NetZero

UPSTREAM FACILITY

Learn how we can reduce Greenhouse Gas Emissions from your facilities

Executive Summary

STUDY | SOLUTION | INSIGHTS

COLLABORATION BETWEEN:

MCDERMOTT

io consulting

Schneider Electric

Executive Summary

The 2018 World Energy Outlook estimated total indirect Green House Gas emissions from oil and gas operations are around 5,200 million tonnes of carbon-dioxide equivalent (CO_2e), and 15% of total energy sector GHG emissions come from the production process. It is critical for the energy sector to tackle this issue. BP, Shell, Total and many other energy companies are now setting aggressive decarbonization targets for their organizations

As industry leaders, McDermott, Schneider Electric and io consulting have partnered to develop a concept for net zero upstream facilities. This concept focuses on an offshore compression facility and combines the expertise of all three organisations to develop an alternative solution that minimises lifecycle facility GHG emissions. The insights and approaches used in this study can be extrapolated to other upstream facilities. The study considered three elements of the lifecycle emissions of a facility:

1 **Embedded Carbon in the equipment and materials** >> 2 **EPCI Emissions** >> 3 **Operational Emissions**

The study demonstrates that for a minimal total expenditure increase of 2%, an alternative solution delivers:

76% reduction in operational emissions | **17% reduction in CAPEX emissions**

Furthermore, offsetting the operational emissions to achieve Net Zero, through direct air capture at a price of $200/tCO2e, would deliver significant improvements on Net Present Value (NPV) and Internal Rate of Return (IRR).

This reduction in GHG emissions is achieved by:

- Importing power from a high renewable mix grid source or using a Power Purchase Agreement for "green electrons"
- Designing out fugitive emission sources, primarily through the use of seal-less compressor technology
- Using digital technology to remotely operate the facility, contributing to an overall normally unmanned installation philosophy
- Designing out the flare system
- Using SF6 free switchgear

[1] For the purpose of this report, embedded carbon and EPCI emissions will be referred to as CAPEX Emissions.

Study

The core of the study was the development and evaluation of five alternative concepts to identify the optimal solution for reducing the lifecycle GHG emissions of the reference case facility.

Reference case

The platform is an offshore compression platform located 100+ km from shore in a water depth of 100+m. The platform is sized to process a maximum capacity of 650 MMSCFD of gas with no provisions for condensate treatment and removal or produced water treatment and removal. The platform has full utilities and support systems.

Concepts evaluated

Concept 1	Minimise Carbon Intensity. The intent of this concept was to develop a facility which has minimal carbon intensity. This is achieved through the use of a renewable energy power supply and the use of equipment and instrumentation that minimises/eliminates potential leaks or venting requirements.
Concept 2	Minimise Infrastructure. This concept was developed to assess the development of a subsea alternative to the platform facility. Minimising infrastructure should minimise embedded carbon emissions and hence support the minimisation of carbon intensity.
Concept 3	Minimise TOTEX. This concept was developed to analyse the emissions associated with equipment selection made to minimise the TOTEX of the facility. The facility uses traditional proven technologies widely used in the offshore oil and gas industry to determine the methods that could be employed to reduce the emissions
Concept 4	Maximise Use of New Technology. This concept was developed to analyse the emissions associated with an unmanned facility that uses non-conventional technologies that may not have been demonstrated at a commercial scale or that are still under development to determine whether there are technologies not yet on the market which may reduce the emissions of the facility and present potential emission reduction opportunities for future projects.
Concept 5	Maximise Technology Readiness. This concept was developed to analyse the emissions associated with an unmanned facility that uses traditional technologies widely used in the offshore oil and gas industry and to determine the methods that could be employed to reduce the emissions.

Side Studies

The concept development and evaluation was supported by five side studies that focused more deeply on specific aspects of reducing lifecycle GHG emissions:

1. **Engineered Offsetting Options**
2. **Removal of Flare System**
3. **Fugitive Emissions Prevention**
4. **Remote Operations & De-manning**
5. **Power Generation**

The insights from each of these studies were incorporated and contributed to the overall solution.

