REIMAGINING A NET ZERO NORTH SEA

AN INTEGRATED ENERGY VISION FOR 2050

CATAPULT Offshore Renewable Energy | Technology Driving Transition OGTC

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INVESTING NOW FOR 2050 – AND BEYOND

The UK offshore energy sector has reached a pivotal moment, a watershed in our industrial history. We are at a threshold when the experience and expertise forged over the last 50 years must be used in partnership with transformational low-carbon technologies to meet the challenges – and grasp the opportunities – presented by the UK's commitment to net zero.

A reimagined North Sea, an integrated net zero energy system, can lead this global drive to deliver the commitments of the Paris Agreement. Up to £416bn investment is required over the next 30 years, but this creates a fantastic business opportunity that by 2050 could potentially contribute £125bn per year to the UK economy, while supporting more than 230,000 jobs.

Delivery of a transformation of this magnitude, building on the skills and capabilities already present across the UK energy sector, will not only help deliver the net zero goal but reinvent our nation for a sustainable future – creating a sector with technology, skills, services and an innovative ecosystem which will be a global leader and exporter in the net zero economy.

There are challenges to delivering this integrated energy vision. This report outlines three possible scenarios. They are not definitive, however they clearly show the size of the potential prize and, importantly, the risks of inaction: the potential loss of jobs; the loss of transferable skills, and the loss of our competitive position globally.

This is a time for action, for a clear strategy and for cross-sector collaboration. We are pleased to present this report from OGTC and ORE Catapult which, in addition to our own analysis, has benefited from significant input from a range of cross-sector energy organisations.

We hope this report will be a catalyst for action and stimulates urgent investment to make sure that we, as a nation, seize the opportunity to lead the world with the development of technologies for a net zero energy future.

Professor
Dame Anne Glover CBE
Non-Executive Director
ORE Catapult

Martin Gilbert
Chair
OGTC

A SHARED VISION FOR THE UK'S ENERGY INDUSTRIES

The innovation required to deliver an affordable net zero energy future is a transformational opportunity for the offshore oil and gas and renewable energy sectors. Now is the time to focus on the synergies between these two sectors to reimagine the North Sea.

We are excited that our organisations are at the heart of this change, alongside industry, government and academia. The potential for investment in clean technology to drive green economic growth, high value jobs and global export opportunities is equally exciting.

The creation of an integrated net zero offshore energy system requires hundreds of billions of pounds of investment, but can generate trillions in value. It can deliver affordable energy for homes and businesses in communities across the country, as well as maximising opportunities for export of services, electricity and hydrogen, whilst minimising reliance on imports.

It can capitalise on our combined skills, expertise and capabilities, generating substantial economic value while fulfilling our net zero ambitions. This report identifies major innovation opportunities, but also the impact of failing to act.

The North Sea energy industries can be world-beating in this net zero economy, with a diversified supply chain that meets UK energy demand while simultaneously providing next-generation technologies here in the UK and in markets around the world.

Early investment is crucial to sustain and create jobs, secure technology leadership, drive down emissions and capitalise on export opportunities.

FAILURE TO ACT NOW WILL RESULT IN SIGNIFICANT JOB LOSSES OVER THE NEXT DECADE AND SERIOUSLY UNDERMINE OUR COMPETITIVENESS

This UK is, and can continue to be a global energy leader.

1. THE COUNTRY CAN BE A SUPPLIER OF ENERGY, RATHER THAN A BUYER

2. WITH INVESTMENT NOW, THE UK CAN BE A WORLD LEADER IN THE DEVELOPMENT AND EXPORT OF NET ZERO ENERGY TECHNOLOGIES

3. WE CAN RETAIN OUR COMPETITIVE POSITION IN ENERGY SKILLS, CAPABILITY AND JOBS

The four nations of the United Kingdom must deliver as much of our energy demand as possible from our indigenous resources, not just in the North Sea but across the UK. With appropriate investment at pace, we can leverage and capitalise upon our existing capabilities to be the supplier of next generation, net zero energy technologies. This will ensure that we create new jobs and a vibrant, competitive supply chain delivering innovative solutions at home and internationally.

This report outlines three potential scenarios to deliver this opportunity, to reimagine the North Sea and build on our strong energy foundations. Each scenario requires clear intent, supportive policies, investment at pace and strong alignment to unlock our vast potential over the next 30 years and beyond.

Each scenario, however, is vastly different and varies not only in energy mix, but also in the level of social and economic impact.

WHAT THESE SCENARIOS MAKE CLEAR HOWEVER, IS THAT WE MUST ACT AND INVEST NOW OTHERWISE THE OPPORTUNITY TO REALISE ANY OF THESE BENEFITS COULD BE LOST

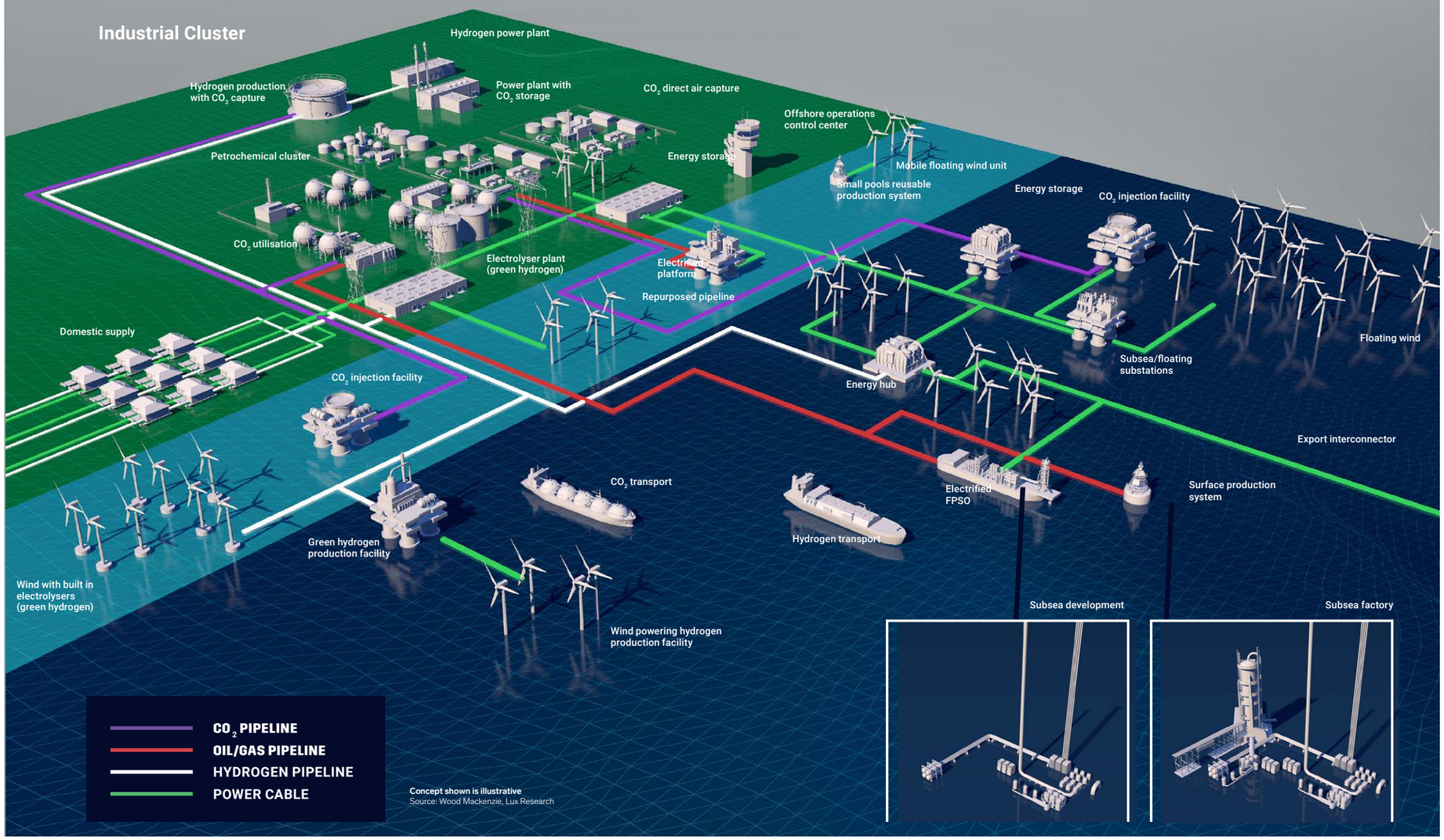
OGTC and ORE Catapult are excited to share this vision for the future; to outline our ambition to work in collaboration with industry, government and academia to deliver innovative technologies to drive down costs for the consumer. Let's seize the moment.

