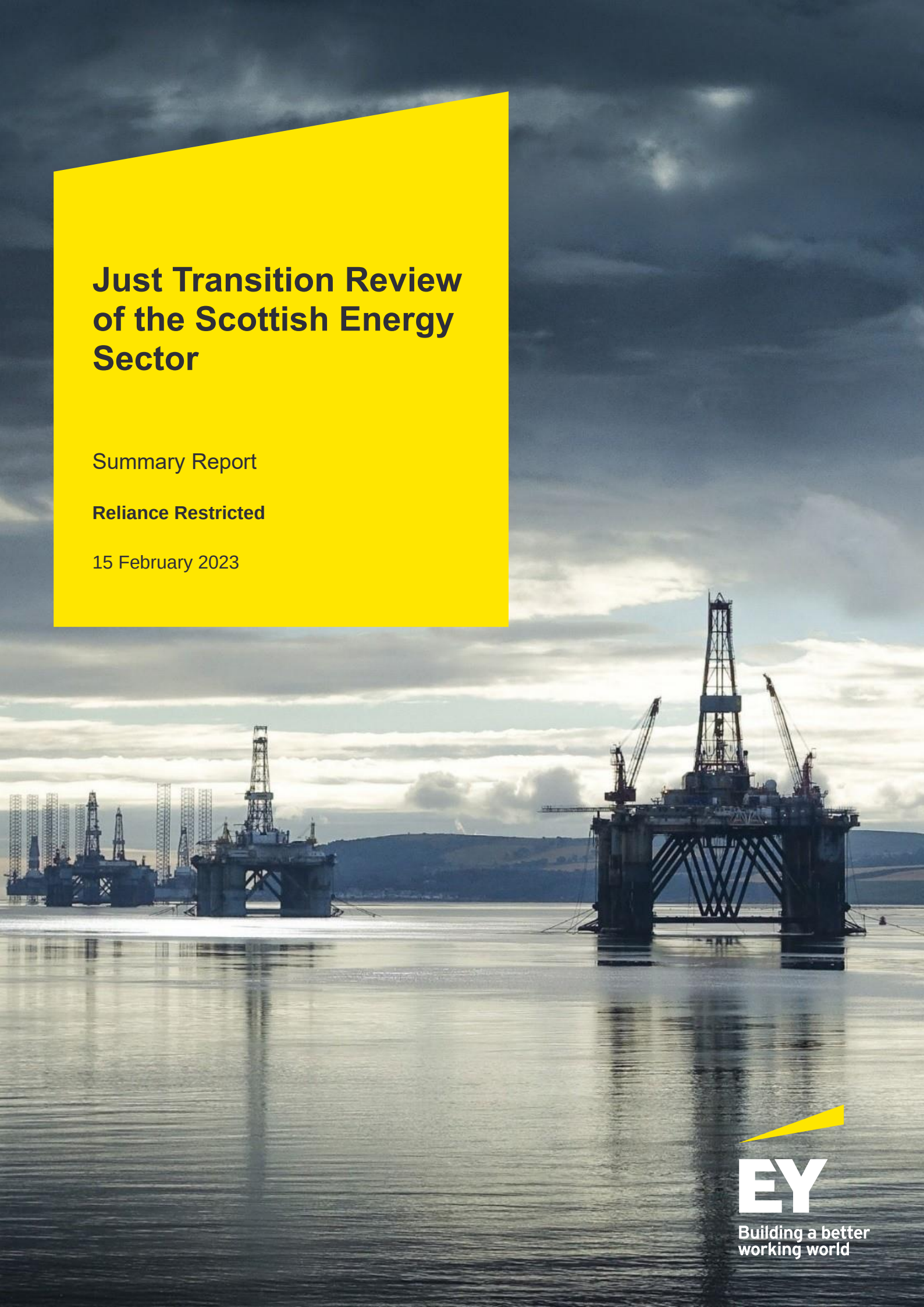
Just Transition Review of the Scottish Energy Sector

Summary Report

Reliance Restricted

15 February 2023



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Please see Appendix C for a copy of our Transmittal letter, which summarises the purpose of this report, restrictions on its use and the scope of our work.

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Abbreviations

Abbreviation	Description
BEIS	Department for Business, Energy and Industrial Strategy
BEV	Battery Electric Vehicle
bn	Billion
BOP	Balanced Options (Under ESC's whole system energy model)
CAPEX	Capital Expenditure
CCC	Climate Compatibility Checkpoint
CI	Carbon Intensity
CCUS	Carbon Capture Usage and Storage
CfD	Contract for Differences
CO_2	Carbon Dioxide
CXC	ClimateXChange
DPA	Dispatchable Power Agreement
DUKES	Digest of UK Energy Statistics
ESC	Energy Systems Catapult
ESJTP	Energy Strategy and Just Transition Plan
ETS	Emissions Trading System
EU	European Union
EY	Ernst & Young LLP
FES	National Grid Future Energy Scenarios
FID	Final Investment Decision
FPSO	Floating Production Storage and Offloading
GDP	Gross Domestic Product

Abbreviation	Description
GHG	Green House Gases
Gt CO_2e	Gigatonnes of carbon dioxide equivalent
GVA	Gross Value Added
GW	Giga Watt
ICE	Internal Combustion Engine
IPCC	Intergovernmental Panel on Climate Change
k	Thousand
LCOE	Levelised Cost of Energy
m	Million
MtCO2e	Million tonnes of carbon dioxide equivalent
Mmboe/d	Million Barrels of Oil Equivalent per Day
NSTA	North Sea Transition Authority
NSTD	North Sea Transition Deal
O&G	Oil and Gas
OEUK	Offshore Energies UK
OPEX	Operational Expenditure
OPRED	Offshore Petroleum Regulator for Environment & Decommissioning
rUK	Rest of the UK
ScotNS	The Scottish North Sea
SG	Scottish Government
SOC	Societal Change (Under ESC's whole system energy model)
SNP	Scottish National Party
T&S	Transport and Storage

Abbreviation	Description
TEC	Technology scenario (Under ESC's whole system energy model)
TWh	Terawatt-hour
UKCS	United Kingdom Continental Shelf
UKG	United Kingdom Government

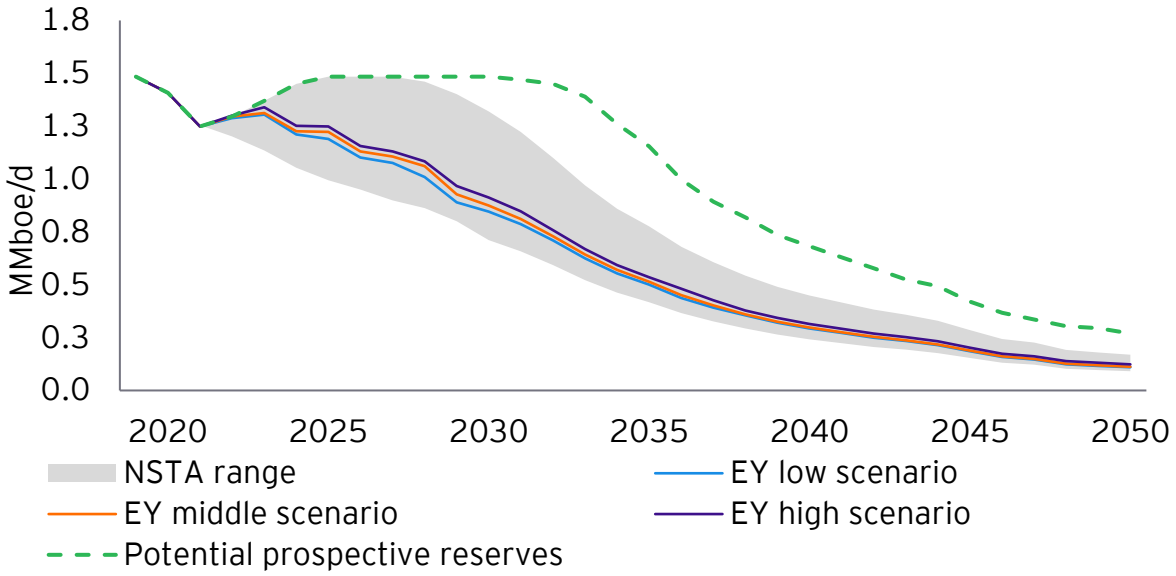
1. Key findings

Scottish O&G production will decline, and undeveloped reserves will be increasingly hard to exploit

O&G from the ScotNS will decline and the economic impact of the decline will be significant

- Our bottom-up forecast shows there will be a marked and continued decline in Oil and Gas (O&G) production in the Scottish North Sea (ScotNS) from 2019 levels, which were materially lower than the peak reach in the late 1990s.
- Of the predicted remaining production over 80% is from already sanctioned fields with less than 20% forecast to be from new developments.
- Any new discoveries will be smaller and harder to extract, requiring more upfront investment for a shorter period of production. It is unlikely that the decline trend will change even if higher O&G price scenarios drive future exploration. Whilst the UK has enjoyed a stable regulatory environment, low political risk, and a relatively stable fiscal regime, recent events including the introduction of the Energy Profits Levy have undermined investor confidence.
- The O&G industry supports 57,000 direct and indirect jobs in Scotland and is responsible for £16bn of gross value add (GVA). This is equivalent to 9% of total Scottish 2019 GDP. These jobs and GVA contribution will reduce as the decline continues.
- O&G is a high value export-led industry – most of the production is exported, either to the rest of the UK or globally. This means that the jobs are high value compared to the Scottish average, with an average wage of £88,000 for direct jobs, and £51,000 in the supply chain, compared to a Scottish average of £29,000.
- Many jobs are also concentrated in the North East of Scotland, meaning the decline will affect it more markedly.

Scottish O&G production scenarios compared to NSTA UKCS forecast and potential prospective reserves



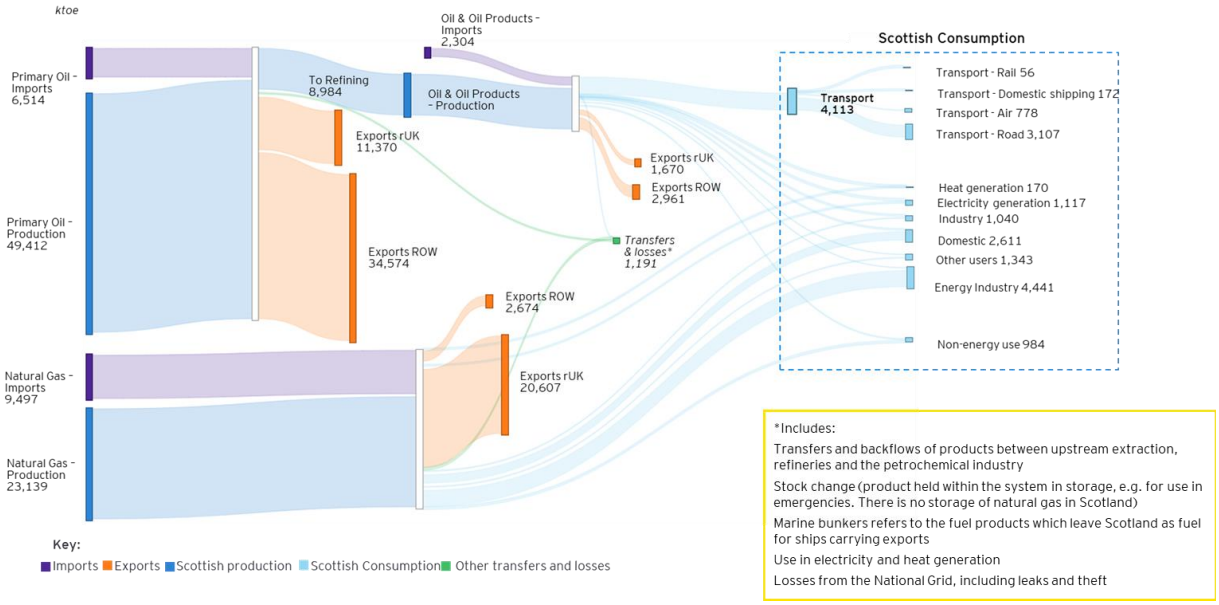
Source: EY, NSTA. The chart includes estimates that illustrate how cumulative NSTA reserves could apply as a production trajectory. These have been developed to provide comparable production pathways that align with the EY forecast.

Note: The above graph represents deviations to the ScotNS production pathway under different high, medium and low oil price scenarios modelled by EY. See Chapter 1 for more detail on this methodology.

Scotland is a net exporter of O&G, but despite significant domestic production, Scotland still imports O&G. Domestic demand is not directly linked to production and requires separate policy intervention.

- Scotland's levels of O&G imports and exports are driven by a combination of different complex factors, including; price, demand, and what trading conditions deem the most profitable option. These conditions change daily due to the complicated nature of the global O&G market. The story for natural gas is slightly different, as some imports are due to the physical infrastructure of the UK gas grid and direct links with Norwegian fields.

- In 2019 Scotland exported 49% less crude oil, 24% less refined oil products, and 37% less natural gas to the rest of the world (ROW) than in 1999. Scotland's relationship with the ROW, and the rest of the UK (rUK), will continue to evolve as ScotNS production continues to decline.



Source: SG - Physical commodity balances of oil, gas and petroleum products
Digest of UK Energy Statistics (DUKES) 2021 - GOV.UK (www.gov.uk) (commodity balances)

There are several pathways that are consistent with Scotland's contribution to Paris Agreement global emissions goals, depending on what action is also taken elsewhere

- In 2015, the international community agreed - through the Paris Agreement - to limit the increase in global temperatures to 1.5°C relative to pre-industrial levels.

- Based on carbon budgets produced by the Intergovernmental Panel on Climate Change (IPCC), the forecast decline in Scottish O&G production (shown by the ScotNS O&G Production Forecast) is steeper than the decline required at a global level to keep temperature rises below 1.5°C (should Scotland maintain its current share of global O&G production).

- We have developed a range of illustrative potential transition pathways, based on alternative sets of assumptions for how effort to meet the Paris Agreement goals might be distributed globally. These pathways have enabled us to explore the impact that different rates of transition would have on Scotland's economic

footprint, i.e. jobs and GVA, as well as other factors such as infrastructure, skills development, energy security, environmental and regional impacts.

- Scotland could transition at a slower or faster rate than is required at a global level, but an accelerated decline in ScotNS production would not necessarily reduce global emissions at the same speed, because:
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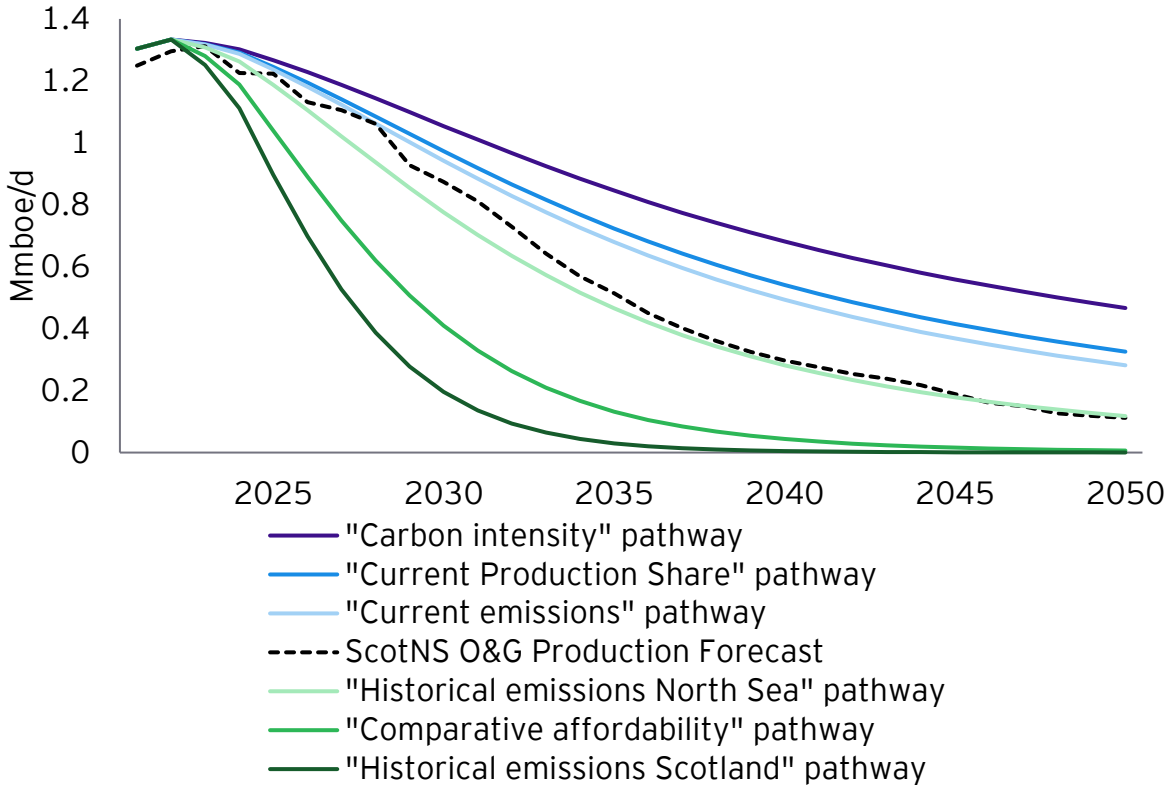
  - Scotland could transition at a slower or faster rate than is required at a global level, but an accelerated decline in ScotNS production would not necessarily reduce global emissions at the same speed, because:
- Scottish demand for O&G is not directly linked to domestic production and will therefore require separate policy intervention. However, Scotland will need to carefully manage the decline in O&G alongside the growth of the new low carbon sector to minimise any negative impacts of transition on society and the economy.

Scotland's potential production pathways



Source: EY analysis

The Just Transition brings a set of challenges, but also opportunities for Scotland

- While Scotland has been successful developing renewable electricity generation and decarbonising this energy sector, the transition to a low carbon economy is only beginning.

- Space heating, transport and industry remain highly dependent on O&G as an energy source. Replacing fossil fuels in these parts of the economy will not be straightforward and will require significant government support. Scotland and the UK have a strong track record in reducing emissions in the electricity generation sector but the remaining fossil fuel dependent sectors of the economy present a much greater challenge to decarbonise.

