Energy Integration & Industry Transition

The role of the Oil & Gas Offshore Industry in the transition to a Low Carbon Economy in the UK

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1. Introduction

The world is transitioning to a low carbon economy. At a policy level, the UN and Conference of Parties have established a new 'rule book' that is driving net zero targets for carbon emissions, but this must be demonstrated at country level.
The UK already has the Committee on Climate Change, an independent, statutory body advising the Government on emission targets and reporting to Parliament on progress made in emission reduction. The country has reduced carbon emissions by 44% when compared to 1990 levels (National Statistics, 2018) thanks to technology advancement, specifically in electricity and renewable energy generation.
Policy changes are taking effect and driving change in the world's economy and in the financial sector. In Mark Carney's (2018) recent speech at the European Commission Conference, the increasing pressure from investment sectors for disclosure of climate related financial risk and for 'decarbonisation' was highlighted.
The technology and policy changes required to mitigate carbon emissions will require significant investment. The IEA and IRENA (2017) estimate that the low-carbon transition would require $3.5 trillion in energy sector investments every year for decades – twice the present rate. To achieve the 2°C scenario by 2050, nearly 95% of electricity supply will need to be low carbon, 70% of new cars electric, and the intensity of CO_2 emissions from the industrial sector must to fall by 80%.
We're already seeing the impact of these policy and investment changes. Several countries have committed to phase out the sale of new petrol and diesel cars in the next two decades – Norway as soon as 2025 (Ola Elvestuen, 2018). This means that several major automotive manufacturers have announced plans to phase out vehicles powered solely by internal combustion engine, including Volvo by 2019 (Ibison, 2017) and VW by 2026 (Rauwald and Sachgau, 2018).
At country level, UK government is implementing policy changes that will end the sale of petrol and diesel cars and vans by 2040 (Department for Transport, 2018), ban gas heating in new houses from 2025 (Hammond, 2019) and require smart meter installation across every home by the end of 2020 (BEIS, 2018).
Critically, society is demanding change in the light of serious climate change concerns. Most recently we've seen the protests by Extinction Rebellion in London, and there has been a rise in high profile activists – from veteran Sir David Attenborough, through to the next generation with Greta Thunberg and her School Strike for Climate movement.
However, this journey requires a balanced approach. Hydrocarbons are needed in the short term to provide basic heat, power and transport, alongside products such as clothes, phones and medicine. Many essential goods are hydrocarbon-based and simply switching off the taps would create additional vulnerabilities. Even the foundations of greener energy sources such as offshore wind and solar are still dependent upon the production of carbon-intensive materials like steel and cement. While action is important, so is the thought process.
The transition to low-carbon is a complex issue, but one that the Oil & Gas industry can contribute to solve.

2. Aim

This essay aims to demonstrate that the current UK Offshore Oil & Gas Industry and its landscape, skills, infrastructure and supply chain, can play a fundamental role in supporting a just energy transition to a net zero carbon economy, and be part of it. The essay has the following objectives:

- To discuss the concept of a "just transition" in the context of the current UK O&G Industry;
- To explore the opportunities to "reuse Vs. abandon" the existing industry infrastructure and 'ecosystem' (supply chain, logistic infrastructure, workforce and skills, industry bodies, academic research, etc.);
- To discuss the technology development roadmap for the transition, suggest actions that can be taken with existing technology or requiring technology innovation and assess the practicality of available options (cost or feasibility);
- To discuss the economic and regulatory enablers required to make the transition happen;
- To present the business case for the just energy transition to a net zero carbon economy.

3. The just transition and the UKCS context

Scotland is committed to growing a low-carbon, inclusive economy; Scotland's Economic Strategy sets out the ambition to create a more cohesive and resilient economy that improves the opportunities, life chances, and wellbeing of every citizen, while the Climate Change Bill commits Scotland to being carbon-neutral by 2050.

The Paris Agreement, signed in 2015, includes a "just transition" imperative, and Scotland's Government established a Just Transition Commission in September 2018 to ensure the transition supports local communities and creates high value jobs within the country. The Oil & Gas Industry in the UK employs ca 300,000 people, many based in Scotland, so a careful management of the transition from a jobs perspective is particularly relevant.

The Climate Change Bill was introduced to the Scottish Parliament as a direct response to the Paris Agreement. The Paris Agreement requires parties to increase action to reduce greenhouse gas emissions while taking into account "the imperatives of a just transition of the workforce and the creation of decent work and quality jobs".

The 2050 vision statement for energy in Scotland (Energy and Climate Change Directorate, 2017) sets two targets for the Scottish energy system by 2030: supply 50% of the energy for Scotland's heat, transport and electricity consumption from renewable sources; and increase by 30% the productivity of energy use across the Scottish economy. The ambition is to develop "A flourishing, competitive local and national energy sector, delivering secure, affordable, clean energy for Scotland's households, communities and businesses."

