OLUKA, N., IYALLA, I., MAHON, R. and ANDRAWUS, J. 2023. Decarbonisation of offshore oil and gas production platforms a case study of the North Sea. In *Proceedings of the 2023 SPE (Society of Petroleum Engineers) Nigeria annual international conference and exhibition (NAIC 2023), 31 July - 02 August 2023, Lagos, Nigeria*. Richardson, TX: SPE [online], paper number SPE-217186-MS. Hosted on OnePetro. Available from: https://doi.org/10.2118/217186-MS

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2023

The associated file with this output contains the presentation slide file used at the conference. The full paper is hosted on OnePetro and is available from https://doi.org/10.2118/217186-MS

Society of Petroleum Engineers
Nigeria Annual International Conference & Exhibition

July 31 - August 2, 2023
EKO HOTEL & SUITES
Lagos, Nigeria

SPE-217186-MS
Paper Title: Decarbonisation of Offshore Oil & Gas Production Platforms a Case Study of the North Sea

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INTRODUCTION

United Kingdom Continental Shelf (UKCS) oil and gas platforms are essential to the UK's energy supply. However, these platforms' power generation methods significantly increase greenhouse gas (GHG) emissions by **14 MT CO_2** yearly (NSTA, 2020).

Gas turbines: Common conventional combustion system used on offshore installations for power generation but have low efficiency, ~**30% on average** and generate significant CO_2 and NO_x emissions (Marvik et al. 2013).

Diesel-powered generators: Generate enough electricity to power the entire platform and use **20 to 30 m^3 of diesel fuel daily** leading to high running costs (IPIECA, 2013).

Greenhouse gas emissions: In 2018, **CO_2 accounted for 88% of the emissions** from offshore platforms as a result of power generation activities using offshore combustion systems (NSTA, 2021).

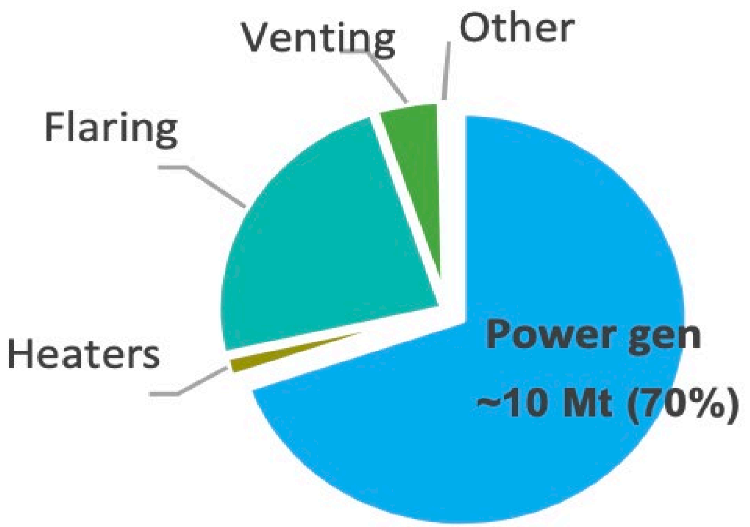

Figure 1: United Kingdom Continental Shelf greenhouse gas emissions (NSTA, 2020)

OBJECTIVES

This study uses a **Sustainability Assessment** approach to analyse decarbonisation via electrification options for offshore oil and gas platforms in the North Sea. The following key objectives will be addressed:

- Evaluate offshore platform electrification options: Assess and compare various electrification methods and technologies available for offshore platforms in the North Sea.
- Develop an Environmental Impact Assessment plan for alternative power generation for the electrification of offshore platforms.
- Analyse the cost implications for the electrification of platforms in the Central North Sea.
- Propose the best option for the electrification of offshore platforms after analysing the options.

METHODOLOGY

1. Multicriteria Criteria Decision Analysis (MCDA) incorporates technical, economic, and environmental criteria for evaluating electrification options.

2. Simple Additive Weighting (SAW) technique standardises decision-making. Assigns weights to criteria based on relative importance enabling the ranking of electrification choices for optimal sustainability.

Benefits:

1. Comprehensive evaluation of electrification options.
2. Holistic approach to sustainability assessment.
3. Facilitates informed and balanced decision-making.

Case Study Selection

- Platform analysis
- Identification of electrification options
- Requirements for electrification options

Data Analysis

- Analysis of criteria for each electrification method
- Sustainability Assessment to assess performance indicators of options
- Ranking of indicators

Option Selection

- Ranking of electrification options
- Selection of best option

SUSTAINABILITY INDICATORS

Based on a comparative framework developed by Dincer et al. (2021), the three electrification options for the Elgin Franklin platform are weighted against Sustainability Assessment indicators:

1. **Technical** – Requirements for connecting offshore platforms to the National Grid and offshore wind farms.
2. **Economic** – Evaluating the electrification cost to ensure the best possible development.
3. **Environmental** – Assessing the environmental impact of electrification options.

