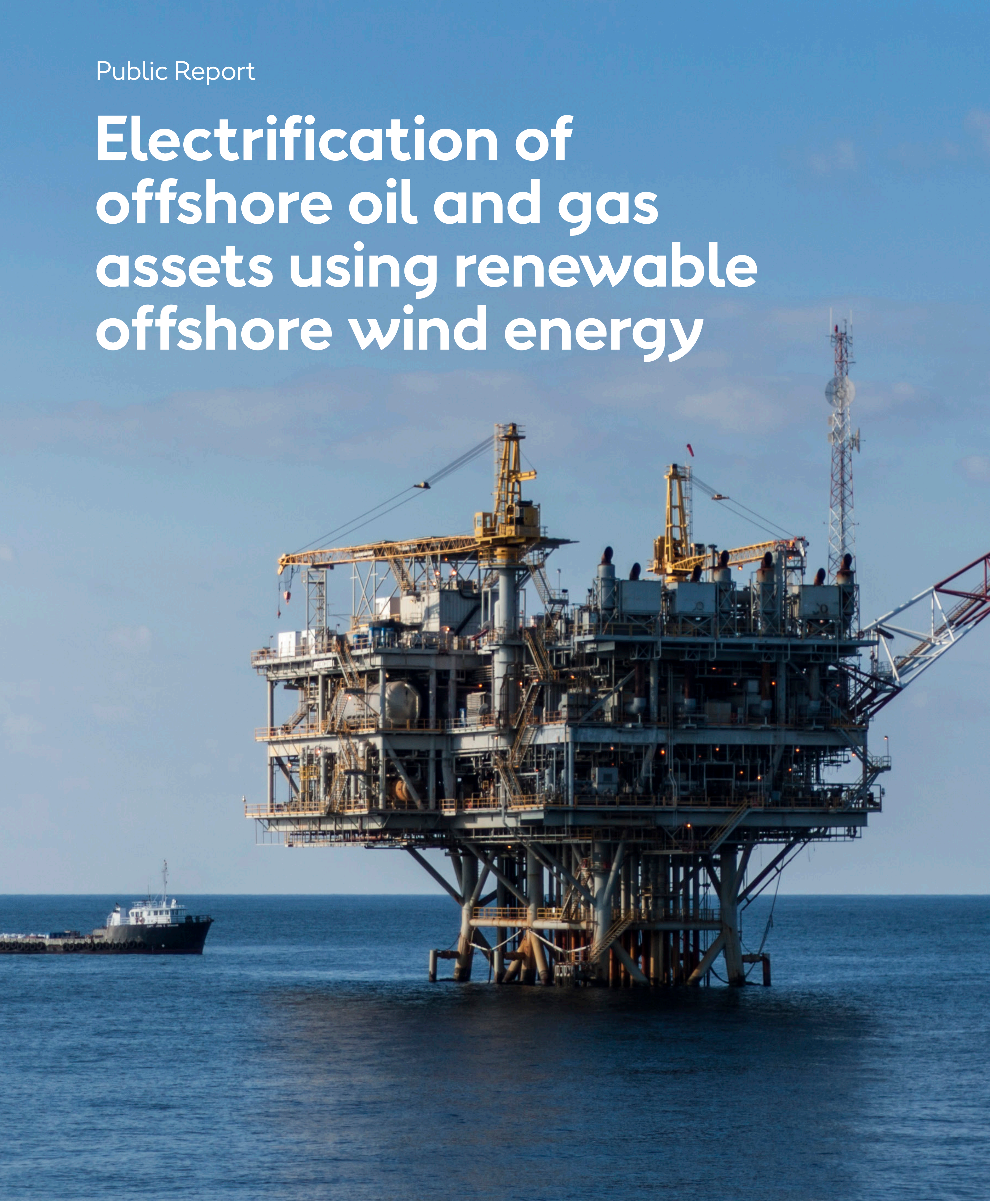
Public Report

Electrification of offshore oil and gas assets using renewable offshore wind energy



Project partners

Ørsted

Goal7

NEPTUNE ENERGY

Notice

The report has been prepared by a consortium of Ørsted, the world's leading offshore wind developer, constructor and operator of offshore wind farms, Neptune, a leading exploration, and production company focussed on meeting society's energy needs and creating value for all its stakeholders, and Goal7, a consultancy which supports implementation of clean and affordable energy, acting as the Project Neos technical coordination partner.

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The consortium would like to give thanks and acknowledgement to the following parties.

North Sea Transition Authority

The consortium would like to thank the NSTA. This Public Report is supported by funding through the 'Decarbonisation competition for the electrification of offshore O&G installations'. The competition, managed by the NSTA, is designed to advance the electrification of offshore installations on the UKCS. The competition follows the government's commitment in the North Sea Transition Deal to support funding for early-stage decarbonisation studies.

Worley

The consortium would like to thank Worley Services UK Ltd for delivery of aspects of the technical scope summarised in this Public Report, including the load flow and load factor analysis, design modifications required on the O&G platform, 'optioneering' of high, medium and low uptime cases, energy balancing, CAPEX/OPEX calculations and schedule analysis.

Sealand Projects and Net Zero Technology Centre

Preceding this Public Report, a collaborative study was undertaken involving Neptune Energy and Sealand Projects supported by the Net Zero Technology Centre. This study focussed on the electrification of an oil and gas installation from nearby wind farms at varying stages of development. The study evaluated four options for electrification and concluded that there is a significant opportunity for electrification of offshore installations and collaboration between offshore wind and O&G operators. The consortium appreciates the value of this study which help support feasibility for platform electrification.

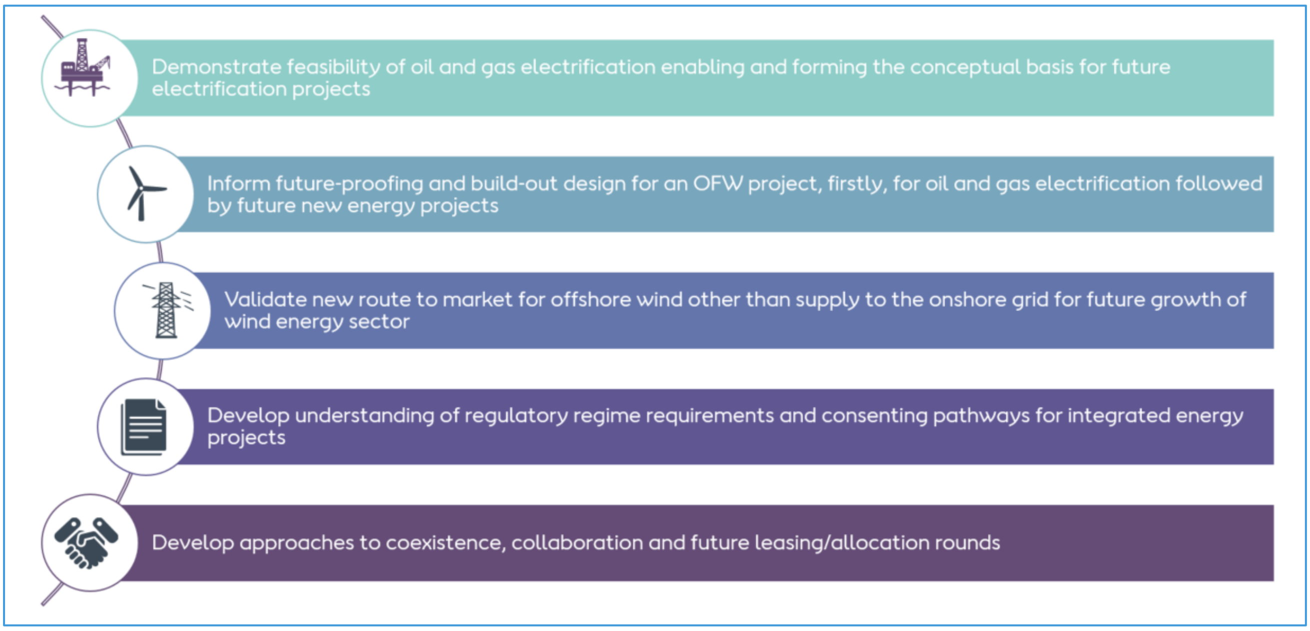
Executive Summary

Background

This Public Report has been prepared by a consortium of Ørsted, Neptune, and Goal7 and represents a summary of the output of Project Neos. Project Neos is a pre-FEED study which investigated the technical and commercial aspects of establishing an electrical connection between an Offshore Wind Farm (OWF) and an offshore Oil and Gas (O&G) installation. The delivery of Project Neos was supported through the North Sea Transition Authority (NSTA) managed '£1 million decarbonisation competition for the electrification of offshore oil and gas installations'[1].

The motivations underpinning the delivery of Project Neos in part link to the UK O&G industry commitment to progressively decarbonise upstream extraction and production operations through the coming decades, and also link to the UK offshore wind industry investigating a potential new route to market. Platform electrification presents a unique opportunity for cross-industry collaboration and carbon emission reduction.

When defining what success would look like, the consortium identified the objectives below. Project Neos has met the objectives.



Concept and Case Overview

There were two key concepts developed for Neos and three low-, medium- and high-uptime cases supporting each concept:

- **Concept 1** considered a direct connection from two turbines situated at the end of two arrays connected by two subsea cables to an O&G installation.

This concept requires minimum intervention to a typical wind farm design. However, the load factor may be limited dependent on the configuration at the OSS.

- **Concept 2** considered a dedicated connection from the OWF Offshore Substation (OSS) connected by two subsea cables to an O&G installation.

[1] North Sea Transition Authority (NSTA): £1million decarbonisation competition for the electrification of offshore oil and gas installations - 2021 - News - News &
publications (nstauthority.co.uk)

This concept requires space on the OSS for additional equipment. However, the load factor is expected to be higher than for Concept 1.

The cases developed for each concept were:

- **Low-uptime** case which represented full decarbonisation of power generation and gas compression where platform production was deferred in low / no wind periods.
- **Medium-uptime** case which represented a case where power generation was retained on the platform and 50% gas compression was maintained in low / no wind periods.
- **High-uptime** case which represented full power generation and gas compression redundancy where 100% gas compression was maintained in low / no wind periods.

Project Neos investigated the following scope in relation to the above concepts and cases:

- Load Flow Analysis;
- Design Modifications;
- Energy Management;
- Cost Model Assessment; and
- Schedule Analysis.

Load Flow Analysis

Load flow analysis was carried out to establish minimum power requirements needed to supply the existing O&G installation from the OWF, as well as to analyse the variations in reactive power capabilities and power flows. The key finding of the load flow analysis was that the proposed system design is feasible for O&G installation electrification.

Design Modifications

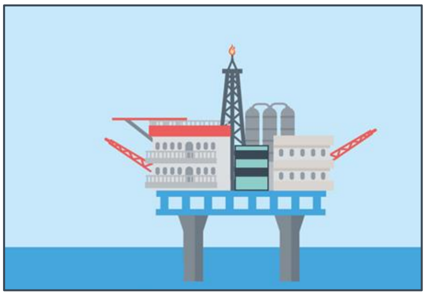
Load flow analysis informed design modifications required at both the OWF and O&G installation. At the OWF, design changes comprised:

- The addition of two new subsea cables;
- Systems to connect the subsea cables to the OWF for each concept; and
- New metering and controls systems for each concept.

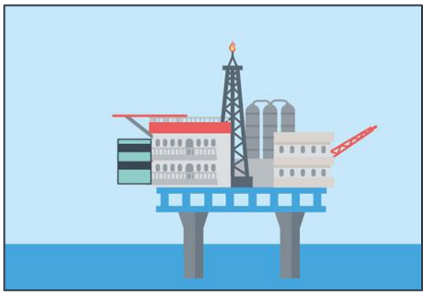
The O&G installation design changes comprised:

- Electrical changes including new equipment at the O&G installation to connect the subsea cables including new switchboard, transformers, and shunt reactors; and
- Changes to compression including replacement of existing Gas Turbines (GTs) with Variable Speed Drives (VSDs) and electric motors in the low- and medium-uptime cases. The high-uptime case added two new replica motor driven compression trains.

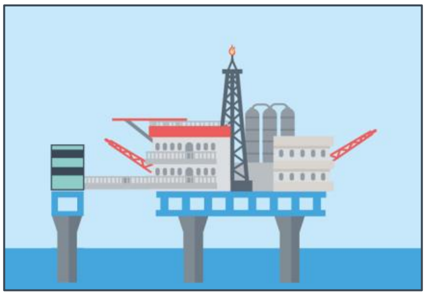
The design modifications were considered for implementation through three options: as an integrated platform solution, new hang-off module, or new bridge-linked platform (BLP). In all cases, integration of new equipment into existing platform facilities would have a major brownfield impact. A new hang-off module would also have considerable brownfield impacts, but less of an impact on existing systems compared to integrated modifications and a feasible option. In conclusion, both the hang-off module and new BLP were suitable for brownfield modification, with a hang-off module considered to have less complexity than a new BLP facility.



Option 1: Integrated solution



Option 2: New hang-off module



Option 3: New BLP

Energy Management

Load factor analysis was undertaken to analyse whether the OWF could deliver reliable power supply to an O&G installation to meet the load requirements. The findings of the load factor analysis evidenced that, in isolation, there were significant gaps in power supply that would result in unacceptable production downtime for an O&G installation if connected to an OWF with no energy storage. In total, there were 1,088 hours in a year over 84 periods where wind generation could not meet the demand of an O&G installation. This represented 12.4% production downtime. This calculation was made based on a typical wind profile over a one year period for an OWF in the Southern North Sea. Profiles over a longer period of time and in different areas may vary.

- An energy storage solution to meet 100% production availability for the low-uptime case would need to supply 1,124 Megawatt Hour (MWh) of energy with estimated CAPEX of £247m. The size, weight and cost of the energy storage solution mean that this is not considered a feasible solution.
- However, an energy storage solution which is designed to provide balance, stability, and support the change-over from offshore wind to backup (conventional) power generation and compression and vice versa in the form of an offshore micro-grid could help optimise how energy is used and should be further investigated.

Cost Model and Schedule Analysis

The cost model included CAPEX estimates for the design modifications to the OWF, subsea cables and design modifications to O&G installation. In all cases, the integrated option represented the lowest CAPEX value, followed by a hang-off module and subsequently the BLP. To achieve improved uptime also requires additional CAPEX. For all options and cases, subsea cables have the highest CAPEX requirement.

The OPEX model included an assessment of platform operating costs for all cases. The OPEX differed for each option due to new infrastructure associated with each concept and case and was therefore incremental.

A high-level cost model was developed which considered several inputs. The cost model demonstrates the range within which an electrification project becomes viable by setting ranges for each input and determining where a project becomes Net Present Value neutral. For the parameters associated with this project, NPV neutrality occurs when Total OPEX is c.£7.5m/yr., Remaining Field Life is 8yrs., Carbon price is £135/Tonne and CAPEX is below £65m.

This high-level cost modelling suggested that projects with limited remaining field life, requiring dual cables above 50kM or requiring a BLP, and/or at today's (EU-ETS) CO_2 pricing, are significantly challenged. However, external variables such as gas price have more influence and therefore financial viability can change. The project has also revealed that there are many opportunities to improve on the base case design to reduce CAPEX and further financial modelling considering alternative pricing structures has shown to be beneficial. Both should be investigated in more detail.

Project Neos demonstrated that in many situations, platform electrification could be economically viable, however it would need to have certain parameters related to maximum CAPEX circa £65m, similar level of OPEX associated with this project i.e., circa £7.5m/yr., which includes O&M or direct OPEX, the cost of purchasing electricity (the Power Purchase Agreement), and savings from not consuming gas for power generation. Other significant influencing factors are carbon price and the robustness of carbon price forecasting as well as remaining field life.

