BETA PHASE

# INCENTIVE

Innovative Control and Energy Storage for Ancillary Service in Offshore Wind

***A Strategic Innovation Fund project & Offshore Wind Accelerator collaboration***

# Document information

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Project Partners: Scottish & Southern Electricity Networks Transmission, National Energy System Operator (NESO), University of Strathclyde, Carbon Trust.

OWD Partners: bp, EnBW, Equinor, Ocean Winds, Ørsted, RWE, ScottishPower Renewables, Shell, SSE Renewables, TotalEnergies, Vattenfall.

Project Advisory Panel: Fluence, Hitachi Energy, GE Verona, SMA, Siemens Energy.

**Confidentiality Period**

This report shall be kept confidential for a period of five (5) years following the Completion Date INCENTIVE Beta Phase1.

# Contents

# Abbreviations

| | |
|---|---|
| **BAU** | Business as usual |
| **BESS** | Battery energy storage system |
| **CBA** | Cost benefit analysis |
| **ENA** | Energy Networks Association |
| **GB** | Great Britain |
| **GC** | Grid code |
| **HVDC** | High-voltage direct current |
| **INCENTIVE** | Innovative control and energy storage for ancillary services in offshore wind |
| **NESO** | National Energy System Operator |
| **OWF** | Offshore wind farm |
| **SCL** | Short circuit level |
| **STATCOM** | Static synchronous compensator |
| **TO** | Transmission Owner |
| **TSO** | Transmission System Operator |

# Project definitions

| Term | Definition |
|---|---|
| **STATCOM or Base STATCOM** | A static synchronous compensator, a type of dynamic reactive compensation equipment (DRCE) and a core component of most alternating current (AC) connected offshore wind farm (OWF) transmission systems. They are installed to provide reactive compensation and voltage control capability at the transmission interface point (TIP) with the onshore system. |
| **GFM STATCOM** | A STATCOM with grid forming control. This can be further enhanced by the addition of supercapacitor energy storage. |
| **INCENTIVE STATCOM** | A grid forming STATCOM with supercapacitor energy storage located at the offshore transmission owner's (OFTO's) onshore substation, intended to meet its STC requirements for reactive power compensation. By augmenting the STATCOM with supercapacitor energy storage, the asset can provide grid forming capabilities in line with the GC0137 requirements. |
| **BESS** | A battery energy storage system, a generation asset that can earn revenue by energy trading or providing a range of active and reactive power services. |
| **GFM BESS** | A BESS with grid forming capabilities in line with the GC0137. |
| **INCENTIVE BESS** | A GFM BESS with up-rated converters (also known as over-sized converters) installed and operated by the windfarm developer with its own grid connection (not located on the OFTO's onshore substation). Unlike the INCENTIVE STATCOM, this device is not used to meet the OFTO's STC requirements for reactive power compensation.<br><br>Over-sizing the converter enables the BESS to provide stability services without reducing normal import/export capacity. |
| **INCENTIVE solution** | INCENTIVE BESS or INCENTIVE STATCOM |

# 1. Executive summary

The table below presents a list of all further work that would be beneficial to accelerator INCENTIVE solutions to market, following on from the close of the INCENTIVE Beta Phase in October 2024. Full details are set out in this document below.

| No.* | Description | Key stakeholders | Cost** | Duration*** |
|---|---|---|---|---|
| **1** | Information exchange with German TSOs | • German TSOs and their OEMs<br>• OWF developers<br>• GB TOs<br>• NESO | <£100k | 12 months |
| **2** | Improved inertia provision from OWF + INCENTIVE solution | • OWF developers<br>• INCENTIVE solutions OEMs<br>• NESO | ~£100k | 12 months |
| **3** | Strengthening weak grid connections for OWFs using INCENTIVE solutions | • OWF developers<br>• INCENTIVE solutions OEMs<br>• NESO | ~£100k | 12 months |
| **4** | Input into new GB grid forming working group | • OWF developers<br>• INCENTIVE solutions OEMs | <£100k | 12-24 months |
| **5** | Evolving the understanding and definition of inertia in GB | • OWF developers<br>• INCENTIVE solution OEMs<br>• NESO | £100-200k | 12 months |
| **6** | Evolving the understanding and definition of strength to connect in GB | • OWF developers<br>• INCENTIVE solution OEMs<br>• NESO | £100-200k | 12 months |
| **7** | OWF developer ownership regulatory model | • Project Champion<br>• Other OWF developers<br>• INCENTIVE solutions OEMs<br>• NESO<br>• Ofgem | ~£100k | 12 months |
| **8** | TO ownership regulatory model | • GB onshore TOs<br>• INCENTIVE solutions OEMs<br>• NESO<br>• Ofgem | ~£100k | 12 months |
| **9** | First-of-a-kind deployment of GFM STATCOM with supercapacitor storage in GB | • First mover OWF developer<br>• Other OWF developers<br>• GFM STATCOM with supercapacitor storage OEM | £5-10m | 36 months |
| **10** | Guidance for OWF developers | • OWF developers<br>• INCENTIVE solution OEMs | <£100k | 3 months |
| **11** | Guidance for GB onshore TOs | • GB onshore TOs<br>• INCENTIVE solution OEMs | <£100k | 3 months |

