Oil & Gas Authority

UKCS Energy Integration

Interim findings

Cover photos:

Equinor's floating wind concept (Hywind, drawing) was piloted successfully offshore Scotland (picture) and will be used to electrify oil and gas platforms in the Tampen area.

Neptune Energy has converted an existing offshore platform (Q13a, picture) to power imported from the shore and is now installing a containerised electrolyser module to pilot offshore hydrogen generation (drawing).

Contents

Foreword

The UK government's legally-binding commitment to net zero emissions by 2050 means there is a duty on everyone to act now and do everything possible to achieve this. This applies to regulatory authorities like the OGA and it applies to the oil and gas industry.

Government forecasts that oil and gas will remain an important part of our energy mix for the foreseeable future, during the transition to net zero, and that the UK is expected to remain a net importer.

While the drive to net zero doesn't mean the UK will immediately stop needing oil and gas, there is a growing expectation that the oil and gas industry goes much further in reducing its carbon footprint from operations, while helping solve the big challenges around carbon capture and hydrogen which will 'move the needle' in meeting our climate change targets.

The UK's infrastructure, subsurface reservoirs and expertise, along with a world-class supply chain which is already diversifying into renewables, make it well-placed to be a global leader in the energy transition.

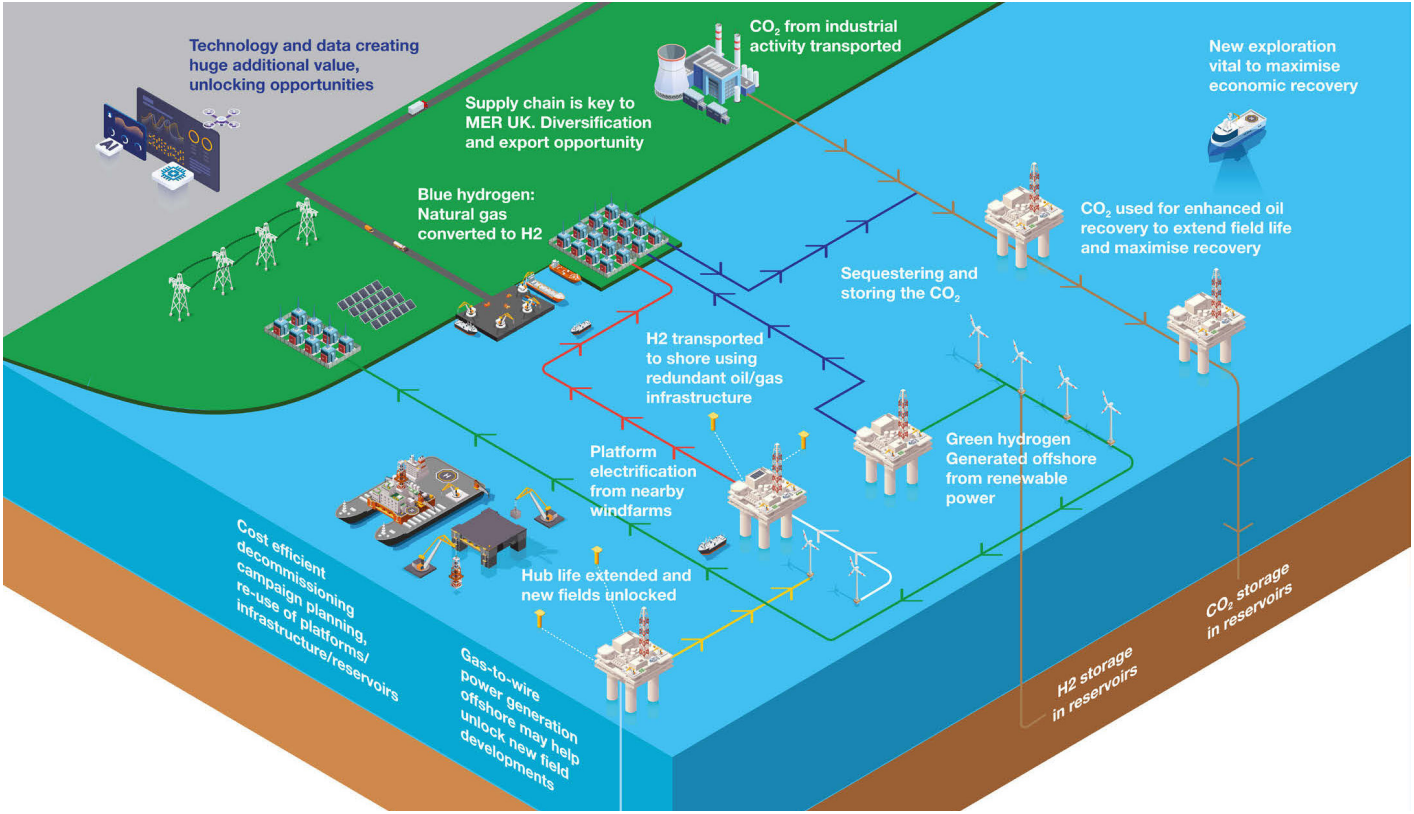
A more integrated offshore energy sector, including closer links between oil and gas and offshore renewables, will be vital to accelerate the energy transition.

- Platform electrification could reduce emissions on oil and gas installations by using electricity generated from windfarms instead of diesel
- Gas-to-wire may enable gas to be converted to electricity offshore and transported using existing windfarm cables
- Natural gas produced offshore can be converted to hydrogen using methane reforming, with the CO_2 stored in reservoirs
- Offshore energy hubs can enable hydrogen to be generated offshore using windfarms and either stored in reservoirs or transported to shore using oil and gas infrastructure

This report summarises the findings from the technical assessment (Phase 1) of the UKCS Energy Integration project. The economic and regulatory assessment (Phase 2) is well underway, and the project will conclude 2Q 2020, after which a final report and action plan will be published.

