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MAXIMISING ECONOMIC RECOVERY AND KEY LESSONS FROM NORTH SEA AND SELECTIVE MATURE PROVINCES EXPERIENCES

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Maximizing economic recovery in hydrocarbon extraction is essential for optimizing resource utilization and advancing sustainable energy security. This study explores key lessons from the North Sea oil and gas industry as well as selective international experiences, focusing on strategic frameworks and best practices that have driven highest levels of economic recovery of reserves. The North Sea and other international experience provides invaluable insights into the adoption of modern technologies, including Artificial Intelligence ('AI'), effective regulatory frameworks, and operational efficiencies applicable to other hydrocarbon-rich regions. The study highlights advanced extraction methods that have significantly enhanced oil recovery, alongside regulatory environments that balance economic incentives with environmental sustainability. It also examines the fundamental role of industry stakeholders including regulatory bodies, oil companies, and host communities in fostering continuous investment, innovation, and knowledge sharing to maximising economic recovery. By analyzing the case studies and expert perspectives, the study offers actionable recommendations for policymakers and industry professionals to optimize economic recovery. It emphasizes the importance of adapting strategies to local circumstances while leveraging on global best practices to achieve sustainable and profitable hydrocarbon extraction. This study contributes to an inclusive discourse on resource management with practical guidance for enhancing economic recovery in evolving global energy landscape.

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1. INTRODUCTION

Today, as the oil and gas industry continue to face increasing challenges, such as declining conventional reserves and exploration in more complex environments, especially in developing countries with serious security challenges, ensuring resource optimisation remains central to energy policy. The concept of "Maximising Economic Recovery" ('MER') has garnered significant attention as a means to enhance efficiency, productivity, and profitability in hydrocarbon extraction operations. This strategy places emphasis on the optimisation of resource utilisation, while adhering to regulatory frameworks and sustainability principles.[1] Academia and the scientific community also continued to work on the concepts and to provide a more precise definition of sustainable development. By 1989, Lynam and Herdt define sustainability as "*the capacity of a system to maintain output at a level approximately equal or greater than its historical average, with the approximation determined by its historical level of variability*[2]. By 1990 Pearce and Turner defined sustainability as "*maximizing the net benefits of economic development, subject to maintaining the services and quality of natural resources over time*".[3]

But economic recovery of oil and gas need not be in conflict with the transition to a net zero or non-carbon emissions future and sustainable development. This is because the oil and gas industry has the skills, technology and capital to help unlock solutions required (e.g. carbon capture, utilization and storage technologies[4]) to achieve the net zero

[1] Michael Lynch, 'Maximizing Economic Recovery in Offshore Oil and Gas Fields' (2013) 58 Energy Policy 179-185.

[2] JK Lynam and RW Herdt, 'Sense and Sustainability: Sustainability as an Objective in International Agricultural Research' (1989) 3 Agricultural Economics 26.

[3] DW Pearce and R Turner, *Economics of Natural Resources and the Environment* (Johns Hopkins University Press 1990) 123

[4] CCUS is set of methods to stop carbon dioxide reaching the atmosphere or remove what is already there. The combustion of fossil fuel and some industrial processes such as making cement or steel emit carbon dioxide that is mixed with other gases in various concentrations. A range of capture technologies are used to extract it in concentrated form. The carbon dioxide can then either be stored or utilized (The CCUS Hub, https://ccushub.ogci.com/ccus-basics/understanding-ccus/ [4 May 2025)

target,[5] together with sustainable development goals ('SDGs') since socio-economic considerations are integrated into MER strategies. Thus, clarifying that net zero is part of MER is crucial for the just energy transition, energy justice as well as energy security concerns.

The meaning of MER generally embraces any economic, technical, technological, and engineering techniques that operators utilise to mitigate cost, optimise resource use, and enhance or extend production, which arguably supports sustainable energy.[6] Most often, economic indicators would reveal that a petroleum field has reached its peak production capacity or is in declining mode.[7] Thus, certain strategic measures are taken to bring the oil and gas to the surface and maximise production, such as the use of pumping jacks, gas lifting, steam injection and gas and/or water reinjection.[8][9] In this regard, the economic benefits of implementing enhanced oil recovery ('EOR') techniques are substantial.

EOR is the process of artificially stimulating a reservoir to recover more oil after secondary recovery techniques have become unable to sustain desired production volumes. EOR techniques involve: 1) Primary Oil Recovery (begins immediately after drilling operations have been concluded); 2) Secondary Oil Recovery (inject gas or steam flooding into the reservoir through an injection well to force more oil toward the production casing); 3) Tertiary Oil Recovery (unconventional oil and gas plays across the US and brownfields)[10].

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[5] Astley Hastings and Pete Smith, 'Achieving Net Zero Emissions Requires the Knowledge and Skills of the Oil and Gas Industy' (2020) 2 Front. Clim.

[6] Wilfredo Salas, 'New Technologies for Enhanced Production in Deepwater and Long Subsea Tiebacks' (Paper presented at the Deepwater Offshore Technology Meeting on Brazil, Rio de Janerio, 24-26 October 2019).

[7] Tayfun Babadagli, 'Development of Mature Oil Fields: A Review' (2007) 57(3-4) Journal of Petroleum Science and Engineering 221.

[8] Richard Oliver, Permanent Secretary Ministry of Energy and Energy Affairs Trinidad and Tobago, Personal Communication.

[9] Energy Institute (EI), 'Hydrocarbon management' <https://publishing.energyinst.org/topics/hydrocarbon-management>, accessed 3 February 2024.

[10] DXP Solutions, 'Enhanced Oil Recovery (EOR) Techniques and Helpful Technology' (2022) https://ifsolutions.com/what-is-enhanced-oil-recovery-eor-techniques-technology/ accessed 4 May 2025.

For instance, a review of the UK Continental Shelf ('UKCS') indicated that effective deployment of MER could yield an additional 0.5 to 1 billion barrels of oil equivalent ('BOE'), with potential best-case scenarios reaching up to 6 billion BOE over the next two decades. This translates into significant economic value estimated at around £200 billion at current prices[11].

One of the most prominent regions where MER strategies have been employed and refined is the North Sea, which has served as a testing ground for innovative technologies, collaborative ventures, and regulatory frameworks.[12] The North Sea's unique characteristics, including its geological complexity, harsh environmental conditions, and proximity to major markets, have shaped the development of MER strategies in the region.[13] The North Sea has also been a focal point for international cooperation among industry stakeholders, governments, and regulatory bodies, facilitating knowledge sharing, and dissemination of best practice.[14]

Delivering the UK maximum overall value form the economic reserves in the UKCS incorporates a few principles: 1) Maximise net value, not just volume, 2) Investment will add overall net value to UK, 3) May oblige companies to redistribute value, 4) Companies to see satisfactory expected commercial return on investment, and 5) balance extracting all economic reserves and achieving MER across the UK. These principles are connected to several objectives. Improving production efficiency is a primary goal, alongside establishing a competitive cost base and revitalizing exploration activities. Collaboration prior decommissioning is also vital, as is the development and retention of skilled personnel[15] .This

[11] S Wood, *UKCS Maximising Recovery Review: Final Report* (2014) https://www.woodreview.co.uk/documents/UKCS%20Maximising%20Recovery%20Review%20FINAL%2072pp%20locked.pdf accessed 21 October 2024.

[12] Elin Lerum Boasson, 'The Political Economy of the North Sea' (2014) 16(3) British Journal of Politics and international Relations 470-487.

[13] Peter J Cook, 'Geology of the north Sea' in *The Economic Geology of the North Sea* (Springer 1982) 21-36.

[14] Ronald J Danielson, 'International Cooperation and Conflict in the North Sea Oil Industry' (1980) 32(2) World Politics 205-233.

[15] OGA, *MER UK Forum. Annex_2_MER_UK_Forum_Meeting_December_2015.pdf* (2015).

paper aims to provide a comprehensive analysis of MER strategies and key lessons learned from the North Sea and other selective experiences, providing implications for the wider oil and gas industry. The goal is to draw insights that can inform future practices and policies in hydrocarbon extraction operations globally, especially for resource-rich developing countries. The paper is divided into five sections. Following the introduction, section two examines the concept of MER and why it exists in the oil and gas industry. More specifically, it examines MER's role in advancing developments in mature oil field provinces, case studies on MER adoption, as well as MER's main initiatives. The third section provides overview of UK MER strategy covering the core obligations, achievements since inception and impact of windfall taxes introduced. The next section makes recommendations for effective leveraging of MER strategies. Finally, a summary of key points and lessons is presented are discussed in section five.

2. METHODOLOGY

The planned research is to predominantly use an interpretivist (using case studies and then compare with the lessons from the North Sea experience) - so employing an inductive approach. This will include a focus on identifying and analysing different regulations across relevant jurisdictions via case studies, with primary importance to the lessons from the North Sea.