*No priority hierarchy is implied here by the numbering.
**There will be cost efficiencies if multiple options are conducted in parallel.
***The options can be run in parallel, starting immediately. Duration should not be read cumulatively.

# 2. Introduction

## 2.1. Purpose of this document

This document is intended for publication, via the ENA portal[1], at the end of the INCENTIVE Beta Phase (in October 2024).

The purpose of the document is to compliment the End of Phase Report, which is also being shared publicly on the ENA portal. The End of Phase Report gives a public summary of all work conducted in the INCENTIVE Beta Phase. It also highlights the Deliverables that were produced.

This document goes further and sets out the status at the end of the Beta Phase (October 2024) of the innovative solutions developed in INCENTIVE, and sets out what further work may be beneficial to bring these innovative solutions to commercialisation.

This document is intended for use by any party interested in developing INCENTIVE solutions, or in enabling their integration into the energy system.

## 2.2. Background on INCENTIVE

For full background, please see the INCENTIVE Beta Phase End of Phase Report on the ENA portal.

However, in brief, the INCENTIVE project ran from March 2022 to October 2024 and examined how OWF developments in Great Britain (GB) can support system stability, particularly GB's falling inertia levels, and hence avoid severe instability events (such as the 9 August 2019 event[2]).

The project has been run in three Phases: Discovery, Alpha and Beta.

In the Discovery Phase, a large number of possible technologies were identified as being potentially capable of delivering inertia to the network. Of these, four categories of innovative solutions ("INCENTIVE solutions") were shortlisted as showing potential for further study in this project: STATCOM; BESS; HVDC terminal; synchronous condensers. In the INCENTIVE use case, these would all be located at or near the onshore substation of the OWF development.

In the Alpha Phase, the commercial and technical feasibility of these various shortlisted INCENTIVE solutions was investigated, with an increased number of possible sub-options solutions identified. Alpha Phase showed compelling economic arguments and high-level technical feasibility for the majority of the INCENTIVE solution options.

In the Beta Phase, those INCENTIVE solutions which showed most promise in the techno-economic analysis of the Alpha Phase were taken forward for detailed, site-specific analysis. Beta Phase worked with three OWF developer sites in the GB and five OEMs, and undertook site- and OEM-specific technical and commercial feasibility studies. A key part of this work was working with Ofgem to develop workable regulatory models. Please see the Beta Phase End of Phase Report for more details.

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[1] https://smarter.energynetworks.org/

[2] https://www.ofgem.gov.uk/sites/default/files/docs/9_august_2019_power_outage_report.pdf