Dr Andy Samuel
Chief Executive

UKCS energy integration vision



Project overview

Led by the OGA, in collaboration with:

Department for Business, Energy & Industrial Strategy

THE CROWN ESTATE

ofgem

The project aims to:

- **Unlock UKCS energy integration opportunities**
- **Leverage oil and gas infrastructure for CCS, wind and hydrogen**
- **Enable partnering of oil and gas operators and supply chain with renewables**

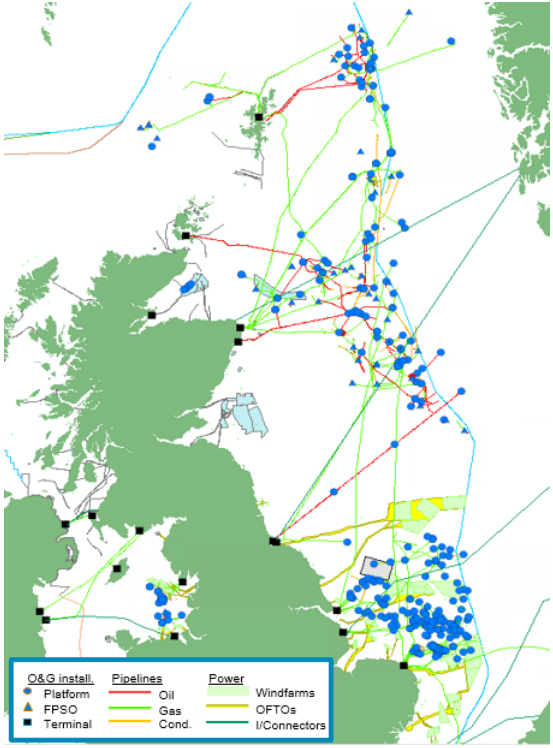
The project comprises two phases:

1. **Technical options (completed)**
2. **Economic and regulatory assessment (ongoing)**

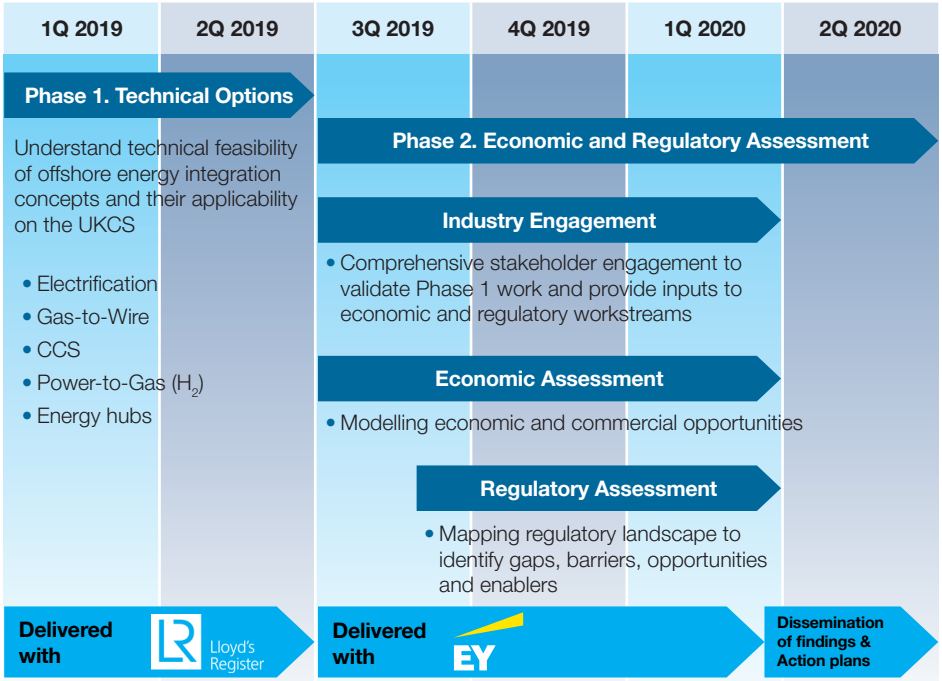
This report describes the findings from Phase 1

Funded by £1m grant from the Better Regulation Executive's Regulators' Pioneer Fund

UKCS infrastructure (oil and gas, renewables and power transmission)



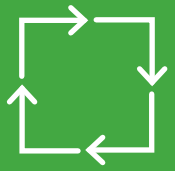
Timelines



COMPLETION SUMMER 2020

UKCS 'size of the prize'

Actions to address priority barriers and enablers



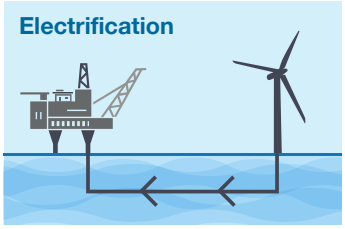
Facilitate 'quick win' projects to accelerate cross- sector synergies

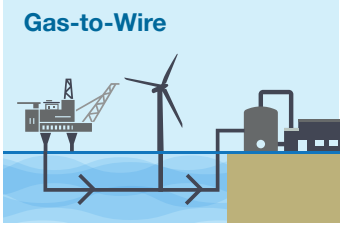
Phase 1

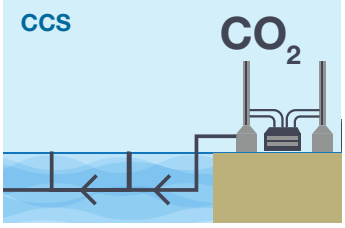
Phase 1 delivered with Lloyd's Register

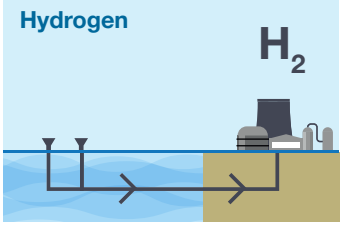
- Five offshore energy integration concepts assessed (Lloyd's Register)
  - Platform Electrification
  - Gas-to-Wire (GTW)
  - Carbon Capture and Storage (CCS)
  - Hydrogen (H_2) – both 'Blue' (methane reforming, with capture and storage of resulting CO_2) and 'Green' (water electrolysis, using power from renewable sources)
  - Energy Hubs
- Development options
  - Stand-alone
  - Reuse
  - Synergies
- Technical feasibility (with current and future technologies)
- Costing and sensitivities
- Build-up scenarios
- The purpose of this document is to communicate interim project findings and engage industry on the project Phase 2

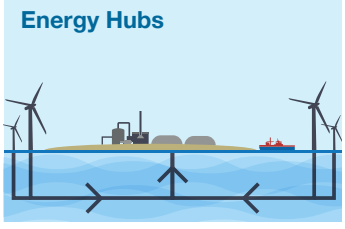
Offshore Energy Integration Concepts











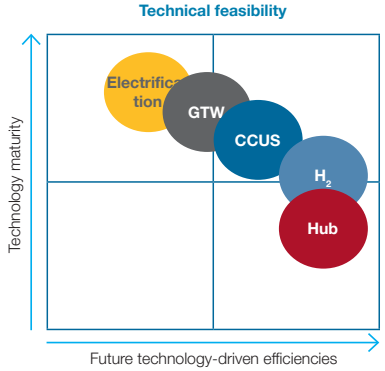
Phase 1 summary findings

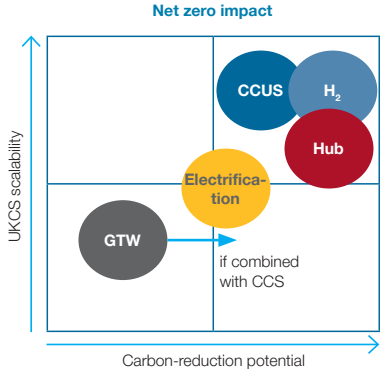
The UKCS is a critical energy resource, which can be transformed to support the net zero target	**The UK has significant wind power potential, untapped carbon storage capacity, and extensive oil and gas infrastructure in place**	**Phase 1 of the study reviewed five technology concepts which integrate multiple energy sources on a technical ground. Phase 2 of the project will address economic and regulatory aspects**
Opportunities for UKCS deployment are plentiful, diverse and location-specific	**All technology concepts offer carbon reduction benefits but differ in terms of scalability and timeline**	**Platform electrification and gas-to-wire are mature and can enable near-term oil and gas industry emissions reductions, but there are cost challenges**
CCS can accelerate decarbonisation of the UK economy and re-use oil and gas infrastructure	**Hydrogen and energy hubs can enable the full-scale deployment of wind power and other renewables**	**Larger energy hubs – on or offshore – can help capture the full potential from renewables**