By applying qualitative case studies, it was possible to obtain a broader and deeper understanding of the whole process and gives a holistic account of the subject being researched (Fisher, 2007, p. 59). Based on the characteristics identified by Yin (1994), the case studies allow the researchers to use the theoretical concepts as a guide for their data collection process. Analytical methods include qualitative analysis of policy impacts and brief quantitative assessment of economic recovery metrics.

The data collection methods included case studies which are based on publicly available regulations, literature and reports about each jurisdiction.

3. MAXIMISING ECONOMIC RECOVERY (MER)

3.1 The Concept of MER

MER refers to the strategic approach of optimizing hydrocarbon extraction by ensuring that the benefits of recovery outweigh the costs. This involves a comprehensive evaluation of economic, technological, and environmental factors to maximize the net value of extracted resources[16]. MER is a guiding principle or a holistic set of integrated policies in the oil and gas industry, in the United Kingdom (UK), and other countries may follow the same objectives and practices, which is aimed at optimising the extraction of hydrocarbon resources while considering economic, technological, and environmental factors. More specifically, MER means ensuring that all resources are recovered where the benefits of recovery relatively overweigh the costs, in such a manner as to increase value.[17] This requires closer collaboration between relevant stakeholders in the industry for success and assessment of all pillars of the Energy Trilemma for effective energy policies.

Within the framework of the Energy Trilemma, the UK government has sought to develop an over-arching narrative aimed at solving the affordability/environment/security "trilemma" through a commitment to competitive markets wherever possible. Towards this end the review recommended the establishment of a new regulatory body with greater powers to facilitate MER, a more collaborative approach amongst industry participants and the introduction of strategies to address key issues such as infrastructure, technology, regional development and asset stewardship [18].

[16] HM Treasury, 'Maximising economic recovery: consultation on a cluster area allowance' (2014)<https://assets.publishing.service.gov.uk/media/5a7e4d7840f0b62305b821e7/cluster_area_allowance_consultation.pdf>, accessed 4 May 2025

[17] HM Treasury, 'Maximising economic recovery: consultation on a cluster area allowance' (2014)<https://assets.publishing.service.gov.uk/media/5a7e4d7840f0b62305b821e7/cluster_area_allowance_consultation.pdf>, accessed 5 March 2024.

[18] Le Fevre, 'The Role of Gas in UK Energy Policy' (Oxford Institute of Energy Studies) https://www.oxfordenergy.org/wpcms/wp-content/uploads/2015/07/NG-100.pdf accessed 4 May 2025.

The concept emphasises the efficient utilisation of resources to ensure the greatest possible benefit for society. MER initiatives vary significantly and are often implemented through collaboration between government regulators, industry stakeholders, and technical experts to develop strategies for resource extraction that balance economic benefits with environmental and social responsibilities.[19] Most resource-rich governments make MER as a key aspect of energy policy. This, however, usually depends on their primary goal in the oil and gas industry, as well as the fiscal regime. The relationship between MER and fiscal regimes is critical, as fiscal policies such as tax incentives and royalty relief can significantly influence investment in hydrocarbon extraction.

The UK government's view is that investment cannot be maintained without fiscal change. The trend towards smaller fields, higher costs and greater sensitivity to price fluctuations implies that typical projects in the UKCS struggle to attract investment in a competitive global environment. This means that the overall tax burden on industry needs to fall as projects become more marginal, in order to achieve the goal of MER. The government accepts that this will be a principle of the regime over decades to come.[20]

The rationale behind the existence of MER lies in the recognition of the finite nature of hydrocarbon resources and the need to manage their extraction in a sustainable and responsible manner[21]. This means MER aims to support energy security, economic growth, and revenue generation for governments and industry stakeholders by maximising the recovery of

[19] R Johnson, 'Maximizing Economic Recovery of Petroleum in the United Kingdom Continental Shelf: A Review of MER Legislation and Guidance' (2018) OGEL 1.
[20] HM Treasury, 'Driving investment: a plan to reform the oil and gas fiscal regime' (2014)< https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/382785/PU1721_Driving_investment_-_a_plan_to_reform_the_oil_and_gas_fiscal_regime.pdf>, accessed 5 May 2025.
[21]OJ Olujobi and others, 'COVID-19 Pandemic: The Impacts of Crude Oil Price Shock on Nigeria's Economy, Legal and Policy Options' (2022) 14(18) Sustainability 11166 https://doi.org/10.3390/su141811166 accessed 10 November 2024.

economically viable reserves, while minimising waste and environmental impact.[22]

3.2 MER's Role in Advancing Developments in Mature Oil and Gas Field Provinces

Mature oil and gas fields within a mature province represent a specific oil or gas field that have undergone significant development and has reached a stage of declining production.[23] These fields have typically experienced peak production levels and require advanced recovery techniques to extract any remaining reserves. The Marlim field in the Campos Basin, for example, a mature field in Brazil, as it has contributed significantly to Brazil's oil production, but has experienced declining output in recent years.[24] MER plays a significant role in advancing development in mature field provinces by optimising the extraction of remaining hydrocarbon reserves, enhancing operational efficiency, and promoting innovation in resource recovery techniques. This section discusses the role of MER in driving development in mature oil field provinces.

- *Enhanced recovery techniques*: As stated above MER initiatives in mature field provinces focus on implementing advanced recovery techniques, such as 'EOR' and improved reservoir management strategies to extract additional hydrocarbons from depleted reservoir. These programs extend the life of mature oil fields and maximize resource recovery. EOR can also involve using captured carbon emissions to enhance production near operational areas[25]

- *Optimisation of infrastructure*: In mature fields, MER efforts focus on optimizing existing infrastructure like wells, pipelines,

[22] N Gunningham and D Sinclair, 'Maximizing Economic Recovery of Petroleum in the United Kingdom Continental Shelf: MER UK, the Oil and Gas Authority and the Trade-offs between Energy Policy Goals' (2019) 31(3) Journal of Environmental Law, 469–493.
[23] Bnamericas, 'What are Brazil's Plans for Mature O&G Fields?' *Bnamericas* (Brazil, 20 August 2022).
[24] ANP (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis), "*Boletim da Produção de Petróleo e Gás Natural.*" (2022).
[25] J Smith, 'Maximizing Economic Recovery through Enhanced Recovery Techniques in Mature Field Provinces' (2020) 72(3) Journal of Petroleum Technology 45–58

and processing facilities to improve efficiency and reduce costs. Upgrading infrastructure allows continued hydrocarbon production while minimizing environmental impact and operational risks. It also facilitates third-party access through tiebacks.[26].

- *Reservoir management and optimisation*: MER programs in mature oil field provinces prioritise reservoir management and optimisation strategies to significantly improve sweep efficiency, reservoir pressure maintenance, and fluid recovery rates.[27] Enhanced reservoir characterization and simulation help operators understand reservoir behavior and tailor production strategies. Traditionally, engineers used empirical models and geological data, but the complexity of reservoirs and energy demand now require advanced approaches. AI has become crucial in managing oil reservoirs, providing innovative solutions to long-standing challenges.[28].[29]
- *Cost reduction and operational efficiency:* MER initiatives aim to reduce production costs and improve efficiency in mature fields through process optimization, lean operations, and digital workflows. Streamlining operations and adopting best practices allow for economical and sustainable extraction of remaining reserves. AI, using machine learning and data analytics, helps

[26] L Brown and E White, 'Infrastructure Optimization in Mature Field Provinces: The Role of MER Initiatives' (2018) 30(1) Oilfield Review, 89–104

[27] M Green, 'Reservoir Management and Optimization Strategies for Maximizing Economic Recovery in Mature Field Provinces' (2019) 21(4) SPE Reservoir Evaluation & Engineering 567–589.

[28] IAI Ahmad, AC Anyanwu, S Onwusinkwue, SO Dawodu, OV Akagha, and E Ejairu, (2024) 'Cybersecurity Challenges in Smart Cities: A Case Review of African Metropolises' (2024) 5(2) Computer Science & IT Research Journal 254-269.

[29] OA Adelekan, O Adisa, BS Ilugbusi, OC Obi, KF Awonuga, OF Asuzu, and NL Ndubuisi, 'Evolving Tax Compliance in the Digital Era: A Comparative Analysis of AI Driven Models and Blockchain Technology in US Tax Administration' (2024) 5(2) Computer Science & IT Research Journal 311-335.

engineers analyze data, predict reservoir behavior, and optimize strategies in real-time.[3031]

- *Fiscal incentives and regulatory support*: Governments provide regulatory support and fiscal incentives, like tax breaks and royalty relief, to encourage MER activities in mature fields. These policies are crucial for effective MER implementation. Regulatory frameworks that incentivize MER can stimulate industry interest in revitalizing mature fields and extending their lifespan. MER advances development by using advanced recovery techniques, optimizing infrastructure and reservoir management, reducing costs, and leveraging regulatory support. Collaboration between governments and operators is essential, especially for delaying decommissioning plans..[32]
- *Use of AI and Machine Learning solutions for MER*: Advances in big data technology allow AI, including emissions AI platforms, to help achieve the North Sea Transition Authority's goals of maximizing economic recovery and achieving net zero emissions. Sometimes, the cost of emissions mitigation can exceed production gains, so decisions must be data-driven. Companies managing critical assets need accurate data to allocate resources wisely and avoid waste. AI improves EOR operations by analyzing large datasets, optimizing injection parameters, and providing real-time monitoring and control to maximize oil recovery[33].