Considering the CAPEX limits illustrated above it is unlikely that electrification projects that require a BLP to house additional equipment, or a 100% redundant (dual cable) connection >50 km in length can be viable for projects that have less than 10 years remaining field life. However potential high gas prices or carbon prices, or opportunities for field life extension through repurposing can change this. There are also opportunities related to converting CAPEX to OPEX in the form of a tariff payment, as well as structuring the PPA pricing to reflect expected trends in direct OPEX that show promising results and should be investigated further.

Economic analysis shows that it is possible to supply electricity from an offshore windfarm to a nearby O&G platform in a commercially viable way.

Schedule analysis determined that the delivery schedules for all cases would follow a similar trajectory for delivery. For all cases and options, the delivery schedule is achieved in three to four years.

Conclusion and Next Steps

Emissions from O&G installations can be significantly reduced by supplying power via a connection to an OWF. This delivers a new route to market for the offshore wind industry with potential for a positive business model under certain conditions identified by Project Neos.

The values presented in the table below demonstrate emission reduction through total or partial electrification of O&G installation power demand. Low, medium and high uptime cases reflect growing levels of back-up thermal power generation maintained in the system to compensate for wind power intermittency.

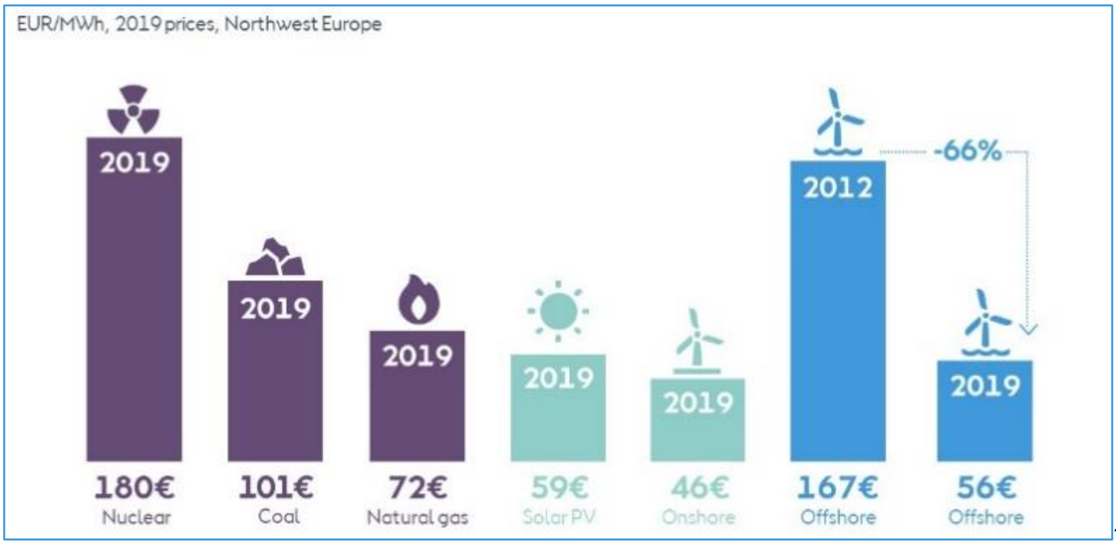
	Low-Uptime Case	Medium-Uptime Case	High-Uptime Case
Annual CO_2 Emissions Reduction (Tonnes of CO_2)	80,000	72,000	67,000
Annual CO_2 Emissions Reduction (% of unabated emissions[2])	100	94	87
Total CO_2 Emissions Reduction[3] (Tonnes of CO_2)	615,000	574,000	533,000

The table above summarises emissions reductions expected for the low-, medium-, and high-uptime cases. The emissions reduction is less than 100% in the medium-uptime and high-uptime cases which reflects the use of fossil fuels to compensate for low/no wind periods to maintain production.

Globally, the UKCS has one of the largest portfolios of OWF projects in various stages of development and construction. Next to onshore wind, OWFs now have the lowest Levelized Cost of Energy (LCoE) and are already cost-competitive with all other sources of UK power, demonstrated in the figure below. In addition, OWFs often are, or will be, located at relatively short distances from O&G installations, improving the business case for the connection for offtake of electricity to O&G installations.

[2] Note that study focused on a future case when gas compression is online, and emissions reduction do not reflect current CO_2 emissions. The reduction is based on a future forecast of emissions when gas compression is online.

[3] Assumed life of field / years of production.

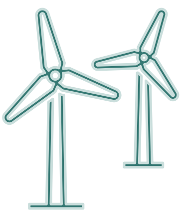


[4]

Accessing this lower cost renewable energy in proximity to existing O&G installations is critical to the O&G industry reaching its NSTD targets and supporting the UK's transition to Net Zero.

However, the primary outcome of Project Neos is evidencing that electrification of an O&G installation exclusively from an OWF without a grid connection (configured to provide electricity in low/no wind periods) does not provide a reliable power supply to sustain O&G production, operations, and compression. However, in the absence of a grid connection, electrification of an O&G installation from an OWF coupled with back-up (conventional) generation and an energy storage solution balances and stabilises the electricity supply to the O&G installation.

Project Neos has highlighted the areas required for further technical investigation which are outlined below. Project Neos has also considered wider complexities beyond technical feasibility which require consideration to ensure realisation of platform electrification in the short-term. There is sufficient confidence in the feasibility of OWF for offshore O&G installation electrification, through back-up (conventional) generation and energy storage, to support further work on the concept and development of commercial mechanisms to encourage such developments.

Project Specific	
	**Project Neos learnings:** Present the results of the NSTA decarbonisation competition for the electrification of offshore oil and gas installations[5] to the industry, facilitating knowledge sharing and ensuring any ongoing or future electrification initiatives can leverage the technical findings of Project Neos for their respective concept select work.
	Integration to 'in-flight' OWF project: Investigate procurement timelines and key decision gates are aligned to enable the platform electrification technical solution. Consideration of future proofing investments may be required to ensure procurement timelines are not prohibitive to realising platform electrification.
	PPA structuring: Further development of PPA structuring, including point-to-point single offtake solutions that likely have mismatches in tenure versus remaining O&G field-life, the associated risks with this and how they can be mitigated.
	Investigate grid back-feed: via the OWF and determine any technical issues or limitations, the potential regulatory challenges that may occur because of such a non-

[4] Source: BloombergNEF – 1H 2019 LCOE Update, current LCOE. and Ørsted Calculation.

[5] North Sea Transition Authority (NSTA): £1million decarbonisation competition for the electrification of offshore oil and gas installations - 2021 - News - News &
publications (nstauthority.co.uk)

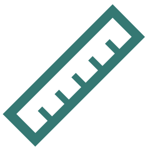
Project Specific

standard configuration, interfaces to the Offshore Transmission Owner (OFTO), and the impact on electricity costs due to importing at higher priced periods and incurring Transmission Charges.

Brownfield modifications: Further assess extent, optimal design, costs, and potential downtime/risks resulting from implementing platform electrification.

Level of electrification achievable/required: Consideration of short term versus long-term (repurposing) including plant and processes which could be converted to electric, base power levels and redundancy needs. Redundancy needs will require consideration regarding whether one or two cables represent the viable technical solution.

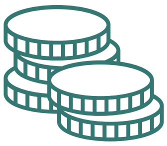
Joint Industry



End-to-end Availability & Reliability Study/FEED: A full FEED study is required to assess levels of back-up generation and supporting technology such as energy storage solutions required to maintain stable operations/production (managing within hour/minute variability on load and production sides).

O&G operating procedures/processes: Assess changes to operations that would enable electrification whilst ensuring high uptime/production, with specific reference to battery storage solutions and levels of back up generation.

Integrated solutions: Combining the three 'NSTA decarbonisation competition' enabling projects[6] to assess end-to-end solution opportunities.



Energy transition opportunities: investigate future offshore power demand through the transition of assets to new operational activities, such as hydrogen production and CCS, to map further potential OWF offshore offtake opportunities.

Regulatory

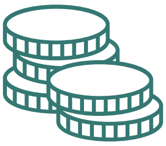
Lease and consenting regime: The Government and Regulators Electrification Group (GREG) should provide clarity of the enduring regulatory and consenting regime. It is imperative that the consenting approach to brownfield projects does not introduce significant risk to the existing generation consents held by O&G installation and OWF and does not result in protracted consenting timelines which may impact projects undertaking early future-proofing activities.

Clarity is required regarding the applicability of a **seabed lease from TCE** and timelines for connecting infrastructure should a lease be required.

Need for policy support to underpin project need-case and support decision making on consent applications for platform electrification infrastructure.

Clarity on future carbon pricing: Confirmed retention of an ambitious UK-wide carbon floor price compliant with Net Zero, to enable and incentivise investment decisions and commercial agreements.

[6] North Sea Transition Authority (NSTA): Three winners named for £1m offshore electrification competition - 2021 - News - News &
publications (nstauthority.co.uk)

Regulatory	
	**Anticipatory Investment recovery model:** Support to enable retrofitting of brownfield projects to make minor infrastructure investment decisions, which would enable future electrification opportunities.
	CfD regime clarification: LCCC confirmation required that Behind the (CfD) Meter supply of electricity to offshore offtakers does not conflict with the principles of the CfD and the associated terms and conditions.

Acronyms

Acronym	Definition
AC	Alternating Current
BEIS	Department for Business, Energy, and Industrial Strategy
BLP	Bridge Linked Platform
CAPEX	Capital Expenditure
CCS	Carbon Capture and Storage
CfD	Contracts for Difference
CO_2	Carbon Dioxide
CO_2	Carbon Dioxide Equivalent
COD	Commercial Operation Date
cPPA	Corporate Power Purchase Agreement
DC	Direct Current
DCO	Development Consent Order
EMS	Energy Management System
EPC	Engineering, Procurement and Construction
ETS	Emissions Trading System
EU	European Union
FEED	Front End Engineering Design
FID	Final Investment Decision
GBP	British Pound Sterling
GHG	Greenhouse Gas
GT	Gas Turbine
GREG	Government and Regulators Electrification Group
GTC	Gas Turbine Compressor
GTG	Gas Turbine Generator
GWh	Gigawatt Hour
HLV	Heavy Lift Vessel
kV	Kilovolt
kVA	Kilovolt-Ampere
LCCC	Low Carbon Contracts Company
LCoE	Levelised Cost of Energy

Acronym	Definition
LP	Low Pressure
MLA	Marine Licence Application
MMO	Marine Management Organisation
MP	Medium Pressure
MT	Megatonne
MVA	Megavolt-Ampere
MW	Megawatt
MWh	Megawatt Hour
NPS	National Policy Statements
NPV	Net Present Value
NSTA	North Sea Transition Authority
NSTD	North Sea Transition Deal
OFTO	Offshore Transmission Owner
O&G	Oil and Gas
O&M	Operations and Maintenance
OGA	Oil and Gas Authority
OPEX	Operational Expenditure
OPRED	Offshore Petroleum Regulator for Environment & Decommissioning
OSS	Offshore Substation
OWF	Offshore Wind Farm
PAU	Pre-Assembled Unit
PCS	Power Control System
PO	Purchase Order
PPA	Power Purchase Agreement
PWA	Pipeline Works Authorisation
SE11	Stewardship Expectation 11
SoLR	Supplier of Last Resort
TCE	The Crown Estate
TCES	The Crown Estate Scotland
UKCS	United Kingdom Continental Shelf
VSD	Variable Speed Drive
WTG	Wind Turbine Generators

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1. Introduction

Project Neos is an industry-leading pre-Front End Engineering Design (FEED) study which has investigated the technical and commercial aspects of establishing an electrical connection between an Offshore Wind Farm (OWF) and an offshore Oil and Gas (O&G) installation. Project Neos has proven the feasibility and cost effectiveness (under certain circumstances) of electrification for decarbonisation of O&G installations, as well as a new route to market for the offshore wind industry.

The delivery of Project Neos was supported through the North Sea Transition Authority (NSTA[7]) managed '£1million decarbonisation competition for the electrification of offshore oil and gas installations'[8]. This Public Report provides the outputs and findings of Project Neos and contextualises the findings in relation to realisation of O&G installation electrification using offshore wind energy.

This Public Report has been prepared by a consortium of Ørsted (the world's leading offshore wind developer, constructor, and operator of OWFs), Neptune (a leading exploration and production company focussed on meeting society's energy needs and creating value for all its stakeholders), and Goal7 (a consultancy which supports implementation of clean and affordable energy).

The consortium has demonstrated the value and importance of cross-industry collaboration with respect to offshore platform electrification, and the consortium is pleased to share the outputs of the work in this Public Report.

1.1 Background

There are numerous UK policy, strategy, and legislative mechanisms supporting electrification of O&G infrastructure. The OGA Energy Integration report[9] identified that energy integration through electrification, and further integration of Carbon Capture and Storage (CCS) and hydrogen, could help the UK realise 30% emissions abatement and facilitate a further 30% contribution to the UK's Net Zero abatement target through further expansion of the offshore wind industry.

Platform electrification is possible through having a dedicated connection to the onshore grid. However, due to distance from shore and subsequent cost of infrastructure related to lower power ratings this is not seen to be commercially viable. Therefore, this study considered whether electrification of O&G installations was viable from OWF.

In conjunction with the UK Net Zero ambitions, both the OWF and O&G industries have specific drivers to engage in offshore electrification projects as summarised below.

The following motivators encourage engagement from the OWF industry:

- The removal of the negative price cap within the Contracts for Difference (CfD), Allocation Round 4 Rules[10] as drafted by the Department for Business, Energy, and Industrial Strategy (BEIS). The negative price cap removal incentivises developers to find alternative solutions to mitigate any increased revenue risk associated with market price volatility.
- Platform electrification using offshore renewable energy sources supports whole system solutions for carbon abatement of other industries such as O&G.

The following motivators encourage engagement from the O&G industry:

- It is imperative that the UK O&G industry decarbonise upstream extraction and production operations. This is supported through the North Sea Transition Deal (NSTD)[11] which sets emissions reduction targets of 10% by 2025; 25% by 2027; and 50% by 2030 (against a 2018 baseline). The

[7] Termed NSTA from March 2022. Previously termed Oil and Gas Authority (OGA).

[8] North Sea Transition Authority (NSTA): £1million decarbonisation competition for the electrification of offshore oil and gas installations - 2021 - News - News &
publications (nstauthority.co.uk)

[9] UKCS Energy Integration – Final Report

[10] Contracts for Difference and Capacity Market Scheme Update 2021 (publishing.service.gov.uk)

[11] North Sea Transition Deal - GOV.UK (www.gov.uk)

NSTD explicitly mentions full and partial offshore electrification through supply of power from onshore networks or through the creation of integrated energy hubs incorporating offshore renewables.

- The OGA Strategy is legally binding and requires industry to operate consistently with Net Zero ambitions, lowering production emissions and making serious progress on the solutions that can contribute to the UK achieving Net Zero.
- The Strategy encourages collaboration across industries. Stewardship Expectation 11 (SE11) – Net Zero: SE11 (Net Zero Transition Authority, 2021) supports implementation of the OGA Strategy and aims to create a culture of greenhouse gas emissions reduction on the United Kingdom Continental Shelf (UKCS), throughout the entire O&G lifecycle. It also encourages collaboration between relevant parties (such as the renewables industry) to support and progress energy integration developments so as / in order to maximise emissions abatement potential. Examples where electrification of O&G installations from OWF supports SE11 are as follows:
- Infrastructure life extension through repurposing for alternate uses such as CCS and hydrogen production, making electrification a cost-effective solution to power such operations.
- Improved O&G production efficiency by minimising wasted fuel i.e., improve energy intensity metrics and reduce carbon intensity metrics of O&G installations. Improving the energy and carbon intensity of installations supports energy security, which is particularly relevant during periods of high energy prices.

Platform electrification could represent the first step in developing integrated energy hubs through improving the commercial and environmental case for sharing offshore electricity infrastructure between O&G installations, OWFs and other industries such as CCS and hydrogen facilities located nearby. Whilst this has not been considered in detail within this Report, the outputs summarised are relevant and applicable to integrated energy hubs.