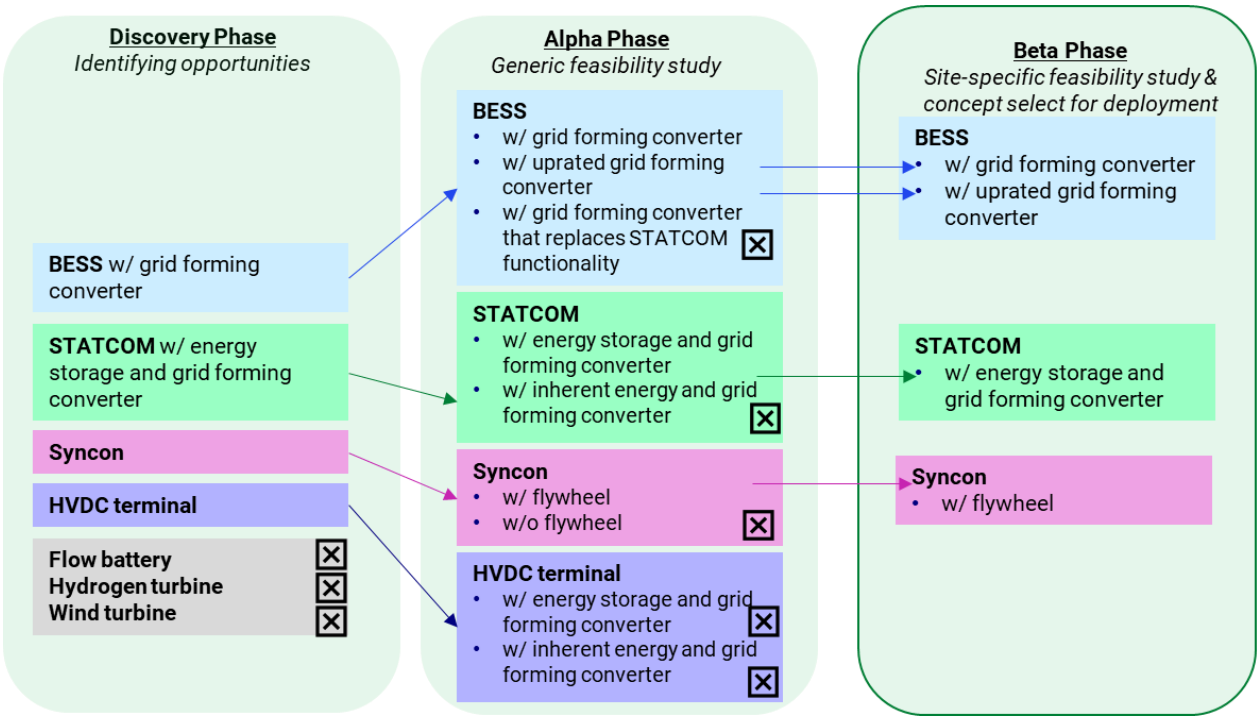


**Figure 1 - overview of INCENTIVE solutions being developed in INCENTIVE**

## 2.3. Background on WP6 of Beta Phase

This document sits within WP6 of Beta Phase.

Following delivery of WP2-5 of Beta Phase, a number of new barriers and corresponding further research questions and activities have been identified. Addressing these will enable and accelerate the uptake of INCENTIVE solutions in GB and globally.

WP6 was scoped as a final work package to examine the required further work in more detail, and to provide this document as a publicly available record, to ensure that interested parties can build upon the progress made by the INCENTIVE project.

## 2.4. WP6 methodology

The INCENTIVE consortium conducted the following tasks in WP6:

- Continued engagement with OWF developers and OEMs to assist their uptake of the INCENTIVE results, particularly to understand where OWF developers are struggling to procure INCENTIVE solutions from OEMs and to understand what is creating issues in the procurement process.
- Engaged with a wide range of stakeholders to identify possible funding routes for further innovation work. This included engagement with GB transmission owners (TOs) and the Offshore Wind Accelerator[3] Steering Committee.

[3]https://www.carbontrust.com/our-work-and-impact/impact-stories/offshore-wind-accelerator-owa

- Engaged with German TSOs who are developing GFM STATCOMs with supercapacitor storage in their onshore transmission networks in Germany, to explore knowledge sharing between the German transmission industry, the GB transmission industry and the offshore wind industry.
- Produced a CBA guidance document to help OEMs and developers understand the potential value of stability services and conduct their own cost-benefit analysis (Deliverable D6.1).
- Produced this document, setting out what further innovation work is required to take GFM STATCOMs with supercapacitor storage to market, particularly in GB.

## 2.5. Setting the scene – general need for further work

The UK's 60GW-by-2030 offshore wind target means lots of new-build assets (generation, storage and transmission) are under development. INCENTIVE has pushed to ensure these new-build assets will include the capability to stabilise the system – to "build better" – using novel technologies that can provide stability. INCENTIVE has shown that the "build better" approach is a much cheaper way of providing stability than building standalone assets for stability services, which are separate and additional to the generation and transmission assets.

If the huge pipeline of new-build assets (generation, storage and transmission) is built without the capability to provide stability, this opportunity will be lost. Once they are built, they are built. The assets being built today will be in operation until ~2050-2070. As an industry, we are working in a closing window of opportunity to "build better".

INCENTIVE has championed the accelerated uptake of novel technology to provide stability to seize the opportunity whilst the window remains open.

However, this is step change in capability and philosophy for the renewable generation and transmission businesses. This will require further innovation work after INCENTIVE Beta Phase to continue the accelerated push.