Colette Cohen OBE
CEO
OGTC

Andrew Jamieson
Chief Executive
ORE Catapult

EARLY INVESTMENT IS CRUCIAL TO SUSTAIN AND CREATE JOBS, SECURE TECHNOLOGY LEADERSHIP, DRIVE DOWN EMISSIONS AND CAPITALISE ON EXPORT

THE SIZE OF THE CHALLENGE IS SURPASSED ONLY BY THE POTENTIAL REWARDS OF SUCCESS



NET ZERO NORTH SEA: AN INTEGRATED ENERGY VISION FOR 2050

The UK offshore energy sector faces a fundamental challenge: how best to build on the hard-won technological advances of the last 50 years to meet head-on the imperative of reaching net zero by 2050.

Widespread change is being dictated by climate science and demanded by society. The UK's offshore wind industry is already at the heart of the global drive towards net zero and our oil and gas industry, as a further crucial element of the national economy, stands ready to act as part of a positive and sustainable response.

Contributions will come from every part of the offshore energy system.

The oil and gas sector has a track record of delivery in one of the world's harshest marine environments, a history of technological innovation, and is an economic and jobs powerhouse. Hydrocarbon production will continue for decades – this is essential in providing a safe, secure energy supply to power industry, heat homes and enable travel – however carbon emissions must be eliminated. The oil and gas sector stands ready to act in partnership with all other sectors of the energy industry.

The offshore wind sector has proven to be one of the stand-out industrial successes of recent years, with the UK leading the world in the deployment of fixed-bottom offshore wind, pioneering floating wind and driving costs down further and faster than anyone thought possible just a few years ago.

Willing partners and energy innovators – with their inherent vision and invention – are equally as important and include blue and green hydrogen, carbon capture and storage (CCS) and marine renewables, along with earlier-stage technologies.

The size of the challenge ahead is surpassed only by the opportunities that will come with success. The rewards of reaching or exceeding net zero by 2050 will extend to encompass UK manufacturing, long-term job creation, energy security, investment and innovation. Benefits will also ripple outward to encompass a global advantage and leadership position in new international markets.

CREATING A ZERO CARBON NORTH SEA ENERGY INDUSTRY

THE VISION

This report outlines three scenarios designed to create a zero carbon North Sea energy industry – Emerging, Progressive and Transformational.

Each represents one potential path to 2050, albeit with varying degrees of associated benefit. They should not, however, be read as the only options available; there is space to operate flexibly across scenarios - nothing can be ruled out.

They do however provide a guiding vision, a template that will benefit industry, stakeholders and government as they prepare to commit to a clear and actionable strategy, and deliver a more integrated energy mix driven by consumer demand. The end goal of net zero will lead the way, with flexibility and commitment working hand in hand with technology innovation. However, the economic and social impacts must be weighed alongside the environmental, and due emphasis given to economic recovery and future national prosperity.

The offshore energy sector already possesses many of the technologies required, albeit at varying scales of maturity, cost-effectiveness and scale. There is a huge opportunity to be innovative across the emerging energy solutions, from both fixed and floating offshore wind, carbon capture, utilisation and storage (CCUS) and blue and green hydrogen, while also delivering improved efficiency and carbon footprint reduction in existing oil and gas operations.

Storage, interconnection and networks will multiply the advantages, while onshore initiatives and the ongoing development of marine renewables will also complement wider ambitions.

Understanding the ongoing role of hydrocarbons is also essential. The offshore energy industry is building this strategy for 2050 based on a complete picture of the UK emissions footprint, using analysis from the UK Committee on Climate Change (CCC). It includes a fully net zero contribution from domestic gas and/or oil rather than reliance on imports.

THE BENEFITS

A wide range of industries, extending beyond traditional silos and towards a broader, more integrated offshore energy sector, are ready to take part. Small and medium sized enterprises are poised to contribute, research and development will be ramped up, and ports and communities around the UK will benefit from investment and employment.

Excellence across engineering, design, manufacture and installation provides a foundation for the necessary change. Technology development and innovation are critical to delivering affordable solutions for both the realisation of the net zero goal and the increased value associated with necessary cost reductions.

Rewards for success are huge: as many as 232,000 direct and indirect jobs, total economic impact of up to £125bn per year and potential cumulative investment of £416bn by 2050, depending on the exact path chosen.

Inaction, by contrast, risks a downturn in offshore energy sector employment between now and 2035, due to potential loss of employment in oil and gas and slow progress in offshore renewables. Without accelerating action and investment, the UK will not only experience net job losses, but also a loss of global leadership in the emerging net zero energy arena and failure to meet its net zero targets.

It is important to note that our scenarios are focused on domestic markets. However, new markets represent substantial added opportunities – particularly to strengthen growth in a post-Brexit economy. Examples include the export of green hydrogen to meet an anticipated surge in global demand, electricity interconnection outside the UK, and carbon sequestration for European neighbours.

These are tremendous opportunities for the UK, but if we are slow to act, we could lose thousands of jobs, billions of pounds of inward investment and vast export opportunities. There are already many overseas challengers, vying to secure leadership in energy transition solutions. It is critical that we accelerate progress – dramatically – to embrace these opportunities and retain our position as a global leader in energy.

NEXT STEPS

This report is designed to spark action.

