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Decarbonising New Oil & Gas Developments in the UK North Sea

DEVEX June 2023

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Identifying critical issues and creating value

Revealing opportunities and creating value

Explaining value, ranges and uncertainty

Helping improve performance and grow value

Helping resolve differences of opinion

Pathfinding the route to low emissions energy

Helping responsible investment and development

Guiding the transaction processes

Presentation outline

Decarbonising new oil and gas development projects – we have a lot of technology already available to do so, we just need to change our way of thinking to incorporate them and consider doing so early in the design stages.

- This presentation will use Orcadian Energy's Pilot field case study to demonstrate that
  - Alternative solutions can achieve significant reductions in Scope 1 and 2 emissions
    - But we have to change our design emphasis during the design phase to focus on emissions reduction.
- The case study will give an overview of the technologies identified and implemented in that project.
- Discuss key takeaways for new developments looking to reduce GHG emissions associated with the facility.

Orcadian Energy's Pilot field - Overview

Heavy oil field located off the east coast of Aberdeen with 79MMbbl of proven and probable reserves, discovered by Fina in 1989. Fully appraised with 7 wells and 3D seismic.

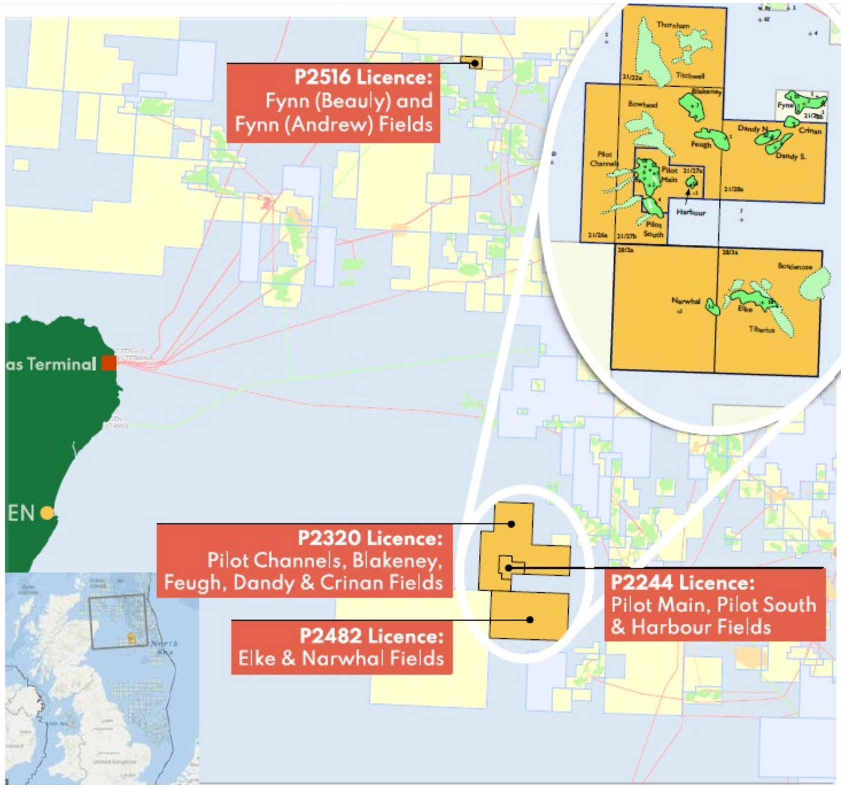
- 5 wells were cored, 2 wells were tested including a short horizontal well that produced 1,800bopd.
- Original "standard" development concept of FPSO using
  - Gas Turbines, water injection, heaters and coalescers etc
  - Waterflood project emissions intensity of 24.7 kgCO2e/bbl.
  - Lower than other W.flood projects, but higher than UK N.Sea average in 2018 ~21 kg/bbl.

Concept rejected by the North Sea Transition Authority:

- Subsurface uncertainty required maturation
- Emission reduction measures required assessment:
  - A reduction in overall emissions intensity.
  - Potential pathway to net zero investigated.
  - Consideration of the use of existing infrastructure, alternative fuels and carbon capture.
- Orcadian Energy went back to review the design concept and how to decarbonise the project.