# 3. Recommended further work

*Please note that INCENTIVE has explored all of the options below with a range of stakeholders, including OWF developers, INCENTIVE solution OEMs, GB TOs, NESO and German TSOs. However, at the time of writing, none of these stakeholders have committed to further work. Where they are mentioned below, it is purely in the context as recommendations for their involvement, in the view of the INCENTIVE project.*

### 1. Information exchange with German TSOs

#### Need

In Germany, the world's first GFM STATCOM with supercapacitor storage is being installed by an onshore TSO in 2025[4], with other GFM STATCOMs with supercapacitor storage at other locations in

[4] https://www.siemens-energy.com/global/en/home/press-releases/siemens-energy-technology-stabilizes-german-power-grid.html

Germany thereafter[5]. In Germany, the GFM STATCOM with supercapacitor storage is being developed as a way of providing stability at low cost.

During their development process, the German TSOs, together with their OEMs, are conducting a range of technical testing (including factory testing and physical commission testing) and are taking detailed specification and design decisions.

In INCENTIVE, despite detailed analysis of stability market requirements and simulated testing of INCENTIVE STATCOM devices, challenges remained for OWF developers, OEMs and the project team in specifying the INCENTIVE STATCOM for the offshore wind and GB markets.

There is benefit to continue this engagement to ensure the offshore wind industry and GB TOs learn from the progress made in Germany. This could include sharing of results between INCENTIVE (e.g. windfarm + INCENTIVE STATCOM testing results) and the German TSOs (simulations and real testing data from the physical assets on the grid). This cross-border collaboration will enable cross pollination of two parallel activities, and will accelerate understanding in both countries, to the benefit of consumers. As the German TSOs will shortly install the world's first GFM STATCOM with supercapacitor storage, this is a great opportunity for GB to leverage the knowledge from that initiative.

### Aims

- Enable the offshore wind industry and GB transmission industry to learn from German TSOs, who are world-leaders in the development of GFM STATCOM with supercapacitor storage.
- Enable the German transmission industry to learn from the INCENTIVE project.

### Scope

- Agree NDA.
- Share results between German TSOs and INCENTIVE to enable validation of previous work.
    - Methods for specification and location selection of the GFM STATCOM with supercapacitor storage
    - EMT test results
    - CHIL/factory test results
    - Supercapacitor aging test results
    - Commission test witnessing / result sharing (first commissioning happening in 2025)
    - Operational data
    - CBA results
    - Development guidance

### Outputs

- Improved understanding of technical performance of the GFM STATCOM with supercapacitor storage
- Improved guidance for specification of GFM STATCOM with supercapacitor storage.
- Validated simulation testing.

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[5] https://www.hitachienergy.com/uk-ie/en/news-and-events/press-releases/2024/02/hitachi-energy-and-transnetbw-make-german-grid-fit-for-future

### Who needs to be involved[6]

- German TSOs and their OEMs
- OWF developers
- GB TOs
- NESO

### Cost

- Low cost (<£100k)
    - The big benefit of this is that the German TSO work is ongoing already and INCENTIVE has already done significant work. This would simply build on the top of this to add significant value at low cost.

### Funding routes

- For OWF developers – funds may be available from the Offshore Wind Accelerator (subject to Offshore Wind Accelerator Steering Committee approval)
- For GB transmission industry – Network Innovation Allowance would be optimal
- Could also be funded by Strategic Innovation Fund, if part of a larger initiative (i.e. coupled with other, larger pieces of work listed here).

### Duration

- 12 months

## 2. Improved inertia provision from OWF + INCENTIVE solution

### Need

- During INCENTIVE Beta Phase, a postulation was developed that "INCENTIVE solution + OWF" can provide more inertia response than standalone GFM BESS, GFM STATCOM or synchronous condenser elsewhere on the system.
- The hypothesis is that the INCENTIVE solution can provide true "inertia" for short time before the OWF takes over with dynamic "fast frequency response" from the turbines themselves.
- This could greatly decrease the cost of providing inertia compared to standalone stability assets, and hence greatly improve the business case for OWFs to provide inertia.
- This could also decrease the requirements on GFM turbines in future, reducing costs further for OWF developers, and hence consumers.
- This question was discussed, but not answered, in INCENTIVE.

### Aims

- Maximise inertia provision to system from OWFs at low cost.

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[6] These are the key stakeholders who need to gain the knowledge to implement the solutions commercially. The project delivery itself could include additional organisations, such as research institutes, academia and consultants.

