already reduced. WP2 and WP3 of Stage 1 are aimed to reduce this risk further.

Regulatory Barriers

In the Alpha Phase, regulatory barriers or uncertainties have been identified, which may reduce the business case for INCENTIVE solutions, or even prevent workable business models in some cases. We will seek to clarify these regulatory issues with Ofgem in the course of WP2 of the Beta Phase Stage 1. On the basis of these clarifications, we will develop commercial business models for demonstration in Beta Phase Stage 2, and subsequently commercial roll-out.

The regulatory uncertainties found in Alpha Phase are listed below:

- Ofgem and DESNZ position on ownership and operation of assets providing stability services (including INCENTIVE solutions) is under review.
- This must be resolved before INCENTIVE solutions will be invested in commercially: current regulation and uncertainty in future regulation inhibit clear business models for INCENTIVE solutions, despite their economic benefits to the energy system.
- Current Grid Codes (GC) and System Operator Transmission Owner Codes (STC) provide avenues for assets that provide voltage control at onshore substations to be owned by generators (who have access to NGENSO's stability markets).
- However, the specific GC and STC for INCENTIVE solutions is not currently clear due to the OFTO regime, particularly in relation to STATCOMS which we believe are required to be divested by the OWF developer to the OFTO. These GC and STC could inadvertently prevent workable business models for some INCENTIVE solutions.
- Specific GC and STC for INCENTIVE solutions requires investigation, agreement and demonstration in the Beta Phase.
- Ofgem and DESNZ position on ownership and operation of the future offshore network more generally is under development.
- In order to achieve the advantageous co-development of INCENTIVE solutions with the main windfarm development, it will be important to ensure that there is a level of alignment in timing between Contracts for Difference auction rounds and any future stability market auction rounds, i.e. if an offshore wind farm secures a Contract for Difference but does not yet have a stability contract in place, the offshore wind farm will likely proceed to be built without stability capability and the opportunity will have been lost (since retrofit is more costly).

The INCENTIVE Beta Phase allows Ofgem, DESNZ and ESO to trial and demonstrate regulatory and market arrangements to inform their thinking. INCENTIVE brings together all key stakeholders (Ofgem, DESNZ, ESO, onshore transmission network owners, and OWF developers) to address the issue of OWFs providing inertia to the onshore networks. Further, such collaborations will benefit the future development of the future offshore network, so INCENTIVE can nurture the collaborative, innovative relationships between these key stakeholders.

Business As Usual

INCENTIVE is devised to drive the innovative INCENTIVE solutions to BAU as quickly as possible – it is the project's main priority and the scope has been built around this.

There are two main areas currently preventing BAU adoption of INCENTIVE solutions.

The first area is technical risk. OWFs providing inertia to the grid has never been done before. Through engagement with the OWF developer partners and INCENTIVE solution suppliers in the Alpha Phase, demonstration of the INCENTIVE solutions is required to accelerate their adoption as BAU. WP3 of Stage 1 of Beta Phase will model supplier-specific INCENTIVE solutions at specific sites on the GB network, to de-risk the technical performance of the INCENTIVE solutions. On the basis of this, the Stage 2 demonstration will be scoped and executed.

The second area is commercial risk. Stability markets are in their infancy. OWF developers have not historically focused on participating in stability markets. WP2 of Stage 1 of Beta Phase will devise workable business models for BAU implementation. These business models will be site-specific for the Stage 2 demonstration. However, non-site-specific business models will also be created to ensure that the outcomes of INCENTIVE are applicable not just to the Stage 2 demonstration, but can also be applied at other locations on the GB network.

To ensure the results are adopted by OWF developers, the consortium includes 10 leading OWF developers, who have all committed to the project time of their relevant technical and commercial development teams. Further, the project has identified "Project Champion" OWF developers, who will champion the innovation by providing an OWF development site to study the implementation of INCENTIVE solutions in Beta Phase Stage 1, with a view of possibly demonstrating the INCENTIVE solutions at those sites in Beta Phase Stage 2. The OWF development sites put forward will continue to be developed by the Project Champions in parallel with INCENTIVE. If Beta Phase Stage 1 shows there is a positive case for INCENTIVE solutions, and that demonstration is required, then the Beta Phase Stage 2 demonstration may form part of the overall construction of the new OWFs. This provides a direct route to BAU for INCENTIVE solutions. RWE, EnBW and Orsted will be Project Champions.