In addition, there are several benefits associated with electrification of existing and future O&G installations that could support the need:

- O&G installation electrification provides opportunities for upskilling and reskilling the UK workforce in integrated energy transition projects, developing whole system solutions, and their operation.
- O&G installation electrification promotes job creation in skilled, high salary positions.
- Future-proofing the offshore industry improves the sustainability of existing assets and enables further offshore industrial development by enabling other industries, such as CCS and offshore hydrogen production.
- Supports the development of policy, regulation, and consenting regimes in the UK for integrated energy projects which will attract investment and maintain the UK's position as a leader in decarbonisation of the energy industry.

1.2 Report Objectives

This Report presents the outputs of the pre-FEED investigations undertaken by the consortium and provides recommendations about technical enablers and reflects the technical learnings in the context of commercial and regulatory aspects.

The findings presented in this Report:

- Seek to advance understanding of whole system solutions for electrical connection of an OWF to an O&G installation.
- Provide valuable information and learning to both industries through collaboration and application of solutions to achieve Net Zero.
- Encourage and accelerate new routes to market for the offshore wind industry.

1.3 Scope

This Public Report comprises the following sections:

Section 2 of the Report presents the technical scope overview and the technical assumptions which underpin the pre-FEED study undertaken:

- **Section 2.1** – Facilities Overview: Reference installation descriptions are provided.
- **Section 2.2** – Concepts Overview: Project Neos examined two concepts connecting the OWF to the O&G installation using subsea cables which are presented in this section.
- **Section 2.3** – Optioneering and Case Overview: An optioneering exercise was undertaken to determine low-, medium- and high-uptime production cases under the two concepts described in **Section 2.2**.

Section 3 presents the summarised technical outputs of Project Neos:

- **Section 3.1** – Load Flow Analysis: A study undertaken to determine the minimum requirements to supply power to an O&G installation from an OWF and advise the design modifications required.
- **Section 3.2** – Design Modifications: Analysis of the OWF and O&G infrastructure and system design changes required to facilitate offshore platform electrification.
- **Section 3.3** – Energy Management: A high-level assessment of the capacity of energy storage required to bridge the gap between supply and load, as well as control, and operation within an offshore micro-grid arrangement.
- **Section 3.4** – Cost Model Assessment: Analysis of the system Capital Expenditure (CAPEX) and Operational Expenditure (OPEX) requirements, including separate consideration of the required anticipatory investment for new-build projects or the retrofitting expenditure for existing project, or highly matured development projects.
- **Section 3.5** – Schedule Analysis: Schedules and deliverability analysis is presented for each case and infrastructure option for implementation.
- **Section 3.6** – Technical Findings Summary: Key findings associated with the technical outputs of Project Neos.

Section 4 details commercial and regulatory complexities and contextualises the technical findings of Project Neos, as outlined below:

- **Section 4.1** – Technical Next Steps: Overview of areas for further technical investigation.
- **Section 4.2** – The Need for Policy Support: Consideration of the policy support currently provided to platform electrification projects.
- **Section 4.3** – Consenting and Leasing of Integrated Energy Projects: Discussion regarding the consenting and leasing regime for platform electrification projects.
- **Section 4.4** – Contracts for Difference: Alignment of platform electrification projects with the CfD.
- **Section 4.5** – Making the Business Case for Electrification: Commercial enablers for platform electrification from OWF.

Conclusions and next steps are provided in **Section 5**.

2. Technical Scope Overview

This section provides an overview of the technical concepts, technical assumptions and optioneering, which underpin the pre-FEED study.

As Project Neos is intended to support cross-industry learning, the technical aspects are generic, replicable, and saleable, as far as practicable, to ensure wide applicability and relevance to platform electrification projects.

2.1 Facilities Overview

The partners provided production and facilities information relevant to typical assets operating in the Southern North Sea.

2.1.1 Offshore Oil and Gas Installation

A reference installation having the following characteristics was used as the basis for the study:

- Located in any area on the UKCS where there are offshore wind developments.
- Mid field life asset with a production forecast to support an electrification business case.
- Gas treatment / compression is required to meet gas pipeline entry specifications because the facility has a gas export pipeline where a gas specification is applicable.
- Two gas compression trains, driven by mechanical drive Gas Turbines (GTs) rated at 7.2 MW on each train (14.4 MW total), provide energy for gas compression at full production (each train providing 50% of compression requirements). The power rating of the GTs for compression is variable across the O&G industry but two trains operating in parallel driven by GTs on an offshore facility is typical.
- Each gas compression train consists of two stages: low pressure (LP) and medium pressure (MP). Stages of compression are variable across the O&G industry and there are typically between one and three compression stages on an offshore O&G installation depending on development production lifecycle. Two compression stages represent the mid-point in this case.
- Other equipment includes heaters, pumps, engines, and backup emergency power supply which are typically found on an offshore O&G installation.
- Emergency power is supplied from a 1,250 Kilovolt-Ampere (kVa), 400 V emergency diesel generator to a 400 V switchboard if the main power supply is lost. All offshore O&G facilities include emergency backup power supply.
- Total power requirements on the installation are 19.4 MW (including: gas compression, other equipment, and emergency power supply). Power requirements on O&G installations vary significantly and are specific to production operations with < 10 MW on smaller facilities and upwards of 50 MW on the largest. 19.4 MW represents a mid-size facility on the UKCS.

2.1.2 Offshore Wind Farm

A reference installation representing one 375 MW power park module of an OWF with the following characteristics was used as the basis for the study:

- 25 Wind Turbine Generators (WTGs), each with 15 MW nominal power distributed in five arrays and five WTGs in each array.
- Each array connected to an OSS, which is in turn connected to the onshore grid via a high-voltage subsea cable.

Distance to the O&G installation was 80 km as this was considered a reasonable average distance between OWF and O&G installations on the UKCS.

One power park module was determined to be more than sufficient to deliver the required 19.4MW to the O&G installation relevant to this study. It would of course be possible to connect more WTGs and thereby increase total capacity, if necessary.

2.2 Concepts Overview

Project Neos examined two concepts connecting the OWF to the O&G installation using subsea cables which are presented in this section.

2.2.1 Overarching Concept Assumptions

The following overarching assumptions are applicable to both concepts and the cases defined following optioneering (see **Section 2.3**):

- Back-feed from the onshore grid is not considered and is therefore out of scope for this pre-FEED study. The rationale for this exclusion was to ensure the study focussed solely on the feasibility of offshore O&G installation electrification from an OWF.
- Two 100% rated 66 Kilovolt (kV) cable connections are considered between the OWF and O&G installation to ensure maximum redundancy and availability.
- A 66 kV shunt reactor and step-down transformer to 11 kV connect each cable to the O&G installation's 11 kV switchboard. This approach requires minimal electrical design changes to the O&G platform.
- Electrification includes substituting Gas Turbine Generators (GTGs) and GT driven compression (GTCs). It excludes emergency power generation because this is intended to power critical systems when main power generation is lost.

Note that O&G installations can either have GTC or motor compression. Project Neos considers GTCs because electrical motor driven compression is less challenging for electrification.

2.2.2 Concept 1: Direct Connection

Concept 1 is a direct connection from two OWF inter-array cable strings, connecting 10 WTGs to the offshore O&G installation. Two subsea cables are extended and run from the final WTG position on the chosen inter-array cable strings to the O&G installation (**Figure 2-1**).

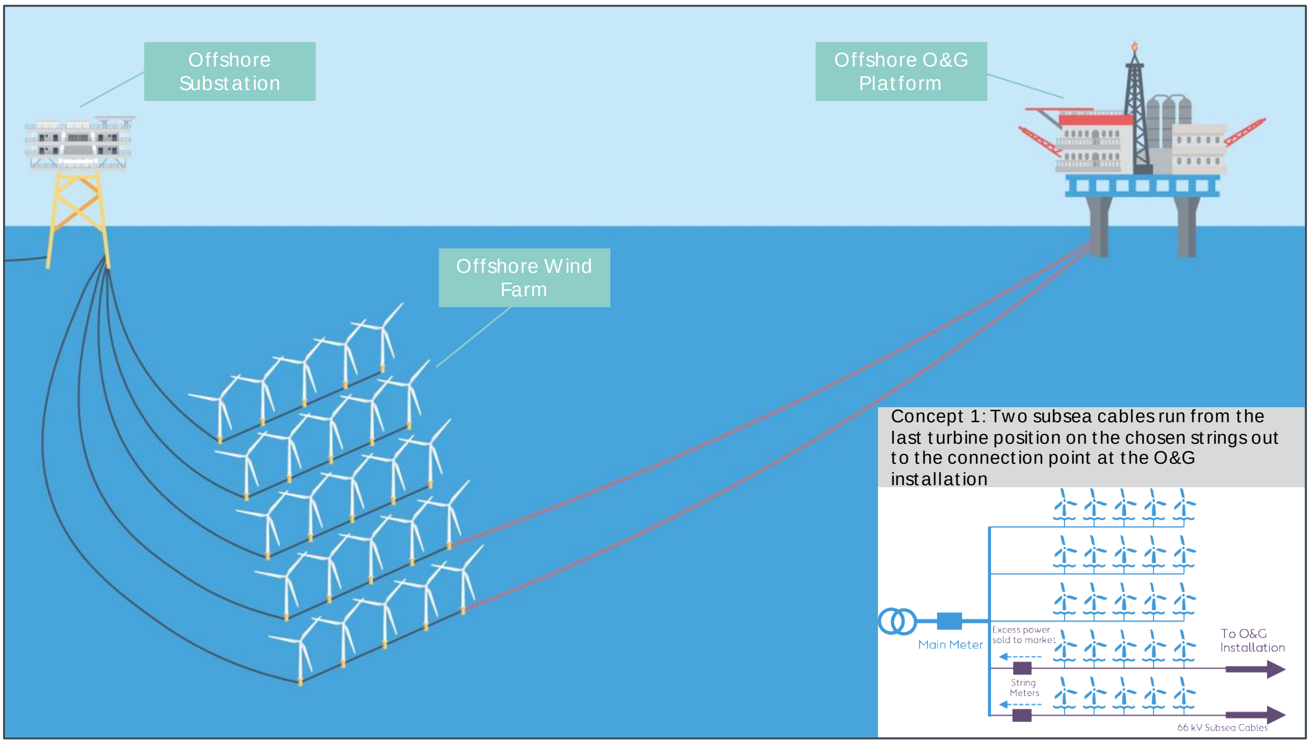


Figure 2-1: Concept 1 Overview

Concept 1 does not require changes to the OSS design and requires only minor changes to the OWF design, such as extension of the cable from the final WTGs on the relevant strings. This minimises the level of investment required and therefore could enable this solution to be retrofitted to existing OWFs.

However, this arrangement may add complexity to metering and controls because there are two additional locations at which metering, and control will be required on the OWF.

With a total installed capacity of 375 MW, connection of two OWF array strings was considered sufficient to deliver the required 19.4 MW to the O&G installation including providing a level of redundancy.

2.2.3 Concept 2: Dedicated Connection

Concept 2 is a dedicated connection using cables connected to the OSS. This would need additional switchgear bays on the OSS to install two subsea cables between the OSS and the O&G platform.

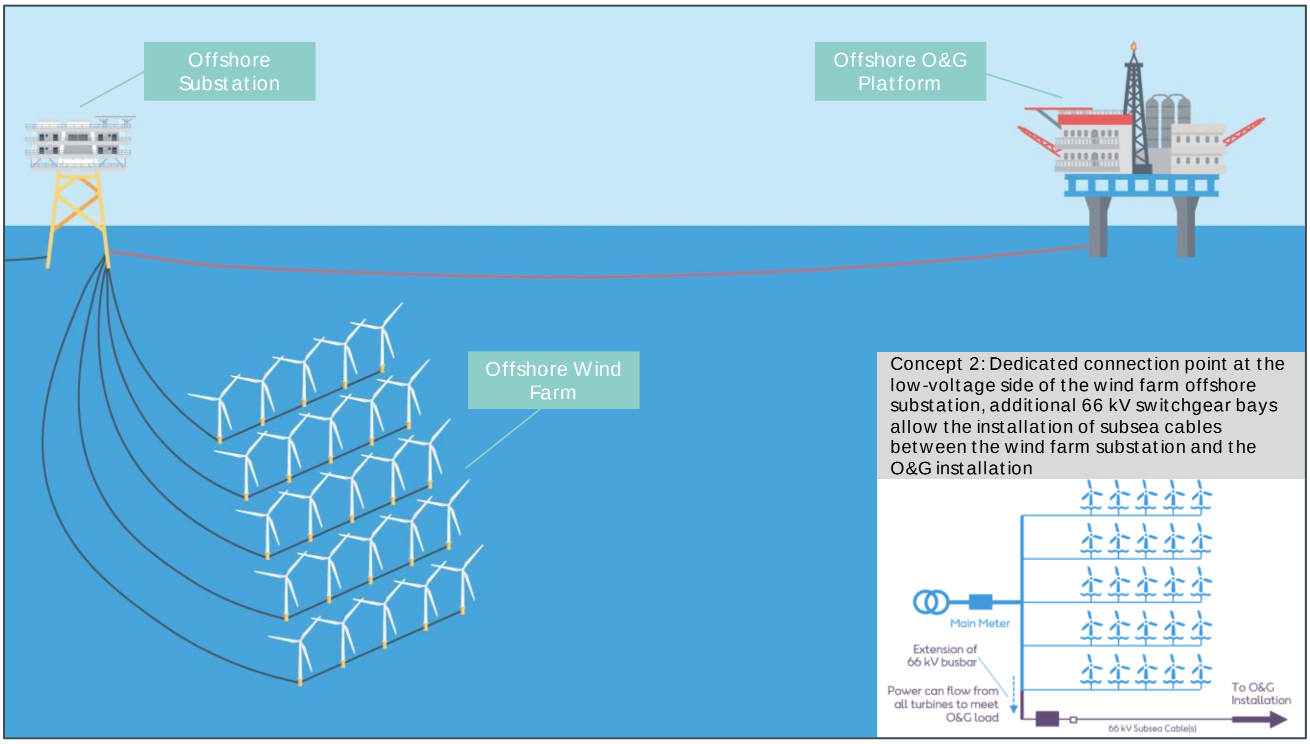


Figure 2-2: Concept 2 Overview

Concept 2 simplifies the control and metering arrangements and connects all the WTGs within the power park module to the OSS[12], maximising the load factors which can be achieved[13]. However, space requirements on the OSS means retrofitting modifications would be challenging so this concept is better suited to greenfield projects.

With a total installed capacity of 375 MW, one power park module is sufficient to deliver the required 19.4 MW to the O&G installation including providing a level of redundancy.

2.3 Optioneering and Case Overview

An optioneering exercise was undertaken to determine low-, medium-, and high-uptime production cases under the two concepts described in **Section 2.2**. The rationale for these cases is as follows:

- The low-uptime case provides no backup power generation or gas compression. The platform can therefore only maintain emergency power during low/no wind periods (or when connection to the OWF is lost). This case represents maximum decarbonisation potential of an installation as it would not operate with use of fossil fuels for power generation or compression.

12 Note that OWFs may have several OSS and access to all WTGs in an OWF may not be provided through a dedicated connection to one OSS.

13 Average load factor is important for determining OWF performance. The load factor is calculated through the ratio of the actual amount of electricity produced, compared to the amount of output that would have been produced if it operated at nameplate capacity.

- The medium-uptime case provides partial backup retaining existing power generation which can support 50% gas compression (one gas compression train). The platform can therefore maintain partial production during low/no wind periods. This case represents a scenario where concessions on production volumes are made for decarbonisation.
- The high-uptime case provides full backup (100% redundancy) and ensures that full platform production can be maintained in low/no wind periods. This case represents an equivalent electrification scenario which maintains production at current levels and no concessions on production volumes are made for decarbonisation.

An overview of the optioneering exercise is presented in **Figure 2-3** below. A summary of each case is provided in **Table 2-1**.