- This decade may be a point of inflection as technologies are now becoming available that can reduce our current reliance on O&G. As sectors decarbonise,

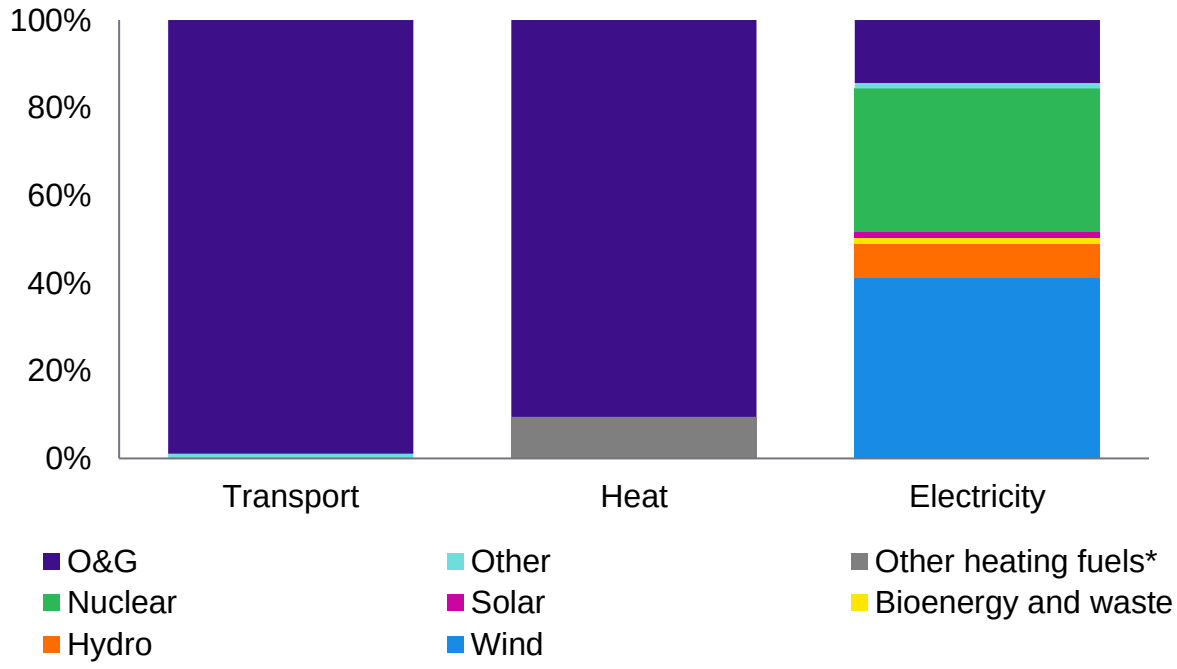
there will be increased demand for electricity, resulting in a greater need for low carbon power.

- New technologies often carry an upfront cost premium, which discourages adoption by consumers. Other factors have perpetuated O&G use – low carbon prices and allowances (including tax incentives) for some industries, infrastructure assets with long asset lives (such as the gas grid), consumer familiarity and historical government support have all played a role in perpetuating O&G use.

- The policy response to move to a net zero economy will mean addressing these issues, enabling the emergence of new technology and encourage consumers uptake.

- Moving to new technologies and industries will mean new supply chains and industries replacing older ones. There will be losses as well as gains, and taking advantage of new opportunities will require the appropriate infrastructure, skills, and support.

The Scottish Energy System – Three key sectors



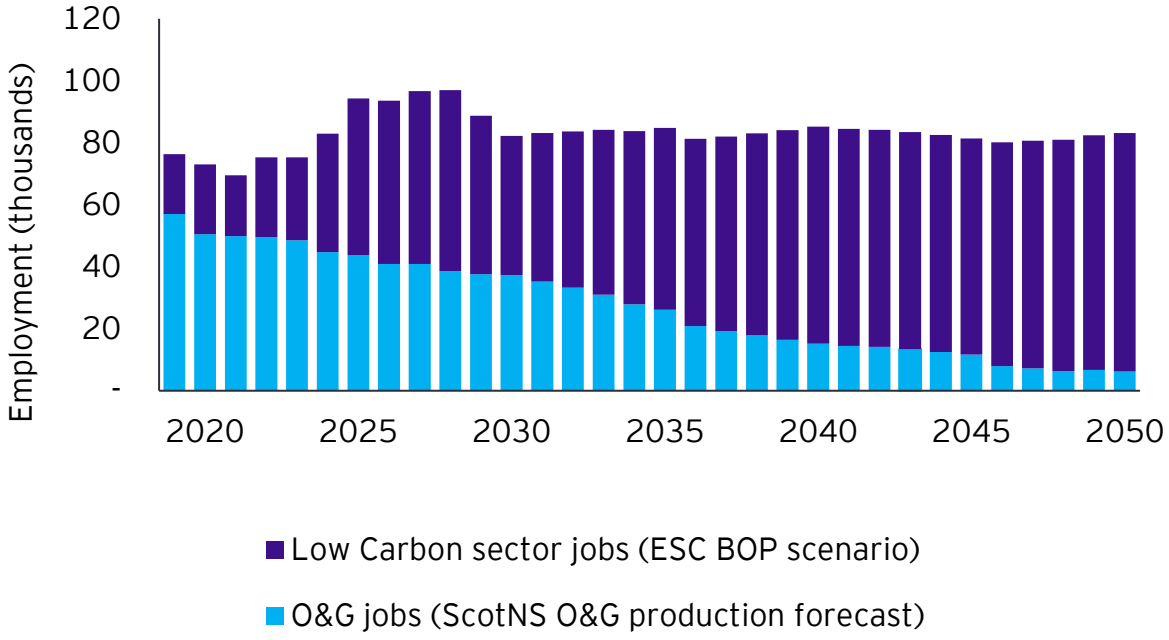
* Other heating fuel sources include electricity, solid mineral fuels and biomass

Source: Annual energy statement 2019 - gov.scot (www.gov.scot) Scottish Energy Statistics Hub – Proportion of electricity consumption by fuel Scottish Energy Statistics Hub – Number of ultra low emission vehicles licenced

We forecast a long-term increase in new low carbon technologies in the ScotNS and this will create jobs but it is unlikely to replace the lost O&G GVA

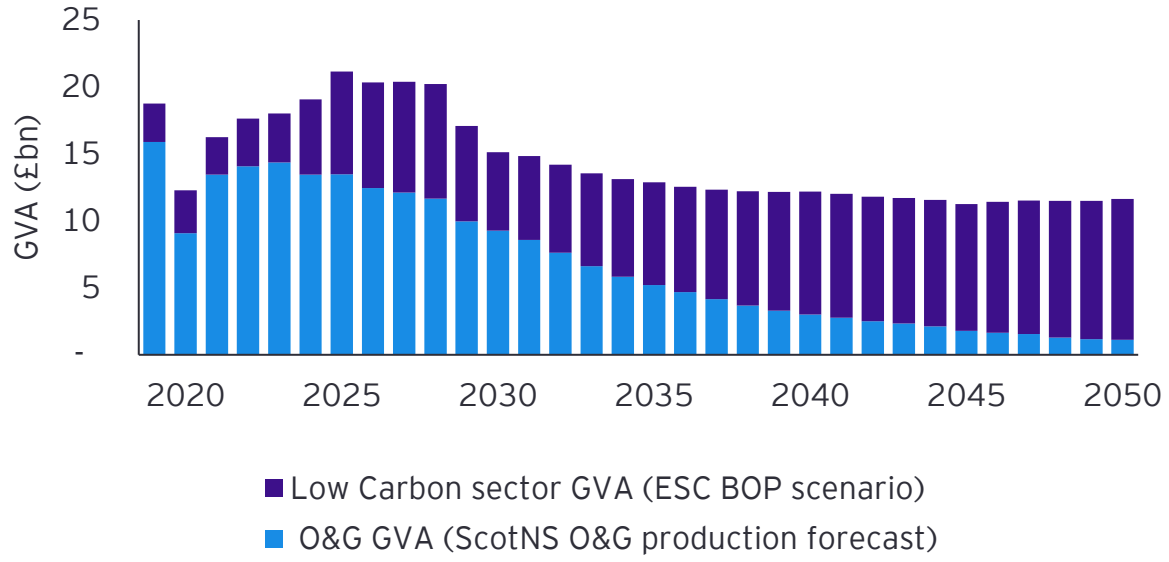
- The ScotNS will gradually become an 'integrated energy basin' rather than a predominately O&G basin, as new low carbon technologies are developed.
- Scotland currently has a growing offshore wind sector, but only nascent hydrogen and carbon capture sectors. It is hoped that, over time, these sectors will become significant industries in the ScotNS.
- Forecasting the pace of change and the precise energy mix is difficult – but the Energy Systems Catapult (ESC) has created a 'whole systems energy model' with scenarios that could develop given the right policies and support. One such scenario, the Balanced Option scenario (BOP) predicts a further 30GW of wind, 9.5GW of hydrogen production capacity and 26.4 $MtCO_2$ of carbon capture in 2050 compared to 2019.
- If this development takes place, it should be possible to replace the jobs lost from the decline of O&G as workers join these new industries, however replacing the lost GVA will be more challenging.
- By 2050, total Scottish O&G and low carbon GVA may be reduced to £12bn, compared to £19bn in 2019. This is primarily due to the value of the jobs in the new low carbon sectors being lower than those in the existing O&G sector.
- Critically, achieving the forecasted number of jobs requires the timely rollout of the new industries and for Scotland to be successful in capturing supply chains serving these new industries. This will be one of the biggest challenges in the shift to a low carbon economy.

Total jobs between O&G sector and replacement low carbon sector (BOP scenario) (direct and indirect)



Source: EY analysis

Total GVA between O&G sector and replacement low carbon sector (BOP scenario) (direct and indirect)



Source: EY analysis

Note: These graphs compares the BOP scenario with the ScotNS O&G Production Forecast. The jobs and GVA position will change depending on the pathway modelled and rate of transition.

There is potential for wind, CCUS and hydrogen to fill the economic gap left by O&G but significant early investment and policy intervention is required to support this growth

- Significant investment is required to support the growth in jobs and GVA that could arise from low carbon sectors. We estimate the minimum level of investment required to 2050 in offshore wind, CCUS and hydrogen production to offset the loss of O&G jobs to be £33.3bn.
- Each of the main low carbon sectors presents different risks and different business models, and these will need to adapt and change as the scale of investment increases in order to get the best value for bill payers and tax payers.
- There is a potential for wind, CCUS and hydrogen to fill the gap left by O&G but several key issues must be addressed before the jobs and GVA are realised. For example:
    - Wind technology is mature, cost effective and provides a potential route to meet Scotland's future electricity demands. However, wind power suffers from intermittency and currently relies on natural gas as a flexible back up. Tackling intermittency is a significant challenge for the power sector, both in terms of technology and of appropriate business models to support rollout.
    - Scotland has significant carbon storage potential with well-mapped, vacant O&G stores in the North Sea. Carbon capture technology can be implemented in high emitting sectors or to support hydrogen creation. However, the designation of a CCUS cluster in Scotland requires support from the UKG.
    - Hydrogen is the least mature business model. A model for blue and green hydrogen is being developed that is based on the renewable contract for difference, aligning the cost of hydrogen with that of natural gas so that it can compete. Realising potential for hydrogen will depend on the availability of suitable off-takers, but the model should result in financeable projects when technology risk is taken into account.

  - Although these investment models either exist, or are in development, they will come at a cost. Additionally, the models, particularly CCUS, are being actively developed by UKG and bound to the UK energy system.

- Even where business models exist and low carbon industries are able to develop, it is not certain that Scotland will benefit economically as it has from O&G. Policy interventions are required to stimulate growth in low carbon technologies, develop a supply chain, develop people and skills and ensure communities are not left behind.

- Interventions are crucial to develop a supply chain for low carbon industries in Scotland which is capable of replacing the Scottish O&G supply chain and subsequently securing Scotland's position as a major global player in the low carbon sector. To create a Just Transition, policies that support the development of people and skills should ensure no-one is left behind. Lastly, and importantly, policies are also needed to ensure that all communities in Scotland, including the North East of Scotland, are protected through the transition.

2. Introduction and overview

This analysis explores the types of policies that will be required to successfully manage a Just Transition from O&G to new low carbon sectors

Scotland's Just Transition

Scotland's Just Transition creates an exciting opportunity to continue Scotland's journey from fossil fuels to Net Zero emissions. Scotland's climate change ambitions are well established, and progress has been made achieving these targets, but the scale of the challenge requires a whole system approach to exploring the impact and opportunities presented by the transition.

This analysis will explore the potential dynamics between sectors in decline and new growth sectors, and what types of policies will be required to support the development of new sectors. The transition must provide support as Scotland's O&G industry declines and create opportunities to support the investment in new low carbon technologies. This will bring jobs and economic growth as Scotland becomes a leader in these technologies.

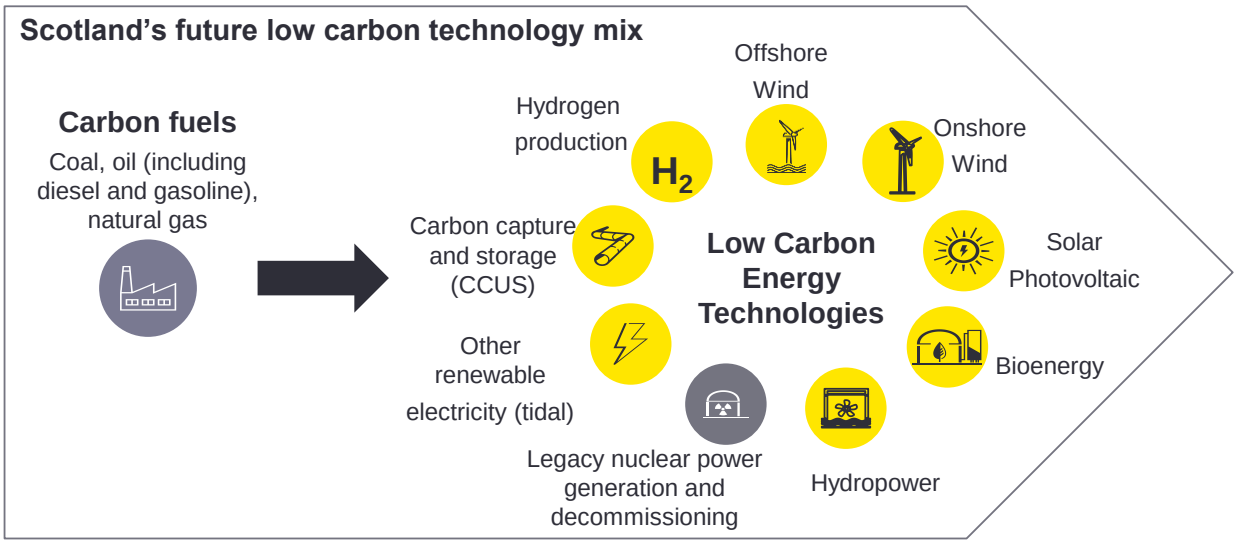
Background and context

The climate emergency is one of the biggest issues facing the world. The need for a Just Transition requires a re-deployment of capital and step change in behaviours, and the Scottish Government (SG) has put this at the forefront of its policy objectives. For SG, a Just Transition refers to both the outcome – a fairer, greener future for all – and the process that must be undertaken in partnership with those impacted by the transition to net zero.

The Scottish National Party (SNP) and Scottish Green Party's Shared Policy Programme, published on 1 September 2021, states that, in order to achieve a Just Transition, it is crucial to understand North Sea Oil and Gas (O&G) production against the backdrop of the global climate emergency and Scotland's economic security and wellbeing, before then going on to take urgent proactive steps to deliver that transition.

Our analysis aims to better understand the future prospects for the “Scottish North Sea” (ScotNS)[1] including the pathway of O&G production, Scotland’s energy requirements and how Scotland’s energy activity aligns with its climate change commitments. Additionally, we explore the Just Transition impacts of a declining ScotNS and a rise in employment in low carbon sectors. This work was conducted independently and overseen by an independent expert panel. It has provided an analytical evidence base that has been used to underpin the relevant parts of SG’s Energy Strategy and Just Transition Plan.

The Energy Strategy and Just Transition Plan (ESJTP) sets a vision for Scotland's energy system to 2045. Our 2050 findings align with data sets that underpin this analysis, but we acknowledge Scotland’s 2045 legislative targets are different.



[1] 1For the purpose of our analysis, we have followed the methodology that assumes the Scottish portion of the UK Continental Shelf (UKCS) is based on activities within the Scottish adjacent waters boundary. This was defined during the devolution of fisheries management policy and is described in the Scottish Adjacent Waters Boundaries Order (1999). Other definitions may exist that present alternative perspectives on Scottish production, however, this definition follows existing Scottish Government practice and is used as a basis for the Scottish O&G production statistics in this analysis.

Our analysis provides an evidence base of how Scotland's energy requirements and production capacity align with its climate change targets and the goal of the Paris Agreement as we transition to net zero

Our reports

We produced three reports to provide analysis on Just Transition issues for SG:

- The first report (Chapter 1) set out the current and future state of the Scottish O&G industry and how it fits into the Scottish Energy system, including forecasts of production and the anticipated decline in O&G jobs and Gross Value Added (GVA) that will result.
- The second report (Chapter 2) set out the factors that contribute to the current patterns of the consumption of that element of the O&G not exported to the rest of the UK (rUK) or further afield.
- Chapter 3 explores the dynamics of the transition from O&G to low carbon energy and the interventions required to support a Just Transition.

Following the completion of Chapters 1, 2 and 3, this summary report focuses on capturing the key conclusions from our work in a more concise format to support the co-design of the final Energy Strategy and Just Transition Plan.

Please see the accompanying databooks that support all the tables and graphs in this report.

Our conclusions are based on information that was available at the time of developing our reports. Chapters 1, 2 and 3 were completed prior to the issuing of this report.

Limitations of our scope

Our report is focused on developing baseline evidence of the O&G sector in Scotland and analysing the economic impact of the growth in the low carbon energy production sectors. However, it does not represent a whole economy perspective on the energy transition and not all economic consequences have been quantified. Alternative methodologies and assumptions may result in different outcomes.

