Oil & Gas Authority

UKCS Energy Integration

Final report

Annex 1. Offshore electrification

Department for Business, Energy & Industrial Strategy

THE CROWN ESTATE

ofgem

August 2020

UKCS Energy Integration project

Oil & Gas Authority

Funded by £900k grant from the Better Regulation Executive's Regulators' Pioneer Fund

Led by Oil & Gas Authority

in collaboration with

Department for Business, Energy & Industrial Strategy

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- Engaged widely across industry and regulators
- Understood potential of UKCS assets and technologies for net zero, and synergies across the different energy sectors
- Identified hurdles (economic, regulatory) and recommend avenues to realise full technologies' value

Project timeline

1. **Technical options** *1Q-2Q 2019* — Lloyd's Register
2. **Economic and regulatory assessment** *3Q2019-1Q2020* — EY
3. A **Phase 3** is proposed to follow to implement recommendations, accelerating UKCS energy integration projects

This document is an annex to the final report of the UKCS Energy Integration Project available on the OGA web site.

This annex should be read in conjunction with the assumptions and notes contained in the main report.

Information and findings in this Annex should be considered in the context of ongoing Government regulatory and policy frameworks related to offshore renewables, referenced in the Appendix.

Contents

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Offshore electrification – summary

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- The O&G industry could significantly reduce GHG emissions (by ~2-3 MtCO2e pa) by sourcing power for its UKCS platforms either from the shore or from offshore renewables
- Economics of converting existing platforms (brownfield electrification) could potentially be improved through cross-industry projects which supply power from offshore windfarms
- CO_2 abatement costs in the range of £23-43/tonne could be enabled by these synergies, making electrification potentially attractive compared to other options to reduce emissions
- Electrification of newbuild platforms (greenfield) would be more attractive (£6-15/tCO_2) due to Capex savings from platforms equipment simplification
- The Windpower sector could accelerate its growth by supplying ~6.5TWh pa of electricity to O&G installations, and by reducing development costs sharing electricity transmission infrastructure
- Cross-industry projects would need to be consented over the next 3-5 years to match the O&G opportunity timelines
- There may be project opportunities already in the planning phase and which could be accessed soon, as well as potential regulatory pathways for windfarms dedicated to O&G

Offshore electrification – findings

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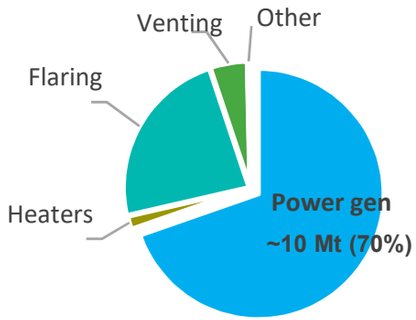
Electrification is an essential response by O&G industry to Net Zero

- Abate power emissions from O&G platforms (~10 MtCO2 , 70% of offshore emissions or 10% of total UK energy sector)
- Extend operating life of existing assets and achieve cost efficiencies in the development of new oil and gas fields
- Economics critically depend on electricity and carbon pricing - power from UK shore would be unattractive at current prices
- Joint projects to share infrastructure and sourcing power directly from offshore windfarms can significantly improve economics

Opportunity to accelerate offshore windpower growth

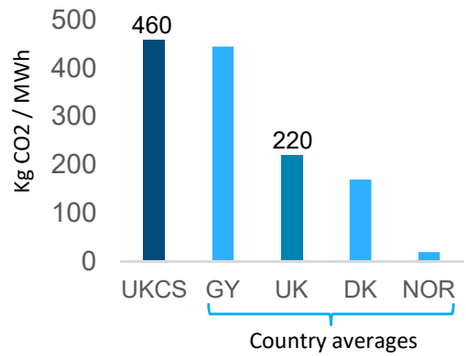
- Large growth of offshore windpower expected (~75GW by 2050)
- Expansion in new areas (eg Scottish waters) with favourable wind conditions but water depth and infrastructure challenges
- Energy supply to O&G platforms could represent a commercial opportunity for renewable power developers today
- Co-investing in transmission infrastructure and leveraging O&G deep-water technologies could support growth

UKCS O&G emissions (14MtCO$_2$e)



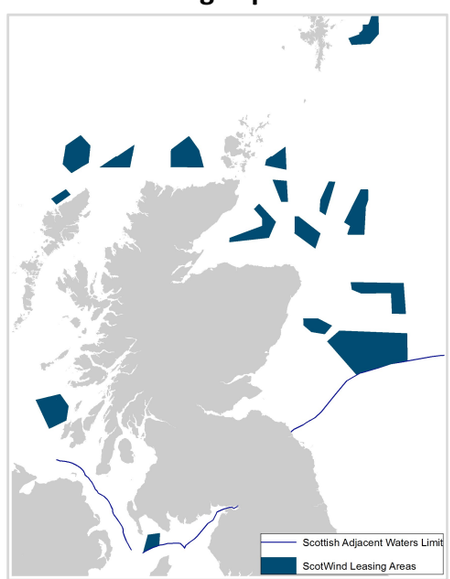
Source: EEMS 2018, EIP

Carbon intensity of power generation



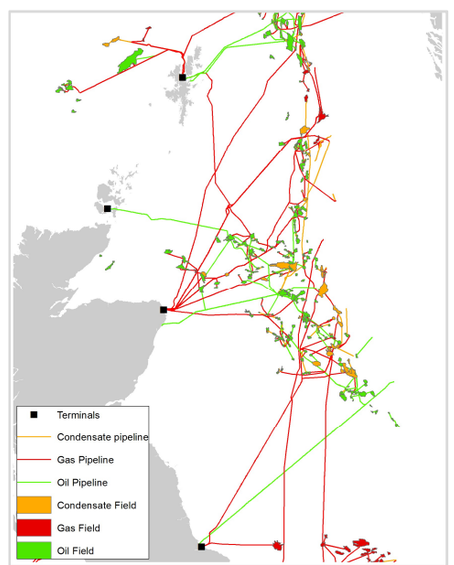
Source: EIP *GY – Germany, DK – Denmark, NOR – Norway*

ScotWind Leasing expansion



Source: CES

O&G fields and infrastructure



Source: OGA

Offshore electrification – recommendations

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1: Industry should engage and collaborate on electrification opportunities across energy sectors

- Sourcing electricity for O&G directly from offshore renewables to reduce project lifecycle costs
- Consider hybrid schemes that are Capex-efficient, e.g. partial platform electrification, with gas-to-wire generation capacity to provide power continuity and optimise (or avoid) link to shore
- Engage developers of interconnectors for access to international supply options (e.g. Norway) and sharing of transmission infrastructure
- Investigate wider industry participation (supply chain, and midstream) to improve projects' economics

2: Government should consider measures to promote investments in offshore electrification, e.g.

- Energy-intensive industry (EII) tariffs exemption for offshore users
- Carbon price on offshore power emissions more in line with onshore
- Enabling sharing of offshore electricity infrastructure and anticipatory investments

3: Enhanced regulatory coordination to facilitate cross-industry projects

- Align planning and consenting regimes to support cross-industry developments (O&G and windpower)
- Regulatory coordination to expedite industry projects

Enhanced coordination in offshore electrification[1]

Vision: Enable offshore electrification to reduce O&G industry GHG emissions and accelerate offshore windpower growth in the 2020's. Proactively support industries connecting and facilitate joint projects.

