

TOWARDS NET ZERO:

**The implications of the
transition to net zero
emissions for the
Engineering
Construction Industry**

Authors

Element Energy is a strategic energy consultancy, specialising in the intelligent analysis of low carbon energy. The team of over 60 specialists provides consultancy services across a wide range of sectors, including the built environment, carbon capture and storage, industrial decarbonisation, smart electricity and gas networks, energy storage, renewable energy systems and low carbon transport. Element Energy provides insights on both technical and strategic issues, believing that the technical and engineering understanding of the real-world challenges support the strategic work.

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EXECUTIVE SUMMARY

The Engineering Construction Industry (ECI) underpins the UK economy, with involvement in the design, construction, maintenance and decommissioning of critical industrial and energy infrastructure. The expertise of this industry covers sectors such as the oil and gas industry, power generation through conventional, nuclear, and renewable technologies, water treatment and waste management, and the processing industries such as chemicals, pharmaceuticals, and food and drink. The industry employs over 190,000 staff, with a wide set of skills ranging from medium and high education qualifications to supporting and technical roles. The Engineering Construction Industry Training Board (ECITB) is the industry body that ensures appropriate and industry specific training is provided, matching the industry's needs.

The ECI and the challenge of net zero

The ECI is a dynamic industry, operating in a continuously changing market. The industry is currently on the verge of transformation driven by the deployment of innovative digital technologies and a shift in governmental policy to mitigate the effects of climate change. The industry has already been extensively involved in the penetration of renewable energy, such as offshore wind, in the UK energy mix. It is about to face a bigger challenge but also a great opportunity. The UK government has committed to the ambitious target of achieving net zero emissions by 2050, following the recommendations of the Committee on Climate Change (CCC) in the Net zero Report. This legislative change means that every sector of the UK economy will have to decarbonise, a process that will require wide-scale deployment of low carbon technologies. Both current and new technologies will be required to achieve climate targets; the CCC's report highlighted the need for deployment of hydrogen and carbon capture and storage (CCS) technologies at scale due to their pivotal role in achieving deep cross-sector decarbonisation.

Hydrogen gas could successfully replace natural gas in many applications including industry, power generation and domestic heating; hydrogen is also a clean alternative to conventional fossil fuel transport. Unlike fossil fuels, hydrogen does not have any carbon emissions at the point of usage. Low-carbon hydrogen could be produced from renewable electricity sources, through the reformation of natural gas, or gasification of biomass. In order to capture any emissions associated with hydrogen production from natural gas, CCS will be needed. This technology consists of capturing, transporting, and storing carbon dioxide emissions from the source of origin to underground facilities, such as depleted hydrocarbon fields or aquifers under the seabed. CCS will also help decarbonise other sectors, including power generation and certain industrial sectors where decarbonisation through hydrogen is not technologically feasible or cost effective.

The CCC estimates that industry will be the largest single consumer of hydrogen in 2050, consuming over 40% of the 270 TWh/year hydrogen produced in 2050. As a result, it is expected that most technologies will be implemented in areas with a high concentration of industrial sites (so called industrial clusters). There are six main industrial clusters in the UK: Grangemouth in Scotland; Teesside, Humber, and Merseyside in the North of England; South Wales; and Southampton in the South of England. Decarbonisation of industrial clusters is at the forefront of the Government's Industrial Strategy, which aims to achieve one low-carbon industrial cluster by 2030, followed by achieving a net zero emissions cluster by 2040. All five remaining main industrial clusters will have to decarbonise by 2050 to meet the net zero targets. This will be achieved using a combination of measures, including hydrogen fuel switch, CCS, electrification, and energy efficiency improvements, with an estimated captured emission of over 20 MtCO₂/year in 2050.

There is a potential of over £40 billion in revenues for the ECI sector by 2050

The large scale of deployment will bring both opportunities and challenges for the engineering construction industry. We estimate that the value of the activities conducted by the ECI, in the form of front-end engineering design, detailed design, construction, commissioning, maintenance, and decommissioning of hydrogen, CCS, and power technologies, could reach a cumulative of £14-21 billion between now and 2035, and £18-32 billion by 2050. This analysis only considered a handful of key technologies that are seen as pivotal to reaching the net zero goals by the CCC. However, a wider variety of technologies will be needed, increasing the potential revenues for the sector. In addition to this tangible revenue potential, the net zero transition will lead to the development of unique expertise in the UK. As the first developed economy to declare a net zero target, the UK will have the potential to develop skills that could be exported to decarbonise other markets and countries that may follow the UK in enshrining net zero targets in legislation.

This increasing momentum is supported by the UK Government in terms of funds, industry challenges and investment opportunities that are created for the private sector and supported by the public sector. The Clean Growth Strategy hosts several competitions to drive the development of hydrogen, CCS and industrial fuel switching, totalling more than £162 million directed to research, development of commercial demonstration scale projects, and roll-out of low-carbon technologies. The private sector is also playing a significant role in fuelling this momentum by initiating some of the key projects and regional partnerships, such as HyNet and H21 North of England, to drive hydrogen deployment across parts of the UK.

The engineering construction industry and the ECITB must be prepared to capture this opportunity. Unlocking the full potential will require both closing any skills gaps through retraining and upskilling of current personnel, as well as mitigating workforce shortages. As with any large-scale transition, the road to achieving net zero emissions by 2050 will be full of new challenges and uncertainties related to the skills required to deploy enabling technologies.

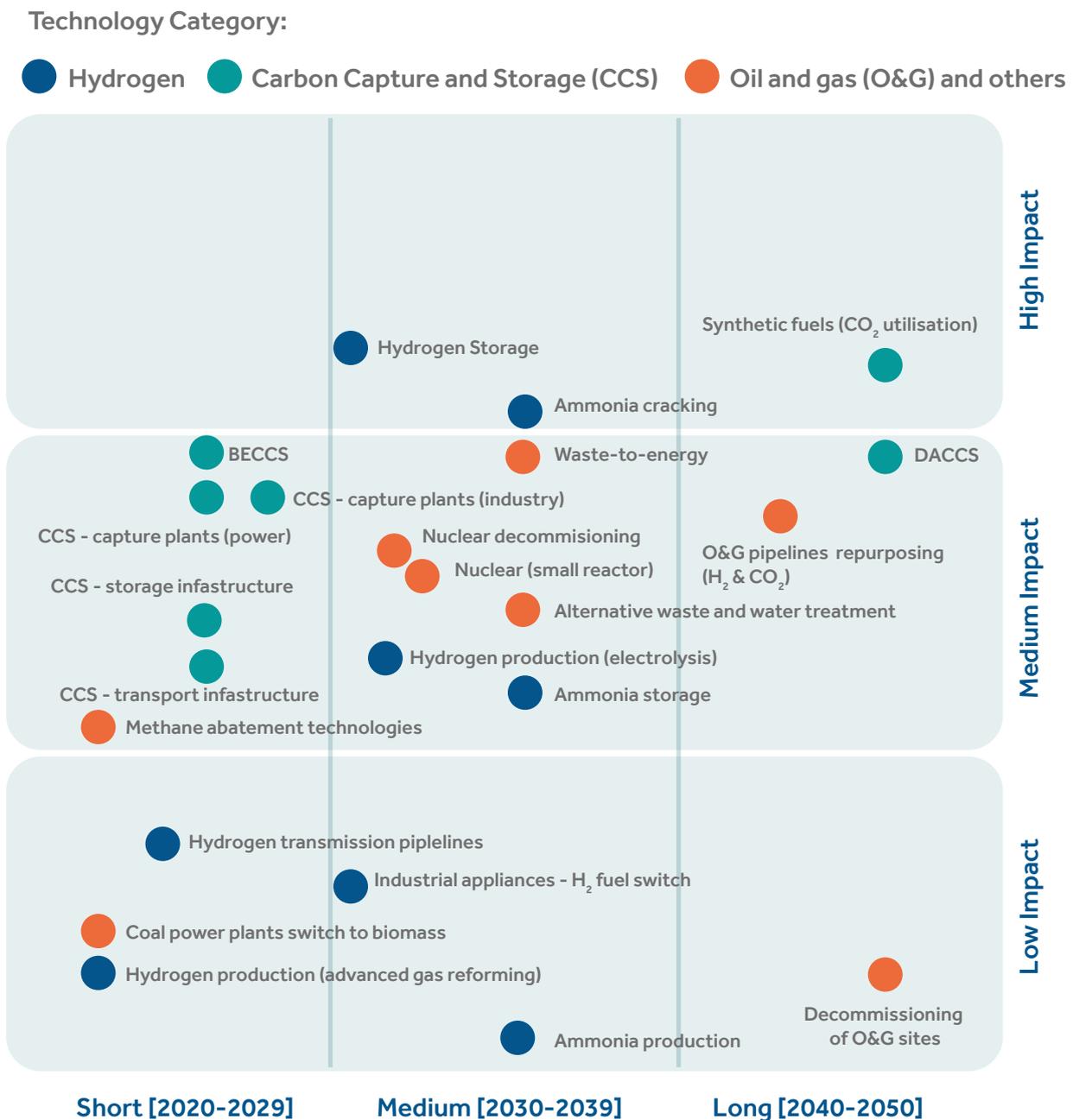
Industry should be ready for the disruption brought by the decarbonisation technologies

Over 20 decarbonisation technologies were assessed as part of this study. The technologies expected to be deployed are not completely new and many have already been used in certain industrial settings. However, the wide variety of technologies needed to achieve net zero emissions by 2050, and the unprecedented scale of deployment, could disrupt the engineering construction industry, and the 145 occupations it currently comprises.

Our assessment finds that none of the nine main technologies expected to be rolled-out within the next 10 years is expected to bring a major skills disruption. However, caution should be exercised as skills will need to be transferred from other sectors and there may be significant workforce shortages. This will be the case

especially for the technologies adopted in the short term, due to the limited timeframe to retrain and/or recruit personnel, and to the highly disruptive technologies expected to be deployed in the medium and long term.

The short term is expected to be characterised by the early deployment of hydrogen production technologies, carbon capture and storage, and emission mitigation measures in the oil and gas sector. These technologies are expected to have limited disruption potential; hydrogen production through reformation and electrolysis has already been used by UK industry, whilst CCS shares some design and operational features with the oil and gas industry (although areas of retraining still exist, e.g. around CO₂ monitoring that may use a combination of seismic and pressure



monitoring). Oil and gas operatives will need to receive industry-related training on how to build and operate newer technologies, including CCS, but the underlying foundational skills are currently present in the industry.

More disruptive technologies are expected to be deployed in the medium and long term. Those would include the development of technologically uncertain concepts, such as hydrogen storage in salt caverns, synthesis of fuels from captured carbon dioxide, or direct air carbon capture and storage, which have not been deployed at scale before and thus the full extent of the skills required is currently unknown. Technologies such as hydrogen storage may also require skills that are currently not widely available within the engineering construction industry and would require similar skills to those employed by the exploration and mining industries. However, most of the technologies expected to be rolled-out in the medium and long term will be similar to today's assets and are likely to pose a low to medium disruption level. A similar impact is expected to be seen in the waste and water treatment sectors, where the transformation will focus on new operational procedures, design and efficiency improvements. Advanced nuclear technologies are expected to be deployed in the future. These are likely to be characterised by modular and innovative designs and will require major upskilling and retraining. In light of the skills and workforce shortages the nuclear industry is already predicting the uptake of these new technologies will create a need to recruit new workers and migrate skilled workers from other industries.

Further complexities will be brought by the decarbonisation of industrial clusters

Industrial clusters are expected to be at the epicentre of decarbonisation infrastructure development, such as hydrogen production and CCS. Under the current UK industrial strategy and net zero legislation, industrial clusters must decarbonise by 2050. Cluster development proposals are already emerging, in line with the funding competitions initiated by the government. For example, the Zero Carbon Humber consortium is aiming to decarbonise the Yorkshire and Humber industrial area. The project is looking to build clean hydrogen production facilities and CCS infrastructure. This aims to decarbonise over 40 industrial sites and enable negative-emissions through the use of bioenergy with CCS (BECCS) at the site of the Drax power plant. This would represent a significant opportunity for the ECI both during the initial development of anchor projects in the region by 2027, but also in the long term when the hydrogen production and CCS infrastructure are expected to be scaled up.

Industrial decarbonisation is not limited to the Humber area; industrial clusters all across the UK have similar plans. It is thus expected that building of decarbonisation technologies within industrial clusters will start in the 2020s, with the first low-carbon cluster becoming operational by 2030, and the first net zero cluster by 2040.

