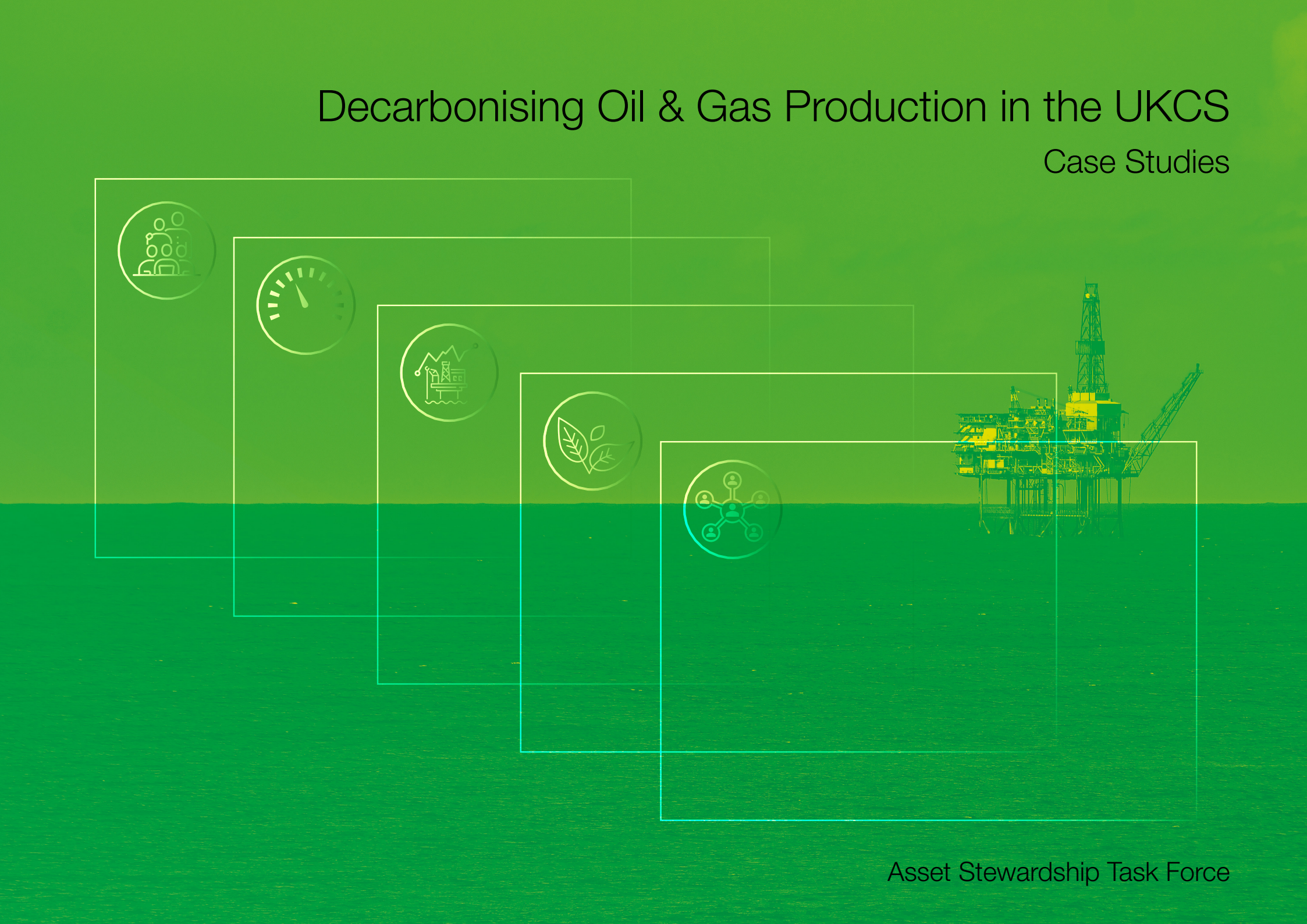
Decarbonising Oil & Gas Production in the UKCS

Case Studies



Asset Stewardship Task Force

Foreword

Arne Gurtner and Scott Robertson
Co-Chairs of the Asset Stewardship Task Force (ASTF)

In 2019, the government introduced a legally-binding commitment to put the UK firmly on a pathway to net zero greenhouse gas emissions by 2050.

The Committee on Climate Change suggests that between 2018 and 2050 the UK must reduce annual greenhouse gas emissions from 451 $MtCO_2e$ to <29 meaning that the oil and gas industry must go further and faster to reduce its footprint.

At the request of the North Sea Transition Steering Group (formerly MER UK Steering Group), the Asset Stewardship Task Force (ASTF) was asked to champion operator net zero contribution in the UKCS over the next five years.

The booklet is an amalgamation of 15 standalone case studies which highlight tangible and specific examples of where oil and gas operators are contributing towards net zero.

The examples in this booklet are neither exclusive nor exhaustive: they are drawn from OGA tier one interviews and landscape feedback. They cut across a wide range of themes, showing the diverse range of activities being undertaken to tackle both scope one and two emissions.

These case studies serve as a reminder to industry that no contribution to the net zero journey is too small: we all have to "do our bit" – where practical – to work towards the target. This kind of ongoing effort and commitment are what will help drive a culture where net zero becomes a core part of all operations.

Looking to the months ahead, a sector deal, alongside a global underwater hub and energy transition zone, are offering a real boost to the industry following such a tough period. Now is the time to make the most of these upcoming opportunities and keeping up pace with low-carbon solutions so that case studies like these become less and less unique, and more and more commonplace.

"Technology plays a critical role in the success of the North Sea transition. One of the TLB's key priorities for transition is decarbonising existing operations where technology is essential to measuring, reporting and reduce greenhouse gases will provide clarity on emissions from existing operations and help us to take on the actions required to reduce emissions and ensure sustainability of these reductions."

Mikki Corcorcan
Co-chair of the Technology Leadership Board (TLB)

Good Practices

Culture	Energy Management System Certification Inspiring Net Zero Capital Investment Projects
Measure, Report, Lower	Digital Emissions Management CO_2 Reduction in Ageing Assets Methane Emission Detection & Reduction Strategy
Capital Asset Development	Power & Gas Ring Main Fulmar: Auk Interconnector Project Carbon Capture at SEGAL Terminal – St Fergus
Net Zero Enabling Technologies	Triton FPSO: Emission Reduction Think Wider, Study in Detail Electrification: Evaluation Framework
Stakeholder & Partner Engagement	Incorporating Paris Agreement/Sharing NCS Best Practice Setting Environmental Targets within Financing Energy Area Plan Collaboration

Within this Case Study Booklet, the ASTF/OGA has adopted "CO_2" in respect to all matters pertaining to Carbon Dioxide Equivalent (CO_2e)

Culture

Energy Management System Certification

NEPTUNE ENERGY

Project Value

OPEX £25K fees over 3yrs, with £50K of delivery resource.

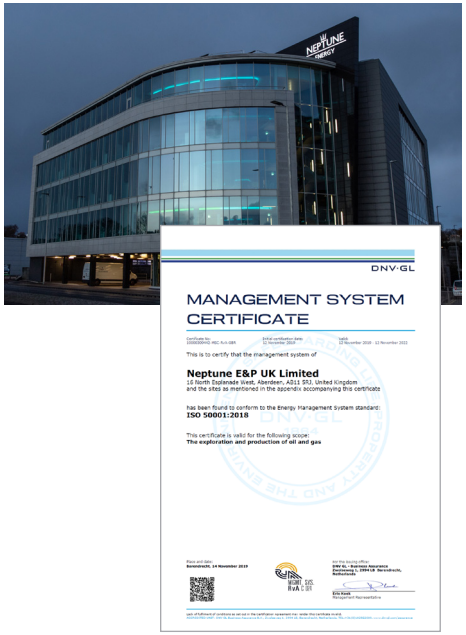
25% Office Energy Saving.

Project Scope

Energy use for the UK Corporate Group including Offshore Assets.