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1) Composition and vision of proposed 'coordination groups' yet to be agreed with relevant stakeholders

UKCS electrification opportunity

Power generation by the O&G sector

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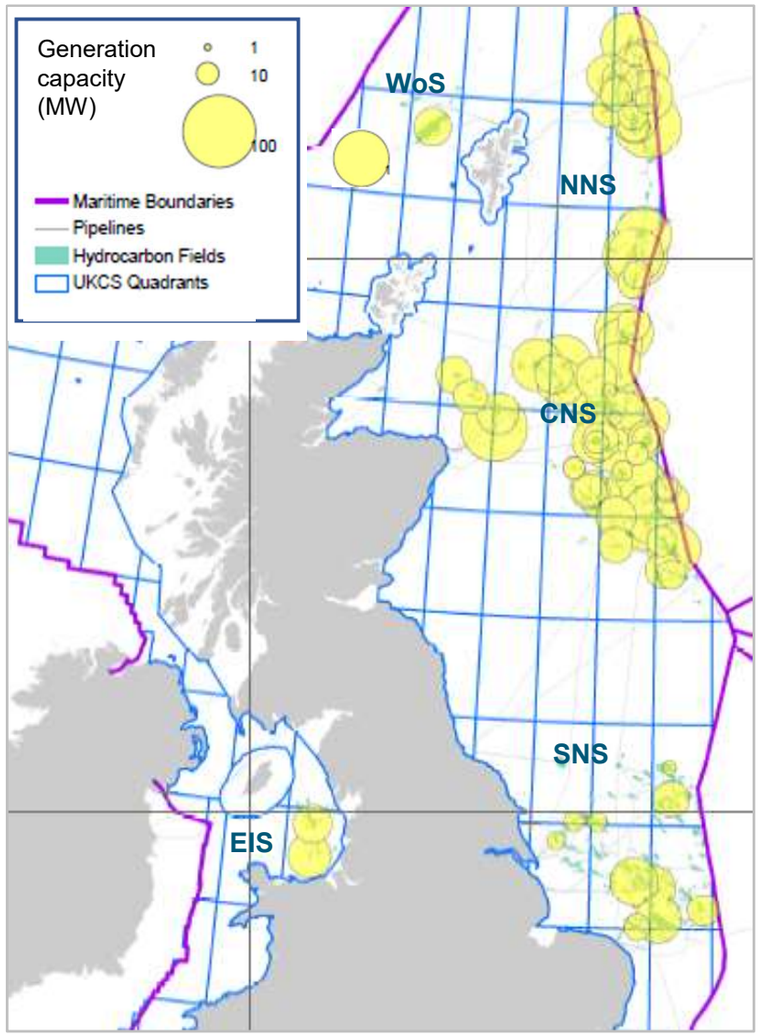
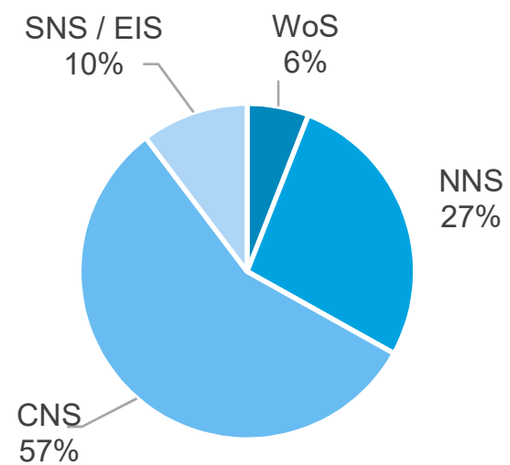
Generation capacity[1] by O&G installation



2018 power production[1] by area (Total ~21 TWh)



A total of ~21 TWh/year of power[1,2] is generated offshore, from gas or diesel turbines, and diesel engines on O&G platforms and floating facilities

- 57% of power consumption is in **CNS**, likely to continue into the 2040s due to asset longevity
- In **NNS, SNS and EIS,** power usage is expected to decline faster
- **WoS** power demand is expected to grow with new assets planned

On a UK scale[3], O&G offshore power production is significant:

- ~6% of UK generation in 2018
- Equivalent to the domestic electricity consumption of a region the size of Wales
- Comparable with the total windpower generated on the UKCS in 2018 (26.6 TWh)

1) Based on 2018 O&G installation emission data (BEIS EEMS) and typical emission intensities and uptime for the generation equipment employed

2) The total figure (estimated for 2018) includes electricity generation and mechanical drive for compressors and pumps

West of Shetland (WoS), Northern North Sea (NNS), Central North Sea (CNS), Southern North Sea (SNS), East Irish Sea (EIS)

3) Based on data from BEIS and Office for National Statistics

O&G power emissions

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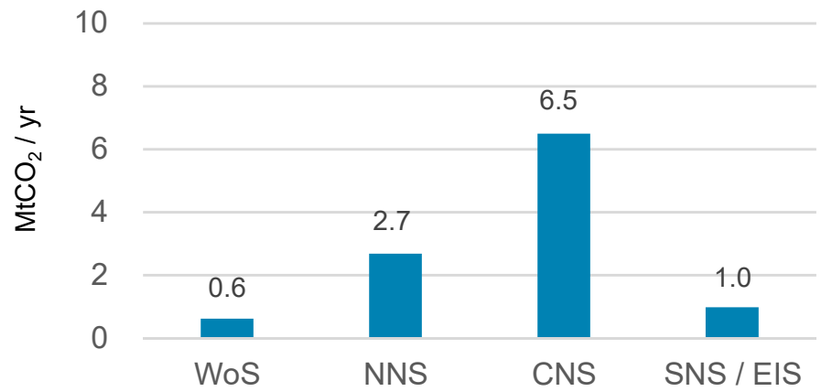
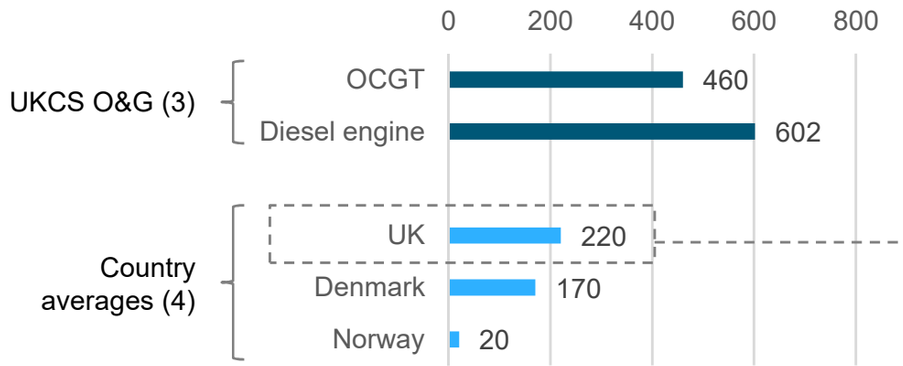
UKCS power emissions[1] (Total ~10 $MtCO_2e$)

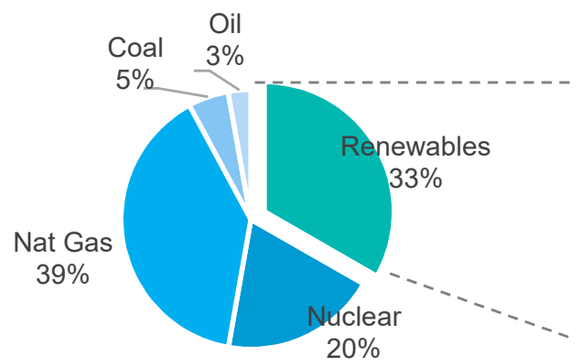


- Power generation accounts for **~10$MtCO_2e$ of GHG emissions**[1], ~70% of total offshore O&G emissions[2]
- These emissions are **significant on the overall UK scale:**
  - ~11% of the total UK energy supply sector[5] (due to the higher carbon intensity of offshore O&G generation vs. UK average)
  - Equivalent to ~88% of onshore industrial emissions in Scotland[6]

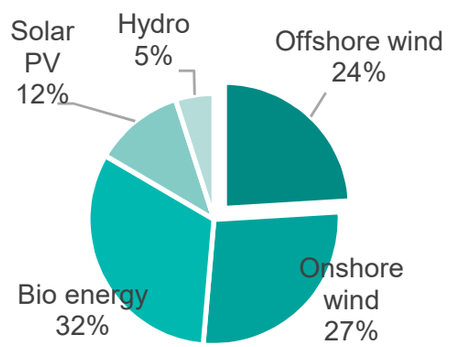
Carbon intensity of power generation ($kgCO_2/MWh$)



UK power generation mix in 2018[7]
100% = 334 TWh



UK renewables mix in 2018[7]
100% = 111 TWh



1) Based on 2018 O&G installation emission data (BEIS EEMS)
2) See chart on page 4
3) Typical emission intensities of offshore power equipment (EIP)

4) 2018 country averages from BEIS and IEA, 5) BEIS GHG emission national statistics,
6) SEPA data of 2018 Scottish industrial emissions, 7) BEIS energy statistics

O&G electrification potential

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- Offshore power emissions can be abated by phasing out thermal generation and supplying power via cables (electrification)