- The tight deployment timeframes and the wide variety of technologies that may be rolled-out may exacerbate current skills shortages, especially for meeting the 2030 and 2040 milestones. The engineering construction industry is already facing the prospect of an aging workforce, with 91,000 engineers and 29,000 engineering technicians expected to retire or be close to retiring by 2026 and difficulties in recruiting new talent. The increasing lack of appetite among many workers, particularly millennials, to relocate for work purposes may also pose a challenge for the industrial clusters.
- Industrial collaboration will be needed to bring together the multi-sector expertise required to decarbonise industrial clusters. Industry should be aware of both the need for collaboration and the benefits of collaborating and should have a proactive attitude towards potential partners.
- The cluster decarbonisation approach and technology configurations are expected to vary across the UK, with uncertainties regarding the exact mix of technologies used within each cluster. This uncertainty needs to be clarified in a timely manner, to avoid a delay in ECI companies investing in skills development.
- It is expected that on-the-ground activities, such as construction, will be most affected by the scale of deployment. Industry is optimistic about conducting the design studies for the projects kicking-off in the 2020s. However, this may be outsourced to overseas offices which already possess the appropriate expertise. Building skills for the front end engineering and detailed design of new technologies should not be neglected as this could represent an opportunity to build expertise that could be exported in the future.

The net zero transition will be transformative across the full engineering construction industry project lifecycle. Although the 'on the ground' activities would suffer the largest disruption, early project phases prior to winning the work will also be affected. For example, the personnel involved in bid writing and commercial activities will require 'low-carbon technology awareness', which will need to be delivered through additional training.

Key recommendations for the engineering construction industry

Harnessing the opportunities of the net zero transition will require close collaboration between industry and the government. Future actions should focus on three main aspects: identifying and closing skills gaps, minimising any skills shortages, and leveraging on policy and innovation.

Identify and close skills gap



Supplement skills gaps with transferable skills through accelerated programs



Attract new workforce by making ECI sector a more attractive and competitive employment environment

Minimise skills shortages



Develop a proactive attitude towards collaboration and the management skills required for cross-sector work



Harness the transformative impact of digitalisation to improve workforce efficiency, productivity and utilisation

Leverage policy and innovation



Work closely with government to ensure comprehensive new skills development in the UK, with potential for skills export in the future



Drive and influence a strong link between industrial clusters and local education institutions to accelerate workforce inflow

industry to make the sector more attractive will be needed in the long term. The industry should focus recruitment efforts on the younger generations that are looking for high-impact careers, such as fighting climate change.

Minimise skills shortages

The CCC's ambitious target to achieve net zero by 2050, with significant cluster decarbonisation milestones by 2030 and 2040, will require thousands of new entrants to join the industry, especially given the aging workforce. The second set of actions will therefore have to focus on ensuring sufficient workforce.

Decarbonisation of industrial clusters will require multi-sector involvement, with a wide range of technologies deployed within a small geographic area and a tight timeframe. Collaboration between industry stakeholders will be key in achieving the appropriate numbers of personnel and a wide spectrum of capabilities required for large decarbonisation projects. Industry players must be aware of the benefits of collaboration and have a proactive attitude to working with partners. Deep-dives into the types of technologies used in each cluster may help to reduce uncertainties, identify the type of work required in each area, and narrow down the expertise required from different partners. In addition, industry should make use of the powerful digital and data-driven technologies that could improve staff efficiency, productivity and utilisation, and minimise the effects of the retiring workforce.

Leverage policy and innovation

Policy interventions will be required to support expansion of the sector in the future. Whilst industry is optimistic about meeting the early milestones, it is expected that some aspects of the roll-out, particularly the FEED and detailed design of early projects, will be conducted from overseas, by international offices with existing expertise in hydrogen and CCS technologies. However, to support the long-term transition, the UK will need to build this expertise at home. The industry needs to work closely with the government to ensure the development of a rounded skill set in the UK. These skills will not only be crucial for achieving net zero emissions by 2050, but could also represent an opportunity for the UK, with the potential of exporting similar services to other countries looking to decarbonise in the future. Clarity on the governmental decarbonisation agenda could provide industry with the certainty required to invest in skills development within the UK.

In addition, ensuring appropriate local training in areas where the infrastructure will be rolled out will be crucial, especially in the context of lower mobility willingness of younger generations. The ECITB could help to build a strong connection between industrial clusters and local education institutions that could provide appropriate training for the technologies expected to be deployed in the area. This would ensure the availability of a trained workforce around industrial clusters and would reduce workforce shortages.

Identify and close skills gaps

This study has completed an initial review of the current skills gap, by examining the level of disruption brought by over 20 technologies. Whilst most technologies are expected to lead to low and medium disruption, actions towards closing any gaps should be taken both in the short and long term.

A variety of projects are expected to be commissioned in the 2020s, with FEED and detailed engineering design to be contracted within the next few years. The tight timeframes will make recruiting and training of new talent difficult. To mitigate these impacts, the skills gaps could be covered by **retraining the current workforce for the future, through accelerated learning programmes**. For example, given the similarities between the oil and gas industry and CCS, current oil and gas personnel already share many of the skills required for CCS operations and could be retrained accordingly. For example, pipe fitters and designers, leak test technicians, and off-shore barge operators currently providing services for the oil and gas sector could all be retrained for the needs of building and operating CCS infrastructure.

However, whilst this would mitigate the short-term impacts, a **repositioning of the engineering construction**

ACRONYMS

| | | | |
|------------------------|--|----------------------|------------------------------------|
| ATR | Autothermal Reforming | EIA | Environmental Impact Assessment |
| AD | Anaerobic Digestion | FEED | Front-End Engineering Design |
| BECCS | Bioenergy with Carbon Capture and Storage | GHG | Greenhouse gas |
| BEIS | UK Department for Business, Energy and Industry Strategy | H₂ | Hydrogen |
| CAPEX | Capital Expenditure | LDAR | Leak Detection and Recovery |
| CCC | Committee on Climate Change | LNG | Liquified Natural Gas |
| CCGT | Combined Cycle Gas Turbine | MBT | Mechanical Biological Treatment |
| CCS | Carbon Capture and Storage | Mt | Mega tonne |
| CCUS | Carbon Capture, Utilisation, and Storage | NG | Natural Gas |
| CO₂ | Carbon Dioxide | NTS | National Transmission System |
| CO₂e | Carbon Dioxide Equivalent | O&G | Oil and Gas |
| DACCS | Direct air capture with CCS | ONS | Office for National Statistics |
| ECI | Engineering Construction Industry | SIC | Standard Industrial Classification |
| ECITB | Engineering Construction Industry Training Board | SMR | Steam Methane Reforming |
| | | UKCS | UK Continental Shelf |

NOTE ON TERMINOLOGY

Throughout the report, blue hydrogen refers to hydrogen produced from a feedstock of natural gas (with or without any biomethane mixing) by autothermal reforming (ATR) coupled with carbon capture, utilisation, and storage (CCUS) of the resulting carbon dioxide emissions. Green hydrogen refers to hydrogen produced through water electrolysis using renewable electricity, without any associated emissions.

Whilst Carbon Capture, Utilisation, and Storage (CCUS) and Carbon Capture and Storage (CCS) are used almost interchangeably in the literature, for consistency purposes, this report only uses CCUS, with an exception when CCS is used directly in the cited sources.

1. INTRODUCTION

This chapter provides an overview of the Engineering Construction Industry (ECI) sectors and gives insights into typical project phases, each with a wide range of occupational skills. The geographical distribution of the ECI across the UK, also discussed in this chapter, is essential in understanding the implications of the future transition.

1.1 Context

The UK government has recently set a UK net zero emissions target of 2050, based on analysis and recommendations from the Committee on Climate Change (CCC). Achieving these ambitious targets will require rapid deployment of key decarbonisation technologies such as carbon capture, utilisation, and storage (CCUS), hydrogen and negative emissions technologies (e.g. BECCS, Bio-energy Carbon Capture and Storage). To enable the transition to net zero, the engineering construction industry and its industrial training body, the Engineering Construction Industry Training Board (ECITB), will be instrumental in delivering the technology and infrastructure required through:

- Expanding and developing the required expertise in new low-carbon technologies to support and drive decarbonisation in a timeframe consistent with the net zero commitment.
- Delivering the required training, resources and qualifications to support the ECI during the evolution of core sectors.

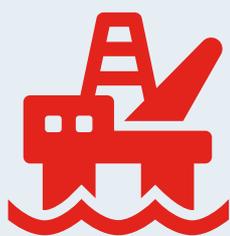
The aim of the study is to identify the implications of the transition to net zero emissions for the engineering construction industry, through:

- Examining key decarbonisation technologies required to achieve net zero emissions by 2050, with a focus on hydrogen and CCS, and their likely timescales of deployment.
- Understanding the future market opportunities and challenges for ECI companies in the core ECI sectors.
- Assessing the implications for skills in terms of risks and opportunities for the existing workforce, areas of gaps and skills shortages.
- Identifying key recommendations and potential actions for the industry to mitigate these impacts and fully capture the opportunities associated with the net zero target.

1.2 Overview of the engineering construction industry

With over 190,000 workers and a contribution of as much as £325 billion¹ in turnover to the UK economy, the engineering construction industry operates across the oil and gas, nuclear and renewables sectors, as well as major process industries, such as chemicals, pharmaceuticals, food processing, water and waste treatment. For the purposes of this research, we analysed the contribution of each sector to the UK economy workforce size, dominant skills and future potential trends impacting the different sectors were analysed².

Oil and Gas Industries



The oil and gas sector is one of the largest sectors in the UK in terms of economic impact, turnover and employment. Although the sector is dominated by existing capital investments and several mergers and acquisitions due to the prolonged fall in oil prices, the sector still supports over 270,000 jobs (70% of which are technical roles and the rest are supply chain, procurement and HR) in the UK³. During the energy transition to net zero, the oil and gas sector will continue to be an important part of the UK energy mix. The sector is expected to be dominated by synergies with hydrogen, CCS and offshore renewables⁴. Decommissioning of old assets is another trend in this sector. As of 2019, the Decommissioning expenditure in the UK is estimated at £1.5 billion per annum⁴. Skills and workforce demand in this sector will also be partially driven by the needs of these integration and decommissioning projects.

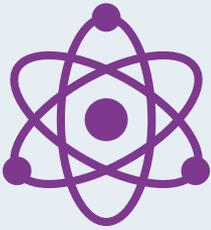
¹ The Economic Footprint of ECI Report, ECITB, 2018

² The sectors analysis was loosely guided by the key publications of ECITB including, ECITB Industry 4.0 Report, ECITB strategy 2020 – 2022 and ECITB Labour Market Outlook Report.

³ Oil and Gas UK Economic Report 2019 – Facts and figures sheet

⁴ Oil & Gas Authority – UKCS Energy Integration, Interim Findings Report.

⁵ OGUK Decommissioning Insights 2019 Report.



Nuclear

The nuclear industry in the UK is a core part of decarbonisation strategy. Currently, there are 15 nuclear reactors generating almost 20% of the country's electricity, however, all but one of these reactors are due to retired by 2030. As part of the nuclear sector deal published in 2018, industry and Government plans to invest up to £200 million to support the sector. With this major expansion, the nuclear sector is expected to require an increase in workforce from 88,000 to over 100,000 between 2017 and 2021. Given the majority of the current workforce is due to retire in the coming years, this workforce demand is expected to equate to an annual inflow of 3,300-8,600 new-joiner engineers⁶.



Power and Renewable Energy

The energy mix in the UK has significantly changed with a shift to a lower emissions system. This systematic change is set to be driven by the net zero objective. The power sector is expanding rapidly towards gas generation and phasing out coal plants. Renewable energy is another growing sector within the UK achieving a record high of 40% of electricity generated in Q3 2019⁷. As of 2018, the UK has the largest capacity of installed offshore wind in the world, sustaining a workforce of 10,000 individuals in 2018 and this is expected to grow to 36,000 by 2032. Contrary to the oil and gas sector, there will be no decommissioning activities of renewable assets needed in the immediate or short term. Overall, power and renewables sectors are more concerned with medium-term skills gaps and skills shortages, particularly for technicians and engineers.



Chemical and Pharmaceutical industry

In the UK, the chemical and pharmaceutical sectors combined form the second largest sectors in terms of revenues and added value to GDP, at £50 billion and £17.8 billion respectively. The chemical industry employs around 100,000 employees directly, the majority of which are in science and engineering, and is currently facing challenges filling technical and professional roles. The UK's pharmaceutical workforce consists of 63,000 workers, of which 24,000 work in research and development, with a noticeable shortage in new sector entrants. Both sectors could experience a future shortage of skills, especially with the uptake of automation, robotics, digitalisation, new processes and materials.



Food and Drink

The food and drink sector is a significant contributor to manufacturing and export revenues in UK. Overall, the sector employs 400,000 people, with a third of the workforce due to retire by 2024. In terms of skills, 30.8% of employees are low-skilled, 36.7% are semi-skilled, requiring experience and training and 32.5% are skilled or highly skilled at graduate or PhD level. The sector faces a challenge to attract talent in engineering and R&D. Similar to chemical and pharmaceutical industries, this sector will be impacted by automation and advanced production facilities.

⁶ Nuclear Workforce Assessment 2017, Nuclear Skills Strategy Group, July 2017.