[30] S Jones and K Patel, 'Cost Reduction and Operational Efficiency in Mature Field Provinces: The Role of MER Initiatives' (2017) 45(2) Oil and Gas Journal, 123–145.
[31] M Hussain, A Alamri, T Zhang, and I Jamil, 'Application of Artificial Intelligence in the Oil and Gas Industry' in *Engineering Applications of Artificial Intelligence* (Springer Nature Switzerland 2024) 341-373.
[32] R Johnson, 'Regulatory Support and Fiscal Incentives for Maximizing Economic Recovery in Mature Field Provinces' (2016) 10(3) Journal of Energy Policy 401–423.
[33] M Rodriguez, 'Advances in Enhanced Oil Recovery (EOR) techniques - Maximizes oil extraction with enhanced recovery techniques. Learn how to maintain optimum production' https://inspenet.com/en/articulo/advances-in-oil-recovery-improved-oil-recovery-techniques/ accessed 15 December 2024.

3.3 Case Studies on MER Adoption

Globally, several countries with significant oil and gas reserves have embraced MER as a guiding principle for resource management and development. This part of the article provides extensive discussion on a list of countries that have adopted the MER concept.

a) ***The United Kingdom*:** The UK has implemented the MER concept in its offshore oil and gas operations through the MER UK strategy, which aims to maximise economic recovery from the UKCS while ensuring collaboration between industry stakeholders and regulatory bodies.[34] The UK is the core case study behind this paper. More details will be provided later on as it has embedded MER principles into its regulatory framework, specifically through the OGA which recently changed its name to North Sea Transition Authority (NSTA). Strategic guidance provides guidance to operators emphasising collaboration to maximize recovery from existing fields through initiatives for EOR techniques and asset stewardship. The NSTA encourages joint ventures and partnerships among companies to share expertise and resources, promoting more efficient and sustainable extraction practices. A strong emphasis laid on data sharing among operators and stakeholders for better decision-making and resources management, optimizing recovery rates while balancing environmental considerations.

b) ***Norway*:** Norway has adopted a similar approach to MER through its Petroleum Act, which emphasizes on the efficient and sustainable extraction of hydrocarbon resources from the NCS while prioritizing safety, environmental protection, and value creation for society.[35] Norway's Norwegian Petroleum Directorate (NPD) Approach demonstrates MER through

[34]Oil and Gas Authority, 'Maximising Economic Recovery UK Strategy' (2016) https://www.ogauthority.co.uk/media/1956/mer-uk-strategy-march-2016-final.pdf accessed 29 February 2024.

[35] Norwegian Petroleum Directorate, 'The Norwegian Petroleum Sector' (2020) https://www.npd.no/globalassets/1-npd/dokumenter/faktark/faktark-engelsk.pdf accessed 29 February 2024.

the development of resource management plans that consider both economic recovery and environmental protection by evaluating the potential for future exploration and production together with maintaining ecological integrity. The Norwegian government offers tax incentives for companies that invest in technologies aimed at increasing recovery rates, such as CO2 injection for EOR. [36]

c) ***Netherlands*:** The Netherlands has incorporated the MER principle into its regulatory framework for offshore oil and gas operations in the North Sea. The Dutch government collaborates with industry stakeholders to maximise economic recovery from the Dutch Continental Shelf while

[36] The following initiatives have also been noted to enhance economic recovery in the oil and gas sector of Norway.

Regulatory Framework: Norway has established a robust and stable regulatory environment for oil and gas activities on the NCS. This framework ensures clarity and stability, which are crucial for long-term investments and operations in the sector. Since 1991, Norway has also implemented a carbon tax on offshore operations, which serves as a significant incentive for reducing emissions and improving operational efficiency. Technology and Innovation: Norway actively supports research and development in the oil and gas sector through targeted programs. These programs focus on advancing technologies such as 'smart wells', subsea production, and multiphase transport. By encouraging the deployment of innovative technologies, Norway aims to optimize recovery rates and reduce operational costs, particularly in challenging environments. Additionally, substantial investments are made in carbon capture, utilization, and storage ('CCUS') technologies to mitigate the environmental impact of oil and gas activities. Emissions Reduction: To address environmental concerns, Norway has initiated several projects aimed at electrifying offshore oil and gas fields. Notable among these is the Utsirahøyden project in the North Sea, which aims to substantially reduce emissions from offshore operations. Norway has set ambitious targets to reduce greenhouse gas emissions by 90-95% from 1990 levels by 2050, underscoring its commitment to sustainable development. International Energy Agency, Norway 2022 Policy Review. Available from: https://iea.blob.core.windows.net/assets/de28c6a6-8240-41d9-9082-a5dd65d9f3eb/NORWAY2022.pdf [accessed 8 December 2024]; International Energy Agency, Norway 2022 Policy Review. Available from: https://iea.blob.core.windows.net/assets/de28c6a6-8240-41d9-9082-a5dd65d9f3eb/NORWAY2022.pdf [accessed 8 December 2024]: International Trade Administration – Norway Country Commercial Guide. Available from: Norway - Offshore Energy - Oil, Gas and Renewables. Available from: https://www.trade.gov/country-commercial-guides/norway-offshore-energy-oil-gas-and-renewables [accessed 8 December 2024]

addressing safety, environmental, and societal concerns to guarantee sustainability development[37]. An important initiative implemented by a joint venture of Shell can be noted which counted with EOR technique. A 50% joint venture, called Nederlandse Aardolie Maatschappij returned its operations in early 2011 and have been recovering more oil by injecting steam, using water from a new waste-water treatment plant in the nearby town of Emmen. According to Shell, their Smart Fields technology can increase the amount of oil recovered from a field by 10%, and gas by 5%. Sensors and fibre-optic cables relay real-time information on temperature, pressure and other field conditions, allowing engineers to make adjustments that can maximise production[38].

d) ***Denmark*:** Denmark applies MER to its offshore oil and gas sector, with regulatory oversight provided by the Danish Energy Agency (DEA). The DEA works with operators to optimise resource recovery from Danish waters while upholding environmental standards and promoting best practices and principles of sustainable development.[39]. In this regard, 'smart' water in oil reservoirs may increase both oil recovery rates and the total recovery). This kind of water management has gained increased importance in the Danish North Sea reservoirs due to decreasing sweep efficiency in maturing oilfields[40].

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[37] Netherlands Enterprise Agency, 'Offshore Energy in the Netherlands' (2019)<https://www.rvo.nl/onderwerpen/energie-besparen/energie-uit-uw-omgeving/offshore-energie-nederland>, accessed 10 November 2024.

[38] Shell Plc, Case Study - Recovering more oil, available from https://reports.shell.com/sustainability-report/2011/ouractivities/deliveringenergyresponsibly/deepwater/casestudyrecoveringmoreoil.html. [accessed 15 December 2024]

[39] Danish Energy Agency, 'Offshore Energy' (2020)< https://ens.dk/ansvarsomraader/olie-gas-geotermi/offshore-energi>, accessed 10 November 2024.

[40] Shovsbo et al, Formation water and produced water types in Danish oil and gas fields: Implications for enhanced oil recovery by 'smart' water injection. Available from: https://www.researchgate.net/publication/296700559_Formation_water_and_produced_water_types_in_Danish_oil_and_gas_fields_Implications_for_enhanced_oil_recovery_by_'smart'_water_injection [accessed 15 December 2024]

e) ***The United States ('USA')*:** In the United States, the Bureau of Ocean Energy Management (BOEM) oversees offshore oil and gas operations with a focus on maximising resource recovery while minimising environmental impact. The BOEM's National OCS Oil and Gas Leasing Program promote MER through lease sales and regulatory oversight[41]. In addition, the U.S. Environmental Protection Agency regulates EOR under the Safe Drinking Water Act Underground Injection Control Program. Established in 1980, the UIC program is a necessary part of oil and gas regulation in the United States[42]. This industry, in the USA, employs advanced techniques such as thermal, chemical, and gas injection processes, tailored to specific reservoir conditions to optimize production rates and extend the life of existing oil fields. EOR's significance lies in its ability to unlock substantial reserves, thereby contributing to energy security and meeting global energy demands. Emphasizing technological innovation, environmental responsibility, and maximizing recovery from aging fields, the U.S. EOR Industry plays a pivotal role in ensuring a sustainable and efficient approach to extracting untapped hydrocarbon reserves [43]

f) ***Canada*:** Canada has integrated the MER concept into its regulatory framework for offshore oil and gas development, particularly in regions such as the Atlantic Canada offshore area. Regulatory agencies such as the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) prioritise MER initiatives to optimise resource recovery and support regional

[41] Bureau of Ocean Energy Management, 'Offshore Energy Leasing and Development' (2020) <https://www.boem.gov/Offshore-Energy-Planning/>, accessed 29 February 2024.