Reservoir key properties

Characteristic	Units	Value
Oil water contact	2724	ft
Oil Column	>100	M
Gross sand thickness	50-60	ft
Net to gross ratio	0.95	Fraction
Porosity	0.34	Fraction
Water saturation	<0.1	Fraction
Permeability	2 to 8	Darcies
Oil gravity	12° - 17°	API
Oil viscosity	c. 400	cP
Gas-Oil ratio	80	Scf/bbl
Reservoir temperature	31	°C
Salinity	72,000	ppm



Developing a decarbonisation road map

Re-assessing the design through the lens of GHG emissions reduction only.

Oil recovery mechanism EOR Optimisation

- Water/ Polymer flood, gas reinjection/ lift gas.

Electrification & Electrical Architecture

- Grid connection from onshore
- Alternative power generation
  Renewable power import
- Power generation efficiency
  Variable speed drives

Energy Use Optimisation / Balancing

- Heat recovery optimisation
- Heat pump Vs Steam heating
- Waste heat available Vs demand

Process Technologies (Topsides processing)

- Oil water separation, Gas dehydrating technologies
- Minimised system pressure losses?
- Wash water generation (LoSal technology)
  Heat pumps

Flaring

- Combustion technology
  Vapour recovery
  Operating philosophy

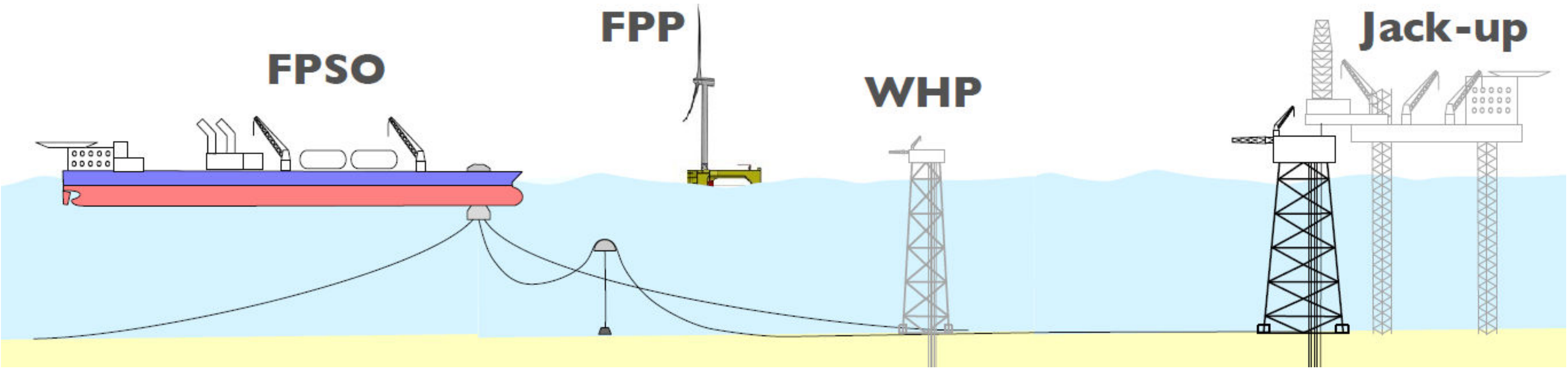
Carbon Capture

- Compact modularise technology
  Disposal route
- Energy integration with main process plant

Emission reduction technologies identified

After re-assessing the overall field development scheme from the reservoir through to the topsides, multiple technologies were identified that could significantly reduce emissions.