The opportunities that come with responding to the net zero challenge will require decisions in the immediate term on progressive policies, as well as on investment and funding streams. Achieving the 2050 target, and tapping into the huge economic benefits that success can create, will necessitate removal of barriers, new technological innovation, and the formation of new partnerships and alliances.

The three scenarios in this report are designed to provide a clear framework to inform all of the above, to offer an outline of what is both possible and required, and to clearly illustrate the potential opportunity with the right level of both public and private sector engagement.

The offshore energy sectors are seeking closer agreement and understanding with regulators and governments at both the UK and devolved level, establishing clearer and where possible funded forward paths that will allow innovators and the supply chain to grasp the opportunities presented by meeting the challenge of net zero. Coordinated action will further ensure the UK keeps pace with global competitors while protecting hard-won jobs and expertise.

A reimagined North Sea awaits.

THERE IS NO CHOICE BUT TO ACT NOW

REIMAGINING THE UK'S ENERGY SECTOR

Economy

£125bn

Up to £125bn per year in total economic activity in the UK energy offshore sector by 2050, depending on the path selected

Technology

Critically, a reimagined North Sea will drive blue and green hydrogen production at scale and create a significant role for marine renewables, while driving improvements to storage, networks and interconnection

Offshore wind

Commitment to significant expansion of floating and fixed offshore wind, combined with anticipated cost savings, will boost energy security, reduce dependence on imported energy and increased production of green hydrogen

Carbon capture

Cost-effective, widespread deployment of carbon capture and storage will enable the broadest range of technologies and industries to contribute to the zero-emissions vision

Reduced costs

Innovation can drive increased affordability across a number of technologies and ultimately reduce the cost of energy to consumers in the net zero world

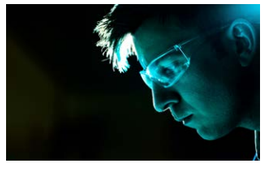
Jobs

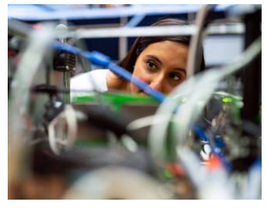
232,000

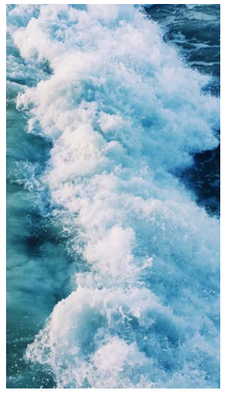
232,000 offshore energy jobs are possible by 2050, up from 140,000 direct and indirect today; the severity of the predicted employment downturn this decade can be considerably reduced

Continuity

UK hydrocarbons will continue to fulfil necessary UK energy demand through net zero domestic production, reducing reliance on imports and reducing emissions through technologies such as electrification







Exports

The opportunities of net zero will multiply beyond UK borders: green hydrogen as a commodity, carbon sequestration as a service, the transfer of hard-won skills and expertise to new markets

An integrated energy vision for the UK North Sea will enable investment by operators, developers and the supply chain in infrastructure and critical technologies, while simultaneously allowing regions and educators to plan for the skills of tomorrow.

The right actions, adopted now, will not only establish a well-marked path towards net zero, it will open the door to the opportunities of a reimagined North Sea and the full range of benefits from a positive, just transformation.

THE POWER OF AN INTEGRATED PLAN

Our integrated energy vision is built on four main pillars – offshore wind, oil and gas, hydrogen and CCS – all interdependent and interacting to achieve the mid-century goal.

This is not to ignore sectors such as marine renewables, complementary onshore technologies including wind and solar, and the need for expanded storage, improved networks and upgraded infrastructure. The North Sea energy system can achieve the biggest rewards, however, with coordinated action across all fronts, with equal parts leadership and vision from the core contributors.

2050: OFFSHORE WIND

Technological advances, particularly in floating wind, are expected to drive down costs, increase efficiencies and increase the areas available for potential development all around our coastline. Deployment of between 60GW and 150GW by 2050 – to both supply electricity for domestic consumption and export, and power green hydrogen production – is central to the net zero North Sea, depending on the path chosen, but benefits could potentially extend further. The sector can generate up to £1 trillion in economic impact across the UK over the next 30 years, while accelerated deployment from 2026 to reach an ambitious target of 49GW by 2030 – above and beyond what is currently mapped and including significant expansion of floating wind – could potentially offset anticipated job losses in the oil and gas sector.

2050: HYDROGEN

Hydrogen offers a substantial economic opportunity for the UK based on abundant renewable energy, supply chain expertise and huge export market potential, with Europe's hydrogen market anticipated to grow to £105bn by 2050.

Blue hydrogen can become a critical intermediate solution as we transition to net zero. It will be an important bridge to green hydrogen and at half the cost, will help build a hydrogen economy and create demand. Without this, harnessing the full potential of green hydrogen could be at risk.

Action and investment in green hydrogen is required now as part of a long-term strategy. We must develop the best most affordable solutions in areas including electrolyser catalysts, saltwater electrolysis and combined renewables/production facilities. By doing so, we can replicate, for green hydrogen, the success created in reducing the cost of offshore wind.

2050: OIL & GAS

Investment can accelerate decarbonisation of oil and gas production while increasing operational efficiency across what will remain a £15bn sector through 2050 (measured in terms of UK employment and production to meet domestic demand). Electrification and integration with renewables will be critical, coupled with technologies that will deliver net zero production emissions from the sector. The UK is transitioning to become reliant on renewable energy sources rather than hydrocarbons, however oil and gas is still required and world-leading skills and innovative organisations can service this industry in its mission to decarbonise.

2050: CARBON CAPTURE & STORAGE (CCS)

Widespread deployment of CCS will decarbonise oil and gas and blue hydrogen and enable the development of a net zero North Sea. The segment is a crucial component in future domestic hydrocarbon generation, as a carbon sink for industrial decarbonisation, and will open the door to the UK becoming both a world leader in the sector and a key European location for sequestration. Early adoption will dovetail with demand for blue hydrogen in the near term and set the stage for large-scale production of green hydrogen in the medium term.

EMERGING
PROGRESSIVE
TRANSFORMATIONAL

Our three scenarios – Emerging, Progressive and Transformational – have been selected to illustrate a range of options for 2050 and build on the Further Ambition Scenario as outlined by the Committee for Climate Change (CCC) in its 2019 report 'Net Zero: the UK's contribution to stopping global warming'.

A number of outcomes are reflected based on varying contributions, and degrees of maturity and cost reductions, across blue and green hydrogen, domestic and imported hydrocarbons, CCS, offshore wind and other renewables.

Emerging is built around significant contributions from gas and blue hydrogen with wind and CCS playing a supporting role, while under **Progressive** the energy mix also features gas, along with blue and green hydrogen and a larger contribution from offshore wind. Under the **Transformational** scenario, green hydrogen and wind take a leading role with a reduced contribution from gas and lowered requirement for CCS.

The potential upsides from our scenarios are clear: 232,000 direct and indirect jobs, total annual economic impact of up to £125bn and potential cumulative investment of £416bn by 2050, depending on the exact path chosen.

