

# SIF Beta Close Down Report Document

## Date of Submission

Jul 2025

## Project Reference Number

10067856

## Project Progress

### Project Title

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

### Project Reference Number

10067856

### Lead Funding Licensee

SSEN - Scottish Hydro Electric Transmission

### Funding Licensee(s)

NESO - National Energy System Operator

### Project Start Date

July 2023

### Project Duration

19 Months

### Nominated Project Contact(s)

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## Project Summary

Inertia in the GB electricity network is falling. Without novel solutions, adding additional renewable generation capacity will become increasingly challenging, leading to significant instability events on the onshore networks (which are already occurring, but can be expected to get worse), and increasing the operating cost of the GB network system and therefore consumer bills. Historically, renewable generators have not treated system inertia as their problem as system inertia has been high due to the presence of (mostly fossil fuelled) synchronous generation. However, we are already seeing renewable generation curtailed due to low system inertia.

The INCENTIVE project has investigated 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 OWF developments. OWFs and their associated grid infrastructure providing inertia to the onshore network is not an incremental innovation, but a stepchange in thinking that could be replicated globally.

INCENTIVE has investigated OWFs with:

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

Collectively, we refer to these as "INCENTIVE solutions".

The Project brought together SSENT, NESO (formerly NGESO), OWF developers, technology suppliers and Ofgem, to help build a cross-industry understanding of how offshore wind could provide inertia through the use of BESS with GFM converters and STATCOMS with grid forming converter and super capacitors.

## Scope of the Project

The project consisted of five core work packages, and an additional sixth work package which was added during project delivery to ensure the dissemination and successful close out of the project.

**WP1:** Project management

**WP2:** Business model development

**WP3:** Technical assessment

**WP4:** Site selection

**WP5:** Stage 2 scoping

**WP6:** Additional work: preparing for posterity

## Summary Key Findings

The main outcomes of the project can be summarised into two areas:

1. Clarity around the process of installing INCENTIVE solutions from a regulatory and commercial perspective. Specifically, identifying key routes to enabling market participation of these technologies, and understanding the asset ownership of such devices.
2. Understanding of the technical performance and specifications, and adjustments to technical markets/ grid codes that could enable INCENTIVE solutions to operate within the inertia market.

The SIF challenge of the INCENTIVE Beta phase was whole system integration. The INCENTIVE project has built collaboration with a large whole-system consortia, enabling innovation between a large group of generators, transmission networks and OEMs, as well as various teams within NESO and Ofgem. This whole-system approach has enabled new insights on the use of offshore wind to provide ancillary services (inertia) to the wider system, with a view of enabling further offshore wind (and other renewable penetration). The innovations have included insights across a wide range of interdependent areas, such as regulations, grid codes, markets and technical design specification. In terms of whole system integration, the key deliverables which discuss the technical benefits of offshore wind inertia provision and integration all sit within WP3, and the key commercial and regulatory whole system innovations are found within WP2.

## Main learning generated by the Project

- Feasible regulatory model for INCENTIVE solutions identified.
- Simulation testing has shown INCENTIVE solutions will meet grid code.
- CBA is positive for INCENTIVE solutions but may need to be improved before INCENTIVE solutions can be invested in (see bullet point below).
- However, the current market and grid code requirements require an inertia response for 5 seconds, which is detrimental to the business case. This definition of inertia response may need to be updated in future iterations of market requirements and grid code.

## Knowledge Creation And Dissemination

Several lessons have been learnt in the process of delivering INCENTIVE Beta Phase, namely:

**Contracting:** Contracting a large consortium such as that of the INCENTIVE Beta Phase, takes a large effort and can be difficult to align across such a broad spectrum of organisations.

**Lesson learnt:** Start early and allow time Although we got contracts signed in good time it was a big effort. In any future phase, we would plan to have an opening procurement phase to ensure procurement and contracting time is factored in.

**Next Phase:** INCENTIVE Beta Phase project was scoped as a shorter Beta Phase project, with the view of an additional follow-on phase to conduct the physical demonstration. Such a physical demonstration of novel technology is a big commitment, and these conversations and commitments take significant time.

**Lesson learnt:** Start scoping and business case creation early and be clear on resources required for demonstration. Identify key delivery partners, and their resource requirements as early as possible. Ensure all key decision makers in those companies are aware of the need for a decision as early as possible, and support them to make the necessary commitment decision.

**Model sharing:** INCENTIVE Beta Phase has used OEMs' models in the process of the technical work undertaken. This process of

procuring these models was slower than anticipated due to additional tuning time requirements and coordination of several organisations.