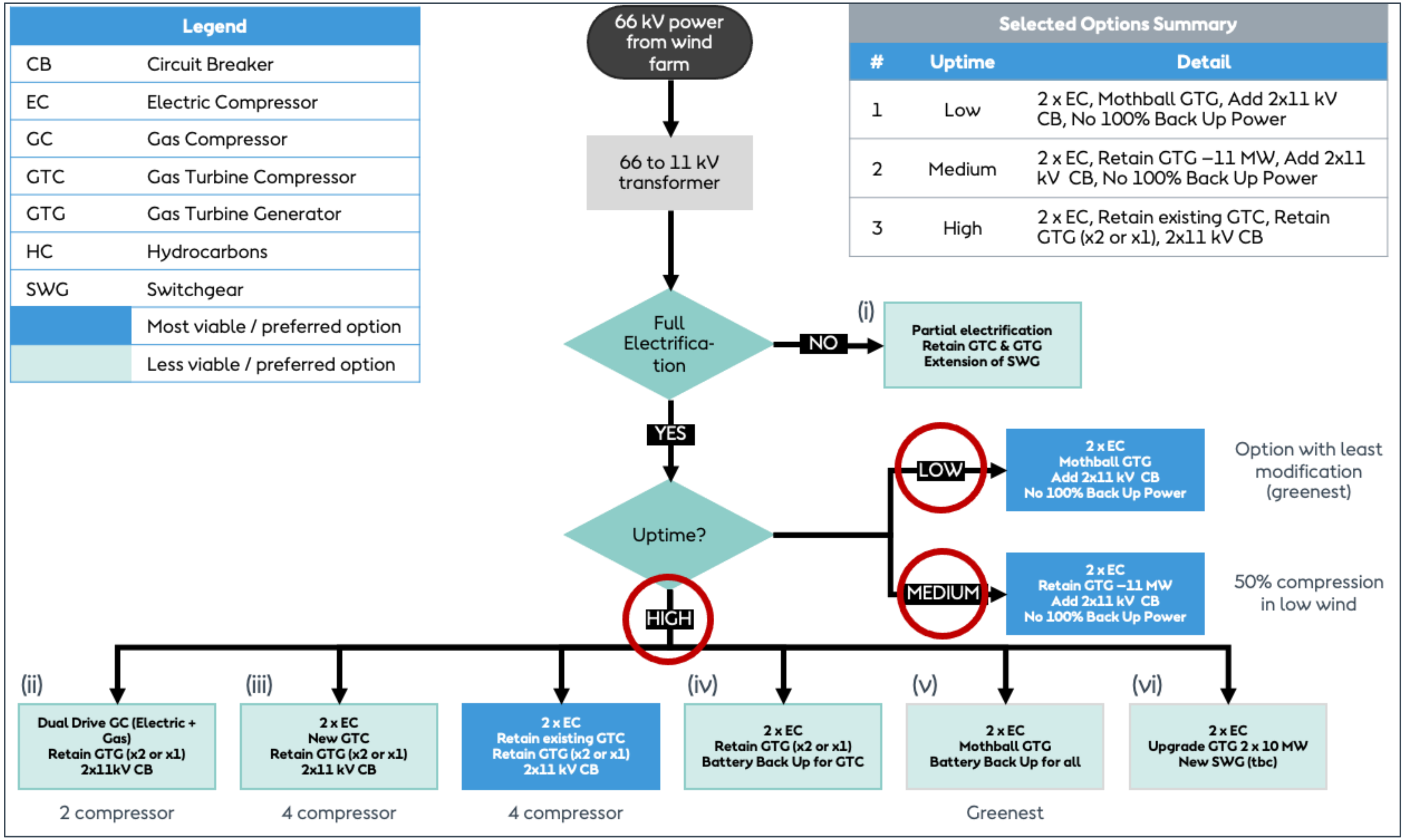


Figure 2-3: Optioneering Outputs

Table 2-1: Summary of Low-, Medium, and High-Uptime Cases

Case	Description	Equipment	Standard Operation	Operation during Low/No Wind Periods
Low[14]	Relies solely on power from the OWF for production purposes. The two existing GTGs will be replaced by a connection from the OWF to the switchboard and two GTs for compression will be removed and replaced with electrical motors, fed from the 11 kV switchboard via a new VSD.	OWF connection 2 x VSD 2 x motor 2 x existing compression train	Powered by the OWF during normal operations. No produced hydrocarbons used for fuel during normal production.	No platform production or power available. Increased use of emergency diesel generator to provide essential power when GTGs are unavailable.
Medium	Allows for electrical supply from the OWF, and two GTGs to supply electricity during low/no wind periods. The existing two GTs for compression will be removed and replaced with retrofitted electrical motors fed from the 11 kV switchboard via a new VSD.	OWF connection 2 x VSD 2 x motor 2 x GTG 2 x existing compression train	Powered by the OWF during normal operations. No produced hydrocarbons used for fuel during normal production.	The existing GTGs will be brought online as a secondary source of power using hydrocarbons as the fuel source. Existing GTGs do not have sufficient power to drive both compression trains; only 50% gas compression will be achieved i.e., one compression train will be in operation.
High[15]	Allows for electrical supply from the OWF and two GTGs, as well as retaining the existing two GTs for compression to provide compression during low/no wind periods. Both existing two GTGs and two compression trains (including their GTs) will be retained. New, replica, compression trains will be installed with electrical motor drives fed from the 11 kV switchboard via VSDs. New process valving and piping will provide the option to route the production gas stream through either the new electrical driven compression trains, or the original GT driven trains.	OWF connection 2 x VSD 2 x motor 2 x GTG 2 x existing compression train 2 x new compression train	Powered by the OWF during normal operations. No produced hydrocarbons used for fuel during normal production.	During no/low wind periods, the platform will revert to its original operating status; with the platform powered by the existing GTGs and GTs for compression. The existing GTGs and GTs for compression will be brought online using produced hydrocarbons as their fuel source. This will provide 100% redundancy for power supply and compression. GTGs will be retained in idle state ready to start-up power generation. No change in CO_2 emissions will be achieved during no/low wind periods.

[14] Best case for decarbonisation of an O&G installation.

[15] Best case for production availability. This option retains full process production but would mean doubling up hardware and additional controls for compression.

2.3.1 Options Not Progressed

Several options outlined in **Figure 2-3** were not progressed and the basis and rationale for this is summarised in **Table 2-2** below. Note that the concept numbers provided in Table 2-2 refer to the less viable / preferred options labelled in **Figure 2-3**.

Table 2-2: Summary of Options not Progressed

Concept Number	Option Description	Basis for Screening Out
(i)	Partial electrification	Project scope only included cases which could provide full electrification.
(ii)	Dual drive compression	This concept involved conversion of the existing compression trains to add an electric driver to each train, as well as retaining the existing GTC such that the trains could be driven via electricity when sufficient wind power is available and via gas during low/no wind periods. This was not progressed due to the technical and physical difficulties envisaged with installing a brownfield retrofit to existing machinery. This may be a plausible alternative to the new compression trains required for the high uptime case; therefore, further study is recommended should this case progress in the next phase (detailed in **Section 4.1**).
(iii)	New gas turbine driven compression trains	Excluded as it is impractical; two new electrical driven compression trains can be installed without modification to the existing trains.
(iv)	Energy Storage back-up with retention of existing GTGs	The existing GTs for compression would be replaced with electrical motors. Upon wind outage the existing GTGs would be started on gas/diesel fuel, with the power deficit provided through energy storage. The power deficit is estimated at circa 8 MW to maintain full production, the size and cost of installing and operating energy storage with this power requirement is not considered feasible. However, an energy storage solution is required with further consideration of this case and others provided in **Section 3.3**.
(v)	Energy Storage back-up for all systems	Existing GTGs not retained with energy storage required to provide full power back-up, which for full production is circa 19 MW required over a duration of 82 hours. The size and cost of installing and operating energy storage with this power requirement is not considered feasible. However, an energy storage solution is required with further discussion provided in **Section 3.3**.
(vi)	Upgrade GTGs to provide full power back-up	The existing GTCs would be replaced with electrical motors to drive gas compression, such that all systems would be fully electrified for normal operation via wind driven electrical power. The two existing GTGs (each at 5.5 MW) would be replaced with larger sets at 10 MW each, each equivalent to roughly 50% of the full production load upon full electrification. These would be brought online during a low / no wind period. This option lends itself more readily to a new installation, as the retrofit and modifications required are significantly intrusive and would impact ongoing production during execution. The GTGs would be larger both physically and electrically. Physically they would provide an installation challenge and the existing fuel gas system would be undersized. Electrically they may present a challenge to the switchboard in terms of capacity and fault stress.

3. Technical Findings

3.1 Load Flow Analysis (Electrical System Design)

Load flow analysis was carried out to establish the minimum power requirements needed to supply the O&G installation from the OWF and provide consideration to the gap between OWF output and O&G installation production needs. The load flow analysis focussed on subsea cable capacity under load and no-load conditions, the feasibility of applying a 66 kV operating voltage to the O&G installation and considering the impact to reactive power capabilities.

3.1.1 Electrical System Configuration

Load Flow Analysis considered the two connection concepts (**Concept 1** and **Concept 2**) (see **Section 2.2**) and the different cases for power supply (low-, medium-, and high-uptime cases). Different scenarios were analysed depending upon generation and voltage ranges of the OWF.

The scope of this study did not include detailed electrical systems analysis: a harmonics assessment, energisation study, inrush study, control and operations, dynamics studies, and contingency analysis. Further study is recommended in the next phase as detailed in **Section 4.1**.

3.1.2 Load Flow Analysis Key Findings

The overarching finding of load flow analysis was that the equipment configurations were deemed feasible in terms of power transmission capacity and voltage limits at each end of the system. Other key findings associated with load flow analysis were as follows:

- 80 km of 66 kV cross-linked polyethylene cable containing three copper cores is needed to connect the OWF to the O&G installation. There will be a need to confirm the cross-section of cable if further data becomes available in later stages of an electrification project.
- It was estimated that the 66/11 kV transformer would be in the order of 30 Megavolt-Ampere (MVA) because a new compression train would increase the load to 14.4 MW.
- Active power losses were assessed with no significant losses identified through a generation range of 0 – 100%.
- In contrast, Project Neos initially assumed that shunt reactors would be required for reactive power compensation at the O&G installation. The OWF is much larger than the O&G installation which led to an assumption that these may be needed to absorb excess reactive power. Load flow analysis showed that these may not be required at the O&G installation, which would represent a significant cost-saving to an electrification project.
- The requirement for a second 66 kV subsea cable was assessed with findings showing that one cable could potentially provide sufficient power from 25 WTGs. Further reliability and availability analysis is needed to confirm if a second cable is really required
- The analysis only considered one subsea cable connected to the O&G installation in use at any given time. If two cables are required, the second cable, or changing the cross section of the cable, could have an impact on the reactive power generated by the cable, hence a reactor might be needed. This will also have an important impact on the cost of the project and further study would be required in later stages of an electrification project.

3.2 Design Modifications

Several design, electrical, compression and layout changes are required for both the OWF and the O&G installation to establish an electrical connection. The design changes identified were based on the outputs of load flow analysis described in the preceding **Section 3.1**.

3.2.1 Wind Farm Design Changes

The new connections proposed from the OWF to the O&G installation in **Concept 1** and **Concept 2** (**Section 2.2**) will require physical design changes to the OWF and changes for control and operation of the reconfigured electrical infrastructure. The design changes identified are summarised in **Table** 3-1 below and are not deemed significant in terms of complexity to implement and therefore could be applied to in-flight projects.

Table 3-1: Offshore Wind Farm Design Changes

Concept 1	Two new subsea cables	New subsea cable routings from the final WTGs to the O&G installation	New interlocking system arrangements from the WTGs to the subsea cables (mechanical and electrical)	A new metering, control and protection configuration for operation of the WTG arrays and subsea cables
Concept 2		New subsea cable routing from the OWF OSS to the O&G installation	New interlocking system arrangement from the OWF OSS to the subsea cables (mechanical and electrical)	A new metering, control, and protection configuration for operation of the OWF, OWF OSS and subsea cables

3.2.2 O&G Installation Electrical Changes

Electrical system changes are required on the O&G installation to accommodate the new connections and supply power to new equipment. The platform electrical system expansion for both concepts include:

- A new 66 kV switchboard to connect the two new subsea cables from the OWF.
- Two 66/11 kV transformers connected to the existing switchgear.
- Two new shunt reactors[16] to compensate the reactive power flow due to longer runs of the cables.
- Two new feeders added in the switchgear for the VSDs.
- Modifications to the existing low voltage switchgear to meet the power supply requirements of the auxiliaries for the compressors and motors and any other low voltage supply required for the newly added equipment.

3.2.3 O&G Installation Compression Changes

The electrification of the O&G installation will require both physical changes to the gas compression system in terms of unit changeout and changes for control and operation of the reconfigured infrastructure, depending on the uptime case. There may also be additional changes needed to the routing of pipework and valving. The details of the changes for the low-, medium-, and high-uptime cases are provided in Table 3-2 below. Note that the low and medium cases require the same modifications to the compression system and have therefore been aggregated.

Table 3-2: O&G installation Compression Changes

Low-/Medium-Uptime Case	The two existing compressor trains will have their respective GTs removed	The GTs will be replaced with an electrical motor	n/a	n/a
High-Uptime Case	The two existing compression trains will be retained and available for operation	A new duplicate pair of two electrically driven compression trains will be installed	The new compression trains will have an electrical motor	Interconnected pipework and valving will be installed between the two respective compression train systems

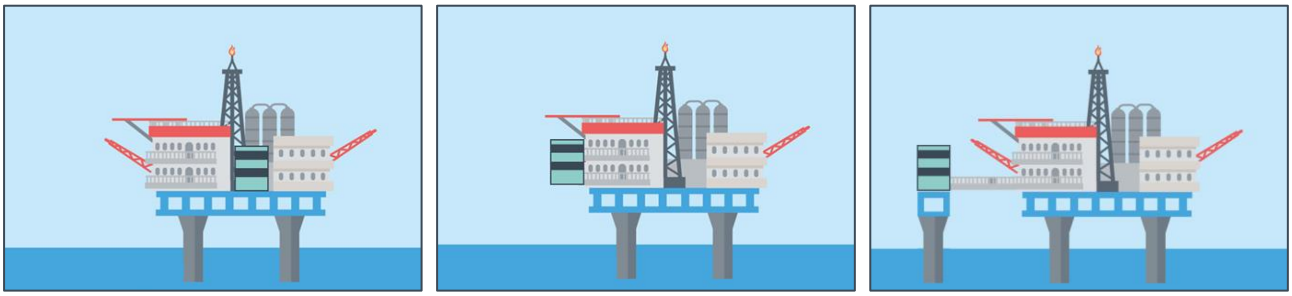
[16] There may be an opportunity to remove shunt reactors from the electrical design; their need should be assessed as the project matures.

3.2.4 O&G Installation Layout Changes

Brownfield modifications on O&G installations will require considerable layout changes and cause disruption to production operations, which are complex to manage. In contrast, designing infrastructure for electrification into greenfield projects is less complex without impacts on existing infrastructure and operations. Solutions were developed for each of the low-, medium-, and high-uptime cases. All cases will require new equipment to be installed via the use of a heavy lift vessel (HLV)), which adds expense and complexity to the operations but is not unusual for the industry.

Three potential layout changes for installation of equipment and systems to a brownfield O&G platform were investigated, as outlined in Figure 3-1 below:

- Option 1: Equipment integrated on the platform (inc. Pre-Assembled Unit (PAU) modules).
- Option 2: Hang-off module from the O&G platform.
- Option 3: Bridge Linked Platform (BLP) adjacent to the O&G platform.



Option 1: Integrated solution **Option 2: New hang-off module** **Option 3: New BLP**

Figure 3-1 – Layout Changes for Brownfield Modification

A description of the equipment design changes, and estimated module weights were produced for each option and for each of the uptime cases. This is summarised in Table 3-3 below, note the low- and medium-uptime cases are effectively the same physical solution and have been aggregated.