All three achieve net zero by 2050, however investing now to pursue Transformational will generate the highest growth in jobs, and the greatest rewards for the UK economy.

However, no matter the scenario, none will be successful in isolation and as such, are designed to support and contribute to wider UK efforts as outlined by the CCC's modelling of other segments of the economy. These include planned emissions-saving pathways across the building sector, heating, from industrial processes, and in all segments of transport.

Overlapping technologies will be of particular value in the net zero big picture, particularly CCS and hydrogen - both blue and green - which is a potential fuel for transport, heating and industry.

It is also important to note that the Emerging, Progressive and Transformational scenarios are focused on domestic markets; new markets represent added opportunity – for instance the export of wind-powered green hydrogen to meet anticipated significant global demand, electricity interconnection outside the UK, and carbon sequestration for European neighbours. This is an enormous opportunity for the UK to position itself as a leading exporter of net zero energy technology and knowhow, and embrace the social, economic and environmental benefits that come hand in hand.

The skills and expertise developed to meet domestic challenges, honed in the search for innovation and affordable solutions, will offer further economic opportunities beyond the UK market.

All of the scenarios are based on 60% UK content in offshore wind and hydrogen, and 70-75% in oil and gas and CCS, which is essential if we as a nation are to unlock the potential of next-generation energy development. They are also based on the belief that the UK will be greatly enhanced if we embrace the integrated energy vision at pace: driving a clear hydrogen strategy, ramping up offshore and floating wind and capitalising on our indigenous oil and gas assets via innovative technologies including electrification and CCS.

The Emerging, Progressive and Transformational scenarios are furthermore rooted in ambition: to decarbonise our own country while opening the door to delivery of services and technologies to export markets as a global net zero leader; to provide affordable energy for consumers and businesses by reducing the cost of critical technology; to enable our future pathway through coordinated, cross-industry action.

AT A GLANCE

AN INTEGRATED ENERGY VISION FOR 2050

	TODAY 2020	EMERGING 2050	PROGRESSIVE 2050	TRANSFORMATIONAL 2050
Summary	> Blue and green hydrogen not commercially available > Gas import dependency rising year on year > Floating wind trials in UK waters > CCS under development but not operational	> Blue hydrogen plays a major role > Large reliance on imported gas > Negligible role for floating wind > Significant requirement for CCS	> Blue and green hydrogen play a major role > Moderate reliance on gas imports > Large role for floating offshore wind > Significant requirement for CCS	> Green hydrogen plays a major role > Low reliance on imported gas > Crucial role for floating wind > Moderate requirement for CCS
Economy	£40bn Total Ecomomic Impact	£80bn Total Ecomomic Impact	£100bn Total Ecomomic Impact	£125bn Total Ecomomic Impact
Jobs	140,000 Direct & Indirect	113,000 Direct & Indirect	158,000 Direct & Indirect	232,000 Direct & Indirect
Imports	UKCS / Imports ~45%	UKCS / Imports ~45%	UKCS / Imports ~30%	UKCS / Imports ~10%
Investment	£10bn Average historic CAPEX p.a	£6.5bn Average CAPEX p.a	£9.4bn Average CAPEX p.a	£13.4bn Average CAPEX p.a

Offshore energy mix

	TODAY 2020	EMERGING 2050	PROGRESSIVE 2050	TRANSFORMATIONAL 2050
Offshore wind	Electricity 32TWh	Electricity 289TWh	Electricity 380TWh Hydrogen 101TWh	Electricity 380TWh Hydrogen 340TWh
Hydrogen	27TWh	270TWh	Blue 195TWh Green 75TWh	Blue 17TWh Green 253TWh
Oil & Gas	~40% IMPORTS Oil 640TWh Gas 700TWh	81% IMPORTS Oil 270TWh Gas 801TWh	72% IMPORTS Oil 270TWh Gas 555TWh	54% IMPORTS Oil 270TWh Gas 333TWh
Carbon Capture & Storage (CCS)	0 $MTCO_2$/year	140 $MTCO_2$/year	113 $MTCO_2$/year	81 $MTCO_2$/year

Technology priorities

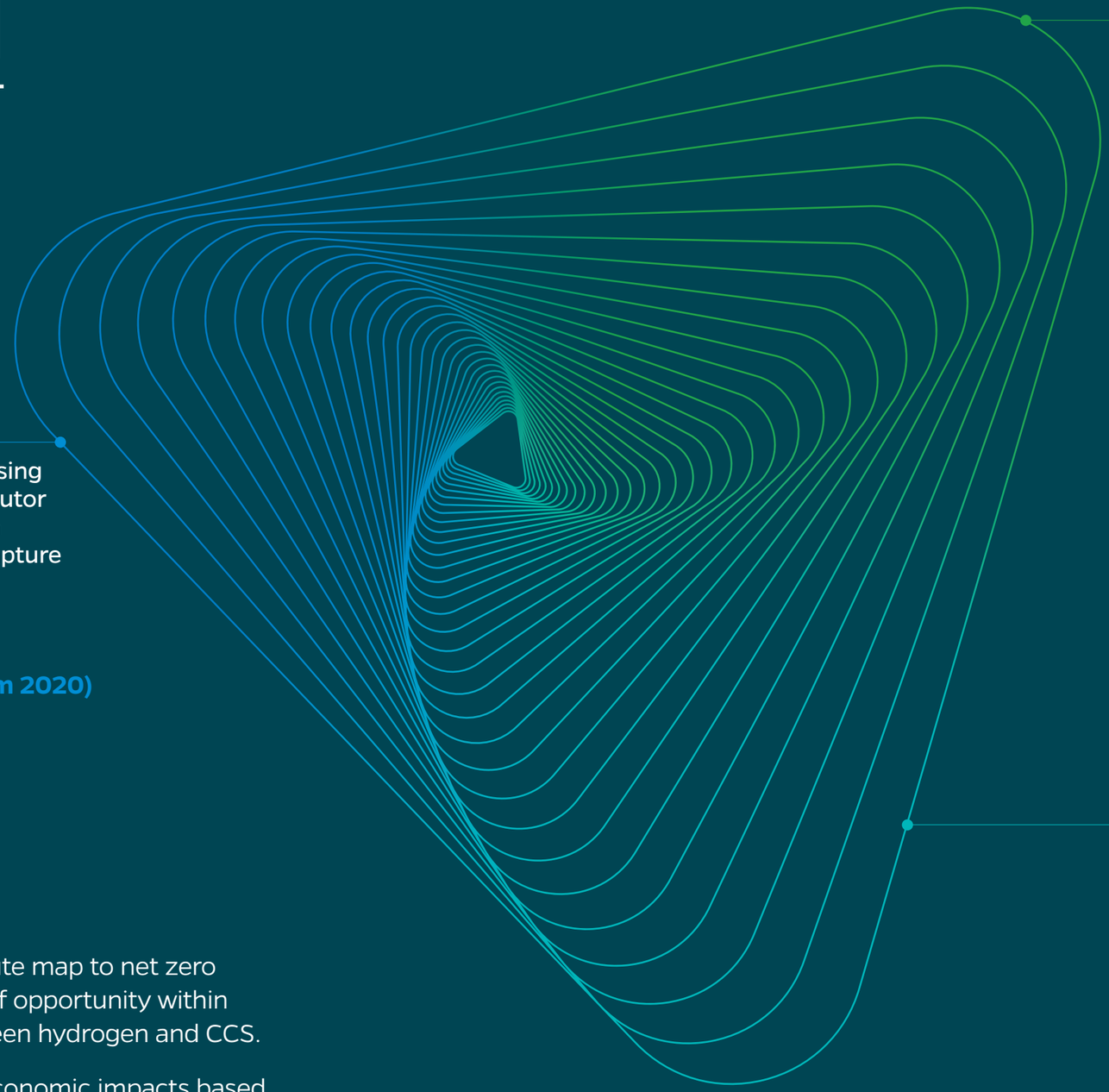
				Innovation cost savings	
Green Hydrogen	Electrolyser catalyst innovation	Seawater electrolysis	Subsea electrolyser solutions incorporating compression	£55bn	Cost Reduction **61%**
Offshore Wind	Reduced cost floating wind foundations	Innovative floating wind mooring systems	Dynamic cabling solutions to reduce downtime	£97bn	Cost Reduction **24%**
Blue Hydrogen	Enhanced SMR reactor membranes and catalysts	Alternative production methods eg, plasma pyrolysis	High-capacity sorbents more durable at high temperatures	£6.5bn	Cost Reduction **32%**
Carbon Capture & Storage	Modular retrofittable carbon capture solutions	Modelling geological behaviour of CO_2	Direct air / seawater capture	£1.3bn	Cost Reduction **13%**