INCENTIVE will also engage with SSENT's System Planning Team and Whole Systems Team (including regulatory codes subject matter experts) to ensure the work being undertaken will lead to BAU adoption of the INCENTIVE solutions. Whilst it is likely that the INCENTIVE solutions will be owned and operated by OWF developers, it is still essential for onshore transmission owners to understand these new assets and how to integrate them to the onshore networks.

Further, Alpha Phase has found that some of the findings may not be limited to the location of the onshore substation of offshore windfarms: there could be benefit in all other planned STATCOMs and synchronous condensers being augmented to provide inertia, regardless of their location on the network. This finding has relevance to SSENT, who will construct and operate STATCOMs and synchronous condensers in the future. Thus, while the focus will be at the onshore substation of offshore windfarms, SSENT's System Planning Team will be engaged to ensure they understand the solutions sufficiently such that the results can be translated to other locations on the SSENT network.

This is particularly relevant since, under DESNZ Holistic Network Design, there have been indications that onshore transmission owners may enter competitive markets to build assets in the future, including offshore infrastructure and stability assets. This could open the door to SSENT owning and operating INCENTIVE solutions.

Also under DESNZ' Holistic Network Design, the future development of offshore networks will require strong collaboration between onshore transmission owners and OWF developers. While INCENTIVE is a small part of this overall process, building collaborative innovations between onshore networks and OWF developers will be of strategic importance going forward. SSENT will therefore use INCENTIVE to upskill the System Planning Team and System Performance Team regarding offshore transmission and stability market participation in the future, which will also help BAU adoption.

Regarding dissemination, a dissemination strategy will be developed in WP1 of Stage 1, which will ensure all networks and other stakeholders are educated with the successes of the project. All results will be shared with other networks if requested and all other networks will be invited to partner / witness the demonstration in Stage 2

Commercials

Consumer interaction and engagement

Beta Phase Stage 1 will have limited interaction with consumers. Stage 1 focuses on demonstrating technical and commercial feasibility, then scoping a large expenditure demonstration project in Stage 2. Consumers will not be a key stakeholder in the majority of this work.

However, in WP5, as part of scoping Stage 2, the potential impacts to consumers of a Stage 2 physical demonstration will be considered and factored into the Stage 2 project plan.

At the time of writing, it is believed that the Stage 2 demonstration will not impact consumers greatly as it is likely to be a new-build asset as part of a new-build OWF. Thus, the work will likely be folded into the construction and commissioning work of a new-build OWF. However, this will be confirmed in Stage 1.

Supply shortages and interruptions

Stage 1 of the Beta Phase will not create any supply shortages and interruptions, as it is focused on demonstrating technical and commercial feasibility, and scoping a large expenditure demonstration project in Stage 2. There will not be any supply shortages or interruptions caused by Stage 1.

However, in WP5, as part of scoping Stage 2, the potential supply shortages and interruptions of a Stage 2 physical demonstration will be considered and factored into the Stage 2 project plan.

At the time of writing, it is believed that the Stage 2 demonstration will not create significant supply shortages and interruptions, as it is likely to be a new-build asset as part of a new-build OWF. Thus, the work will likely be folded into the construction and commissioning work of a new-build OWF. This assumption will be confirmed in Stage 1

Commercialisation

A pathway to commercialisation is at the core of the INCENTIVE project and the Beta Phase Stage 1 scope.

The Alpha Phase found promising economic assessments for a range of INCENTIVE solutions. Beta Phase Stage 1 will build on this by developing workable business models. A site-specific business model will be created for the Stage 2 demonstration itself, to ensure there is a strong value proposition for the Stage 2 demonstration. However, non-site-specific business models will also be created to ensure that the results of INCENTIVE can be applied to other locations on the GB network, which will assist commercialisation.

The primary customer segment for inertia provided by INCENTIVE solutions is the ESO. The value proposition for the ESO is to have more sources of inertia, and hence a more competitive inertia market. The primary customer segment for the INCENTIVE solutions themselves are OWF developers. The value proposition for the OWF developers is to create additional revenue streams for their OWFs through stability markets, to strengthen the network in the vicinity of their OWF connections to improve their power exports, and to help strengthen the overall system to allow more renewable penetration.

These customers are all represented in the project consortium, which will assist commercialisation of the innovation.