Technology screening

Concept	Technical feasibility	UKCS potential
Platform Electrification	• Proven technology • Combination with (floating) offshore wind being piloted	• UKCS-wide • Opportunities via windfarms, inter-connectors or shore
Gas-to-Wire	• Individual elements proven (e.g. Open Cycle Gas Turbines (OCGT), and offshore power transmission)	• Niche solution • Southern North Sea (SNS) and East Irish Sea (EIS) opportunities also via windfarm cables
CCUS	• Already piloted offshore (Norway) • Oil and gas field repurposing to be tested	• UKCS-wide • Very large CO_2 storage capacity, and oil and gas synergies
Hydrogen	• Blue – existing technology (methane reforming) still has efficiency advantages • Green – hydrolysis concepts can be improved and also transferred offshore	• Blue: UK wide, with onshore gas plants repurposing a key option; integration with CCS necessary • Green: UKCS wide, following future windfarm expansions
Energy Hubs	• Individual elements proven, integration yet to be tested • Significant cost challenge	• Natural islands: e.g. Shetland, Orkney • Artificial islands: e.g Dogger Bank • Onshore/Offshore: EIS, Wales and NE England

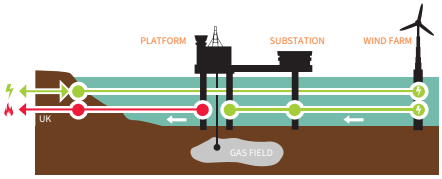
Central North Sea (CNS)
East Irish Sea (EIS)
Northern North Sea (NNS)
Southern North Sea (SNS)
West of Shetlands (WoS





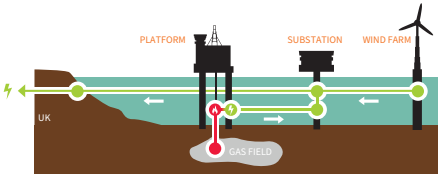
Potential build-up scenarios

Transform O&G Production | **2020s** | **Ramp up energy transition** | **2030s** | **Delivery Net-Zero** | **2040s**



1. Electrification

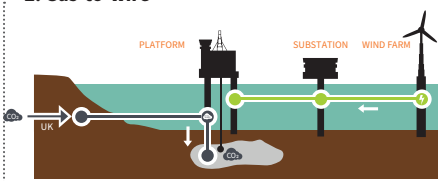
- Power platforms from windfarms
- Reduce emissions and opex



2. Gas-to-Wire

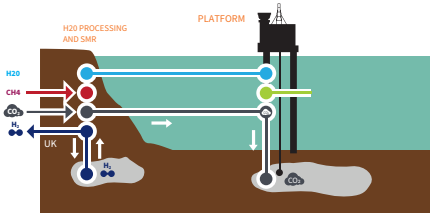
- Offshore power generation
- Reduce opex and balance grid
- Can be combined with CCS

2. Gas-to-wire



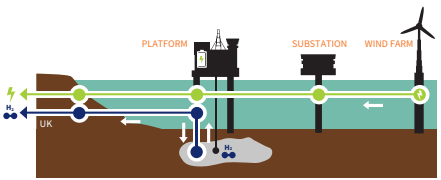
3. Carbon Capture & Storage

- Capture onshore emissions
- Transport and store offshore
- Repurpose O&G infrastructure



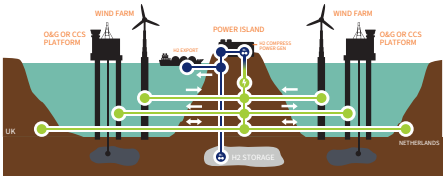
4.1 Blue Hydrogen

- Enables continuing use of natural gas and hydrogen economy
- Combined with CCS to support net-zero



4.2. Green Hydrogen

- Critical storage and transportation solution for renewable energy
- Enable hydrogen economy



5. Large-scale Energy Hubs

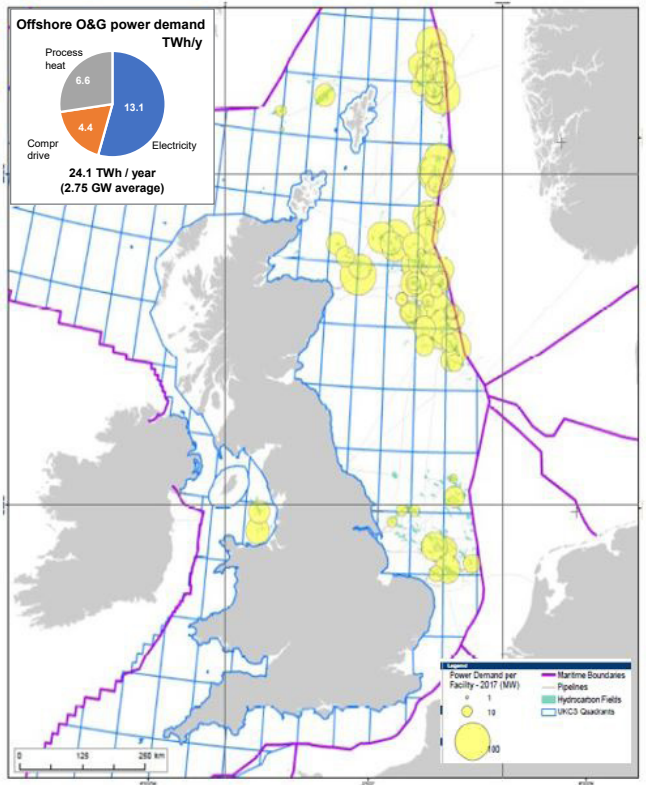
- Co-locate renewable generation, energy storage and transportation
- Build economies through scale
- Enable low-carbon industrial clusters