SCENARIOS IN DEPTH

EMERGING

Renewable electricity plays an increasing role with gas still a significant contributor to the overall energy mix, alongside a significant requirement for carbon capture and storage.

> £80bn economic impact
> 113,000 jobs (20% decrease from 2020)
> £6.5bn investment per year



TRANSFORMATIONAL

An energy system driven by offshore wind and green hydrogen.

> £125bn economic impact
> 232,000 jobs (66% increase on 2020)
> £13.4bn investment per year

PROGRESSIVE

An increased share of offshore renewables dominates the electricity market, alongside a blue/green hydrogen split and a major role for carbon capture and storage.

> £100bn economic impact
> 158,000 jobs (13% increase on 2020)
> £9.4bn investment per year

Our different scenarios all offer a route map to net zero by 2050 and include varying levels of opportunity within renewables, oil and gas, blue and green hydrogen and CCS.

They predict a range of significant economic impacts based on elements including specific technological advancement, electricity generation and the energy mix.

EMERGING

Renewable electricity plays an increasing role with gas still a significant contributor to the overall energy mix, alongside a significant requirement for carbon capture and storage.

KEY ASSUMPTIONS

Renewables

60GW
60GW offshore wind (lower than CCC's May 2019 75GW target)

~4000
Would require ~4,000 turbines fixed and floating by 2050 based on 15MW capacity

Limited expansion of other marine renewables

Increase in onshore wind and solar

65%
of electricity from renewable generation

Hydrogen

100%
blue hydrogen with CCS

337.5TWh
of gas required for blue hydrogen

Oil & Gas

100%
UK oil demand met from UK production

81%
of gas supplied from imports

Carbon, Capture & Storage

140 $MTCO_2/y$
At scale, around 140$MTCO_2$/y in 2050

33%
for blue hydrogen

11%
for electricity generation

WHAT IT LOOKS LIKE

Total economic output across the UK economy is boosted from £40bn in 2020 to £80bn in 2050 but total jobs decrease from 140,000 to 113,000.

The Emerging scenario is expected to lead to a decrease in direct and indirect jobs in the domestic offshore energy sector, from a total of around 140,000 in 2020 to 113,000 in 2050. See page 26 for more detail.

Efficiency gains and cost reductions will be necessary for blue hydrogen production and CCS

Cost reductions are possible across the Emerging scenario on the back of technology and innovation upgrades, particularly in CCS. Crucial enablers include advanced Steam Methane Reformation (SMR) reactor membranes and catalysts, high capacity sorbents and alternative methods to SMR such as plasma pyrolysis. Key areas for innovation include direct air capture and modular/retrofittable solutions, as well as compatible well plug and abandonment and reservoir monitoring.

Power generation is primarily from low-carbon sources expected to total 16$MTCO_2$/y

Electricity from renewables will meet around 65% of demand, along with nuclear and bio-energy with CCS. Gas will meet around 17% of generation with a significant CCS component. Total emissions to be offset under this scenario are expected to total 16$MTCO_2$/y.

Total energy production remains heavily reliant on hydrocarbons, primarily gas, which would require significant imports

To generate power and produce hydrogen, as well as meeting demand for domestic and industrial uses, more than 500TWh of gas would be required, at approximately 800,000 BOE/d, roughly similar to demand in 2020. This far outstrips UK domestic resource potential, leaving the UK reliant on total imports of approximately 80%.

WHAT IT REQUIRES

£202bn
cumulative investment through 2050

Significant increase in blue hydrogen production, with more than 60 plants with total capacity greater than 35GW

Cost reduction and increased efficiency of carbon capture, transport and storage technology

Life extension and electrification of oil and gas assets to reduce production emissions and ensure highest proportion of supply comes from domestic sources

Reduction in cost of floating wind

PROGRESSIVE

An increased share of offshore renewables dominates the electricity market, alongside a blue/green hydrogen split and a major role for carbon capture and storage.

KEY ASSUMPTIONS

Renewables

100GW
100GW offshore wind (higher than CCC's May 2019 75GW target)

~6600
Would require ~6,600 turbines fixed and floating by 2050 based on 15MW capacity

Limited expansion of other marine renewables

Increase in onshore wind and solar

80%
of electricity from renewable generation

Hydrogen

73%
blue hydrogen with CCS

27%
green hydrogen

101TWh
of offshore wind provides 75TWh of green hydrogen

244TWh
of gas provides 195TWh of blue hydrogen

Oil & Gas

100%
UK oil demand met from UK production

72%
of gas supplied from imports

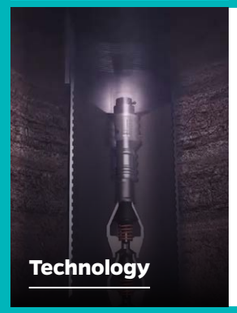
Carbon, Capture & Storage

113 $MTCO_2/y$
At scale, around 113$MTCO_2$/y in 2050

WHAT IT LOOKS LIKE

Total economic output across the UK economy is boosted from £40bn in 2020 to £100bn in 2050 and employment increases from 140,000 to 158,000 jobs

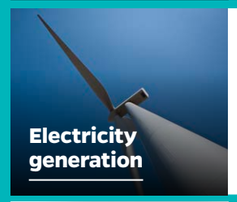
Overall growth is significant with declining oil and gas revenues offset by expansion in offshore renewables jobs alongside hydrogen and CCS. Direct and indirect employment in the offshore energy sector jumps from 140,000 in 2020 to 158,000 in 2050 under the Progressive scenario. See page 26 for more detail.