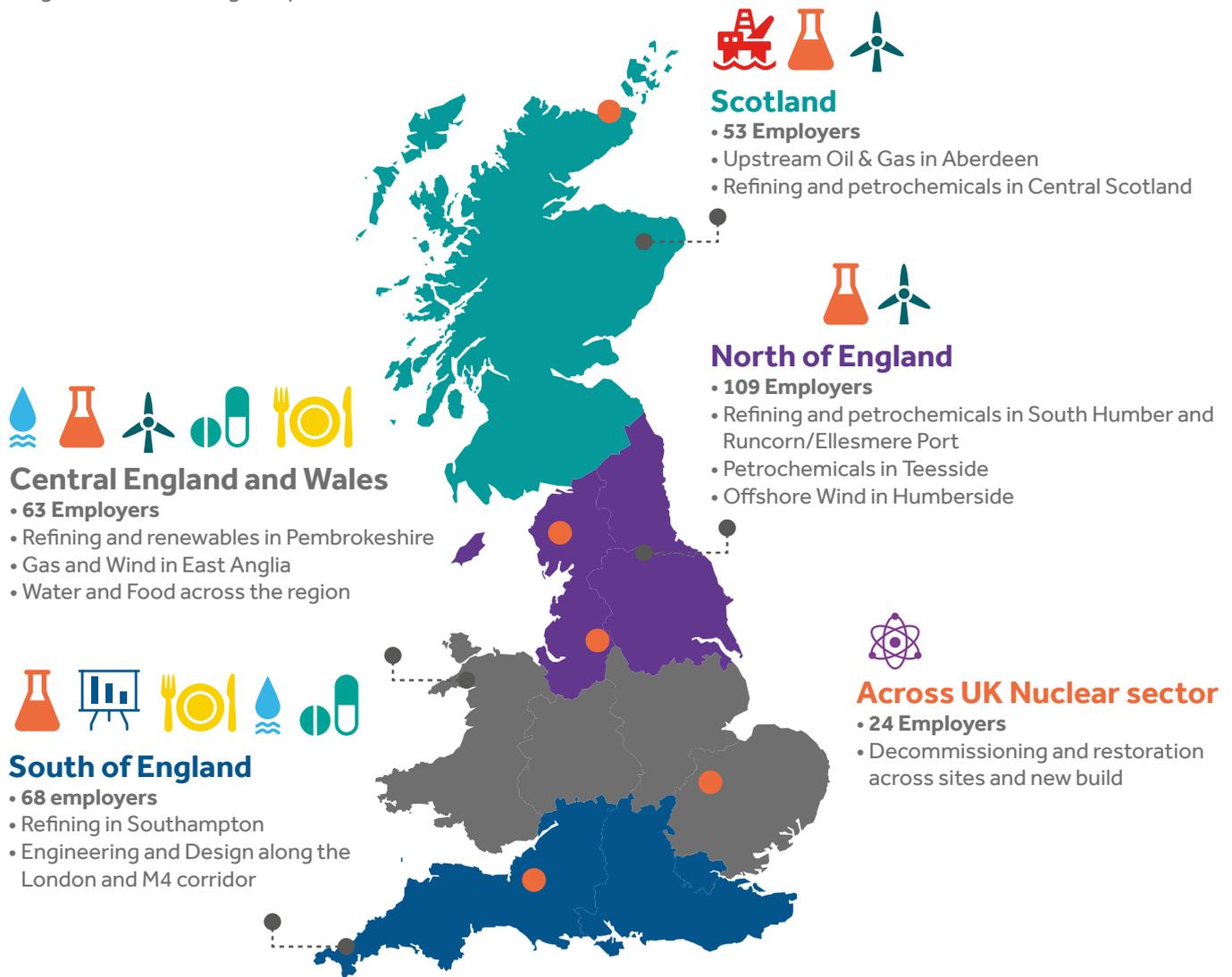
⁷ Carbon Brief Analysis: UK renewables generate more electricity than fossil fuels for first time: <https://www.carbonbrief.org/analysis-uk-renewables-generate-more-electricity-than-fossil-fuels-for-first-time>

Waste and Water Treatment



The sector is facing increased pressure to reduce its carbon footprint and energy impact, as well as help mitigate some of the impacts of climate change. These will represent a significant pool of activities for the sector and will fuel the adoption of emerging alternative waste and water treatment technologies. In addition, the expected 7% increase in the UK population by 2025 will require an a larger workforce to accommodate the needs of the expanding population. Thirdly, the aging infrastructure in the water sector will require considerable investment in replacements and upgrades which, given its duration could pose a huge opportunity for ECI sector.

The ECI sectors are distributed unevenly across different regions of the UK as shown in Figure 1. For example, whilst the centre of the UK represents the base for most sectors, the oil and gas industry is predominantly based in Scotland, alongside some refining and petrochemical activities.



Industry Sector Key



Orange dots show the location of existing nuclear power station sites and do not reflect the location of ECI companies involved in the nuclear sector or that of future nuclear deployment

Figure 1: Distribution of ECI sectors across the UK

1.3 Workforce involved in engineering and construction activities

The engineering construction industry is based on contracting, for different services and activities, to clients, operators and asset owners in the industries it serves (e.g. oil and gas, water and waste, power). These contracts can range from off-site activities, such as front-end engineering design (FEED) and detailed design, to on-site services, spanning the full life cycle of the project (Figure 2), including construction, operations and maintenance activities.

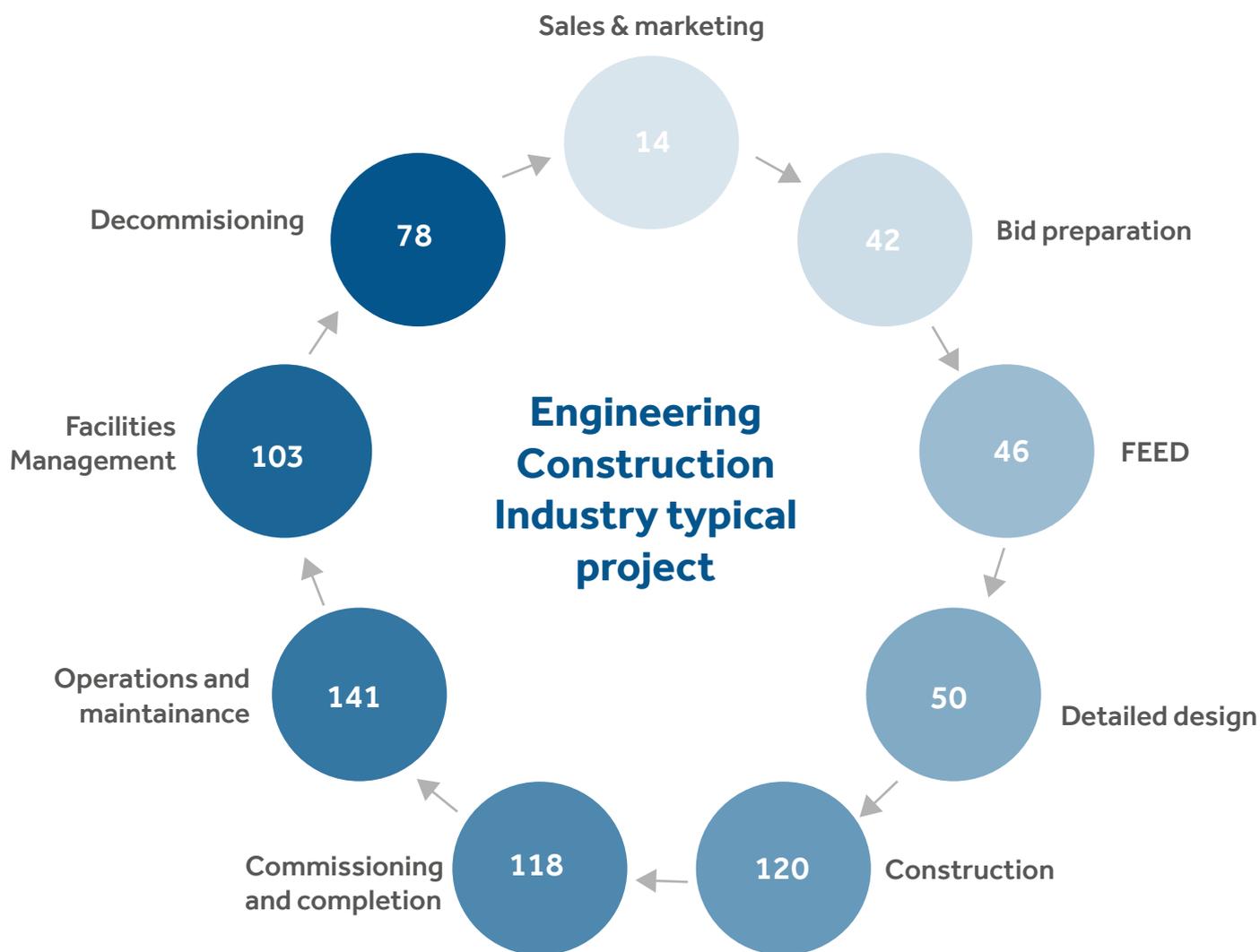


Figure 2: ECI project phases and the count of occupations required at each phase

The ECI workforce is trained in around 145 occupations covering different functions along the project phases, such as sales, bid preparation and contracting, construction management, design, construction, and operations and procurement support. Figure 2 shows the number of occupations currently applicable in each project phase. The responsibilities of each team vary, however it can be observed that later project stages, once the project is awarded require a higher number of skills and occupations, given the complexities of the tasks undertaken on-site.

Project phases at the early stages of the lifecycle are characterised by job functions that can be office-based, with staff assigned on more than one project. Some

tasks and activities include market analysis, business development, managing clients and public relationships, writing bids and developing proposal strategies. In addition, technical engineering work and design, such as feasibility studies, environmental impact assessments (EIA), the creation of design packages, and project roadmaps represent an important stream of ECI activity that is also conducted offsite.

On-site activities could include construction work (fabrication, welding, erection of structures), quality control, performance monitoring and reporting, as well as maintenance and inspection of existing assets already in operation.

1.4 Transformation in the engineering construction industry

The ECI is a very dynamic industry which has experienced disruptions and transitions in the past. The industry has shown resilience in adapting its workforce to accommodate the changing industrial landscape and is expected to sustain this trend in the future.

In the last decade, there have been two major trends with direct impact on ECI sectors and eventually to its workforce; the phasing out of coal power plants and the offshore wind boom. The ECITB is working with industry players to ensure industry retains its skilled workers that were impacted by the phase out of aging assets and technologies. An example of this is the training and upskilling of EDF Energy Cottam coal-fired power station workers into other sectors. With the anticipated closure of all coal power plants in the UK by 2025, the ECITB has rolled out a re-skilling programme to enable transfer of existing coal-fired power station operatives to nuclear new build⁸.

In addition to the shift to cleaner energy examined in this report, the ECI is also experiencing several disruptors such as the fourth industrial revolution (Industry 4.0), the advent of new materials and fabrication technologies, and an ever changing economic and political environment⁹. Industry 4.0, bringing together the use of big data, predictive maintenance enabled by high-speed Internet, Artificial Intelligence and automation is expected to have a broad impact on the different ECI sectors¹⁰. This will require the industry to change the way it works, will create new roles by harnessing the value of transferable skills, and will improve productivity of the current workforce. Digitalisation will enable the transition to smarter more affordable energy by increasing the renewable energy penetration, grid flexibility, and demand side response mechanisms. Whilst the detailed potential of Industry 4.0 in accelerating the low-carbon energy transition is not fully examined in this study, the role of digital technologies and big data cannot be overlooked and will be discussed in the remainder of this report.

⁸ ECITB Annual Report 2018

⁹ The impacts of Brexit were not assessed in this study, however uncertainty around Brexit's impacts on mobility of workforce from The European Union remains until the publication of the EU Exit terms.

¹⁰ INDUSTRY 4.0: The impact of technological change on the Engineering Construction Industry, ECITB, 2019



2. CHALLENGES AND OPPORTUNITIES OF THE NET ZERO TRANSITION ON ECI SECTORS

2.1 What is the UK net zero transition?

The Committee on Climate Change (the CCC) is an independent, statutory body established under the Climate Change Act 2008. The CCC provides advice to the UK Government and reports to Parliament on progress made in reducing greenhouse gas emissions and preparing for climate change. The Committee's Net zero Report, published in May 2019, showed that achieving net zero emission targets by 2050 is economically feasible using today's decarbonisation technologies¹¹. The report recommended that the UK enshrines in legislation a 100% reduction in greenhouse gas emissions by 2050, compared to 1990 levels. This unprecedented level of ambition would affect all sectors of the economy, including industry, transport, electricity, heating, and agriculture across the UK.

Following the recommendations of the CCC, the UK government passed the net zero legislation in June 2019, pledging to support and incentivise industry to reach net zero by 2050.

"Government must implement an approach to incentivise industries to reduce their emissions through energy and resource efficiency, electrification, hydrogen and CCS in ways that do not adversely affect their competitiveness."¹².



Industrial clusters are hubs of large industrial plants of energy-intensive industries (e.g. iron and steel, refineries and cement) that significantly contribute to the UK local economy and also to carbon emissions. There are six key industrial clusters identified around the UK as shown in Figure 3 responsible for emitting 40 million tonnes of carbon dioxide per year – equating to about one third of all business and industrial emissions.¹³ The UK government committed to helping industry and industrial clusters decarbonise whilst retaining competitiveness, as part of the Industrial Strategy roadmap published in 2017.