Energy integration technologies

Platform electrification

- UKCS platforms are far from shore and widely distributed: hence local gas/diesel power generation
- UKCS platforms power demand is ca. 24 TWh/year (or 2.75 GW annual average)
- This represents over 5% of UK power demand, accounting for over 10% of total power plant emissions
- Expected 25% demand decline by 2030 due to decommissioning, but with stable (CNS) and growing (WoS)
- Opportunity: lower emissions, lower opex, lower capex (greenfield) enabler to further transition (e.g. CCS)
- Concept currently under consideration in CNS, WoS and EIS
- Challenges include high capex (cables, substations, brownfield) and limited platform remaining operating life (brownfield)
- Synergies with UKCS power infrastructure (windfarms and interconnectors) include opportunity to repurpose oil and gas assets

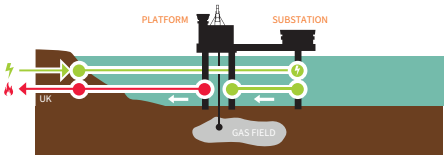
Oil and gas platform power demand (2017)



Electrification options

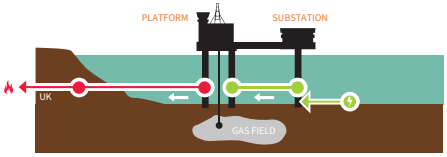
1. Power from shore

- Cables from the shore, extending grid offshore
- Power supply continuity
- High capex investment in cables and substations
- Additional costs, if brownfield



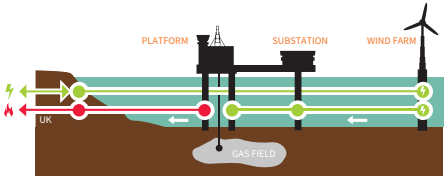
2. Power from interconnectors

- Capex savings (shorter cables)
- New interconnectors planned across CNS/SNS
- Low carbon power from Norway or Denmark

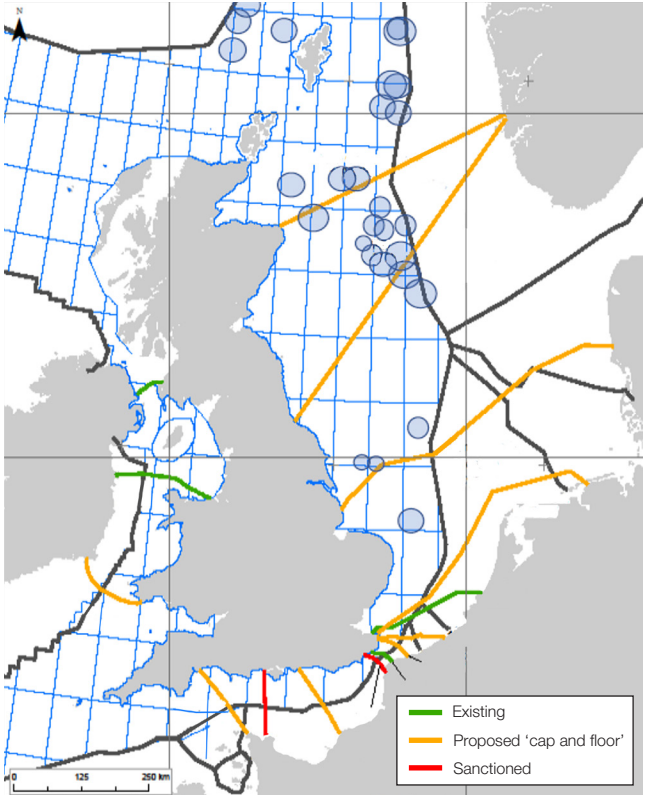


3. Power from windfarms

- Capex savings (cables and substations)
- Potential sources from planned SNS wind farms and floating wind installations in CNS/NNS/WoS



Oil and gas power demand (2030) and interconnectors

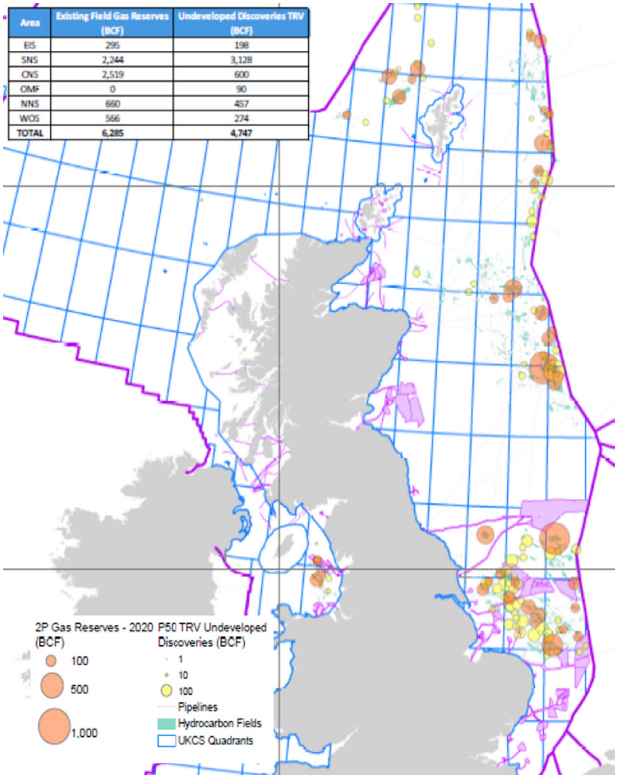


Gas-to-Wire

- UKCS has 6.3 trillion cubic feet (TCF) proven and probable ('2P') gas reserves and 4.7 TCF contingent resources ('2C') discovered
- Gas-to-Wire represents a local opportunity to develop stranded resources and/or extend asset life
- May support wind power through:
  - Infrastructure sharing
  - Grid balancing
  - Market rate opportunities
- Deployable in the short-term, as based on mature technology (OCGT)
- Requires lean cost models to be attractive, e.g. latest industry proposals of small generators on jack-ups or barges
- Active industry interest in SNS and EIS
- Could be combined with CCS to abate emissions

UKCS 2P gas reserves and 2C resources

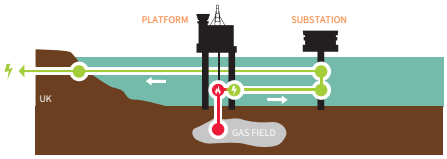
Area	Existing Field Gas Reserves (BCF)	Undeveloped Discoveries TRV (BCF)
EIS	295	198
SNS	2,244	3,128
CNS	2,519	600
OMF	0	90
NNS	660	457
WOS	566	274
TOTAL	6,285	4,747



Gas-to-Wire options

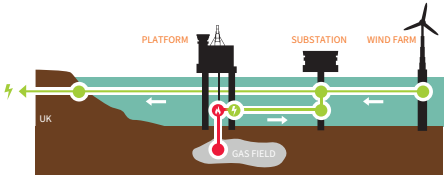
1. Power export to shore

- Requires investment in dedicated transmission equipment
- Higher capex option
- Efficient concepts (jack-up and barges are possible)