**Lesson Learnt:** In the Project Plan, set aside adequate time to procure models (or other inputs) from OEMs. OEMs can require additional time internally to get sign off and to fine tune their models for specific use cases, additionally coordinating multiple OEMs separately and confidentially takes more time than anticipated and it is important to ensure everyone has the time and ability to sign off on each stage.

## Intellectual Property Rights Generation

The Relevant Foreground IPR is solely the INCENTIVE deliverables, which can be made available to other networks upon request. No other IPR has been generated.

Deliverables developed - **please refer to Table 1 - Intellectual Property Rights Generation.**

Out with the project consortium, the INCENTIVE project has also collaborated with National Grid Transmission (NGET) and Scottish Power Energy Networks (SPT) during the delivery of the Beta Phase, so all transmission networks in GB are aware of its outcomes.

## Data Access Details

All insights are contained within the Deliverables listed in Section 4 above. These are confidential to the INCENTIVE project but may be made available to GB licensed networks in accordance with the SIF Governance document. Upon request, non-GB licensees may be granted a licence on terms to be agreed with the INCENTIVE partners, in accordance with the SIF Governance Document.

At the time of writing (Beta Phase close out), INCENTIVE has submitted two papers to IET's ACDC 2025 conference. We are waiting to hear if these submissions are successful. We are also planning a public webinar in December 2024 to disseminate key outcomes.

## Route to Market / Business as usual

The innovation is not yet ready for implementation. This is due to nascent, and rapidly evolving, grid code and market definitions for the technology, meaning the technical asset specification is unclear and the revenue streams are uncertain. These present barriers to invest in these solutions, and hence their implementation. Details on the steps that various parties need to take towards implementation are set out in D6.2, which is uploaded to the ENA website alongside this document.

D6.2 denotes the necessary steps and further work to bring these technologies to BAU. This specifically falls into the following 11 areas:

1. **Information exchange with German TSOs**
2. **Improved inertia provision from combination of OWF + INCENTIVE solution**
3. **Strengthening weak grid connections for OWFs using INCENTIVE solutions**
4. **Input into new GB grid forming working group**
5. **Evolving the understanding and definition of inertia in GB**
6. **Evolving the understanding and definition of strength to connect in GB**
7. **OWF developer ownership regulatory model**
8. **TO ownership regulatory model**
9. **First-of-a-kind deployment of a Grid forming (GFM) STATCOM with supercapacitor storage in GB**
10. **Guidance for OWF developers**
11. **Guidance for GB onshore TOs**

D6.2 describes the need, aims, scope outputs, costs and duration expected for each of these areas required to bring these technologies to BAU.

Recommendations for furthering of the project can be found within D6.2, which is uploaded to the ENA website alongside this document.

INCENTIVE has shown there is great potential in INCENTIVE solutions; but that there are also significant barriers to their deployment. Whether these barriers will be reduced in time for the offshore wind industry to uptake these solutions will depend on the barriers being addressed. There is an element of urgency here. Offshore wind farms are being built very rapidly with huge targets by 2030 and 2035. Opportunities will be lost to install INCENTIVE solutions if the barriers are not addressed quickly. D6.2 describes this in more detail, which is uploaded to the ENA website alongside this document.

Work in the INCENTIVE Beta Phase has remained aligned with the Beta Phase application. In line with the Beta Phase application, the Discovery and Alpha Phases raised CRL from 1 to 4. At the end of Beta Phase, CRL is 5. The further work documented in D6.2, which is uploaded to the ENA website alongside this document, sets out how to raise CRL to 8.

Procurement of INCENTIVE solutions is one of the key barriers to address that will enable their utilisation. In INCENTIVE Beta Phase, we found that – due to nascent and rapidly evolving grid code and market requirements – it is unclear how to technically specify INCENTIVE solutions to OEMs. There is also uncertainty in terms of INCENTIVE solution revenue streams. This makes procurement difficult at the current time. The key to enabling widespread procurement will be to provide absolute clarity and certainty in terms of grid code definitions and revenue potential. This will enable offshore wind developers to specify requirements to their OEMs and the OEMs to deliver solutions that meet these requirements. D6.2 sets out steps to achieve these goals in more detail.

Commercialisation has always been at the core of the INCENTIVE project. The key step forward INCENTIVE Beta Phase has made towards commercialisation of INCENTIVE solutions is the development of a workable regulatory models. However, INCENTIVE Beta Phase has also unearthed additional barriers to commercialisation in the form of nascent and rapidly evolving grid code and market requirements, making the commercial investment case for INCENTIVE solutions unclear at the current time. D6.2 sets out the steps to overcome these newly identified barriers in detail.