Additionally, our analysis utilises Energy System Catapult's Scottish whole energy system scenarios, described overleaf. This represents one possible set of scenarios, however other net zero pathways exist, that may result in different forecasts.

This analysis does not provide recommendations on the appropriateness of future O&G exploration.

Scotland can create a diverse and integrated low carbon economy, with multiple energy sources generating significant levels of low carbon energy by 2050

Scotland's future energy system

Scotland's energy system is complex and the way we generate and consume energy will continue to change. This complexity will continue to grow and predicting Scotland's future carbon technology mix is challenging.

To help explore Scotland's whole energy system, ClimateXChange (CXC), on behalf of SG, commissioned Energy Systems Catapult (ESC) to develop a set of Scotland-specific whole energy system scenarios. These scenarios demonstrate different routes for Scotland to meet its climate change targets, allowing different choices and potential implications to be explored. Please see appendix A for a description of the ESC methodology and background on the scenarios.

ESC developed three scenarios that explore the different levels of societal and technology change needed to explore pathways to achieve Scotland's climate change targets. Of these three scenarios, the Balanced Options (BOP) scenario has been used as a reference point to highlight a potential future scenario.

The BOP scenario seeks to balance technology innovation with a degree of societal change to meet climate change targets, as well as resulting in the closest outcome to net-nil job[2] losses under the ScotNS O&G decline scenario.

[2] "Net-nil job losses" refers to a position where the gain in low carbon jobs fully offsets the loss of O&G jobs and there is a nil change in energy sector jobs across O&G and low carbon energy

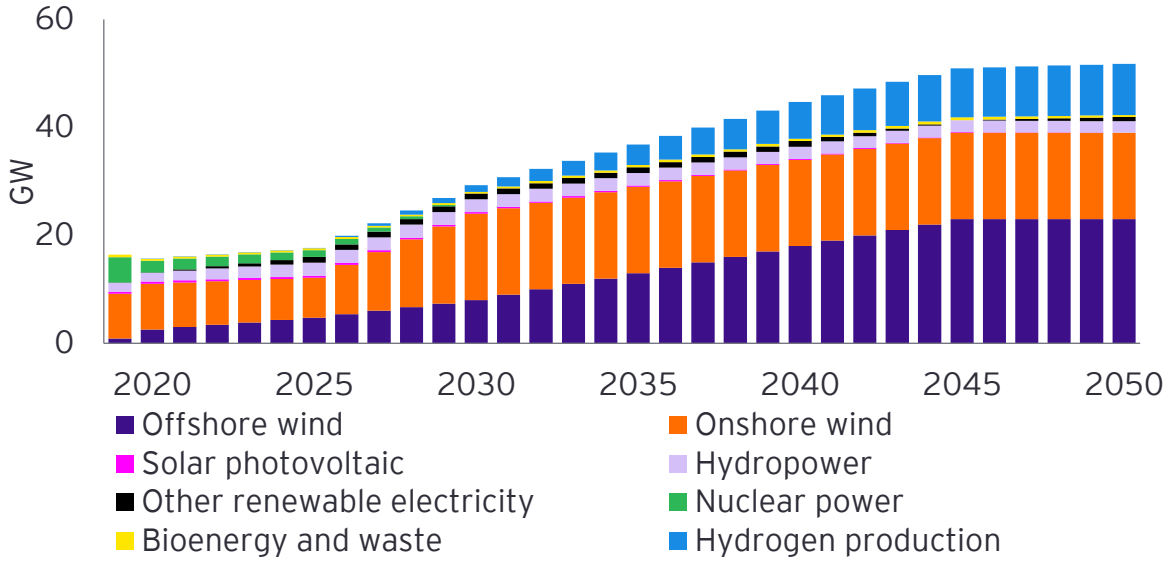
Under the BOP scenario, total generation capacity increases from 16.5GW in 2019 to 42.3GW by 2050 as we electrify more sectors. The other key energy mix outcomes under BOP are outlined below:

- Total wind generation increases from 9.2 GW in 2019 to 39 GW in 2050. In 2019 90% of total wind generation was onshore, but the BOP model forecasts a shift to offshore, with only 41% onshore in 2050.
- Nuclear capacity reduces to nil by 2030.
- Hydrogen production grows from nil in 2019 to 8.6GW (with output of 70.6 TWh2) by 2050.
- Carbon captured grows in each scenario from nil in 2019 to 26.4 MtCO2 by 2050.
- There is limited growth in capacity of hydropower, solar, bioenergy and tidal overtime in the BOP scenario.

The BOP scenario assumes significantly lower levels of solar and a higher proportion of wind compared to other global energy models. The individual fuel mix of every country (including Scotland) will differ and be highly dependent on a range of factors including local geography.

SG's ESJTP has not been developed to completely align with the ESC model, which is just one of the sources of evidence and data points supporting the development of the plan. As such, we note there may be some misalignment with the policy targets established in the ESJTP and the assumptions we outline in this report relating to the ESC scenarios. As it is a third party model, we have not sought to validate the reasonableness of the ESC model scenario assumptions as part of this analysis.

BOP – electricity generation capacity and hydrogen production capacity[3]



Source: EY analysis based on Energy Systems Catapult

The chart illustrates how Scottish low carbon energy production could evolve, ensuring that Scotland's energy needs can be met while reducing the use of fossil fuels.

Achieving this future will require policy change and investment but has the potential to bring jobs to Scotland, and will offset the losses that Scotland will suffer as a producer of O&G.

Policymakers will need to actively manage the Just Transition. The decline in the O&G sector and the corresponding growth in the low carbon sectors could follow several trajectories.

The Climate Change Committee[4] recently reviewed Scotland's progress against its climate change targets and recommended SG develops an urgent plan for how it will meet its 2030 targets. For the transition to occur and for Scotland to meet its targets, Scotland needs to build on its strengths – not just utilising its natural resources such as wind energy, but transitioning its world class O&G supply chain, and leveraging its

[3] ESC scenarios outline hydrogen production in TWh, this has been converted to GW assuming a 86% load factor based on the Scottish Hydrogen Assessment
4 Climate Change Committee – Progress in reducing emissions in Scotland – 2022 Report to Parliament

colleges, universities and capability for innovation. However, the energy transition presents Scotland with a series of challenges:

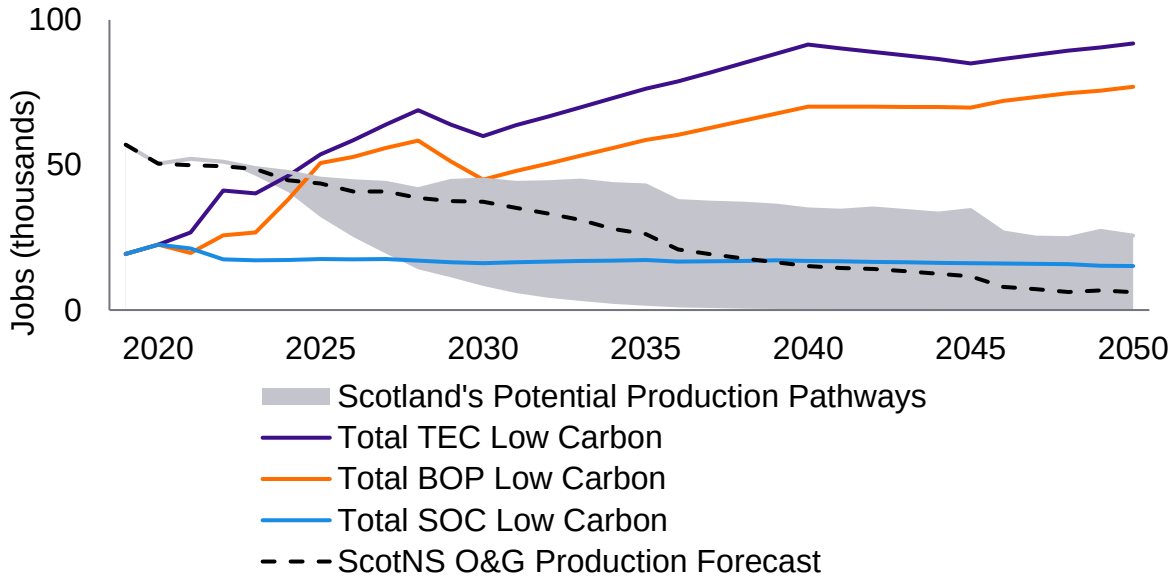
- SG will need to develop a strategy for supporting new investment in an integrated UK energy market. Decisions are currently made by the UKG and UK regulators, where risks and funding are able to be spread across the whole of the UK, if this were to change alternative risks sharing mechanisms would need to be found.
- The decline in O&G is likely to be rapid and challenging. Jobs in the industry are long term, high value and concentrated in the North East of Scotland. Our analysis demonstrates that growth in the low carbon sectors has the potential to replace the lost jobs associated with the decline in the O&G sector. However, Scotland's overall energy GVA is expected to fall, due to the low carbon sector having a lower GVA per job value than the O&G sector. This gap may be exacerbated if the ESC low carbon scenarios are not realised.
- The energy transition will require workforce retraining. It is not easy for people or firms to transition to new jobs or new markets, even where there is overlap between the markets and a potential re-application of skills and capabilities.
- The costs to the economy of rolling out new low carbon technologies are considerable and, without intervention, will not be equitably distributed. All forms of energy will be more expensive and will have the greatest impact on those for whom energy costs are a higher proportion of their spending, i.e., those on lower income.

SG's strategy needs to combine five critical interlinked components to support the Just Transition:

1. To stimulate the right level of low carbon technologies
2. To develop the supply chain in Scotland
3. To skill or reskill the workforce
4. To protect affected regions and communities
5. To build resilience and enable grid enhancement

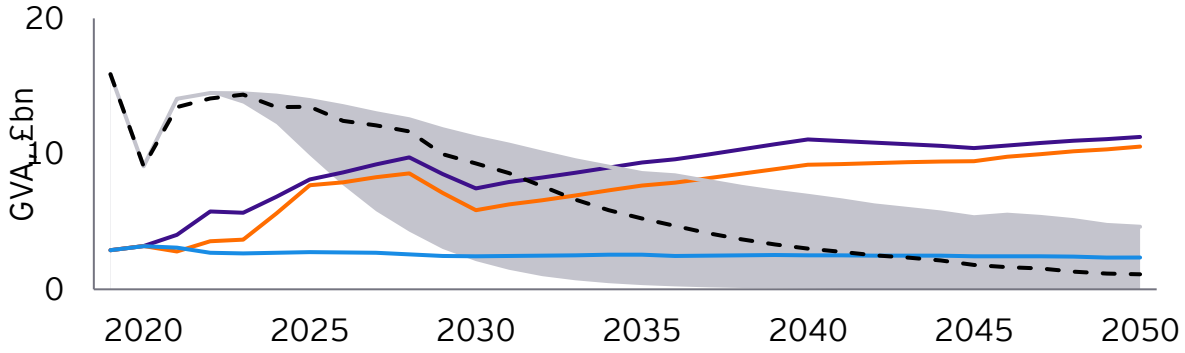
The timing of policy interventions will be crucial – a list of potential policy interventions is given overleaf, as well as information on whether SG or the UKG will have the primary responsibility for implementing the interventions. For Scotland to achieve its ambitions, many of the interventions will need to put in place over the next two or three years, and will require significant coordination between both SG and UKG. More detailed discussion on the implications of these policy interventions can be found in Chapter 3.

Decline in O&G jobs and growth in low carbon jobs using ESC scenarios (direct & indirect jobs)



Source: EY analysis

Decline in O&G GVA and growth in low carbon GVA using ESC scenarios (direct & indirect GVA)



Source: EY analysis

3. Chapter 1 – A baseline review of the O&G sector in Scotland

O&G production from the ScotNS will decline and reserves will be increasingly hard to exploit. However, the sector still represents a large economic footprint, particularly in the North East of Scotland

Scotland is home to a mature O&G sector and production from the ScotNS will decline.

- O&G production from the ScotNS will continue to decline and we forecast that by 2050 production levels will be significantly less than current production. For example, by 2035 production is forecast to fall to 0.5 Mmboe/d, 33% of 2019 levels and by 2050 production is forecast to fall to 0.1 Mmboe/d, 7% of 2019 levels.

- This decline trend is unlikely to accelerate because over 80% of the forecast production will arise from existing sanctioned fields. The remainder will come from new probable and possible developments.

- However, uncertainty exists and production may increase if future reserves are exploited, supported by higher O&G prices. However, future production is impacted by several complex factors and is hard to quantify.

- For example, the 2019 North Sea Transition Authority (NSTA) reserves analysis indicates that there are between 6.3bn and 11.7bn barrel of oil equivalent (boe) of reserves in the UK Continental Shelf (UKCS) and additional undiscovered prospective resources of 7.6bn boe expected between now and 2050.

- Future production will be dependent on a number of factors, including O&G prices and technical, regulatory and economic limitations to exploiting reserves. Please see Chapter 1 for a detailed description of our methodology, assumptions and results.

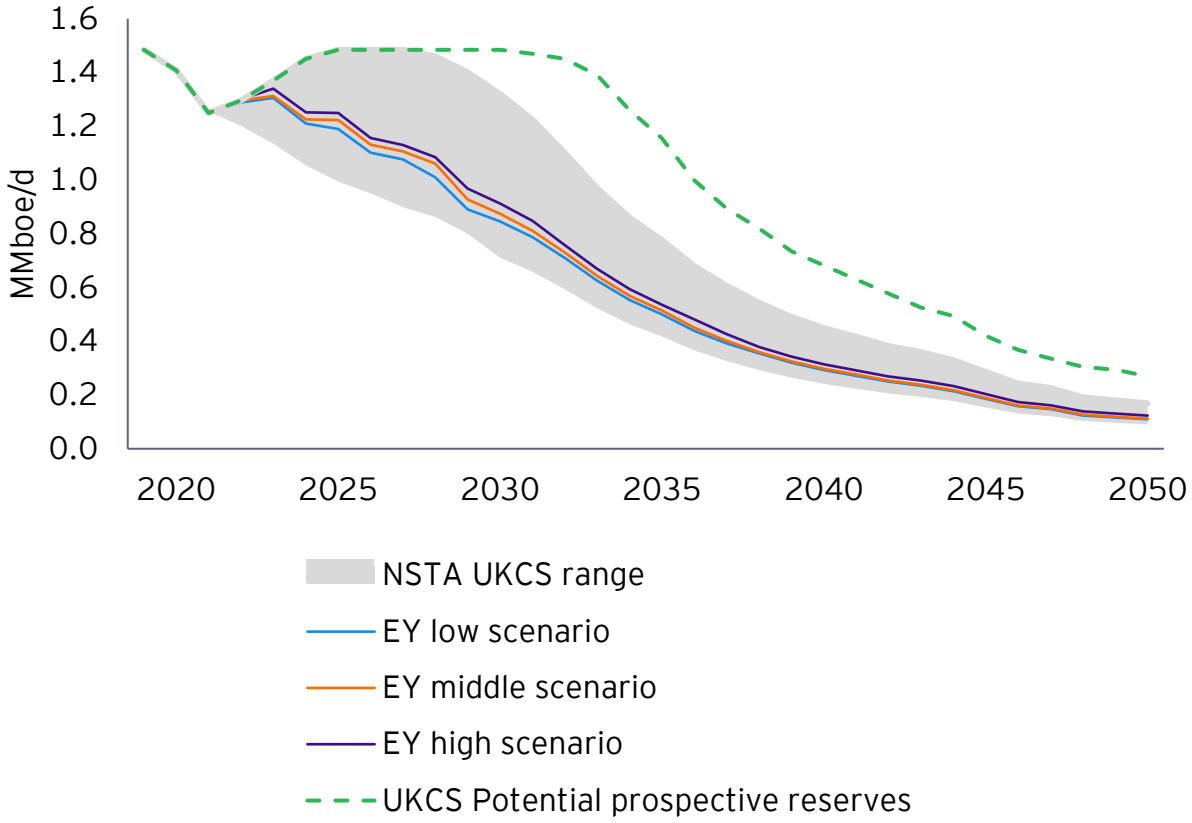
The economic footprint of Scottish O&G production is large and its decline will impact the North East of Scotland negatively in the absence of a Just Transition.

- The economic footprint of the ScotNS is significant and our analysis shows that the offshore O&G sector supports an estimated 57,000 jobs. These are high value compared to the Scottish average, with an average wage of £88,000 for direct jobs, and £51,000 in the supply chain (indirect employment), compared to a Scottish average of £29,000. Of the 25,000 direct O&G jobs, 98% were located within Aberdeen City and Aberdeenshire.

- The industry is responsible for a total GVA of £16bn, equivalent to 9% of total Scottish 2019 GDP (including a geographical share of UK Extra-Regio activity). In Chapter 3, we analyse the investment needed to replace the lost economic impact of the O&G sector.

- The forecast decline in employment and GVA is significant: from 57,000 to 32,000 jobs by 2030, creating a challenge for a Just Transition. Our modelling adopts conservative assumptions regarding the scale of the jobs/GVA in the Scottish supply chain, meaning impact of decline may be more severe.

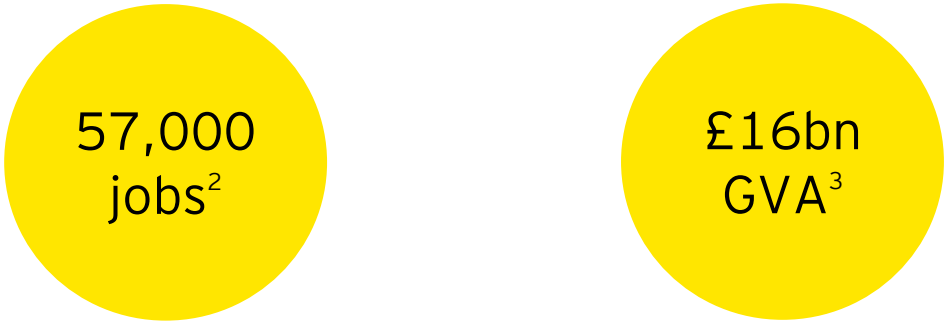
Scottish O&G production scenarios (sanctioned, probable and possible) compared to NSTA UKCS forecast and potential prospective reserves[1]



Source: EY, NSTA. The chart includes estimates that illustrate how cumulative NSTA reserves could apply as a production trajectory. These have been developed to provide comparable production pathways that align with the EY forecast.