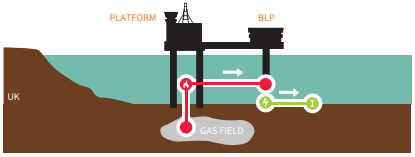
2. Power export to wind farms

- Exploits spare capacity in windfarm cables
- GTW intermittent export
- Significant capex savings in cables and substation

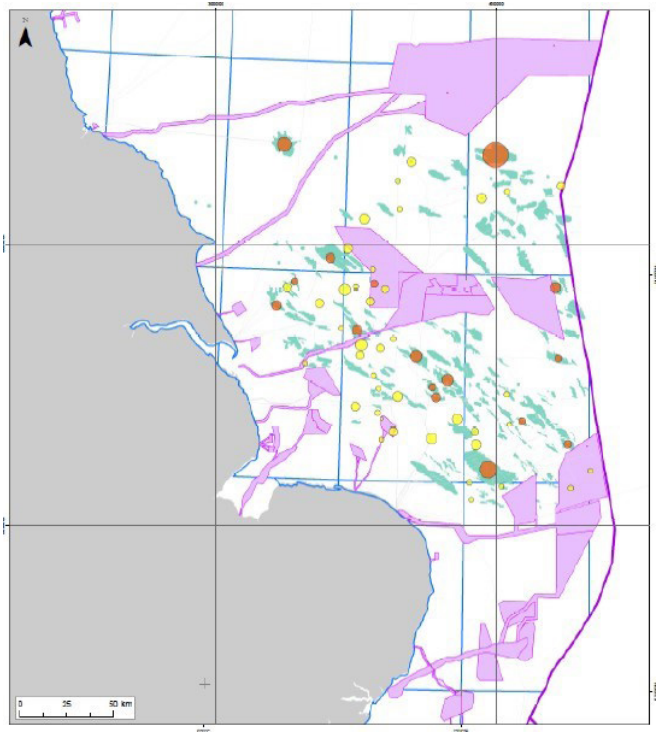


3. Power export to interconnectors

- Potential synergies with planned interconnectors
- Options across CNS/SNS



SNS 2P gas reserves and 2C resources

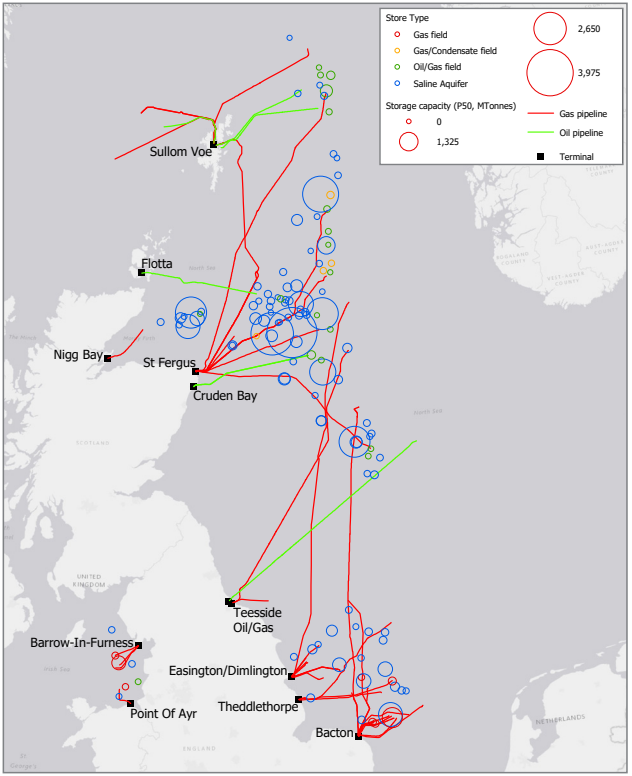


Sources: BGS CO_2 stored database; OGA NDR infrastructure data; OGA GIS

Carbon Capture and Storage (CCS)

- CCS is essential for meeting climate change targets and can support decarbonisation of industry, and enable further low carbon technologies, e.g. hydrogen from natural gas (blue hydrogen) with carbon storage
- The UKCS is a strategic asset in terms of its storage capacity, with an estimated 78 gigatonnes (GT) CO_2 potential storage capacity, including 8 GT in depleted oil and gas fields
- The storage capacity is large as well as widespread, with opportunities across the UKCS, including with significant oil and gas infrastructure synergies in SNS, EIS, CNS
- Long-term integrity of potential subsurface stores needs to be assessed, but international experience is available, e.g. Sleipner saline aquifer pilot in Norway, operating for 20 years.
- Reusing oil and gas infrastructure (reservoirs, wells, platforms and pipelines) may be possible and lead to capex savings – however, potential for reuse needs to be evaluated on a case-by-case basis
- CO_2 Enhanced Oil Recovery (EOR) may provide over 1 bnboe of additional oil recovery and capacity for over 0.5 GT of CO_2 storage

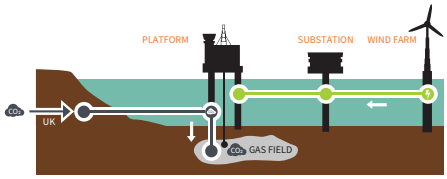
Potential CO_2 stores and existing oil and gas pipelines



CCS options

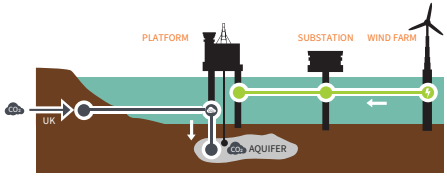
1. Depleted hydrocarbon fields

- Oil and gas fields well understood as long-term gas stores
- Some infrastructure (pipelines, platforms) may also be reused. Benefits include cost and time efficiencies



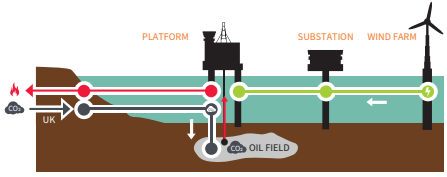
2. Saline aquifers

- Large overall capacity in aquifers, but require individual assessment
- Very large individual stores, may drive down CCS unit costs
- Favourable location (distance to shore and existing infrastructure)