Whilst the 10 OWF developer project partners have strong interests in GB, they are global players (together they represent the vast majority of global offshore wind farm developments outside of China) and they will seek to commercialise INCENTIVE solutions internationally. INCENTIVE provides the opportunity for the GB networks to lead the way globally in bringing inertia-providing OWFs to commercial reality.

INCENTIVE solutions can be implemented at all future OWF connections within GB and internationally. There is therefore a huge scope for scale-up following Beta Phase, which will provide the GB system (and other international systems) with more sources of inertia.

Regarding new partnerships, an additional OWF developer (Ocean Winds) partner is joining the project for Beta Phase, in addition to the nine OWF developer partners that have been involved in the previous two Phases. Ocean Winds has a pipeline of projects in the north of GB connecting to the SSN Transmission network, so is a strong addition to the project.

Further, the Beta Phase Stage 1 will include three "Project Champion" OWF developer partners, EnBW, Orsted and RWE. These

partners will provide sites for study in Beta Phase Stage 1, and will seek to host the demonstration of Beta Phase Stage 2.

Further still, Beta Phase Stage 1 will include an Advisory Panel with 5 leading suppliers of INCENTIVE solutions to ensure supplier input is provided to the project and the outputs are taken up by suppliers in BAU. For the Stage 2 demonstration, one or more INCENTIVE solution suppliers will be required to be a formal partner or contractor, which will be decided in Stage 1. For any commercialisation after Stage 2, it is expected that contractual relationships between OWF developers and INCENTIVE solutions suppliers will be necessary.

It should be noted that the OWF developer partners and the Advisory Panel members are global organisations. Their employees working on this project may be based in the UK, EU or other territories.

Regarding additional project partner capital, the Beta Phase Stage 2 will be co-financed by the OWF developers in the consortium, in a funding split to be decided in Stage 1. Following the Stage 2 demonstration of the innovative technologies and workable business models, it is expected that the OWF developers will raise capital for implementation of INCENTIVE solutions as part of the process for raising capital for their new wind farm developments.

Intellectual Property Rights

For Beta Phase Stage 1, the majority of the IPR arrangements will follow the default recommendations of Chapter 9 SIF Governance Document. There may be some Background IPR and some Foreground IPR that fall within the exemptions of Clause 9.2 and 9.14 of the SIF Governance Document.

At the time of drafting this application we are unable to provide a definitive list of the specific pieces of Background IPR and Foreground IPR that we would request to be exempt from the default treatment as we are still in talks with the relevant parties. However, an explanation of the situation is provided below.

Beta Phase Stage 1 will receive commercially sensitive information from INCENTIVE solution suppliers on the Advisory Panel (in the form of software models of their innovative products and commercial information about their innovative products) and the Project Champion OWF developers (in the form of site data for their development sites where they are interested in a Beta Phase Stage 2 demonstration). Due to the innovative nature of the technologies in question, and commercial sensitivities in relation to their operation, it is likely that at least some of the inputs and outputs will be necessarily confidential, meaning that these inputs and outputs cannot be fully shared with all project partners or anyone outside the INCENTIVE project. Please see the letters of support attached to question 3 for more details on what confidential information these parties are providing to the project.

INCENTIVE will use an IP register to track the Background IPR, the Foreground IPR, and the use and access rights to all this IP. The main contract governing the project (the Collaboration Agreement) will include detailed, mutually agreed terms governing IP that are in line with the SIF Governance Document.

It is proposed that, for expediency, and in line with the Discovery and Alpha Phases, Carbon Trust will sign the project's Consortium Agreement on behalf of the OWF developers in the consortium, as the representative of the OWA programme. With this contracting arrangement, and to encourage BAU adoption of the INCENTIVE solutions, we would expect OWF developers to have access to Background and Foreground IPR like any other project partner.

INCENTIVE will also include an Advisory Panel of INCENTIVE solution suppliers (at the time of writing GE, Siemens, Mitsubishi, Hitachi and Fluence, but others may be added before kick-off). To encourage BAU adoption of the INCENTIVE solutions, we intend to make all Foreground IPR available to the Advisory Panel, under confidentiality, in exchange for the Background IPR and in-kind contributions that they are providing.

Costs and Value for Money

We are currently applying for funding for Beta Phase Stage 1 only (i.e. not Stage 2). The rationale for this is set out in question 7.