Working with non-network partners was a key part of INCENTIVE. The project consortium consisted of 11 offshore wind developers and 5 OEMs in addition to networks. As the project progressed through Discovery, Alpha and Beta, the main commercialisation model developed ended up being for offshore wind developers rather than networks. In this regard, a workable regulatory model was devised that enabled offshore wind developers to install and operate INCENTIVE solutions. The project worked with offshore wind developers and a range of OEMs, using three different offshore wind farms as case studies to work through the various technical and commercial barriers, with a view of commercialising the innovation at those windfarms. This included assisting the offshore wind developers and OEMs in understanding market requirements and translating these into asset specifications, all while providing analysis on the potential revenue streams and therefore business case for the INCENTIVE solutions.

## Policy, Regulatory and Standard Barriers

Work Package 2 of the project investigated the regulatory needs to enable the ownership/ operation of an INCENTIVE STATCOM (STATCOM with grid forming converter and supercapacitors). INCENTIVE worked with various teams at Ofgem and NESO, as well as with offshore wind developers and OEMs, to devise novel regulatory arrangements to enable INCENTIVE solutions. A workable model was devised. In order to finalise this regulatory model, it will be necessary for an actual offshore wind project to request to use the regulatory model devised and to work with Ofgem to see it through to implementation. D6.2 describes this in more detail, which is uploaded to the ENA website alongside this document.

In addition to this, the work undertaken in INCENTIVE Beta Phase has uncovered additional barriers to BAU deployment of these technologies, namely the '5 second rule' which is based on the capability to deliver inertia (or Active ROCOF Response Power) for 5 seconds. The design driver for this is a test defined in Grid Code Table PC.A.5.8.2 which requires energy to be provided for a 1Hz/s frequency ramp from 52 Hz to 47 Hz to be quantified. This storage duration also accommodates scenarios where inertia power is provided for successive frequency events without charging or discharging. This onerous requirement reduces the available provision of inertia at a market level. However, the need for this onerous requirement could be disputed and proposed changes to this requirement could enable BAU uptake of INCENTIVE solutions (particularly INCENTIVE STATCOM) and enable them to both provide these services and operate within the inertia market. Examining this definition may be required, as set out in D6.2.

## User needs

The key users of INCENTIVE solutions include OWF developers, onshore networks and electricity system operators.

All key users of these solutions were represented in the consortium of the INCENTIVE project. At the start of the project, their needs were identified as:

- 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.
- NESO 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.

The scope was designed to address these needs.

The project has reduced some of the key barriers preventing OWF developers installing these new technologies, which in turn will enable OWFs to provide necessary inertia to the onshore grid, and therefore widen the pool of potential inertia suppliers to NESO. In particular, a key user need addressed was the development of a workable regulatory model for OWF developers to install and operate INCENTIVE solutions.

However, additional needs were identified during the course of Beta Phase. As described in Section 7, the improved understanding of the '5 second rule' has improved user need understanding and impacted upon all parties. Developers, TOs and OEMs may need this to be clarified or relaxed before some of these technologies become truly attractive. In addition to this, the project has found that local system strength could potentially be more important for developers and TOs when looking to invest in these technologies, rather than just the inertia market value.

These are key new user needs, which can be addressed through the further work identified in D6.2.

We have ensured that user needs have been at the heart of the project and have shaped the project scope and delivery. This can be seen through our continuous engagement with Ofgem, NESO, offshore wind farm developers and OEMs and our pursuit of cost-beneficial inertia provision for the GB energy user.

We have a large consortium that has been built intentionally to avoid duplication of effort. To build alignment across the industry on the user needs and the solutions to those needs.

## Impacts and benefits

Progress towards benefits in application - **please refer to Table 2 - Impacts and Benefits.**

As mentioned in Section 7, the INCENTIVE Beta Phase has uncovered an additional barrier to BAU deployment of the grid forming STATCOM with supercapacitors namely the '5 second rule' which is based on the capability to deliver inertia (or Active ROCOF Response Power) for 5 seconds. Without change to the market design in relation to this, the business case for the INCENTIVE STATCOM may be reduced. This is one of the key aspects to be addressed in further work, as set out in D6.2.

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 solutions have the potential to 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 in Beta Phase is based on a 250MVA STATCOM, 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.

## Risks, Issues and Constraints

A Risk Register has existed since Discovery Phase of the INCENTIVE project and has been provided to UKRI. This risk register manages, rates, and reviews all identified risks and assumptions, the most notable of which are discussed below.

### Key Risks:

1. The risk that INCENTIVE Beta Phase does not deliver a workable business model for an offshore wind farm developer or a transmission owner to own and operate INCENTIVE solutions.