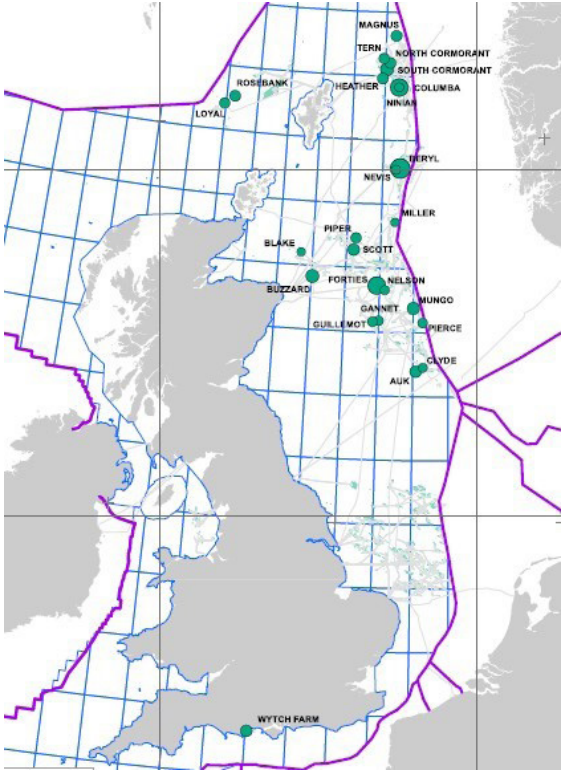


3. CO_2 Enhanced Oil Recovery (EOR)

- CO_2 dissolves into oil, facilitating its recovery
- UKCS fields may yield >1bnboe recovery and store >0.5 GT CO_2
- Synergies with other CO_2 projects



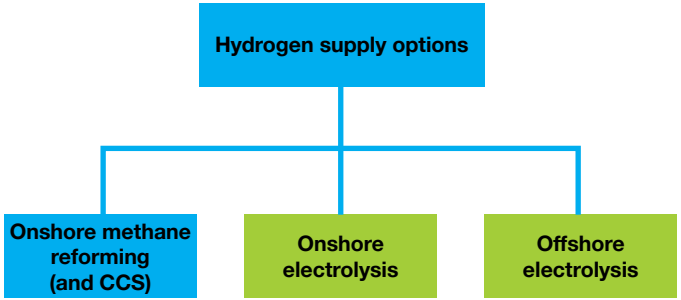
Potential CO_2 EOR reservoirs



Source: LR SENEOR database

Hydrogen

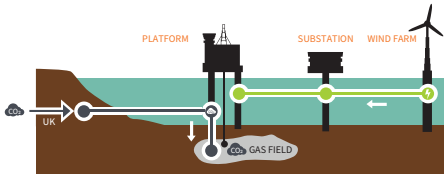
- Hydrogen has the potential to transform the UK energy system by 2050, as a key energy vector for power, heating, and transport
- Two production avenues:
  - Blue hydrogen – from methane reforming, with capture and storage of resulting CO_2
  - Green hydrogen – from water electrolysis, using power from renewable sources
- Onshore blue hydrogen generation may leverage existing gas terminals, with efficient access to gas supply, blending and pipeline networks
- There are alternative reforming technologies (e.g. steam methane reforming (SMR), and autothermal reforming, (ATR)) with efficiency levels in H_2 production and CO_2 capture cycles
- Green hydrogen generation can also take place onshore, using electricity generated from offshore renewables
- However, offshore green hydrogen generation may also be placed offshore, potentially repurposing legacy oil platforms. Depending on distances from shore, this may provide efficient energy transmission



Hydrogen options

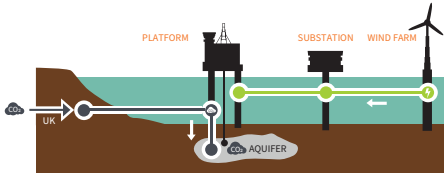
Blue – Onshore methane reforming and H_2 storage, offshore CCS

- Onshore: methane reforming
- Offshore: wind powered desalination; CO_2 storage



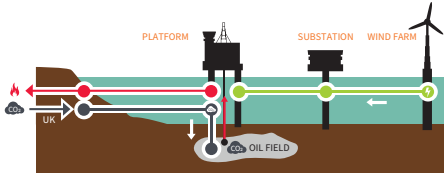
Green – Onshore electrolysis and H_2 storage

- Onshore: wind powered electrolysis; H_2 storage
- Offshore: wind powered desalination



Green – Offshore electrolysis and H_2 storage

- Offshore: wind powered electrolysis on platforms
- H_2 storage in spent fields or salt caverns
- H_2 transportation with re-used pipelines



Onshore proven but technology still evolving – projects in planning phase (e.g. Hynet, Acorn)

Offshore to be piloted (Q13a in NL, and proposed Flotta scheme)

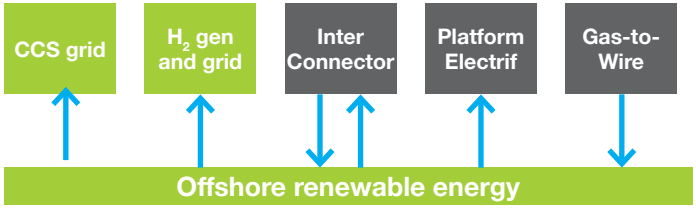
Offshore infrastructure large re-use potential: SNS, EIS and Northen North Sea (NNS)

Larger hubs can help capture full potential: Shetland, Orkney, SNS, EIS and NNS

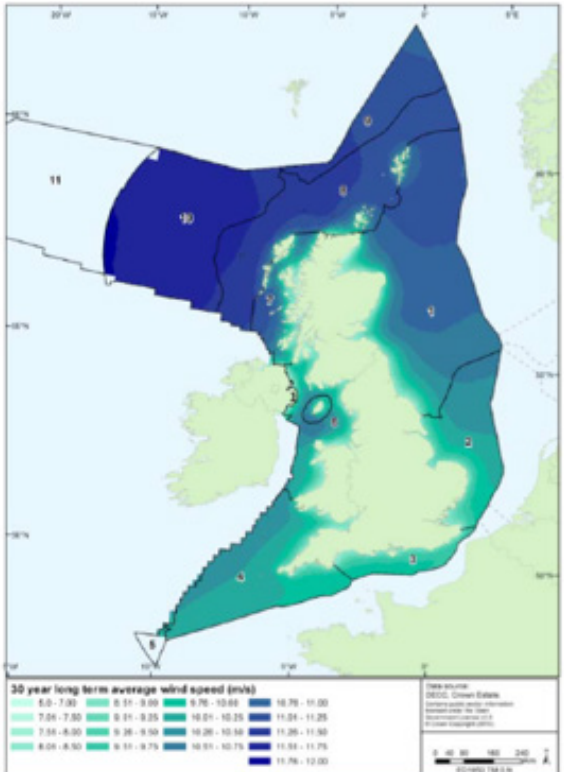
Energy hubs

- Energy hubs – on or offshore – can support energy transition by integrating renewable electricity generation with carbon and hydrogen storage and transportation solutions to enable or address:
  - more optimal offshore windpower locations
  - renewables supply intermittency
  - cost-efficient carbon capture, usage and storage
  - potential interconnection with other countries
- In deeper waters, energy hubs could be combined with floating windfarms
- Scope to reuse oil and gas infrastructure, e.g. heavy steel jackets and concrete gravity-based structures
- Widespread UK opportunities:
  - Onshore (e.g. Merseyside, Humber and Teesside)
  - Offshore (e.g. Dogger Bank and around CNS and NNS oil clusters)
  - Islands (e.g. Shetland and Orkney)