Includes:

- London and Aberdeen offices;
- Cygnus Alpha and Bravo assets in the Southern North Sea



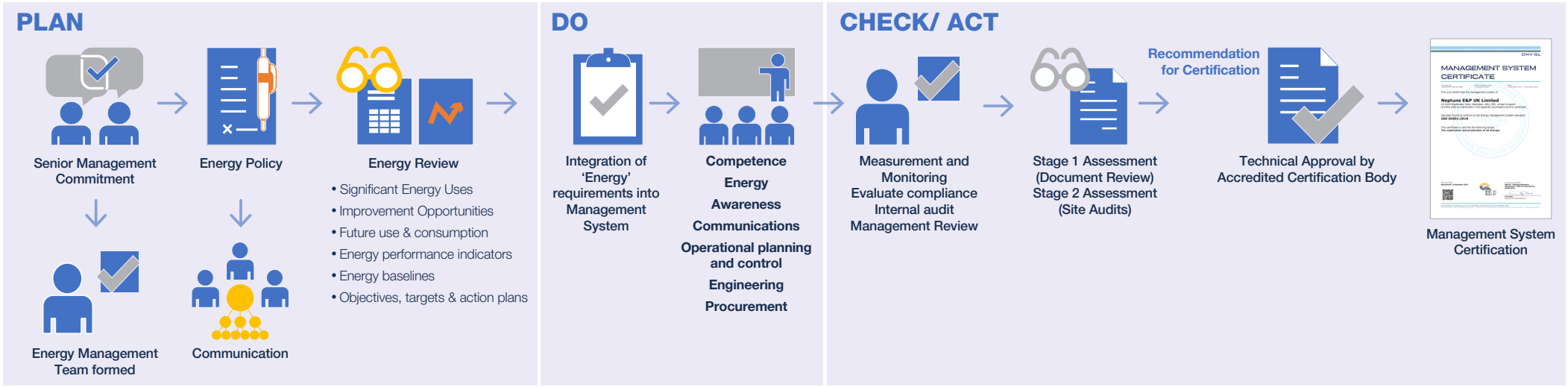
Good Practice:

A ‘Business Case for ISO 50001 Certification’ was developed and presented to UK Leadership Team showing the scope, risk drivers, implementation programme, and high-level assessment of required work, resources and cost.

With approval, a member of Senior Management was nominated to sponsor an Energy Management Team (EMT). The EMT was established with representatives from each Operational Area of significant energy use. Energy management boundaries and scopes were defined, enabling a gap analysis to be performed on the existing management system against ISO 50001 requirements. Essential tasks were identified and consolidated into a formal action plan with responsibilities clearly defined, including needs for awareness training.

The certification body was subsequently engaged, with implementation timescales geared towards company requirements and compliance with ‘The Energy Savings Opportunity Scheme (ESOS) Regulations’. All management system standards follow ISO’s high-level structure, core text, terms and definitions, so with ISO 14001 (Environmental Management Systems) accredited certification already in place, many common elements simply required further development, e.g. management review.

Energy Management System Certification



Applying the ISO 50001 PDCA framework:

Plan: A UK Energy Policy, approved by the CEO, was formally communicated to all Staff and Contractors by the Managing Director and the Head of HSEQ.

Following the policy, an energy review considered all energy sources, consumptions, facilities and personnel effecting energy use. Energy flow diagrams were developed to aid understanding and identify all data sources. Annualised energy usage trends were developed to promote an understanding of underlying changes. The EMT developed a definition for Significant Energy Use (SEU) based on energy consumption and/ or energy improvement opportunities. SEUs were determined, including the variables affecting their performance.

Energy objectives, targets and actions plans were set for each SEU. Robust onshore and offshore monitoring and measurement processes allowed scrutiny of progress towards targets. Specific 'energy management' requirements were integrated into existing business processes and procedures, e.g. engineering and procurement.

Do: Training, for Staff & Contractors to increase Energy Performance Awareness.

With formal training and competence systems already in place, specific awareness training was introduced for employees and contractors to inform how individuals and roles can impact overall energy use. The Cygnus Asset Team created an energy use video, which now forms part of the platform induction.

Check-Act: A quarterly EMT meeting evaluates in place elements, including ongoing monitoring and analysis of energy consumption and performance.

Internal energy audits were conducted as part of initial implementation, with further audits planned and conducted annually.

Within 6 months of completing the gap analysis, accredited certification was achieved following 7 days of third-party audit and technical approval. This enabled Neptune UK to achieve compliance with regulatory energy efficiency requirements (ESOS), along with a 25% saving in energy consumption for one onshore asset (Aberdeen office).

Success factors include:

Management commitment

Formation of an experienced Energy Management Team

Focussed Resource during initial implementation (1 person)

Previous investment in metering, data collection and reporting systems.

Overall Benefit: Implementation of ISO 50001 has improved energy management within the organisation, providing higher visibility of improvement activities, whilst reducing GHG emissions through increased energy awareness amongst our teams (staff & contractors). With an embedded Energy Management System, we are best placed to deliver upon future emission reporting and forecasting requirements.

Inspiring Net Zero

TOTAL

Project Value

CO_2 Reduction 100,000 - 500,000te

Project Scope

Total's ambition to meet Net Zero by 2050 and to be the responsible energy major means that in the UK we must continually develop and implement plans to reduce our Green House Gas (GHG) emissions whilst also increasing our energy and performance efficiency.

In order to achieve our carbon reduction goals, it is essential that our emissions performance is embedded within our operating culture and a key metric in decision making and business strategy. Our culture change initiatives are promoted through a number of themes:

- Inspire & Engage
- Build on the Ambition
- Progress the Longer Term

Further improving the "low carbon culture" is seen as a strategic driver for Total E&P's UK business in 2021.

Good Practice:

With an ambition to become the responsible energy major, Total is embarking upon a step change in energy efficiency and GHG emissions reduction, adopting an Integrated Management approach to Net Zero, building beyond ISO50001:2018.

Accreditation to ISO50001:2018, has provided the framework and stepping-stone to develop an energy efficiency and emission reduction strategy which supports our target of delivering a reduction of 20% of GHG emissions by 2025 based on our 2019 baseline. The management practices required to meet the ISO50001:2018 standard has been woven into our existing processes certified under ISO140001:2015. This has led to minimal disruption to daily business as fewer new documents had to be created.

Coupled with a changing culture driven by the MD and senior management, we are changing the nature and focus of our conversations to deliver on our ambition, which can only be met with support from all departments. We have held many positive and constructive sessions engaging with and inspiring our colleagues to play their part in delivering and evolving our emission reduction ambitions. Our engagement has inspired a sense of collective ownership of these targets.

There is a constant challenge on our performance from not only our leadership teams but also external stakeholders, and we are continually looking for efficient ways to improve our operations. The engagement we have carried out with our colleagues ensures that we receive an abundance of new ideas to optimise our operations based on business needs and challenges. This allows us to prioritise projects to deliver the greatest impact.

Inspiring Net Zero

Approach

Inspire & Engage

GHG emissions are forecast and tracked with a view to improving performance over the long term. A Carbon Footprint Reduction (CFR) Taskforce was established mid-2020, to refine and deliver our strategy. The objective is to rapidly develop cultural change, and provide the tools and practices needed for individual business units to take ownership and responsibility for their emission reduction targets, evolve their performance conversations, and drive improvements.

- **Improved data visualisation:** This has been a key focus to support performance management conversations and enable informed decisions which provide opportunities to change operational practices and implement projects.
- **"Total Sessions":** These are talks which focus on opening up the discussion around carbon reduction and energy transition with our colleagues. These often feature external guests and have covered popular topics associated with the energy transition, to educate, raise awareness and provide updates on our progress. This has proven to be an incredibly successful initiative with consistently high attendance and engagement across our onshore and offshore sites.
- **"Carbon Quest":** This is a training competition which was rolled out to our operational sites to engage operational teams on GHG emission reduction.

Building on Ambition

The CFR Taskforce is working with the wider business unit teams to identify and deliver emission reduction opportunities on our operated assets. Commitments to carbon reduction are already reflected in our long-term plans. Workshops have been held to systematically identify further emission reduction opportunities and resources have been assigned to ensure that they are appropriately prioritised and implemented.

In 2020, we delivered projects that have the potential to save 170kt CO_2 a year – around 10% of our total emissions. These were primarily focused on efficiencies to our power generation, but also covered our vented emissions and imported utilities.

Longer-Term

Budgetary commitments have been made to progress engineering on strategic and operational projects which reduce emissions (for example platform electrification), and we continue to reforecast our emissions profiles on an annual basis.

We actively engage with industry consultations and are involved in joint industry projects to look at basin wide energy transition solutions.

Harbour Energy

Project Value

CAPEX £115M
CO_2 Reduction 34,000te

Project Scope

Tolmount Main was designed and sanctioned as an ultra-low emissions unmanned platform with no flare, minimal venting, and power generated by energy efficient micro-gas-turbines using field gas.

The adjoining Tolmount East Development was initially intended as a similar ultra-low emissions unmanned platform which would take power demand from Tolmount Main. Through further engineering and optimisation Premier drove Tolmount East to a subsea solution, transforming it to a zero direct emissions project by inherent design.

It is intended that Tolmount East will be developed on a Net Zero basis. The very low CO_2 emissions emitted over the development and operating field life (CO_2 of ~34,000te) will be offset in nature-based projects.