The vision is guided by three core principles and built around six priorities:

- Principles: whole-system view; inclusive energy transition, and smarter local energy models.
- Priorities: Consumer engagement and protection; Innovative local energy systems; Energy efficiency; Renewable and low carbon solutions; System security and flexibility; Oil and gas industry strengths.

The last priority in particular states "we will support investment, innovation and diversification across our oil and gas sector, working with industry to advance key priorities such as maximising the recovery of remaining resources, subsea engineering, decommissioning and carbon capture and storage – collaboratively addressing the challenges of today and preparing the sector and its workforce for a positive role in Scotland's future energy system."

Within this context, Scotland Government set up a Just Transition Commission with the purpose of advising Scottish Ministers on the development of "a carbon-neutral economy that is fair for all". The commission is chaired by Professor Jim Skea, who is also Co-Chair of Working Group III (Mitigation) of the Intergovernmental Panel on Climate Change, and includes representatives from Government, Industries, Universities, Environment and Energy focused NGOs, Workers Unions, Energy Networks and Oil & Gas Industry.

"The Just Transition principles can be summarised as:

- plan, invest and implement a transition to environmentally and socially sustainable jobs, sectors and economies, building on Scotland's economic and workforce strengths and potential
- create opportunities to develop resource efficient and sustainable economic approaches, which help address inequality and poverty
- design and deliver low carbon investment and infrastructure, and make all possible efforts to create decent, fair and high value work, in a way which does not negatively affect the current workforce and overall economy" (Just Transition Secretariat, 2019)

Several authoritative scenarios for the Energy Transition, like the IPCC (2018) and the Shell Scenarios (2018), show that Oil & Gas will remain a relevant component of the energy mix for the next 20 to 30 years at least. This is due to the need to satisfy increasing energy demand while renewables grow, to provide baseload and peakload compensation to renewables variability, and to sustain hard to decarbonize sectors.

Oil is also the feedstock for thousands of petrochemical products that are essential goods, supporting civilization and the transition itself. Air and road vehicles, particularly EV, depend on lightweight plastic; composite materials, fertilizers, pharmaceutical products, and many other items of daily use are hard to replace with sustainable renewable alternatives. While the recyclability of plastics needs to increase, a level of feedstock to assure essential goods will remain necessary.

There is, therefore, a case to ensure the current Oil & Gas production in the United Kingdom Continental Shelf (UKCS) is extended to maximum economic recovery, assuring part of the global demand, as opposed to abandoning production prematurely just to find the necessity of shifting production to other oil & gas regions to meet the existing demand.

4. The case for reuse Vs Abandon

There are over 250 assets and 45,000 kilometres of pipeline installed within the UKCS. Many of these assets are nearing the end of their economic life and installation operators are looking to decommission these facilities in an efficient and cost-effective manner. However, current cost forecasts for this activity exceed £58bn (Oil and Gas Authority, 2018). Approximately half of this cost burden will be borne by the operators, but the other half will be paid for with tax payer money.

By 2025, 580 pipelines in the Central and Northern North Sea are due for decommissioning. That's a total length of around 3,700km with a decommissioning value estimate of £847m. The Energy transition consultancy Pale Blue Dot estimates that preserving and reusing the existing pipelines for CCUS would provide the opportunity to save 75% capital expenditure, compared to build new ones for that purpose (Pale Blue Dot, 2018).

This infrastructure, along with the rest of the UK Oil & Gas industrial ecosystem - supply chain, workforce skills and expertise, academic research, governance institutions – provides a formidable asset for a just transition, enabling to jump start the key processes to build the Innovation System for a lower carbon economy in the short term and for a net zero economy in the longer term.

The Net Zero Economy requires an innovation system to develop and deploy at pace the technology innovation required to reduce the cost of low and zero emissions energy production and that of other decarbonization technology.

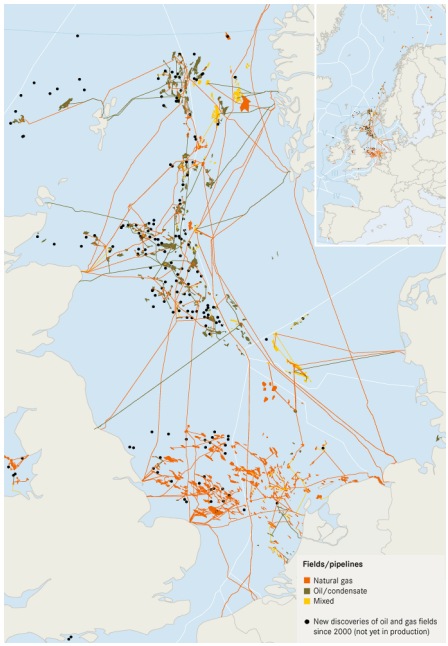

Figure 1 - Offshore oil and gas fields under exploitation, new discoveries not yet in production and pipelines (Source: OSPAR, 2009)