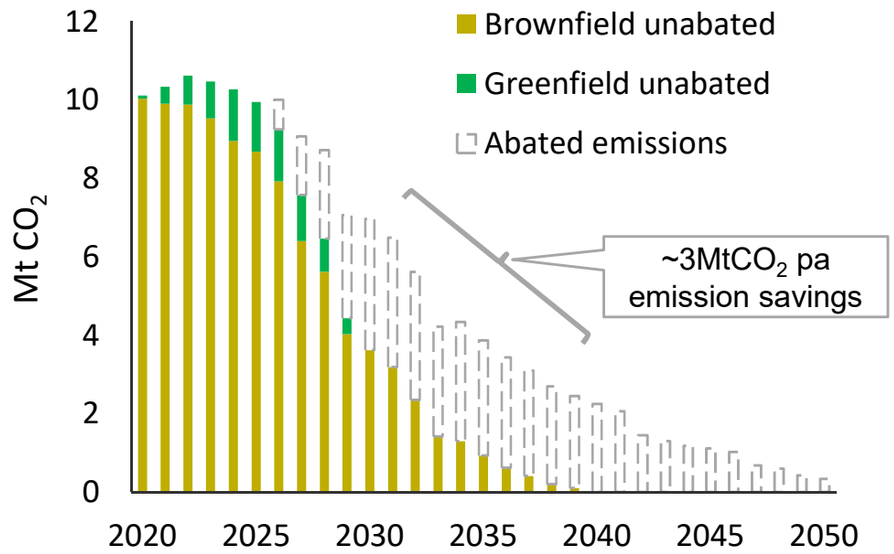
Brownfield electrification

- A significant portion of UKCS future O&G production is expected from fields and installations already existing[1]
- Electrification of the large platforms with long residual life is key for the sector overall emission abatement
- Additional benefits are safer offshore operations, reduced maintenance costs, and avoiding replacement of generation equipment, less reliable after a long service life

Greenfield electrification

- The UKCS has over 5bn BOE of hydrocarbon resources being considered, or yet to be considered, for new developments[1]
- Electrification of newbuild assets would support simpler installation designs, savings on equipment Capex, and it would not require brownfield modifications

Potential emission reductions from O&G power generation (EIP scenario)



Assumptions

- Brownfield electrification of ~14 existing platforms during the 2020s, with average power emissions ~150ktCO_2 p.a. and remaining life >2030
- Progressive electrification of greenfield developments during the 2020s

1) *Without considering future exploration findings, the OGA estimated UKCS hydrocarbon resources of 7.8bn BOE in developed reserves and contingent resources in already producing fields, and 5.2bn BOE of contingent resources in proposed new developments and other marginal discoveries (OGA, UK Oil and Gas Reserves and Resources, July 2019)*

UKCS windpower growth

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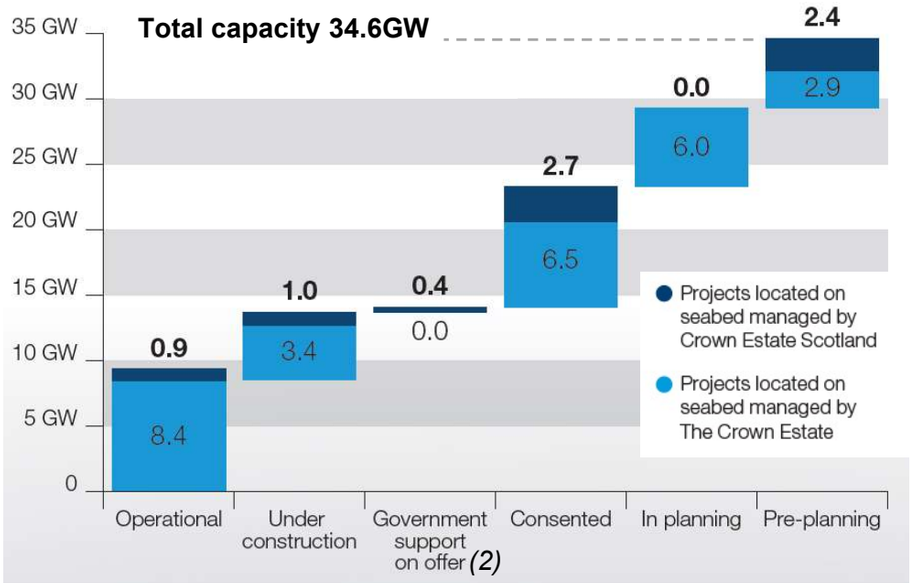
UK offshore windpower portfolio (as of Aug 2019)[1]

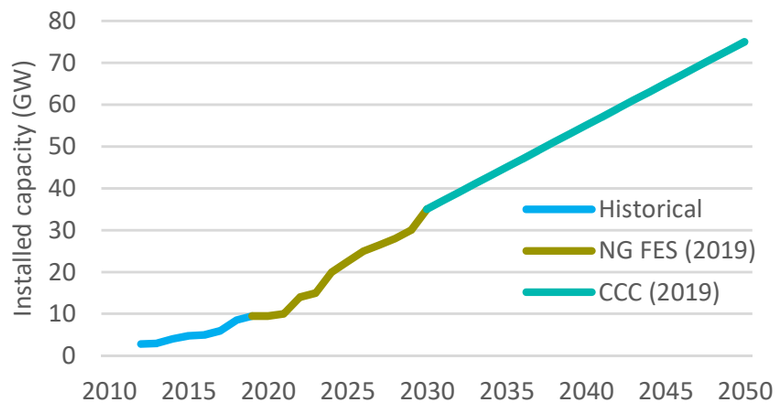


- Strong growth in UKCS windpower[3] to 9.3GW since the 2000s
- Strong pipeline of project opportunities for additional 25.3GW:
  - 4.4GW sanctioned and under construction
  - 9.6GW consented but not sanctioned
  - Further 11.3GW in earlier planning phases

Further potential expansion

- TCE Offshore Wind Leasing Round 4 is targeting between 7 and 8.5GW of capacity (opened in October 2019)
- CES ScotWind Leasing is targeting up to 10GW of capacity (opened in June 2020)
- NG FES 'Two Degrees' case (2019) implies offshore windpower generation of 210TWh p.a. by 2050 (or 60-70GW capacity)
- CCC indicated the need for 75GW of offshore windpower capacity to achieve net zero (2019)

Potential growth in UK offshore windpower capacity



1) *TCE, Information memorandum: Offshore Wind Leasing Round 4 (Sept 2019)*
2) *Chart does not include results of the Contract for Difference Round 3, announced in Sept 2019, which has awarded support to additional 6.5GW capacity in six windfarms*

3) *UKCS is the largest offshore windpower basin with 35% of wordwide capacity installed (end of 2018, source International Renewables Agency)*

See appendix for acronyms, further references and assumptions

Windfarm expansion areas

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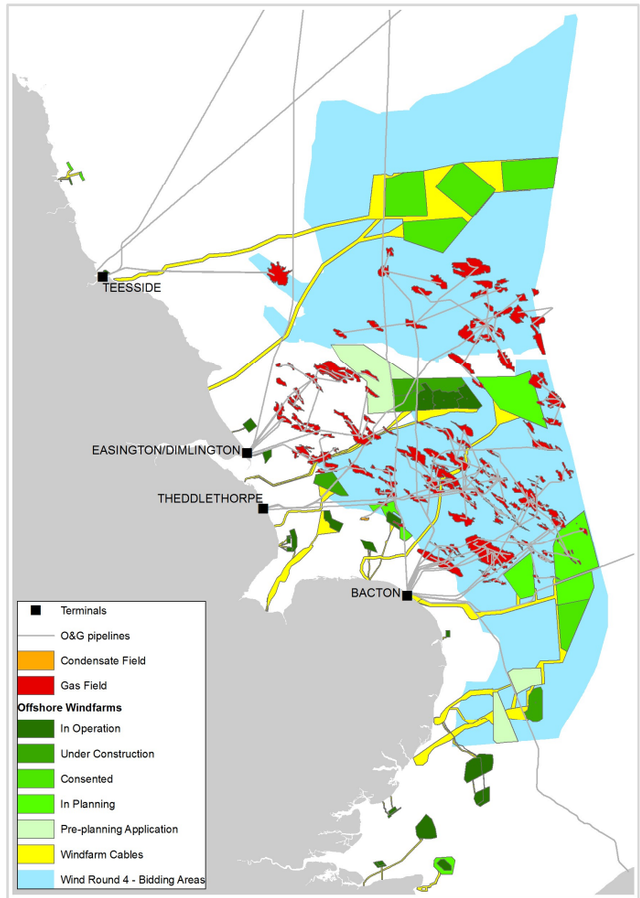
Southern North Sea and Irish Sea

- Current windfarm projects are near areas of O&G operations
- Round 4 will have greater overlap with current O&G areas
- Anticipated need for significantly more transmission infrastructure to land the new offshore windpower