**Mitigation:** A workable regulatory model has been defined, with input from NESO and Ofgem. However, it is the stable market (the fact it is nascent and asks for a 5 second duration requirement) that may mean the INCENTIVE STATCOM has a reduced business case. Innovation funding may be required for first mover of this technology. The nascent nature of the market also may inhibit INCENTIVE BESS. To address these residual risks, there is a wide range of further work, which has been specified in D6.2.

2. Risk that Beta Phase finds that market and regulatory changes are required for a workable business model, and these are not agreed by Ofgem and NESO, meaning the business case falls through.

**Mitigation:** Continuous engagement with Ofgem and NESO has been achieved. It is likely market changes are required to enable

INCENTIVE solutions to participate effectively. It is highly likely regulatory derogations are needed to enable INCENTIVE solutions. Whilst a regulatory model has been devised, it will require a first-mover project / demonstration to apply the regulatory model for the regulatory model to be finally approved. To address these residual risks, there is a wide range of further work, which has been specified in D6.2.

3. Risk that INCENTIVE Beta Phase knowledge not well managed and disseminated, following negative FID for Next Phase. There is a strong need to ensure the work done has legacy. This means the work done must be left in a state such that a third party can pick it up without the support of the INCENTIVE project.

**Mitigation:** Additional work package, WP6, was proposed by the INCENTIVE team and agreed upon by UKRI to address this risk. This has been funded through reassigning contingency to this work package, and dissemination and supporting deliverables created to ensure the knowledge gained throughout the project has been managed.

## Working in the open

In INCENTIVE Beta Phase we have developed and executed a dissemination strategy, including public dissemination through a public webinar which will take place at the end of the project and through submitting papers to the IET ACDC Global 2025 conference. The IET ACDC Global conference is an ideal place to present the INCENTIVE project to potential UK stakeholders due to its focus on the latest advancements and technologies in both AC and DC power transmission.

The INCENTIVE Beta Phase project has continuously sought project partner input, through regular meetings with all parties involved in the project, and additional meetings with external stakeholders such as NESO, Ofgem, DESNZ, OFTOs, and other TOs (NGET and SPT).

Engagement with consortium members included:

- Three biweekly calls with three OWF developer “Project Champions” who have offered their offshore wind development projects as case studies to the project
- Regular bilateral meetings with all key OEMs
- Quarterly large consortium meetings, where we bridged the gap between this innovation project and the TO community, the OWF developer community (with 11 OWF developers present) and the OEM community (with 5 OEMs present)
- Weekly delivery group meetings to coordinate between all work packages

The INCENTIVE project has engaged its large industry stakeholder group in order to transparently share learnings. Currently, no additional research projects are investigating these technologies in the UK. The project has made efforts to engage with German TOs to more fully understand projects in Germany looking at similar technologies. See D6.2 for more information on the potential for additional knowledge sharing between INCENTIVE and the German TSOs.

Throughout the project we have also been in contact with other transmission companies in the UK, namely NGET and SPT, to ensure we are not duplicating work and to disseminate learning. The majority of the European offshore wind industry is also present through the 11 developers and 5 OEMs in the INCENTIVE consortium.

Dissemination and collaborative working are at the heart of the INCENTIVE project, which is reflected in its large and broad project consortium. The INCENTIVE project has engaged with 5 OEMs, 11 offshore wind developers, 3 UK TSOs, NESO, Ofgem, and German TSOs to involve all stakeholders in discussions on bringing these technologies into BAU. This engagement ensures effective knowledge sharing, industry upskilling for technology adoption, elimination of redundant efforts, and comprehensive dissemination of project outcomes through the quarterly consortium meetings.

Throughout the INCENTIVE Beta Phase, we have worked with DESNZ and Ofgem in order to discuss asset ownership and operation models which could exist within current regulations and what adjustments might be required to bring these technologies to market.

We have understood that GB TOs also see a strong value in a physical demonstration of these technologies at onshore locations within their networks, and not just adjacent to offshore wind farms.

German TSOs are due to install a world first STATCOM with grid forming control and energy storage in 2025. There would be benefit from an exchange of information between INCENTIVE, the GB transmission industry, the global offshore wind industry and these German TSOs. See D6.2 for more details on this.

## Costs and value for money

The budget of this project was managed through budget trackers held by SSEN-T on a joint



SharePoint.

The project has demonstrated value for money by delivering its intended work plan and outputs in line with the originally planned budget.

**Please refer to Table 3 - Costs and value for money** to see spend until end of October 2024.

### **Special Conditions**

Project Specific Conditions (PSCs) have been met by the following, **please refer to Table 4 - Special Conditions.**

### **Material change**

No material changes were submitted.

### **Documents uploaded where applicable**

Yes