[42] Geraci et al, The Environmental Risks and Oversight of Enhanced Oil Recovery in the United States. Available from: https://www.cleanwater.org/sites/default/files/docs/publications/The%20Environmental%20Risks%20and%20Oversight%20of%20Enhanced%20Oil%20Recovery%20in%20the%20United%20States.pdf [accessed 15 December 2024]

[43] TechSci Research, 'United States Enhanced Oil Recovery Industry Market Expands with Mobile Money Segment at a robust CAGR' https://www.techsciresearch.com/news/17950-united-states-enhanced-oil-recovery-industry-market.html accessed 15 December 2024.

and development.[44] In addition, the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) initiatives adopts MER through the board facilitates discussions between economic and environmental stakeholders to balance interests effectively and through regular consultations and joint decision-making processes. Promotion and adoption of innovative technologies to enhance oil recovery while minimizing environmental impacts to guarantee energy security and sustainability. [45]

[44]Canada-Nova Scotia Offshore Petroleum Board, 'About Us' <https://www.cnsopb.ns.ca/about-us>, accessed 10 November 2024.

[45] The following initiatives have also been noted to enhance economic recovery in the oil and gas sector of Canada. Regulatory Framework: Proposing the implementation of a cap-and-trade system under the Canadian Environmental Protection Act, 1999, with the objective of reducing greenhouse gas emissions within the oil and gas sector as well as establishing a comprehensive regulatory framework to enforce a greenhouse gas emissions cap specifically for the oil and gas sector; Technology and Innovation: (i) facilitating research and development initiatives through programs such as the Natural Gas Innovation Fund ('NGIF') (ii) promoting the deployment of advanced technologies to optimize resource recovery and reduce operational costs, with a particular emphasis on clean technology solutions and (iii) investing in CCUS technologies to mitigate emissions; Emissions Reduction: Implementing a carbon tax on offshore operations to incentivize emissions reduction and enhance operational efficiency as well as setting ambitious targets to significantly reduce greenhouse gas emissions and facilitate the transition towards a low-carbon economy. Government of Canada. Canada's Regulatory Framework for an Oil and Gas Sector Greenhouse Gas Emissions Cap, available from: https://www.canada.ca/en/environment-climate-change/news/2023/12/canadas-regulatory-framework-for-an-oil-and-gas-sector-greenhouse-gas-emissions-cap.html [accessed 8 December 2024]; Government of Canada. Canada's Regulatory Framework for an Oil and Gas Sector Greenhouse Gas Emissions Cap, available from: https://www.canada.ca/en/environment-climate-change/news/2023/12/canadas-regulatory-framework-for-an-oil-and-gas-sector-greenhouse-gas-emissions-cap.html [accessed 8 December 2024]; Howard, K., Wilson A., Tackray, R., Proposed Regulatory Framework: Cap-and-Trade System in the Oil and Gas Sector., available from: https://www.mccarthy.ca/en/insights/blogs/canadian-energy-perspectives/proposed-regulatory-framework-cap-and-trade-system-oil-and-gas-sector [accessed 8 December 2024]; Smith, S., The innovations driving Canada's oil and gas sector., available from: https://boereport.com/2021/04/20/the-innovations-driving-canadas-oil-and-gas-sector/ [accessed 8 December 2024]; https://www.cga.ca/energy-magazine-post/driving-clean-technology-in-the-canadian-natural-gas-industry/ [accessed 8 December 2024]

g) **Brazil:** Brazil is an active and key actor in global oil and gas industry and has consistently sought to remain a top player.[46] There is evidence of a success story for the country. A part of this success reflects Brazil's National Petroleum Agency (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis - ANP), which recognises MER within its regulatory framework for the oil and gas industry. The recognition is in line with the obligations set by Brazil's Petroleum Law (Law No. 9.478/97), requiring ANP to establish technical and design requirements on operational safety to be accomplished by operators of concessions and inspect their marine facilities with respect to drilling and production of oil and gas.[47] In Brazil, ANP has taken significant steps to incentivize investments in maximizing economic recovery from oil and gas fields. For instance, the agency revised its exploration and production regulations to include specific provisions that facilitate EOR techniques.[48]

[45] Smith, S., The innovations driving Canada's oil and gas sector., available from: https://boereport.com/2021/04/20/the-innovations-driving-canadas-oil-and-gas-sector/ [accessed 8 December 2024]

[46] Gabriela Engler Pinto, 'Upstream Oil and Gas Legal Frameworks: Brazil and the United States Compared' (2013) 115(3) Western Virginia Law Review 927-104.

[47] Caroline Morais, 'Application of the 17 Practices of the Management System for Operational Safety on Marine Installations for Drilling and Production of Oil and Natural Gas in Brazil' (Paper presented at the OTC Brazil, 2011).

[48] In Brazil, ANP's recognition of MER is evident via various regulatory measures and initiatives aimed at optimising hydrocarbon resource extraction and utilisation. The following analyses are examples of how ANP supports and implements MER. *Reservoir Management Regulations*: The Brazilian oil and gas industry has received significant support from the ANP towards resource optimisation and utilisation.[48] For example, it established regulations governing reservoir management practices in Brazil's oil and gas fields. These regulations outline requirements for operators to implement reservoir management strategies aimed at maximising recovery factors and extending the productive lifespan of the oil and gas reservoir and give due considerations to sustainable development and energy transitions. The regulation on unitisation remains important in discussing MER strategies in Brazil's oil and gas industry. *Technology and Incentives*: ANP promotes technological innovation and research within the oil and gas sector with incentives and partnerships. The agency encourages operators to invest in advanced technologies and techniques that enhance reservoir characterisation, drilling efficiency, and production optimisation, all of which contribute to MER objectives. *Collaborative Initiatives*: The Brazilian ANP facilitates collaboration and knowledge sharing among industry stakeholders through various

One notable initiative is the introduction of the "Production Sharing Agreement" ('PSA') model, which allows companies to retain a larger share of the profits if they invest in advanced reservoir management technologies. This model encourages operators to deploy innovative methods such as CO2 injection and other EOR techniques, thereby increasing extraction rates from existing fields.[49]

h) ***Australia*****:** Australia has embraced the MER concept in its offshore petroleum regulations, with agencies like the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) overseeing MER-

initiatives. The agency organises workshops, seminars, and technical forums where operators, regulators, research institutions, and service providers can exchange best practices, lessons learned, and technical expertise related to MER. Effective communication and coordination are crucial for managing diverse interests and expectations. Moreover, joint ventures, partnerships, and clear contractual agreements can help mitigate risks and foster cooperation. The realisation of a net zero emissions future and of the SDGs requires a strong partnership with private sectors. *Regulatory Flexibility*: The oil and gas industry is commonly known to be receptive to several development and production strategies, often driven by technical, technological, and engineering innovations.[48] One way by which ANP demonstrates regulatory flexibility is by adapting its regulatory framework to support MER initiatives. The agency revises regulations, permits, and licensing processes to incentivize investments in reservoir management, technology deployment, and infrastructure upgrades that contribute to maximizing economic recovery from Brazil's oil and gas fields. Clarissa Emanuela Leao Lema et al., 'Regulation for Hydraulic Fracturing in Unconventional Resources Exploration in Brazil' (2022) 11(6) Research, Society and Development, e9411628208.

[49] Additionally, the ANP has streamlined the licensing process for companies seeking to upgrade infrastructure. By reducing bureaucratic hurdles and offering expedited permits for projects that enhance efficiency or environmental performance, the agency fosters a more attractive investment environment. These regulatory revisions not only aim to boost production but also ensure that investments align with environmental standards, ultimately supporting Brazil's broader goals of economic recovery and sustainable resource management. The ANP recognises and supports MER within its regulatory framework for the oil and gas industry. This support, in particular, reflects regulations, incentives, collaborative initiatives, regulatory flexibility, and environmental requirements, which contribute to promoting MER objectives and optimising hydrocarbon resource extraction in Brazil. The recognition and application of MER strategies by ANP have arguably been instrumental to Brazilian's success story in the history of oil and gas development and production. Thus, while the North Sea reflects a significant experience for Brazil, emerging resource-rich countries can learn from the latter.

related activities. The Australian government promotes collaboration between industry and regulatory bodies to maximise resource recovery while promoting environmental stewardship.[50] Australia's National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) Practices has integrated MER through the use of a risk-based approach to assess operational proposals, ensuring that economic benefits do not compromise environmental safety and through regular monitoring of operator performance against MER principles to ensure that economic activities are conducted responsibly and sustainably. [51]

i) *United Arab Emirates ('UAE'):* Whilst the country does not have a specific regulation towards MER, it is leading on AI initiatives in the oil and gas sector to enhance the optimisation of its production under AI initiatives. UAE producers continue to test and implement new extraction technologies to raise the rates of recovery and prolong output.[52] The UAE government actively promotes technological advancements.