Table 3-3: O&G installation Physical Layout Changes

	Structural Option	Description	Approx. Weight (T)	Complexity of Installation (from O&G perspective)	Suitable for Brownfield Modification
Low-/ Medium-Uptime	**Option 1:** Integrated on the platform	• Shunt reactors to be mounted on new deck extension with no major brownfield issues. • Two PAUs are required. One for the transformers and the other for the switchgear and the two VSDs. The transformers and shunt reactors will require a HLV for installation • Depending on platform topside design some equipment may have to be relocated requiring brownfield modification.	435		Possible
	Option 2: Hang-off module from platform	• All equipment required for electrification is placed in a hang-off module. • Current turbine exhausts for the GTCs can be removed due to electrification. • Existing staircases may have to be removed and integrated in the new module.	450		Possible
	Option 3: BLP adjacent to the platform	• All equipment required for electrification is placed in a new adjacent module on two levels. BLP is mounted on an 8 m diameter monocolumn and connected to the platform via a bridge.	1800		Yes
High-Uptime	**Option 1:** Integrated on the platform	• Shunt reactors to be mounted on new deck extension with no major brownfield issues. • Two PAUs. One for the transformers and the other for the switchgear and the two VSDs. • Two new compression trains would be located to minimise the distance for the required interconnecting pipework. • The switchgear and VSD PAU would be housed on top of the new compression module resulting in major brownfield impact, intrusive requirements, and greater installation complexity.	870		No
	Option 2: Hang-off module from platform	• All equipment required for electrification is placed in a hang-off module. • Two new compression trains would be located on processing deck for brownfield to minimise the distance for the required interconnecting pipework.	885		Possible

Structural Option	Description	Approx. Weight (T)	Complexity of Installation (from O&G perspective)	Suitable for Brownfield Modification
Option 3: BLP adjacent to the platform	• All equipment required for electrification is placed in a new adjacent module on two levels. BLP mounted on an 8 m diameter monocolumn and connected to the platform via a bridge. • Two new compression trains would be located on processing deck for brownfield to minimise the distance for the required interconnecting pipework	2230		Yes

3.3 Energy Management

In addition to the electrical system modelling above, the total emissions reduction opportunity was estimated for each of the low-, medium-, and high-uptime cases. The emissions reduction related to each case result from the reduction in the combustion of hydrocarbons in the GTs to generate electrical power and/or produce mechanical drive for the compressors. An emissions reduction factor of 4,050 tonnes CO_2 per MW of power saved was used, assuming a specific CO_2 emission of 2.61 kg CO_2 per kg fuel combusted. The emissions reduction for each case is summarised in **Table 3-4** below.

Table 3-4: Emissions Reduction for each Uptime Case

Parameter	Low-Uptime Case	Medium-Uptime Case	High-Uptime Case
Annual CO_2 Emissions Reduction (Tonnes of CO_2)	80,000	72,000	67,000
Total CO_2 Emissions Reduction (Tonnes of CO_2)	615,000	574,000	533,000

As can be seen from the table, the opportunity is significant and therefore analysis was conducted to establish whether the OWF could deliver an adequate level of power supply reliability to meet the O&G installation load requirements. In addition, a preliminary high-level review of energy balancing solutions such as energy storage has been assessed, including:

- A review of the energy requirements to be met by the OWF based on load factor analysis.
- Description of the system design philosophy.
- Description of the operating philosophy of the system.
- Conclusions and recommendations based on the results of this assessment.

3.3.1 Load Factor Analysis

The first step to estimate the energy requirements was to determine the energy consumption demanded by the systems on the O&G installation and compare that to the OWF power generation to identify the gaps that need to be covered by an alternative power supply such as energy storage.

An installed load on the O&G installation of 19.4 MW has been determined. This includes 5 MW load on the GTGs plus 14.4 MW load on motor driven compression (2 trains, 7.2 MW each).

3.3.2 OWF Generation

Both Concept 1 and Concept 2 have an installed capacity of 375 MW (25 WTGs of 15 MW) the total energy production over 1 year is expected to be 1,807 GWh.

The figure below shows the wind power output over one year for a typical OWF located in the Southern North Sea together with the load requirements of the O&G platform. OWF power output over a longer period and in different areas may vary.

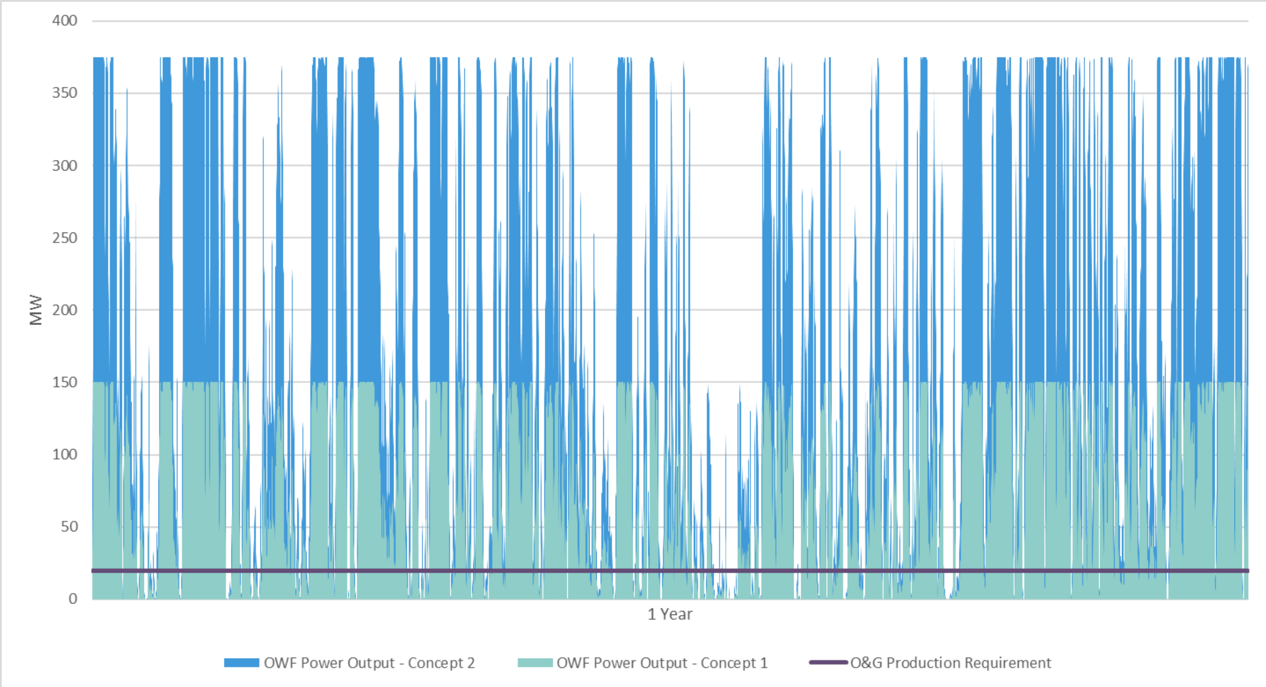


Figure 3-2: Annual Profile (OWF Generation vs O&G installation Consumption)

These profiles identified when the wind generation is insufficient to meet the O&G installation's requirements.

The analysis showed:

- 1,088 hours a year (12.4% of hours) in 84 gaps where wind generation could not meet the demand of the O&G installation.
- The total energy required during these gaps is equal to 11,921 MWh (8.6% of the total energy consumption of the platform and 0.66% of the total energy generated by the wind farm).
- The longest gap identified occurred during July, lasting 82 hours with an energy requirement of 1,005 MWh.
- The average gap during the year was 13 hours.

Peak load on the GTGs over 1 year was approximately 2 MW with an additional 14.4 MW for gas compression. Based on this, the considerations detailed in Table 3-5 below were made.

Table 3-5: Wind Power Availability Considerations

Wind Power	Consideration
> 16.4 MW	Facility runs as normal, with full 2 x gas compression (2 MW base load plus 14.4 MW full compression load)
9.2 < 16.4 MW	Facility runs on 1 x gas compression (2 MW base load plus 7.2 MW single compression train)
2 < 9.2 MW	Facility is operational without production or gas compression, managed process slow/shutdown
< 2 MW	Facility is on essential services supplied, managed facility slowdown where 1 MW is the required emergency supply
No wind	Effectively a platform trip (Emergency systems kick-in). Black start is required

From this analysis 62 of the 84 gaps during the year would have resulted in no power for the O&G installation, requiring use of the facility's uninterrupted power supply and emergency generator, leading to a black start of the platform upon power restoration and considerable production and revenue losses.

3.3.3 Energy Balancing

Considering the above, a high-level review of the capability of energy storage to bridge the gap between supply of electricity from the OWF and the O&G load requirements was considered:

- Largest gap – 82 hrs (1005 MWh), covering 100% of the missing power supply from the OWF
- Average gap – 13 hrs (145 MWh), covering 69.4% of the missing power supply from the OWF
- Smallest gap – 1 hr (16 MWh), covering 7.7% the missing power supply from the OWF

An energy storage solution to meet 100% production availability for the low-uptime case would need to supply 1,124 MWh of energy with estimated CAPEX of £247m. The size, weight and cost of the energy storage solution mean that this is not considered a feasible solution.

However, an energy storage solution, which is designed to provide balance and stability and support the change-over from OWF to backup power generation and compression and vice versa, and in the form of an offshore micro-grid could help optimise how energy is used and should be further investigated.

The fast response characteristics of energy storage means it would be suited to act as a buffer to maintain voltage and frequency stability supporting change-over between alternative sources of power generation i.e., the OWF and GTGs.

A typical configuration of the offshore microgrid is illustrated in Figure 3-3 below. Note that the energy storage system is connected to the OWF for recharge and discharges energy to the O&G installation. The power control system (PCS) attached to the energy storage system converts AC to DC and vice versa. Energy storage comprises the battery storage as well as the power conversion system to convert from DC to AC and vice versa. A transformer is then needed to match the voltage of the system it is being connected to.

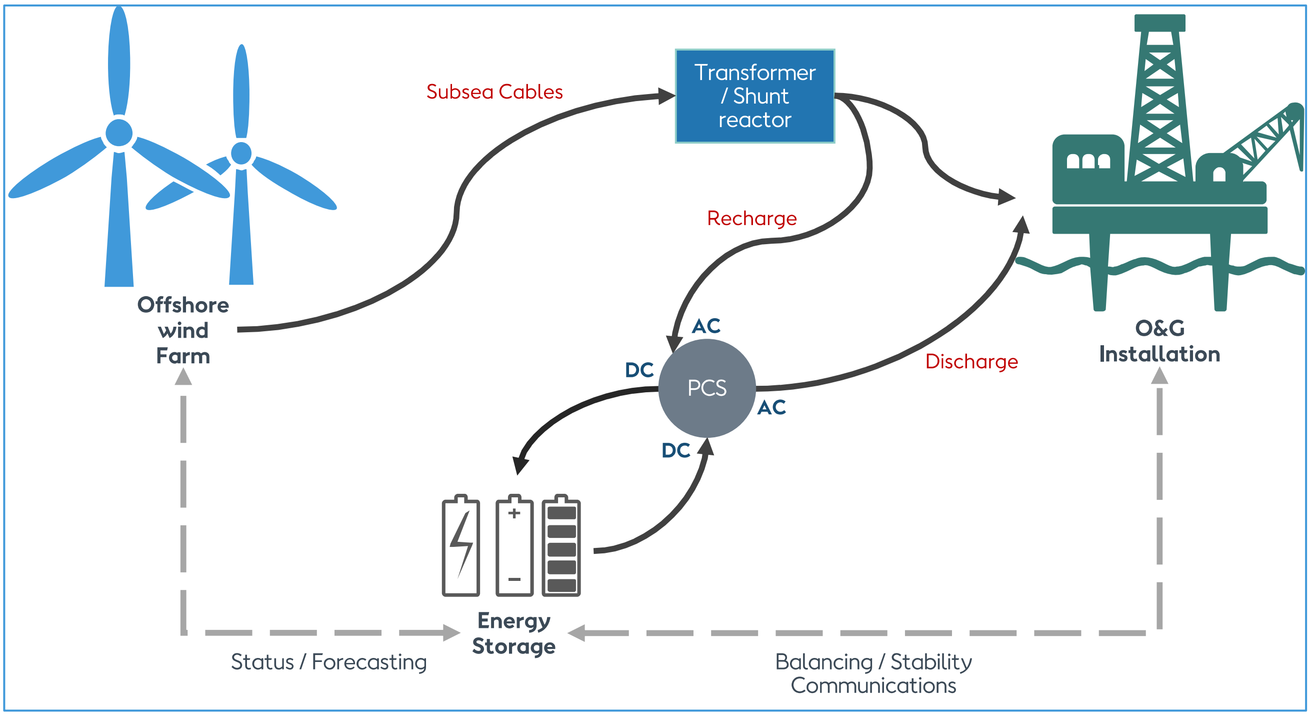


Figure 3-3: Configuration including energy storage

In this situation the electrical system would prioritise renewable electricity from the OWF and include an Energy Management System (EMS). The EMS will communicate with the O&G installation EMS as well as take data from the OWF forecasts to ensure that the energy storage is charged/discharged to balance loads and meet O&G installation demand. It is likely that modifications will be needed to the OWF operating philosophy and controls to provide priority to the O&G needs.

3.4 Cost Model Assessment

3.4.1 Assumptions and Scenarios in the CAPEX Model

CAPEX estimates have been prepared for each of the low-, medium-, and high-uptime cases. However, the low- and medium-uptime cases have been reported together as they require similar O&G installation modifications and equipment. Each of the low-/medium- and high-uptime cases have been cost estimated against the three different structural options for the installation of equipment and systems on the O&G installation (**Section 3.2.4**), resulting in six CAPEX estimates (**Table 3-7**).

Each CAPEX estimate is split across three categories for each solution as shown in **Table 3-6**.

Table 3-6: CAPEX Estimate Split

OWF modifications	• Study and FEED • EPC Engineering and Project Management • Procurement • Installation • Commissioning
Subsea cables	• Study and FEED • EPC Engineering and Project Management • Procurement • Installation • Commissioning
O&G installation modifications	• Study and FEED • EPC Engineering and Project Management • Procurement • Installation • Fabrication and Fit-Out • Greenfield Installation • Brownfield Modifications and Hook-Up Commissioning

The estimates are Class 5 as per AACE Classification System[17], which includes a 25% contingency allowance. All costs are presented in GBP based on Q1, 2022 rates. These estimates have not been subject to formal cost risk analysis; however, this would be recommended for the next phase of a platform electrification project.

3.4.2 CAPEX Estimate Results

CAPEX estimates are presented in **Table 3-7** below. Option 1 (equipment integrated on the platform) was found to have the lowest CAPEX for each of the uptime cases. While option 3 (BLP adjacent to the platform) was found to have the highest CAPEX for each of the uptime cases.

Achieving the high uptime case also requires a greater capital investment of approximately £26m compared to the low or medium uptime cases, for any of the three different structural options, due to the addition of the standalone electrically driven compression modules.

[17] 87R-14: Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Petroleum Exploration and Production Industries (aacei.org)

Table 3-7: CAPEX Estimate

Case	Structural Option	CAPEX Estimate Class 5 Range
Low/Medium Uptime	**Option 1:** Integrated on the platform	£117m – £218m
	Option 2: Hang-off module from platform	£123m – £230m
	Option 3: BLP adjacent to the platform	£141m – £263m
High Uptime	**Option 1:** Integrated on the platform	£137m – £256m
	Option 2: Hang-off module from platform	£143m – £267m
	Option 3: BLP adjacent to the platform	£160m – £298m

An example CAPEX breakdown is shown in Figure 3-4 below to demonstrate the proportion of CAPEX spend for the uptime cases and structural options. The majority of the total cost is associated with procurement CAPEX, specifically the procurement of the two new subsea cables. The costs associated with the new subsea cables also make up a significant proportion of the installation and commissioning CAPEX. Meanwhile, the design modifications on the O&G installation comprise a large proportion of the engineering and project management CAPEX.