Many players contribute to an innovation system; Figure 2 from the University of Utrecht represents the model for a mature system. The UK Oil & Gas offshore industry can straightforwardly be mapped on this model, but an attempt to map a system that supports emerging technologies like Carbon Capture Utilisation and Storage, Hydrogen Production at scale, and marine renewables would provide a patchy and disconnected result, with the possible exception of offshore wind.

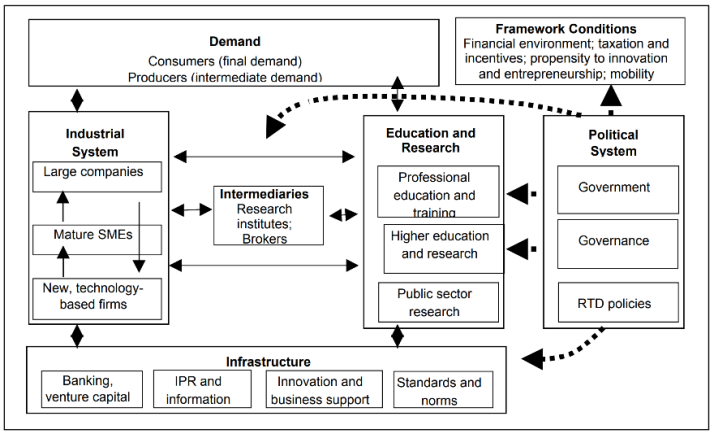

Figure 2 - A National Innovation System Model (Source: E. Arnold and S. Kuhlman)

We need therefore to fill the gaps if we want these technologies to rapidly evolve and innovate in order to be significant contributors to a just transition to a low carbon economy.

Figure 3 shows the seven key processes that needs to be at work simultaneously for an innovation system to develop:

- Entrepreneurial activities to build new businesses or transform existing ones;
- Knowledge development, via Research & Development by Universities or other Research and Technology Organisations (RTOs);
- Knowledge diffusion, through publications and other knowledge exchange initiatives;
- Guidance of the search via roadmaps or pathways by Government, Industries, Communities;
- Market formation, enabled by government policies and market forces;
- Resource mobilization, channels and mechanisms to allocate financial, human, and technical resources to the challenge;
- Creation of legitimacy, to counteract the resistance to change and mobilise both Industry and public opinion.

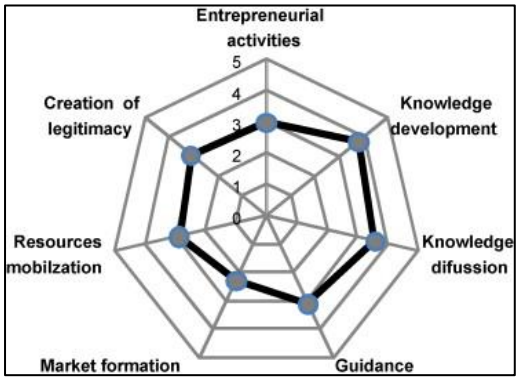

Figure 3 - Key processes for development of innovation systems - Analysis on CCS (Source: K. Alphen, M. Hekkert, W. Turkenburg)

The Oil & Gas Offshore Industry of today can provide a formidable set of building blocks to kickstart and enable a rapid development of the integrated, balanced and net-zero offshore industry of tomorrow.

Figure 4 shows how many of the required components of an Innovation system could be built upon the existing Scottish Oil & Gas Industry system to develop a net-zero carbon offshore industry providing clean energy, essential goods and products and contributing to the growth of UK Economy.