As a part of the Government's industrial decarbonisation programme, the industrial decarbonisation programme aims to accelerate the deployment of low-carbon technologies across these clusters, and scale-up the infrastructure by the mid-2020s. The industrial clusters mission seeks to harness the scale of the industrial clusters to create opportunities to work together to find cost-effective solutions to decarbonisation. This will lead to attracting innovators, investors and problem solvers to create a low-carbon exemplar that others in the UK and internationally can learn from and replicate. The industrial clusters mission has set an ambition to establish at least one low-carbon cluster by 2030 and the first net zero carbon cluster by 2040.

¹¹ The CCC report includes three measures for deep decarbonisation of different sectors: 1) Core measures for key sectors, 2) Further ambition options which are more challenging to reduce emissions and 3) Speculative options relying on lower technology have very low levels of technology readiness, very high costs, and/or significant barriers to public acceptability

¹² As stated in the Committee on Climate Change, Net Zero - The UK's contribution to stopping global warming report

¹³ UK Industrial decarbonisation programme

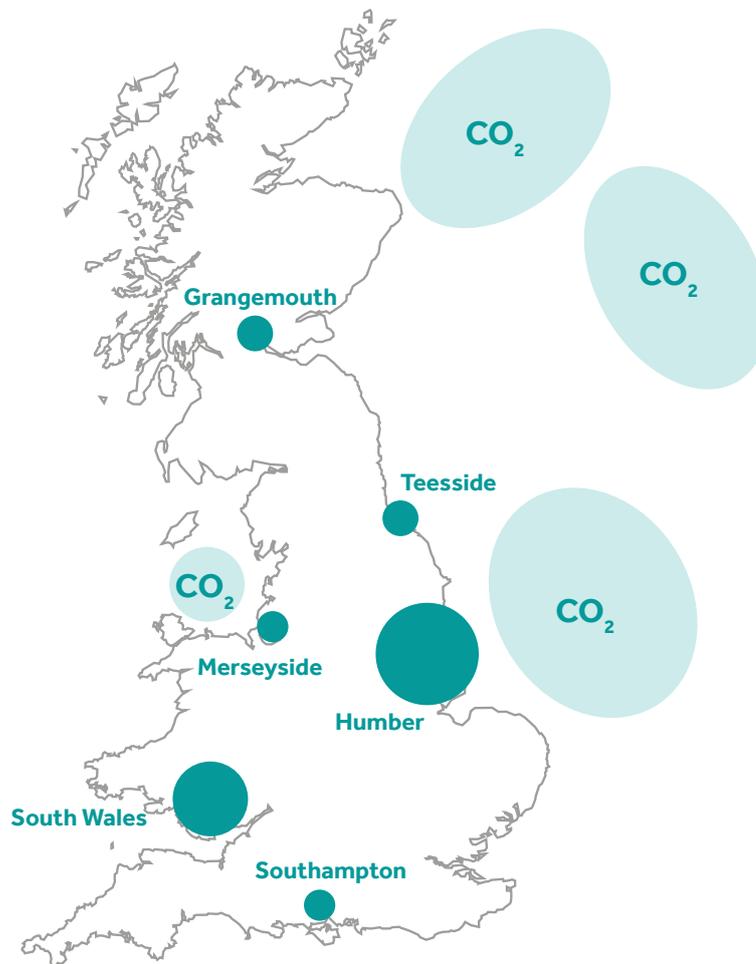


Figure 3: Clusters locations in UK (Industrial Strategy) and potential CO₂ storage sites

2.2 Current initiatives driving the net zero transition

Beyond the UK net zero commitment there needs to be a collective action across investors, government, industry, regulators and civil society to achieve this goal. The UK government has been engaging closely with industry to create and develop deployment frameworks and roadmaps for different decarbonisation technologies to support the delivery of short and long-term emission reduction targets. These efforts are being mobilised through different industry challenges, funds and investment opportunities created for the private sector and backed up by the public sector. The following section explores some of these efforts that are closely related to decarbonisation technologies explored in depth in this study.

Through the Clean Growth Strategy, Innovate UK, the Research Councils and BEIS expect to invest around £162 million in industrial research and innovation, including carbon capture, usage and storage (CCUS), including:

- **Hydrogen supply competition**¹⁴ – £20 million programme aiming to accelerate the development of low carbon hydrogen solutions.
- **Industrial fuel switching to low carbon alternatives**¹⁵ – a £20 million competition allocating funding to investments in fuel switching processes and technologies aiming to increase its technology readiness level (TRL) before 2030. Key fuels and technologies are hydrogen, biomass and electrification.
- **CCUS Innovation programme**¹⁶ – a £15 million call for CCUS innovations aiming to reduce overall CCUS costs and drive a quicker deployment in UK and internationally.

As a part of the efforts to decarbonise industrial cluster(s) by 2030, the Industrial Decarbonisation Challenge aims to accelerate the cost-effective decarbonisation of industry

¹⁴ <https://www.gov.uk/government/publications/hydrogen-supply-competition>

¹⁵ <https://www.gov.uk/government/publications/industrial-fuel-switching-to-low-carbon-alternatives>

¹⁶ <https://www.gov.uk/government/publications/call-for-ccus-innovation>

by developing and deploying low-carbon technologies. It also aims to enable the deployment of supporting infrastructure at scale by the mid-2020s. The challenge is funded through £170 million from the Industrial Strategy Challenge Fund (ISCF), which is expected to be matched by up to £261 million from industry. Opportunities for industry engagement include:

- Delivering detailed designs for industry-scale technologies focusing on deep decarbonisation of at least one cluster.
- Feasibility studies and deployment roadmaps for achieving the first net zero cluster.
- Creating a joint industry/government/academic-led research programme to act as a shared knowledge base.

Additionally, there are several planned and on-going projects led by industry and targeting the commercialisation of decarbonisation technologies/programmes in the near future, including:

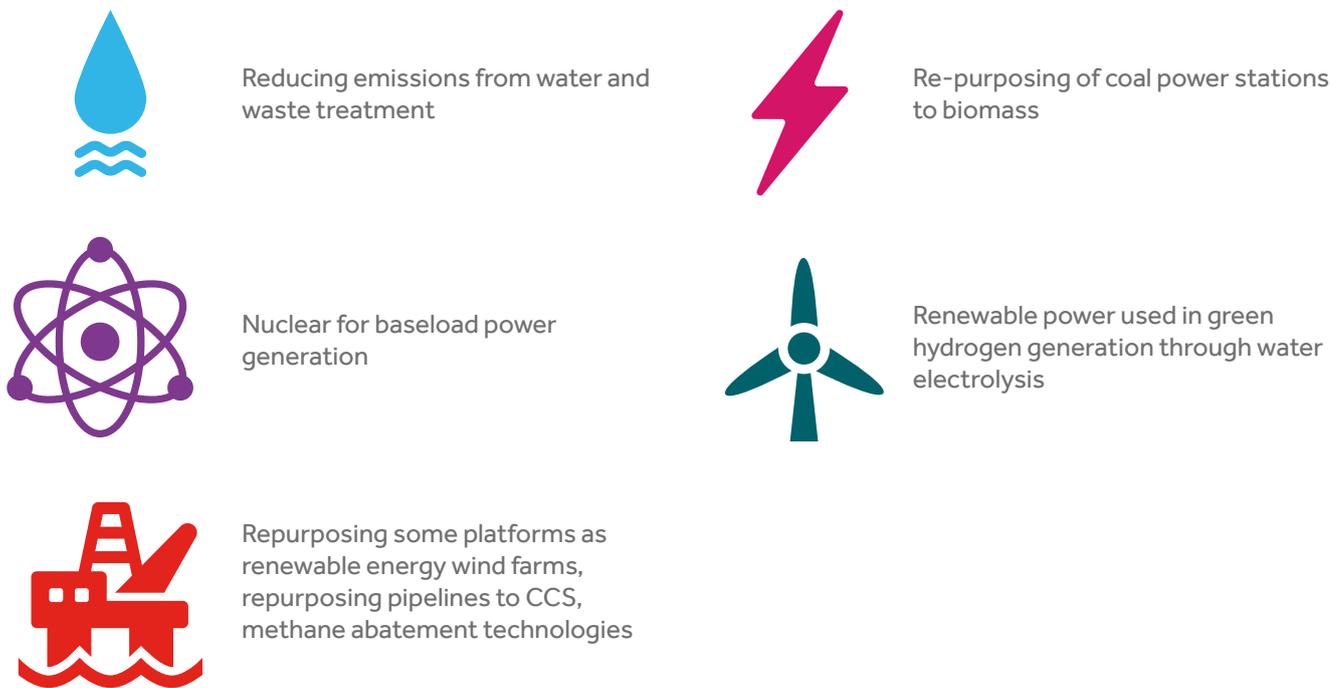
- HyNet (North West) and H21 (North of England) are examples of projects with wide scope looking into hydrogen production at scale, conversion of gas networks to hydrogen for domestic, commercial and industrial use, and deployment of CCS infrastructure. Key players include Cadent, Progressive Energy, Equinor and the University of Chester.
- The Zero Carbon Humber partnership, led by Equinor, Drax and National Grid Ventures, aims to build the world's first zero carbon industrial cluster and decarbonise the North of England. Currently, the DRAX power station is one of the biggest clean energy sources in UK, relying on biomass for electricity generation. The project aims to deploy CCS at scale, delivering negative emissions from Drax station by combining carbon capture with Biomass (BECCS), and decarbonising local industry through hydrogen and CCS. A case study on the Zero Carbon Humber project is included in section 3.4.
- Acorn is an on-going project aiming to develop a CCUS supply chain in Aberdeen, centred at St. Fergus gas terminal. The project hopes to utilise existing oil and gas assets in deploying carbon capture technologies in natural gas and hydrogen production. The FEED is currently under way, and is being conducted by Pale Blue Dot.

2.3 Disruptive technologies and trends across ECI

The CCC Net zero report recommended the decarbonisation of all sectors of the UK economy. This ambitious target will require the deployment of a wide variety of technologies, many of which are already deployed in the UK, such as renewables and nuclear power generation.

In addition to conventional low-carbon technologies, the Net zero report recommended the prioritisation of investment in key technologies, such as hydrogen (including generation, usage, and storage) and carbon capture, utilisation and storage (CCUS), due to their pivotal role in achieving large-scale decarbonisation and the long timeframe required for their deployment. Both these technologies are established, already in use or at demonstration scale in the UK and/or globally, however the net zero transition will require their deployment at an unprecedented scale. This chapter focuses on the elements required to deploy hydrogen and CCUS. In addition, the impact of ongoing trends related to the decarbonisation agenda on other ECI sectors, such as industry, power, oil and gas, water and waste are also examined. For the purposes of this research, we have adopted a technology-centric approach (diving into the specifics of each technology) in order to understand whether the capabilities and skills currently present in the engineering construction industry will be appropriate to deploy these technologies in the future.

Current technologies used in the net zero context



Key enabling decarbonisation technologies

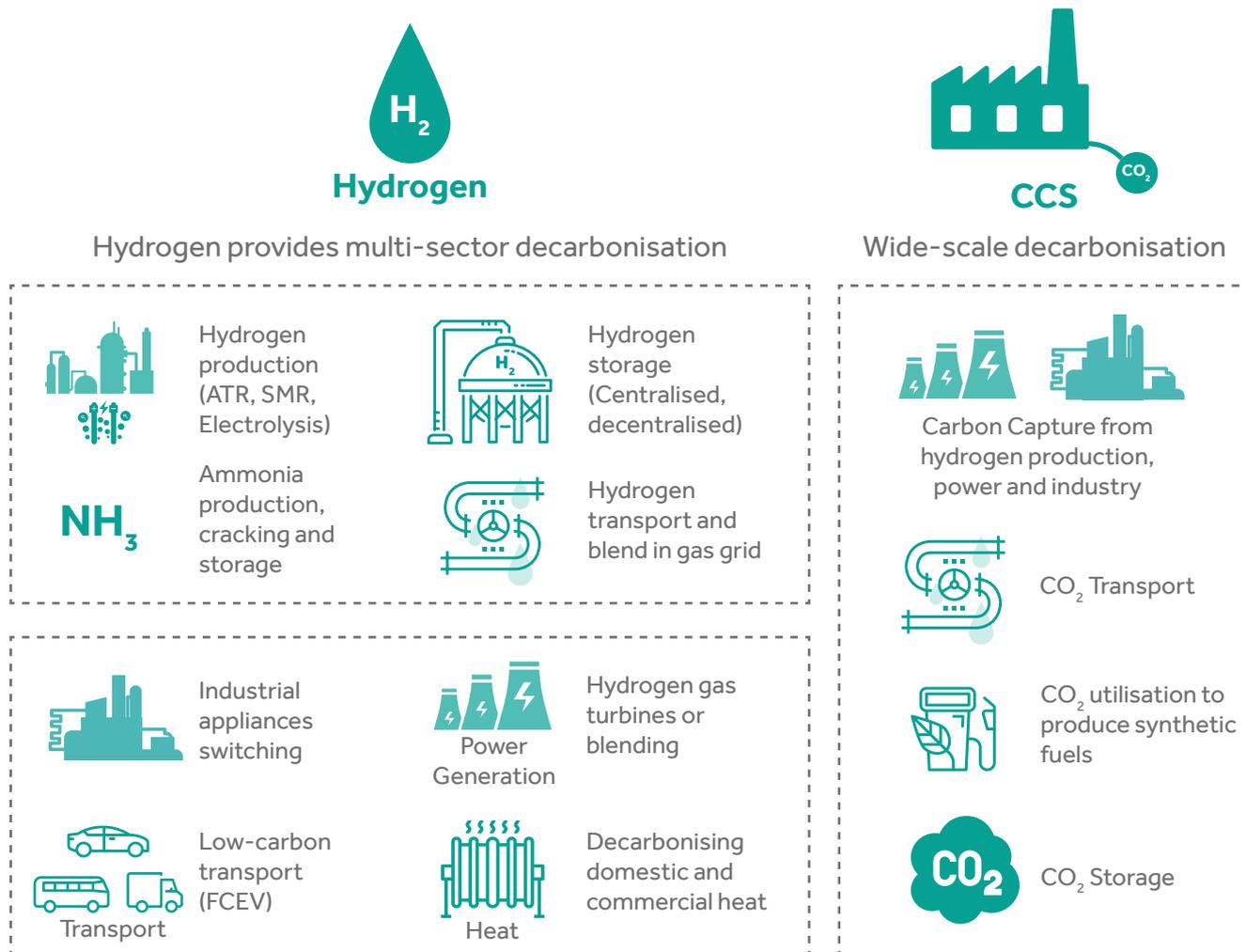


Figure 4: Overview of decarbonisation technologies required to achieve Net zero emissions