Note: The above graph represents deviations to the ScotNS production pathway under different high, medium and low oil price scenarios modelled by EY. See Chapter 1 for more detail on this methodology.

Employment and GVA contribution (2019)



[1] The chart includes estimates that illustrate how cumulative NSTA reserves could apply as a production trajectory. These have been developed to provide comparable production pathways that align with the EY scenarios.

[2] This excludes an additional 22,000 induced jobs that are attributable to the upstream extraction sector

[3] This excludes an additional £2bn of induced GVA contributions that are attributable to the sector.

Upstream O&G emissions are falling and will reduce further as production declines. Internationally, some O&G producers have higher production emissions and therefore increasing imports could raise emissions unless demand falls

We analyse the upstream emissions associated with the O&G sector. The UKCS has absolute emissions targets, but this may not necessarily result in a major 'per barrel' reduction in emissions.

- The industry's emissions reduction targets, introduced through the North Sea Transition Deal (NSTD), create an opportunity to reduce its carbon footprint through measures such as reducing venting, flaring and investing in platform electrification. The deal aims to reduce emissions from O&G production by 10% by 2025, 25% by 2027 and 50% by 2030 (against a baseline of emissions in 2018). The ScotNS's natural decline will be the largest factor in the decline in total emissions, but the industry will also need to support emission reduction measures to meet its decarbonisation targets. We do not analyse emissions from O&G use, or the emissions impact of reducing demand.

- ScotNS emission reduction activity is possible but comes with operational and commercial challenges and requires large scale investment. For example. Norway, with comparable geology and operating conditions, has supported platform electrification and benefits from a decarbonised electrical grid, historical carbon taxes, and longer dated reserves.

- The NSTD commitments demonstrate that the UK O&G industry is taking steps towards emissions abatement activity. However, if global O&G producers are compared with the UK (and ScotNS), UK carbon intensity levels can be seen to be lower than the global average and lower than many other offshore O&G producing basins.

- Unless Scotland's O&G demand reduces with the decline in ScotNS production, then domestic demand will have to be met by increased O&G imports from countries with higher carbon intensity levels (and the impact of transport emissions must also be considered), meaning Scotland's overall O&G-related GHG emissions may rise (although our emissions analysis does not assess future O&G

demand, the energy transition is expected to influence future O&G demand patterns).

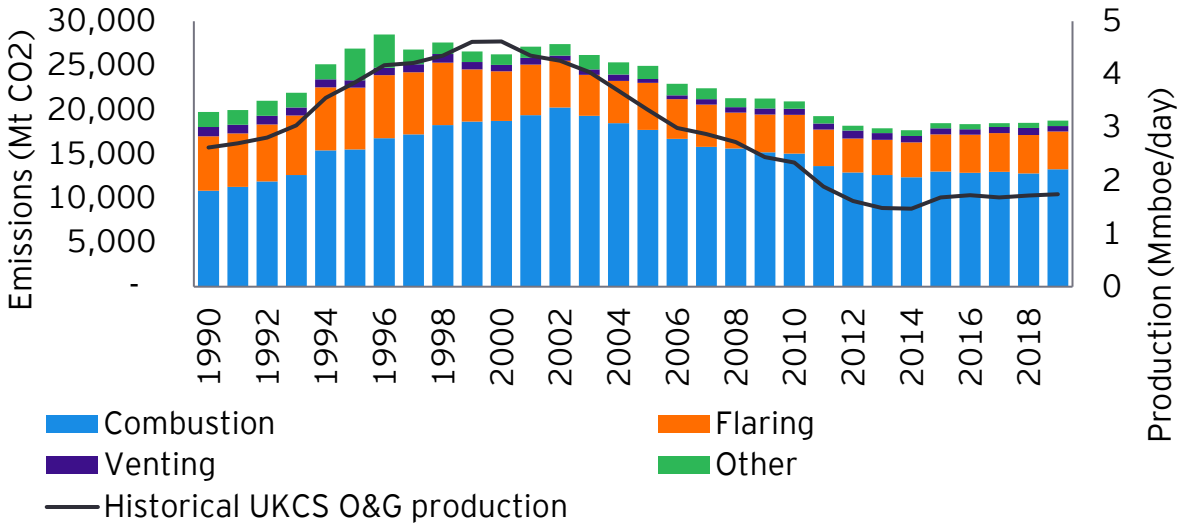
- However, the position is complex and Scotland already imports much of the crude oil used at Grangemouth refinery, so this increase is unlikely to be significant immediately. On average, imported crude oil comes from areas with a higher carbon intensity of extraction than the ScotNS. In 2019 Scotland's largest imports of crude oil came from Nigeria, Norway, Russia and the USA. It is common in the global market for oil producing nations to import oil in order to procure the most economically viable price per barrel, as well as the correct oil type to create the desired end product.

ScotNS O&G production is a significant source of GHG emissions, but upstream GHG emissions (Scope 1) arising from the ScotNS are lower than global averages.

- Although emissions arising from upstream O&G production in the ScotNS represent less than 10% of the total emissions produced from a barrel of oil, this still represents significant levels of GHG emissions.

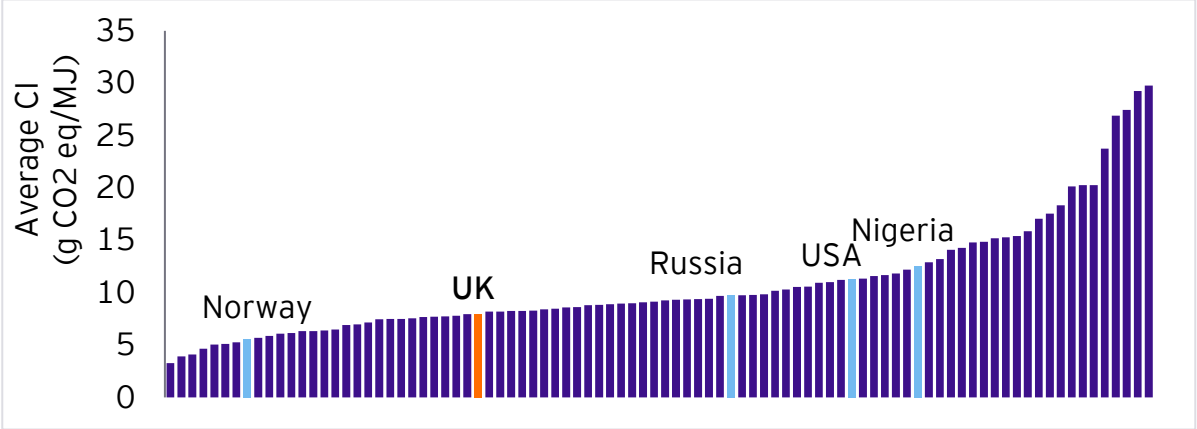
- The geology, infrastructure and the operating environment result in a varied ScotNS emissions profile. However, upstream ScotNS GHG emissions 'per barrel' are lower than other offshore producing nations. Additionally, future ScotNS GHG emissions will continue to fall with lower production levels and the introduction of NSTD activities.

Historical UK upstream GHG emissions



Source: NAEI, NSTA

Estimated global upstream crude oil carbon intensity (2015)

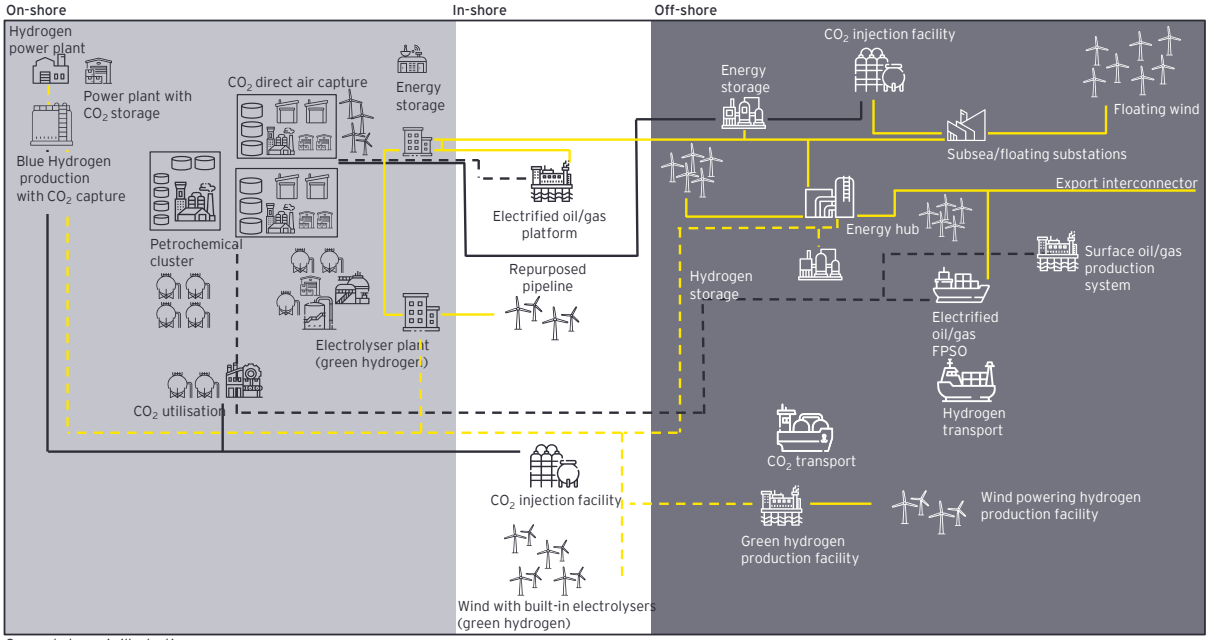


Source: Stanford University

Note: This report was written prior to the Russian invasion of Ukraine in 2022. Scotland has since stopped all imports of Russian oil and gas.

There is potential for the ScotNS to transition toward an integrated energy basin ecosystem with renewables, hydrogen, O&G and CCUS linked together to produce net zero energy

The conceptual diagram illustrates the potential North Sea energy basin ecosystem. It incorporates a number of low carbon technologies that are currently being developed. Further information on the integrated energy basin can be found in Chapter 1.



Concept shown is illustrative
Source: Wood Mackenzie, Lux Research

Infrastructure re-use for transition is possible but challenging – timing and O&G pricing will be significant hurdles to repurposing, as will aligning to emerging technologies

Existing O&G infrastructure can support the energy transition, but it comes with challenges.

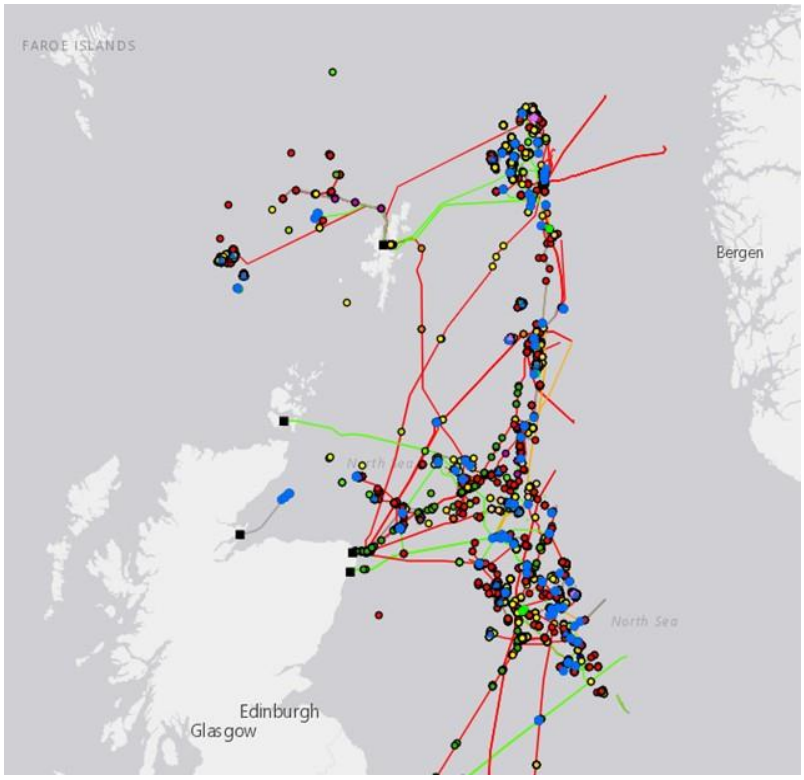
- The ScotNS O&G infrastructure can facilitate the transition to an integrated energy basin, as it offers physical links to offshore sites that can be re-purposed and re-used to deliver the net zero economy.

- There is a significant volume of O&G infrastructure in the ScotNS but planning for the re-use of O&G assets is challenging as their value is directly linked to prevailing commodity prices, which have been particularly volatile in recent years.
- The energy transition offers potentially significant opportunities for O&G industry. Offshore Energies UK (OEUK) estimates that decommissioning spend in the ScotNS could reach £16.6bn over the next decade, £13.1bn of which relates to assets in the ScotNS. The development of greener ways to decommission and the identification of circular economy efficiencies offer the chance to create substantial economic value.

The ability to re-use infrastructure varies across different asset types and will depend on the development of alternative technologies in the ScotNS.

- For example, a number of asset types appear to be viable or potentially viable for re-use, including platforms and floating production storage and offloading (FPSO) units, pipelines and onshore terminal sites. Reservoirs can also be used for carbon or hydrogen storage.
- CCUS and hydrogen are energy transition sectors which offer near-term uses for existing infrastructure. In the future, a move to more integrated energy systems, such as offshore green hydrogen production (potentially using platforms) and hydrogen storage to deal with intermittency, could unlock further opportunities.
- However, there are barriers to infrastructure re-use that need to be overcome. These include high operating costs for aging assets, the O&G industry's complex ownership and commercial model, as well as the fact that the O&G industry would need to no longer have a use for those particular assets.
- Lastly, the re-use of infrastructure can also support the supply chain and help retain high value jobs. The growing low carbon offshore sectors can draw on the Scottish O&G industry’s world class supply chain concentration of skills, expertise, capabilities, and experience. However, the tax implications and change of use arrangements will need to be fully quantified.
- Please refer to Chapter 1 – Section 6 for more detailed discussion on Scottish O&G infrastructure.

The extent of O&G infrastructure in the ScotNS



Offshore platforms = blue dots

Wellheads = red dots

Ancillary infrastructure = yellow dots

Pipelines

- Red line = Gas,
- Green line = Oil,
- Orange line = mixed hydrocarbons

Source: NSTA maps, https://NSTAuthority.maps.arcgis.com

Trade flows with rUK and the ROW will change with the decline of ScotNS production levels. Domestic demand is not directly linked to production and requires separate policy interventions.

Scotland imports O&G despite production volumes exceeding demand.

- Scottish demand has never been the primary driver of ScotNS 'indigenous' production. The majority of Scottish O&G production is exported to the UK and further afield. For scale, total Scottish consumption of O&G in 2019 was only 20% of total Scottish O&G production volume, with a significant portion of the O&G consumed being imported rather than coming from ScotNS fields.

- 65% of Scottish demand for refined oil products in Scotland is met by Grangemouth, Scotland's only refinery. Grangemouth's capacity could meet all of Scottish demand, but it has historically exported around 40% of its output due to external economic drivers in the wider global oil market. Scotland also imports

smaller volumes of refined oil products from the rUK as the road fuel consumed in the North of Scotland is supplied by English refineries via exchange agreements.

- It can be more economically beneficial for Grangemouth to import to meet domestic demand while oil originally produced in the ScotNS is exported.

- The natural gas used in Scotland comes from a combination of ScotNS production and imports from Norway. Scotland imported gas in 2019, despite ScotNS production being 2.5 times Scottish demand. This is due to the layout of existing infrastructure which means that some pipes run from ScotNS directly to rUK gas terminals, while some Norwegian fields connect directly to St Fergus gas terminal in the North East of Scotland.

The relationship with rUK is changing as production falls.

- Oil exports to rUK have fallen over time. The ScotNS no longer fulfils most of the demand for oil in the rUK, although this flow is still significant.

- Exports, including to the rUK, have fallen more significantly than domestic consumption of O&G products.

- The shift in gas is more striking. Historically, the ScotNS supplied most of the UK grid, but now the rUK is supplied largely from other sources and Scotland now also imports gas, particularly during periods of high demand as the National Grid balances demand.

Domestic demand has also shifted

- Scottish demand for gas has steadily increased since the 1990s as gas has replaced coal in electricity generation. This has been a factor supporting improvements in air quality and a reduction in GHG emissions.

- Despite declining production, demand from the transport industry, particularly road fuel, has remained steady over the last 20 years, as has demand for O&G in heating. According to the 2020 Annual Energy Statement, ~75% of Scotland's energy consumption came from O&G, putting Scotland behind its target to deliver the equivalent of 50% of total energy consumption from renewable sources by 2030.

- Scottish demand for O&G should decline as SG net-zero policies come into effect, such as electric vehicle rollout and low carbon heating initiatives. However, should low carbon replacements be insufficient to meet Scotland's energy demands, any continuing reliance on O&G could result in increased imports as domestic O&G production continues to decline.

Scotland is still exporting widely to the rest of the world given global demand for ScotNS oil.

- In 2019, 40% of Grangemouth's production of oil and oil products was exported, although this has been scaled back significantly since the mothballing of one crude distillation unit (CDU) and a fluidised catalytic converter (FCC) unit at the site in 2021.

- Scotland exported 93% of Scottish production of crude oil in 2019. Export levels are determined by price, demand, and where trading conditions mean this is the most profitable option. Export destinations have historically been further afield, resulting in greater GHG emissions due to the distance of oil transportation.

- Gas exports are predominantly to rUK and, to a lesser extent, the Republic of Ireland due to the infrastructure of the National Grid and fact that pipelines from ScotNS gas fields directly supply rUK.