Energy hub components



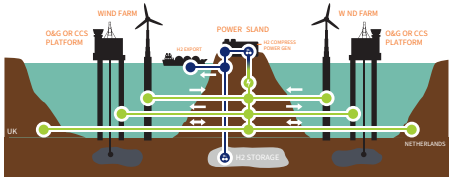
UKCS average windspeed conditions



Energy hub options

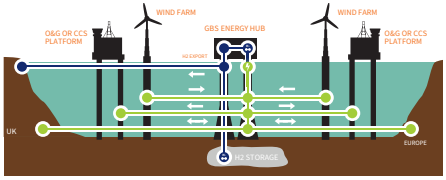
1. Power island

- Artificial island option - high capex
- Onshore locations may also be suitable (e.g. Orkney, Shetland, Humberside)



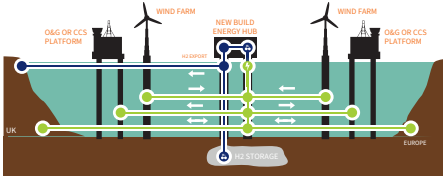
2. Re-purposing of oil and gas assets

- Long-lasting gravity based structures (GBS)
- NNS locations for sustained high windspeed
- Reservoir storage and pipelines
- Capex savings

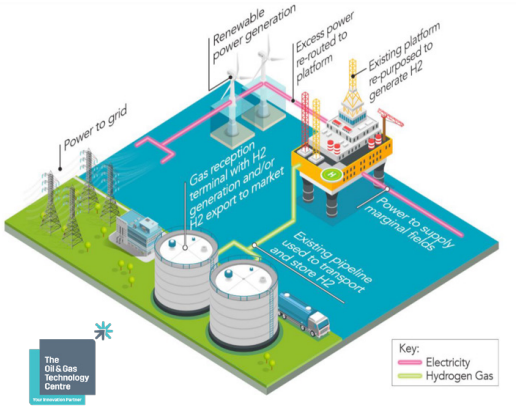


3. New-build offshore platform

- Platform hub to connect and optimise usage of existing and new installations:
  - Wind
  - Oil and gas
  - Future CCS and H_2



Example: Orkney Flotta energy conversion – proposed



Phase 2

Phase 2 scope

(delivered with EY)

Phase 2 is conducting an economic assessment and identification of regulatory enablers to help realise the opportunities for a more integrated offshore energy sector.

The project has prioritised a number of real world projects, across the different technology concepts and UKCS areas, for industrial engagement and economic assessment, to test how integrated business models could be delivered.

The study comprises three workstreams:

1.Integrated economics

- Assessing each business model from an economic and commercial perspective
- Develop scenarios and sensitivities to identify how to improve commercially viability

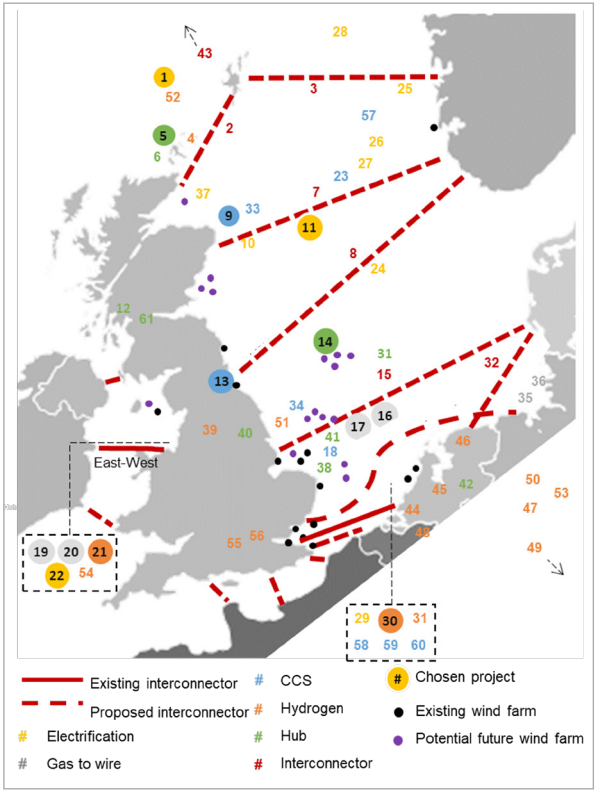
2. Cross industry synergies

- Comprehensive stakeholder engagement to provide inputs into the analysis, validating findings and recommendations
- Promoting contacts across industry sectors to accelerate joined-up plans for UKCS energy concept developments

3. Regulatory coordination

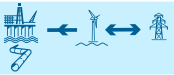
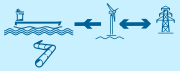
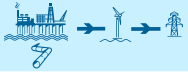
- Inventory of regulations which apply to each business model
- Highlight any regulatory barriers, synergies, and areas for improvement

Industry projects engaged in Phase 2



Phase 2 ‘business models’

We have defined 8 stand-alone business models from the technologies reviewed in phase 1

	Business models		Economic and strategic opportunities
1	Brownfield Electrification		→ Reduced greenhouse gas (GHG) emissions → Greater recovery of oil and gas → Opex savings
2	Greenfield Electrification		→ Reduced GHG emissions → Greater recovery of oil and gas → Capex and opex savings
3	Brownfield Gas to Wire		→ Extension of asset life/gas recovery → Capture peak electricity prices → Grid balancing
4	Greenfield Gas to Wire		→ Greater recovery of gas → Scope to capture peak electricity prices/balance grid → Synergies with offshore wind
5a	Offshore CCUS		→ Access to vast CO_2 storage capacity of UKCS → Contribution to Net Zero targets → Re-use of oil and gas infrastructure
5b	Offshore CCUS & Blue Hydrogen		→ Enabler for clean use of gas → Access to vast CO_2 storage capacity of UKCS → Re-use of oil and gas infrastructure
6	Offshore Green Hydrogen		→ Energy storage and transportation solution for renewable power → Supports growth of renewables in previously non-commercial areas → Re-use of oil and gas infrastructure
7	Offshore Energy Hub		→ Logistical advantages from combining between technologies → Synergies between energy sources and energy storages → Economies of scale and re-use of oil and gas infrastructure

This will help develop a set of recommendations addressing the following questions:

What are the relative advantages of the different UKCS options to support Net Zero?

How can these be enabled or promoted?

How can regulatory hurdles be mitigated?