COMMITMENT TO ACHIEVING NET ZERO BY 2035

LOW CARBON BY DESIGN

FLARING & VENTING

PROCESS EFFICIENCY

METHANE

METRICS, TARGETS & REDUCTIONS

DEVELOPMENT → OPERATIONS → DECOMMISSIONING

Good Practice:

Harbour Energy, through our Climate Change Policy, is committed to producing oil and gas responsibly to help meet the world's energy needs, with a commitment to achieve Net Zero by 2035 in respect of Scope 1 & Scope 2 emissions.

Designing for low emissions is critical in ensuring that we meet our commitment; Harbour Energy's Climate Change Policy drives a culture to ensure that facilities are low carbon through use of Best Available Technologies (BAT), whilst continuing to facilitate operations-based reductions, supply chain alignment, the use of standard emission calculations and open performance reporting to external auditors such as CDP. By working to instil carbon assessment in our business decisions, we actively design low carbon facilities as part of development planning. Harbour Energy is working with its supply chain in 2021 to set GHG and emissions KPIs in contracts with high environmental impacts.

A key part of our culture is empowerment; whereby everyone can suggest and improve on emissions performance. In 2020 our "Environmental Hopper" emissions improvement mechanism was launched. This allows any opportunities to reduce CO_2 emissions in projects or operated assets to be suggested, defined, screened and assessed, in order to instil the cultural mind-set of continually driving improvement in emissions reduction measures, where no idea is too simple or too small.

Measure, Report, Lower

Digital Emissions Management

Canadian Natural OPEX

Project Value

Incurred OPEX >£100K
CO_2 Reduction >7,000te/yr

Project Scope

In 2020, OPEX Group launched an AI-driven solution focused on helping customers to continuously operate their assets with the lowest achievable emissions.

As an existing customer of OPEX's data analytics solutions, CNR chose to trial the new cloud-based technology on the Tiffany asset.

Following the successful deployment this has now been rolled out to all of CNR's UKCS assets to support efforts to monitor and lower emissions across their operations with early insights specifically related to power generation opportunities.

Using AI to Operate Assets with the Lowest Achievable Emissions.

Good Practice:

CNR International's asset teams use OPEX's AI-driven software to help them reduce operational emissions. The solution allows them to:

- Measure, monitor and visualise comprehensive emissions data down to individual source or emitter
- Automatically calculate the lowest achievable emissions (minutely) for any operating mode, configuration or operational constraint
- Detect sources of excess emissions as they occur and assign and take actions to optimise energy efficiency, minimise power consumption or reduce flaring

The software is displayed in the asset control rooms and utilised by onshore engineers as part of their daily workflows. This brings an increased awareness of the emissions impact of operational configurations and allows the teams to focus on managing and reducing emissions. Examples of the types of daily emission reduction opportunities that are identified include;

- Reducing the discharge pressure set points of booster pumps to save 5te/d of CO_2
- Quick detection and repair of a problematic pressure control valve which eliminated excess emissions of 17te/d of CO_2 during the start-up of the export compressor
- Identification of 13te/d CO_2 saving opportunity with single Sea Water Lift Pump operation vs dual
- Cross shift learnings in process start-up and equipment change-over, have enhanced opportunities to reduce emissions by 1-22te/d

By enabling data-driven decisions across the assets, CNR is driving cultural change with the ultimate aim of lowering emissions and carbon-related costs.

CO_2 Reduction in Ageing Assets

PERENCO

Project Value

CO_2 Intensity Ratio reduction from 165.6 to 63.3te of CO_2 per million cubic metre in 7 years

Projects

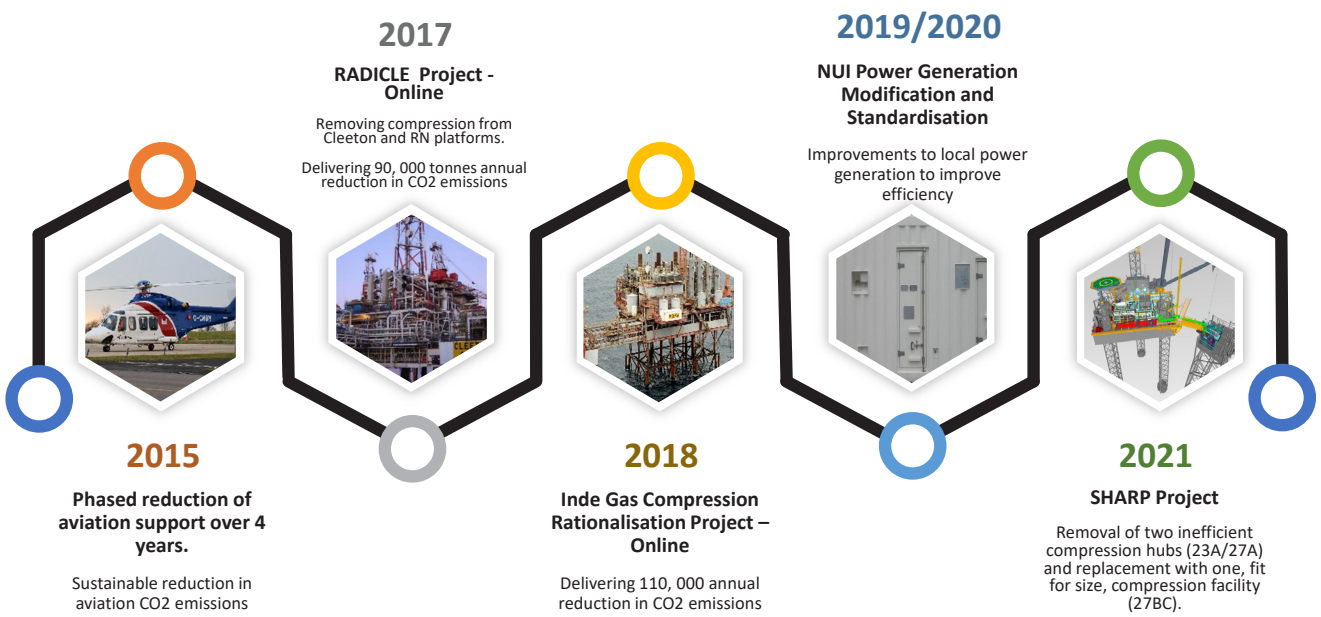
Phased reduction of aviation support in favour of more efficient walk to work options (2015 to date)
The reduction in aviation dependence in favour of high reliability/ efficiency walk to work options.

RADICLE Compression Rationalisation (2017)
Cessation of offshore gas compression associated with Cleeton and Ravenspurn field hubs and consolidation of onshore compression at Dimlington Terminal.

Inde Gas Compression Rationalisation (2018)
Rationalisation of fuel gas facilities for Inde 23A field compression facilities.

NUI Rationalisation (2019/2020)
Delivering replacement of older, less efficient, stand alone generation in favour of standardised modern, lean units. The combining with platform loading reviews is leading to downsizing of power generation requirements across the fleet.

Decommissioning (2019 to date)
The adoption of new decommissioning techniques and right sized equipment, allowing operations to be executed in the most efficient manner and with emissions reduction benefits.



Good Practice:

Since 2015, Perenco UK (PUK) has progressed an area-wide strategy of CO_2 reduction across our Southern North Sea (SNS) Ageing Assets, the strategy is built upon the following good practice:

- **Compression Facilities Management** – One of the major contributors to high CO_2 emissions, for aged infrastructure, are older, inefficient, over-sized, compression facilities. The ability to tackle this issue head on has been the key to PUK reductions in CO_2 emissions. Over the past five years we have delivered three strategic projects addressing the key goals of improved operational efficiency and emissions reduction.
- **Power Generation** – In common with compression management, aged assets also typically utilise inefficient, dated, local power generation. PUK has undertaken a rolling program of standardising, manufacturing and replacement of its NUI generation fleet, in favour of modern, right-sized units. In combination with platform loading reviews, PUK has been able to significantly reduce its power generation footprint.
- **Aviation Support Reduction** – As improved platform access options (Walk to Work) have become available, PUK has shifted its dependence from aviation to modern marine access vessels. W2W provides far greater efficiencies in respect of time on platforms, substantially decreasing the number of visits required and associated CO_2 emissions.
- **Decommissioning** – The adoption of novel decommissioning techniques (top-sides skidding) and fit for purpose equipment (repurposed jack-ups) has allowed for the use of higher efficiency, appropriately sized, equipment, commensurate with PUK NUI decommissioning operations. This has enabled a significant reduction of rig moves and heavy lift vessel deployment.

CO_2 Reduction in Ageing Assets

PERENCO

Projects cont.

Southern Hub Area Rationalisation Project (SHARP) (2021)

Project Value

CAPEX £140M
CO_2 Reduction 125,000te/yr

Project Scope

The SNS (South) asset base, of the PUK portfolio, consists of two very large heritage fields, Indefatigable and Leman, with connected feeder fields.

Both fields are served by Nodal compression platforms and fed by a large number of Normally Unattended Installations (NUI).