### Scope

- Through additional simulation testing with OEM and windfarm models:
    - Examine the inertia response of “INCENTIVE solution + OWF” in comparison to INCENTIVE solution acting alone.
    - Examine the impact this may have on INCENTIVE solution and wind turbine specifications (particularly with regard to mandatory grid forming wind turbine specification, which may be introduced in the coming years).
    - Examine what this means for the cost of inertia provision from offshore wind.
- As optional or follow-on work to this electrical testing, understand and resolve the regulatory and tendering challenges regarding using multiple cooperating assets to provide a single inertia response, where these multiple assets are located behind different connection points (e.g. the turbines and INCENTIVE solution being separate by OFTO assets).

### Outputs

- Improved understanding for how INCENTIVE solutions can optimally be deployed.
- Improved guidance for INCENTIVE solution and wind turbine specification.

### Who needs to be involved

- OWF developers
- INCENTIVE solutions OEMs
- NESO (not actively, but informed)

### Cost

- Medium cost (~£100k)

### Funding routes

- For OWF developers – funds may be available from the Offshore Wind Accelerator (subject to Offshore Wind Accelerator Steering Committee approval)
- INCENTIVE solution OEMs – could contribute time and models instead of cash
- NESO – could contribute time to follow progress and to take onboard the outcomes

### Duration

- 12 months

## 3. Strengthening weak grid connections for OWFs using INCENTIVE solutions

### Need

- During the course of INCENTIVE (whose main focus was addressing the drop in inertia in GB), it became clear that the inertia market incentives may not be sufficiently clear or sufficiently valuable to incentivise OWF developers to install INCENTIVE solutions.
- However, OWF developers may be more interested in using INCENTIVE solutions to strengthening their local grid connection.

- Offshore wind farms often connect into “weak grids”, which are locally unstable with low short circuit levels. This places limits on the green energy they can export to the system: when the short circuit level is too low, renewable generators must turn down out of merit. This is bad economically and environmentally (as they must be replaced typically by gas).
- The traditional way of strengthening a local grid is to install a synchronous condenser. However, this is expensive and is likely to increase LCOE for the OWF in question, which may prevent the OWF from winning a contract for power offtake (with government or private sector), and hence from reaching financial close and being built.
- GFM devices, such as GFM STATCOM or GFM BESS, may provide a significantly better value option than a synchronous condenser.
- However, it is not yet clear to what extent they strengthen the local grid.
- Weak grids and how to strengthen them is a nascent area of understanding in the global industry.

### Aims

- Enable OWF connections, and maximise energy export, in weak grid areas at low cost.

### Scope

- Through additional simulation testing with OEM and windfarm models
    - Examine to what extent GFM STATCOMs and GFM BESS can strengthen the grid connection of OWFs vs using (more expensive / less valuable) synchronous condensers
    - Examine how this can increase power exports (and therefore revenues) at lower costs than using a synchronous condenser.

### Outputs

- Improved understanding for how INCENTIVE solutions can optimally be deployed.
- Improved guidance for INCENTIVE solution and wind turbine specification.

### Who needs to be involved

- OWF developers
- INCENTIVE solutions OEMs
- NESO (not actively, but informed)

### Cost

- Medium cost (~£100k)

### Funding routes

- For OWF developers – funds may be available from the Offshore Wind Accelerator (subject to Offshore Wind Accelerator Steering Committee approval)
- INCENTIVE solution OEMs – could contribute time and models instead of cash
- NESO – could contribute time to follow progress and to take onboard the outcomes

### Duration

- 12 months

## 4. Input into new GB grid forming working group

### Need

- NESO is launching a new grid forming grid code group to update the nascent grid forming grid codes. NESO has identified this group as a good opportunity for INCENTIVE results to influence future nationwide grid forming grid code.
- Beta Phase has also identified clarity issues between NESO's stability market and NESO's compliance testing requirements, which need to be resolved to give developers clarity on how to specify GFM assets, including the GFM STATCOM and GFM BESS.

### Aims

- Improve the clarity of grid forming definitions.

### Scope

- Disseminate INCENTIVE results to the new grid forming working group.
- Review proposed updates to Grid Code.

### Outputs

- Improved grid codes.