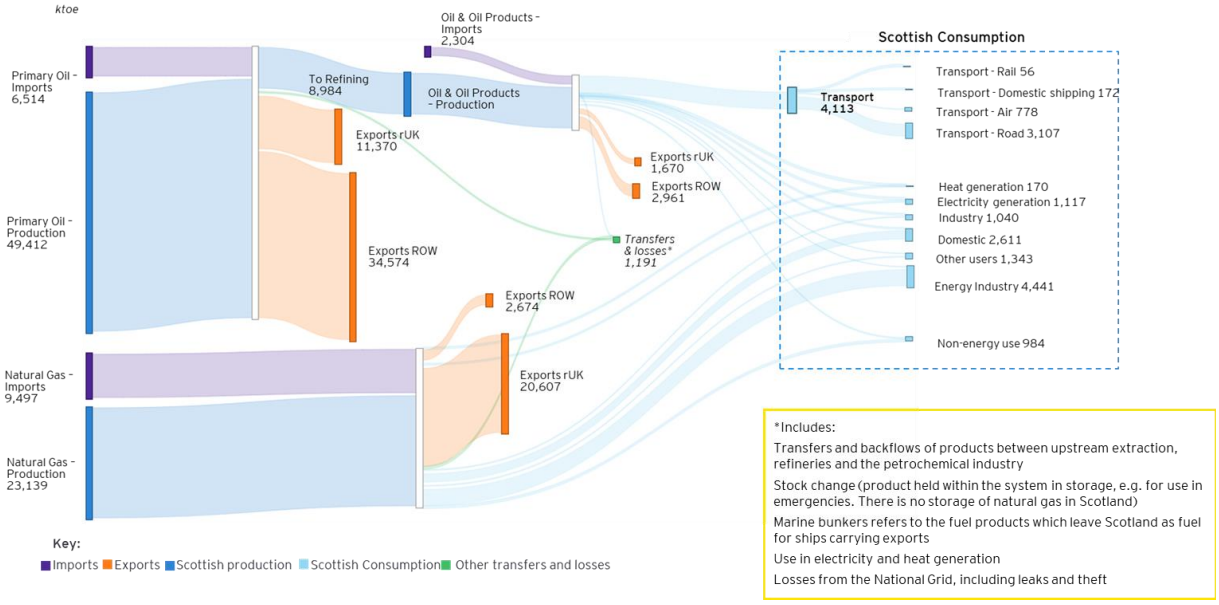
Energy security requires steady trade flows.

- Scotland has no gas storage and very little oil storage. Coupled with global competition, this puts greater pressure on energy security, although Scotland does have direct physical interlinks with Norwegian gas supply fields, as well as existing trade agreements for liquefied natural gas (LNG) landing at St Fergus Gas Terminal. While this helps with energy security concerns regarding supply, increased imports can result in increased prices.

- Scottish (and UK) energy security is more reliant on a diversity of sources of O&G and a degree of domestic production than storage, and any particular source (e.g., Russia) can be replaced rapidly. Expanding storage to cover even a short time period would be extremely expensive.

Note: all figures in this page have been taken from SG's - Physical commodity balances of oil, gas and petroleum products, based on BEIS' Digest of UK Energy Statistics (DUKES) 2021 - GOV.UK (www.gov.uk)

Scotland's O&G flows in 2019 illustrate Scotland's position as a net exporter, as well as the scale of ScotNS production compared to Scottish consumption levels



Source: SG - Physical commodity balances of oil, gas and petroleum products
Digest of UK Energy Statistics (DUKES) 2021 - GOV.UK (www.gov.uk) (commodity balances)

Scotland has been an attractive jurisdiction for investment but the ScotNS still faces a decline because of dwindling and difficult to extract reserves and cost

- The UKCS has been an important part of the global O&G industry since the 1960s and, despite production peaking in the early 2000s, it continues to attract investors. However, with falling production levels and limited future prospective resources, its role as a global O&G producing basin is expected to diminish.

- The ScotNS has been an attractive jurisdiction in regulatory and taxation terms which has helped it compete for global capital. The UK's commercial, regulatory and fiscal environment has historically been regarded as relatively stable, allowing

for predictable returns, an investor-friendly environment and generally attractive conditions for investors. In 2016, in an effort to stimulate more investment in the UKCS, UKG made the fiscal regime more generous to support the development of offshore fields. However, the introduction of the Energy (Oil and Gas) Profits Levy (EPL) in 2022 has resulted in a new tax regime for the O&G industry, resulting in a less stable investment picture for the UKCS (and ScotNS).

- The ScotNS benefits from geographical proximity to an established market in Europe and the security of local demand, making it a relatively attractive location for O&G production.

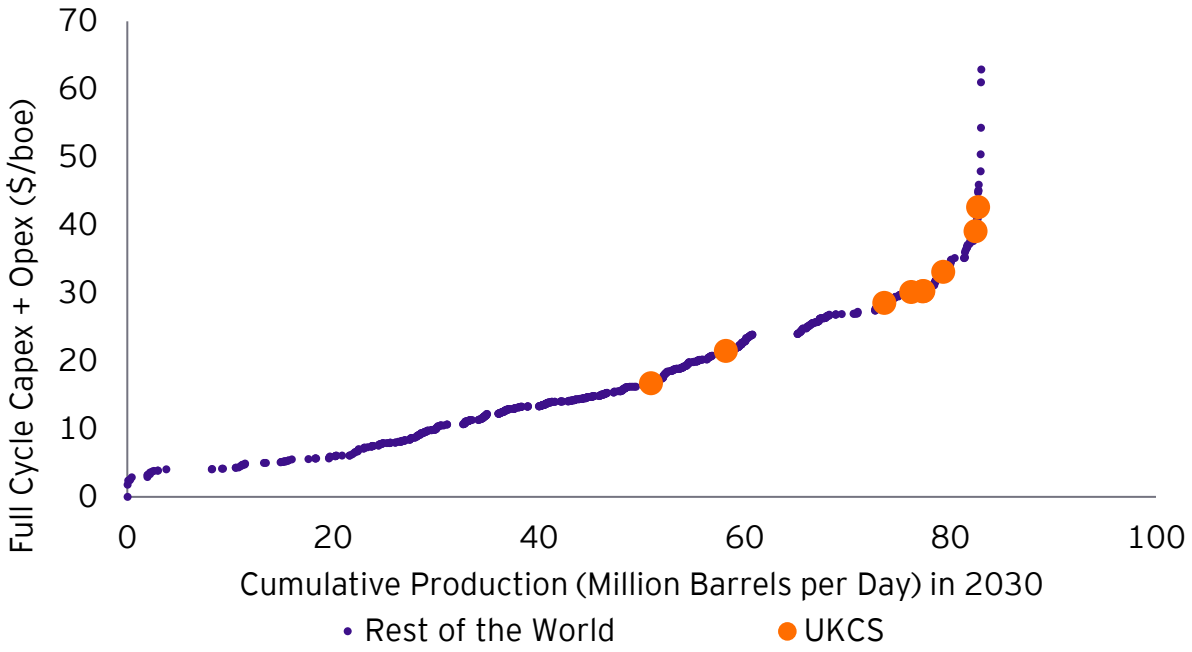
- The maturity of the ScotNS also means that investors can rely on its sophisticated infrastructure landscape and access a world-class supply chain. Future supply chain capacity will be impacted by several factors, but recent downturns in commodity prices have reduced capacity.

But the physical nature of reserves presents challenges for investment.

- The geology and geography of remaining UKCS reserves makes their exploitation harder and more expensive. Global costs of production present a complex picture, but the cost of production in the UK is higher than other basins. As a result, the UK has seen a slowdown in investment, which is reflected in the production forecast.

- As the chart shows, the cost of the ScotNS fields on a ‘whole-life’ basis tends to be higher than other basins globally, in other words, it is more expensive to extract O&G in the ScotNS than other global basins (although there is significant variance on a field by field basis). This is likely to be more marked for new discoveries where the infrastructure costs are similar to existing fields but the longevity of their economic life is shorter.

UKCS vs. Rest of the World cost curve – individual fields



Source: GlobalData

Since the time of writing this report O&G prices have been significantly impacted by war in Ukraine and the economic consequences and duration of this geopolitical risk cannot be fully predicted. Although we do not expect it to alter the underlying conclusions, any period of prolonged high prices will have an impact on future production forecasts. Historical geopolitical events have impacted oil prices but other factors, such as the response from other O&G producing nations, will also need to be considered.

Following the Russian invasion of Ukraine, the UKG announced that it would phase out all imports of Russian hydrocarbons by the end of 2022. The UK has the ability to move away from Russian hydrocarbons relatively quickly and easily compared to other European countries that have historically had a greater share of hydrocarbon imports from Russia. Despite this, the UK could still be indirectly impacted through price levels and price volatility.

4. Chapter 2 – O&G demand in Scotland

O&G continues to be the principal energy source supporting economic and social activity in Scotland

Our analysis focuses on domestic consumption of O&G and what factors have driven Scotland's current pattern of demand. There are five key themes:

1. **Technology & cost** – limited progress has been made cutting O&G use outside of electricity generation, because new technologies carry a cost premium, making O&G use the obvious choice for consumers and businesses.

2. **Taxation, carbon pricing and levies** – the structure of levies (such as those supporting renewable generation, which sit with electricity rather than gas customers) influences consumption. Carbon pricing forms a critical incentive, but only applies to electricity generation, energy intensive industry and aviation.

3. **Infrastructure, assets and business models** – some assets with long lives (such as the gas grid), can 'bake-in' O&G use. The rate of replacement, even of shorter-lived assets such as boilers and cars, means that even when replacement technologies become dominant in the market it will take time to substantially reduce O&G use.

4. **Consumer expectations** – the existence of cheap and convenient energy has shaped consumer expectations and the transition will require an active and continuing shift in public attitude, as well as the provision of high quality alternatives to fossil fuels.

5. **Government policy and economic growth** – Governments have historically supported the consumption of O&G in pursuing economic growth, such as airport expansion. Planning and other policies that have historically assumed the dominance of O&G have reinforced this.

Sector specific points:

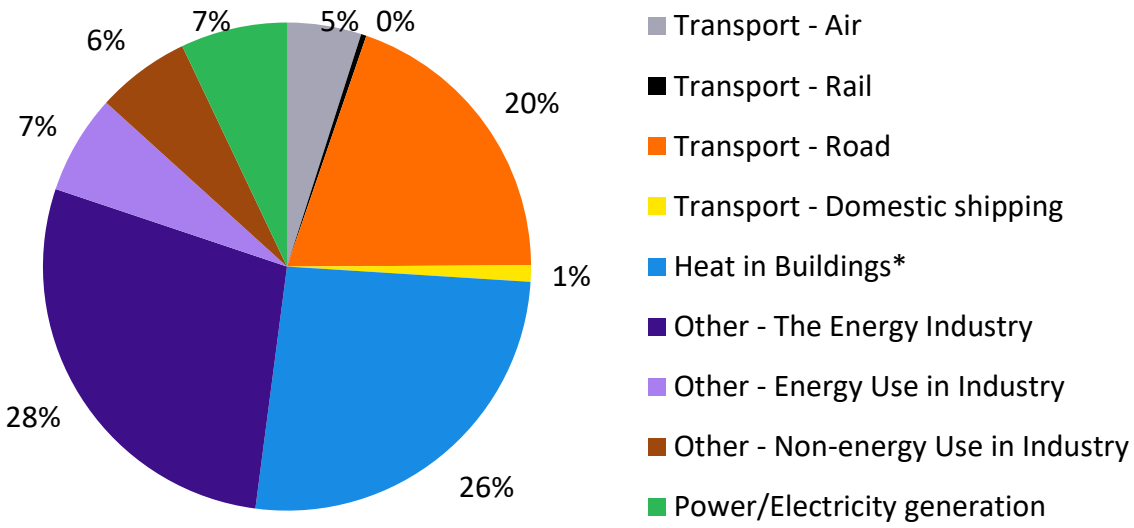
- Despite progress being made there are still challenges ahead for electricity generation, which will need to more than double to facilitate the decarbonisation of other sectors. This growth will require grid reinforcement as well as the

development of support mechanisms for dispatchable low carbon power, potentially including CCUS. If this is achieved Scotland has the potential to become a low carbon energy hub for the whole of the UK.

- Heat sector decarbonisation will also require a robust supply chain for new technologies such as heat pumps. These new technologies are currently more expensive than existing fossil fuelled alternatives, but the recent increases in the price of gas means that alternatives will become more attractive as they become more widely available.

- In the transport sector, road and rail are in a better position to see rapid change over the coming years, particularly as technology continues to develop which will bring cost efficiencies over time. However, further decarbonisation in these sectors is dependent on grid capacity constraints. In other sectors, such as shipping and aviation, new technology choices are less certain and will require further research and development. As such, the pathway to reducing O&G in these areas is less clear.

- Changing current consumption patterns will require a combination of policies. As well as all government policy having Net Zero as part of decision making, more specific policies will be required to support new supply chains, accelerate take-up of new technologies as they become viable, and to ensure that they are affordable.



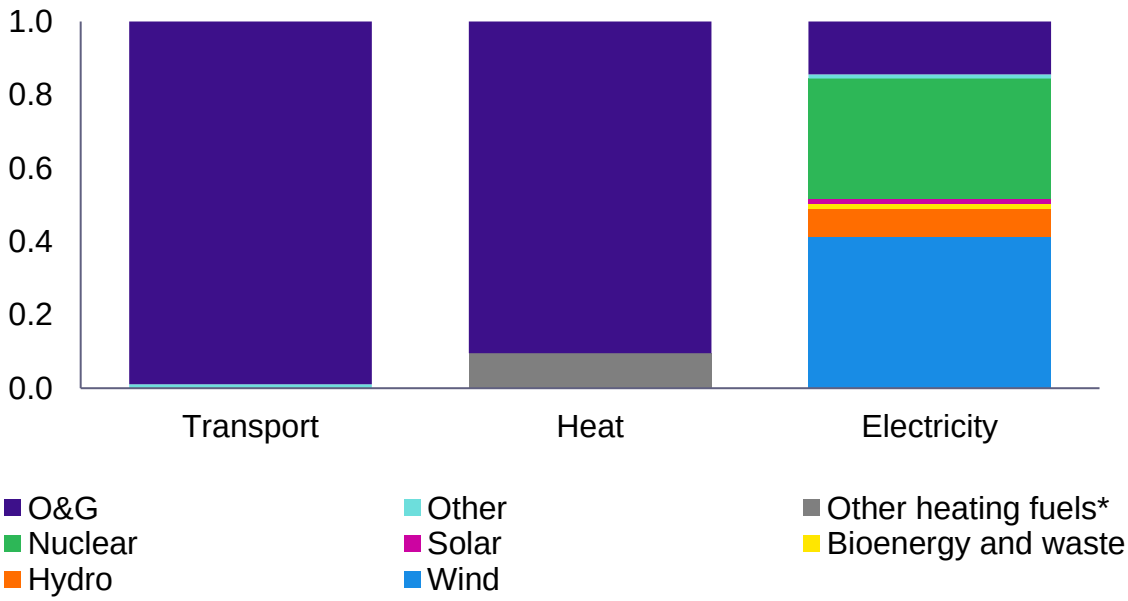
Source: SG - Physical commodity balances of oil, gas and petroleum products
Digest of UK Energy Statistics (DUKES) 2021 - GOV.UK (www.gov.uk) (commodity balances)

Key theme 1: Technology and cost

Fossil fuels have been easy to use and transformative.

- Scotland's current pattern of demand has been significantly impacted by the relative convenience of using O&G to supply energy. Using fossil fuels as a source of energy was transformative in facilitating the industrial revolution and continued innovation in the 20th century.
- Global consumption of fossil fuels has accelerated rapidly in the second half of the 20th century. Since 1980 alone, consumption has approximately doubled.
- Scottish demand for fossil fuels is still significant and it plays an important role in Scotland's energy mix, especially in the transport and heat sectors.

The Scottish Energy System – Three key sectors



* Other heating fuel sources include electricity, solid mineral fuels and biomass

Source: Annual energy statement 2019 - gov.scot (www.gov.scot) Scottish Energy Statistics Hub – Proportion of electricity consumption by fuel Scottish Energy Statistics Hub – Number of ultra low emission vehicles licenced

New technologies to replace O&G are relatively recent.

- In relative terms, alternatives to O&G are in their infancy. The internal combustion engine (ICE) has been a viable technology for 125 years and, whilst Battery Electric Vehicles (BEVs) technology is almost as old, BEVs have only recently

offered comparable utility and performance. Additionally, heat pumps are recognised as an effective tool to support heat decarbonisation in buildings, but current rollout rates are low (recent evidence shows only 3,000 low carbon heating systems were installed in Scotland's homes annually).[5]

- The historical adoption of fossil fuels is an established trend across many sectors of the economy. There are a range of reasons for this, but the lack of alternative technologies that were as cheap or as easy to implement as the O&G solution was a contributing factor.

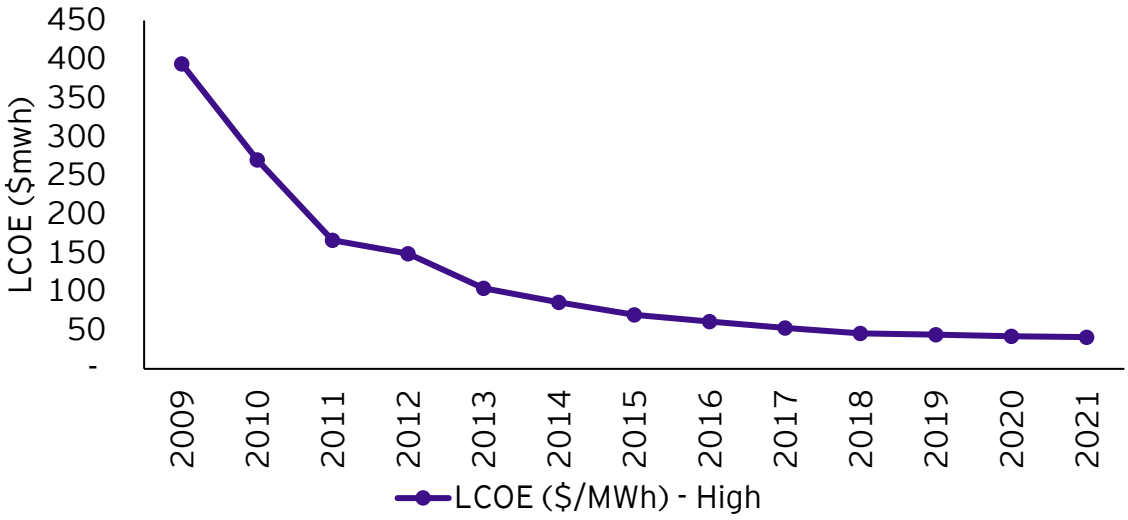
Costs to consumers can be high, reducing the take-up of new technology.