The current infrastructure is significantly over-sized and excessively complex, both in terms of process and plant integrity operations, leading to increased cost and higher carbon emissions to support its future operations.

The SHARP project seeks to reduce process complexity and integrity overburden by introducing a new, fit for purpose, compression jacket, whilst removing from service, aged and inefficient existing compression facilities and decommissioning large areas of plant and infrastructure.

On completion of the project PUK will have achieved significant reductions in CO_2 emissions due to improved compression efficiency, reduced flying commitments, reuse of existing capabilities to introduce a new jacket etc.

Decommission 23A Compression

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Decommission 27A Compression

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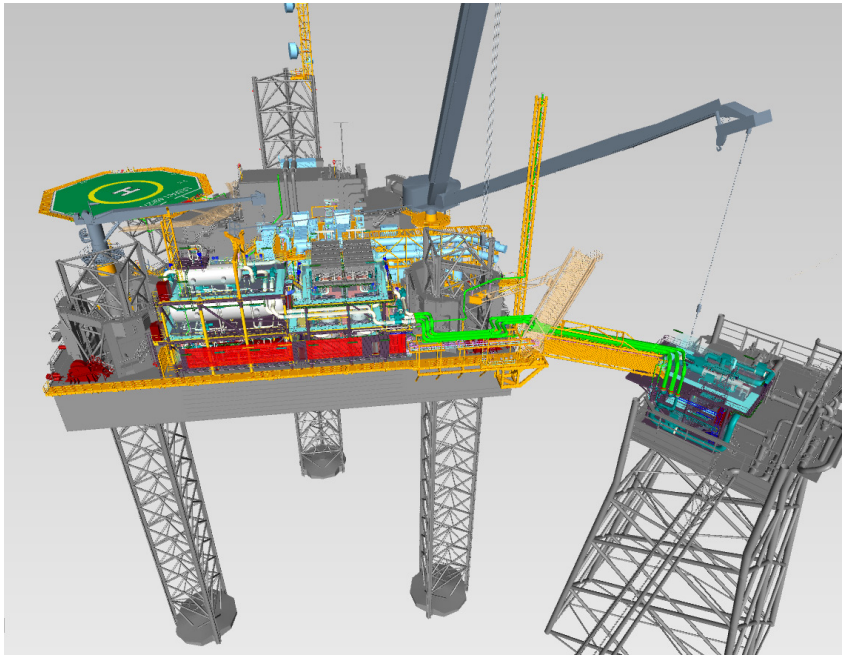


New 27B Compression Jacket

SHARP Learnings

- Recognition that good business and emissions reduction are not mutually exclusive, inherent to the ultimate value of SHARP.
- Recognition that effective interventions, on the largest assets, offers the most significant emission reduction potential, along with additional important, measurable, risk reduction factors.
- Creative, strategic, thinking is essential in delivering a SHARP type solution. Organisations must start from a ‘nothing is off the table’ position and avoid being constrained by orthodoxy.
- Creative repurposing of strategic resources (decommissioned jack-up) is both inherently a green approach and an opportunity for CAPEX reduction.
- CO_2 reduction benefits are multi-faceted. SHARP benefits included decreased venting, decreased fuel gas usage and reduction in emissions associated with flying and power consumption.
- Regulators are not necessarily an obstacle to radical solutions, provided engagement is early and proposed solutions are technically capable of navigating regulatory hurdles.

Methane Emission Detection & Reduction Strategy

Project Value

Early development phase

Project Scope

The project trialled methane emission monitoring techniques on Glen Lyon FPSO (Floating Production Storage Offload) for combustion sources flare and gas turbines.

Current practice is to calculate methane emissions using gas volumetric flow and composition, and applying an industry standard combustion efficiency. These established methodologies can result in potential to under or over reported emissions.

The monitoring approach combined measurement and models. A multispectral infrared imaging camera was used to accurately determine flare combustion efficiency. The camera measurements, along with gas turbine exhaust sampling, were used to initiate / calibrate system specific predictive emission models. The integrated techniques generated near-real time methane emission monitoring capability to provide operational insight into equipment performance and could potentially inform reporting.

Glen Lyon FPSO

Good Practice:

BP's ambition is to become a net zero company by 2050 or sooner, and to help the world get to net zero. The ambition is supported by 10 aims, one of which is to install methane measurement at all major oil and gas processing sites by 2023 and reduce methane intensity of operations by 50%.

In pursuit of this, an integrated methane monitoring programme adopting a range of innovative techniques is being developed to ensure appropriate coverage of BP's North Sea oil and gas operations and their associated emission sources.

Methane monitoring techniques are rapidly evolving and represent a field of active research and development leading to the availability of a variety of commercial technologies.

Careful consideration is required in selecting the right monitoring techniques using technical, cost and operational criteria, but also to check offshore suitability, e.g. use in the remote and harsh West of Shetland environment. BP is progressing toward operational readiness in partnership with vendors and industry as a whole.

The Methane emissions detection project adopted a 'learn by doing' mentality promoting an outcome focus, which has delivered fast track learnings.

Learnings are transferable to other methane sources (i.e. vents and fugitives) which enables a complete picture of asset methane emissions.

Capital Asset Development

Power & Gas Ring Main

Apache

Project Value

CAPEX > £200M
CO_2 Reduction 100,000 – 500,000te

Project Scope (Phase 1)

In 2003/04, Apache installed an electric power and gas ring main, connecting all five Forties platforms to facilitate efficient power sharing across the Forties Field.

In addition, outdated generators were replaced with more efficient models to increase power generation, from 32MW to 55MW.

The investment afforded centralisation of three control centres to a single centre on Forties Alpha, reducing offshore manning risks whilst enhancing efficiencies.

Project Scope (Phase 2)

In 2016, Apache developed the Aviat Field, 23km from Forties, to provide additional fuel gas to meet power demands and avoid diesel consumption.

The Power & Gas Ring Main has enabled continuous field wide electrification, executed under various projects including: cranes, MOL pumps, ESP conversions, HP PWRI pumps, additional WI pumps plus additional generation upgrades.

Good Practice:

Apache's installation of an electric power and gas ring main allowed for future field investment, flexible development options, and demonstrated the company's early commitment to reducing its carbon footprint. This has been further demonstrated through subsequent equipment upgrades, which resulted in increased production efficiency and a reduction to emissions and operating costs.

Development of the Aviat Field enabled Apache to reduce diesel consumption, as the power generated from Aviat gas along with Forties associated gas is shared field wide by the power ring main to optimise energy.

Apache's phased project investment has extended the Forties field life reducing emissions and OPEX costs. Environmental benefits, achieved between 2016-2019, include:

CO_2 **Reduced 354,887 tonnes** of CO_2

Diesel usage **reduced by 94%** (by volume)

Flaring **decrease by 61%** (by mass)

Apache is now actively investigating electrification from the mainland and power sharing options across both its Forties and Beryl Field to further reduce its emissions whilst maximising economic recovery from its North Sea operations.

Power & Gas Ring Main

Apache is an oil & gas exploration and production company with operations in the United States, Egypt and the United Kingdom and exploration activities offshore Suriname.

Our vision is to be the premier exploration and production company, contributing to global progress by helping meet the world's energy needs.

Headquartered in Houston, we employ 3,000 people globally with over 600 individuals based in Aberdeen, where we operate the Forties and Beryl Fields.

As of year-end 2020, Apache has interests in approx. 516,000 gross acres in the U.K. North Sea and contributed 14% of Apache's 2020 production and approx. 13% of year-end estimated proved reserves.

The Future of Energy

As the world transitions to a cleaner energy mix, oil and gas will continue to play an important role. Apache is committed to helping produce those needed resources in a clean and socially responsible manner.

Our ISO 50001 certified Energy Management System defines our strategic approach to becoming even more effective in tackling the world's energy challenges and ensures we are accountable for delivering continuous energy improvement.

Fulmar: Auk Interconnector Project

REPSOL SINOPEC Resources UK

Project Value

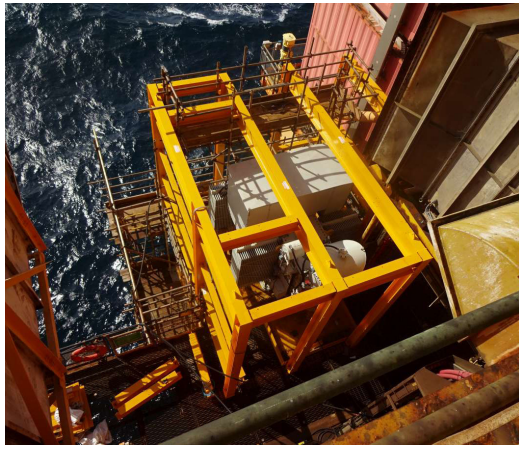
CAPEX £4.5M
CO_2 Reduction c. 25,000te/yr

Project Scope

In Q4' 2019 Repsol Sinopec Resources UK delivered an electric grid solution to the Auk asset from Fulmar Alpha.