### Who needs to be involved

- OWF developers
- INCENTIVE solutions OEMs

### Cost

- Low cost (<£100k)

### Funding routes

- For OWF developers – funds may be available from the Offshore Wind Accelerator (subject to Offshore Wind Accelerator Steering Committee approval)
- INCENTIVE solution OEMs – could contribute time instead of cash

### Duration

- 12-24 months

## 5. Evolving the understanding and definition of inertia in GB

### Need

- INCENTIVE has identified that NESO's current stability market does not optimally value the contribution the GFM STATCOM with supercapacitor storage can make to the system, thus reducing its revenues from the stability market. This is both for overall system stability ("inertia") and local grid strength ("SCL"). This is likely because the GB requirements were drafted with synchronous condensers and BESS in mind, as the GFM STATCOM with supercapacitor storage is a more novel technology that is only recently coming to market.
- In GB, there is a requirement for assets to hold 5 seconds' worth of energy when delivering their "inertia" response. This requirement arises from the requirement to be able to respond to a single event for 1 second, but that each provider must be able to respond for 5 successive events. The supercapacitor energy storage in the GFM STATCOM with supercapacitor storage is not well suited for such a long energy storage duration. Supercapacitors are low-maintenance and highly-efficient energy stores with the ability to provide high power output, but they do not store much energy. They therefore are great at delivering lots of power over short periods of time (1 to 2 seconds). This 5 second energy storage requirement will reduce the revenue that a GFM STATCOM with supercapacitor storage can obtain. This 5 second rule therefore is reducing the business case, and in turn is deterring and may even prevent a cheap, useful technology entering the GB market.
- There is interest from OEMs and OWF developers to investigate this 5 second rule and whether relaxing it could be beneficial to the GB system: relaxing the rule may make system operation easier and cheaper by allowing this technology to participate in the way it is designed to operate.
- INCENTIVE has also identified clarity issues between NESO's stability market and NESO's compliance testing requirements, which need to be resolved to give developers clarity on how to specify GFM assets, including the GFM STATCOM and GFM BESS.
- There is a need to provide evidence and arguments to NESO to ensure the GFM STATCOM with supercapacitor storage is being fairly valued by the inertia market.

### Aims

- Ensure the contribution of INCENTIVE solutions is understood and fairly valued.

### Scope

- This will involve a combination of technical simulation analysis and CBA work to understand if the GB system can stay stable if the 5 second rule is relaxed; how assets providing inertia can "hand over" to frequency response assets after ~1 second following an event; and whether reducing the 5 seconds to 1-2 seconds will make stable operation of the system cheaper (without sacrificing stability).

### Outputs

- Evidence to evolve the definition of "inertia" in the nascent GB market to an appropriate definition, which reduces barrier to novel, lower cost solutions.

### Who needs to be involved

- OWF developers
- INCENTIVE solution OEMs

- NESO (not active, but informed)

### Cost

- Medium cost (£100-200k)

### Funding routes

- For OWF developers – funds may be available from the Offshore Wind Accelerator (subject to Offshore Wind Accelerator Steering Committee approval)
- INCENTIVE solution OEMs – could contribute time and models instead of cash
- NESO – could contribute through BAU or Network Innovation Allowance funds

### Duration

- ~12 months

## 6. Evolving the understanding and definition of strength to connect in GB

### Need

- As with option 5 above, INCENTIVE has identified that NESO's current stability market does not optimally value the contribution the GFM STATCOM with supercapacitor storage can make to the system, thus reducing its revenues from the stability market. This is both for overall system stability ("inertia") and local grid strength ("SCL"). This is likely because the GB requirements were drafted with synchronous condensers and BESS in mind, as the GFM STATCOM with supercapacitor storage is a more novel technology that is only recently coming to market.
- There are a number of new metrics to define weak grids and a number of suggested approaches how to strengthen them. In recent months, it has become apparent that INCENTIVE is well placed to provide evidence into this area.

### Aims

- Ensure the contribution of INCENTIVE solutions is understood and fairly valued.

### Scope

- Literature review to find all newly proposed system strength metrics.
- Create representative models of OWFs with weak grid connection.
- Electrical studies to demonstrate how INCENTIVE solutions can improve the system strength for the various new metrics.
- Share results and disseminate to NESO.

### Outputs

- Evidence to evolve the definition of "strength to connect" to a more appropriate definition, which reduces barrier to novel, lower cost solutions.