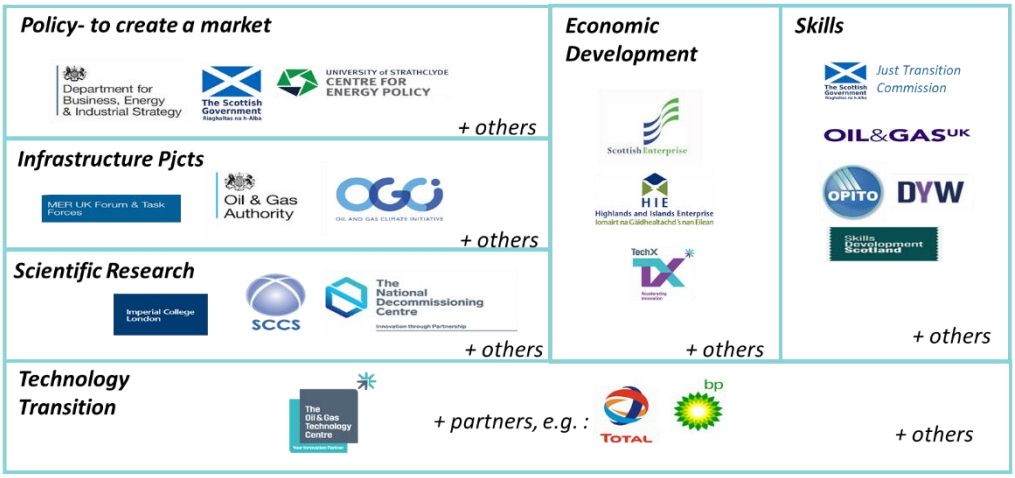

Figure 4 – Low Carbon Energy Transition Innovation System based on the existing Scottish Oil & Gas Industrial System (Source: Corradi, 2019).

International research (Slaper & Ortuzar, 2015) shows that industry clusters lead to higher employment, greater economic growth and improved productivity. Innovation in terms of new technology, new products and services more often takes place within industry clusters than when developed in isolation.

There is, hence, the opportunity to generate considerable societal and economic value by deviating from the silo-ed approach of both the Oil & Gas and the Renewable sectors, avoiding the creation of new silos with CCUS, Hydrogen and other emerging technologies. Focus should be placed on a cluster approach for the whole Offshore Industry, integrating and connecting these sectors within a net-zero energy production basin.

5. A Roadmap for the industrial transition

The move to a net zero carbon energy mix should comprise a transition rather than a switch. In "*No quick switch to low-carbon energy*", Kramer and Haigh (2009) described some of the hard realities associated with the massive scale-up of new technologies and the timeframes needed for such scale-ups. Electric renewables, solar and wind still track the path predicted in that paper.

In every credible scenario, from IEA World Energy Outlook (2018) and IPCC (2018) to the Shell Scenarios (2018), oil and gas will remain and essential component of the energy mix, necessary to meet demand for decades to come. As discussed in the previous chapter, the infrastructure and business system could be leveraged to accelerate the development of a net zero offshore industry.

A proposed roadmap for the energy transition could be built along two complementary programs, and ambitions, summarized in Figure 5.

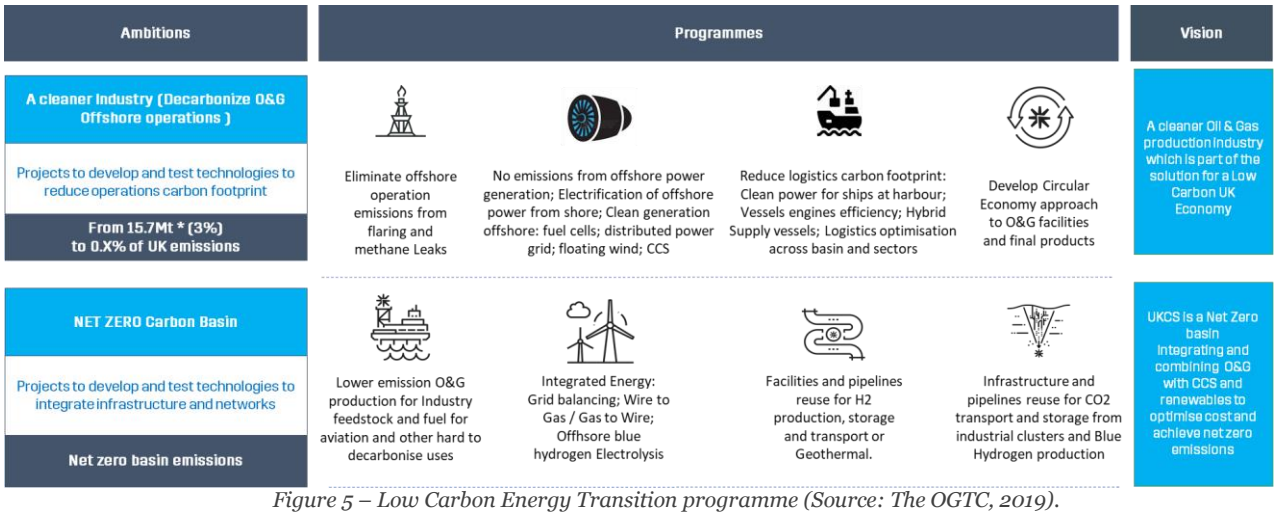

Figure 5 – Low Carbon Energy Transition programme (Source: The OGTC, 2019).