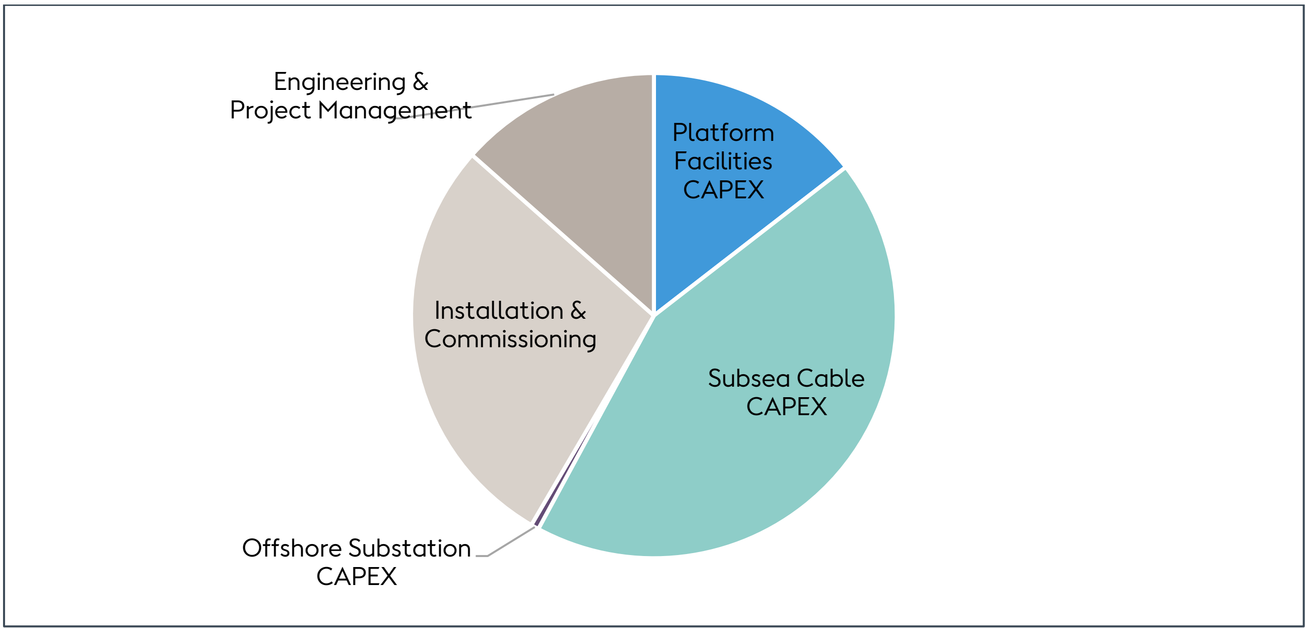


Figure 3-4: Indicative CAPEX Breakdown for a Low/Medium Uptime Case Integrated on the Platform

3.4.3 Direct OPEX

Direct OPEX is the incremental change in the cost of operations and maintenance due to the O&G installation having new infrastructure as per the CAPEX estimates (Section 3.4.2). The direct OPEX for each of the low-, medium- and high-uptime cases for both concepts are summarised in Table 3-8 below.

Table 3-8: Direct OPEX

Low-uptime	• No incremental OPEX. • Increase due to increased electrical equipment offset by lower compression demand.
Medium-uptime	• Increase of £1m/annum OPEX due to increased maintenance burden for retaining existing GTs.
High-uptime	• Increase of £2m/annum OPEX to cover incremental increase in maintenance burden in having to maintain GTCs and electrical equipment.

3.4.4 Cost Model Summary

The high-level cost model illustration below aims to identify the parameters in which a platform electrification project from an OWF could be considered viable. The model assumes that with a combination of power generation sources, additional production outages would not occur and therefore no cost of lost production is anticipated.

The following inputs have been used:

- Platform OPEX: 2% of brownfield modification CAPEX.
- Platform decom: 10% of brownfield modification CAPEX.
- Uptime from offshore wind: 88%.
- Electricity price: £65/MWh – average forward curve 2022-2030 from Aurora GB Renewables Market Forecast Jan 2022.
- Gas price: Wood Mackenzie Q4 2021 Base case.
- FX: GBP/€1.18, GBP/USD 1.43-1.52.
- 10% Discount Rate.

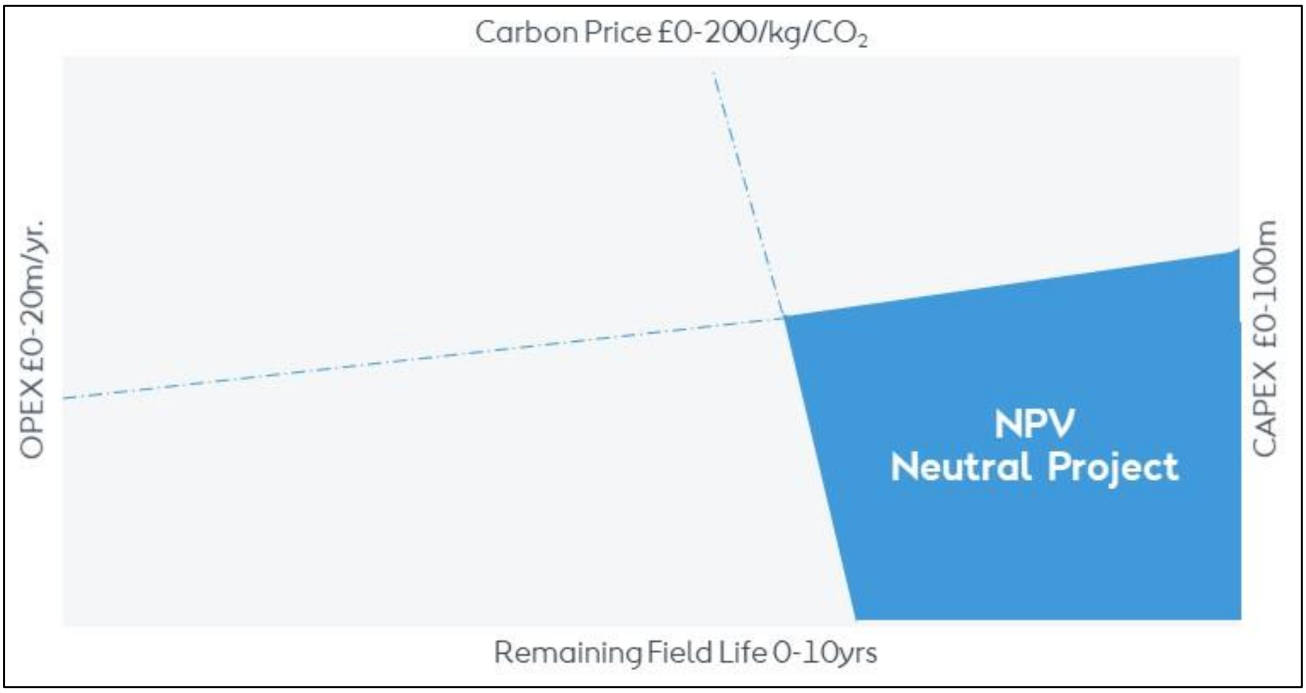


Figure 3-5: Electrification Project NPV Model

The data presented in this section demonstrates that in many situations, platform electrification can be viable, however would need to have certain parameters related to max CAPEX circa £65m, relevant to the OPEX associated with this project i.e., circa £7.5m/yr., which includes O&M or direct OPEX, the cost of purchasing electricity (the PPA), and savings from not consuming gas for power generation. However, other significant influencing factors are carbon price and the robustness of carbon price forecasting as well as remaining field life.

Considering the CAPEX limits illustrated above it seems unlikely that electrification projects that require a BLP to house additional equipment, or a 100% redundancy (dual cable) connection >50 km distance can be viable for projects that have less than 10 yrs remaining field life. However potential high gas prices or carbon prices, or opportunities for field life extension through repurposing can change this. There are also opportunities related to converting CAPEX to OPEX in the form of a tariff payment, as well as structuring the PPA pricing to reflect expected trends in direct OPEX that show promising results and should be investigated further.

3.5 Schedule Analysis

A schedule analysis has been prepared in alignment with the CAPEX estimates (**Section 3.4.2**) for each of the low-, medium-, and high-uptime cases to estimate the time required for engineering design, procurement, construction, installation, and commissioning.

Basic level 1 schedules have been produced (**Figure 3-6**, **Figure 3-7**, **Figure 3-8** and **Figure 3-9**) for each of the three different structural options for the installation of equipment and systems on the O&G installation (**Section 3.2.4**). The low- and medium-uptime cases have been reported together as they require similar O&G installation modifications and equipment and are presented for each structural option as **Figure 3-6**, **Figure 3-7** and **Figure 3-8**.

Figure 3-9 presents structural option 1 (integrated on the platform) for the high-uptime case. In relation to the two other structural options, the high-uptime case would follow a very similar schedule to the low-/medium-uptime case with the key difference being that the facility preparation period is greater, due to installation of the new compression module. On the basis that the differences are minor between the high- and low-/medium-uptime cases, individual schedules have not been repeated for the high-uptime case hook-on module or BLP structural options.

A feasibility study is allowed for in all options as further work must be performed and project-specific assessments made prior to any FEED commencement. This is considered a typical approach. Specific areas requiring further project-specific assessment include:

- Offshore surveys;
- Structural capacity and analysis of loads;
- Destruct and construct requirements; and
- Further assessment of facility electrical system.

As industry-standard, a period of FEED is allowed with a small gap for reviews and approvals prior to commencement of detailed design. The four schedules presented assume that long lead items are ordered 12 weeks after commencement of detailed design, allowing for full tendering. It should be noted that the overall schedules may be reduced by a focused tendering process in the FEED stage, such that purchase order (PO) commitments can be placed earlier in detailed design.

For all of the four cases presented, the subsea cable purchase order can be placed shortly after the commencement of detailed design. The lead time is estimated at 12 months followed by a six-month vessel installation campaign, preferably taking place in summer months. The longest lead item for the low-/medium-uptime cases being the procurement of the transformers and switchgear, which is assumed at 14 months.

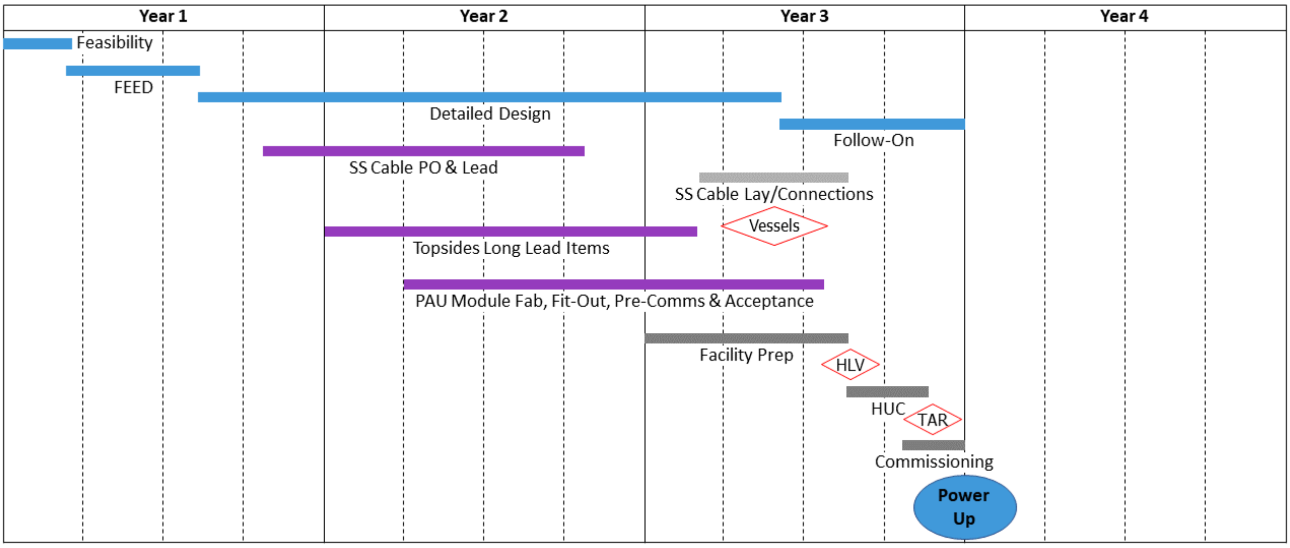


Figure 3-6: Integrated on the Platform Schedule (Low/Medium Case)

As shown in Figure 3-6, for option 1 (integrated on the platform) the total onshore fabrication time is 16 months. It is noted that the commissioning period must be maintained to as low as practicable as the O&G platform has no process power until systems are electrified and connected to the OWF. The total shutdown time for this option is estimated at four weeks.

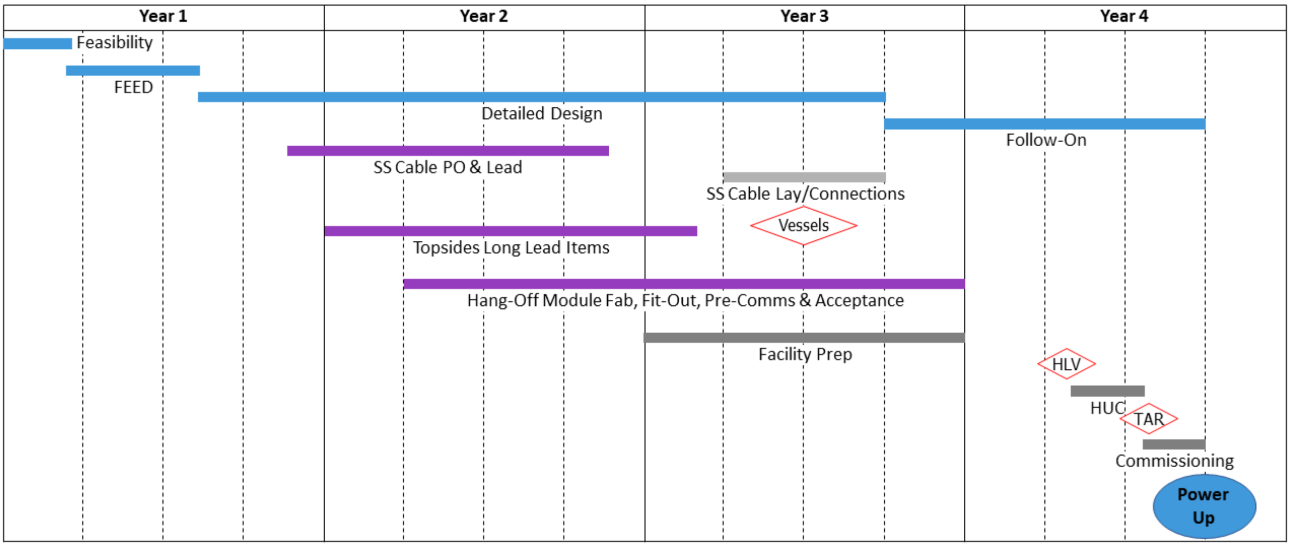


Figure 3-7: Hang-Off Module Schedule (Low/Medium Case)

As shown in Figure 3-7, for option 2 (hang-off module from platform) the total onshore fabrication increases to 21 months for the module build time. The module is anticipated to be ready for installation, including internal commissioning, 10 months from the last long lead item. As with option 1, the facility is prepared in advance and the total shutdown time is estimated at four weeks.