### Who needs to be involved

- OWF developers
- INCENTIVE solutions OEMs
- NESO (not active, but informed)

### Cost

- Medium cost (£100-200k)

### Funding routes

- For OWF developers – funds may be available from the Offshore Wind Accelerator (subject to Offshore Wind Accelerator Steering Committee approval)
- INCENTIVE solution OEMs – could contribute time and models instead of cash
- NESO – could contribute through BAU or Network Innovation Allowance funds

### Duration

- ~12 months

## 7. OWF developer ownership regulatory model

### Need

- INCENTIVE has devised a regulatory model for OWF developers to develop and retain ownership of the INCENTIVE solution.
- However, this regulatory model will need to be trialled on a real-world first-mover OWF project for the regulatory model to take effect.
- Further work will then be needed to make enduring regulatory change on the basis of the first mover trial.

### Aims

- Remove regulatory barriers to enable OWF developers to install INCENTIVE solutions.

### Scope

- Identify first mover OWF development project (i.e. a “Project Champion”)
- Work with the Project Champion and Ofgem to agree the regulatory trial.
- On the basis of the trial, work with Ofgem to agree enduring change

### Outputs

- Enduring regulatory change.

### Who needs to be involved

- Project Champion
- Other OWF developers
- INCENTIVE solutions OEMs

- NESO
- Ofgem

### Cost

- Low cost (~£100k)

### Funding routes

- This could be combined with scope 9 (below) in a large, subsidised first-mover deployment project. These funds could from Ofgem's Strategic Innovation Fund, if rules are changed to enable non-networks to apply. Otherwise, other UKRI or UK Government funding routes could be explored.
- For OWF developers – funds may be available from the Offshore Wind Accelerator (subject to Offshore Wind Accelerator Steering Committee approval)
- INCENTIVE solution OEMs – could contribute time instead of cash
- NESO – could contribute through BAU or Network Innovation Allowance funds

### Duration

- ~12 months

## 8. TO ownership regulatory model

### Need

- INCENTIVE has devised a regulatory model for OWF developers to develop and retain ownership of the INCENTIVE solution at the onshore substation of OWFs.
- GFM STATCOMs with supercapacitor storage are being developed by onshore TSOs in Germany (away from OWF connections). There could be benefit to GB consumers in GB onshore TOs to also installing GFM STATCOMs with supercapacitor storage, instead of regular STATCOMs.
- However, the regulatory model to enable and incentivise onshore TOs to install GFM STATCOMs with supercapacitor storage is not clear.

### Aims

- Enable onshore TOs in GB to install GFM STATCOMs with supercapacitor storage in their networks.

### Scope

- Demonstrate benefit to GB consumers for onshore TOs to install GFM STATCOMs with supercapacitor storage instead of regular STATCOMs.
- Building on regulatory analysis from INCENTIVE, devise regulatory and financial framework for GB onshore TOs to install GFM STATCOMs with supercapacitor storage.
- Work with Ofgem to agree either a trial or enduring mechanism.

### Outputs

- Regulatory and financial framework for GB onshore TOs to install GFM STATCOMs with supercapacitor storage in their network.

### Who needs to be involved

- GB onshore TOs
- INCENTIVE solutions OEMs
- NESO
- Ofgem

### Cost

- Low cost (~£100k)

### Funding routes

- GB onshore TOs – either through BAU or Network Innovation Allowance funds

### Duration

- ~12 months

## 9. First-of-a-kind deployment of GFM STATCOM with supercapacitor storage in GB

### Need

- GFM STATCOMs with supercapacitor storage are being developed in Germany by German TSOs, with world first-of-a-kind deployment and commissioning of an asset on the German onshore transmission system due to take place in 2025.
- However, this is still a novel technology and there are barriers to its deployment in GB. For OWF developers, uncertainties in GFM STATCOM with supercapacitor storage costs (which are likely to be higher for first movers) and uncertainties in their value (in the nascent and uncertain inertia market) may mean that OWF developers see the investment as too high risk.
- Further, OWF developers play in a very competitive market, with a strong drive to lower costs and to deliver projects quickly. Adding additional complexity of a novel GFM STATCOM with supercapacitor storage will only be considered worthwhile if the asset adds significant benefit to the OWF development without raising costs and without introducing additional complexity and resource burden, and without creating project timeline delays.
- These issues will be particularly acute for the first mover, which may inhibit a first mover stepping forward. This could be seen as a classic “valley of death” problem.
- To address this, the first mover could be supported by innovation funding, from UK Government or Ofgem. The first mover would be taking on an additional burden for the benefit of the wider industry / society, and so could be fairly supported in this endeavour.