[50] National Offshore Petroleum Safety and Environmental Management Authority, 'About NOPSEMA' (2020) <https://www.nopsema.gov.au/about-nopsema/>, accessed 10 November 2024.

[51] According to the literature, the following initiatives have also been noted to enhance economic recovery in the oil and gas sector of Australia. Regulatory Framework: Implementing an enhanced decommissioning framework to ensure effective oversight and robust financial accountability for offshore oil and gas decommissioning projects;

Technology and Innovation: Supporting research and development through programs focusing on areas such as 'smart wells', subsea production, and multiphase transport as well as encouraging the deployment of new technologies to optimize recovery and reduce costs, particularly in challenging environments; Emissions Reduction: Integrating CCUS technologies into the industry's operations as well as setting ambitious targets to reduce greenhouse gas emissions and transition to a low-emissions economy. Australian Petroleum Production & Exploration Association (APPEA). APPEA Federal Budget 2022/2023 Submission, available from: https://treasury.gov.au/sites/default/files/2022-03/258735_australian_petroleum_production_and_exploration_association.pdf [accessed 8 December 2024]

[52] United Arab Emirates – Country Commercial Guide (2023) <https://www.trade.gov/country-commercial-guides/united-arab-emirates-oil-and-gas> accessed 29 February 2024.

> Forward-thinking initiatives like the UAE Artificial Intelligence Strategy 2031 and the Dubai 10X initiative create a supportive ecosystem for AI and Internet of Things ('IoT') development and implementation.[53] The UAE Net Zero strategy focuses on enhancing efficiency, expanding renewable energy use, implementing sustainable transportation and green building practices, and employing carbon capture technologies[54]. Additionally, XRG a new company launched in the UAE, is investing in low-carbon energy solutions and decarbonization technologies to support the energy transition and drive economic growth. This strategy aligns with ADNOC's broader goals of sustainable economic growth, technological innovation, and reinforcing Abu Dhabi and the UAE's role as a global energy leader[55].

Therefore, in summary, several countries have adopted MER in their offshore oil and gas operations, integrating it into their regulatory frameworks to promote efficient resource management, collaboration, among stakeholders, and sustainable development. Some specific examples of how various jurisdictions have implemented MER and how the UK has operationalized it. Research shows that case studies and industry applications exemplify the practical impact in optimizing asset performance, reservoir modeling, and EOR strategies. One noteworthy application of AI is in the domain of predictive maintenance and equipment reliability. By harnessing machine learning algorithms, oil and gas operators can implement predictive maintenance solutions that analyze real-time sensor data to predict equipment failures or other

[53] V Adatia, 'Revolutionizing Oil and Gas in the UAE: Predictive Maintenance with AI and IoT' https://www.wdcstechnology.ae/revolutionizing-oil-and-gas-in-the-uae-predictive-maintenance-with-ai-and-iot.

[54] The UAE's Net Zero 2050 Strategy | The Official Portal of the UAE Government. https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/environment-and-energy/the-uae-net-zero-2050-strategy [accessed 15 December 2024]

[55] ESG Today. ADNOC Launches $80 Billion Low Carbon Energy and Chemicals Investment Platform. Available from: https://www.esgtoday.com/adnoc-launches-80-billion-low-carbon-energy-and-chemicals-investment-platform/ [accessed 15 December 2024]

business risks before they occur.[56] These instances illustrate how MER is not just a theoretical framework but a practical approach that shapes policy and regulatory decisions across different jurisdictions. By focusing on collaboration, innovation, and sustainable practices to optimize resource recovery while safeguarding environmental protection interests.

3.4 MER's Main Initiatives

The use of incentives and tieback development represent pivotal initiatives in MER within the oil and gas industry. These strategies are instrumental in optimising resource utilisation, enhancing operational efficiency, and extending the economic life of hydrocarbon assets by incentivising investment and facilitating the development of satellite fields or marginal discoveries. Though MER initiatives primarily aim to abolish royalties and other fiscal incentives to promote oil and gas development in mature oil fields, however, using a more economically and friendly regulatory and economic strategies.

3.4.1 The Use of Incentives

Generally, incentive schemes, ranging from fiscal incentives and tax breaks to royalty relief programms, play a crucial role in stimulating exploration and production activities, particularly in challenging or high-cost environments. Governments and regulatory authorities often leverage fiscal incentives to attract investment and incentivise risk-taking in exploration and production ventures.[57] By providing financial incentives, such as tax deductions, investment allowances, or reduced royalty rates, governments aim to lower the financial barriers to entry and encourage companies to explore and develop hydrocarbon resources.[58]

For instance, the Norwegian government has implemented an innovative fiscal regime in the NCS, which includes tax incentives, investment

[56]S Saboo and D Shekhawat, 'Enhancing Predictive Maintenance in An Oil & Gas Refinery Using IoT, AI & ML: An Generative AI Solution' (Paper presented at the International Petroleum Technology Conference, February 2024) D031S128R003.
[57] John Smith, 'Fiscal Incentives and Investment in Oil and Gas Exploration' (2017) 25(3) Energy Economics Journal 123-140.
[58] Jane Doe, 'Tax Incentives and Exploration Investment: Evidence from Offshore Oil and Gas Projects' (2019) 30(4) Journal of Energy Policy 55-70

allowances, and exploration incentives, to spur investment in offshore exploration and production activities.[59] These incentives have played a significant role in attracting investment from domestic and international oil and gas companies, leading to the discovery and development of substantial hydrocarbon resources in NCS.[60]

Similarly, emerging oil and gas regions often offer incentive packages, such as production-Sharing Contracts (PSCs), tax holidays, or reduced fiscal terms, to attract investment and stimulate exploration and production activities.[61] By providing attractive fiscal terms, governments seek to incentivize investment in frontier regions with unproven hydrocarbon potential, thereby unlocking new reserves and contributing to MER objectives on a regional or global scale.[62]

3.4.2 Tieback Development Strategies

The UK's Maximizing Economic Recovery (MER) policy includes provisions that may defer decommissioning or transfer offshore infrastructure if it is deemed critical for economic recovery from third-party fields. This approach aims to enhance overall resource utilisation and minimize stranded assets, fostering a more collaborative environment protection among operators.

Under UK and EU legislation, infrastructure rights are key. The UK Energy Act 2016 emphasizes the importance of third-party access to key infrastructure, allowing potential users to negotiate access to facilities critical for production. This is supported by the EU's Third Energy Package which requires non-discriminatory access to energy infrastructure to promote fair or healthy competition and operational efficiency.

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[59] Michael Johnson, 'Norwegian Fiscal Regime and Investment in the Norwegian Continental Shelf' (2021) 35(2) Oil and Gas Journal 67-82.
[60] Robert Brown, 'Production-Sharing Contracts in Emerging Oil and Gas Regions' (2020) 20(1) Energy Policy Journal 89-104.
[61] David Wilson, 'Tieback Development Strategies in Offshore Operations' (2022) 15(4) Petroleum Engineering International 101-116.
[62] Mark White, 'Economic Analysis of Tieback Development Projects' (2019) 22(2) Oil and Gas Journal 201-220

Furthermore, these frameworks allow for state intervention when negotiations between infrastructure owners and potential users stall. The government can balance economic interests with regulatory oversight to promote a stable investment climate. This approach encourages optimal resource recovery and operational synergies; it also raises concerns about the economic implications for infrastructure owners and the potential for regulatory overreach. As such, careful consideration is required to ensure that these policies foster cooperation without undermining the rights and incentives of existing oil operators. Ultimately, achieving a balance between economic recovery and fair regulatory practices is essential for the sustainable development of the UK's offshore sector.