** GHG 15.7 Mt total emissions from operations. CO2 14.2 Mt is 2017 data for Flaring and Turbines only (EEMS Database, UK Gov)*

The first ambition is centred around the delivery of a cleaner oil and gas industry, that can support emission reductions. By continuing to drive efficiency in operations and through the reduction of unnecessary activity and waste – including reductions in operational emissions from flaring, power generation and leaks, which accounted for 3% of total UK GHG emissions in 2017 (Oil & Gas UK, 2018) – the Industry's carbon footprint can be lowered considerably.

While there is currently a rationale for maximisation of economic recovery to fulfil the Oil & Gas demand for heating, transport or power during the transition, there is no case for the wasted emissions from production. There is therefore an imperative for the Industry to adopt and develop technology to better control or eliminate flaring, and to abate emissions from offshore power generation. This could be done by electrification from shore, through integration with offshore renewables like floating wind turbines, or by applying CCUS to offshore power generation.

Additional emissions are generated by the logistic activities associated with Offshore operations: over 4,000 Supply Vessel journeys (Aberdeen Harbour Board, 2018) and around 40,000 helicopter journeys (500,000 passengers, Civil Aviation Authority, 2016) are taken yearly, to and from offshore platforms. Supply Vessels spend a lot of time idle next to a platform or anchored using marine engines to maintain position. Even when anchored within the harbour, vessels keep their engines idling to generate electricity on board and emitting a large amount of pollutants, displayed in Table 1

Table 1 – Emissions (kg/tonne fuel) for "in port" operation (Source: Entec, 2002).

	NO_x	SO_2	CO_2	HC	PM
Offshore supply vessels	52	52	3179	4.6	7.8

Emission reductions could be achieved from electrification of power provision to vessels at berth or from offshore platforms. Implementing hybrid Hydrogen Diesel injection vessels is another way to reduce emissions: The European Marine Energy Centre (EMEC) is running a project to design and integrate a hydrogen diesel dual fuel injection system to power a ferry between the Kirkwall and the island of Shapinsay (funded by Innovate UN – £430,000 grant) (HyDIME, 2019). Further emissions abatement could be achieved by leveraging digital technologies to optimize logistics, reduce supply vessel trips and increase automation and remote operation to decrease the number of personnel offshore and consequent helicopter trips.

Figure 6 presents a proposed roadmap for the development of innovative technology in key areas, supporting the delivery of this ambition. Some of these activities (highlighted in blue) have already been initiated by The Oil & Gas technology Centre in Aberdeen, supporting a company called EC-OG to undertake FEED work for a North Sea field trial of a Subsea Power Hub (SPH), a ground-breaking turbine system which harnesses the energy within ocean currents to produce autonomous electrical power for multiple applications (The OGTC, 2019).

The overall outcome of this set of initiatives would significantly reduce the emissions from offshore activities, contributing to turn the Oil & Gas offshore sector into a cleaner production industry with a role within a low carbon economy.

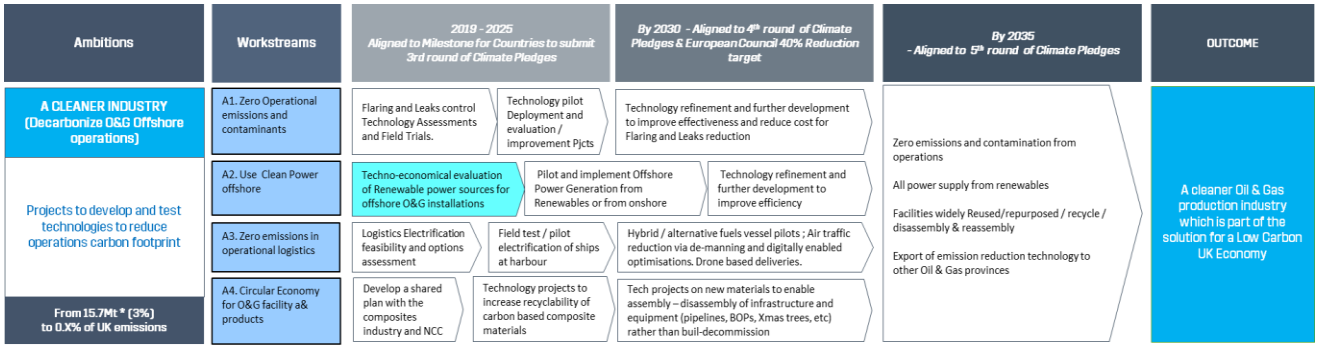

Figure 6 – Cleaner Industry activity roadmap - Low Carbon Energy Transition programme (Source: The OGTC, 2019).