### Aims

- Unlock low-cost stability from GFM STATCOMs with supercapacitor storage across GB, by bridging the valley of death for the first mover.

### Scope

- Innovation funding support for first OWF developer (or possibly a TO on an equivalent network-focussed project) to install GFM STATCOM with supercapacitor storage instead of regular STATCOM.
- Building on INCENTIVE, assist first mover through asset specification, testing and commissioning.
- Use testing results to validate INCENTIVE results.
- Disseminate findings to whole industry.

### Outputs

- First deployment of GFM STATCOMs with supercapacitor storage in GB.

### Who needs to be involved

- First mover OWF developer (or first mover TO, if on an equivalent network-focussed project)
- Other OWF developers
- GFM STATCOM with supercapacitor storage OEM

### Cost

- High cost (~£5-10m)

### Funding routes

- UK government / UKRI funding
- Ofgem's Strategic Innovation Fund could be an option; however, currently this is intended for the regulated network companies so it is unclear how this programme could be used to support an OWF developer deploying innovative assets
- For OWF developers – funds may be available from the Offshore Wind Accelerator (subject to Offshore Wind Accelerator Steering Committee approval)
- GFM STATCOMs with supercapacitor storage OEM – could contribute time instead of cash

### Duration

- ~36 months

## 10. Guidance for OWF developers

### Need

- INCENTIVE – and any of work 1 to 9 above – has created technical, economic and regulatory insights into the development of INCENTIVE solutions. The deliverables produced are numerous and detailed, including in-depth analysis of many nuanced issues.
- There would be benefit in producing a focused, practical guidance document for OWF developers to use to develop, install and operate INCENTIVE solutions.

### Aims

- Ensure industry-wide uptake of INCENTIVE solutions, by clear dissemination of main INCENTIVE project findings.

### Scope

- Condense the INCENTIVE findings into a focused practical guideline for OWF developers.
- This will include aspects around key metrics, site characteristics, asset specification and sizing, testing, interactions, operation, regulatory model and accessing revenue streams.
- The results of the investigations in items 1 to 9 above and the design guideline to be drawn up in item 10 must provide information about the specification for new functionalities and required hardware so that it can be requested and ordered from manufacturers on the market. The specifications should be kept functional so that each manufacturer can develop and offer its own solution.
- Engage with OWF developers to understand their needs from the guidance document.
- Disseminate the guidance document.

### Outputs

- Guidance document for OWF developers.

### Who needs to be involved

- OWF developers
- INCENTIVE solution OEMs

### Cost

- Low cost (<£100k)

### Funding routes

- OWF developers – funds may be available from the Offshore Wind Accelerator (subject to Offshore Wind Accelerator Steering Committee approval)
- INCENTIVE solution OEMs – could contribute time instead of cash

### Duration

- ~3 months

## 11. Guidance for GB onshore TOs

### Need

- INCENTIVE – and any of work 1 to 9 above – has created technical, economic and regulatory insights into the development of INCENTIVE solutions. The deliverables produced are numerous and detailed, including in-depth analysis of many nuanced issues.
- There would be benefit in producing a focused, practical guidance document for GB onshore TOs to use to develop, install and operate INCENTIVE solutions.

### Aims

- Ensure industry-wide uptake of INCENTIVE solutions, by clear dissemination of main INCENTIVE project findings.

### Scope

- Condense the INCENTIVE findings into a focused practical guideline for GB onshore TOs.
- This will include aspects around key metrics, site characteristics, asset specification and sizing, testing, interactions, operation, regulatory model and accessing revenue streams.
- Engage with TOs to understand their needs from the guidance document.
- Disseminate the guidance document

### Outputs

- Guidance document for TOs.

### Who needs to be involved

- GB onshore TOs
- INCENTIVE solution OEMs

### Cost

- Low cost (<£100k)

### Funding routes

- GB onshore TOs – Network Innovation Allowance
- INCENTIVE solution OEMs – could contribute time instead of cash

### Duration

- ~3 months

# 4. Next steps by INCENTIVE partners

At the time of writing, it is envisaged that items 1, 2, 3, 4 and 10 will be taken forward through the Carbon Trust's Offshore Wind Accelerator programme, by an offshore wind developer funded follow-on project. Should the reader of this document have any questions regarding the status of this, or whether any additional further work has been taken forward, they are recommended to get in touch with SSEN Transmission, National HVDC Centre or Carbon Trust.

**carbontrust.com**

**+44 (0) 20 7170 7000**



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