Scottish waters

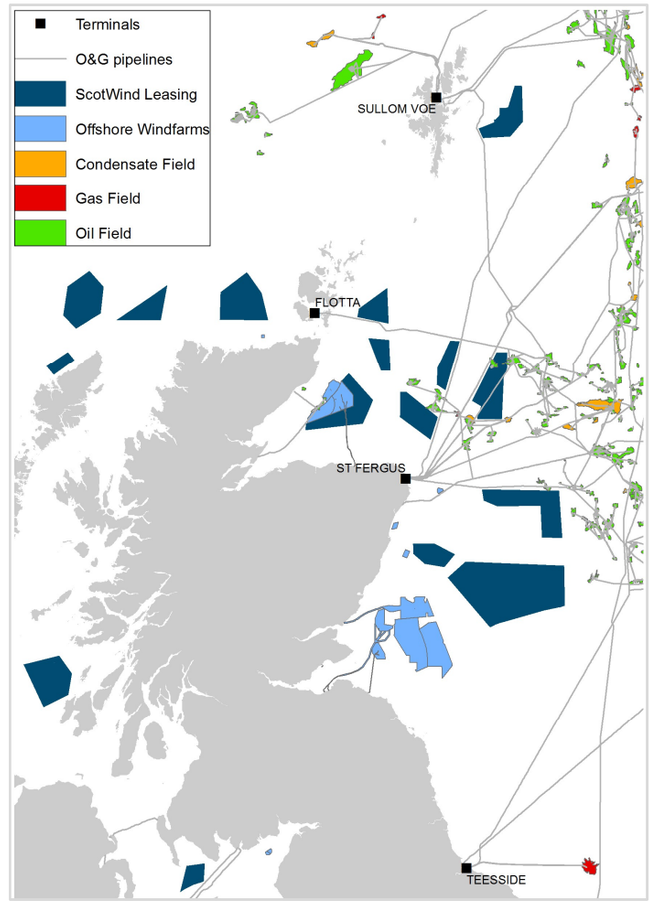
- Current wind project pipeline (6.5GW, with ~1GW under construction) is in areas nearer to shore
- ScotWind Leasing round targets areas closer to O&G installations
- New acreage in regions with stronger windspeed and deeper water (potential for floating wind)

Windpower and O&G in SNS



TCE data and OGA Digital Platform

Windower and O&G in Scottish waters



CES data and OGA Digital Platform

Cross-industry synergies

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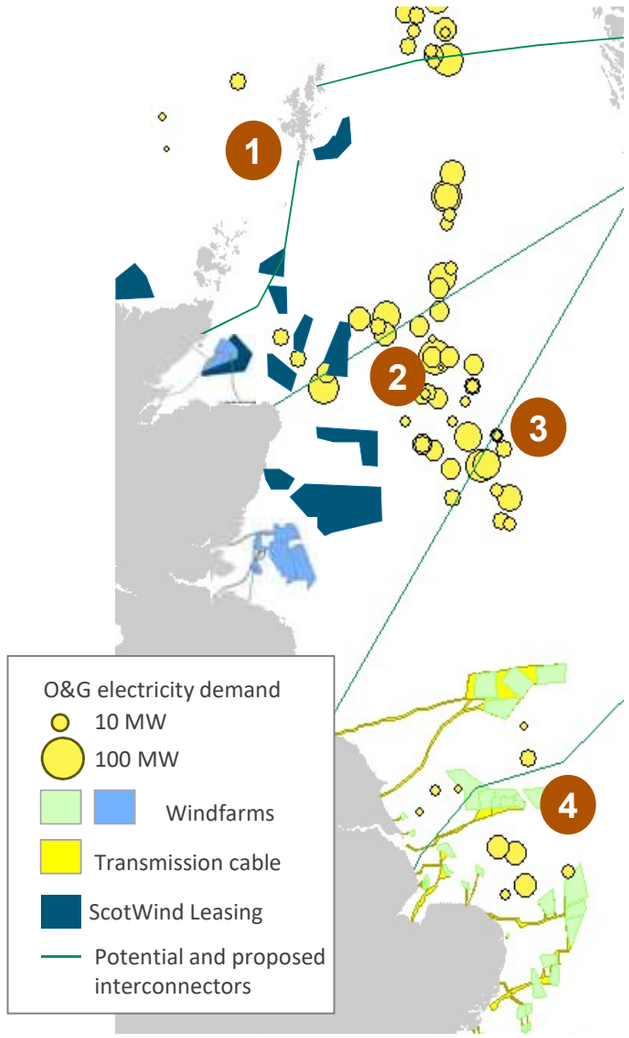

CES and TCE data and OGA Digital Platform

Opportunity examples

1. Windpower supply and transmission link with the mainland would enable electrification of greenfield O&G projects West of Shetland
2. Brownfield O&G electrification in Outer Moray Firth could be combined with windpower developments in the area, and ScotWind Leasing opportunities
3. Electrification of Central North Sea platforms at a greater distance from the UK shore could potentially benefit from cross-border power supply and floating wind
4. Several cross-industry opportunities in the Southern North Sea, due to closer proximity between windfarms and O&G operations, and Round 4 future expansion

Potential synergies

- O&G access to lower-cost electricity directly from offshore windfarms, creating commercial opportunity for wind developers to expand
- Sharing of investment in transmission infrastructure between O&G and renewables (and potentially also with interconnector projects)
- Reuse O&G infrastructure (eg. platforms for electricity transmission equipment, and onshore terminals as onshore bases)
- Gas-to-wire[1] to potentially help balancing electricity supply and increase cables utilisation

1) Offshore thermal generation using marginal gas resources, potentially sharing cables with windfarms to export power to shore. Industry is looking at combination with CCS technology to abate emissions, storing the CO2 in the offshore reservoir

Economic findings

Economic analysis

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- **EIP has considered notional projects to illustrate the key economics drivers of offshore electrification**

Brownfield electrification

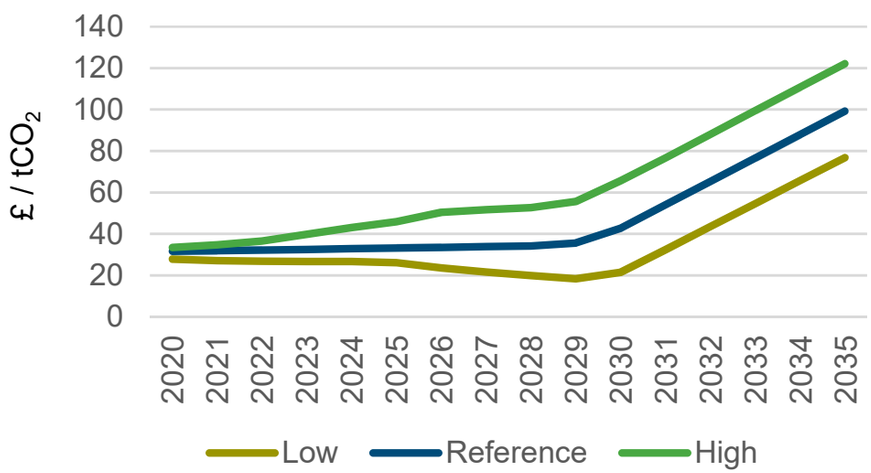
- Seven CNS platforms are converted to external power supply, for overall emission abatement of 1.7MtCO_2 pa
- Key economic driver is electricity sourcing, modelled either as from UK shore, cross-border from Norway, or directly from an offshore windfarm
- Additional sensitivities considered are costs of transmission infrastructure and brownfield modifications

Greenfield electrification

- Four newbuild O&G platform are designed to be powered via cables from either the UK shore or a nearby windfarm
- Overall emission abatement of 0.7MtCO_2e

- Models results are presented in terms of:
  - Project Benefit-Cost Ratio[1], to allow comparison among electrification options
  - Levelised cost per tonne of CO_2 abated, to allow comparison with other types of GHG abatement investments
- The carbon tax level was assumed as per the reference case of BEIS energy price projections (chart below)

Carbon prices projections[3]
(Electricity supply sector, inclusive of EU ETS and UK CPS)



Methodology and assumptions are described in appendix

1) *Benefit-Cost Ratio: ratio between discounted project benefits and initial Capex invested*
2) *Discounted project cash flow (before avoided carbon taxes) divided by the undiscounted tonnes of CO_2 abated during the project life*