However necessary, the impact of these solution won't enable the decarbonisation of the entire basin. That's why a second-stage ambition should also be pursued: a net zero carbon basin. Oil and gas production can then be integrated with offshore renewables, hydrogen production, CCS (including CO2 storage from industrial clusters) – all enabled through re-use and re-purpose of existing infrastructure and systems. This systems-based approach would harness the skills and expertise of different industries, linking diverse workforces.

The interconnected network of existing pipelines and infrastructure from the Oil & Gas Industry can be the backbone of an integrated low carbon offshore industry. Producing Hydrogen at the scale of a low carbon economy requires either large amounts of renewable energy and water (Green Hydrogen) or the use of methane with associated carbon capture and storage (Blue Hydrogen). Offshore O&G installations approaching end of production offer the opportunity to combine both at scale, leveraging offshore wind associated with water desalinization plants, and developing methane reforming plants in proximity to underground carbon storage locations.

The Oil & Gas Technology Centre is involved in the early-stage development of a business case for transforming the use of offshore infrastructure, re-purposing assets and demonstrating the viability for decentralised hydrogen generation. The next phase will entail investigation on potential to establish electrolysis technology in marine environment, with capability to

produce sufficient hydrogen to power marginal field developments - a step change from the carbon intensive power generation methods currently used.

Further technology development and testing are necessary to confirm feasibility for use or adaptation of pipelines for CO_2 and H_2 transport and storage, to verify wells plugging and abandonment barrier verification for Co2 storage, to effectively integrate gas and renewable sources through Wire to Gas and Gas to Wire technology, to make Hydrogen production and use offshore possible, etc. Figure 7 presents a roadmap for the development and deployment of technologies for integration of infrastructure and networks.

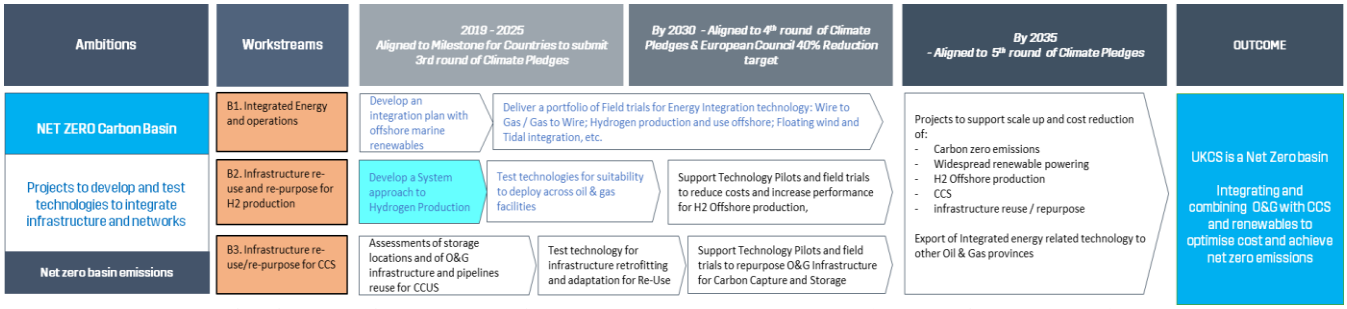

Figure 7 – Net Zero Carbon basin roadmap - Low Carbon Energy Transition programme (Source: The OGTC, 2019).

A connected cluster of Energy related offshore activities and industries can maximise value to society by accelerating the development of a net zero energy production system that leverages existing infrastructure and delivers a just industrial transition. The results, knowledge and expertise developed through the implementation of these programmes will provide a model for adoption to other maturing Oil & Gas basins globally, further contributing to global GHG emission mitigation and increasing export potential of UK goods and services.

6. The role of Government

The ambition of a net zero carbon basin in the UK Continental Shelf won't be realized on technology and market forces alone. it will require support across government, academia, industry, and broader society to believe in and support it. Figure 8 lists a series of Building Blocks for Energy Innovation Policy that can provide a framework for the essential role played by Government in enabling this industrial transition.