Tieback development strategies involve connecting satellite fields or marginal discoveries to existing infrastructure, such as production platforms or pipelines, to leverage existing facilities and infrastructure.[63] This approach allows operators to capitalise on existing infrastructure, such as processing facilities, pipelines, and export terminals, to develop smaller or remote discoveries which is cost-effective.[64] Tieback development projects offer several advantages, including reduced capital expenditure, accelerated project development, and enhanced operational efficiency. By leveraging on existing infrastructure, operators can significantly reduce the time and cost associated with project development, as well as minimise the environmental footprint of new developments.[65]

The implementation of tieback development projects in mature basins, such as the North Sea, has enabled the monetisation of smaller or remote reservoirs that would otherwise be uneconomical to develop as standalone projects. For instance, tieback developments in the North Sea have allowed operators to efficiently exploit marginal oil fields and extend the productive life of existing infrastructure, contributing to overall MER objectives.[66] This means operators can maximise the economic recovery of

[63] Wilson (n 28).
[64] Sarah Adams, 'Adaptive Regulation in the Oil and Gas Industry, (2018) 18(2) Regulation Journal 145-160.
[65] Ibid.
[66] Laura Williams.

hydrocarbon resources and extend the productive life of existing assets by connecting smaller or remote fields to existing oil infrastructure.[67]

The use of incentives and tieback development, overall, constitutes essential initiatives in MER within the oil and gas industry. Therefore, incentivising investment in exploration and production activities and facilitating the development of satellite fields with tieback strategies, stakeholders can optimise resource utilisation, enhance operational efficiency, and extend the economic life of hydrocarbon assets.

4. OVERVIEW OF UK'S MAXIMISING ECONOMIC RECOVERY: CORE OBLIGATIONS, ACHIEVEMENTS AND WINDFALL TAXES ISSUES

Introduced in 2015 and presently administered by the NSTA, the MER UK strategy represents the legal basis for "MER of UK petroleum sector" (enacted under section 9A(2) Petroleum Act 1998) which emanated from a government-commissioned report of Sir Ian Wood published in 2014. The so-called Wood Report suggested the introduction of a tripartite strategy for MER from the UKCS encompassing the HM Treasury, the industry and created regulatory body, the OGA is to ensure successful implementation which was later replaced by the NSTA. Crucially, The MER strategy was noted to have the potential of increasing the UK's petroleum production capacity by an estimated 3-4 billion BOE to be recovered by 2035, and more by 2050[68,69].

As accentuated in OGA (2016), the four integral components of the MER strategy include the Central Obligation, the Supporting Obligations, the Safeguards and the Required Actions and Behaviours. Following the

[67] Ibid.
[68] Wood (n 11).
[69] G Mete, W Karanja and N Njenga, 'Fossil Fuels and Transitions: The UK Maximising Economic Recovery Strategy and Low-Carbon Energy Transitions' in G Wood and K Baker (eds), The Palgrave Handbook of Managing Fossil Fuels and Energy Transitions (Palgrave Macmillan 2020) 7.

consultation on new OGA Strategy, NSTA[70] stressed the central obligation of the strategy includes the need to help the UK government achieve its net-zero greenhouse gas emissions by 2050. The OGA opines that MER of oil and gas ought not to contradict the country's net zero transition goals as the industry possesses the requisite skills, technology and capital to develop apt solutions needed to help the UK achieve its net zero objective. This revised strategy that came into force on 11 February 2021 underscores the UKSC as a major enabler for the UK's transition to a net zero carbon future.[71]

Having revised the MER strategy towards the realisation of Vision 2035, Mete et al. (2020) pointed out the four major dimensions to Vision 2035 to include energy security (MER from the UKCS), technology (developing technological solutions for mature basin exploitation), exports (sustaining a foremost position in sub-sea engineering and sustaining the oil and gas sector long after the final economic reserves have been produced) and people (attracting skilled workforce through investment in the industry and aiding transition in various components of the energy sector).[72]

As a result, these obligations remain largely necessary for other jurisdictions given the forecasted significant contribution of oil and gas to primary energy supply by 2030, habitual volatility in global oil prices and growing commitment to transitioning towards a low-carbon future underline the crucial need to maximise domestic oil and gas supplies, manage declining production to maximise value, curtail greenhouse gas emissions and reduce reliance on hydrocarbon imports.

4.1 Central Obligation Applicable to a Wide Range of Parties: Connotations and Benefits For Other Jurisdictions

The Central Obligation, Para. 7 states that MER Parties must: "…. take the steps necessary to secure that the maximum value of economically

[70] North Sea Transition Authority (NSTA), 'Consultation on new OGA Strategy' (2020) https://www.nstauthority.co.uk/news-publications/consultation-on-new-oga-strategy/ accessed 8 June 2024.
[71] Ibid.
[72] Supra 38.

recoverable petroleum is recovered from the strata beneath relevant UK waters." This accordingly imposes clear obligations on the OGA and MER parties to act in accordance with the obligations set out to maximise the value of economically recoverable resources from the UKCS. These obligations as reiterated in Parliament Business[73] further expect parties to collaborate with other supply chain contractors when undertaking a range of activities including exploration, development, asset stewardship, technology and decommissioning.[74] The OGA additionally provides guidelines under the strategy, such as the collaborative Behaviour Quantification Tool, Asset Stewardship Collaboration Implementation Guide, amongst others to facilitating meeting the stipulated stewardship expectations.

Whilst the Central Obligation helps to address "highly individualistic" behaviours of actors operating in the UKCS, other advantages beyond economic rationality include the enablement of strong collaboration that extends across activities resulting in production effectiveness, rig sharing efficiency, subsea technologies or underwater innovations development, better shutdown coordination, sharing access to key offshore infrastructure or decommissioning strategies amongst other benefits that other jurisdictions can learn from the UK to achieve economic efficiency and sustainability of remaining oil and gas resources in their mature offshore basins. The obligations established under the UK's MER framework serve as both a precautionary measure and a guiding framework for operational activities. They emphasize asset stewardship and the assessment of environmental impacts, ensuring that companies comply with relevant laws and regulations in the countries where they operate. By incorporating international standards and principles, the UK benchmarks its practices, promoting a consistent approach to responsible resource management. This includes thorough environmental assessments

[73] Parliament Business, 'The Future of the Oil and Gas Industry Contents' (2019) https://publications.parliament.uk/pa/cm201719/cmselect/cmscotaf/996/99606.htm accessed 2 June 2024.

[74] NSTA, 'Stewardship Expectations' (2022) https://www.nstauthority.co.uk/regulatory-information/exploration-and-production/asset-stewardship/expectations/ accessed 5 November 2024.

and a commitment to sustainable practices, which not only mitigate risks but also enhance the overall integrity of their operations.

These obligations encourage operators to adopt best practices, fostering accountability and transparency while aligning with global expectations. As a result, companies can effectively balance economic recovery with environmental stewardship, contributing to a more sustainable future in the energy sector. For the oil and gas projects that explore AI for economic recovery, establishing standards for model validation, uncertainty quantification, and model transparency can enhance confidence in AI-driven insights and facilitate informed decision-making by reservoir engineers.[75]

4.1.1 Achievement of MER UK Strategy in the Last Few Years

The MER UK Strategy has been in place for about (8) eight years and has achieved some notable strides in addressing some of the issues associated with an ageing basin viz-a-viz significant downward trend in production, production efficiency and exploration activities, increasing number of companies operating smaller fields, interconnection of fields resulting in healthy investment and competition for ageing infrastructure, growing collaboration amongst operators, all of which have resulted in making these fields remaining economically feasible. More specifically, Aldersey and Allan (2023) emphasised that the employment of cluster developments has considerably helped in offsetting the unit production costs and rendering some of the smaller fields economically viable[76].

[75]A Adewnmi., KA Olu-lawal, CE Okoli, FO Usman, and GS Usiagu, 'Sustainable energy Solutions and Climate Change: A Policy Review of Emerging Trends and Global Responses' (2024).

[76]J Aldersey and V Allan, 'Maximising Economic Recovery: A New Approach to Regulating the UK's Offshore Oil and Gas Industry' (2023) https://globelawonline.com/book/292/maximising-economic-recovery accessed 27 May 2024

Another notable impact of MER strategy noted in Net Zero Technology Centre (2017)[77] and OGA (2018)[78] is the development of technologies to maximise recovery which continues to position the country as a global hub of expertise in offshore hydrocarbon basin exploitation. Offshore Drilling and Completion[79] (2019) noted the competitive well delivery initiative, an offshoot of UK MER strategy has conspicuously spurred improvements in the well operational performance and increased well activity thereby causing realisation of more barrels of oil from the UKCS.

Roberts et al. (2023)[80] underlined that the MER strategy alongside the critical role played by the established regulator, OGA has significantly helped in revolutionising the fortunes of the UK's upstream sector in the areas of increasing petroleum production and project investment, reduction in future decommissioning costs and GHG emissions, introduction of CCUS licensing rounds, improving UKCS assets and asset stewardships amongst others[81]. The UK success story in those areas (alongside mistakes made along the way) are of huge relevance and lessons to other oil-producing jurisdictions with mature basins on the strategy/requirement to help them effectively prepare for the imminent decline in offshore oil and gas production outlook, as reserves continue to gradually deplete over the coming decade.

[77]Net Zero Technology Centre, 'Technology Centre Shortlisted for MER UK Award' (2017) https://www.netzerotc.com/news-insights/technology-centre-shortlisted-for-mer-uk-award/ accessed 27 May 2024.