Hydrogen technologies

Generation and use of hydrogen are not novelties. In fact, hydrogen has been used for more than a century as an industrial feedstock and energy source in the manufacture of chemicals and refining of hydrocarbons. The hydrogen molecule is the simplest and lightest molecule known, with a high energy content per unit of mass, and could be feasibly produced and stored at scale. However, the decarbonisation agenda has recently placed hydrogen in

the spot-light due to a) its lack of direct emissions at the point of use (burning hydrogen only generates water), and b) the wide diversity of hydrogen generation pathways from low-carbon sources. These attributes allow hydrogen to be a versatile decarbonisation vector with high deployment potential across multiple sectors of the economy, with an estimated demand of 270 TWh/year in 2050 according to CCC's Net zero report.

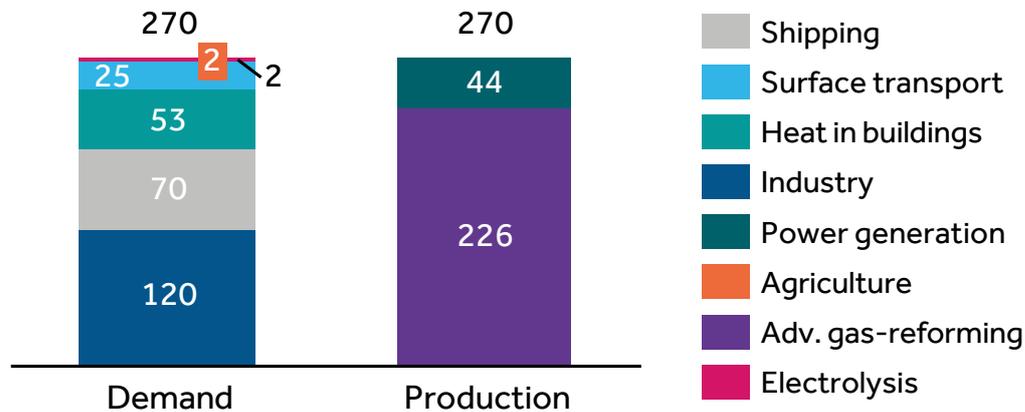


Figure 5: Hydrogen supply and demand (TWh/year) in 2050 under the CCC Net zero Further Ambitions scenario

Decarbonisation potential of hydrogen

- Given its similarities to natural gas, hydrogen is considered a 'low disruption' option for **decarbonisation** of industry, compared to electrification or CCS. Some industrial appliances (such as boilers, furnaces, ovens and kilns) using natural gas could be retrofitted and converted to hydrogen rather than fully replaced. Within the UK, it is estimated that industry alone will be the biggest consumer of hydrogen in 2050, with a total demand of 120 TWh/year (44% of total generation).
- Although the CCC scenario considers limited usage of hydrogen in **power generation**, there is evidence that several turbine manufacturers and leading energy companies are already conducting research into using hydrogen, either as a pure gas or blended with natural gas^{17 18}. Recent work conducted by Element Energy also suggests that up to 14 GW generation of installed generation capacity could utilise hydrogen in the UK by 2035¹⁹.
- Hydrogen could play a significant role in **other sectors**, outside of the ECI core business. Hydrogen fuel cell vehicles represent an alternative to polluting petrol and diesel vehicles, from cars to trucks and buses that the UK plans to ban from sale by 2040. Hydrogen could also be used to decarbonise domestic and commercial heating, with several projects underway investigating a complete gas grid conversion to hydrogen²⁰ or blending of hydrogen with natural gas²¹. Although the deployment of hydrogen technologies within these sectors may not fully apply to the current work areas of the ECI, the construction of large-scale hydrogen production facilities to supply the transport and heating sectors would be built as part of the wider infrastructure deployed by the ECI.

¹⁷ The Enel Fusina 12 MWe power plant which has been operational since 2009.

¹⁸ In March 2018 Mitsubishi Hitachi Power Systems announced a partnership with the Netherlands Carbon-Free Gas Power project to support the conversion of one of the units of the Dutch 1.32 GW Magnum gas-fired powerplant to 100% hydrogen Power Magazine, January 2018

¹⁹ The Enel Fusina 12 MWe power plant which has been operational since 2009.

²⁰ H21 North of England Programme (Northern Gas Networks and Equinor)

²¹ HyNet website

Hydrogen production

- **Reformation of natural gas** involves the high-temperature treatment of natural gas with water vapours to produce hydrogen and carbon dioxide. This can be achieved through two similar technologies: simple steam methane reformers (SMRs) and more efficient autothermal reformers (ATR). Such technologies are already used at industrial scale, for example to produce hydrogen for the synthesis of methanol and petrochemicals. However, the decarbonisation requirement will add another level of complexity to current hydrogen production installations, requiring capture of the emissions through CCS, generating so-called 'blue' hydrogen. Large-scale deployment of reformation facilities is expected, with the CCC estimating that 83% of the hydrogen demand in 2050 would be provided by ATRs and SMRs.
- An alternative zero-carbon 'green' hydrogen generation technology is **water electrolysis using renewable electricity**. This is already used at small scale in certain industrial applications or for hydrogen production for transport applications. However, as the UK is moving towards net zero, larger scale electrolyzers are expected to be deployed, generating 44 TWh/year hydrogen in 2050. These would likely be built by the assembly of multiple electrolyser modules hosted in so called "electrolyser houses", in the close proximity to the renewable electricity sources and the hydrogen users or grid inject points.
- **Gasification** can be used to produce hydrogen from the chemical reduction of biomass, at high temperature. Although this process is currently not used at scale for hydrogen production, the technology is very similar to the gasification of coal, routinely used in Asia to produce hydrogen for fertiliser synthesis. The CCC report does not consider gasification of biomass as main pathway to achieve wide-scale decarbonisation, however this technology may have a significant role in a bio-energy based decarbonisation scenario.

Hydrogen transport

Once produced, hydrogen requires transportation infrastructure from source to the point of use.

Hydrogen pipelines could be used to distribute hydrogen short distances within industrial clusters and across the UK through a national hydrogen transmission system, similar to today's gas infrastructure. The first pipeline infrastructure should be deployed simultaneously with the first hydrogen production facilities in the-mid 2020s.

Long distance transport of hydrogen, across and between continents, could be achieved either by pipeline (e.g. similar to the gas interconnector across the English Channel) or as liquified hydrogen and/or ammonia shipped by sea tanker.

Hydrogen storage

Deploying hydrogen on a large-scale would require some degree of hydrogen storage to account for the inter-day and seasonal volatility in hydrogen demand arising especially from the use of hydrogen in domestic and commercial heating. Hydrogen produced at times of low demand needs to be stored to secure hydrogen supply during demand peaks. Large scale hydrogen storage could have the potential of absorbing the surplus of renewable energy that may be not used within the energy system but could be converted to hydrogen. The two main technologies available for storing hydrogen are described below:

- **Underground storage**, in the form of salt caverns, represents an established way of storing natural gas and could be used for hydrogen storage. However, there are still certain technological and operational uncertainties regarding the feasibility of hydrogen storage in salt caverns. In addition, the limited geographic availability of salt caverns across the UK, with most geological formations present in the North of England region, constrain the nation-wide use of this storage technology.
- Conversion of hydrogen to **ammonia** is seen as an emerging solution that could solve the problem of hydrogen storage in areas with limited salt cavern availability, such as Scotland and South Wales²². Ammonia is a well-characterised chemical compound, key in fertiliser manufacturing, with increased stability and ease of manipulation compared with hydrogen. This storage approach would require the installation of large ammonia production plants, over ground ammonia storage tanks, and ammonia cracking facilities that would convert ammonia back to hydrogen at times of demand. In addition, the UK could emerge as a leader in production of clean ammonia that could be exported to other markets via ship or pipeline.

Carbon capture and storage technologies

CCS is seen as complementary to hydrogen. It is used to capture emissions from hydrogen generation and in decarbonising other sectors, such as capturing emissions from power plants and industries with large process emissions. The technology consists of capturing CO₂ emissions, transporting them via pipeline, and either storing them underground or utilising the captured CO₂ for other applications, such as synthesis of aviation fuels.

²² H21 North of England (NoE) Report, Northern Gas Networks and Equinor, 2018

Carbon capture plants installed at the site of the emitters (e.g. industry, power stations, hydrogen producers) are used to separate and compress carbon dioxide before transport and injection underground. Although technical specifications vary from case to case, the full infrastructure consists of pipelines, separation and absorption towers, and compressors and resemble installations currently deployed in the chemical industry. Captured CO₂ is compressed and **transported** to storage facilities via pipeline, both on-shore and off-shore. **CO₂ can be stored** in various types of underground sites, with storage in

depleted hydrocarbon fields and aquifers under the sea surface, representing the most likely storage option for the UK. The deployment of wide-scale CCS would require repurposing of current and derelict oil and gas assets. However, the availability of direct storage is limited in the case of two of the main UK industrial clusters, South Wales and Southampton, which would require additional infrastructure of compression and liquefaction, and subsequent transport (e.g. by tanker or ship) to storage sites.

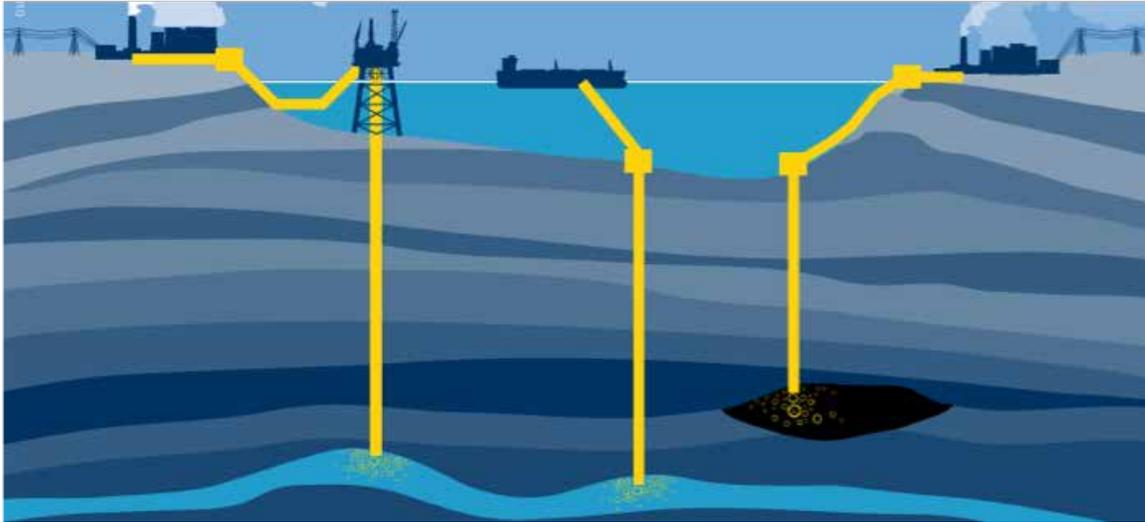


Figure 6: Visualisation of the carbon capture and storage supply chain²³

A considerable amount of work from the engineering construction industry, covering both on-shore installations and off-shore facilities, will be required to deploy CCS in the following sectors:

- CCS can be used to capture **industrial emissions**, either from natural gas combustion where replacement with hydrogen is not technologically feasible (e.g. certain processes in refineries, steel and chemicals manufacturing) or from industrial processes that release with CO₂ emissions due the nature of the process (e.g. cement and ammonia production). Given the primary need for CCS in industry, CCS infrastructure will be deployed around industrial clusters.
- **Hydrogen production** from natural gas reformation would require CCS. It is expected that hydrogen generation would be located in the proximity of industrial clusters, close to highest hydrogen demand, and due to the synergies arising from using the same CO₂ transport and storage (T&S) infrastructure deployed to decarbonise industry.