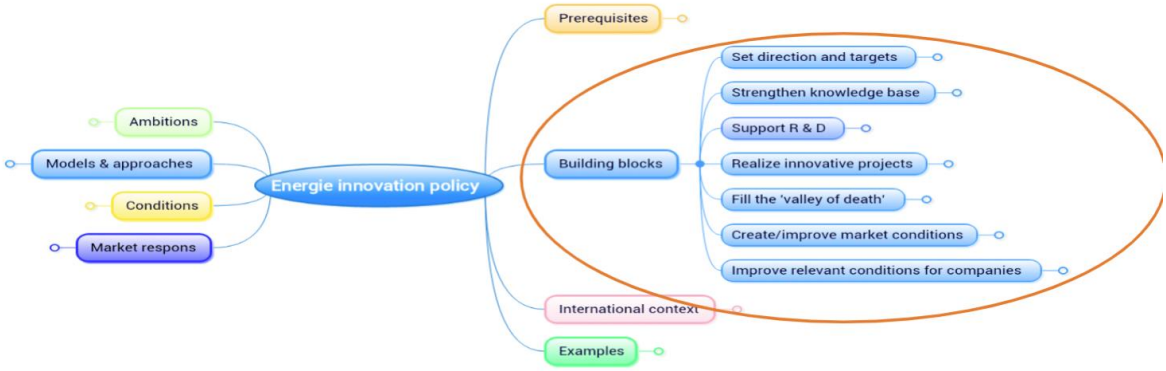

Figure 8 – Building Blocks of an Energy Innovation Policy Portfolio (Source: Bert Stuij, 2019)

The first point on the list may be the most relevant – setting direction and target. Both the UK and the Scottish Government have policy teams at work on Hydrogen and CCUS. The Department for Business, Energy and Industrial Strategy (BEIS) of the UK Government is aiming, by the end of 2019, to:

- review models and market-based frameworks to support investment in CCS infrastructure;
- identify existing O&G infrastructure suitable for re-use, develop adequate policy;
- launch Industrial Energy Transformation Fund (£315M);
- deliver results from the CCU demonstration programme (£20M) and the CCUS Innovation Programme (£45M).

The Government's position on CCUS evolved a lot over 2018, and the current ambition is to deploy 10 Mt_{CO2} p.a. by 2030, 20Mt by 2035 and at least 60 Mt, potentially more than 100Mt, by 2050 (BEIS, 2018).

Collaboration between the private and public sector have proven in recent years to be more effective than direct intervention or pure regulation in the UK. An interesting approach, implemented in Scotland in the past five years, is that of City Region Deals: agreements between Scottish Government, UK Government and local government, designed to bring about long-term strategic approaches to regional economy improvement. City Region Deals are implemented by regional partners and overseen by the Scottish City Region Deal Delivery Board. Each deal is tailored to its city region, reflecting individual economic strengths and weaknesses, and comprises a programme of interventions to support positive, transformative change. Intervention is delivered collaboratively with partners drawn from the broader public sector, such as Scottish Enterprise and Skills Development Scotland, as well as businesses, colleges and universities (Scottish Government, 2019).

Signed in 2016, the Aberdeen City Region Deal is a 10-year deal to encourage investment in innovation, internationalisation, digital connectivity, and infrastructure across the city region. Projects successfully delivered to date include the Oil and Gas Technology Centre, based on the principle of targeted public money being matched by participating industry partners, combined with academic and research capability to deliver results through collaboration.

Established in Feb 2017, the OGTC has implemented a successful delivery model combining high industry engagement, UK research expertise and critical technology development, effectively leveraging both industry and public funding. The Centre has accelerated Technology Development through successful partnerships across the Oil and Gas industry, cross-sector and with universities. Together with industry, over £100M have been invested on projects targeting today's Industry challenges and aiming to unlock tomorrow's potential. Over 180 projects are underway with over 50 field trials planned.

Extending this successful model, supported already by several industry stakeholders, appears to be the most effective and efficient way to pursue the Energy Integration and Industry Transition ambitions described in this paper. Following a proven model would also avoid further complicating the technology development landscape in Scotland and to Aberdeen city region.

7. The Business Case

The business case for an integrated and net-zero offshore industry needs to be considered at a macro-economic level (UK + Scotland), with both Governments playing essential roles in creation, support, enforcement and participation on the industrial transition. The work being progressed by BEIS in 2019 is crucial in defining the pathway. Additional dimensions to consider in the transition include skills, economic development, and scientific research, as well as the stakeholders and institutions that should to be involved and contributing.

Combined, these provide a huge sustainable global market with export potential for Scottish companies, ensuring that the indigenous industry continues to thrive within a low carbon economy. This also guarantees a continued social license to operate, thus extending the potential of the North Sea. The energy transition is expected to drive a step change in power generation, automation, carbon capture & data analytics, creating high skills jobs and opportunities to work across industries with renewables and manufacturing resulting. This will accelerate the transformation of the Oil and Gas industry and assist in the transformation of companion industries.

Aberdeen and Scotland are recognised as one of the leading Oil and Gas capitals of the world. This reputation is built on practices of excellence in project delivery, development and deployment in the exploitation of a major hydrocarbon asset (the North Sea) and a strong, highly skilled supply chain. As the North Sea production declines and overseas markets continue to grow, there is increased pressure to retain the local world-class supply chain and to maximise economic recovery, while addressing the global movement to a Low Carbon Economy. The region has key strengths in place that need to be capitalised on, ensuring full the potential of the transition is delivered:

- Extensive 40-year track record
- Willingness and ability to diversify
- Excellent education and training network
- World class research, development and innovation community
- Existing industry wide technology development centre with strong cross sector connections
- Highly skilled and mobile workforce

Scotland can create global competitive advantage as a leader in transformational energy technologies that optimise productivity, reduce carbon emissions and integrate oil and gas operations with marine renewables and with Hydrogen

production and CCUS operations. This will create new high-value jobs and increase exports, while maximising economic recovery and value from the North Sea.