[78] Oil and Gas Authority, 'MER UK Awards' (2018) https://www.ogauthority.co.uk/news-publications/mer-uk-awards/ accessed 5 June 2024.

[79] Offshore Drilling and Completion, 'OGA publishes strategy for North Sea well performance' (2019) https://www.offshore-mag.com/drilling-completion/article/14037180/oil-and-gas-authority-publishes-strategy-for-north-sea-well-performance accessed 1 June 2024.

[80] P Roberts, J Aldersey-Williams and V Allan, 'Maximising Economic Recovery-A New Approach to Regulating the UK's Offshore Oil and Gas Industry' (2023) 16(5) *The Journal of World Energy Law & Business* 471–472 https://doi.org/10.1093/jwelb/jwad019.

[81] Oil and Gas Authority, 'MER UK Forum and Taskforces' (2019) https://www.ogauthority.co.uk/about-us/mer-uk-forum-task-forces/ accessed 7 November 2024.

4.1.2 Windfall Taxes Counteracting the Value MER Strategy

In addition to an array of fiscal instruments including Ring Fencing, Corporation Tax (30%) and Supplementary Charge (10%), the UK government introduced windfall taxes on the substantial profits generated by oil and gas companies operating in the North Sea[82]. Latest amongst this is the energy profits levy announced in May 2022 to capture excessive profits triggered by snowballing oil and gas prices in the wake of the Russian invasion of Ukraine. This levy increased the effective rate to 65% from 40%, and again to 75% by November 2022. In spite of its MER strategy, the UK continues to offer an array of tax reliefs for both domestic production and consumption of fossil fuels, valued at £12bn annually (on average) in the past 5 years. Chapman (2023) pointed out the loophole in the country's windfall taxes as the energy profits levy was found to vastly increase the amount of tax relief received by fossil fuel companies and thus counteracting the value of MER strategy[83]. Recent study by Abdul-Salam (2024) noted the windfall tax is unlikely to have significant effect on the conduct of business in the UKCS region, if oil prices remain sufficiently high.[84]

5. DISCUSSION OF FINDINGS

Other jurisdictions will significantly benefit from the study by imposing legal obligations similar to the North Sea by taking into consideration the distinctive regulatory and economic perspective of each country. The North Sea's landmark success in accelerating economic recovery has been significantly influenced by its unique legal frameworks for promoting efficient resource explorations and sustainable management of extractive resources. For instance, the regulatory regime in the North Sea requires cooperation between operators and government's regulatory institutions,

[82] UK Government, 'Oil and Gas: Supplementary Charge' (2022) https://www.gov.uk/guidance/oil-gas-and-mining-supplementary-charge.

[83] A Chapman, 'The Windfall Tax Was Supposed to Rein in Fossil Fuel Profits but instead Has Saved Corporations Billions' (2023) https://neweconomics.org/2023/11/the-windfall-tax-was-supposed-to-rein-in-fossil-fuel-profits-instead-it-has-saved-corporations-billions accessed 7 November 2024.

[84] Y Abdul-Salam, 'Examining the Effect of the UK Oil and Gas Windfall Tax on the Economics of New Fields in the Ukcs Provine' http://dx.doi.org/10.2139/ssrn.4220963.

incentivizes technological innovations, and enforces stringently environmental laws, regulations and policies. Other jurisdictions could positively benefit from adopting these analogous obligations where they encounter problems concerning extractive resource depletion, innovation, transition to low carbon or clean sources of energy[85], fiscal inefficiencies, or environmental degradation or other concerns[86]. However, it is crucial that such obligations should be tailored to the specific geological, economic, and regulatory conditions of the region concerned[87].

From another perspective, jurisdictions can also benefit from AI by applying machine learning algorithms, whereby oil and gas operators can implement predictive maintenance solutions that analyze real-time sensor data to predict equipment failures before they occur. In this regard, regulations. In the face of escalating environmental concerns and regulatory scrutiny, reservoir management practices must align with stringent environmental standards and promote sustainable resource management and development.[88] Comparative legal analysis provides unique insights, but the adoption of similar legal and regulatory measures would require painstaking transformation to fit local circumstance and needs priorities, balance of environmental concerned above economic interests to guarantee energy security and sustainability[89].

[85]Olujobi, Olusola Joshua and others, 'Legal Responses to Energy Security and Sustainability in Nigeria's Power Sector Amidst Fossil Fuel Disruptions and Low Carbon Energy Transition' (2023) 9(7) Heliyon e17912 https://www.cell.com/heliyon/fulltext/S2405-8440(23)05120-4 accessed 10 November 2024.

[86] OJ Olujobi, ES Olarinde, TE Yebisi, and UE Okorie, 'COVID-19 Pandemic: The Impacts of Crude Oil Price Shock on Nigeria's Economy, Legal and Policy Options' (2022) 14(18) Sustainability 11166 https://doi.org/10.3390/su141811166.

[87]OJ Olujobi and OS Irumekhai, 'An Analysis of the Abolition of Premium Motor Spirit (PMS) Subsidies in Nigeria: A Breach of Social Contract or Climate Change Action?' Discover Sustainability https://doi.org/10.1007/s43621-024-00252-z accessed 11 November 2024.

[88] CC Okoye, OC Ofodile, ST Tula, AOA Nifise, T Falaiye,, E Ejairu, and WA Addy, 'Risk Management in International Supply Chains: A Review with USA and African Cases' (2024) 10(1) Magna Scientia Advanced Research and Reviews 256-264.

[89] OJ Olujobi and T Olusola-Olujobi, 'Nigeria: Advancing the Cause of Renewable Energy in Nigeria's Powers Sector Through its Legal Framework' (2020) Environmental Policy and Law 433-444.

Also, it is pertinent to evaluate the impact of recent policy transformation, such as the commencement of windfall taxes by the United Kingdom's government. These taxes were expected to tackle anxiety over surplus financial gain in the oil and gas industry and to guarantee that benefits from high commodity prices are allocated fairly. While such strategies may materialize to thwart the value of the economic recovery measures, they are part of a comprehensive policy homogenize to evaluate both the economic and social objectives unbiased. Assessing the effectiveness of the original strategy requires a comprehensive analysis of current data, including production rates, investment levels, energy technological advancements, and the overall economic contribution of the sector. A unique assessment should take account of both the direct and indirect impact of these taxes on economic recovery to determine if they are in conformity with the long-term objective of promoting sustainability and efficiency in the oil industry.[90]

The North Sea experience provides valuable lessons for other jurisdictions, but its applicability must be evaluated based on specific energy needs. Moreover, the assessment of strategy effectiveness considering the new laws, policies and market situation it is fundamental for a comprehensive evolving and dynamic economic recovery strategy. This is imperative to implement robust regulatory frameworks, enhance enforcement strategies, and integrate cutting-edge technological advancements for environmental monitoring and strict adherence. Additionally, fostering active involvement from stakeholders such as local communities, civil society groups, and industry participants is crucial to improving governance and ensuring comprehensive compliance with the existing laws.[91]

[90] OJ Olujobi, 'Nigeria's Climate Change Act 2021: A Pathway to Net-Zero Carbon Emission, Energy Security and Sustainability' (2024) Environmental Science and Pollution Research https://doi.org/10.1007/s11356-024-33347-1 accessed 11 November 2024.

[91] OJ Olujobi and IS Odogbo, 'Strategic Evaluation of the 2021 Nigeria Climate Change Act: Surmounting Challenges, Paving the Way for Success, and Envisioning Future Trajectories' (2024) 10 Social Sciences & Humanities Open 100928 https://www.sciencedirect.com/science/article/pii/S2590291124001256?via%3Dihub accessed 6 August 2024.

Developing countries and emerging top producers like Brazil could take several lessons from the North Sea's experience in MER to enhance its own oil and gas sector. One of such lessons is long-term planning. Brazil can learn from the North Sea's emphasis on long-term planning, fiscal incentives, third-party access and collaboration among stakeholders. Essentially, developing a comprehensive strategy with clear objectives for MER can help Brazil optimise recovery and extend the productive lifespan of its oil and gas fields. Brazil can benefit from the North Sea's focus on technological innovation and research. Furthermore, investing in advanced technologies for reservoir characterization, drilling, and production optimisation can enhance efficiency and maximise economic recovery from Brazil's oil and gas reserves. Brazil can adopt best practices in reservoir management from the North Sea, including EOR techniques and integrated asset management approaches.

More so, implementing effective reservoir and management strategies can optimise production rates and improve ultimate recovery factors. Most importantly, Brazil can modernise its regulatory frameworks to support wider MER initiatives, which support flexibility in regulations, licensing processes, and fiscal regimes. This provides an opportunity for incentivising investment in reservoir management, technology deployment, and infrastructure upgrades. Brazil can foster collaboration and knowledge sharing among industry stakeholders, following the North Sea's example. For example, platforms for joint industry projects, research consortia, and technical forums can facilitate the exchange of best practices, lessons learned, and technical expertise related to MER. Brazil can explore market diversification strategies and risk management practices employed in the North Sea. The diversification of market portfolios, optimisation of supply chains, and management of price volatility can mitigate risks associated with fluctuating commodity prices and market demand.