- **Electrification –** Providing power from shore.
- **Polymer flooding** – Minimized liquids handling topsides and reduced power consumption.
- **Wash tank technology -** separating oil/water in wash tanks instead of using electrostatic coalescers lowers well fluid heating requirements.
- **Reciprocating gas engines** – most efficient on-board power generation and 'ammonia ready' machines available from 2025.
- **Floating Power Plant (FPP) -** Leasing of a floating wind turbine (1 or 2 turbines).
- **Gas management –** Drill a gas storage well to store excess gas not used, remove the requirement for import gas pipeline,
- **Heat pump technology –** Front end well fluids & low salinity water heating, using seawater as the heating medium.
- **MVDC bus electrical architecture –** reduces weight and space.
- **Power slip ring -** Enabling power import on the FPSO & WHP to use renewable energy from the FPP.



Electrification – Using an onshore connection

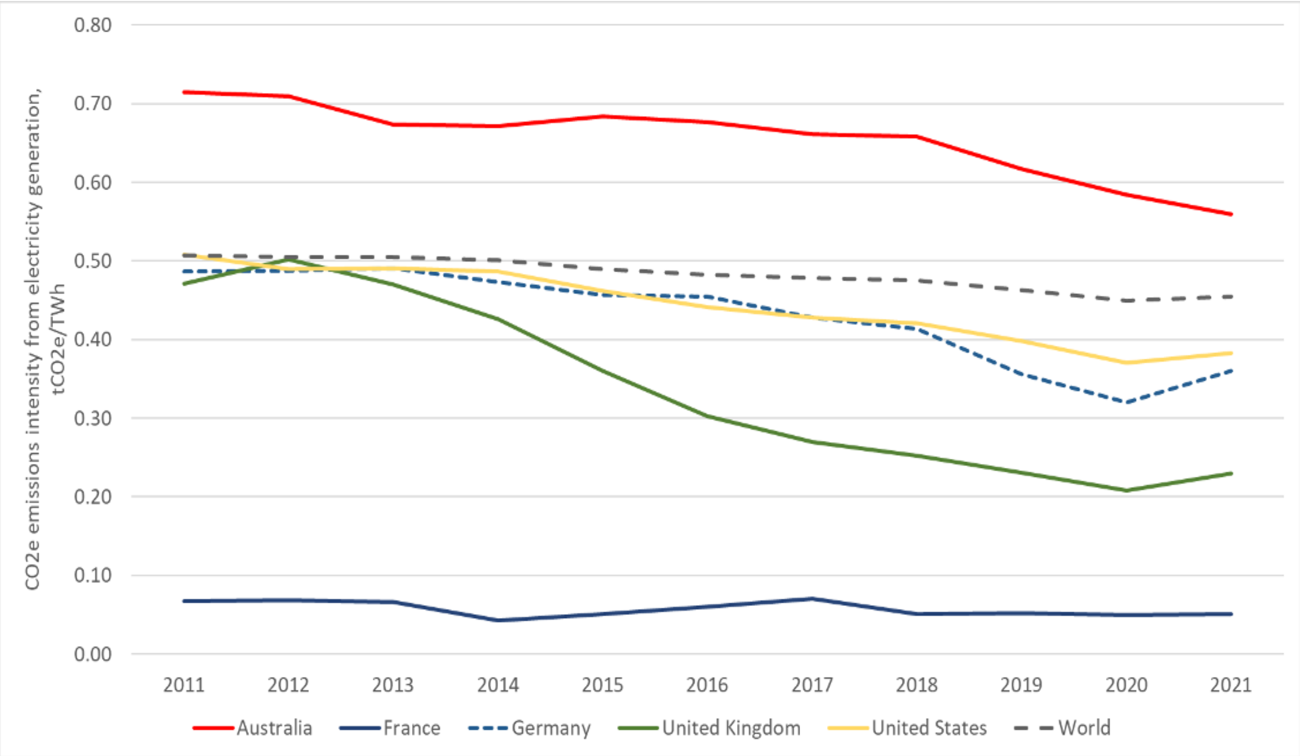
The UK has come a long way in decarbonising it's power generation emissions, but gas will be needed to back-up the renewable energy supply which limits future decarbonisation. Until an alternative can be found, electrification does not provide a pathway to net zero.