Deployment at scale will drive cost reductions particularly in offshore wind

The more balanced energy system of Progressive, with a higher proportion of wind, will also drive innovation in blue hydrogen and CCS. This scenario is based on a reduced cost of green hydrogen, enabling an increasing proportion in the energy mix by 2050.

Key areas for innovation include improved efficiency of existing SMR and Authothermal Reforming (ATR) technologies, alternative blue hydrogen production methods, modelling of geological behaviours for CO_2 and inter-seasonal hydrogen storage, direct air/seawater capture. For floating wind, the focus will be on UKCS-specific foundations and mooring designs as well as dynamic cabling solutions.



Renewables provide 80% of electricity generation

Gas power generation is phased out completely by 2050 under the Progressive scenario, with the balance being made up primarily from offshore wind. This high renewables scenario is contingent on associated improvements in storage, interconnection and networks.

Gradual phasing out of electricity generated from gas by 2050, with resources diverted to hydrogen production

To generate the required power for hydrogen and satisfy demand for domestic and industrial uses, the system would require an input of roughly 400TWh of gas, or marginally lower than current UK demand at 650,000 BOE/d. This demand far outstrips the UK domestic resource potential and results in an import reliance of 72%.

WHAT IT REQUIRES

£293bn
cumulative investment through 2050

Large scale-up of blue hydrogen, requiring significant cost reduction and efficiency gains

Large scale-up of green hydrogen, including cost reduction and efficiency gains

Increased deployment of offshore wind, both floating and fixed, at reduced cost

Oil and gas electrification to extend field life and secure domestic supply

TRANSFORMATIONAL

An energy system driven by offshore wind and green hydrogen

KEY ASSUMPTIONS

Renewables

150GW
150GW offshore wind (double the CCC's May 2019 75GW target)

~10,000
Would require ~10,000 turbines fixed and floating by 2050 based on 15MW capacity

Limited expansion of other marine renewables

Increase in onshore wind and solar

80%
of electricity from renewable generation, significant storage and improved grid flexibility

Hydrogen

7%
blue hydrogen

93%
green hydrogen

341TWh
of offshore wind provides 252TWh of green hydrogen

21.5TWh
of gas provides 17TWh of blue hydrogen

Oil & Gas

100%
UK oil demand met from UK production

54%
of gas supplied from imports

Carbon, Capture & Storage

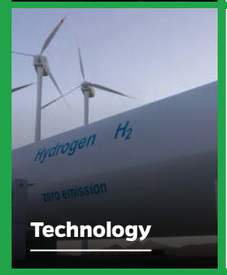
91
$MTCO_2/y$
At scale, around 91$MTCO_2$/y in 2050

WHAT IT LOOKS LIKE

Economic impact and jobs

Total economic output across the UK economy is boosted from £40bn in 2020 to more than £125bn in 2050, and employment increases from 140,000 to 232,000 jobs

The Transformational scenario represents the highest potential increase in total economic impact and jobs. Direct and indirect employment will benefit largely from the deployment of offshore renewables and green hydrogen (80% of total), resulting in 232,000 jobs across the offshore energy sector in 2050, compared with 140,000 in 2020.
See page 26 for more detail.



Technology

Innovation across green hydrogen and offshore wind could result in capex savings of £153bn by 2050

Investment in large-scale deployment of wind and green hydrogen are expected to lead to capex savings of £153bn by 2050. For the latter, key areas include advancement of electrolyser catalysts, subsea electrolysers and compressions systems, and saltwater electrolysers.

For wind, innovation efforts will focus on floating foundations, mooring systems and dynamic cabling solutions. Also key will be development of ammonia or other low-carbon fuelled turbines and marine hydrogen transport solutions.

Electricity generation

A high proportion of renewable electricity enabled by improvements in the wider energy system

Renewables supply 80% of electricity. This is beyond current day variability limits but advances and deployment across battery and hydrogen storage, as well as smart grids, are expected to bridge any gaps.

Traditional gas-fired plants may also be used in conjunction with carbon capture, or alternatively hydrogen power plants, to offset any shortfall in demand during times of low renewables output.

Under the Transformational scenario, reliance on gas for power generation is phased out in the early 2040s, 10 years ahead of the Progressive timeline.

Energy Use

Significant wind and hydrogen leads to reduced reliance on imported gas

Offshore wind and green hydrogen dominate the energy mix in the Transformational scenario for 2050. Reliance on imported gas is cut to 54%, representing a reduction of 355,000 BOE/d from CCC estimates.

WHAT IT REQUIRES

£416bn
cumulative investment through 2050

Floating wind to access deeper waters and increased capacity

Scale-up of green hydrogen requiring significant cost reduction and efficiency gains

Scale-up of early blue hydrogen with cost reduction and efficiency gains by 2035

Fast-track consenting process for new offshore deployments, both wind and hydrogen

Oil and gas electrification to extend field life and secure domestic supply

JOBS AND ECONOMY

THE UK CANNOT AFFORD TO WASTE THE SKILLS, EXPERTISE AND EXPERIENCE THAT EACH OF THOSE JOBS REPRESENTS

The North Sea's necessary journey to net zero represents a massive opportunity for the UK: between £80bn and £125bn of total economic impact in 2050, depending on the path chosen.

It is critical, however, that we act urgently to realise this economic opportunity and create jobs. We need higher investment, quicker intervention routes and accelerated action – not only to achieve this level of economic impact but even more importantly, to secure and create new jobs which will counteract the employment losses we expect to see this decade.

All options – Emerging, Progressive and Transformational – are built on coordinated action across employment, infrastructure and policy, mitigating impacts while maximising rewards. Average annual investment of between £6.5bn and £13.4bn, worth a total of between £202bn and £416bn by 2050, is predicated on cross-sector buy-in, industrial-scale private sector investment and government support.

The supply chain will be encouraged to seize the opportunities on offer, guided by a clear roadmap for the North Sea that facilitates capability-building while simultaneously ensuring that as much value, content and employment as possible remains in the UK.