- The early stage of development of alternative technologies and lack of adoption means that, in a number of areas for consumers, costs are still high and therefore take-up continues to be low. Historically, this is true of certain technologies such as BEVs where, although purchase prices are continuing to fall and savings can be subsequently made on operating costs, the high upfront costs are unattractive for consumers. As noted previously, SG's net-zero strategy includes policies which specifically target BEV infrastructure rollout and the phase-out of petrol and diesel vehicles. In theory these policies should increase demand for BEVs, lowering prices and making them generally more accessible for consumers.

- Costs reduce from sustained research, investment, and widespread use. As such, the current high prices which are discouraging take-up will reduce over time. In electricity generation, where subsidies have been in place for more than 15 years, costs for consumers have reduced significantly. This success could be replicated in the heat and transport sectors if the correct policies are in place to support the development of low carbon technology and encourage the required change in consumer behaviour.

[5] Scottish Government Heat in Buildings Strategy, October 2021

Unsubsidised Solar PV levelised cost of energy (LCOE)



Source: Lazard (Lazard.com | Levelized Cost Of Energy, Levelized Cost Of Storage, and Levelized Cost Of Hydrogen)

Key theme 2: Taxation, carbon pricing and levies

Taxation and government influence on costs of different options.

Cost and externalities

- One reason that using fossil fuels, and specifically O&G, remains competitive, especially where alternatives are increasingly available, is that the externalities of carbon use are not priced in. This means that the wider costs of emitting carbon (both at a local and global level) are not reflected in the cost of using that fuel.
- Any assessment of such costs is subject to debate. This is true of existing public interventions, such as fuel duty, where government adds costs into the consumption of some fuels.

Carbon taxes

- The UK taxes O&G products in different ways: at extraction (taxing energy companies) and through consumption via taxes that impact consumers, such as fuel duty. There are historical reasons for this system of taxation and exceptions are granted, such as “red diesel”.

Carbon trading and pricing

- The UK currently operates a carbon cap-and-trade scheme that aims to create a market with a carbon price signal to incentivise decarbonisation. This is an attempt to have a price for carbon which is anticipated to increase over time, pricing in the externalities associated with emissions.

- This is anticipated to be a major driver of decarbonisation as firms adapt to the increasing cost of consuming O&G without capturing the carbon.

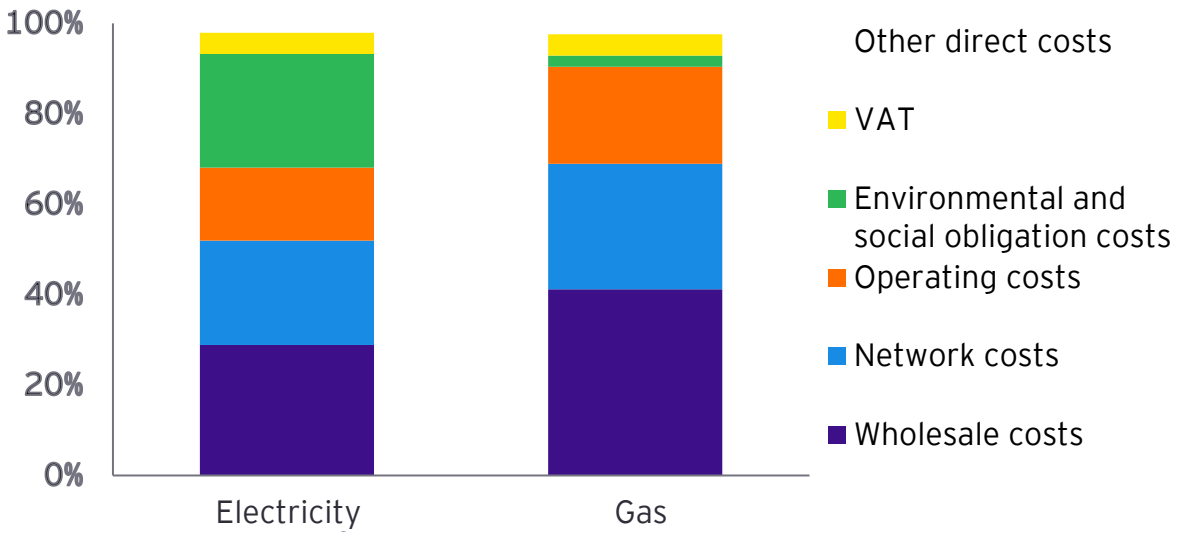
- However, there are currently only a number of 'regulated' sectors where carbon pricing applies: energy intensive industries, the electricity generation sector and aviation. For a number of energy intensive industries (such as steel, sugar, and certain types of manufacturing), firms receive free allowances if production is likely to move to jurisdictions where there is a lower carbon price. This means that the effects of the carbon price are not felt in a number of critical areas of consumption of O&G.

Levies and the electricity generation sector

- Governments and regulators need to make choices about how the costs of the energy transition are going to be met. Historically, electricity has been more expensive than gas, partly due to the greater proportion of environmental and social obligation costs placed on electricity (23%) compared to gas (2%), as shown by the graph below. These are environmental taxes that are designed to pay for certain Government energy policies. Therefore, although electricity is a more environmentally friendly option for consumers (since electricity is already relatively decarbonised) it may also be the most expensive.

- This means in Scotland users of low carbon fuels (e.g., electricity) are paying additional levies while those using more carbon intensive sources of energy (e.g., gas) are not.

Breakdown of an electricity & gas bill



Source: Ofgem – August 2021 breakdown of an electricity and gas bill (All available charts | Ofgem)

- While the costs of renewables have reduced, the need to increase electricity production and deal with the effects of intermittency mean that the costs of transition will need to be borne in other areas. Just Transition considerations mean that it is important to consider where, and how, these costs should be distributed in society and the economy.
- The shape of taxes, carbon pricing and levies helps to determine what fuels are consumed and the rate of change away from consuming O&G.

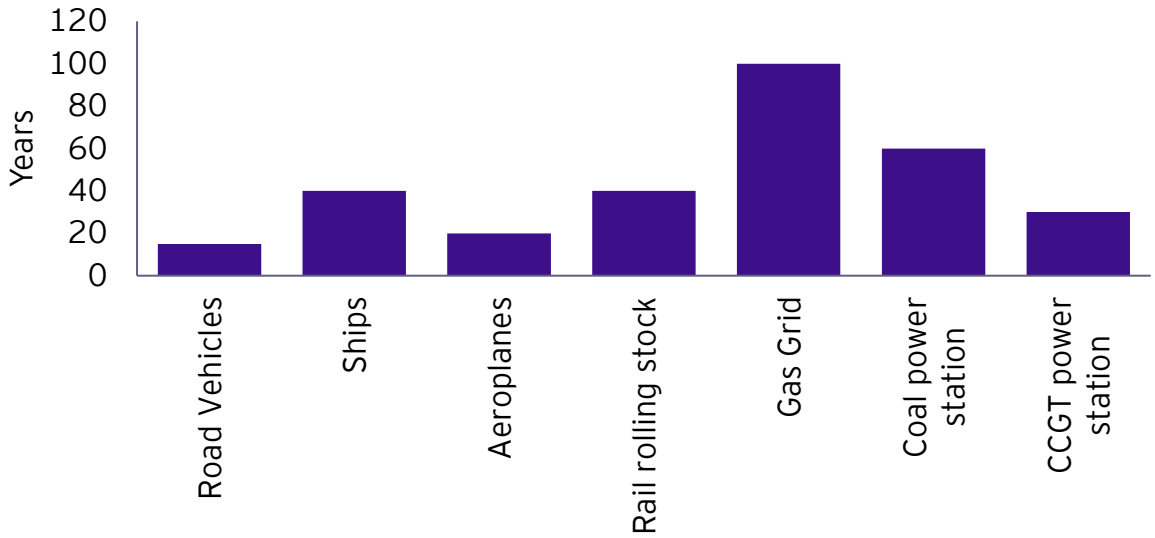
Key theme 3: Infrastructure, assets and business models

The effect of existing infrastructure and assets.

- Fossil fuel consumption is embedded by the historical development of different types of infrastructure and assets, which have long lifetimes and have a significant influence over patterns of demand. Expected useful lives are varied, but even vehicles might have long asset lives in the context of a climate emergency. For example, a diesel bus would be expected to last for 15 years in normal operation, thereby embedding O&G use for over a decade.
- Other assets have longer lives. A clear example is the gas grid which has been expanded incrementally for over 50 years, and supports consumption in our homes

and buildings, as well as historical economic development. The transition will require investment in very different asset classes to those historically favoured by the private and public sector.

Illustrative asset lives



Source: EY analysis

- This means that even at a relatively high market share, low carbon technologies can take an extended period of time to change patterns of consumption substantially. Scotland still uses infrastructure assets that are over 100 years old, such as some elements of Scotland's gas grid or transport network, and while new technologies that are lower or zero carbon exist, the ability to replace what is there is limited by the economic life of assets. This embeds patterns of consumption and slows change.

Investment returns and business models.

- Assets are also embedded in the economy through certain types of business models which are difficult to change. The existence of assets usually means a stakeholder or entity is receiving a return on the assets and therefore has an interest in their continued use.
- In the electricity generation and water industries, regulated utility networks have been successfully maintained through the economic regulation of private firms. This applies to the electricity generation network and the gas grid in Scotland. A regulated asset value mechanism gives investors a regulated return on a notional

value of the assets. This is depreciated over time at a slow rate, while being increased to account for inflation and new capital expenditure. The returns generated mean that there is no immediate end date and the system is effectively set up to be perpetual.

- Often lower carbon technology has a high capital cost but there may be savings in the operation of assets – this is true for wind energy, battery vehicles, etc. This does not necessarily fit well with business models where consumers purchase assets and take depreciation risk.
- A good example is BEVs, where the upfront cost and risks in ownership mean that the model is changing. More vehicles are being leased rather than sold, both for private vehicles and for fleets. The emergence of new business models and their acceptance (for consumers and for businesses having to adapt) takes time and can slow down the rollout of rival technologies to O&G.
- However, once new business models are developed they can more rapidly promote change and reduce O&G consumption.

New infrastructure investment required.

- The energy transition will require new investment across a number of areas. Business models may require change to enable this investment, while ensuring fairness in terms of who pays. For example, the cost of solving the Scottish grid constraints that prevent dispatch of renewable electricity will fall on electricity customers using renewable power.

Key theme 4: Consumer expectations

Consumer expectations can be critical in driving change.

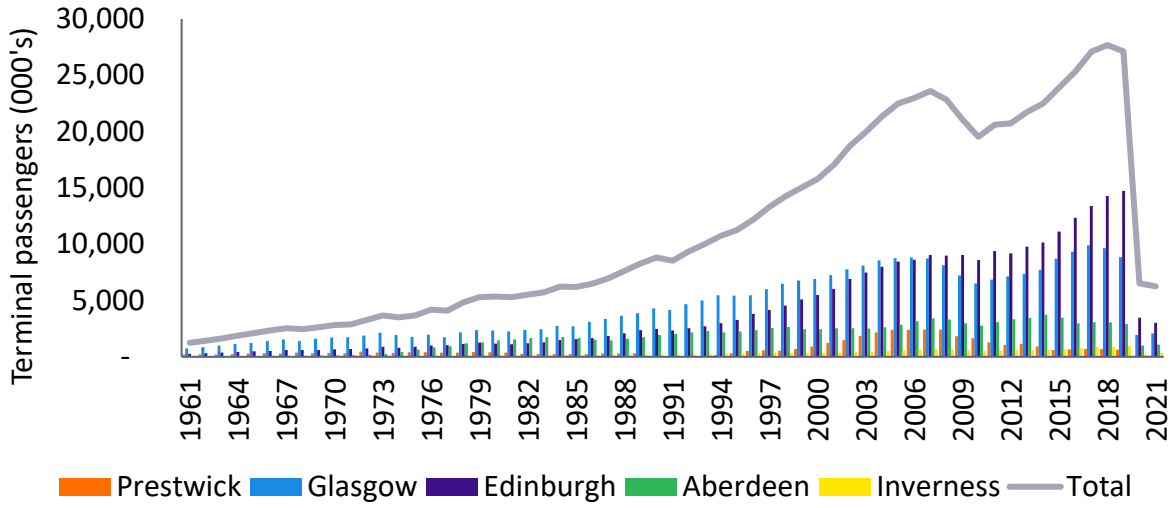
- The development of patterns of consumption has embedded an expectation of relatively low energy prices among consumers, in areas such as heating of homes and certain areas within the travel sector. Although many consumers have started signalling a willingness to change consumption patterns on environmental grounds, high expectations continue to reinforce demand for cheap and accessible O&G, resulting in continued emissions. The transition will likely require a continuing shift in public attitude as well as provision of high quality alternatives to fossil fuels in order to meet consumers' high expectations.

- For example, according to the Build Research Establishment's widely quoted model, the average room temperature in the UK today is around 18°C, compared to 12°C in 1970. Whilst an element of this increase can be explained by improved insulation measures such as double glazing in older homes, consumers' expectations of thermal comfort have also been raised by central heating at home and at work.
- The ESC models future energy scenarios (FES) which highlight different rates of increase in the average temperature of homes. The social change driven scenario (SOC) assumes 19.5°C while business-as-usual assumes 20°C; this drives different outcomes in terms of O&G consumption and therefore emissions.

Expectations of cost and convenience can embed use of O&G.

- The existence of cheap and convenient energy uses and their development over time can change the ways in which people act and consume, and develop expectations.
- An example is the cost and availability of air travel: competition and efficiencies in the sector drove down the comparative price from the 1970s onwards, meaning that consumers became used to cheap air travel to a wide variety of destinations. Customer expectations mean that it is more difficult to introduce changes that would reduce the utility available to consumers.
- Passenger numbers are beginning to rebound from the COVID-19 pandemic, with future demand expected to continue increasing.
- O&G use has not remained static, but has been subject to efficiencies and changes that have led to new consumer expectations. At the same time consumers do not always value low carbon alternatives – such as a zero emission versus a diesel bus, because other factors (punctuality and journey time) are so much more important to them.
- It is clear that there is a lot of discussion and publicity in green alternatives for consumers, but this takes place against a backdrop of expectations created by the ease of use of O&G.

Terminal Passengers from the main Scottish airports 1961-2021



Source: Civil Aviation Authority Terminal passengers 1961 – 2021

Key theme 5: Government policy and economic growth

Governments and regulators have supported O&G consumption.

- Over time, O&G has become embedded across a broad spectrum of sectors in Scotland, making a significant economic contribution, albeit in many cases this has been unevenly distributed. It has been supported and encouraged by **governments and regulators**. Even where change has been targeted (for example, historical reform that promoted cleaner fuels such as gas rather than coal) this has supported new technologies that continue to consume O&G. However, competitive alternative energy sources have not been available until recently and the availability of these alternatives gives both policy makers and consumers new choices.
- **Economic growth** has been a consistent objective for governments, and that objective has caused the pursuit of policies that have led to a continuation or an increase of O&G consumption over an extended period of time. For instance:
  - Governments have supported the expansion of air travel as an economic benefit, improving trade and connectivity. This has meant supporting airport expansion and increased consumption of aviation fuel.
  - Road transport has been seen as an economic benefit in terms of moving people (and expanding labour markets) and goods (both consumer goods and

goods moved between businesses). While support for road transport has fluctuated, ICE technology has been a feature of public policy as a facilitator of an efficient economy for a large part of the 20th century and the early 21st century.

Effects of policies aiming to modernise and reduce pollution.

- Policies to reduce pollution, or even to reduce emissions, have not always created the conditions for the transition to new technologies.
- Governments have pushed consumption toward cleaner fuels over a long period of time, but that has tended to reinforce O&G consumption, particularly that of gas. In heating and in the electricity generation sector, the replacement of coal with gas brought huge benefits in terms of emissions reductions, convenience and ease of use.
- Domestically the availability of natural gas was enhanced by government sponsorship of the distribution network and also the products (heating systems and cooking equipment) that used gas as fuel. In the 21st century, regulation was used to improve the efficiency of gas boilers.
- Coal remained a key part of delivering electricity for far longer and only suffered a radical reduction in its share of electricity generation production as a result of the obligations of the European Union (EU) Emissions Trading System (ETS) scheme and its UK successor.

Planning and placemaking.

- Particularly for transport, the requirements and needs of different transport types are shaped by where and how people live.
- For an extended period of time, planning was directly influenced by mobility assumptions enabled by cars, and this influenced housing policy and planning as well as road building. The longevity of the decisions made in these areas creates inertia in terms of changing lifestyles and particularly affecting the effectiveness of demand management policies.
- This is now changing, with more thought being given to integrated transport solutions in planning new development, but it is not always straightforward to ensure strong public transport links for new developments.

With the key factors driving Scotland's current pattern of demand established, policy interventions are required to support the energy transition.

To design the policy response it is critical that we take barriers into account to ensure that new technologies can be developed and implemented. Low carbon technology is at an inflection point where the rollout into heat and transport can begin to decarbonise the economy.

Our analysis highlights several key areas where solutions can be targeted. These policies, for a range of sectors of the economy, will be required to move towards net zero and to support an energy transition. Chapter 3 of our main report sets this out in more detail, but we have summarised a selection of these below.

Category	Policies & interventions
Technology and cost	► Although progress developing low carbon technology occurs at a global level, governments can support technologies by subsidising research at different points in the value chain – from basic scientific research to applications closer to market. ► This type of intervention can also help to secure the supply chain for new technologies in Scotland. Such examples might include: ► Funding for early stage research into new technologies such as wave or tidal energy. ► Funding for firms investing in manufacturing or other facilities. ► Targeted subsidies for renewables or other technologies can create markets and improve demand. These can work at a high level (such as CfDs for renewables) or using a more targeted approach, for example, including subsidies to incentivise purchase of zero carbon vehicles. Such interventions can bridge funding gaps to create a viable business case. ► Direct regulation can target technologies and drive change – such as the proposed ban on the sale of new ICE vehicles from 2030 onwards.