- The UK has reduced its reliance on coal from 40% to less than 2% in the last decade. In 2022
  - Gas 38.3%
  - Wind 26.7%
  - Solar 4.3%
  - Nuclear 15.5%

Project conclusions

- Electrification can form partial decarbonisation but there is no clearly defined pathway as yet to a zero emissions national grid.
- An onshore connection resulted in unfavourable economics and the distances involved introduced some technical concerns. So, we looked for an alternative solution.

Power generation emissions intensity for electricity generation worldwide



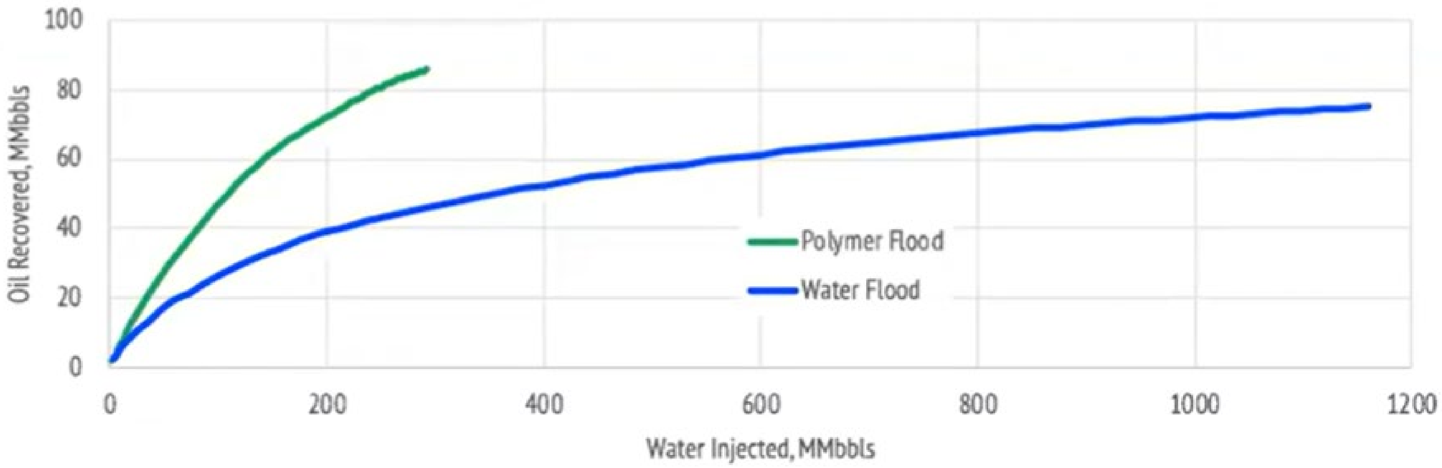
Source: Our World in Data, RISC

Polymer flooding

The use of polymer flood reduced emissions of the original design by 40%.

Polymer flooding

- Significant reduction in liquids handling
  - Less energy in pumping and fluid handling.
- 40% reduction in emissions.
- Increased ultimate recovery.
- Field life significantly shorter.
  - More barrels produced in less time.
    - Improved economics