3) *BEIS Updated Energy & Emissions Projection - Annex M (May 2019)*

Brownfield electrification – notional projects

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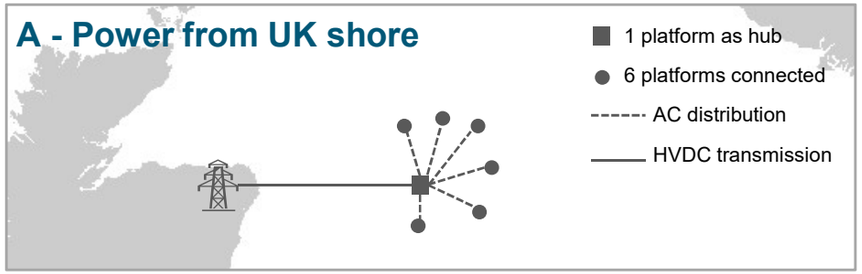
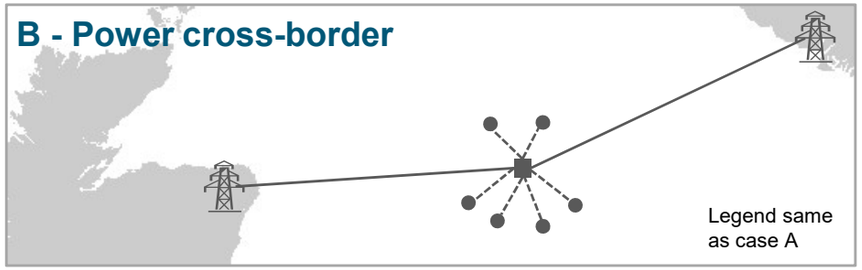
A - Power from UK shore



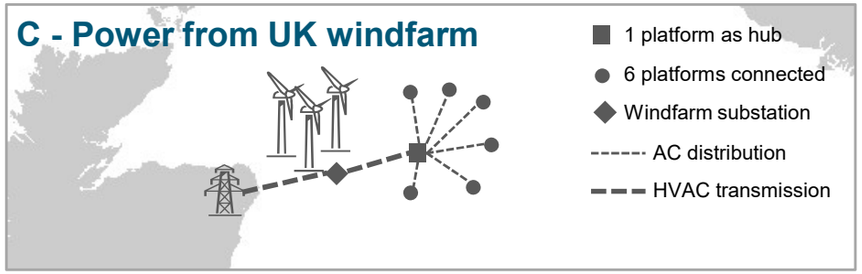
- Electrification of 7 O&G platforms
- Total demand 440MW + losses
- Power from UK shore to hub (230km)
- HVDC transmission to hub
- Platforms' distance from hub 60km
- 1.7 $MtCO_2$ pa emissions abated

B - Power cross-border



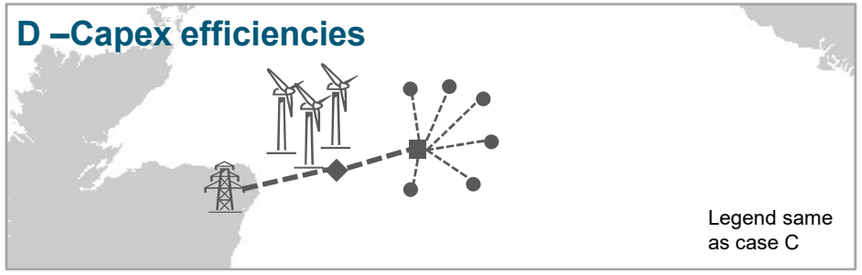
- Power is imported from Norway
- Transmission infrastructure is shared with a notional HVDC interconnector

C - Power from UK windfarm



- Power is sourced from a windfarm half way between hub platform and shore
- 80% power from windfarm
- 20% power from UK shore
- HVAC transmission

D –Capex efficiencies



- 80% power from windfarm
- 20% power from UK shore
- Assumes project cost efficiencies
- -50% reduction in brownfield modification Capex

Models are indicative and intend to illustrate ways in which electrification economics could potentially be improved. Assumptions would need to be confirmed with industry and regulators.

Cost and benefit assumptions

Capex

- HDVC transmission: £650m / hub
- AC distribution: £55 / platform
- Platform new electrical equipment: £13m / platform
- Brownfield modifications: £136m / platforms

Opex - Power supply

- From UK shore ~£60-65/MWh (with exemptions[1])
- From Norway ~£33-40/MWh
- From windfarm ~£35-40/MWh

Benefits

- Avoided turbine replacement Capex £25m/platf
- Avoided turbine opex £6m/yr/platf (avg)
- Additional gas revenue £36m/yr/platf (avg)

1) Based on BEIS Manufacturing industry prices, Table 3.1.1., deducting policy tariffs (CfD, RO, FiT and CCL) for which the O&G companies would have to apply for an EII exemption
2) Based on reported retail prices less assumed distribution charges
3) Based on recent CfD results less network charges
Detail on methodology, acronyms and sources in appendix

Case A – Power from UK shore

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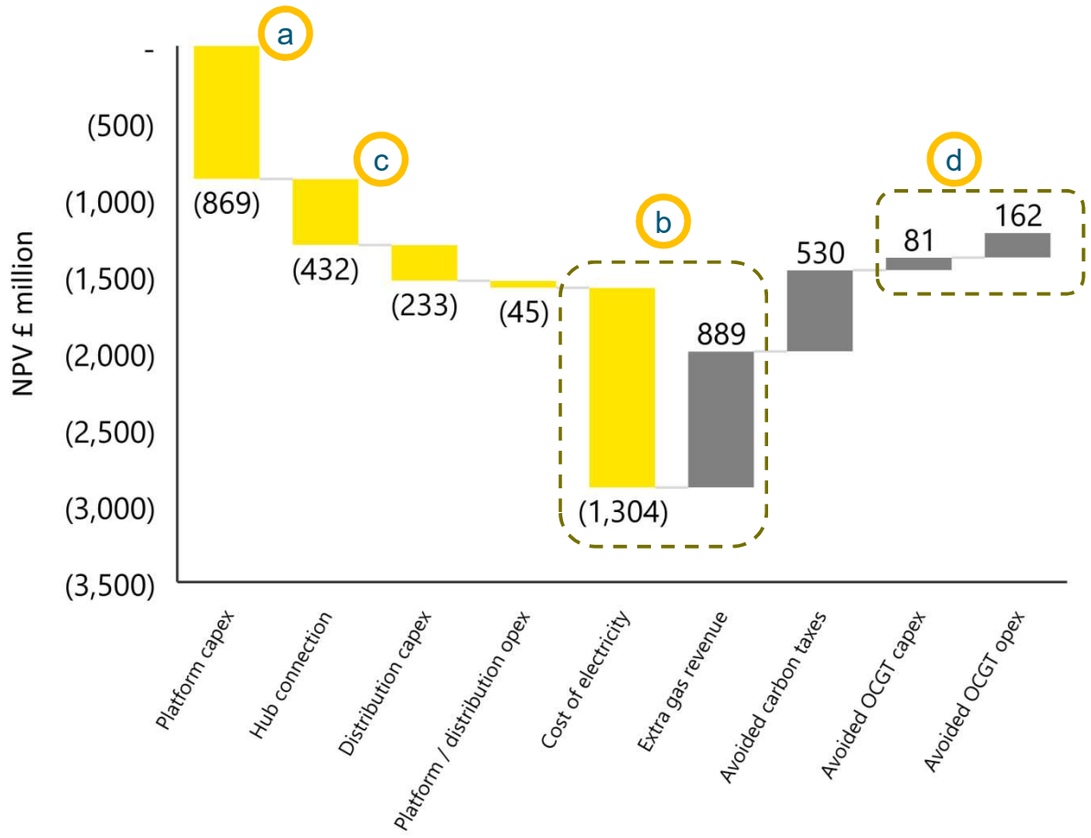
Platform electrification NPV vs gas-fired generation counterfactual



Methodology and assumptions are discussed in appendix

1) *BCR: ratio between discounted project benefits and initial Capex invested*
2) *Discounted project cash flow (before avoided carbon taxes) divided by the undiscounted tonnes of CO_2 abated during the project life*

Key indicators

NPV: -£1,222m

Benefit-Cost Ratio[1]: 0.39

Levelised cost of CO_2 abatement[2]: £77.6 / tCO_2

Main economic drivers

Economics of brownfield electrification from UK shore might not reach break-even, driven by:

a. Capex of platform modifications, assumed at £149m/platform (undiscounted)

b. Electricity cost from UK onshore grid (reduced by assuming EII exemptions) is not offset by the extra gas revenues

On the positive side, the model shows that:

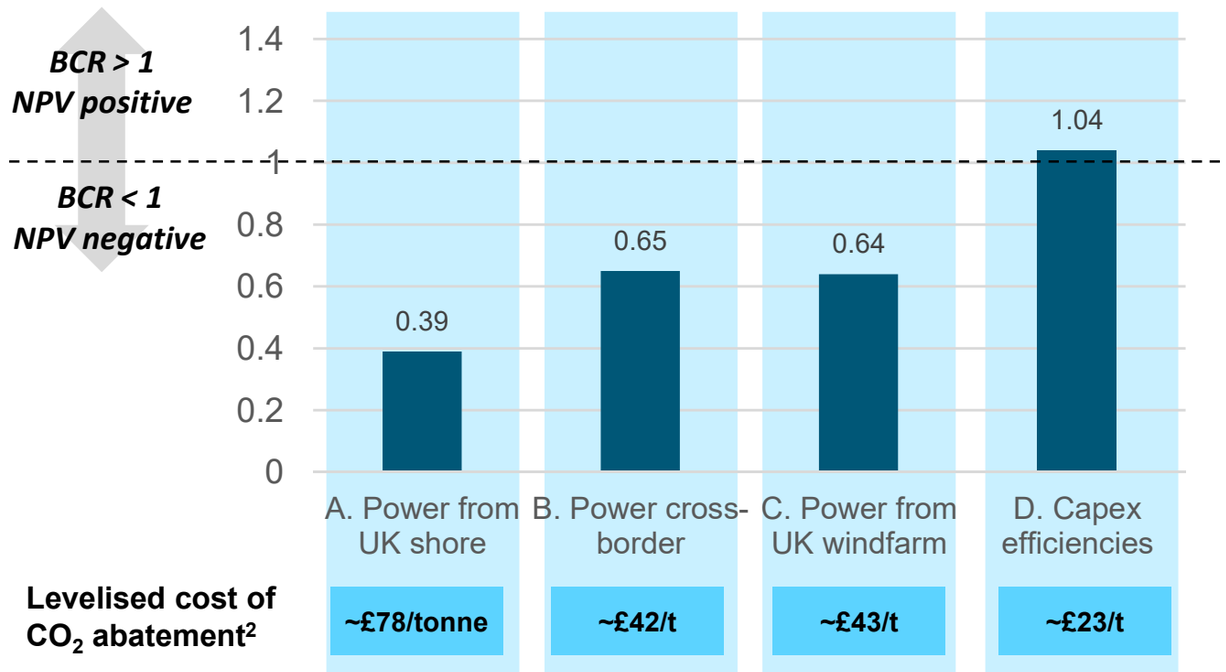
c. The HVDC link from shore could be funded at a low cost of capital (2.9%) and annualised (PV = -£432m)

d. Opex and Capex savings from removing offshore power equipment could be significant, ~£223m (~£534 undiscounted)

Brownfield electrification – summary

Oil & Gas Authority

Benefit-cost ratios[1]



- Main economic drivers of brownfield electrification are electricity prices and platform modification costs
- Project economics could potentially improve by accessing lower-cost electricity supply, and CO_2 abatement cost could potentially be lowered to ~£42-43/tonne
- Lower cost electricity supply options could include:
  - Directly offshore from planned and potential UK windfarms
  - From Norway
- In addition, to achieve break-even, technology-driven Capex efficiencies would be required on platform modifications and power transmission equipment

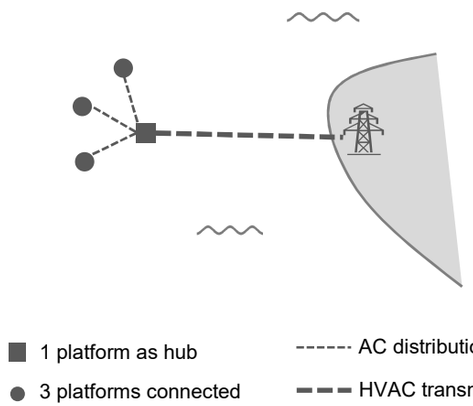
Methodology and assumptions are discussed in appendix

1) *BCR: ratio between discounted project benefits and initial Capex invested*
2) *Discounted project cash flow (before avoided carbon taxes) divided by the undiscounted tonnes of CO_2 abated during the project life*

Greenfield electrification – notional projects

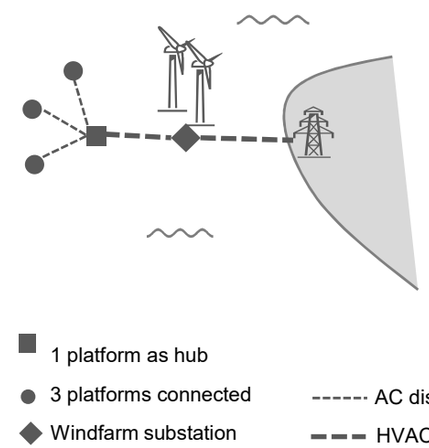
Oil & Gas Authority

A - Power from UK shore



- Electrification of 4 newbuild O&G platforms
- Total demand 240MW + losses
- Hub from shore 108km
- Other platforms from hub 54km
- 0.7 MtCO2 pa emissions abated

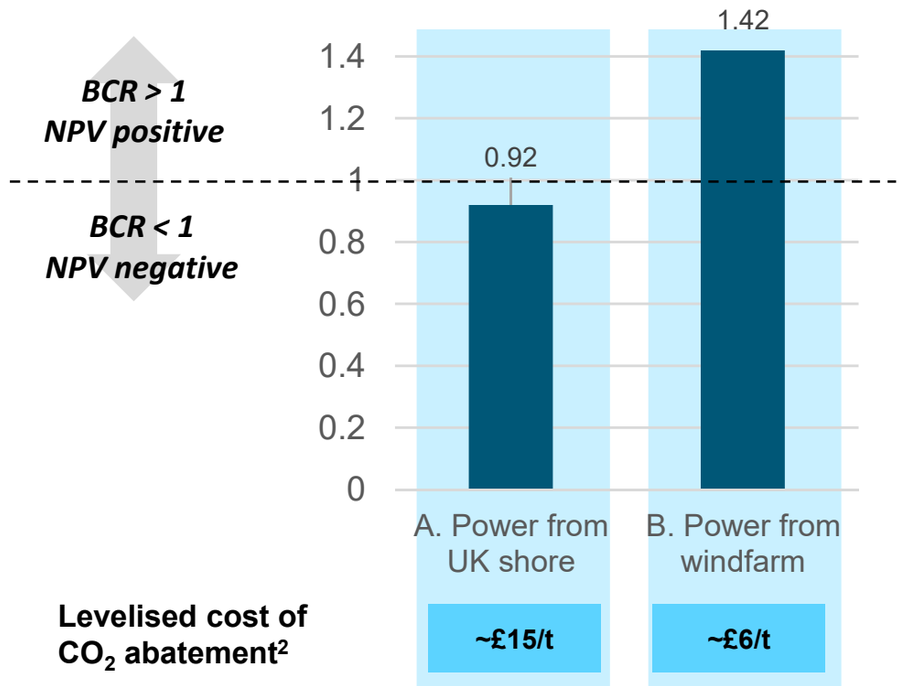
B - Power from windfarm



- Power sourced from windfarm located between platforms and shore
- 80% power from windfarm
- 20% power from UK shore
- HVAC transmission

Models are indicative and intend to illustrate ways in which electrification economics could potentially be improved. Assumptions would need to be confirmed with industry and regulators.