Contacts

OGA
www.ogauthority.co.uk

BEIS
www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy

The Crown Estate
www.thecrownestate.co.uk

Ofgem
www.ofgem.gov.uk

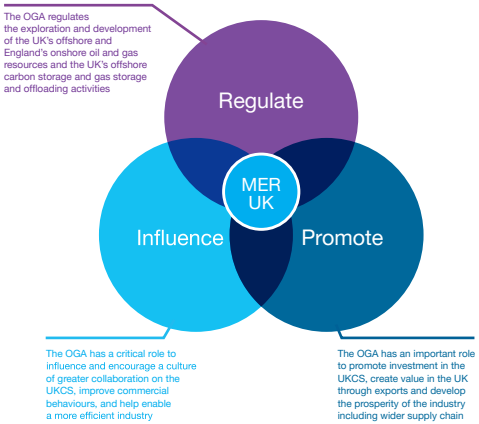
If you would like to contribute to Phase 2 of the UKCS Energy Integration project, please contact the OGA:
oga.correspondence@ogauthority.co.uk

Annex

Project Partners

Oil & Gas Authority

The OGA's role is to regulate, influence and promote the UK oil and gas industry in order to maximise the economic recovery of the UK's oil and gas resources. It is the licensing authority for carbon storage in the UK, approving and issuing storage permits, and maintaining the carbon storage public register. The OGA issued its first carbon dioxide appraisal and storage licence in December 2018.



Department for Business, Energy & Industrial Strategy

Department for Business, Energy and Industrial Strategy (BEIS) is one of the partner organisations taking part in the UK Continental Shelf (UKCS) Energy Integration Project.

BEIS leads the Government's decarbonisation agenda, helping the UK cut emissions by 42% since 1990, faster than any other G20 country. Since legislating for net zero emissions by 2050, the Government has announced around £2 billion to help all sectors of the economy decarbonise. In 2018, more than half of the UK's electricity came from low carbon sources and it is expected this figure will continue to grow.

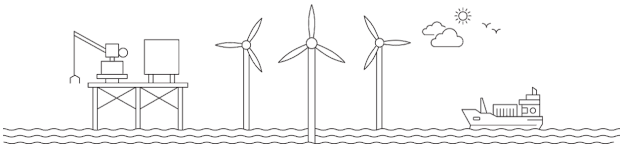
Key BEIS policy areas such as Carbon, Capture, Usage and Storage, oil and gas, gas security, hydrogen and renewables are crucial to UKCS energy integration and various teams from across BEIS input and support the Energy Integration Project. BEIS welcomes being part of this initiative, supporting UKCS energy integration and contributing to the UK's transition to a low carbon economy.

THE CROWN ESTATE

The Crown Estate is a specialist real estate business, created by an Act of Parliament to manage a diverse portfolio that includes the seabed around England, Wales and Northern Ireland, as well as around half of the UK's foreshore.

The Crown Estate works closely with industry and stakeholders to enable the sustainable development of the seabed, including by providing seabed rights for offshore renewable energy, as well as marine aggregates and minerals, cables and pipelines, and carbon capture and storage.

The Crown Estate is pleased to be working with the Oil and Gas Authority and other partners to support this project, helping to pave the way for greater market innovation in the critical area of energy integration, and support the UK's ongoing transition to a low carbon energy mix.



ofgem

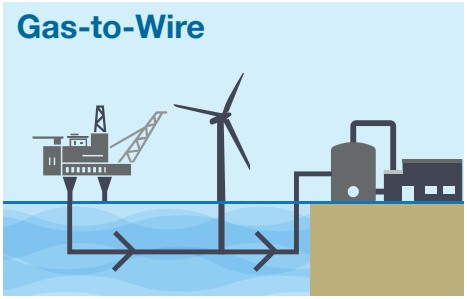
Ofgem is the independent Great Britain energy regulator, working to protect the interests of current and future energy consumers.

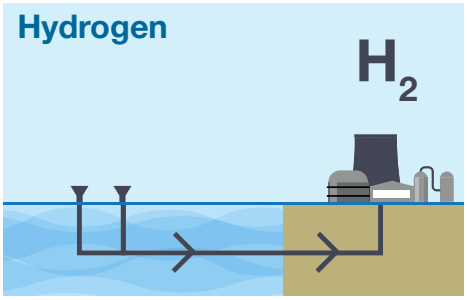
The energy system is undergoing rapid changes and we expect the scale and pace of change to continue. To support this, Ofgem will play its role in facilitating the UK's transition to a decarbonised energy system and to enable smarter and more flexible system arrangements that will benefit consumers.

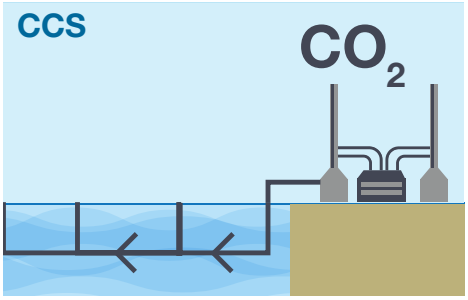
Ofgem therefore welcomes research that can contribute to our understanding of how to best support this transition. Ofgem maintains a broad interest in the role that energy integration could play in this future, and consider that the UKCS Energy Integration project will be a valuable addition to the growing evidence base in this area.

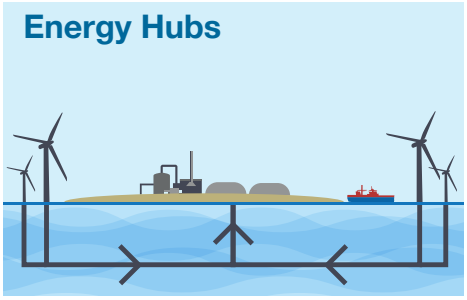
Technical concepts

Offshore Energy Integration Concepts









Concepts summary

Concept	Description
Platform Electrification	• The concept of electrification is to substitute OCGTs, which are used to generate platform power and heat, with electricity supplied by underwater cables • This would remove carbon dioxide emissions that arise from OCGT generation and potentially reducing operational costs
Gas-to-Wire (GTW)	• Gas-to-wire projects aim to tap undeveloped gas reserves and generate electricity for export through an offshore grid • The effect would be to maximise economic recovery of gas reserves • With the addition of CCS, the technology may avoid carbon emissions
Carbon Capture and Storage (CCS)	• The study covers the compression, transport and injection (i.e. excluding capture) of carbon dioxide emissions into offshore subsurface storage sites, and synergies with oil and gas • The concept would offset emissions that are currently produced by power plants and other industrial users and thereby contribute towards the UK's net zero target
Hydrogen (H_2)	• Hydrogen can be produced through natural gas reforming (blue hydrogen) capturing and storing the resulting CO_2 or electrolysis powered by renewable sources (green hydrogen) • It could play a vital role in helping create a hydrogen economy, supporting the transition to a low carbon energy system, help mitigate renewable intermittency, and decarbonise heat and transport
Energy Hubs	• An energy hub combines various elements of the above concepts • Through deploying technologies jointly, it is possible to realise synergies that achieve cost reductions and improvements in efficiency

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