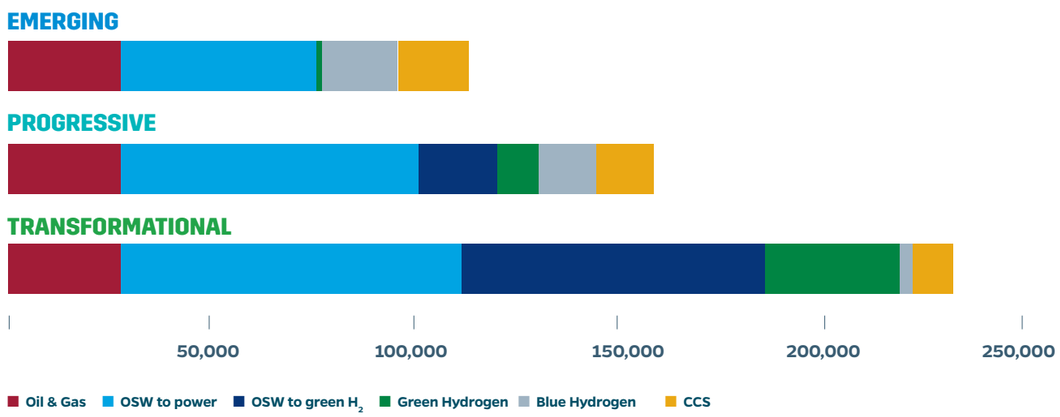
Between 113,000 and 232,000 direct and indirect jobs could be supported in the UK energy sector by mid-century across all sectors, based on the current anticipation of 60% UK local content in offshore wind and hydrogen. Employment in offshore wind, for both power and production of hydrogen, could total nearly 160,000, CCS could support up to 28,000 posts, while blue and green hydrogen could potentially employ 35,000. Domestic oil and gas jobs are expected to be around 27,000 in 2050.

It should be noted that the status quo is not an option; job losses under any business as usual scenario will be significant, particularly in the period to 2035 when employment in oil and gas is expected to drop by around 60,000.

Even in the Emerging scenario, a significant loss of jobs and skills is predicted. The UK cannot afford to waste the expertise and experience that each of those jobs represents..

Industry, supported by government, is ready to invest in training, transferability, innovation and the supply chain; definitive action will ensure the true extent of future employment and wider economic benefit is realised while avoiding the potential negative impacts of the transition to the new North Sea.

2050 Employment (direct and indirect)



ENABLING AFFORDABILITY

Net zero is achievable using existing commercially-ready energy technologies but not in a manner that would currently be considered affordable. It is paramount, therefore, that we enable cost reductions through innovation across all sectors.

Working together, the North Sea sectors can ensure parallel progress on multiple fronts: interplay and interlink between electrification of oil and gas, the increased deployment of offshore wind, the production of hydrogen and the advent of widespread CCS.

The offshore energy sector will work to secure stakeholder and government buy-in and ensure open communication channels with consumers and business users. Mobilisation across all technologies will be accompanied by, and carried out against a background of, the wider socio-economic context.

GREEN HYDROGEN

Potential capex savings 61%

£55bn

Costs are currently uneconomic in what remains a nascent technology with limited practical application. However, we believe there is a huge opportunity to develop the sector at scale, driving dramatically reduced costs – up to £55bn in total between 2020 and 2050 – and increased efficiency.

Potential depends on the net zero option selected. Under the Emerging scenario widespread deployment of the technology – and so development – is unlikely, whereas under the Progressive and Transformational models green hydrogen is a key enabler of 2050 ambitions.

Green hydrogen is most viable in an energy system where excess renewables generation can drive production at scale. This also creates a potential new export market, whereby the UK can supply surplus green hydrogen to parts of mainland Europe.

OFFSHORE WIND

Potential capex savings 24%

£97bn

Cost reductions in offshore wind will be achieved by increasing the capacity of offshore wind turbines, and as more focus is placed on the floating segment in terms of foundation design and manufacture, mooring systems and dynamic cabling. A standardised approach based on the requirements of the UKCS offers the potential for economies of scale and significant local content.

Offshore wind, both fixed and floating, will be deployed at scale across all of our scenarios to meet 2050 ambitions and total capex savings could total as much as £97bn over the 30-year period; finite options for bottom-fixed turbines are expected to drive development of the floating segment at a price point that enables end-users to access affordable energy, with UK Government targeting 1GW by 2030. Demand for more powerful next-generation turbines in the 20MW-class offers the potential for home-grown intellectual property.

BLUE HYDROGEN

Potential capex savings 32%

£6.5bn

The development of enhanced SMR reactor membranes and catalysts, along with alternative production methods and high-capacity sorbents, would drive significant costs savings in the blue hydrogen sector, which is more mature than its green counterpart.

Expansion of the technology, which relies on hydrocarbons to drive production, is seen as key in the near term to help establish market demand among domestic, transport and industrial sources. Development will stimulate CCS, which is required to capture CO_2 emissions created as part of the electrolysis process. Total potential capex savings between 2020 and 2050 are £6.5bn and several CCS projects already in development in the UK, including the Acorn Project and Net Zero Teeside, will help us to accelerate the delivery of blue hydrogen.

CARBON CAPTURE & STORAGE

Potential capex savings 13%

£1.3bn

CCS is a crucial technology partner in the UK North Sea's drive to meet net zero ambitions by 2050. Each illustrative scenario highlights that the ability to capture emissions from domestic generation will be key, opening the door to becoming both a world leader in the technology and a key European location for sequestration.

The unique geology of the UK North Sea provides safe options for long-term storage and, with the right investment, will secure domestic employment and supply chain products. Early adoption will dovetail with demand for blue hydrogen in the near term and set the stage for green hydrogen in the medium term. Capex savings are expected to total £1.3bn between 2030 and 2050.

OIL AND GAS

Variable capex savings

Oil and gas will remain a vital source of energy for the UK in 2050. The industry is committed to responsible consumption, offset by CCS, as part of wider net zero production, alongside electrification, renewables integration, flaring mitigation and advanced leak detection. Remote operation and full digitisation can further mitigate carbon impacts.

Specific cost reductions in the hydrocarbons sector will be most significant in emissions reduction technologies and new subsea equipment designed to tap stranded reserves, as well as through efficiencies across operations. Site-specific demands will dictate the most effective measures to adopt.

TECHNOLOGY FOR 2050

The North Sea energy sector believes investing in large-scale technology advances and adoption will be fundamental to meeting net zero ambitions, while simultaneously addressing affordability through potential capex savings of £154bn through 2050.

Deployment of next-generation solutions is central to the sector requirements and scenarios already outlined, and will address both gaps to be filled and barriers to be overcome in order to make any integrated North Sea energy vision a reality. And crucially, those net zero innovations are key to making energy affordable for domestic, business and industrial consumers.

The offshore energy sector across the North Sea is committed to the development and widespread uptake of new and existing technologies in offshore electrification, CCS, renewables and hydrogen. Also key is a major review of internal processes and products that will enable reduced oil and gas emissions across the value chain.

Valuable work on identifying available technologies and those areas where more work needs to be done has already been compiled by OGTC in its Closing the Gap Report.

Building on that work, the energy sectors are prepared to meet the technology challenge with coordinated action across a number of fronts.

Of particular importance will be support for innovation of the existing contributors – hydrocarbons, wind, hydrogen, CCS – that are critical to delivery of affordable energy, and the acceptance that multiple solutions will be required to meet net zero ambitions.

Further, we believe that execution must be based on expanded UK capabilities in areas including engineering, manufacturing and installation, development of innovation and associated intellectual property, and optimised supply chains, skills and infrastructure.

Investment by the offshore energy industries, supported by government, can also maximise the potential of achieving significant domestic content provision in the face of increasing levels of competition from both North Sea neighbours and beyond.