The industry can bring value to Scotland, in energy security through maximisation of recovery from the O&G sector, but also playing its role in the successful expansion of the renewable industry through co-development, co-location and re-use of facilities. The two industries can be symbiotic - gas to grid offshore may unlock the potential of small developments and capitalising on that opportunity can increase the value of offshore renewables – unlocking floating wind farms, hydrogen production at scale and carbon sequestration and storage.

Increased productivity, higher delivery and a technology-led and carbon focused supply chain, is expected to deliver immense additional value to Scotland:

- Economic value: every 1 billion boe produced generates £50 billion of value for the economy. With 10 - 20 billion boe remaining there is an opportunity to generate between £250 billion and £500 billion.
- Global competitiveness: as other countries strive to decarbonise their hydrocarbon industry; the UK must keep pace to remain competitive and maximise benefit – staying ahead would provide a strong global market position
- Industrial feedstock: growth in use of composites will cause demand for liquid hydrocarbon feedstocks to remain high or even increase – potentially a $105 billion market by 2021
- Supply chain and exports: developing technology and innovative solutions to decarbonise the oil and gas industry will help anchor a world-class supply in Scotland and create valuable export markets
- High value jobs: developing new technologies to transform the oil and gas industry will create new high value jobs across the industry and in other, related sectors
- Research capability: the energy transition challenge will augment and enhance Scotland's academic R&D capability, which can be leveraged at national level and overseas.

8. Conclusions

The Paris Agreement, signed in 2015, includes a "Just Transition" imperative. Scotland's Government established a Just Transition Commission in September 2018 to ensure the transition supports local communities and creates high value jobs within the country. The Oil & Gas Industry in the UK employs ca 300,000 people, many based in Scotland, so a careful management of the transition from a jobs perspective is particularly relevant.

In every credible scenario Oil & Gas will remain a relevant component of the energy mix for the next 20 to 30 years at least. This is due to the need to satisfy an increasing energy demand while renewables grow, the need to provide baseload and peak load compensation to renewables variability, and the need to sustain hard to decarbonize sectors. Green gases like biogas and hydrogen from renewables are likely to be part of the long-term low carbon solution. In the short- to midterm horizon, the production of Hydrogen from methane combined with CCS can provide a low carbon transition alternative for industry, heat, and transport.

Oil is the feedstock for thousands of products made from the petrochemical industry, essential to support civilization and the transition itself. Air and road vehicles, particularly EV, depend on lightweight plastic. Composite materials, fertilizers, pharmaceutical products and many other items of daily use are hard to replace with sustainable renewable alternatives. While recyclability of plastics needs to increase, a level of feedstock will remain essentials.

There is a strong case to ensure the current Oil & Gas production in the United Kingdom Continental Shelf (UKCS) is extended to its maximum economic recovery, filling part of the global demand, as opposed to a premature abandonment of production, which would require a production shift it to other oil & gas regions, decreasing UK's energy security.

There are over 250 assets and 45,000 kilometres of pipeline installed within the UKCS. Many of those assets are nearing end of economic life, and installation operators are looking to decommission these facilities in an efficient, cost-effective manner. Current cost forecasts for this activity exceed £58bn, with approximately half of this cost burden to be borne by the operators, but the other half to be paid for with tax payer money.

This infrastructure, along with the rest of the UK Oil & Gas industrial ecosystem - supply chain, workforce skills and expertise, academic research, governance institutions – provides a formidable asset for a just transition, enabling to jump start several of the seven key processes to build the Innovation System for a lower carbon economy in the short term and for a net zero one in the longer term.

The proposed roadmap for this transition is built upon two programmes and ambitions, the first centred around the delivery of a cleaner oil and gas industry, supporting the reduction in emissions. These second ambition, a net zero carbon basin, can only be developed upon the successful implementation of the first stage. A systems-based approach to the integration of oil and gas production with offshore renewables, hydrogen production, and CCS enabled through re-use of existing infrastructure and systems, harnesses the diverse strengths of these industries and their diverse workforces.

Collaboration between private and public sector have proven to be more effective than direct intervention or pure regulations in the UK, and the success achieved already by the Oil & Gas Technology Centre in Aberdeen in its first years provides a platform for the launch and implementation of this ambitious Energy and Industry Just Transition.

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