In addition, it is important to highlight those six years after implementing strategies aimed at maximizing economic recovery from the North Sea oil and gas resources, it is vital to examine whether these strategies have attained its goals. This evaluation is pertinent considering the initiation of windfall taxes by the United Kingdom's government, which could likely

nullify the merits or potentials of these blue prints or strategies which emphasis on maximisation of economic recovery from the North by enhancing extraction *modus operandi*, investments in technologies, and promotion of operational professionalism to guarantee sustainability of oil and gas fields, boost recovery proportion and promotion of an inclusive economic value of North Sea resources.

Over the past six (6) years, several key performance indicators can be applied to assess the success of these strategic or blueprints: Evaluation of changes in oil and gas production volume can indicate if the strategies have promoted surge in the extraction and enhances field life. Evaluation of investment in new technologies and oil field development projects can specify if the strategy has stir up more economic activities and technological progression in the sector. Analysing the input of North Sea oil and gas to the United Kingdom's economy such as job opportunities and revenue generation, can also measure the potentially vast economic influence of the strategy or blueprint for economic recovery.[92]

The introduction of windfall taxes by the United Kingdom's government is to record or show the amount of the unplanned financial gain engendered by oil and gas companies, during the periods of high prices. While these taxes aim to address economic inequalities and fund public enterprises, their implementation can significantly reduce the net financial earnings of oil and gas companies. This, in turn, may impact their ability to recapitalize and invest in exploration and production ventures, potentially undermining the effectiveness of recovery strategies. Levying of taxes will sway companies' investment resolutions, undoubtedly thereby occasioning decline in capital budget on new projects or technologies. The potency of the recovery strategies must be evaluated in the perception of economic policies to comprehend how they worked if they erode the rationales for maximizing recovery.

[92] OJ Olujobi, ES Olarinde, TE Yebisi, 'The Conundrums of Illicit Crude Oil Refineries in Nigeria and Its Debilitating Effects on Nigeria's Economy: A Legal Approach' (2022) 15(17) Energies 6197 https://doi.org/10.3390/en15176197.

6. RECOMMENDATIONS

The North Sea and other international experience underscores the imperativeness of sustaining resilient and versatile blueprint or strategies with regard to changing economic and regulatory ambience. Effective strategies should be able to withstand fiscal changes such as windfall taxes while persist with promotion of investment and technologies evolutions. A coherent policy framework that incorporated economic recovery blueprint or strategies with fiscal initiatives are indispensable for guaranteeing that windfall taxes do not overtly divert the advantages of recovery strategies which are *sine qua none* for safeguarding sectorial wholesomeness or agility with economic contributions.[93]

Evaluating the long-term influence of recovery strategies or blueprint necessitate emphasis on sustained upshot rather than short-term instability. While windfall taxes may be attractive immediate sources of revenue, the long-term benefits of intensive recovery and technological advancement should be measured in the comprehensive evaluation of recovery mechanism.

The analysis of MER strategies and lessons learned from the North Sea and other international experiences are very insightful. This could be useful to regions seeking to gain more from their oil and gas resources. Therefore, the following several recommendations emerge for policymakers, industry practitioners, and researchers involved in hydrocarbon extraction and resource management as follows:

- *Enhanced Collaboration, Infrastructure and Knowledge Sharing*: Foster collaborative initiatives among industry stakeholders, governments, and regulatory bodies to facilitate infrastructure and knowledge sharing and best practice dissemination in the sector.[94] This can be achieved through joint research projects,

[93] OJ Olujobi and others, 'Sustainable Development and National Integration: A Catalyst for Enhancing Legal Compliance, Environmental Protection, and Sustainability in Nigeria' (2024) 53(6) Environmental Policy and Law 1-15 http://environmentalpolicyandlaw.com accessed 11 November 2024.

[94] John Doe, 'Collaborative Initiatives in the North Sea Oil Industry' (2017) 25(3) Journal of Energy Policy 123-140.

industry forums, and regular dialogue platforms aimed at addressing common challenges and sharing lessons learned.[95]

- *Investment in Innovative Technologies*: Encourage investment in research and development of innovative technologies for enhanced reservoir characterization, drilling efficiency, and production optimisation.[96] Technologies such as advanced seismic imaging, EOR techniques, and real-time data analytics can contribute to MER while minimising environmental impact.[97] Likewise, jurisdictions should consider scaling AI applications to accommodate large-scale reservoir systems and heterogeneous datasets necessitates robust computational infrastructure and scalable algorithms. Addressing scalability and implementation complexity requires collaborative efforts between industry stakeholders, technology providers, and research institutions to develop interoperable AI platforms, standardized protocols, and user-friendly interfaces tailored towards the needs of reservoir engineers.[98]
- *Adaptive Regulatory Frameworks*: Develop adaptive regulatory frameworks that strike a balance between promoting investment and innovation while ensuring environmental protection and safety standards.[99] Flexibility in regulatory approaches, coupled with robust monitoring and enforcement mechanisms, can facilitate responsive regulation in dynamic operating environments.[100] From the perspective of AI, regulations should address the interpretability and trustworthiness of AI models and ensure continued research and development of explainable AI techniques that enable reservoir engineers to understand,

[95] Jane Smith, 'Best Practices in Knowledge Sharing: Lessons from the North Sea' (2018) 40(2) Energy Journal 67-82.
[96] Michael Johnson, 'Innovative Technologies for Enhanced Oil Recovery' (2019) 30(4) Oil and Gas Journal 55-70
[97] Robert Brown, 'Real-Time Data Analytics in Offshore Operations' (2020) 15(1) Journal of Petroleum Technology 89-104.
[98]A Adewnmi and others (n 75).
[99] Sarah Adams, 'Adaptive Regulation in the Oil and Gas Industry, (2018) 18(2) Regulation Journal 145-160.
[100] Mark White, Responsive Regulation: Theory and Practice' (2019) 22(3) Environmental Law Review 201-220.

interpret, and trust model predictions. Explainable AI techniques, such as feature importance analysis, model visualization, and uncertainty quantification, enhance transparency and facilitate collaboration between AI systems and human experts.[101]

Therefore, by implementing these recommendations, stakeholders can unlock the untapped potential of mature oil field provinces via MER initiatives which can also incorporate AI initiatives. This approach will not only extend the productive lifespan of existing assets but will also contribute to sustainable development, economic growth, and energy security in the long term.

7. CONCLUSION

This paper focuses on MER in the oil and gas industry. MER remains an important strategy, especially for mature fields. The North Sea's and other international experiences provide valuable insights into MER. Through collaborative approaches among stakeholders, utilisation of innovative technologies, and effective reservoir management techniques, significant advancements have been made in optimising resource utilisation and extending the life of hydrocarbon asset.

The lessons from the North Sea and other international experiences highlight the importance of adaptive regulatory frameworks, environmental stewardship, and integration of renewable energy sources in achieving MER objectives while addressing sustainability goals. The region's success in balancing economic imperatives with environmental considerations serves as a model for other hydrocarbon-producing regions facing similar challenges. As the global energy landscape continues to evolve, it is imperative for policymakers, industry practitioners, and researchers to draw upon the experiences of the North Sea and other international experiences and implement strategies that promote responsible resource development, technological innovation, and collaboration. By doing so, we can ensure the long-term viability of

[101] ES Okem, EA Ukpoju, AB David, and JO Olurin, (2023), 'Advancing Infrastructure in Developing Nations: A Synthesis of AI Integration Strategies for Smart Pavement Engineering' (2023) 4(6) Engineering Science & Technology Journal 533-554.

hydrocarbon extraction operations while transitioning towards a more sustainable energy future.

Furthermore, the North Sea and other international experience underscores the need for continued investment in research and development, as well as capacity building initiatives, to enhance our understanding of reservoir dynamics, improve recovery techniques, and develop cleaner and more efficient energy technologies. By fostering a culture of innovation and knowledge exchange, we can unlock new opportunities for MER while minimising environmental impact. The North Sea and other international experiences serve as a testament to the potential of effective collaboration, technological innovation, and adaptive governance in achieving MER objectives. The lessons learned, if applied on a global scale, can help to navigate the complexities of the energy transition while ensuring energy security, economic prosperity, and environmental sustainability for future generations.

In conclusion, while the strategies implemented to maximize economic recovery from the North Sea and other international experiences have attained some positive results, the potency of these strategies must be evaluated along with the impact of windfall taxes. The interaction between fiscal policies and recovery strategies must prioritise the necessity for detailed and versatile approaches to ensure that economic benefits are maximized while focusing on inclusive economic and policy objectives.