Benefit-cost ratios[1]



Methodology and assumptions are discussed in appendix

1) *BCR: ratio between discounted project benefits and initial Capex invested*
2) *Discounted project cash flow (before avoided carbon taxes) divided by the undiscounted tonnes of CO_2 abated during the project life*

Regulatory analysis

Regulatory framework

Oil & Gas Authority

Powering O&G platforms from the UK shore

O&G installation scope

- Electrification of O&G platforms would be subject to the same regulatory requirements of UKCS oil and gas field developments[1]
- The OGA is responsible for reviewing and giving consent to the proposed Field Development Plan (FDP), including the platform power supply option selected
- The electrification of an existing platform would require the submission of an FDP Addendum (FDPA)
- OPRED is responsible for the environmental regulation, requiring submission of an Environmental Statement, and agreeing Decommissioning Security Arrangements
- In addition, safety regulation is the responsibility of the Offshore Safety Directive Regulator, combining the HSE Energy Division and OPRED as competent authority for offshore safety
- Electricity cables between platforms would be consented by the OGA via the Pipeline Work Authorisation process[2]

Electricity supply and transmission scope

- Given project novelty, regulatory aspects would need clarification
- Cables connecting offshore installations to shore, potentially subject to the regulations for windfarm cables
- Connection to grid, involving NG and distribution companies
- Potential application of the Unbundling regulations related to electricity/gas production and transmission
- Regulatory framework to allow shared access to offshore cables

O&G electrification from windfarms

- Combined projects would fall under both the Petroleum Act 1998 and the renewable legislation (Energy Act 2008)
- A larger number of regulators would be involved due to the additional requirements for the windfarm (see next slides)
- New windfarm projects involve a planning and lease award process, incl. environmental consenting and route to market agreements – with overall timelines of ~10 years

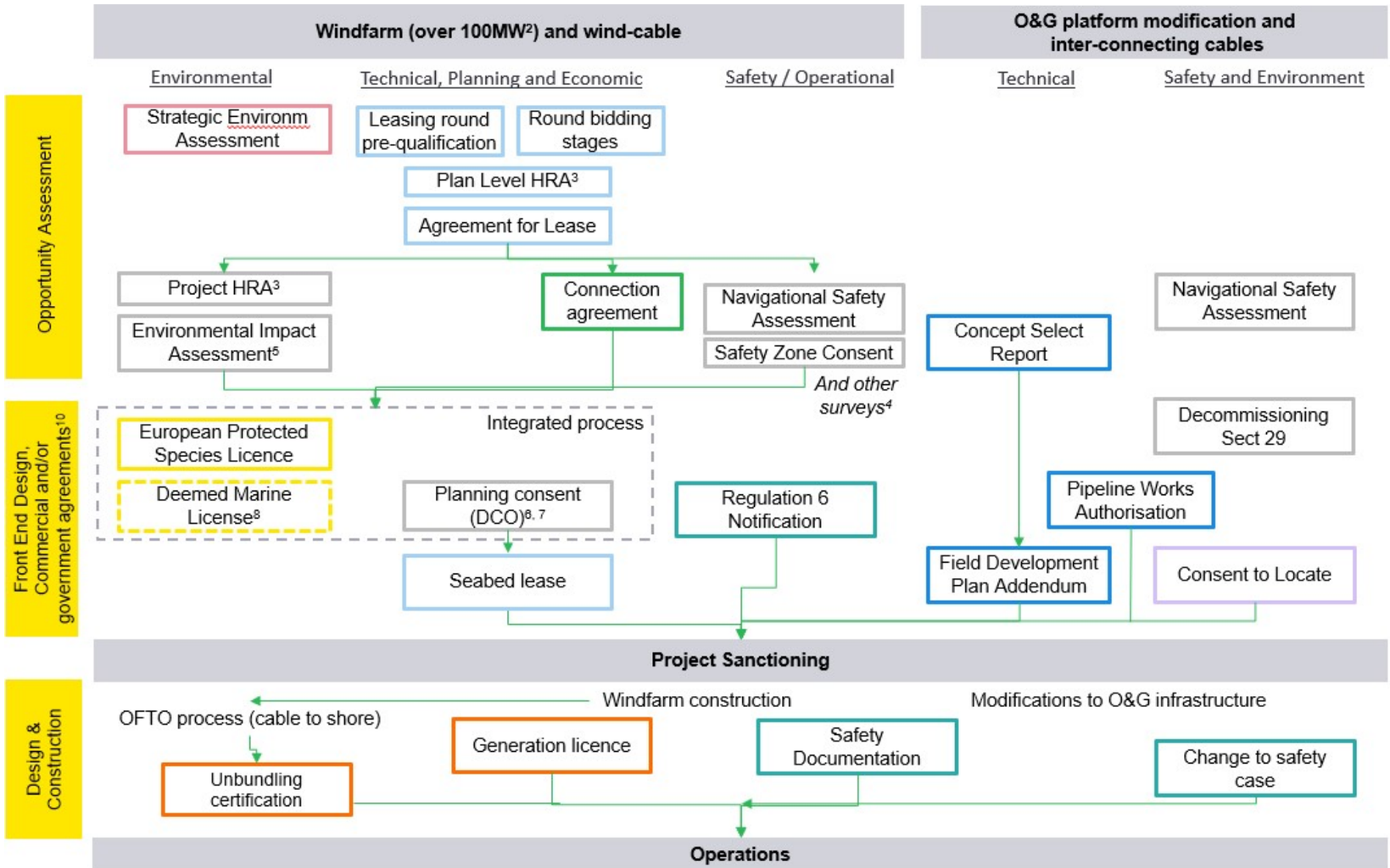
Questions to be addressed include:

- How could windpower and O&G electrification timelines be better aligned, given the shorter lifetime of O&G assets?
- How could ‘access to seabed’ be managed if proposed windfarms were to be installed on licensed O&G acreage?
- Could ‘route to market’ decisions be simplified if windfarm developments are for sole supply of O&G installations?
- Could surveys and results of an O&G environmental impact assessment used (where applicable) to satisfy requirements of windfarms in the vicinity of installations?
- Would OFTO[3] regulation apply and would it permit the shared access to third-party offshore cables?

1) https://www.ogauthority.co.uk/media/6099/fdp_guidance_requirements-document-oct_update-2019v2.pdf
2) https://www.ogauthority.co.uk/licensing-consents/consents/pipeline-works-authorisations/
3) https://www.ofgem.gov.uk/electricity/transmission-networks/offshore-transmission

Brownfield electrification – regulatory map

England and Wales



Windfarm leasing and consenting process would be considerably longer than consenting to the O&G platform modifications.

To align timelines, an electrification project may consider windfarms already consented, but not sanctioned for lack of CfD or sale/purchase agreements.

	The Crown Estate
	MMO / NRW / DAERA
	BEIS / PINS
	Oil and Gas Authority
	Health and Safety Executive
	National Grid
	Ofgem
	Local and Harbour Authority
	OPRED
	Environmental Agency

MMO – Marine Management Organisation, NRW – Natural Resources Wales, PINS – Planning Inspectorate National Schemes, SEPA – Scottish Environmental Protection Agency, DAERA - Department of Agriculture, Environment and Rural Affairs

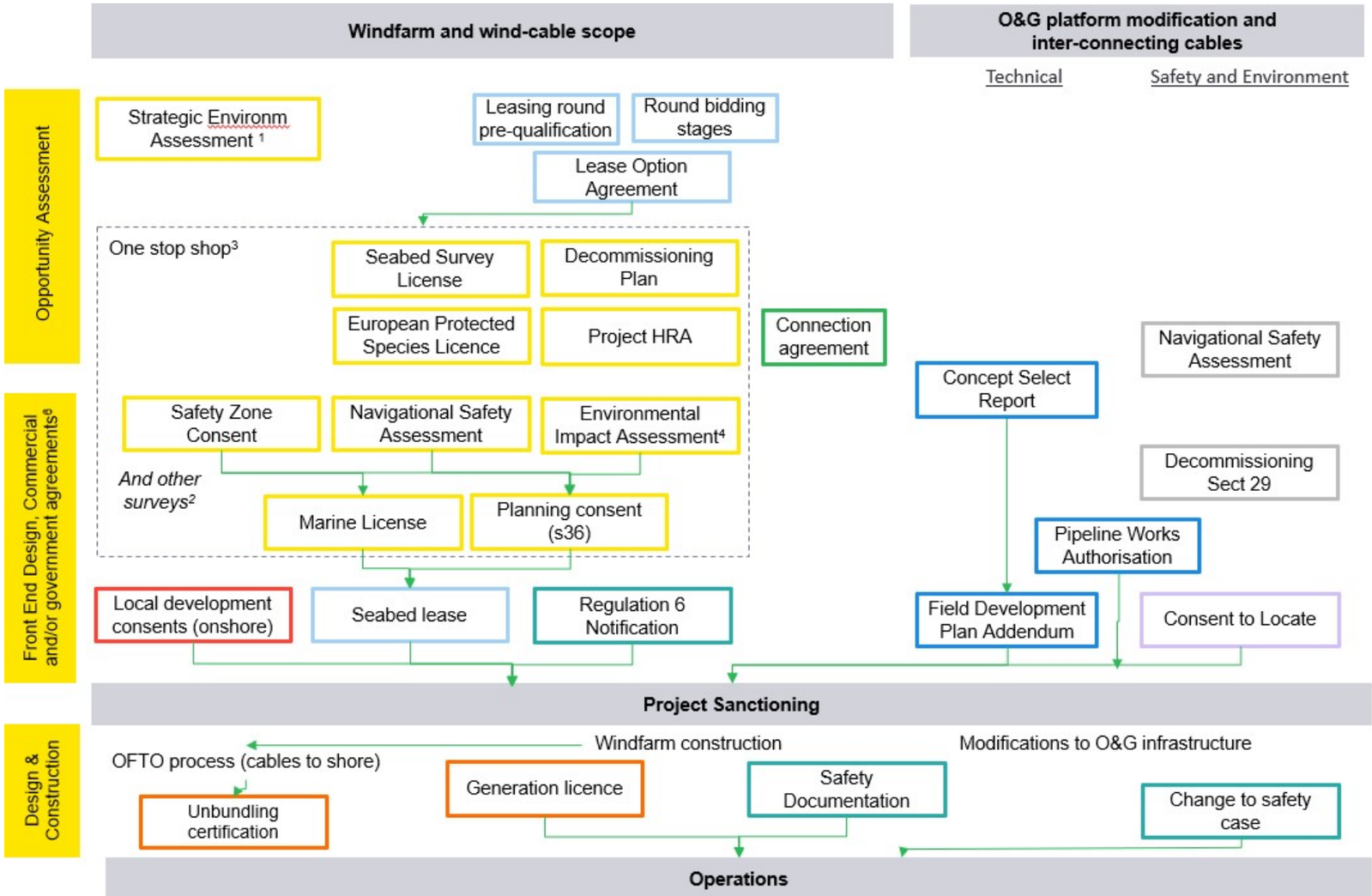
Other acronyms in appendix
Regulatory map footnotes in appendix