Orcadian Energy Production Profiles
https://orcadian.energy/

- **Subsurface engineering can lead to significant reductions in emissions.**

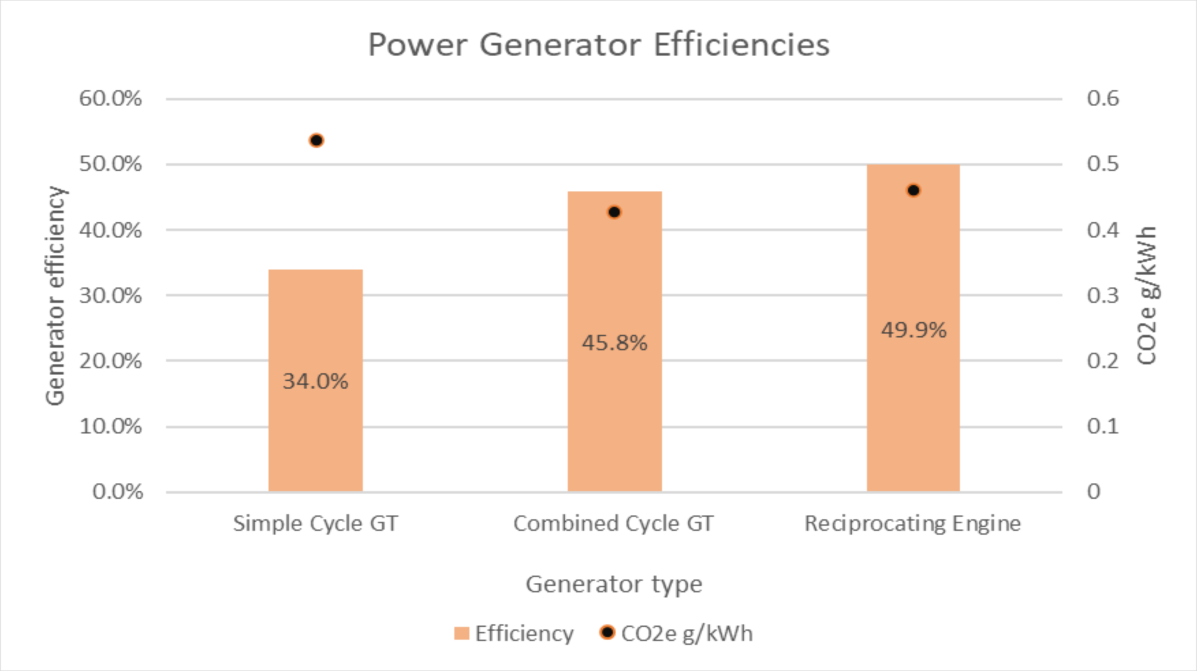
Process optimisation – Power generation

Process optimisation produced a further 34% reduction in emissions from the original design. The most significant was the power generation.

Process optimisation

- All process optimisations led to circa 34% reduction in emissions.
- Most important was the fossil fuelled back up power generation.
- Need for flexible back-up for Floating Wind Power Plant (FPP)
  - capability to supply ~0-100% of the power.
- Wartsila dual fuel gas reciprocating engine selected
  - More efficient than simple cycle GT or combined cycle.
  - Flexible to turndown requirements
  - Ammonia ready design.
- Green ammonia can be used if it becomes available.

Wartsila 31DF engine



- **The 'ammonia ready design' future proofs the design and enables further emissions reduction in the future.**

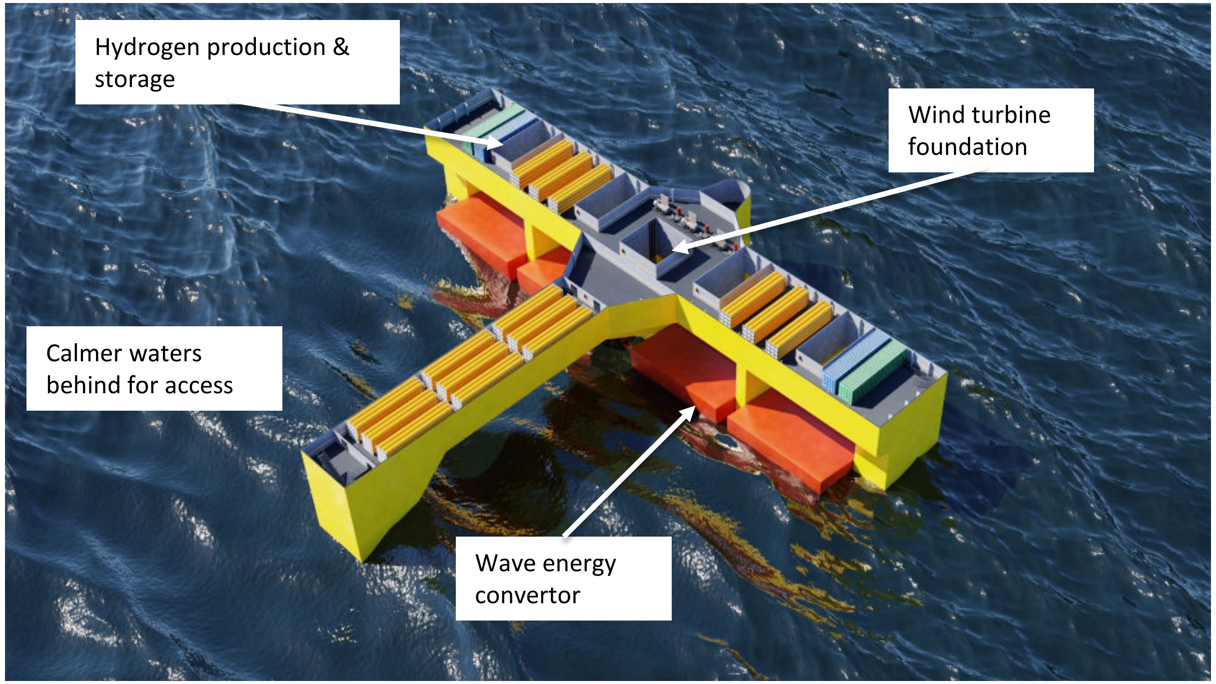
Renewable energy supply – Floating Power Plant