Category	Policies & interventions
Taxation, carbon pricing and levies	► Increasing the cost of O&G technologies through taxation can change the balance between technologies. O&G is already extensively taxed, but there are areas where this has not changed in recent years – for example, UKG has held or reduced the level of fuel duty over the past decade. ► The UK ETS is a 'cap and trade' scheme, which on an annual basis sets a cap on the total amount of relevant greenhouse gases that can be emitted by sectors covered by the scheme. In the scheme, within the cap, participants receive free allowances and/or buy emission allowances at auction or on the secondary market which they can trade with other participants as needed. Each year, installation operators and aircraft operators covered by the scheme must surrender allowances to cover their reportable emissions. The cap is reduced over time, which limits the total amount of carbon that can be emitted. This is intended to make a significant contribution to how the UK meets its legally binding carbon reduction commitments. ► Currently the cost of changing electricity generation technology and of building grid infrastructure falls on a certain set of customers. How regulators and governments choose to spread the burden of paying for new grid infrastructure can change how quickly and fairly this can be rolled out.

Policies & interventions	Category
Infrastructure, assets and business models	► Governments often either own assets such as the road and rail networks (and therefore the level of technological readiness for low carbon technologies that they have), or can control how they will evolve over time. ► Governments can also play a role in the evolution of new business models – potentially through funding not available in commercial markets. ► While regulators have duties to consumers and to companies, governments set the strategic direction and framework within which they work. Where certain outcomes – such as grid capacity – are important for decarbonisation, government can influence spending.
Consumer expectations	► Awareness of the costs of using O&G can be an effective part of policy, but action in specific areas is also required to accelerate change away from O&G. ► Policy can also target consumers' reluctance to change technology and the inertia that can affect different markets. In combination with subsidies, demonstrating that new technologies are effective for consumers can improve demand. Demonstrator projects and pilot schemes are an important part of improving the demand for new technologies and normalising their use. ► Direct programmes to educate consumers and show how new technologies can be employed and work well for them can be effective – for instance, Business Energy Scotland helps publicise energy and heat options. ► Measures to make active travel choices, such as walking and cycling, safer and more attractive options can change the structure of choices made by consumers in transport markets.

Policies & interventions	Category
Actions of government and regulators	► Current patterns of usage have been driven by governments pursuing economic growth and other policy goals. ► One critical policy action is to ensure that the consequences of emitting GHG are considered alongside the merits of economic growth when looking at choice, investment decisions and policies. This can lead to difficult trade-offs but can be used to inform a wide range of policy making. Greater awareness and clear targets now mean that in contrast to the past, these trade-offs are more likely to be actively considered in making decisions. ► Planning policy can be changed and used in two ways: first, to influence the efficiency of new buildings and how they use energy and what sources of energy they use; secondly, to influence population locations - where people live is a key factor in the shape of transport demand and how people use transport networks.

5. Chapter 3 – Just Transition Scenario Analysis

Policymakers will need to actively manage the Just Transition and replace the declining O&G sector

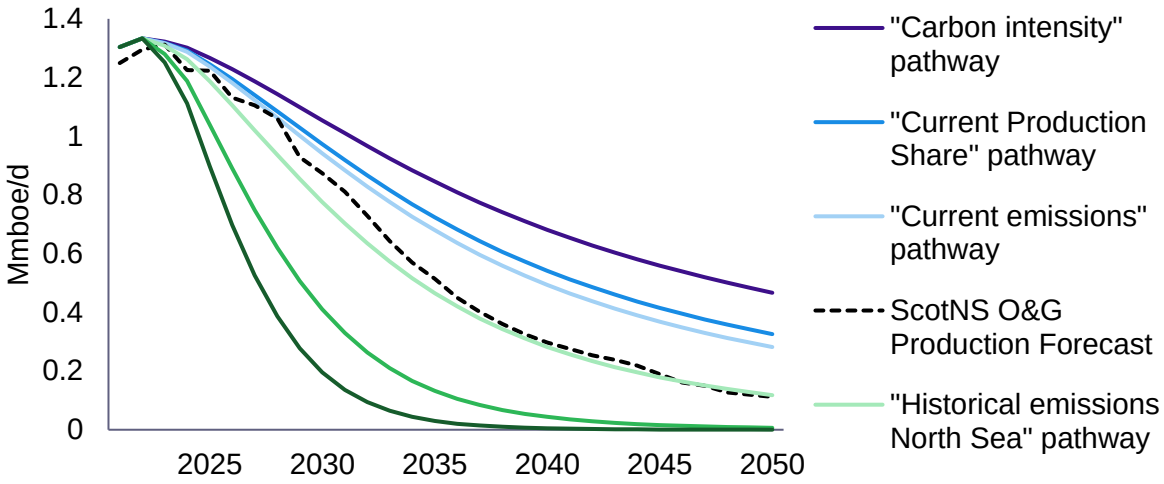
The Energy Transition creates a series of opportunities and challenges for Scotland, most notably, how Scotland can transition from the naturally declining O&G sector and take advantage of the emergence of Scotland's growing low carbon sectors, specifically wind, CCUS and hydrogen.

- Before exploring the positive impact of the new growth sectors, we assess a range of illustrative Scottish O&G decline scenarios which have been developed using EY's Fuelling the Future (FtF) model. These scenarios are all based on global carbon budgets in line with the Paris Agreement 1.5°C global temperature goal. We first explored a model where Scotland retains a constant share of global production. This initial model was then also adjusted for different factors, e.g. the "Carbon Intensity" scenario assumes that Scottish production would decline at a slower rate than the global baseline, because Scottish production is less carbon intensive than production in other countries. Please see Appendix B for the full methodology and assumptions underpinning each of the pathways.

- In reality there are numerous scenarios that could result in a given CO2 output, dependent on oil price, adoption rates, regulation and policy decisions, but the FtF model is constrained by UN carbon budgets to give the most credible mix of market assumptions.

- Our analysis compares the ScotNS O&G production forecast (based on the NSTA stewardship survey) with the Scottish O&G production pathways, highlighting a wide range of possible outcomes. This also provides a basis for ensuring that just transition planning accounts for the dynamics between the sectors in decline and the growth in the low carbon sectors.

Scotland's potential production pathways



Source: EY analysis

- The O&G sector's decline will be determined by a variety of complex economic, legal and policy factors. SG will therefore be unable to target a particular pathway as a matter of policy, even with greater devolved powers over the ScotNS O&G sector. The steepest decline lines would involve actively curtailing production in ScotNS fields that are already sanctioned (over 80% of future production will arise from existing sanctioned fields).

However, for the purposes of this analysis, we have assessed the potential impacts that these production pathways could have on Scotland.

- Decline scenarios that are steeper will accelerate job and GVA losses relative to shallower decline scenarios. These adverse effects would be particularly felt in the North East of Scotland where 98% of direct O&G jobs are located.

- Scottish O&G consumption is not driven by levels of domestic production. If Scotland's demand for O&G is not reduced, less domestic production will eventually result in greater reliance on imported O&G, and depending on where those supplies come from, this could increase global emissions. A steeper pathway could mean Scotland contributes to reducing global emissions, as long as reduced Scottish O&G production is not replaced by more emissions-intensive international production.

- Scotland's ability to be a low carbon energy leader and to be at the forefront of the energy transition is unlikely to correlate with the speed of the decline in the Scottish O&G sector. The scale of investment in the UK and global low carbon sector is already significant from companies involved in O&G and those only working in low carbon sector. As such, a steeper ScotNS O&G production decline would not necessarily accelerate the energy transition.
- A more gradual pathway would allow more time for low carbon energy supply chains to be established, for workers to be reskilled and infrastructure repurposed.

	Steepest pathway (Historical Emissions Scotland)		Middle pathway (Historical Emissions North Sea)		Shallowest pathway (Carbon Intensity)	
	Jobs	**GVA (£m)**	**Jobs**	**GVA (£m)**	**Jobs**	**GVA (£m)**
2019	56,980	15,883	56,980	15,883	56,980	15,883
2030	8,353	2,078	33,127	8,242	44,995	11,194
2050	11	2	6,473	1,166	25,658	4,621

Source: EY analysis

Scotland's low carbon energy production sectors will continue to grow and replace the lost jobs from the O&G sector, but GVA will be harder to replace

Scotland's low carbon sector already has an established economic footprint, but currently supports fewer, less well paid jobs than the O&G sector.

- In 2019, Scotland's low carbon energy sector supported over 19,000 direct and indirect jobs (0.8% of all of Scotland's total employment) and contributed £2.9bn in direct & indirect GVA to Scotland's economy (1.6% of Scotland's total GDP). In comparison, 57,000 jobs were supported by Scotland's O&G sector and its supply chains in 2019, and a corresponding £16.0bn GVA contribution.

- Nuclear power generation and decommissioning makes up roughly a third of the contribution to low carbon sector GVA. Of the £2.9bn sector GVA, an estimated £0.9bn related to nuclear power generation and decommissioning[6] and the remaining £2.0bn related to the rest of the low carbon sector (1.2% of Scotland's total GDP).

The sector's economic footprint will eventually replace the jobs lost in the O&G sector.

- To understand the expected growth in the low carbon sector, we based our analysis on ESC's "whole system energy model" which explores a range of scenarios for Scotland's future energy consumption. The scenarios analyse the implementation of Scotland's future low carbon technologies to 2050, focusing on the key areas of offshore wind, hydrogen and CCUS and the expected output (e.g., GW) from these technologies. Please see appendix A for more information on the ESC scenarios.

- We link the growth in these technologies to increases in economic output, offsetting the losses from O&G decline. Our economic analysis (jobs and GVA) also assumes that Scotland will gain a significant share of the future low carbon supply chain. Although Scotland has a world class O&G supply chain, this is not guaranteed for the low carbon sector.

- The graphs alongside demonstrate the rates of change for jobs and GVA vary across each ESC scenario, with growth in jobs and GVA in the 'Balanced Options' (BOP) and 'Technology' (TEC) scenarios, and a decline in the 'Societal Change' (SOC) scenario. The BOP is the central scenario striking a balance between technology innovation and the societal change needed to meet climate change targets. It also results in the closest outcome to net-nil job[7] losses under the ScotNS O&G decline scenario. Analysis shows:

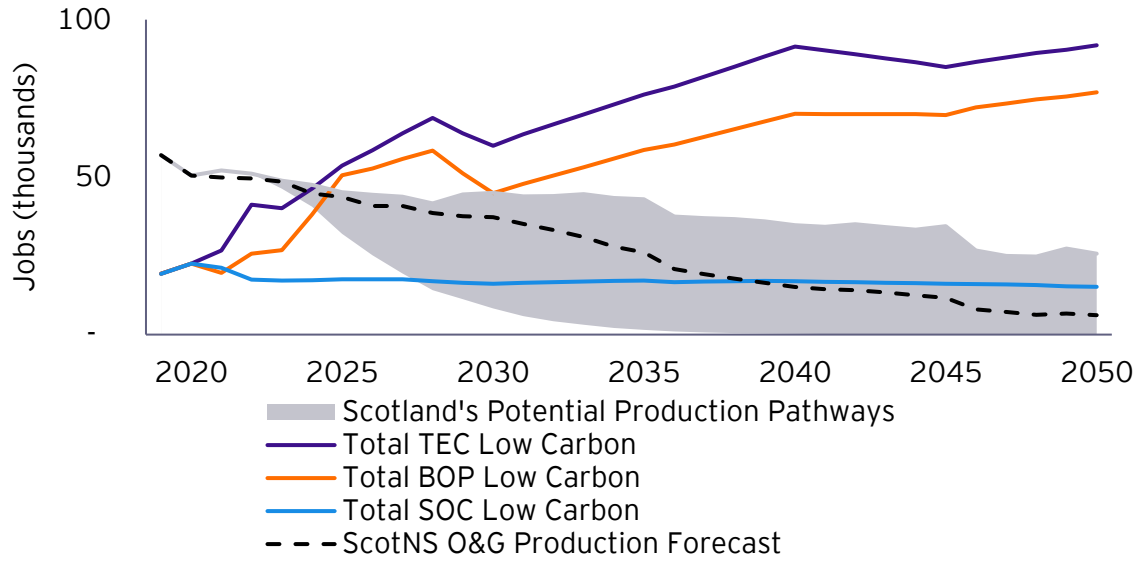
    - When comparing the growth in low carbon jobs per the BOP model against the decline in jobs per Scotland's potential production pathways (EY analysis) four

[6] Decommissioning will lead to the eventual phase out of nuclear in Scotland.
[7] "Net-nil job losses" refers to a position where the gain in low carbon jobs fully offsets the loss of O&G jobs and there is a nil change in energy sector jobs across O&G and low carbon energy.

of the decline pathways result in an overall increase in total energy jobs from 2024 onwards. By 2049 all pathways are expected to reach net job gains (i.e. growth in low carbon jobs exceeds the loss in O&G jobs).

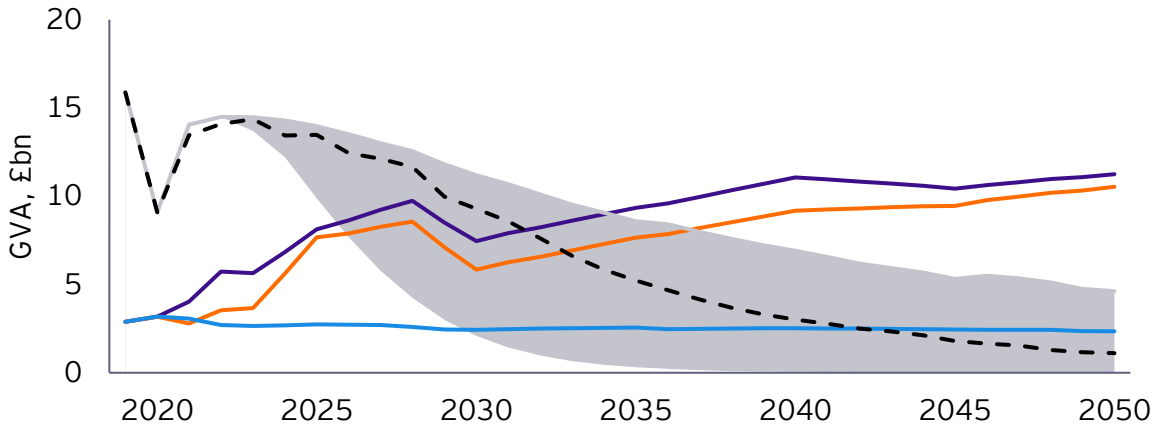
- Under all O&G decline pathways, total Scottish energy GVA is expected to decline from 2030 onwards. This is because O&G GVA per job exceeds the GVA per job value in the low carbon sector.
- Our analysis did not consider the impact on the wider economy of the energy transition, e.g., through increased retrofitting.

Change in O&G jobs under adjusted O&G pathways, with ESC scenarios (direct & indirect jobs)



Source: EY analysis

Change in O&G GVA under adjusted O&G pathways with ESC scenarios (direct & indirect)



Source: EY analysis

There is potential for wind, CCUS and hydrogen to fill the gap left by O&G but significant and early investment and policy intervention is required to support this growth

Significant investment is required to support the growth in jobs and GVA

- We estimate the total level of investment required to 2050 in offshore wind, CCUS and hydrogen production to offset the loss of O&G jobs to be **£33.3bn, split across the three key sectors: offshore wind (£21.5bn), CCUS (£1.9bn) and hydrogen (£9.9bn).**

- The £33.3bn above does not represent the total investment required to implement the ESC BOP scenario, as our analysis is focused on three specific subsectors (**wind, hydrogen and CCUS**), whereas the BOP scenario contains a wider set of subsectors (including biomass, solar, etc.). Additionally, we have not profiled these investment figures over time, due to the absence of third party data from the ESC model.

- We calculate that offshore wind generation capacity would need to stand between 14 and 23 GW in 2050 in order to achieve net-nil job losses, or 33 and 46 GW to achieve net-nil GVA losses across the adjusted pathways. Levels of carbon captured in 2050 would need to reach between 16 and 26 MtCO2e to achieve net-nil job losses, or between 38 and 52 MtCO2e to achieve net-nil GVA. Similarly,

between 6 and 9GW (42 and 71TWh) of hydrogen would need to be produced to achieve net-nil job losses, compared to 14 and 19 GW (101 and 140 TWh) needed to achieve net-nil GVA losses.

- The BOP scenario forecasts offshore wind generation to be 23 GW, carbon captured will be 26 MtCO2e carbon, and hydrogen production to be 9 GW in 2050. In all cases, the BOP scenario forecasts that net-nil jobs will be achieved, but net-nil GVA will be more challenging.

Each of the main low carbon sectors is likely to require a different investment model or an adapted model to allow for the scale of investment required

- We anticipate that several potential routes are needed to realise this investment, including a combination of government support, regulated models and private sector investment.

- **Offshore Wind: We expect the Contract for Difference (CfD) to be the best value for money** and most established model in the future. It is likely to be successful in attracting private sector investment.

- **CCUS: UKG has established a business model for CCUS** investment. The transport and storage (T&S) element will be economically regulated, and government will subsidise emitters through a set of business models based either on the CfD for industrial and waste emitters, or the Dispatchable Power Agreement (DPA) for power emitters. The economic regime for T&S and the contracts for emitters have not yet been completed and tested in the market, but promoters have indicated they are willing to commit equity. Acorn (the Scottish CCUS cluster) is currently on track 2 of the government's cluster sequencing process.

- **Hydrogen: this is the least mature business model.** A model for blue hydrogen is being developed that is based on the CfD, with a variable reference price depending on whether there is a market for low-carbon hydrogen. This will depend on there being suitable off-takers, but it is intended to be financeable taking into account the technology risk.

- Although these investment models either exist, or are in development, they will come at a cost. Additionally, the models, particularly CCUS, are being actively developed by UKG and bound to the UK energy system.