This innovative project comprised the integration of a previously installed 33kV subsea cable (year 2000) with the supply, installation and commissioning of two new 7.5mVA transformers. Structural additions were required on both assets together with a comprehensive safety review and resultant modifications to manage the new risks associated with the HV transformers. Despite some degradation to the communication link since installation useable cores were identified which meant the project could be completed with no subsea interventions.

By reusing equipment, finding suitable safe workarounds and minimising modifications the team were able to implement a significant improvement to the environmental performance of the asset group with the least possible impact.



Good Practice:

Process:

Repsol Sinopec Resources UK progressed an inter-field energy strategy, evolving thinking beyond single asset operating perimeters, whilst seeking to capitalise on existing infrastructure. Repsol Sinopec's development of an electric power connection between Fulmar and Auk enabled greater generating efficiency and operational reliability, whilst reducing logistics and operating costs (OPEX). It clearly demonstrated the company's early commitment to reducing its carbon footprint.

Key factors included:

Optimise Infrastructure – *Re-Purposing a redundant 33kV subsea cable linking the assets.*
The cable had been laid circa 20 years ago by the previous Operator however the topside scope did not proceed at that stage. As part of re-instigating the project, Repsol Sinopec was able to utilise the original transformers and other ancillary items, which had been procured at the time and held in storage. This demonstrated effective use of existing stock and limited the requirement to procure new equipment.

Reduced Diesel consumption – *76% Reduction, from 2019: 8897 tonnes to 2020: 2087 tonnes.*
Auk power generation prior to the successful completion of this scope was from 3 diesel driven Generators. These were emissions intensive and necessitated regular vessel operations to maintain diesel supplies on the asset. Providing power from Fulmar allowed the Generators to be utilised on a standby-only basis and significantly reduced logistical demand.

Use of spare power generation capacity – *10MW available from Fulmar to supply 2.2MW demand on Auk.*
Fulmar asset is operating with no native production and had significant electrical capacity available, from more efficient power generation turbines which run primarily on gas.

Carbon Capture at SEGAL Terminal – St Fergus

Project Value

CAPEX – £100Ms (Order of Magnitude)
CO_2 Reduction – 300,000te/yr

Project Scope

SEGAL Terminal sales gas to the National Grid, is compressed by gas turbine driven compressors, generating flue gas emissions which make up circa 94% of site carbon dioxide (CO_2) emissions of around 300,000 tonnes per annum. Work underway on the Acorn Carbon Capture and Storage (CCS) project creates an opportunity to significantly reduce the site emissions.

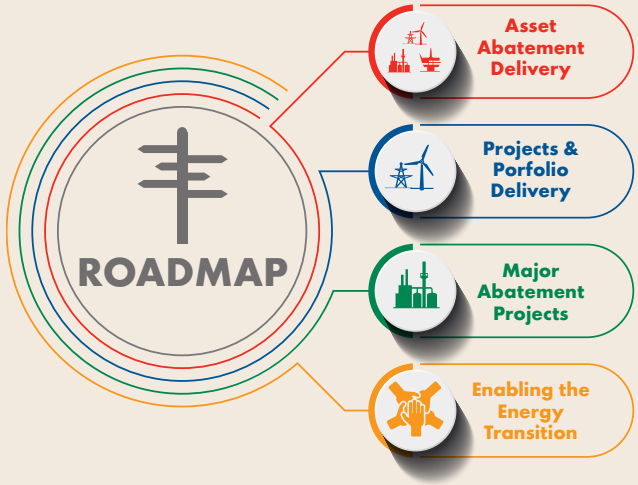
The proposed carbon capture project comprises three distinct processing modules: carbon capture, conditioning and compression, and transport & storage. The gas turbine flue gas is routed by ducting to the capture plant and stripped of around 90% of the CO_2 volume using an absorption process. In the conditioning plant the CO_2 is conditioned to remove water and oxygen required to protect the Goldeneye pipeline from corrosion. The CO_2 is compressed into dense phase for transportation and storage through the 102km Goldeneye pipeline to the Acorn store.

At the Acorn CO_2 Storage Site location, the proposed design would connect the Goldeneye pipeline with new sub-sea infrastructure to a new sub-seawell designed for CO_2 injection. The CO_2 will be injected into the Acorn store and will be monitored. The sub-sea infrastructure will be designed to accommodate additional wells to meet the demand from other companies seeking to reduce their CO_2 emissions.

The CO_2 export composition and injection-well material selection specification allow future flexibility to accommodate other CO_2 sources beyond the St Fergus terminals. This government supported CCS project is working with development and technology experts to ensure knowledge building for this new industry sector to enable further build out plans.

Good Practice:

Shell's target is to become a net-zero emissions energy business by 2050, in step with society's progress in achieving the goal of the UN Paris Agreement on climate change. Shell's Upstream business in the UK has developed a decarbonisation roadmap to create clarity on the decisions required in the next 2-3 years to achieve the UKCS emissions reduction target of 50% by the end of the decade and ultimately becoming a net zero basin by 2050. Within Shell's UK portfolio the SEGAL St. Fergus gas plant is one of the single biggest sources of emissions and plans are underway to decarbonise operations. When considering potential solutions Carbon Capture and Storage (CCS) is a clear front runner; CCS is a Government priority with associated financial support, CCS is a proven technology with improving cost competitiveness.



Carbon Capture at SEGAL Terminal – St Fergus

For a large continuously operating piece of infrastructure for UK energy supply, reliability is critical and any new facilities must have little or no impact on plant availability and minimal interruption during installation. The capture of flue gas requires diversion of the low-pressure flue gases and tie-ins to ducting that carry the gas to the capture and transport plant. This will require a single shutdown for each train aligned with maintenance schedules. The future capture plant start-up and ongoing operation will be designed to have little effect on the existing site operations. The storage operation takes advantage of an existing pipeline and a well understood offshore geological store. Potentially this is one of the best available storage sites for UK CCS. The SEGAL St Fergus terminal is ideally located to take advantage of the Acorn CCS Project which will develop one of the first CO_2 sequestration stores in the UK. The project is working with government support and technology experts to assess the first phase of the Acorn Project and assess the full scale build out plans which will follow this first phase.

Shell as the SEGAL operator (on behalf of owners Shell/Exxon) are working with the Acorn partners as phase 1 of the Acorn project is developed. Phase 1 of the Acorn transport and storage project will then pipe and inject CO_2 at the offshore structure utilising existing infrastructure and new injection wells.

Successful demonstration of this low-cost CO_2 disposal facility for the St Fergus terminal emissions will help facilitate further development of the Acorn Project - looking to store emissions from across Scotland, the UK, and Europe, helping to establish the CCS industry and decarbonising vital industrial sectors.

The Acorn Project is being developed by partners Pale Blue Dot Energy, Harbour Energy and Shell with support from the UK and Scottish Governments, and the EU.

Net Zero Enabling Technologies

Triton FPSO: Emission Reduction

dana PETROLEUM

Project Value

CAPEX > £4M
CO_2 Reduction 27,000te/yr

> £5M on new Separator, to reduce oil in water (OiW) discharge

Project Scope

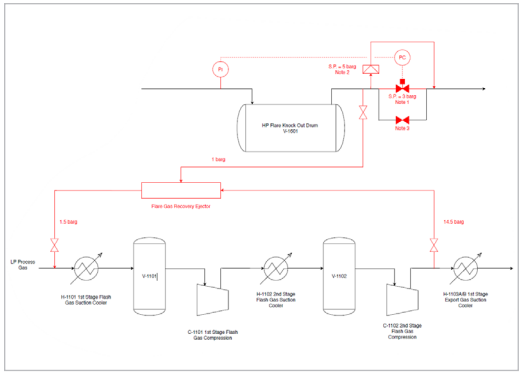
A Triton Asset Life Extension study undertaken in 2020 included a review of how we could practically and economically reduce emissions. Several potential emission reduction measures were identified:

- Install a Flare Gas Ejector to the existing HP Flare Gas System
- Modify systems to use gas import to minimise start-up flaring
- Upgrade the compressor anti-surge logic to minimise emissions
- Install an electrical Reversed Osmosis Water Maker that reduces the need for steam system operation
- Design and install a new First Stage Separator that will increase production, but will also reduce oil in water discharge levels

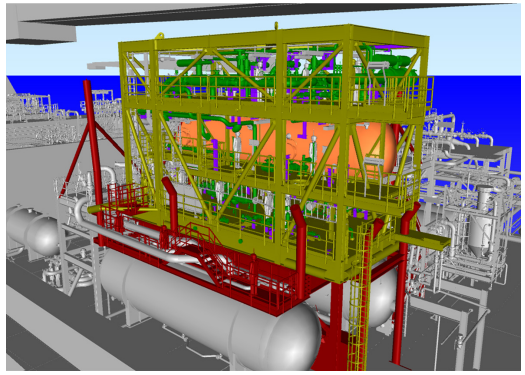
Further identified opportunities may be implemented. Dana continues to review other ways of reducing emissions.