Floating wind turbine technology is developing fast. Adding a single turbine Floating Power Plant to the project led to 14% reduction in project emissions.

- **FPP led to emissions reduction of 14% inproject emissions**
  - However, this does vary upon the size of the plant selected.
- **North Sea compatible design**
  - Wind power 4-15MW
  - Wave power 2-3.6MW
  - Can produce H2 via electrolysers and store it onboard.
- **Turret mooring system**
  - Vanes into wave direction, disconnectable if required
- **Can use wind turbines from different vendors**

Floating Power Plant overview
www.floatingpowerplant.com

Floating Power Plant Option for Pilot field
www.floatingpowerplant.com

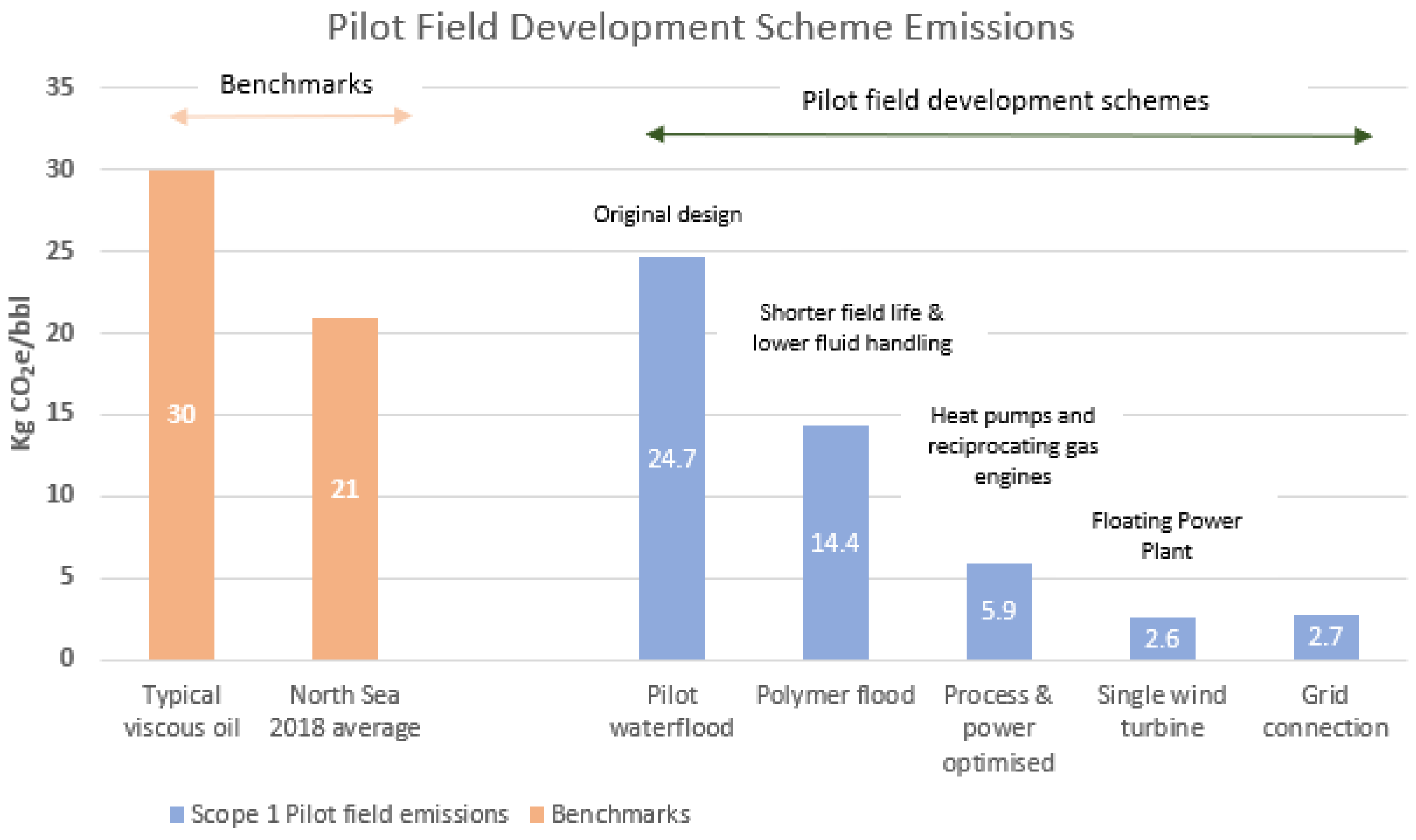


FLOATING POWER PLANT

Overall GHG emissions reduction

Introducing polymer flood, process optimisation changes and a single wind turbine floating power plant led to a total reduction in emissions of circa 90%.

- Project changes led to a total reduction in emissions of circa 90%.
- A letter of no objection was given by the NSTA.
- Emissions similar to that achieved with grid connection.
- Polymer flood expected to lead to the most emissions reductions.
- Overall economic impact of the new concept was minimal:
  (i) CAPEX was slightly lower as the requirement for a gas import line had been removed.
  (ii) OPEX slightly higher as the wind power plant was leased from a 3rd party.
- A grid connection to onshore was found to be economically unfavourable, with several technical difficulties needing to be overcome.



Key takeaways for decarbonising new projects