- **Power generation** based on natural gas or biomass could be decarbonised by CCS. There is evidence that the first bioenergy with carbon capture and storage (BECCS) power station will become operational in the late-2020s and will be based in the Humber area²⁴. Recent Element Energy work²⁵ suggests that UK natural gas power stations could use CCS as early as 2029, with 8-17 GW installed capacity being deployed by 2035.

Aside from storage, carbon dioxide could also be **utilised** for certain applications. Enhanced oil recovery, a process in which pressurised carbon dioxide is injected in almost empty hydrocarbon fields to remove the last deposits, represents one of the earliest and most common cases for CO₂ utilisation, with over 15 years' experience globally²⁶. However, captured carbon dioxide could also be used to produce synthetic fuels²⁷, for example for aviation, which would have a much lower carbon footprint compared to conventional fossil fuels.

²³ One North Sea: A study into North Sea cross-border CO₂ transport and storage, Element Energy, 2010

²⁴ Zero Carbon Humber Cluster project initiative, including the deployment of BECCS at the Drax power station

²⁵ Hy-Impact Series – Study 3: Hydrogen for Power Generation, Element Energy for Equinor, 2019

²⁶ <http://www.ccsassociation.org/what-is-ccs/storage/enhanced-hydrocarbon-recovery/>

²⁷ There are several methods of producing synthetic fuels. For aviation fuels, the Fisher-Tropsch catalytic conversion of captured carbon dioxide and hydrogen could be used. This process currently involves production of fuels from hydrogen and carbon monoxide (generated from methane), with carbon dioxide not currently used as a feedstock. A new optimised process and catalysis may be required to achieve scale development of the CO₂-feedstock alternative pathway, thus giving uncertainty over the future of the process.

Other technologies and sectors

In addition to hydrogen and CCS, other technologies deployed in sectors such as waste and water, oil and gas, and nuclear energy, will play an important role in the transition to net zero.

Oil and gas

Methane Abatement technologies will be deployed to monitor and remove emissions of methane, another powerful greenhouse gas, from oil and gas production. Oil and gas demand will remain significant even in the case of the energy transition, due to the many applications of hydrocarbons in the synthesis of hydrogen, petrochemicals, as an industrial fuel or in power generation with CCS. In addition to its environmental impact, methane has a significant commercial value that could be monetised instead of wasted by release in the atmosphere. This means that emissions reductions could result in economic savings or be carried out at low cost. This combination of environmental and economic concerns is expected to drive the deployment of methane abatement technologies, which could result in important economic savings.

There are a wide range of methane abatement options that can be achieved by combining several technologies, including blowdown capture and routing to the fuel system, early replacement of high-bleed devices, installation of flare completion and venting, redesign of blowdown systems, pipeline pump-down prior to maintenance, vapour recovery units and different frequency Leak detection and Recovery (LDAR) programmes²⁸. If all these technologies are deployed simultaneously, around 75% of the emissions across the oil and gas value chain can be avoided²⁹.

Asset repurposing is required in the context of declining investment in the oil and gas sector. The sector is currently investigating ways to maximise the lifetime and utilisation of current assets, up to and beyond their economic lifetimes. Some repurposing activities focus on treating current assets as key elements in deploying decarbonisation technologies, reducing the cost of the expensive energy transition due to stranded assets. Aging oil and gas production platforms could be repurposed for renewable energy, by using them as conversion and storage units for offshore wind energy or a foundation for wind turbines provided they are structurally sound, with several operators already considering this option. Another important area in repurposing oil and gas infrastructure is utilising oil and gas fields and gas pipelines for CO₂ storage and transport. This will allow the depleted oil and gas reservoirs to be repurposed for CCS commercialisation. However, geological and technical assessments would need to be conducted for both pipelines and fields to

determine their suitability for CO₂ storage. Repurposing of gas infrastructure, in particular of the transmission and distribution grid, is also a crucial element in increasing the penetration of hydrogen as a fuel for domestic heating and industry, whilst maintaining low infrastructure costs. For example, the H21 North of England project of Northern Gas Networks and Equinor, proposes the gradual conversion of the UK gas distribution infrastructure to 100% hydrogen. The project overview shows extensive engineering and financial analysis, demonstrating the technical and economic feasibility of the natural gas grid conversion.

Oilfield services sector diversification – Expanding beyond oil and gas assets, companies providing oilfield services are looking to expand into renewable energy and other low-carbon services. These contractors, usually in charge of engineering, design and managing mega-projects for oil majors, are accelerating their diversifications into low-carbon projects, utilising existing tools and personnel, and examining business models around liquified natural gas (LNG) and biofuels. Uncertainty in oil and gas prices and demand has prompted major Tier 1 service contractors to explore off-shore wind installation and other renewable energy projects, which are perceived as less risky than deep-water drilling operations. In addition, it is expected that oilfield service providers already specialising in reservoir engineering and seismic studies would be looking into utilising this expertise for providing CO₂ storage appraisal services. This is a critical area that would reduce the uncertainty of planned CCS projects and ensure their success. The emergence of CCS is considered a major shift in oilfield services companies' business model that will eventually bring a new portfolio of services to the market associated with different players and workforce skillsets.

Oil and gas decommissioning – Oil and gas operators in the UK are increasingly decommissioning their assets as they are reaching the end of their useful economic lives, with more than £1 billion spent on decommissioning in each year since 2014. There are currently 320 fixed installations in production in the UK, mainly around the North Sea, that are expected to be decommissioned in the coming 30 years³⁰.

²⁸ A full list of Methane abatement options is available in IEA World Energy Model Documentation

²⁹ IEA Methane Tracker

³⁰ Innovation Insights Brief 2019, World Energy Council

Water and waste treatment technologies

The CCC Net Zero report includes both core and ambitious measures to reduce waste and water treatment related emissions. The core scenario includes stopping sending five key biodegradable waste³¹ streams to landfill by 2030 or earlier, in addition to increasing recycling rates. In the Further Ambitions scenarios, there are additional targets for emissions reduction from wastewater treatment, elimination of biodegradable waste in landfills by 2025 and increasing recycling rates to 70% across the UK. In addition to addressing landfill emissions through waste prevention, diversion and reducing methane in landfill sites, the CCC report proposes alternative waste treatment systems, expected to be deployed by the engineering construction industry, as follows³²:

- **Anaerobic Digestion (AD)** is considered the best environmental outcome for food waste that cannot be prevented or redistributed. This is a biochemical process that takes place in the absence of oxygen in a sealed tank called an anaerobic digester. In the UK, the number of AD facilities using food waste or farm waste has increased sharply since the Anaerobic Digestion Strategy in 2016 and there are currently about 4,200 active AD plants. In the context of the net zero transition, the sector is expected to expand considerably.
- **Mechanical Biological Treatment (MBT) Systems** combine sorting of food waste with a form of biological treatment such as composting or anaerobic digestion. These plants could be used to process both mixed household waste and commercial and industrial waste. This method provides an effective way to stabilise and separate waste which is not suitable for recycling, extract recyclable materials and produce a solid recovered fuel.

- **Bio-covers** are considered an inexpensive way to reduce methane emissions from existing landfill through improved landfill cover design. The process is based on the natural process of microbial methane oxidation and requires an improvement in environmental conditions to increase the growth of methane-metabolising bacteria on the landfill site.
- **Waste-to-energy** – A waste-to-energy plant is a type of waste management facility that combusts wastes to produce electricity from non-hazardous non-recyclable materials. In addition, recyclable or hazardous materials are recycled, increasing the environmental and economic benefits. Waste-to-energy power plants coupled with CCS could represent a sustainable approach for achieving negative emissions. Whilst there are limited plans to deploy this technology in the UK at the moment, demonstration of the technology is already underway in Norway. The Klemetsrud Waste-to-Energy facility in Oslo, Norway processes over 400,000 tonnes of non-recyclable municipal solid waste (MSW), generating 55 MW of heat for 40,000 homes and 10.5 MW of electricity. A full-scale carbon capture project is currently under development and aims to capture 400,000 tonnes CO₂/year. It is expected that more such initiatives to be developed in the context of reusing waste for the production of low-carbon or negative-carbon energy.

³¹ Waste stream could contain food, paper and card, wood, textiles and garden waste.

³² CCC Net Zero Technical Report

³³ The use of municipal solid waste (MWS) allows negative-emissions deployment as it may contain a significant fraction of bio-genic carbon, for example under the form of food waste.

³⁴ Waste-to-Energy with CCS: A pathway to carbon-negative power generation, Global CCS Institute, 2019

Nuclear

Nuclear power generation is a critical technology to the UK decarbonisation agenda. This is reflected in the Nuclear Sector Deal (NSD)³⁵ published in 2018 as a dedicated part of the Industrial Strategy focusing on the nuclear sector. Under the NSD, there are three trends that will impact the ECI:

Building new reactors could see costs decrease by 30% by 2030, and at least replace the 20% generation share which the 15 current operational nuclear reactors supply.

The NSD set out plans to build up to 16GW of new nuclear capacity in the UK by the mid-2020s³⁶, including the deployments at Hinkley Point C, Sizewell C, Wylfa Newydd, Oldbury by Horizon Nuclear Power, and Moorside by NuGeneration Ltd.

However, since the publication of the Nuclear Sector Deal, plans by NuGeneration Ltd to develop the Moorside site have been wound up, and Horizon Nuclear Power have suspended their activities at Wylfa and Oldbury until a new financing model is in place to fund their projects. The remaining projects currently in progress beyond Hinkley Point C, are EDF Energy's plans to replicate the HPC design at Sizewell C, and CGN UK's development at Bradwell B.

Advanced Nuclear technologies³⁷ are emerging, represented by Small Nuclear Reactors³⁸, which are characterised by being smaller in size than conventional nuclear plants and designed in a modularised manner. The modular design allows fabrication in a factory environment and transport to site for operation, reducing costs and improving safety by reducing risk of nuclear contamination. In addition, conventional water-cooled reactors are expected to be improved and replaced by more advanced nuclear technology, such as Generation IV reactors that uses novel fuels and coolants, as well as fusion reactor concepts.

Integrated Nuclear supply chain – the Nuclear Sector Deal aims to create a more competitive nuclear supply chain with more UK companies using advanced manufacturing methods and entering domestic and export markets for nuclear goods and services, aiming to create and maintain global excellence.

³⁵ Nuclear Sector Deal – Policy paper, BEIS, 2018

³⁶ NIA: Nuclear New Build in the UK

³⁷ Advanced Nuclear Technologies – Policy paper, BEIS, 2019

³⁸ Small Modular Reactors (SMR) is a type of these technologies, however the naming is proprietary to Rolls Royce. Hence, a more generic terminology of 'small nuclear reactors' is used throughout this document.

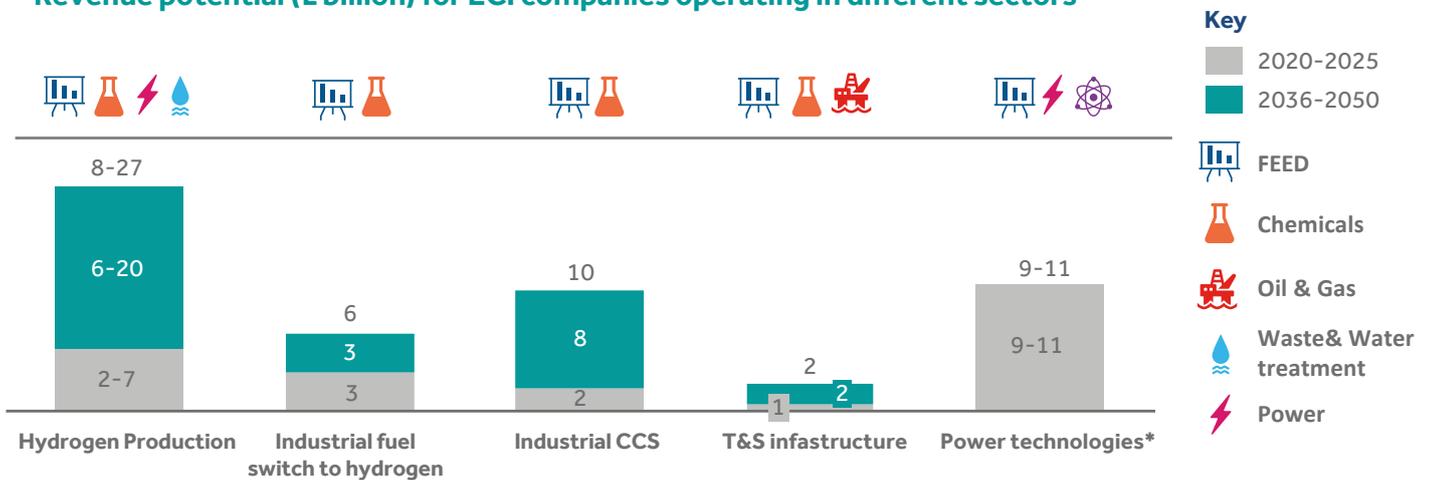
2.4 Future opportunities for the engineering construction industry

The large scale of deployment of decarbonisation technologies and the urgent need to begin the low carbon transition, will mean that a variety of projects are expected to be commissioned in the 2020s. Those would include, among others, hydrogen, CCS, and BECCS. With the first industrial cluster achieving low-carbon status by 2030, the FEED and detailed engineering design studies are expected to be contracted within the next few years (early 2025s). This trend will accelerate as the UK moves towards the net zero emissions target by 2050. There is thus a great potential for the UK engineering construction industry.