All works are subject to final approvals, with deliver anticipated during 2024.

Aerial view, Triton FPSO



Schematic, HP Gas Flare Ejector System



3D view, new First Stage Separator

Good Practice:

Process:

- A focus on emission reduction in conjunction with other ongoing assessments helped to give a more rounded approach to options identification
- A higher number of options using known technologies were identified by this combined approach
- Major scopes such as power from shore and renewals technology were ruled out due to the technology gap, cost and complexity on a brownfield site
- Five scopes were chosen for progression, with a ‘hopper’ of other options identified

Scope and Benefits:

- A reduction of c.50% in flare emissions is anticipated through the use of ejectors which is known technology. Further flare reduction scopes are anticipated to contribute towards an overall reduction in flaring emissions of c.60%
- Replacing the main first stage separators is planned. This is a realistic and attractive solution for Triton that can increase overall production as well as reducing overall oil in water levels, negating the environmental impact of increasing production
- Scopes are being developed further and activity delivery is planned by 2024, subject to final approvals
- 20% reduction in Triton FPSO CO_2 emissions (relative to 2018 emissions) is anticipated from the above projects, all of which are currently economic

Insight:

- A material reduction in emissions is possible on brownfield assets, even with known technology. However larger scopes can become difficult to do
- Making emission reduction part of all activity assessments as opposed to a stand-alone review can yield better results
- While reducing oil in water level is not a net zero target, projects can reduce oil discharges for ageing assets like Triton

Think Wider, Study in Detail

CNOOC

Project Value

CAPEX >£250M
CO_2 Reduction >1,000,000te

Project Scope

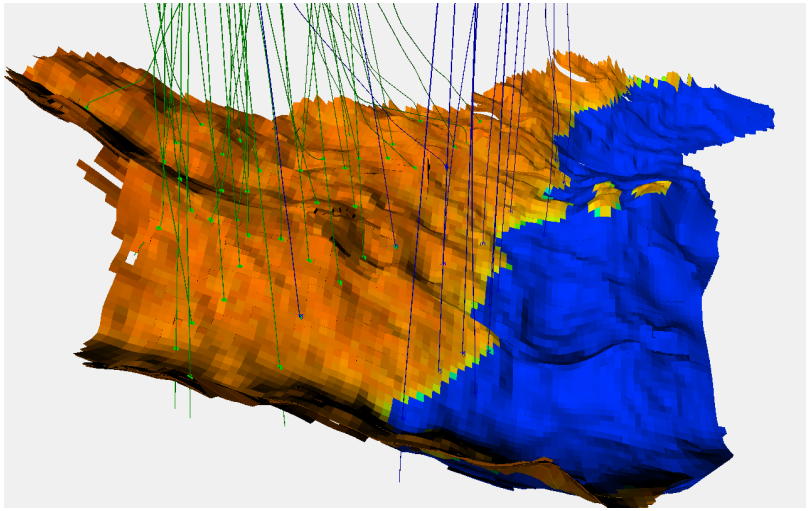
The CNOOC International-operated Buzzard asset is one of the UK's highest producing fields (80mmboe/d) and the largest oil discovery since 1990 (1Bn boe), with over 750mmboe produced since 2007.

With Buzzard now off plateau, identifying Net Zero opportunities necessitates a combination of expansive thinking, with detailed analyses. Three key studies have or are framing impactful Next Zero asset opportunities:

1. **Enhanced Oil Recovery (EOR) through CO_2 Injection** – Previously investigated in detail as part of a Buzzard EOR study. The methodology involved: building detailed reservoir models that closely replicate the geology and physical processes which occur at reservoir level, well performance dynamics, facility and operational models along with project costs estimates (CAPEX)
2. **Carbon Capture and Storage** – CNOOC are currently working to make the reservoir model(s) available for a CO_2 storage study.
3. **Platform integration with offshore renewables and power from shore** – Electrification of Buzzard, and beyond.

Successful progression beyond Final Investment Decision (FID) in a Capital Development Process (CDP) would lead to a material Net Zero impact, for the North Sea.

Aerial view, Buzzard



Buzzard reservoir model

Good Practice:

This good practise reflects upon how when investigating Net Zero, all optionality should be explored, with what-if scenarios considered before discounting options. Divergent thinking should be encouraged through a wide stakeholder group whom regularly challenge assumptions, looking beyond an individual asset and organisation to find those emerging initiatives and relevant projects.

CNOOC has built upon a previous detailed Buzzard EOR study (2015), although unsuccessful at the time due to high Brownfield CAPEX risk, this approach to wider thinking enabled the mindset and subject matter knowledge to support an OGTC led study group focussing on the capture of CO_2 in oil & gas reservoirs. The OGTC led study requires access to full reservoir models to enable detailed research. CNOOC are thus currently working with Joint Venture (JV) Partners to make the Buzzard reservoir model available for this CO_2 storage study. Such an engagement will make the Buzzard model, a product of thousands of hours of effort, available to OGTC, ultimately informing the Buzzard JV Asset of its potential as a CCS Storage Site, prior to its Cessation of Production (COP).

Wider North Sea engagement has led to the identification of new electrification opportunities for Buzzard, including offshore renewables integration and proposed power from shore schemes. Electrification has the potential to significantly reduce Buzzard oil and gas operational emissions and could extend the operating life and enhance cost efficiencies in the development of new fields. Under one electrification scenario, Buzzard could support renewables develop, acting as a service hub to both conventional Oil & Gas and Net Zero development.

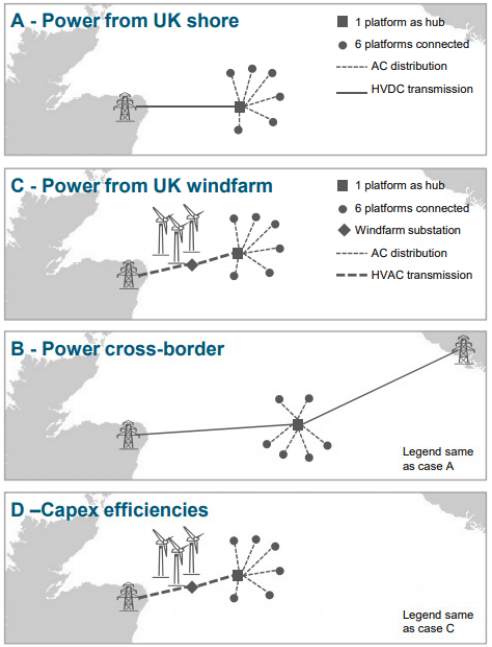
Electrification: Evaluation Framework

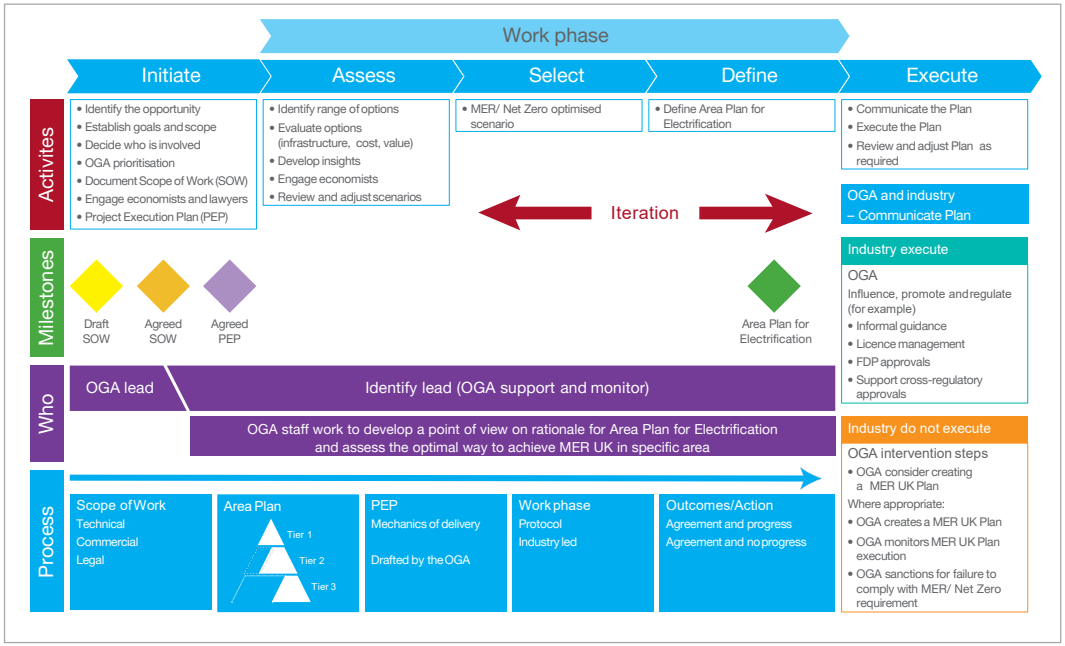
Project Value

CAPEX £100 – 500M
CO_2 Reduction >1,000,000te

Project Elements

- Describe scope of project – asset characteristics (COP, power demand profile etc.), industry collaborators, key studies and next steps
- Describe strategic fit – maximising economic recovery of oil and gas while supporting sector emission reduction commitments (10% in 2025, 25% in 2027, and 50% in 2030 on the pathway to net zero by 2050)
- Describe electrification opportunity – development concept (transmission and brownfield mods), project timeline, capex, risks & opportunities
- Evaluation of alternative technical concepts – define infrastructure, cost, value, insights, uncertainties
- Define preferred option, key benefits – production and cost efficiencies, renewables growth, co-investment, technology deployment
- Describe project timeline including consenting pathway and steps to securing Final Investment Decision