CAPEX Emissions

"Capex" emissions, or the emissions embedded in a facility, are considered "insignificant" when compared to the facility operations and end use of oil and gas products. For renewable energy with significantly less emissions in operations and use, embedded carbon has received more attention as they are a higher percentage of the lifecycle emissions. As oil and gas facilities decarbonize operations, embedded carbon will also become a higher percentage of the lifecycle emissions. Supply chain emissions from capex projects may also factor into future "green" financing and offer the opportunity to transition a low carbon economy.

Embedded Carbon

Embedded carbon emissions were split into three categories: 1) Steel and pipe, where embedded carbon information is widely available; 2) other permanent materials, where weight-based proxies must be used; and 3) permanent equipment, which also required weight-based proxies. Embedded carbon focused on "cradle to grave" lifecycle units, including the carbon footprint in the production of the material. End life of materials were considered qualitatively in both the waste emissions for EPCI (e.g. rejected, damaged, surplus material) and end of life considerations for permanent materials.

EPCI Emissions

Low carbon construction, fabrication, installation and logistics cover the other piece of capex emissions, calculated by applying intensity measures from inputs (e.g. workhours, km-tonnes) to estimate the emissions for the reference case and alternative concepts.

Calculations for fabrication and construction were made using workhours and McDermott's internal data for intensities. The logistics calculations were based on the estimate data for logistics tonnage with assumptions for km-tonne equivalencies by mode of transport and distances travelled between sites.

For installation the study estimated the vessel days required by type of vessel and high-level execution plan. The reference case vessel days were used in conjunction with average per day fuel consumption to create an approximate carbon footprint.

Solution

Not surprisingly, Concept 3: Minimise TOTEX offers the best solution. It utilises power from an onshore, high renewable mix grid connection; electric motor driven reciprocating compressor and seawater cooling.

The results shown in the table show that a 2% increase in TOTEX, delivers:

76% reduction in operational emissions

17% reduction in "CAPEX" emissions (embedded carbon)

36% reduction in topsides weight

This concept uses proven technology and can be installed today. It can be further improved by using seal-less compressor technology to reduce fugitive emissions and by using air coolers, which significantly reduce the maintenance hours for the compression cooling.

Our economic evaluation demonstrated even without any carbon offsetting costs, this concept is extremely competitive with the base case in terms of economic metrics.

Description	Base case	Concept 3 Minimize TOTEX
Total CAPEX (kUSD)	637,500	660,600
% Increase on Base Case CAPEX		**3.65%**
Total OPEX (kUSD)	23630	14890
% Reduction on Base Case OPEX		**37.0%**
TOTEX (kUSD)	661m130	675,490
% Increase on TOTEX		**2.2%**
Operational Emissions (tCO_2e/yr)	387,414	93,070
% Reduction of Emissions		**76.0%**
Topsides Weight Reduction	9610	6195
% Topsides Weight Reduction		**35.5%**
Total "CAPEX" Emissions (tCO_2e/yr)	12555	10477
% Reduction of CAPEX Emissions		**16.6%**

Insights

Decarbonise Power

The majority of operational emissions are related to power generation. The first step in designing a Net Zero facility is to decarbonise power. While dedicated, co-located renewables may be appropriate for a facility with lower power requirements, such as a wellhead platform, this may not be an appropriate answer for a compression platform needing 56 MGWT's as it results in cost, footprint and storage challenges. The study also explored hydrogen fueled turbines. It was concluded the best approach to de-carbonising power on a compression facility is to import power from an appropriate renewable source.

Recommendation:
Import power either through use of a Power Purchase Agreement for "green electrons" or from a high renewable mix grid connection

Design out Fugitive Emissions

Fugitive emissions are the next largest contributor accounting for ~5% for the base case considered in this study. The compressor system produces 99% of all these fugitive emissions. Within the compressor system nearly all the leaks occur due to the use of dry compressor seals. The use of integrated seals presents an opportunity to reduce fugitive emissions by up to 88%.