There is a potential for wind, CCUS and hydrogen to fill the gap left by O&G but several key issues must be addressed before the jobs and GVA are realised

- Scotland must invest in its Low Carbon sectors to meet its Net Zero targets by 2045. These sectors present opportunities for Scotland, help to create jobs, counteract a decline in GVA and support a Just Transition. However, to maximise the benefits, several issues must be considered and opportunities explored:
  - Wind technology is mature, cost effective and provides a potential route to meet Scotland's future electricity demands. The ScotWind leasing round, which secured 27GW of offshore wind generation capacity, highlights the sector's established nature. However, **wind power alone suffers from intermittency**[8] and currently relies on natural gas as a flexible back up. Tackling intermittency is a significant challenge for the sector, and will require the development of other low carbon technologies, such as wave and tidal, to maintain the base load. Currently these are more immature and much more expensive than wind power. There are also capacity constraints with the existing grid, which will need to be expanded to cope with increased electricity generation. Supporting the development of a supply chain that can meet this capacity is another vital opportunity to unlock.
  - Scotland has significant carbon storage potential with well-mapped, vacant O&G stores in the North Sea. Carbon capture technology can be implemented in high emitting sectors or to support hydrogen creation. However, **the designation of a CCUS cluster in Scotland requires support from the UKG.** Hydrogen may assist in the decarbonisation of hard to abate sectors such as industry and specific transport modes whilst also serving as a dispatchable low carbon energy source. Generating hydrogen is still expensive but there is growing international interest. The creation of green hydrogen

8 The Crown Estate, the UK Energy Research centre and other bodies study wind variability. Some years, e.g. 2021, can be exceptionally calm with only a few months providing power above the long-term average. This variability also impacts prices.

would require upscaling of Scotland's renewable energy capacity to meet demand. The creation of this new industry would require government support.

Policy interventions are required to stimulate growth in low carbon technologies, develop a supply chain, develop people and skills and ensure communities are not left behind

Policy recommendations to support growth in the Low Carbon sector

- Our report recommends SG policies and interventions that will help to achieve a Just Transition, building on the analysis across the three reports about the prospects for the O&G industry, how current patterns of consumption have evolved, and what the economic prospects are for new, low carbon, industries.

- It highlights that the growth in the low carbon sectors will help to replace the lost jobs and the economic output associated with the decline in the O&G sector. However, although growth in these sectors will replace many of these jobs, our analysis indicates that replacing the GVA associated the O&G sector will not occur before 2050.

- To achieve this growth will require **policy interventions to stimulate growth in low carbon technologies.** Interventions are also crucial to **develop a supply chain in Scotland** which is capable of replacing the Scottish O&G supply chain and subsequently securing Scotland's position as a major global player in the low carbon sector. To create a Just Transition, polici**es that support the development of people and skills** will ensure no-one is left behind.

- Lastly, and importantly, **policies are also needed to ensure that all communities in Scotland,** including the North East of Scotland, **are protected through the transition.** A full list of the proposed interventions and their timescales has been developed in Chapter 3.

- To ensure that these pathways are achievable, decisions are required imminently to ensure the growth of the wind, hydrogen and CCUS sectors and the development of their supply chains.

Risks associated with the ESC BOP scenario

Our analysis utilises the ESC BOP scenario which contains several assumptions regarding Scotland's future energy scenarios. If the assumptions are not met, there is a risk that the future energy scenarios are not realised. The key risks are:

- The timing and development of the Scottish CCUS cluster
- The development and implantation of a successful hydrogen business model and the need for available off-takers
- The development of capacity market to resolve intermittency issued is developed at scale
- The scale and speed of rollout of the wind sector.

A range of policy levers must be implemented to support a Just Transition. This needs to happen imminently[9]

Policies & interventions	Category	Timing	Owner
Carbon Pricing lobbying	Offshore/Onshore Wind	pre-2025	UKG
Innovation funding supporting technology development	Offshore/Onshore Wind	pre-2025	UKG/SG
Development of the capacity/storage market	Offshore/Onshore Wind	pre-2025	UKG/SG
Investment in the grid network	Offshore/Onshore Wind	pre-2025	UKG
Support for future renewable auctions	Offshore/Onshore Wind	Ongoing	UKG/SG

[9] For further information on each policy, please see Chapter 3.

Policies & interventions	Category	Timing	Owner
UKG support for CCUS clusters	CCUS	By 2026 (potential Acorn Final Investment Decision (FID))	UKG
UKG commitment to expansion phase for Acorn	CCUS	By 2026 (potential Acorn FID)	UKG
Devolved power and funding	CCUS	pre-2025	SG/UKG
Regulatory regime set up for export	CCUS	2025-2030	UKG
Development of a commercial model for green hydrogen	Hydrogen	2025-2030	UKG/SG
Implementation of the blue hydrogen business model	Hydrogen	By 2026 (potential Acorn FID)	UKG
Regulatory support for blending	Hydrogen	For start of production at Acorn (assumed 2028)	UKG
Support mechanisms for off-takers	Hydrogen	When low carbon hydrogen is widely available (assumed 2025-2030)	SG
Forecasting and planning for future needs	People & skills	pre-2025	SG
Alignment of qualifications	People & skills	pre-2025	SG
Career path support	People & skills	pre-2025	SG
Targeted skills funding	People & skills	pre-2025	SG
Regional enterprise zones and Green Freeports	Regional and community impact	pre-2025	SG

Policies & interventions	Category	Timing	Owner
Direct support for those in fuel poverty	Regional and community impact	pre-2025	SG
Support for those in fuel poverty to reduce energy bills	Regional and community impact	pre-2025	SG
Support for regional Infrastructure development	Regional and community impact	pre-2025	UKG/SG
Targeted investment as part of the Just Transition and other future regional funds	Regional and community impact	2025 - 2035	SG
Mapping of short and medium term supply chains	Supply chain	pre-2025	UKG/SG
Attracting FDI	Supply chain	Ongoing	UKG/SG
Access to finance	Supply chain	pre-2025	UKG/SG
Infrastructure and enabling work	Supply chain	pre-2025	UKG/SG
Competitive funding	Supply chain	pre-2025	UKG/SG
Innovation hubs, e.g., catapult mechanisms	Supply chain	pre-2025	UKG/SG
Funding for technology and early stage companies	Supply chain	pre-2025	UKG/SG
Business support inc. start-up/scale-up hubs, advice, grants	Supply chain	pre-2025	UKG/SG
Contractual mechanisms	Supply chain	pre-2025	UKG/SG

6. Appendix A: Energy System Catapult methodology

Scottish low carbon energy scenarios – ESC

To understand the expected growth in the low carbon sector, we based our analysis on the ESC and its three scenarios exploring Scotland's future energy trajectories.

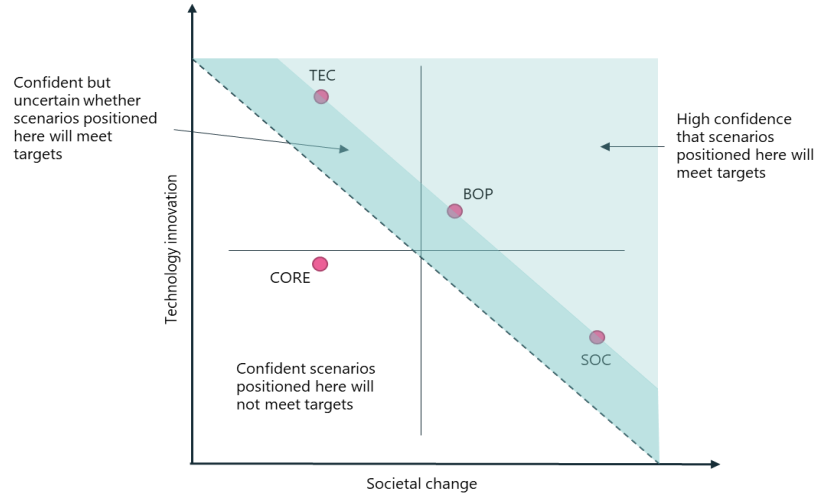
ESC scenarios[10]

- SG and CXC commissioned ESC to develop a set of Scotland-specific whole energy system scenarios. These scenarios demonstrate four qualitatively different routes for Scotland to meet its emissions reduction targets, allowing different choices and potential implications to be explored.
- Technology innovation refers to the extent of innovation in several key technologies important for net zero, including engineered GHG removal and a well-established Scottish supply of biomass. Societal change on the other hand refers to the ability and willingness of people to adopt behaviours more consistent with the net zero transition, including reducing demand for heat, car and air travel and preference for a nature based greenhouse gas removal options.
- Using this framework four scenarios were developed, of which only three would successfully meet Scottish and UK GHG interim and Net Zero targets. These three scenarios are outlined below:
  - **TEC:** TEC was able to remove significant amounts of CO2 by direct air capture and bioenergy with carbon capture and storage used to produce hydrogen and electricity. This reduced the level of societal change necessary to meet targets thus minimising the impact on people's lifestyles.
  - **SOC:** The lower energy demands assumed in SOC meant targets were achievable with far lower amounts of biomass and engineered removals of CO2.
  - **BOP:** BOP combined some technology innovation with some degree of societal change to meet GHG targets in a more moderate way than TEC or SOC.

[10] ClimateXChange - Scottish Whole Energy System Scenarios report, January 2022

- In addition, there is a CORE scenario by ESC which is not 1.5°C compliant, and is hence excluded from the Just Transition.
- The BOP scenarios was determined to be the most plausible scenario and resulted in the closest outcome to net-nil job losses when compared to the ScotNS O&G decline scenario. Hence this scenario has been used as a starting point for further adjustments to the low carbon energy activity levels to achieve net-nil job losses across each of the O&G production pathway scenarios, and understand the minimum required amount of low carbon energy investment and policy in each O&G production pathway scenario.

ESC scenarios



Source: ESC

7. Appendix B: Methodology for development of Scottish Potential Production Pathways

Methodology for development of Scottish Potential Production Pathways

Introduction

We have developed a range of potential Just Transition scenarios which are all based on global achievement of the Paris Agreement 1.5°C goal, but with different assumptions for how the emissions associated with future O&G production and usage are distributed globally. These scenarios lead to very different potential pathways for the Scottish O&G sector, while highlighting what the Just Transition could involve for Scotland and its people. We have set out below a definition of each scenario, a methodology for how each scenario has been calculated, and any assumptions or limitations of our approach and the data sets available.

Approach

We have calculated a percentage adjustment to the Current Production Share Pathway (a "factor") for each scenario by comparing the performance of Scotland (based on UK where data was unavailable) against other O&G producing countries. We have focused on O&G producing countries because the purpose of this analysis is to understand how Scotland’s O&G sector could decline relative to other O&G producing basins. Our analysis includes O&G producing countries that contributed more than 0.5% of global O&G production in 2019 as per the BP Statistical Review of World Energy. We then adjust the Current Production Share Pathway rate of decline by the factor. This methodology should not be taken to imply that the Current Production Share Pathway is in any way preferred to the other scenarios presented below.

	Scenario	Definition	Methodology	Assumptions/limitations	Data set
1	**Comparative carbon intensity of production**	To minimise the environmental impact of O&G production, extraction should decline at a faster rate in areas that have a higher carbon intensity of production	► Obtain an emissions factor (how much greenhouse gas is omitted per unit) for O&G producing nations ► Calculate the weighted average carbon emissions intensity of production across nations ► Compare UK carbon intensity to the weighted average, calculating in percentage terms how UK carbon intensity compares to the weighted average ► Adjust the Current Production Share Pathway rate of decline by this percentage	► UK carbon intensity aligns with ScotNS carbon intensity ► Oil carbon intensity is a reasonable proxy for O&G carbon intensity ► Does not take into consideration how variable carbon intensity of production could be within each country or transportation emissions ► Current carbon intensity gives a reasonable expectation of future carbon intensity (does not account for national plans or deals to improve carbon intensity of production, e.g., NSTD)	► Carbon intensity of crude oil production (measured in gCO2eq/MJ) from journal supplementary materials Global carbon intensity of crude oil production (science.org)

	Scenario	Definition	Methodology	Assumptions/limitations	Data set
2	**Historical emissions caused (North Sea production/global production)**	Countries that have produced greater quantities of O&G have made a greater contribution to emissions and have extracted more economic benefits. Production should therefore decline at a faster rate	► Obtain estimates of historical O&G production by country ► Apply emissions factor estimates to production volumes to calculate historical emissions caused by production ► Using 2020 population estimates, calculate historical emissions from production per capita ► Calculate the average historical emissions caused per capita across producing countries ► Calculate a factor by comparing UK historical emissions caused per capita to the global average, ► Adjust the Current Production Share Pathway rate of decline by this percentage	► Takes UK historical emissions per capita as the basis for the ScotNS– given that ScotNS O&G has been treated as a UK resource, the benefits have not been exclusively held within Scotland ► Does not consider emissions from production ► O&G extracted has a uniform emissions intensity irrespective of location	► Production data per country taken from Our World in Data: https://ourworldindata.org/fossil-fuels which uses BP Statistical Review of World Energy ► Emissions factors taken from Our World in Data: https://ourworldindata.org/fossil-fuels which uses Intergovernmental Panel on Climate Change (IPCC) emissions factors

	Scenario	Definition	Methodology	Assumptions/limitations	Data set
3	**Historical emissions (UK wide)**	Nations that have contributed a greater amount to historical global carbon emissions should transition at a faster rate	► Obtain data on historical CO2 emissions for O&G producing countries and calculate historical emissions per capita ► Calculate an average historical CO2 emissions per capita for O&G producing nations ► Compare historical UK emissions per capita to the average across O&G producing nations, calculating in percentage terms how UK historical CO2 emissions per capita compare to the average ► Adjust the Current Production Share Pathway rate of decline by this percentage	► UK emissions per capita are comparable to Scotland's emissions per capita ► All carbon emissions are of equal importance, therefore there is no weighting towards historical or recent emissions ► CO2 emissions are measured on the basis of production ► CO2 emissions are from fossil fuel use and do not consider land use (e.g., impacts of deforestation)	► The Global Carbon Project fossil fuel emissions data accessed through Our World in Data: https://ourworldindata.org/fossil-fuels ► Our World in Data historical emissions data covers period from 1750 to 2019. ► Population data taken from UN World Population Prospects 2019: https://population.un.org/wpp/Download/Standard/Population/

	Scenario	Definition	Methodology	Assumptions/limitations	Data set
4	**Current emissions on per capita basis**	Nations that have higher emissions per capita should transition at a faster rate	► Obtain data on CO2 emissions for O&G producing countries and calculate emissions per capita ► Calculate an average current CO2 emissions per capita for O&G producing nations ► Calculate UK CO2 emissions per capita, apply an adjustment to this figure using ONS regional CO2 emissions data to estimate Scotland CO2 emissions per capita ► Compare Scotland CO2 emissions per capita to the average across O&G producing nations, calculating in percentage terms how Scotland emissions per capita compare to the average ► Adjust the Current Production Share Pathway rate of decline by this percentage	► CO2 emissions are measured on the basis of 'production' ► CO2 emissions are from fossil fuel use, including coal, and do not consider land use change (e.g., impacts of deforestation)	► The Global Carbon Project fossil fuel emissions data accessed through Our World in Data: https://ourworldindata.org/fossil-fuels ► 2019 emissions have been used as the basis for current emissions. ► Population data taken from UN World Population Prospects 2019: https://population.un.org/wpp/Download/Standard/Population/ ► Scotland CO2 emissions per capita, calculated by adjusting UK CO2 emissions per capita using ONS 2019 regional emissions data: https://data.gov.uk/dataset/723c243d-2f1a-4d27-8b61-cdb93e5b10ff/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2019

	Scenario	Definition	Methodology	Assumptions/limitations	Data set
5	**Comparative affordability for producing countries**	Countries that are more able to afford to transition from fossil fuels should transition at a faster rate	► Obtain GDP per capita for O&G producing nations ► Calculate the average GDP per capita for O&G producing nations ► Adjust UK to Scotland figures by multiplying UK GDP per capita by the ratio of Scottish to UK GDP per capita, calculated using ONS data (Scotland GDP per capita/UK GDP per capita), ► Compare Scottish GDP per capita to the average across O&G producing nations, calculating in percentage terms how UK GDP per capita compares to the average ► Adjust the Current Production Share Pathway rate of decline by this percentage	► GDP per capita is a reasonable basis for assessing different nations' ability to transition from fossil fuels ► Does not take into account how dependent a country might be on O&G and how diversified an economy might be. Further work is required to incorporate reliance on O&G into the affordability scenario.	► World Bank GDP per capita for 2019: https://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG?locations=1W ► Population data taken from UN World Population Prospects 2019: https://population.un.org/wpp/Download/Standard/Population/ ► UK GDP per capita adjusted to Scotland GDP per capita by multiplying by the ratio of Scottish to UK GDP taken from ONS 2019 regional economic data: https://www.ons.gov.uk/economy/grossdomesticproductgdp/bulletins/regionaleconomicactivitybygrossdomesticproductuk/1998to2019

8. Appendix C: Transmittal letter

Reliance Restricted

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Just Transition Review of Scottish Energy 15 February 2023
Sector – Summary report

Dear Sir/Madam

In accordance with our engagement letter dated 22 October 2021, we have prepared our report in relation to the Scottish Government's Just Transition review of the energy sector. This report relates to the Summary Report, the development of outputs to support the co-design of the Energy Strategy and Just Transition Plan.

Purpose of our report and restrictions on its use

This report was prepared on your instructions solely for the purpose of the Scottish Government and should not be relied upon for any other purpose. Because others may seek to use it for different purposes, this report should not be quoted, referred to or shown to any other parties except as permitted under the Engagement Letter. Additionally, we have agreed that you may publish the whole of this report as a single document without amendment or redaction as a portable document format (pdf) file on the world wide web.

In carrying out our work and preparing our report, we have worked on the instructions of the Scottish Government. Our report may not have considered issues relevant to any third parties. Any use such third parties may choose to make of our report is entirely at their own risk and we shall have no responsibility whatsoever in relation to any such use.

Scope of our work

Our work in connection with this assignment is of a different nature to that of an audit. Our report to you is based on inquiries of, and discussions with, the Scottish Government and Transport Scotland. We have not sought to verify the accuracy of the data or the information and explanations provided by the Scottish Government and Transport Scotland.

This report provides analysis to support the development of the Scottish Government's Energy Strategy and Just Transition Plan, including future O&G production forecasts, Scotland's energy requirements and how Scotland's energy activity aligns with its climate change commitments. Additionally, we explore the Just Transition impacts of a declining O&G sector and a rise in employment in low carbon sectors. Any subsequent policy decisions will be informed by the full package of analysis completed from all of the phases of the project and not just the conclusions of this report.

If you would like to clarify any aspect of this review or discuss other related matters then please do not hesitate to contact us.

Yours faithfully

Ernst and Young LLP

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