INNOVATION CAN DELIVER POTENTIAL CAPEX SAVINGS OF £154bn BY 2050

We have identified a range of critical technologies, which include but are not limited to:

Oil & Gas

Ammonia or other low-carbon fuelled turbines

Marine hydrogen transport solutions

Plaform electrification (AC/ DC cabling solutions)

Subsea electrification cost reduction

Offshore Wind

UK-specific floating wind foundations

Innovative floating wind mooring systems

Dynamic cabling solutions to reduce wind downtime

Carbon Capture & Storage

Modelling of geological behaviours of CO_2

Modular, retrofittable carbon capture solutions

Direct air/seawater capture

CO_2-compatible well plug and abandonment techniques

High-capacity sorbents durable at high temperatures

Hydrogen

Seawater electrolysis

Electrolyser catalyst innovation

Subsea electrolyser systems incorporating compression

Improved efficiency of existing SMR and ATR technology

Enhanced SMR reactor membranes and catalysts

Alternative blue hydrogen production methods

Inter-seasonal hydrogen storage

A MASSIVE OPPORTUNITY FOR THE UK

EMERGING

£80bn/y	113,000	£6.5bn	£202bn
Total economic impact in 2050	Total direct and indirect jobs in 2050	Average capex investment per year to 2050	Cumulative capex investment to 2050

PROGRESSIVE

£100bn/y	158,000	£9.4bn	£293bn
Total economic impact in 2050	Total direct and indirect jobs in 2050	Average capex investment per year to 2050	Cumulative capex investment to 2050

TRANSFORMATIONAL

£125bn/y	232,000	£13.4bn	£416bn
Total economic impact in 2050	Total direct and indirect jobs in 2050	Average capex investment per year to 2050	Cumulative capex investment to 2050

METHODOLOGY

ECONOMIC IMPACT

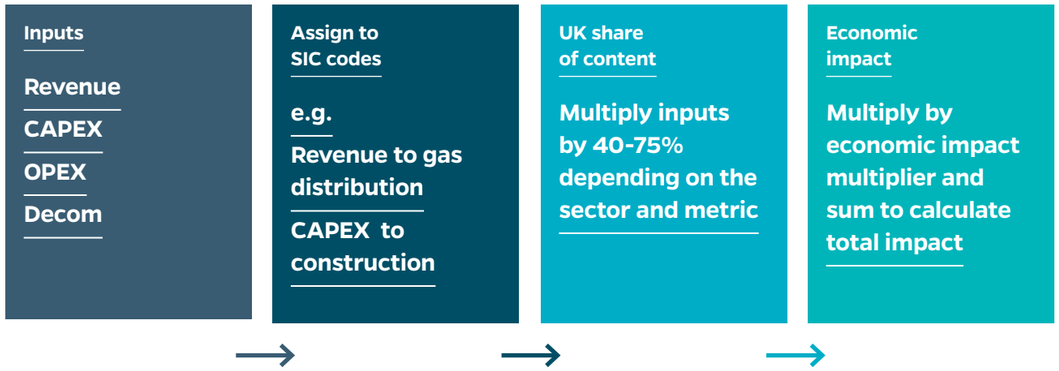
This has been modelled for all sectors using the same methodology.

Inputs have been calculated and split into revenue, CAPEX, OPEX and decommissioning (decom). These metrics have been split further to assign inputs against Standard Industrial Classification (SIC) codes, as each industry has a different multiplier. ORE Catapult calculated inputs for offshore wind and hydrogen. OGTC calculated inputs for CCUS. Oil and gas inputs have been taken from Wood Mackenzie, specifically its model used in the 'Closing the Gap' report.

In all cases, these inputs have been derived from estimates of the trajectory for each of the four sectors for: levels of deployment and decom; levels of revenue per unit of output; level of CAPEX and OPEX per unit deployed; and level of decom cost per unit decommissioned.

These revenue and cost inputs have been multiplied by the assumed UK share of content for each sector and metric. Finally, the UK share of input is multiplied using industry economic impact multipliers to create the model outputs. Model inputs include both the estimated revenue and its multiplier effect, plus the multiplier effect of costs (but not the underlying costs themselves, which are paid for by revenue and therefore including would mean double-counting underlying costs). The total of all these outputs is the total economic impact.

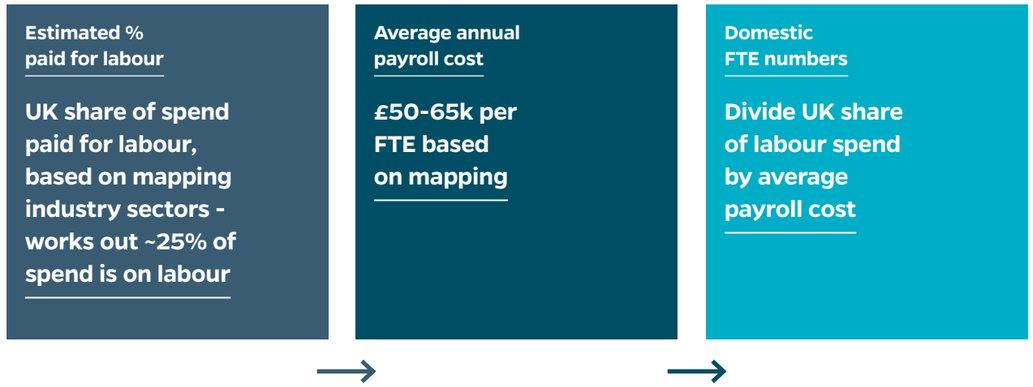
Total economic impact sector revenue (as a proxy for total sector economic output) + multiplier effects of revenue + multiplier effects of CAPEX, OPEX and decom (included to reflect the fact that output multipliers from Input-Output tables do not capture the extent of spend and economic activity in rapidly changing industries).



This method of calculating economic impact differs slightly from the Wood Mackenzie approach used in the Closing the Gap report (September 2020), which included total economic impact rather than just the UK share of economic impact.

JOB ESTIMATES

Direct job numbers for offshore renewables, hydrogen and CCUS have been calculated using the method below:



Indirect job calculation has used the same multipliers as Wood Mackenzie. A minimum baseline number of jobs for each sector has been estimated (not linked to economic impact) – for example, there are green hydrogen jobs today, despite low levels of spending and revenue.

Wood Mackenzie job estimates (and inputs) for oil and gas have been used, rather than calculated.

COST SAVINGS

CAPEX reductions have been modelled based on individually calculated learning rates. The learning rate is a percentage reduction in cost per unit (e.g. cost per MWh) for every doubling of installed capacity (e.g. total number of units or total GW capacity).

Cost savings were calculated based on comparison of modelled CAPEX reduction over time versus current CAPEX costs per unit.

Cost reductions are considered to consist primarily of innovation savings via new technological advancements and scaling factors.

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AN INTEGRATED ENERGY VISION FOR 2050

CATAPULT Offshore Renewable Energy

Technology Driving Transition

OGTC