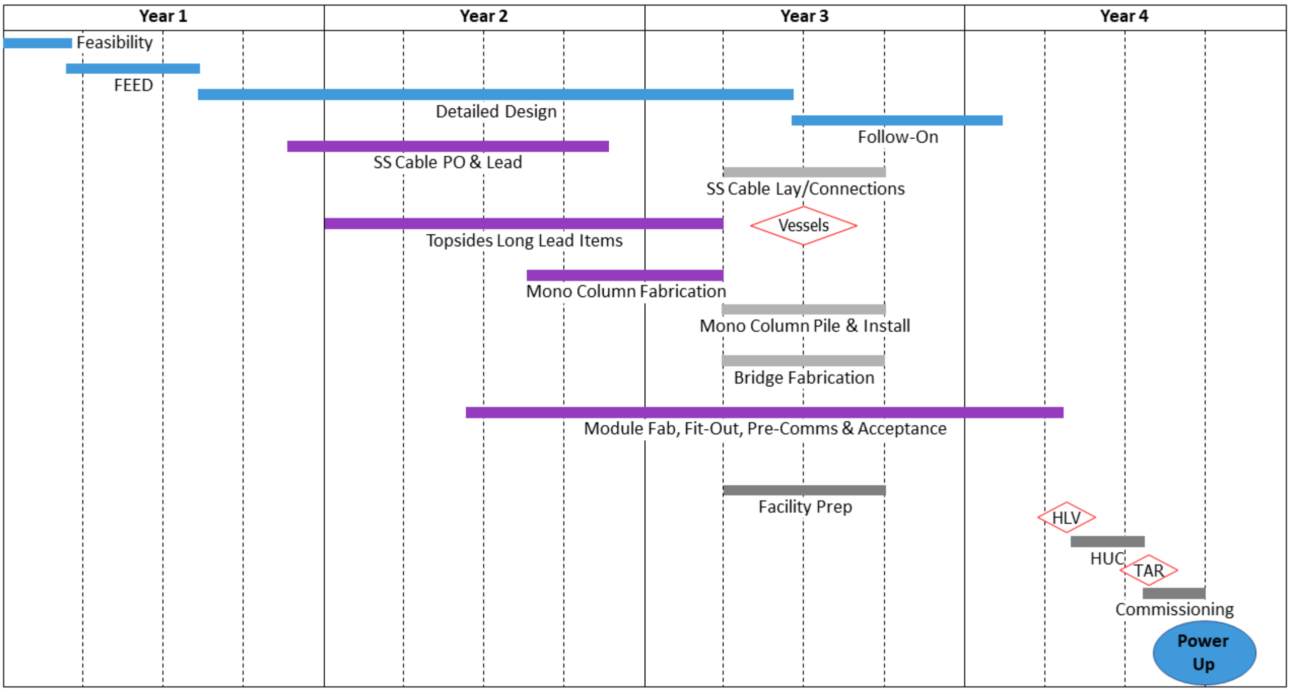


Figure 3-8: Adjacent BLP Schedule (Low/Medium Case)

As shown in Figure 3-8, for option 3 (BLP adjacent to the platform) the total onshore fabrication is estimated at 21 months for the module build time as per option 2. The aim is to install the monocolumn in the summer of year three with the HLV lift of module in the year following onshore construction and commissioning. Total shutdown time remains estimated at four weeks.

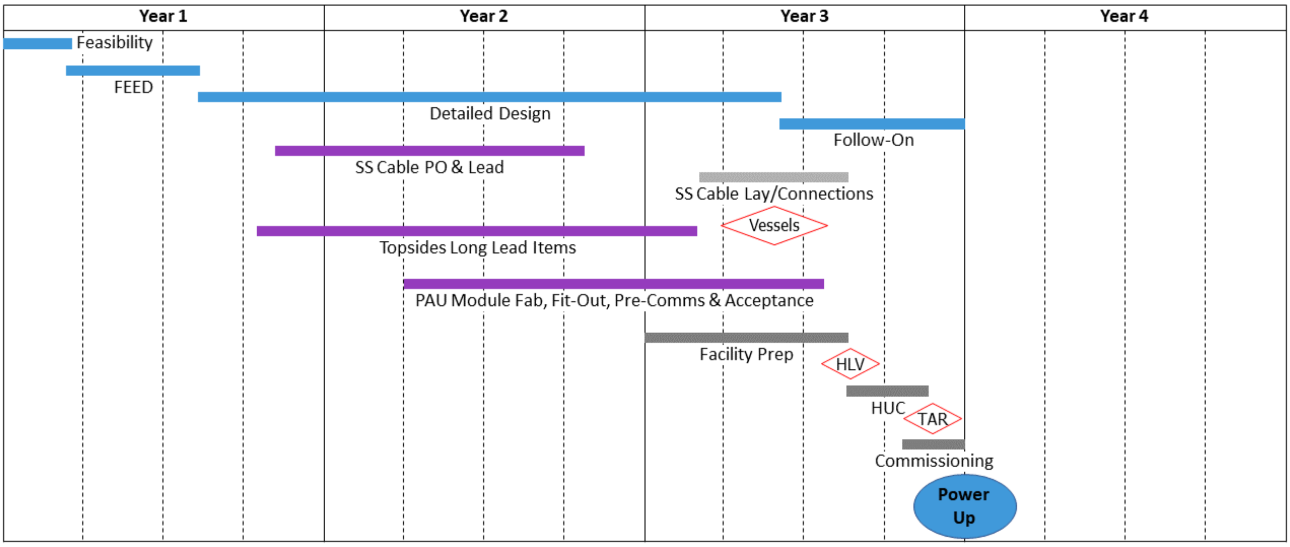


Figure 3-9: Integrated on the Platform Schedule (High Case)

As shown in Figure 3-9, the option 1 high-uptime case would follow a very similar schedule to the low-/medium-uptime case (presented in Figure 3-6). However, the key difference presented is the facility preparation period which is greater due to the installation of the new compression module. For the high-uptime case the longest lead item is the compression trains, at 18 months duration.

3.6 Technical Conclusions

For both concepts and all options, this section demonstrates that electrification of offshore O&G facilities is technically feasible. There have been significant learnings associated with Project Neos, which are important and highlighted below (Table 3-9).

Table 3-9: Technical Conclusions

Reliability and Control	Electrification of an O&G installation exclusively from an OWF without a grid connection (configured to provide electricity in low/no wind periods, or periods of OWF downtime) does not provide a reliable power supply to sustain O&G production operations. This is due to the number and duration of periods when the OWF will not be able to provide sufficient power to meet the demand of the O&G installation. This means that there is a need to retain the ability to generate power and mechanical drive to meet O&G installation power demand and maintain gas compression respectively.
	In the absence of a grid connection, electrification of an O&G installation from an OWF coupled with back up generation plus energy storage is needed to balance and stabilise electricity supply to the O&G installation.
	An energy storage solution is likely not feasible for the low uptime case due to infrastructure size and installation cost resulting from the frequency, duration and power required to meet O&G installation power demand and to maintain gas compression.
	An energy storage system which provides stability and supports the switch from renewable energy power supply to backup power generation to meet power demand and gas compression needs and/or supplement and balance renewable energy supply in low/no wind periods is a credible technical solution for electrification and decarbonisation of O&G installations. An offshore microgrid arrangement and how this can be established in an offshore setting has been identified as an area for further investigation.
	Offshore microgrids, which combine wind, GTGs and energy storage, could provide material reductions in emissions and sustain reliable O&G production operations but will require investment and control systems.
Cost	Subsea cable costs are significant. Further investigation is needed to assess reliability and availability associated with one versus two cables. O&G installations situated near OWF developments will benefit from significantly reduced CAPEX investment.
Brownfield implementation	Existing O&G installations with motor driven compressors and pumps will be easier to electrify due to the reduced platform modification scope and the associated reduced production shutdown. Conversely, facilities with GT driven compression and/or large gas turbine driven pumps will require extensive platform modifications and production shutdowns.
	Executing an electrification project for existing O&G installations will mean downtime with resulting revenue and production losses. There is a need to fully evaluate the extent of losses, optimise design, develop robust business cases, cost models, and mitigate risks.

4. Wider Industry Support – Beyond Technical Feasibility

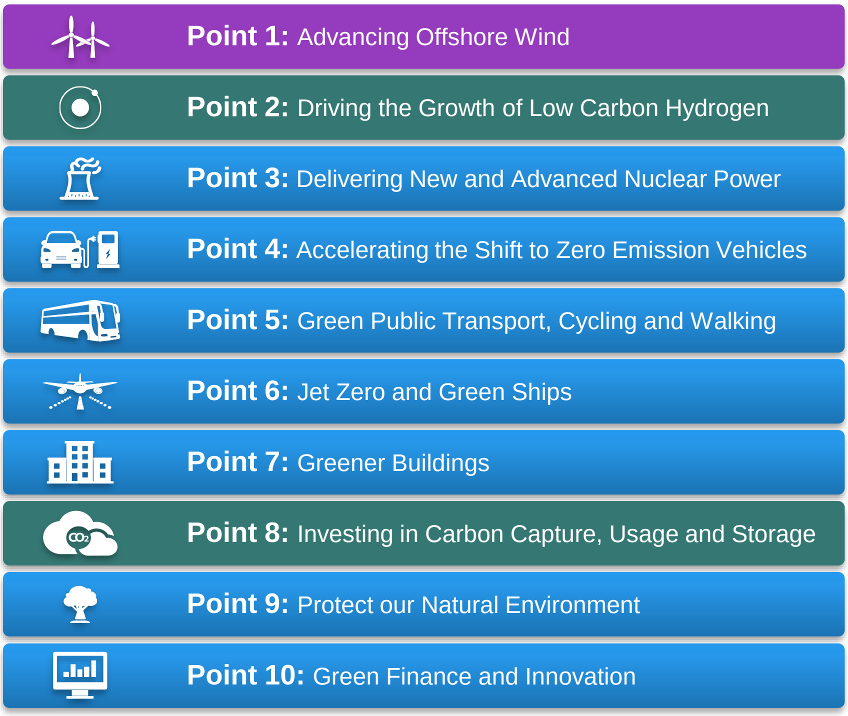
There are numerous additional factors, which are also significant in making an economic case for offshore O&G electrification through connection to OWF developments.

Further detail on these factors is discussed in this section to contextualise the technical findings of Project Neos.

4.1 Technical Next Steps

Section 3 discussed and demonstrated the technical viability of offshore O&G electrification from an OWF. However, the technical work also highlighted several areas where further study is required. The next steps and recommendations from the technical work are summarised in Section 5 below.

4.2 The Need for Policy Support



Platform electrification is supported by several key pieces of UK strategy and government ambitions, for example the Offshore Wind Sector Deal and the NSTD detailed in Section 1.1, which is imperative in underpinning the need-case for these projects. Electrification is further supported by the UK Government's Ten Point Plan for a Green Industrial Revolution. Published in November 2020 the plan aims to reduce UK total emissions by 180 Megatonne (MT) of CO_{2e} between 2023 and 2032 and to work with industry to develop further plans for Net Zero reduction by 2050.

Electrification of offshore O&G infrastructure supports Point 1 'Advancing Offshore Wind'. As discussed in Section 1.1, platform electrification introduces opportunities for infrastructure life extension through repurposing for clean energy solutions and is considered a critical first step for coordination between different types of offshore infrastructure. Platform electrification could therefore be a key enabler for offshore green hydrogen production (Point 2) and CCS developments (Point 8).

Within the UK, National Policy Statements ('NPS') are critical in project development, underpinning the need-case and supporting decisions on major energy infrastructure. The UK energy NPS are currently under review and are expected to be published in 2022.

4.3 Consenting and Leasing of Integrated Energy Projects

To facilitate offshore O&G installation electrification projects, consents to build, operate and maintain the required infrastructure will be required for each project. It is understood that the OWF infrastructure (WTGs, subsea cables, and OSS) would continue to obtain consent under the Marine and Coastal Access Act, and where relevant this would be as part of the Development Consent Order (DCO) process and be the responsibility of the offshore wind developer. Similarly, all required platform infrastructure, including any bridge link platforms which may be required, would continue to obtain consent under the Petroleum Act 1998 and be the responsibility of the O&G developer. There is no regulatory framework which allows for shared access between an offshore wind and O&G developer, or for a linear asset such as a cable to be 'split' halfway to facilitate two regimes. Therefore, it is expected that a separate consent for the two cables connecting to the platform is required to be obtained under one of the regimes.

The GREG is expected to report on the enduring consenting and leasing regime regarding the electrification infrastructure which will be required for each project. The consenting and leasing regime is anticipated to be relevant to the offshore electrical infrastructure (the cables connecting OWF to O&G installation) for both brownfield and greenfield sites, both of which have associated challenges regarding consenting:

- **Brownfield:** Existing developments will have their generation consents in place and therefore additional electrical infrastructure, and associated spatial extension of the consent limits, would mean material amendments to the generation consents of either the offshore wind or O&G operator. This is not an appropriate solution as it opens the generation consents to challenge and introduces risk to the security of the consent which is unlikely to be taken forward by developers as a reasonable option. It is imperative that the consenting approach to brownfield projects does not introduce significant risk to the existing generation consents held by O&G installation and OWF and does not result in protracted consenting timelines which may impact projects undertaking early future-proofing activities and further minimising remaining field life related to the business model development.
- **Greenfield:** If an OWF and O&G operator agree to future-proof generation consents and include electrical infrastructure within the design envelope prior to the consent application, guidance is needed as to which regime this connecting infrastructure would fall under which the GREG is expected to report on. It is important to note that due to differing development timescales, it is likely to be challenging to secure all necessary consents alongside the generation consent and it is therefore expected that the connecting electrical infrastructure will still be consented as a separate piece of infrastructure which would be obtained later than the generation consent. The enduring consenting and leasing regime will require substantial consideration and consultation with industry prior to deployment. While ensuring an enduring regime that is fit for purpose is critical, this process should not impede short term delivery of electrification projects as the technical learnings these early projects will facilitate are critical to future energy systems integration.

The regime promoted by the GREG must acknowledge potential differences in preference between the O&G and OWF partners in terms of ownership of the consent, responsibilities for installation and / or operation and maintenance of the cables.

The GREG is similarly expected to report on the requirement for a seabed lease for the connecting cables from The Crown Estate (TCE), and any associated timelines for this activity.

4.4 Contracts for Difference

The CfD scheme is government's main mechanism to support low carbon generation in the UK. The CfD is a private law contract between a low carbon generator and the Low Carbon Contracts Company (LCCC), a government owned company. It enables the CfD holder to benefit from stabilised revenue over the term of the contract. The majority of inflight OWF projects rely on the CfD as their main source of revenue stability as it de-risks multi-billion GBP CAPEX-investments by providing contracted income at a fixed price.

It is the intention of Government policy (Department of Energy & Climate Change, 2014) to support eligible low carbon electricity generation operating on a "private wire" network. This type of private wire allows for direct connection to an electricity consumer without using any wider transmission infrastructure, and therefore could be applicable in the context of platform electrification from an offshore wind farm. Provisions and precedent relevant to such arrangements exist within the CfD Private Network Agreement (Low Carbon Contracts Company, 2021). The document also sets out the Metering Operational Framework and Technical System Requirements which are also needed to provide the contractual and operational framework for Private Network Generators to participate in the CfD scheme.

However, this type of private wire arrangement has not been implemented before in the context of offshore wind connecting to an offshore consumer and confirmation from LCCC is required that a private wire arrangement does not conflict the principles of the CfD and the associated terms and conditions.

4.5 Supporting the Business Case for Electrification

4.5.1 Anticipatory Investment

Reviewing OWF project development timelines against the NSTD decarbonisation targets and understanding the critical development and construction milestones set by (for example) the CfD contract, it is clear to see that there is misalignment between inflight OWF projects that can provide electrification and the decision-making timeline to secure electrification by offshore O&G operators.

This misalignment means that it would be easy for electrification opportunities to be missed because the OWF has passed critical decision milestones and cannot adapt their design or procurement schedule. The misalignment between the NSTD targets for reduction and OWF leasing are illustrated in Figure 4-1 below.