Without changing our way of thinking about the design development process we are limited on how much we can reduce GHG emissions associated with developments and along with it our societal license to operate.

- **Changing our paradigm**
  - To include GHG emissions reduction as an integral part of the field development plan.
- **Consider GHG emissions associated with the project development from the start**
  - Calculate GHG emissions associated with the development and what is driving them.
  - Subsurface engineering plays an important role in reducing emissions.
  - Electrification concept has a major impact on process equipment selection.
- **Achieving low single digit kgCO_2e/bbl is possible using existing technologies**
  - Electrification from shore.
  - A floating power plant or connection to a wind farm backed up by efficient reliable fossil fuel power generators.
  - Future proof the design for more stringent emissions requirements.
- **Engage with the regulatory body early on**
  - Document and demonstrate what you are doing to identify and implement decarbonisation opportunities.
  - Look for synergies with existing developments, reduces emissions and is seen as favourable.
- **One final note – We are all students of the 'Energy Transition'**

www.riscadvisory.com

Perth

Level 2
1138 Hay Street
WEST PERTH WA 6005
P. +61 8 9420 6660
E. admin@riscadvisory.com

Brisbane

Level 10
95 North Quay
BRISBANE QLD 4000
P. +61 7 3025 3397
E. admin@riscadvisory.com

London

Office 204
20 St Dunstan's Hill
LONDON UK EC3R 8HL
P. +44 (0)203 795 2900
E. admin@riscadvisory.com

South East Asia

Jakarta
Indonesia
P. +61 8 9420 6660
E. admin@riscadvisory.com