Table 1: Sustainability indicators criteria

Indicators	Criteria	Sub-criteria
Technical	Brownfield modification	Topside space for electrical equipment
		Installation and commissioning of equipment
	HVDC transmission	Subsea cables
		Connectors
		Converter stations
	Power management	Buffer capacity
		Waste heat replacement
	Reliability of power	Reliability and uptime
Economic	CAPEX	
	OPEX	
Environmental	Construction	
	Operation	
	Decommissioning	

CASE STUDY: ELGIN FRANKLIN

Table 2: Elgin Franklin offshore oil and gas production platform description

Feature	Description
Location	Central North Sea 200 km east of Aberdeen at a water depth of 92 m
Operator	Total Energies UK
Platform characteristics	TGP-500 Jack up design Steel four-leg 2,715-ton jacket and 1,743-ton topside
Gas processing capacity / oil production capacity	Processing Capacity: 485 MMCFD Oil Production Capacity: 145,000 BOE/D
Reserves	Oil Reserves: 60 million m^3 Gas Reserves: 50 billion m^3
Greenhouse gas emissions (2019)	640,000 tonnes of CO_2
Expected operating life	2040 (based on current reserves)
Estimated CO_2 savings by 2030	10% savings on CO_2 emissions

ELECTRIFICATION OPTIONS

Option 1 - Power from the UK National Grid

Option 2 - Platform-to-platform electrification

Option 3 – Power from offshore wind farms

Table 3: The Elgin Franklin electrification options details

Options	Description
1	Electricity from the UK's National Grid sent through an HVAC cable to a substation converter station in the North Sea off the coast of Aberdeen. The converted electricity is transported through HVDC subsea cable to Elgin Franklin.
2	The Elgin Franklin receives power via HVDC subsea cables from the Johan Sverdrup Platform on the Norwegian Shelf.
3	The Elgin Franklin receives power from the Buchan wind farm in the North Sea via an HVDC cable to a subsea converter station.

RESULTS & FINDINGS

Upon weighing each electrification option across the various sustainability indicators, **Platform to Platform (Option 2)** electrification was the best option for the electrification and decarbonising production on the Elgin Franklin. Table 4 shows how various options performed across the sustainability indicators.

Table 4: Electrification options performance

Sustainability Indicators	Option 1	Rank	Option 2	Rank	Option 3	Rank
Technical	13	1	13	1	10.3	2
Economics	40	3	65	1	55	2
Environmental	38	2	64	1	23	3
Total points	91		142		88.3	

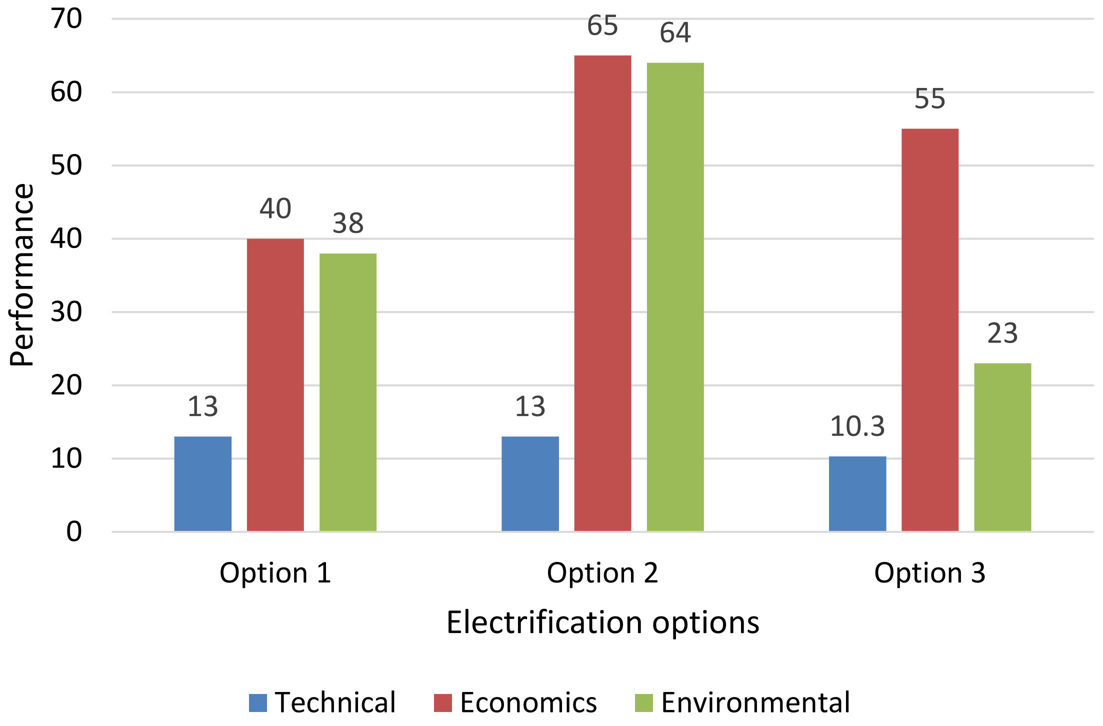

Figure 2: Electrification options based upon sustainability performance indicators

IMPLICATIONS & RECOMMENDATIONS

IMPLICATIONS

1. The study's findings show how crucial it is for the UKCS to consider long-term carbon emissions reduction technology for successful decarbonisation efforts.

2. Sustainability Assessment has been shown to be a useful method for assessing electrification choices and ought to be a major consideration when choosing alternative power sources for offshore activities.

3. To have the least negative environmental impact, subsea cables, essential for electrification, should be produced using the least energy possible.

RECOMMENDATIONS

1. Implement the **"platform to platform"** power supply option as it is the most sustainable method of platform electrification based on the study's findings.

2. Explore further and address regulatory requirements and supply chain management gaps for stakeholders involved in electrification projects' licensing.

3. Continue research on reducing the cost of electrification and explore energy storage options to enhance energy security on platforms.

CONCLUSION

The study highlights that achieving the **2050 Net Zero targets** and ensuring **energy security** in the Central North Sea require electrifying oil and gas installations. After evaluating electrification options using the Sustainability Assessment criteria and MCDA, the **"platform to platform"** (Option 2) power supply emerged as the most sustainable solution. It offers reliable power, efficient management, and minimal environmental impact over its lifespan.

This study provides empirical evidence towards a sustainable path for the UKCS energy transition, but future research should focus on lowering the cost of electrification, easing regulations around electrification projects and investigating energy storage options.