Hydrogen production could bring an opportunity for the ECI of £2.3 to £7.5 billion in revenues in the short term (2020-2035) and an additional £6 to 19.5 billion between 2036 and 2050, depending on the scale of deployment³⁹.

This potential could be tapped by ECI companies specialised in FEED and design, chemicals, power, and water and waste. This includes work will required to allow the industrial use of hydrogen, with an estimated £3.4 billion revenues worth of work for companies involved in the design and installation of industrial appliances, such as those in the chemical industry. Industrial decarbonisation will also require deployment of CCS at industrial sites not suitable for hydrogen usage, which could represent another £10 billion of potential for the ECI sector deploying capture plants, and ~£2 billion in terms of transport and storage infrastructure, leading to a £12 billion potential from CCS projects. Clean power technologies, including nuclear, hydrogen, and CCS technologies could represent between £9-11 billion of potential between 2020 and 2035⁴⁰.

Revenue potential (£ billion) for ECI companies operating in different sectors



* Due to scenario uncertainty and limited data availability, power scenarios stretch to 2035 only
 Figures may not add-up due to rounding

Figure 7: Overview of the potential for ECI from the key decarbonisation deployment of some technologies

The potential could be larger than the estimates above, which only focused on key decarbonisation technologies, and did not consider investment in other technologies that would be needed as part of the energy transition, such as renewables, water and waste, hydrogen storage.

³⁹ Lower range relates to a hydrogen deployment consistent with the CCC Further Ambitions scenario (271 TWh/year in 2050), whilst upper range relates to a wider deployment equivalent to 1,087 TWh/year hydrogen production in 2050 – see appendix for full details.

⁴⁰ Due to scenario uncertainty and limited data availability, power scenarios stretch to 2035 only, in line with the BEIS power projections

3. SKILLS DISRUPTIONS IN THE ENGINEERING CONSTRUCTION INDUSTRY

This section examines the impact on ECI skills of different decarbonisation technologies needed to achieve the net zero target set out by the CCC. We also explore the complexities and opportunities emerging from decarbonisation of the industrial clusters, as outlined by the UK Industrial Strategy. The findings throughout this section are based on a top-down assessment of various technologies and were validated by industrial stakeholders consulted as part of this study. Industrial consultation also covered topics such as the current and expected gaps and shortage in skills, dynamics of workforce mobility, demographics, and expertise.

3.1 Assessment of decarbonisation technologies

A wide variety of decarbonisation technologies required to achieve net zero emissions were assessed based on their potential to impact the skills requirement within the engineering construction industry. The assessment was conducted examining only skills gaps and not the number of trained personnel required. The potential for disruption can be classified into three main categories⁴¹:

- Low impact technologies in this category will require skills that are already present and will bring little or no change in the way the current workforce works.
- Medium impact technologies will require a minor upskilling which would focus on the adaptation of skills for performing various tasks, as well as an increased awareness from the employers and their employees on the specifics of these new technologies.
- High impact technologies are expected to require significantly different skills compared to today. This could be achieved through a major retraining for the handling of different materials or using a new set of work protocols, for example related to the safe operation of CCS infrastructure and avoiding CO₂ leaks.

In terms of timeframe of deployment, the classification of technologies was guided by the CCC key milestones:

- In the short term, corresponding to the 2020 – 2029 period, several projects will be initiated, aiming to lay the foundations of the decarbonisation infrastructure required to achieve net zero targets by 2050. This will include the deployment of key enabling technologies, such as hydrogen and CCS, that will be required for achieving the low-carbon status of one industrial cluster by 2030. This period is also expected to coincide with the beginning of project development activities in other clusters.
- The medium term (2030 – 2039) will see the continuation of work within the other clusters that would undergo a similar transformation after 2030, with one cluster reaching net zero emissions by 2040. This period will be marked by rapid deployment of decarbonisation technologies, including large-scale hydrogen production and storage. This will also coincide with other transitions in the energy sector, such as the retiring and decommissioning of current assets (e.g. nuclear power stations and their replacement with newer and smaller reactors).
- Long term (2040-2050): With one cluster reaching net zero emissions by 2040, the race will be on across the remaining five industrial clusters that will need to decarbonise completely in time for the 2050 net zero milestone. Closing the emissions gap and reaching net zero by the middle of the century will also require newer technologies, such as direct air carbon capture with CO₂ storage and utilisation of CO₂ for synthetic fuels synthesis to be deployed within this timeframe.

Figure 8 below summarises the assessment of these technologies based on the criteria above. A more comprehensive description of the technology components and the ECI sectors involved in their deployment is provided in the text and infographics in section 3.2.

⁴¹ A note on terminology: upskilling is the process of improving the current skillset to perform the same job in different environment, with different materials and/or under changed safety concerns. On the other hand, reskilling is the process of learning new skill or training people to do an entirely different job.

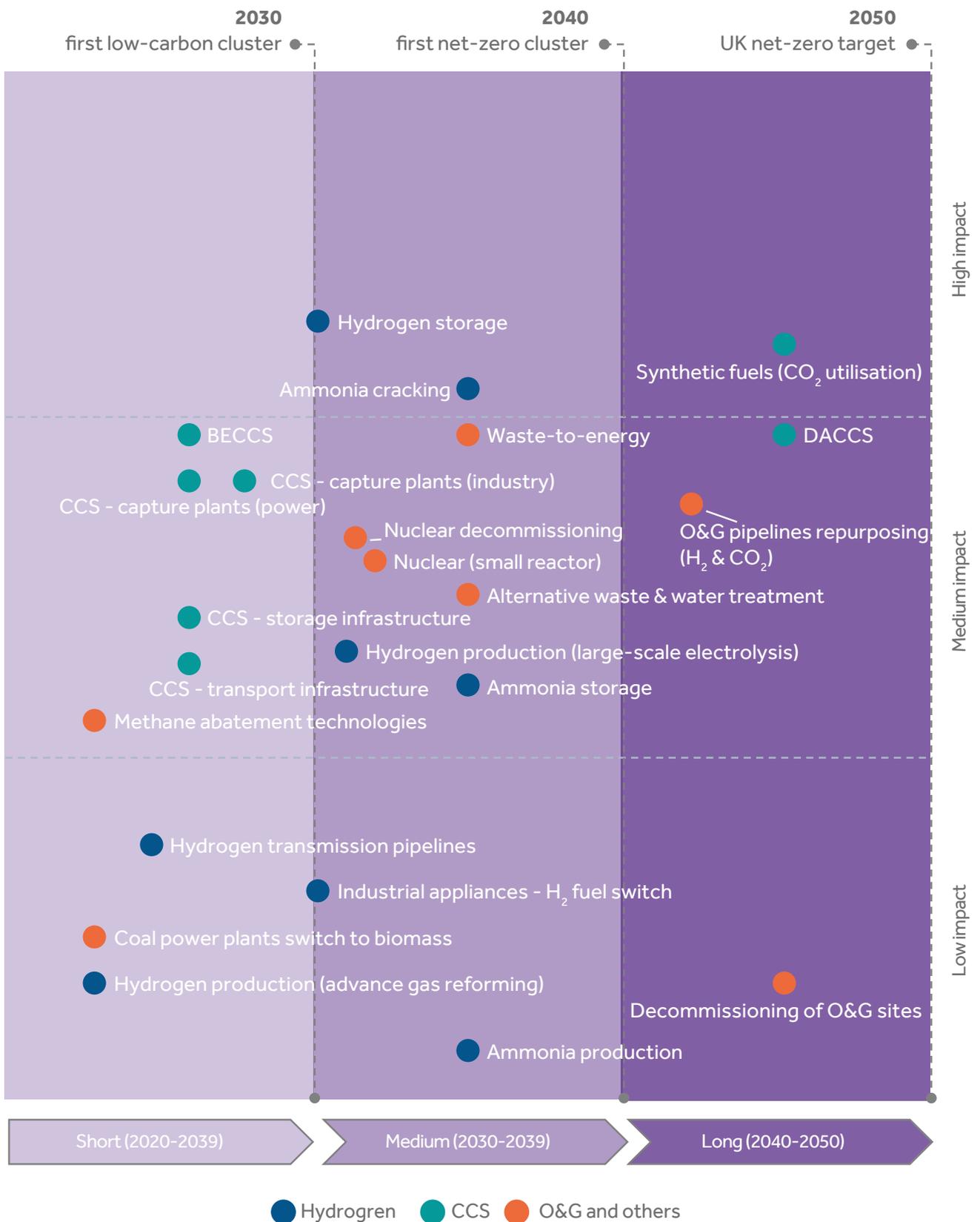


Figure 8: Skills impact matrix for different decarbonisation technology groups

3.2 Detailed discussion of decarbonisation technologies impact on skills

Based on Figure 8 overleaf, it should be noted that only three out of 23 technologies are expected to have a high impact on skills requirements, with the majority requiring only a limited level of retraining. For example, none of the nine main technologies expected to be deployed within the next 10 year is expected to bring a major skill disruption. It can thus be concluded that the ECI sector has the required foundational skills to deploy different decarbonisation technologies considered in this study. However, caution should be exercised as skills will need to be transferred from other sectors and there may be significant workforce shortages. Attention should be given to the technologies deployed in the short term, due to the limited timeframe to retrain and/or recruit personnel, and to the highly disruptive technologies expected to be deployed in the medium and long term.

In the **short term**, no major skill disruption is expected given the nature of the technologies deployed:

- **Hydrogen** production technologies (natural gas reformation and electrolysis) are both mature and are currently in use, with minor skills impacts expected. A small level of disruption is expected in the case of water electrolysis, given the modular design of electrolyser stacks and their integration with the electricity grid and renewable sources of energy. This would require workforce specialised in the connection of large electric equipment to the grid, as well as technical assistance for the connection to water utilities (used as a feedstock for hydrogen production) and to hydrogen transport infrastructure. Once production reaches scale, hydrogen will be used widely in industry. However, industrial applications are unlikely to cause disruption to the engineering construction industry given that hydrogen industrial appliances (e.g. kilns, furnaces, burners, ovens) are expected to be similar to today's natural gas technologies.
- **CCS technologies** are used to capture and inject carbon dioxide in depleted hydrocarbon fields, under the seabed, and require similar skills to the chemicals and oil and gas industry. The capture technologies, either deployed in industry or for power generation, consist of a series of industrial installations and extraction columns similar to those in the chemical industry. In addition, the transport and storage infrastructure resemble typical oil and gas installations. The diagram below gives an indication of how current ECI occupations could be converted to meet the future needs of the CCS network.

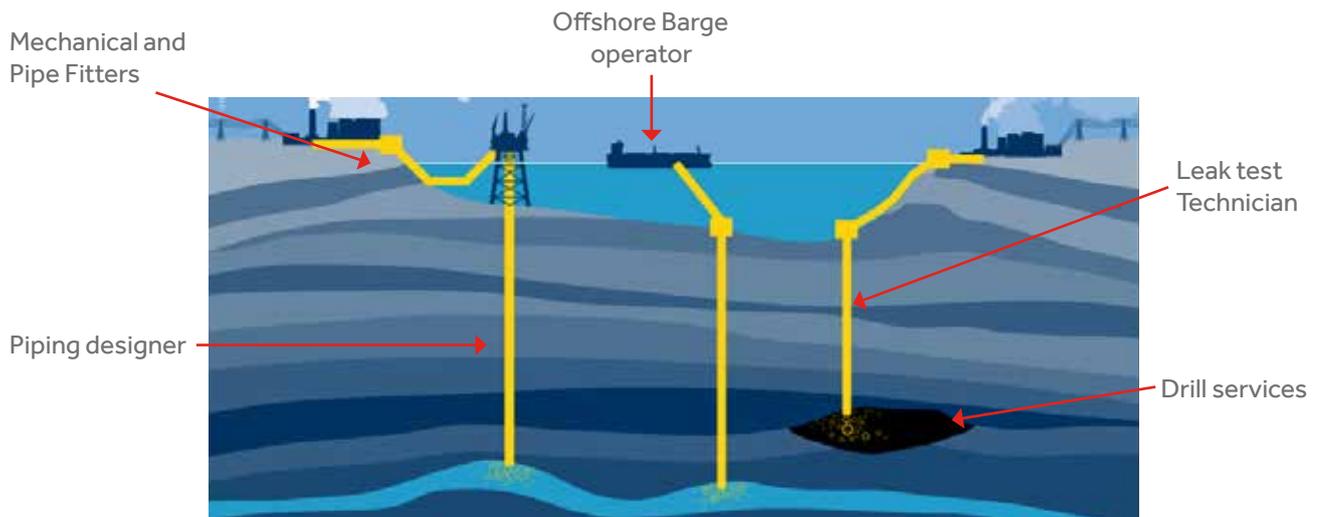


Figure 9: Illustrative example of applicability of oil and gas occupations in the CCS deployment

In the CCS context, the piping designers and fitters would be in charge of designing and building new CO₂ pipeline projects as well as converting existing oil and gas pipeline infrastructure for CO₂ use. The latter activity could be assisted by leak test technicians, ensuring the repurposed infrastructure is structurally and functionally sound. CO₂ would not only be transported by pipeline, but also by sea tanker (e.g. from industrial clusters without nearby storage options). Offloading and injecting this CO₂ would require assistance from offshore barge operators. In addition, the development of storage sites could benefit from the expertise of drill service providers currently operating in the oil and gas sector.