Recommendation:
Only use compressors with integrated seals

Design Out the Flare

For all options studied, the process system can be configured to eliminate the flare completely. While the calculations show a relatively small quantity of emissions derived from flaring (<0.01%), it is recommended that flare systems are still designed out of facilities based on the impact on public perception.

Recommendation:
Design out the flare system

Remove SF6

Sulphur hexafluoride (SF6) is used as the insulation gas in electrical switchgear, it is 23,900 times as potent a greenhouse gas as CO2. While there is minimal leakage during normal operations, SF6 is of concern due to its high potency and the handling of switchgear during the manufacturing and decommissioning process. It will require expert intervention to ensure no leakage particularly during the end of life phase. Companies such as Schneider Electric, ABB and Siemens have developed SF6 free MV Switchgear.

Recommendation:
Only use SF6 free switchgear

Simplify the Process

Simplifying the process to reduce the energy consumption reduces both the emission volume and intensity. This simplification also reduces embedded carbon, removes sources of emissions, and minimises operation and maintenance activities and the manning requirements.

Recommendation:
Design the simplest process that meets the facility performance requirements.

Design for Unmanned Facilities

Reducing manning levels offers the following benefits:

- No requirement for living quarters, reducing embedded carbon and associated emissions.
- Significantly reduced maintenance frequency, curtailing travel emissions
- Less equipment, reduces the embedded carbon and associated power demand for the facility, increasing the viability of renewable power sources
- Predictive analytics for better process control and predictive and risk based maintenance, reducing the likelihood and impact of non-routine events that may result in emissions

Digital technology has advanced such that many facilities can be designed to be unmanned, or with a greatly reduced level of attendance

Recommendation:
Use digital technology to remotely operate and monitor facilities, and drive to minimal manning

Insights (continued)

EPCI Emissions - Marine

Marine vessel activity accounts for the majority of capex emissions in the upstream offshore case. Current reduction measures are limited, and decarbonization of this sector may take much longer than onshore activities. Further decarbonization relies on technology advancements in batteries and hydrogen fuel cells as well as supply availability of alternative fuel like renewable diesel and ammonia. With the right government support and industry coordination, however, marine decarbonization can be accelerated.

Recommendation:
The industry needs to co-ordinate and drive forward marine decarbonization.

EPCI Emissions – Fabrication and Construction

The key challenge for low carbon construction and fabrication is the power demand. Power is particularly challenging in EPCI due to the following factors:

- Locations for fabrication yards that do not provide ideal conditions for renewable sources, such as local wind or hydropower generation
- Locations in developing countries with insufficient power generation and no renewable grid
- Regulatory monopolies on power generation that inhibit renewable power purchasing agreements or microgrids
- Requirements for steady power supply and high peak demands that would require energy storage advancements or renewable grid integration
- Each location will require a bespoke solution, which should be considered in the project planning phase.

Electrification of diesel-driven equipment, including generators, is key but depends on both the power challenge and equipment industry solutions. Alternative fuels like renewable diesel provide a short-term solution but at a higher operating cost.

Recommendation:
Fabrication yards should move to a renewable grid or have separate power purchase agreement that guarantees renewable energy supply. Where this is not feasible, a blend of appropriate renewable sources like rooftop solar and alternative fuels will be the optimal solution on a location by location basis. Temporary construction sites require collaboration with facility developers to implement long-term power solutions from the start, including grid infrastructure and renewable power generation.

Embedded Carbon: Materials

Projects can consider reusing materials or incorporating recycled materials into the design. For permanent plant materials, this mainly encompasses recycled steel but can include recycled concrete, recycled inputs to consumables, and reuse of scrap or excess material from other activities.

Low carbon pathways for steel products are also emerging, including electric arc furnaces, hydrogen direct reduction, and carbon capture.

Recommendation:
Lessons from the building sector and LEED process can help industrial construction understand the opportunities for reuse and recycled inputs. Identifying low carbon suppliers, such as steel produces employing the latest technology, can reduce embedded carbon in the facility.

Designing out waste in the engineering phase should be a focus for both embedded carbon and fabrication and construction methods to reduce overall capex emissions.