To achieve the 25% and 50% NSTD targets in 2027 and 2030 respectively, anticipatory investment in Allocation Round 4 and Allocation Round 5 projects could be possible. However, it is likely that these projects are very mature in their detailed design and likely to be close to or have passed FID, meaning that changes are very challenging to implement. Without intervention such as anticipatory investment support, this could become a barrier to entry for such electrification opportunities.

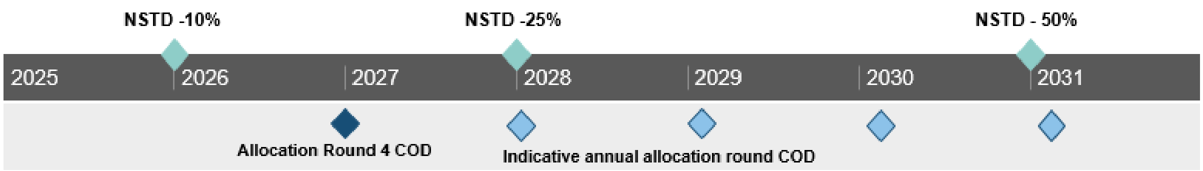


Figure 4-1: NSTD Targets and OWF Allocation Rounds[18]

4.5.2 Power Purchase Agreements

A corporate power purchase agreement (cPPA) is an agreement between an electricity generator and a purchaser of electricity. It is a commercial agreement between the two parties which includes terms for the purchase of electricity, commencement of operations, schedule for deliveries, penalties for failure to deliver, payment terms, and termination. There are several different types of PPA.

A direct wire PPA involves a direct physical connection between the generator and consumer of electricity. Electricity is supplied without using the transmission and distribution systems and can be supplied behind the meter avoiding variable commodity costs. Direct wire PPAs also mean there is no need for an agreement between the consumer and an electricity supplier, rather, the agreement is established directly between the generator and consumer. A direct wire PPA associated with a platform electrification project must be considerate of the remaining field life of an O&G installation.

4.5.3 Carbon Price Uncertainty

Carbon price has been volatile, and decarbonisation projects rely on avoided carbon emissions taxation to support project investment decisions. In 2021/22, there has been a marked increase in carbon price in the UK since establishing a UK ETS following Brexit (Figure 4-2). The UK ETS has also established a price floor of £22/tonne (~€26), which provides a minimum carbon price for abatement of CO_2 emissions. The price floor is based on average prices for allowances under the EU ETS over years 2019 and 2020.

[18] Allocated rounds based upon indicative timeframe.

However, this floor price is very low compared to the high CAPEX investments required for electrification projects.

The future of the UK ETS is uncertain, and as a result carbon price forecasting accuracy is difficult to ensure. In March 2022, BEIS released a consultation on the future of this regime, which addresses design features such as price limits and allocation of carbon allowances. Changes to the regime that are implemented following this consultation could provide a solution to this uncertainty.

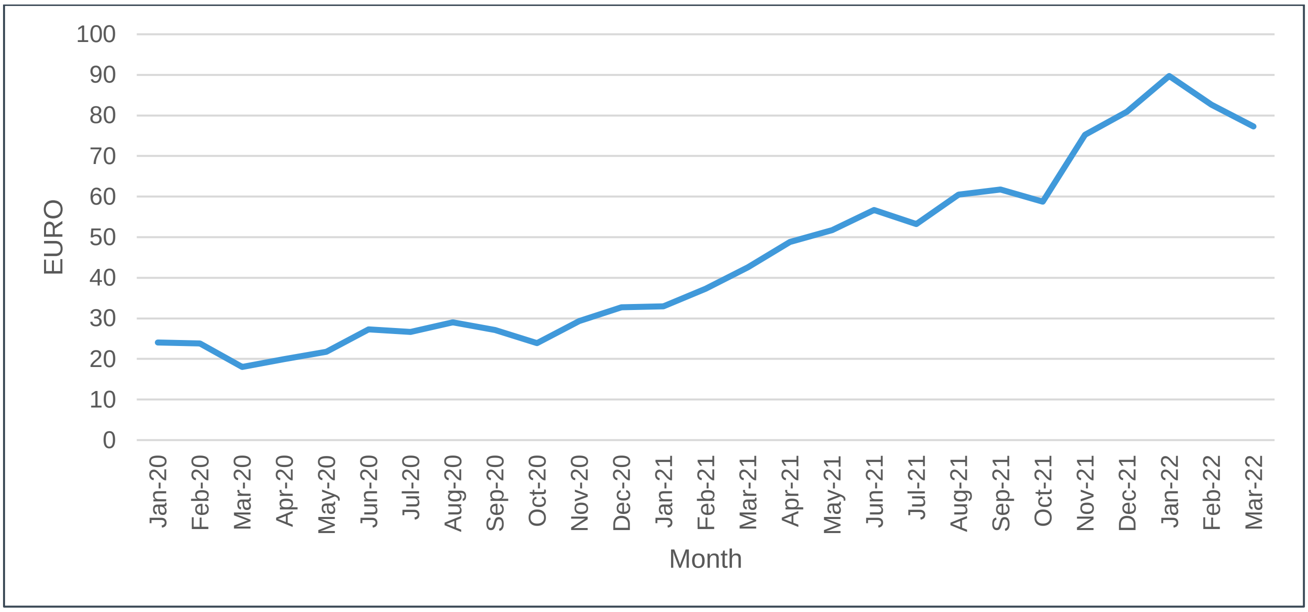


Figure 4-2: UK Allowance Price[19]

4.5.4 Carbon Accounting

Furthermore, platform electrification with renewable energy will allow for the quantification of greenhouse gas emissions from the relevant parties' activities under the GHG Protocol carbon accounting. The O&G platforms will be able to account for reductions in Scope 1 (direct emissions from energy generation/operations) and Scope 2 (indirect emissions from the generation of electricity purchased) respectively.

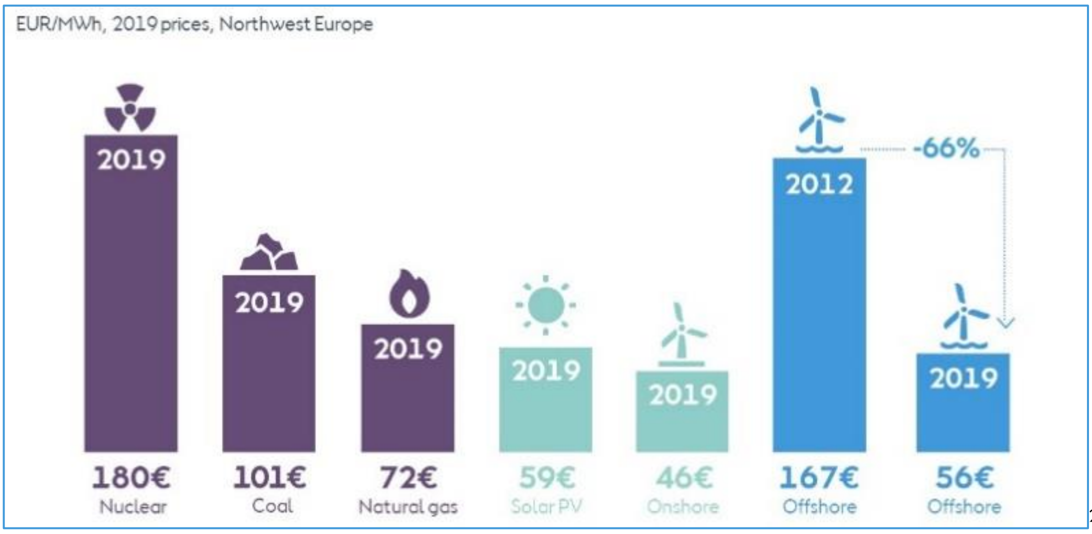
There will be a reduction in Scope 1 emissions from direct combustion of natural gas for power generation and gas compression because of importing electricity from renewable energy. For corporate reporting, the only factor available assumes that Scope 2 emissions associated with import of electricity is sourced from grid electricity, which is a mix of all energy generators into grid electricity. Using the grid electricity factor and applying this to energy imported directly from an OWF is not an accurate representation of Scope 2 emissions exclusively from wind power generation. It is likely that wind power generation will be reportable as zero because CO_2 emissions are zero at the point of origin. Clarity on the understanding of the business value for avoiding or reducing scope 2 emissions could help to strengthen the business case supporting investment decisions.

[19] Investing.com at https://uk.investing.com/commodities/carbon-emissions-historical-data

5. Conclusions and Next Steps

5.1 Conclusions

Globally, the UKCS has one of the largest portfolios of OWF projects in various stages of development and construction. Next to onshore wind, OWFs now have the lowest Levelized Cost of Energy (LCoE) (Figure 5-1) and are already cost-competitive with every other source of UK power, demonstrated in the figure below. In addition, OWFs often are, or will be, located at relatively short distances from O&G installations, improving the business case for the connection for offshore offtake.



[20]

Figure 5-1: LCOE Comparison

Accessing this lower cost renewable energy in proximity to existing O&G installations is critical to the O&G industry reaching its NSTD targets and supporting the UK's transition to NetZero.

Project Neos has demonstrated the technical feasibility of the electrification of an O&G installation utilising an OWF to provide electricity. However, the OWF is not suitable in isolation and there is a possibility to implement a more sophisticated hybrid model using existing back up power generation through energy balancing technologies, such as energy storage operated as an offshore microgrid. This is needed to provide stability, balancing during times of low and no wind, and aid transition between generation sources and modes of operation during low and no wind periods.

The data presented in this section demonstrates that in many situations, platform electrification can be viable, however would need to have certain parameters related to max CAPEX circa £65m, relevant to the OPEX associated with this project i.e., circa £7.5m/yr., which includes O&M or direct OPEX, the cost of purchasing electricity (the PPA), and savings from not consuming gas for power generation. However, other significant influencing factors are carbon price and the robustness of carbon price forecasting as well as remaining field life.

Financial feasibility of an electrification project is reliant on several factors, such as CAPEX and OPEX limits. These limits in today's economic climate are challenging e.g., projects which require BLPs to house equipment and installation of redundancy into infrastructure. The study indicates that facilities with < 10 yrs remaining field life are not financially viable projects. However, high gas and carbon prices, as well as opportunities for field life extension can strengthen business cases. There are also opportunities to convert CAPEX to OPEX as tariff payments, as well as structuring PPA pricing; these should be investigated further.

[20] Source: BloombergNEF – 1H 2019 LCOE Update, current LCOE. and Ørsted Calculation.

Electrification of O&G installations in a microgrid arrangement would significantly reduce emissions but not eliminate them. There will be a continued need to ensure back up power generation and compression on installations to maintain production, which would be achieved by switching to fossil fuel for energy. However, in context, this switch to fossil fuel energy would be for a very small amount of production time (12.4%, see **Section 3.3.2**). Removing fossil fuel energy entirely would rely on being able to switch to alternative sources of low carbon fuel such as hydrogen or e-Fuels during low and no wind periods, however the assessment of this was out with the scope of this study and is not a proven feasible solution at the time of writing.

Project Neos has:

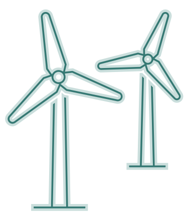
- Evidenced a real-world view of power availability, load factors, and impact on production availability to an O&G installation.
- Demonstrated that electrification of an O&G installation from OWF does not provide a reliable enough power supply for 100 % uninterrupted supply and presented mitigations to achieve reliable power supply.
- Evidenced rationale for an offshore microgrid solution where systems work effectively across sector boundaries between existing power generation and gas compression equipment.
- Enhanced understanding of brownfield modifications and greenfield development options (OWF and O&G installation).
- Established indicative schedules for electrification of existing O&G infrastructure.
- Increased cross-industry collaboration and developed imperative skills in integrated energy developments.

The conclusions are intended to support planned and in-progress electrification projects. There is sufficient confidence in the feasibility of OWF for offshore O&G installation electrification to support further work, development of commercial mechanisms, and regulatory structures to encourage such developments.

5.2 Suggested Next Steps

Project Neos highlighted several areas for further work. These have been categorised and presented as follows:

- **Project specific**: There are several 'quick wins' which industrial partners would be expected to progress as part of a joint electrification project development.
- **Joint industry**: Areas highlighted requiring more detailed investigation which would be applicable to any offshore electrification project.
- **Regulatory**: Issues and development led by the NSTA or other relevant government bodies where clarity or consideration is required. These are provided in **Section 4** and summarised below.

Project Specific	
	**Project Neos learnings:** Present the results of the NSTA decarbonisation competition for the electrification of offshore oil and gas installations[21] to the industry, facilitating knowledge sharing and ensuring any ongoing or future electrification initiatives can leverage the technical findings of Project Neos for their respective concept select work.
	Integration to 'in-flight' OWF project: Investigate procurement timelines and key decision gates are aligned to enable the platform electrification technical solution. Consideration of future proofing investments may be required to ensure procurement timelines are not prohibitive to realising platform electrification.

[21] North Sea Transition Authority (NSTA): £1million decarbonisation competition for the electrification of offshore oil and gas installations - 2021 - News - News &
publications (nstauthority.co.uk)

Project Specific

PPA structuring: Further development of PPA structuring, including point-to-point single offtake solutions that likely have mismatches in tenure versus remaining O&G field-life, the associated risks with this and how they can be mitigated.

Investigate grid back-feed: via the OWF and determine any technical issues or limitations, the potential regulatory challenges that may occur because of such a non-standard configuration, interfaces to the Offshore Transmission Owner (OFTO), and the impact on electricity costs due to importing at higher priced periods and incurring Transmission Charges.

Brownfield modifications: Further assess extent, optimal design, costs, and potential downtime/risks resulting from implementing platform electrification.

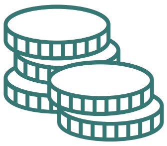
Level of electrification achievable/required: Consideration of short term versus long-term (repurposing) including plant and processes which could be converted to electric, base power levels and redundancy needs. Redundancy needs will require consideration regarding whether one or two cables represent the viable technical solution.

Joint Industry

End-to-end Availability & Reliability Study/FEED: A full FEED study is required to assess levels of back-up generation and supporting technology such as energy storage solutions required to maintain stable operations/production (managing within hour/minute variability on load and production sides).

O&G operating procedures/processes: Assess changes to operations that would enable electrification whilst ensuring high uptime/production, with specific reference to battery storage solutions and levels of back up generation.

Integrated solutions: Combining the three 'NSTA decarbonisation competition' enabling projects[22] to assess end-to-end solution opportunities.



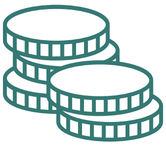
Energy transition opportunities: investigate future offshore power demand through the transition of assets to new operational activities, such as hydrogen production and CCS, to map further potential OWF offshore offtake opportunities.

Regulatory

Lease and consenting regime: The Government and Regulators Electrification Group (GREG) should provide clarity of the enduring regulatory and consenting regime. It is imperative that the consenting approach to brownfield projects does not introduce significant risk to the existing generation consents held by O&G installation and OWF and does not result in protracted consenting timelines which may impact projects undertaking early future-proofing activities.

Clarity is required regarding the applicability of a **seabed lease from TCE** and timelines for connecting infrastructure should a lease be required.

[22] North Sea Transition Authority (NSTA): Three winners named for £1m offshore electrification competition - 2021 - News - News
publications (nstauthority.co.uk)

Regulatory	
	Need for policy support to underpin project need-case and support decision making on consent applications for platform electrification infrastructure.
	**Clarity on future carbon pricing:** Confirmed retention of an ambitious UK-wide carbon floor price compliant with Net Zero, to enable and incentivise investment decisions and commercial agreements.
	Anticipatory Investment recovery model: Support to enable retrofitting of brownfield projects to make minor infrastructure investment decisions, which would enable future electrification opportunities.
	CfD regime clarification: LCCC confirmation required that Behind the (CfD) Meter supply of electricity to offshore offtakers does not conflict with the principles of the CfD and the associated terms and conditions.