Disclaimer: This map is illustrative of the process for consenting and licensing projects, and as such it should not be relied upon.

Brownfield electrification – regulatory map

Oil & Gas Authority

Scotland



In Scotland, the consenting related to windfarm environmental and broader marine impact is coordinated by Marine Scotland working with other statutory consultees (footnote 3 in appendix)

	The Crown Estate Scotland
	Marine Scotland
	BEIS
	Oil and Gas Authority
	Health and Safety Executive
	National Grid / SPTL / SHET
	Ofgem
	Local / Harbour Authority
	OPRED[5]

MMO – Marine Management Organisation, NRW – Natural Resources Wales, PINS – Planning Inspectorate National Schemes, SEPA – Scottish Environmental Protection Agency, OPRED - Offshore Petroleum Regulator for Environment and Decommissioning

Other acronyms in appendix

Regulatory map footnotes in appendix

Disclaimer: This map is illustrative of the process for consenting and licensing projects, and as such it should not be relied upon.

Next steps

Oil & Gas Authority

Findings and recommendations

- Collaboration with Windpower can significantly improve economics of O&G electrification
- At the same time, O&G electrification could represent a growth opportunity for Windpower in new regions
- To capture these synergies, the two sectors should be aware of each others development ambitions and what may facilitate or unlock these opportunities, including:
    - Providing a alternative route to market
    - Sharing cost of infrastructure
    - Accelerating development timelines
    - Jointly approaching regulators
- **The OGA, with other regulators, is proactively engaging both industries**
- **An initial engagement workshop in 2019, will be followed by more in-depth discussion of concrete collaboration opportunities for the next 3-5 years**

Workshop on cross-industry opportunities[1] (October 2019)

1) Organised by EIP in collaboration with Scottish Renewables and RenewableUK

Appendix

Appendix – references

Oil & Gas Authority

UK Industrial Strategy / Clean Growth Strategy

- Industrial Strategy Grand Challenges: Clean Growth https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/industrial-strategy-the-grand-challenges#clean-growth
- The UK Clean Growth Strategy https://www.gov.uk/government/publications/clean-growth-strategy

Offshore O&G Operations

- OGA Chairman challenges the sector to respond to the energy transition challenge https://www.ogauthority.co.uk/news-publications/news/2020/oga-chairman-challenges-the-sector-to-respond-to-the-energy-transition-challenge/
- OGA unveils strategy to support net zero https://www.ogauthority.co.uk/news-publications/news/2020/oga-unveils-strategy-to-support-net-zero/
- Consultation on new OGA Strategy https://www.ogauthority.co.uk/news-publications/consultations/2020/consultation-on-new-oga-strategy/

Energy Markets and Networks

- Rewiring Britain for a net zero future: Ofgem publishes Decarbonisation Action Plan https://www.ofgem.gov.uk/publications-and-updates/rewiring-britain-net-zero-future-ofgem-publishes-decarbonisation-action-plan
- RIIO-2 Draft Determinations for Transmission, Gas Distribution and Electricity System Operator https://www.ofgem.gov.uk/publications-and-updates/riio-2-draft-determinations-transmission-gas-distribution-and-electricity-system-operator

Offshore Windpower

- Offshore Wind: Sector Deal https://www.gov.uk/government/publications/offshore-wind-sector-deal
- BEIS Contracts for Difference (CfD): Allocation Round 3 Results https://www.gov.uk/government/publications/contracts-for-difference-cfd-allocation-round-3-results
- BEIS Contracts for Difference (CfD): Allocation Round 4 https://www.gov.uk/government/collections/contracts-for-difference-cfd-allocation-round-4
- TCE Offshore Wind Leasing Round 4 (2019) https://www.thecrownestate.co.uk/en-gb/what-we-do/on-the-seabed/offshore-wind-leasing-round-4/
- CES ScotWind Leasing (2020) https://www.crownestatescotland.com/what-we-do/marine/asset/offshore-wind/section/scotwind-leasing

Appendix – methodology and acronyms

Oil & Gas Authority

Methodology, assumptions and sources

O&G platform electrification

- The BEIS EEMS database indicate 2018 average offshore GHG emissions from power generation (electrical and mechanical) at ~10 MTCO2e / year
- In forecasting a forward emission baseline, we considered the impact of asset decommissioning based on OGA's 2018 UKSS projections
- Brownfield electrification: assumed 14 existing UKCS platforms (largest assets with the longest residual life) will be converted during 2026-2035
- New asset (greenfield) electrification: assumed 17 greenfield developments (2026-2035) to import electricity avoiding CO_2 power emission

Economic modelling

- Technologies are compared in terms of BCRs and levelised costs
- Model economics are real and pre-tax
- Offshore projects' scope is discounted at 10% (real)
- Hydrogen onshore processing is discounted at 5% (real)
- Electricity transmission infrastructure is discounted at 2.9% (real, from recent cases)

Energy parameters and conversion factors

- UK average power generation emissions 220 KgCO2/MWh (BEIS 2019)
- UK average power emissions excl renewables 330 KgCO2/MWh (BEIS 2019)
- UKCS offshore power generation emissions 460 KgCO2/MWh (typical OCGT)
- UK offshore windpower commercial load factors 39%-47% (2019 BEIS, DNV GL)
- Hydrogen energy density 39kWh/kg (HHV) and 33kWh/kg (LHV)
- Natural gas energy density 14.5kWh/kg (HHV) and 13.1kWh/kg (LHV)
- Blue Hydrogen (methane reforming) energy efficiency 70-75% (NG FES)
- Green Hydrogen (electrolysis) electricity efficiency 70-80% (Various)

Acronyms and abbreviations

BEIS	Department for Business, Energy and Industrial Strategy
BOE	Barrel of oil equivalent
CCC	Committee on Climate Change
CCS	Carbon Capture and Storage
CES	Crown Estate Scotland
CO2e	Carbon Dioxide equivalent
EIP	Energy Integration Project
EII	Energy Intensive Industry exemption from electricity tariffs (link)
EEMS	Environmental and Emission Monitoring System (BEIS)
GHG	Green-house gases
HC	Hydrocarbon
HSE	Health and Safety Executive
NG ESO	National Grid Electricity System Operator
NG FES	National Grid ESO Future Energy Scenarios
OCGT	Open Cycle Gas Turbine generator
OGA	Oil and Gas Authority
OGTC	Oil and Gas Technology Centre
OGUK	Oil and Gas UK
OPRED	Offshore Petroleum Regulator for Environment & Decommissioning
TCE[1]	The Crown Estate
tCO2	Tonnes of Carbon Dioxide
UKCS	UK Continental Shelf
UKRI	UK Research & Innovation
WACC	Weighted averaged cost of capital

1) The Crown Estate manages the seabed around England, Wales and Northern Ireland and provides leases/licences for offshore energy, marine aggregates and cables and pipelines. It is not a regulator, however, for the purpose of this report, it may be grouped together with regulators