Good Practice:

An electrification workstream has been formed between Cluster Groups and Regulators to monitor and report, in support of future investment decisions. The workstream will share progress, develop open book models, report on regulatory and stewardship matters and formulate communication plans. Cluster Groups seek to align with the ASTF Good Practice.

Effective technical and commercial collaboration within the sector can deliver significant benefits to all parties including a step-change in emissions reduction; economies of scale through infrastructure sharing and better regulatory and supply chain engagement. Collaboration must be underpinned by a clear governance framework which ensures broad participation, preserves pace, and monitors strategic alignment through clear feedback mechanisms.

Benchmarking to the OGA Energy Integration report, market proposals and sanctioned projects provides a line of sight to further optimisation. This ensures credibility of project assumptions and facilitates a targeted approach to scope/design improvements.

Clear documentation of economic assumptions and outputs. Aligned views on technical inputs, economic insights, rules of thumb and key value levers. Agreed common approach to modelling and macro assumptions for ease of comparison.

Early and continual **stakeholder engagement** is crucial to effective project delivery. Cross-regulatory engagement on policy and legislative proposals will help remove barriers to project progression. Regulators can also share insights into the changing macroenvironment. Leveraging the skills, capabilities and expertise of the UK supply chain (OEMs, EPCs, investors) can help create innovative low-carbon solutions. Market engagement must be undertaken in accordance with competition law principles.

Stakeholder & Partner Engagement

Incorporating Paris Agreement/Sharing NCS Best Practice

equinor

Incorporating Paris Agreement

Equinor's ambition is to reach net-zero emissions by 2050. This ambition, which includes all production and final energy consumption emissions, sets a clear strategic direction and demonstrates Equinor's continued commitment to long-term value creation in support of the Paris Agreement.

Equinor's climate ambitions:

- Net zero by 2050 – Scope 1, 2, 3 GHG emissions
- Decarbonise oil and gas production - CO_2 portfolio intensity of <8kg CO_2 per boe by 2025 (current global average: 17kg CO_2 per boe, IOGP)
- Achieve carbon neutral operations no routine flaring and near zero methane emissions intensity by 2030
- Grow in renewable energy – production capacity of 4-6GW by 2026 and towards 2035, with an ambition to increase to 12 to 16 GW, dependent on availability of attractive project opportunities.

In our oil and gas activities the priority is to reduce operated emissions through:

- Energy efficiency
- Technology implementation
- Portfolio management – CO_2 a key metric in decision making
- Industry partnerships and policy advocacy

Sharing Norwegian Continental Shelf best practice

During 2020 Equinor UK worked closely with colleagues in Norway to transfer experience and capture learnings from emissions reduction activities on the Norwegian Continental Shelf (NCS).

Following this experience transfer, key learnings were incorporated into the broader Equinor UK portfolio strategy. An emissions reduction roadmap has been developed for the operated Mariner field while on Rosebank the project team is working to reduce emissions from the point of concept. The following NCS experience/good practices have been shared in Government and Industry forums, in contribution to net zero discussions.

Key learnings:

1. **Filter CO_2 knowledge and ambitions into daily operations**
   A key enabler to support climate ambitions, is developing an organisational low carbon culture through embedding CO_2 into daily operational decision-making.

   - In Equinor the POG has been renamed EPOG (Energy and Production Optimisation Group) with the EPOG engineer's role now focused on maximising production on a daily basis in the most energy efficient way using digital technology.

Incorporating Paris Agreement/Sharing NCS Best Practice

2. Business case approach key to net zero investment

The early introduction of a carbon tax in 1991 and access to stable financial support mechanisms have long supported the continuous improvement of emission reductions on the NCS.

A sustainable and enduring combination of CO_2 tax, technology development funding (Enova) and the industry administrated NOx tariff, has created large scale industrial investment and new value chains (The "NOx Fund" enables companies to apply for support for emissions reduction technology)

A specific example of Enova funding includes the Hywind Tampen project, the world's first floating wind farm, powering offshore Oil & Gas with climate and socio-economic benefits not only to Equinor and Suppliers, but a wider Norway.

3. Performance management essential to move the needle

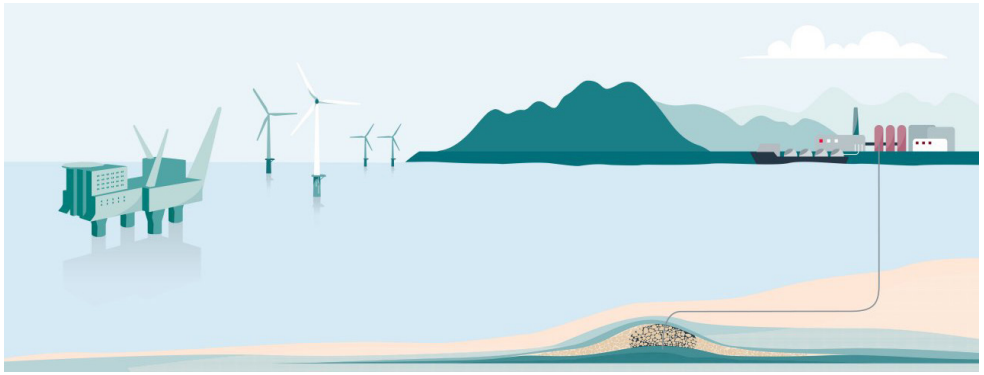
During 2019, NCS business areas implemented emission reduction measures including better-quality Energy Management Plans, with efforts to minimise methane emissions and flaring. Annual NCS CO_2 emissions have reduced by 2 million tonnes because of >400 large and small scale measures to cut emissions.

- Compressor upgrades on Gullfaks and Oseberg fields, resulting in CO_2 emission reductions of nearly 70,000te/yr.
- Supply chain and logistics operations are making important contributions to scope 3 reductions, with average annual emissions cut by approximately 90,000 tonnes since 2011. Measures include measures reducing emissions from helicopters and vessels used for supply, emergency preparedness, rigs moves and storage.
- Fuel consumption has become an evaluation criteria in the allocation of vessel contracts. In addition, requirements have been introduced regarding hybrid battery operation and the ability to connect supply vessels to onshore power for all new long-term contracts. In 2020 a new project was launched to develop the concept of carbon-free ammonia-fuelled supply vessels capable of long-distance sailing. First testing is expected in 2024.

4. Technology and innovation vital to accelerating decarbonisation

Oil & gas operations are largely powered by electricity generated on site using gas turbines. Electrification to decarbonise existing offshore fields first started on the NCS in 1996 and has accelerated more recently with the Johan Sverdrup development through a broader area approach.

- The Utsira High area solution, where reductions from power from shore are estimated at >1,000,000te/yr of CO_2.
- The Sleipner field which has been capturing, injecting and storing more than 20 million tonnes of CO_2 since 1996. Further partial electrification is planned for 2022 which will save more than 150,000 tonnes CO_2 annually.
- Investment in best available turbine technology: Dry, low emission gas turbines, supported by predictive emission monitoring, deliver maximum efficiency and minimum emissions from gas-powered offshore fields.