The total cost for Beta Phase Stage 1 is £1,122,973.

The project is requesting £922,333 of funding (82% of the total cost), with the remaining £200,640 (18% of the total cost) being provided by project partners. In addition to this, there is £365,710 of in-kind contribution. Including the in-kind contributions, the SIF Contribution % is 62%.

This level of funding will lead to outcomes that provide value to the consumer. Beta Phase Stage 1 will technically de-risk INCENTIVE solutions and provide workable business models for demonstration in Stage 2, and then commercial role out. This will provide low-cost inertia, and hence allow the continued penetration of cheap domestic renewables into the GB network. This will in turn allow for cheap, secure energy sources for GB consumers.

Regarding the project contributions, the SIF Contribution % is 61% ((contribution to the project + in-kind contribution)/SIF funding). This is significantly higher than the the minimum 10% compulsory contribution giving excellent leverage of SIF funds.

The Carbon Trust is contributing £185,000 to the project. This cash is coming from the Carbon Trust's Offshore Wind Accelerator programme.

NGESO is contributing £4,215 and Strathclyde is contributing £11,425.

Regarding the in-kind contributions, EnBW as Project Champion is contributing £70,560 in time. Orsted as Project Champion is contributing £72,000 in time. RWE as Project Champion is contributing £40,000 in time. In total, the other OWF developer partners are contributing £128,400 in time. This allocation of technical expertise reflects the OWF developers' commitment to INCENTIVE and highlights the importance of the research subject.

The Advisory Panel is contributing £54,750 of human resource in total (technical expertise within each company). Some will also be contributing software models worth >£100,000s (although this contribution is not being included in the budget since it is Background IP). The allocation reflects the Advisory Panel's commitment to INCENTIVE and highlights the importance of the research subject.

It should be noted that the OWF developer partners and Advisory Panel members are multinational organisations. Their experts, who will work on INCENTIVE, sit in many different locations globally and may be employed by non-UK entities. However, all such partners have strong interest in developing stability services and offshore wind farms in the UK.

SSENT will contract Fraser-Nash to deliver the CBA work in WP2. FNC have been involved as a contractor throughout INCENTIVE and have delivered an excellent standard of work so far. They are uniquely placed to continue this work in Beta Phase Stage 1.

Regarding changes to the project team, the key change is the addition of the Project Champions who will bring practical expertise of developing, constructing and owning offshore transmission assets. They will also bring their sites to be studied in Stage 1, and where the demonstration in Stage 2 may be hosted. Their project development teams will work with INCENTIVE with the aim of building up to a first of a kind demonstration of INCENTIVE solutions as part of a commercial wind farm development.

Another major change is the addition of the Advisory Panel, which brings INCENTIVE solution suppliers closer to the project. Again, their practical expertise will be key when simulation testing the INCENTIVE solutions and scoping the Stage 2 demonstration. In Stage 2 one or more INCENTIVE solution suppliers will become a formal partner or contractor, such that they can supply an INCENTIVE solution for demonstration.

Another major change is the addition of a 10th OWF developer, Ocean Winds. Ocean Winds has a pipeline of projects in the north of GB connecting to the SSEN Transmission network, so is a strong addition to the project.

Although we are not applying for it now, as an early indication for Beta Phase Stage 2 costs, we would estimate that the total cost would be around £5-10M, depending on the size of the INCENTIVE solution to be demonstrated. However, we would expect a portion of this to be funded by the OWF developers in the consortium (particularly the site owner Project Champion developer), and we propose to decide the finance for Stage 2 together with UKRI at the end of Stage 1 through an application to the next Beta Phase round in mid-2024.

Document upload

Documents Uploaded Where Applicable

Yes

Documents:

SIF Beta Project Registration 2023-10-11 2_24

INCENTIVE_Beta Annual Report_Final_20240927.pdf

INCENTIVE_Beta End_of_Phase_Report_v3.0_20241120.pdf

INCENTIVE_Beta-stage-1_D6.2_v1(f)_20241018.pdf

Summary of Small Signal Method Used in INCENTIVE for Interactions Study.pdf

INCENTIVE_Beta_show_and_tell_v2(f)_20241113.pdf

INCENTIVE_Beta_D6.3_v7(f)_20250416.pdf

This project has been approved by a senior member of staff

☒ Yes