References

Equinor.com: Every little bit helps: how we cut CO2 emissions by 2 million tonnes - Energy efficiency - equinor.com

Enova Fund: www.enova.no

NOx Fund: https://www.nho.no/Prosjekter-og-programmer/NOx-fondet/Sok-stotte-fra-NOx-fondet/

Setting Environmental Targets within Financing

Harbour Energy

Project Value

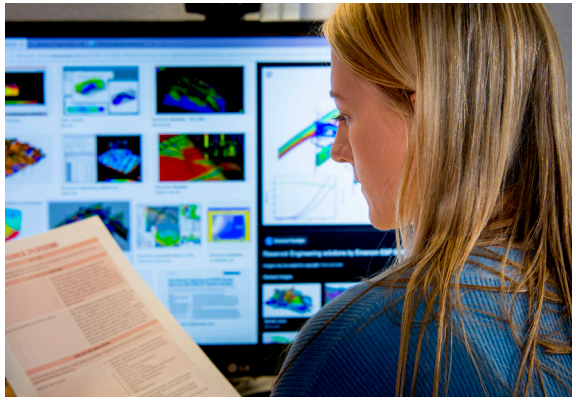
CO2 Reduction >250,000te/yr

Project Scope

30% reduction target in annual absolute operated-asset CO_2 emissions by 2025 and a 50% reduction by 2028.

In June 2020, recognising the important role that the oil and gas industry plays in attaining the goal of net-zero, Harbour Energy incorporated a Reserve-Based Loan margin adjustment in our financing debt facility, linked to carbon emission reductions.

Harbour Energy is the first independent European exploration and production company to set and adopt such environmental targets within our financing.



Good Practice

As a reflection of the importance of climate change, Harbour Energy has committed to attaining the goal of net-zero no later than 2035, well in advance of the UK Government goal of 2050 by:

- Reducing Scope 1 emissions (i.e. directly related to operated assets)
- Reducing Scope 2 emissions (i.e. from the generation of purchased electricity)
- Purchasing offsets for an increasing portion of residual emissions
- Tracking and target-setting of emissions and emissions intensity (with third-party independently verified results)
- Developing all operated projects on a carbon-neutral basis
- Including emissions-related metrics in the company's incentive compensation programme
- Investment in CO_2 capture and storage initiatives with industry partners as well as in nature-based offset projects
- Incentives incorporated in main debt facility (from 2020) tied to progress in reducing emissions, namely:
  - Applying a discount/premium of up to 5.0 bps (0.05%) based on absolute emission reductions with the margin adjustment each year (this will not consider any margin adjustment from the previous year)
  - Annual testing to encourage achievement of a target of a 30% reduction in direct emissions from operated assets for Scope 1 carbon emissions from gross operated assets by 2025
  - Using a sliding curve mechanism to continually incentivise affirmative actions
  - Basing carbon emissions off the aggregate amount of CO_2 emissions from their operated borrowing base assets
  - Annual independent audit of emissions, performed by ERM Certification and Verification Services and, provided by 31 March each year in relation to the previous calendar year.
  - Subsequent audited, annual testing, and emissions reports.
  - Harbour Energy's lending syndicate will receive an annual summary of results and a compliance certificate

Energy Area Plan Collaboration

SPIRIT ENERGY

Project Value

CAPEX >£500M
CO_2e Reduction 1,000,000te (1G te)

Project Scope

Spirit Energy is maturing plans for the conversion of its Morecambe Bay gas hub into a net zero cluster of national scale and importance. At its peak, the Morecambe Bay gas hub supplied 10% of domestic gas demand and played a big part in the UK's conversion from coal to gas. Today, the hub can still heat 1million homes but is expected to reach the end of its gas production life in the mid-to-late 2020s.

The Spirit Energy team is working hard to ensure that the hub goes on to fulfil its potential as a very large carbon store. The capacity of the depleted South Morecambe and North Morecambe gas fields has been estimated at a massive 1 gigaton of CO_2 and the hub infrastructure includes offshore platforms, pipelines, and an onshore terminal and associated connection to the National Transmission System – all of which have reuse potential in a net zero future. The hub is located in an area with a diverse mix of energy producers and there are several adjacent opportunities which may integrate around carbon storage and blue hydrogen manufacture.

The opportunities under consideration expand well beyond that of a typical E&P operation and involve multiple area participants. Collaboration and integration with area stakeholders is essential to realising this opportunity, which would be strategic on a UK scale and hugely important to the area around Barrow-in-Furness in Cumbria.

Morecambe Hub

- Near large centres of population & industry
- Existing infrastructure
- Skilled workforce
- Proximity to renewable power
- World scale reservoirs
- End of field life aligned to emerging opportunities

Opportunities

- Carbon capture & storage
- Blue hydrogen manufacture
- Integration of renewable and nuclear power generation
- Green hydrogen
- Hydrogen storage
- LNG import
- E-Fuels

Good Practice:

Morecambe Hub, operated by Spirit Energy, has started its net zero journey. We are working to align the ambitions of multiple area participants, with varying business objectives, to create an investable and sustainable net zero cluster centred around Barrow-in- Furness and the Morecambe Bay gas fields in the East Irish Sea.

Care – we have a long association with the Barrow area and we care about its future.

Collaboration – Spirit Energy has actively worked with diverse area participants, freely sharing data, decommissioning plans, and technical insight.

Delivery – Our team is able to respond in a timely manner and sustain channels of communication with multiple organisations.

Proactivity – Morecambe Hub has the potential to be a net zero hub of national importance with significant regional benefits. We have proactively engaged with local stakeholders to share our vision, understand the regional picture and gain support.

Agility – The energy transition is new territory with different business models and different players. Spirit Energy has set aside preconceptions and is open to unconventional ideas and opportunities.

Maintaining the above behaviours requires buy-in at all levels of every party involved, to align varying business objectives towards a common goal of making Morecambe Hub's net-zero ambitions a reality.

Glossary

Glossary[1,2]

Perimeter

Whilst all operators will need to reduce emissions, different portfolios are at different stages in their lifecycle and therefore driven by different opportunities. The totality of UKCS GHG emissions from the upstream oil and gas sector, including those emitted at offshore oil and gas installations, onshore terminals processing UK oil and gas, offshore shipping supporting UK oil and gas production (logistics and drilling rigs) and aviation transportation (helicopter journeys) are to be factored.

Definition - GHG

There are 7 greenhouses gases that greatly contribute to UKCS emissions: carbon dioxide (CO_2); methane (CH4); nitrous oxide (N2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); sulphur hexafluoride (SF6); and nitrogen trifluoride (NF3) they are usually combined and stated as a 'CO_2e', or carbon dioxide equivalent.

Within this Case Study Booklet, the ASTF/OGA has adopted "CO_2" in respect to all matters pertaining to Carbon Dioxide Equivalent (CO_2e)

Note: - NF3 is normally associated with emissions from electronics manufacturing and is not, therefore, expected to be significant for oil and gas reporting.

Definition – Scope

Based upon the "International Petroleum Industry Environmental Conservation Association" fourth edition of their Sustainability reporting guidance for the Oil and Gas Industry GHG emissions are classified as either direct or indirect based on three categories; Scope 1, 2 and 3.

Scope 1 emissions are reported as Direct GHG emissions from equipment or other sources owned (partly or wholly) and / or operated by the company. For increased clarity when reporting Direct GHG emissions, those Scope 1 emissions associated with energy sold to others can be reported separately as Direct emissions from exported energy. Examples include; combustion of fuel, flaring, venting (Assets) and fleet vehicles, etc.

Scope 2 emissions occur where an operation purchases energy already transformed into electricity, heat or steam, the GHGs emitted to produce this energy are Scope 2 and reported as Indirect GHG emissions from imported energy. The 2015 update of the GHG Protocol distinguishes between two calculation approaches, 'location' and 'market based' for Scope 2 emissions and it is helpful for companies using this standard to highlight which method is used in their reporting. Examples Include electricity from energy supplier to power plant, heating and cooling or office computers etc.

Scope 3 emissions are reported as Other indirect emissions, which refer to GHG emissions related to a company's value chain. Of the 15 categories of Scope 3 emissions defined in the standard, Category 11 'Use of sold products' is the most relevant to the oil and gas industry. Examples: Emissions produced from sold product, its transportation and processing.

Quantification

In 2018, 18.3 million tonnes of CO_2 equivalent (CO_2e) GHGs were emitted from upstream oil and gas operations, representing 4 percent of total UK emissions. 14.6 million tonnes CO_2e (80 percent) were associated with the production of oil and gas at offshore installations.

14 percent of emissions are from onshore terminals and 5 percent from logistics. The majority (91 percent) of emissions were CO_2, with methane representing the second largest concentration (8 percent of total upstream emissions on a CO_2e basis).

Across the sector the main sources of emissions are from power or heat generation, gas compression, flaring and venting. In 2018, 70 percent of emissions from offshore assets were associated with power or heat generation from turbines, engines and heaters, while 29 percent were from flares and vents.

[1]https://www.ipieca.org/media/5115/ipieca_sustainability-guide-2020.pdf

[2]https://oilandgasuk.cld.bz/OGUK-Pathway-to-a-Net-Zero-Basin-Production-Emissions-Targets-Report-2020