In general, it is estimated that the impact of these technologies will be generally low, with potential upskilling required on the operational side. For example monitoring of storage fields consists of identifying and characterising changes that occur within the storage reservoir as injection proceeds and is necessary to prevent leakage of carbon dioxide. It is usually achieved through a combination of shallow and deep approaches, focussing on a surface-down assessment (e.g. surface seismic or gravimetry) or from wellbores (e.g. well logging, pressure and temperature measurement)⁴². Some of these activities could be undertaken by leak test technicians and geologists working in the oil and gas sector, however training on the specifics of CCS would be expected.

- **Methane abatement technologies** in the oil and gas sector are currently used by most of the oil and gas operators as it helps them market for their products as low-emission resources. Whilst the cost of some new monitoring technologies is still high, the technologies to prevent fugitive emissions⁴³ are well-known, understood and have been used in the industry for some time. Methane abatement measures rely on installation of vapour recovery units, leak detection and repair modules, changing pumps, seals and rods; tasks are similar to other daily tasks done in oil and gas operation. Hence, the methane abatement technologies, whilst becoming a core part of gas production, are not expected to have high impact on skills. Oil and gas operatives will need to receive industry-related training on how to operate newer technologies or equipment models, in addition to the safety training specific to methane handling currently provided, but the underlying foundational skills are currently present in the industry.

In the medium and long term, more disruptive technologies will be deployed:

- **Hydrogen storage in salt caverns**, likely to be deployed once hydrogen production reaches scale, may pose some difficulties, mainly given the unproven stage of the current technologies. Technology uncertainties may bring disruption to the skills required for conducting both the FEED and design as well as the construction of these facilities. It is possible that this technology may require skills similar to those in the mining or oil and gas industries.
- Storing hydrogen in the form of **ammonia** will require the deployment of ammonia production, storage and cracking facilities. Whilst ammonia production and storage are established technologies, already used in the fertiliser industry, ammonia cracking (splitting to hydrogen and nitrogen) has not been deployed at scale before and could cause some disruption to ECI companies. Skills similar to those needed in the chemical industry would be required for building the appropriate production and cracking reactors, as well as the pressurised storage tanks.
- **Oil and gas decommissioning by contrast will have low impact on skills.** Whilst requiring very complex planning and operations decommissioning is a very mature process. Such activities usually comprise of well plugging and abandonment, conductor removal, barge demobilisation, pipelines and power cables, material disposal; for which the required workforce and skills already exist in the UK. Nevertheless, in the coming 30 years, the UK will experience intensive activity of decommissioning the UK Continental Shelf installations, which could potentially pose a workforce shortage risk for ECI companies. This risk could be mitigated by transferring skilled workers from other sectors or from new recruits.
- However, **Assets repurposing** for various uses is not as straightforward as decommissioning and will require detailed studies and planning to ensure feasibility. A more integrated approach will be needed, to create close links between oil and gas sector and renewables in what could be considered an 'integrated offshore energy sector'⁴⁴. Some potential projects include: repurposing oil and gas rigs as low-carbon platforms or renewable energy platforms utilising electricity from windfarms to power oil and gas installation, gas-to-wire projects to convert natural gas to electricity offshore and utilise the existing windfarm cables to transport electricity onshore for further distribution. The oil and gas sector could drive decarbonisation further by integrating hydrogen production installations (e.g. ATRs) powered by renewables from wind farms and using existing depleted reservoirs for CO₂ storage to promote the concept of offshore energy hubs.

⁴² Why monitor CO₂ storage projects?, British Geological Society

⁴³ In the oil and gas industry, fugitive emissions are emissions of natural gas due to leaks (e.g. from improperly sealed pipelines and installations) and/or from other processes that result in the release of unintended emissions

⁴⁴ Interim findings report on UKCS Energy Integration, Oil and Gas Authority, 2019.

- **Pipeline repurposing** for CO₂ transport and storage, required for the successful roll-out of CCS projects, will require minor upskilling for various material handling, CO₂ monitoring, pipeline coating and testing. Repurposing the gas grid for hydrogen transport and end-use in different sectors will be more gradual and will take place over a longer timeframe. The hydrogen transition is expected to be gradual, starting with blending of <20% hydrogen by volume into natural gas, followed by a full-scale 100% conversion. This process will require skills to assess material suitability, as existing steel pipelines transporting hydrogen could be susceptible to material fatigue and embrittlement. Plans are already underway for replacing aging steel sections of the distribution gas grid by high-density polyethylene (HDPE), which would be more suitable for hydrogen. As this process is already underway, the disruption is likely to be limited.
- Building new **nuclear** power stations and decommissioning aging nuclear power stations represent very mature processes, with extensive experience in the UK. However, given the estimated peak in both activities in the coming 10-15 years and a significant proportion of the workforce due to retire within the same timeframe, the nuclear industry could be on the verge of a workforce shortage. This shortage could be reduced by transferring workers from other sectors, such as construction workers, confined spaces and high integrity welders, and steel fixers. In this case, special training, covering the rigorous quality and safety standards in the nuclear industry, would be required. In spite of these efforts, certain shortages may still persist. Highly skilled workers with nuclear expertise, such as technical managers and subject matter experts, will also be required. Such roles require more than 15 year of training and experience. In addition to the prospect of an acute workforce shortage, the advanced nuclear technologies expected to be deployed in the future and characterised by modular and innovative designs will require a major upskilling and retraining.
- The innovations deployed in the **waste and water treatment sector** will relate to simple measures relating to improving efficiency of different processes through behavioural and operational measures (e.g. heat recovery). Such measures are either at proposal stage or already implemented across the UK, in part driven at local levels by Local Enterprise Partnerships⁴⁵. Some measures like process design, increasing product lifespan and reuse of materials will require minor retraining for different material handling. The UK could see a water stress as a result of extended droughts brought by the climate change. Desalination of seawater may represent a coping mechanism to minimise the impacts of dry weather. Early reports note that the UK could have four municipal desalination plants by 2050, however there are no concrete proposals for building desalination plants in the UK at the moment⁴⁶. Water desalination has been deployed in the UK before, with the Thames Water Desalination Plant opening in Beckton, London in 2010⁴⁷. It is thus expected that the UK will have some skills in building desalination plants should this technology be adopted at scale.
- Technological uncertainties around synthetic fuel manufacturing from captured carbon dioxide and direct air capture with carbon capture and storage (DACCS), both in their infancy, may pose medium and high disruption in the long term.

The tables on the following two pages provides an overview of the key decarbonisation technologies, the ECI sectors that they would involve, their likely deployment timeframe (short, medium or long-term) and skill impact potential (low, medium or high-impact), as described in Section 3.1. In the last column, a description of the types of skills required and any similarities to current industries is also provided.

⁴⁵ Several local authorities has set up partnership between local and regional public organisations and energy and utility suppliers, one such example includes SEMLEP (South East Midlands Local Enterprise Partnership)

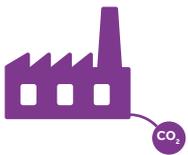
⁴⁶ UK could have four municipal desalination plants by 2050, WaterWorld, 2013

⁴⁷ Salt water plant opened in London, BBC, 2010



Hydrogen technologies

| | Key technology components | Relevant industries | | | | | | | Time-frame | Skills Impact | Comments on skills and industry similarities |
|--|---|---------------------|---|---|---|---|---|---|------------|---------------|---|
| | | | | | | | | | | | |
| Hydrogen Production – Adv. gas reform | Air separation unit, metallic structures, compressors | ● | ● | ● | ● | ● | ● | ● | | | Existing skills similar to the chemical and oil and gas industries |
| Hydrogen Production -Electrolysis | Electrolyser installation, grid connection, AC/DC substation, compressors | ● | ● | ● | ● | ● | ● | ● | | | Minor upskilling for commissioning, installation, start-up, and testing of electrolysers |
| Industrial appliances - H₂ fuel switch | Boilers, furnaces, kilns, ovens and dryers | ● | ● | ● | ● | ● | ● | ● | | | Existing skills for appliance installation and operations |
| Hydrogen storage | Emptying and processing of salt caverns | ● | ● | ● | ● | ● | ● | ● | | | Upskilling in FEED, developing technical and safety plans and operative training |
| Hydrogen transmission | Compressors, pipelines laying | ● | ● | ● | ● | ● | ● | ● | | | Existing skills with minor training on pipes materials suitable for hydrogen |
| Ammonia (Prod., cracking and storage) | Plant building, metallic structures pipeline connections | ● | ● | ● | ● | ● | ● | ● | | | Existing skills similar to chemical industry, upskilling required for cracking and storage ¹ |



CCS technologies

| | Key technology components | Relevant industries | | | | | | | Time-frame | Skills Impact | Comments on skills and industry similarities |
|---|---|---------------------|---|---|---|---|---|---|------------|---------------|--|
| | | | | | | | | | | | |
| CCS capture plants | Capture plant, compressors, exchange columns, pipework ² | ● | ● | ● | ● | ● | ● | ● | | | Minor upskilling needed for welding, erection, testing and inspection; similar to chem ind. |
| CO₂ transport infrastructure | Onshore and offshore pipeline laying | ● | ● | ● | ● | ● | ● | ● | | | Minor technical upskilling for handling of new materials for CO ₂ pipelines |
| CO₂ Storage | Offshore pipeline, injection wells, monitoring | ● | ● | ● | ● | ● | ● | ● | | | Minor upskilling might be needed for oil and gas personnel in FEED and monitoring stages |
| Synthetic Fuels (CO₂ utilisation) | Plant building, metallic structures pipeline connections | ● | ● | ● | ● | ● | ● | ● | | | Upskilling/retraining needed (new technology in UK); similar skills to chemical ind. expected |
| BECCS | Similar to capture plants but capturing emissions from biomass facilities | ● | ● | ● | ● | ● | ● | ● | | | Minor upskilling (similar to capture plants); however some DA capture plants expected to be modular, requiring extra training for the installation and commissioning teams |
| DACCS | Similar to capture plants but capturing emissions directly from air | ● | ● | ● | ● | ● | ● | ● | | | |



Oil & Gas and Water & Waste technologies

Key technology components

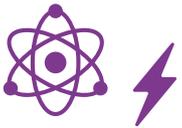


Time-frame

Skills Impact

Comments on skills and industry similarities

| | | | | | |
|---|--|---------------|---|---|--|
| Decommissioning of oil and gas sites | Oil and gas operation basic components (see comments) | ● ● ● ● ● ● ● | ● | ● | Knowledge of new materials, pipe coating, testing, monitoring and inspection techniques needed for pipelines services |
| Oil and gas pipelines repurposing (H₂ and CO₂) | New material, pipe coating, testing, monitoring and inspection, pipelines gauges, laying pipelines | ● ● ● ● ● ● ● | ● | ● | Minor upskilling needed for use of new materials and asset testing (pipe coatings, welding, inspection); testing levels will vary for CO ₂ and H ₂ transport |
| Methane Abatement technologies | Pumps, seals, leak detectors, instruments usually installed on typical oil and gas operation rigs | ● ● ● ● ● ● ● | ● | ● | Minor reskilling for use of new materials and/or operational needs, performance testing and monitoring and hazardous material training |
| Alternative waste and water treatment | Microbial methane oxidation (Micro covers, AD and MBT) | ● ● ● ● ● ● ● | ● | ● | Minor upskilling for material handling, new processes related to AD/MBT |



Power technologies

Key technology components



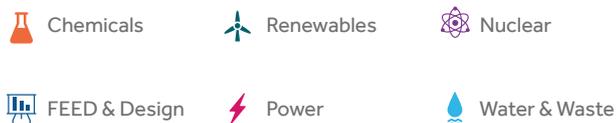
Time-frame

Skills Impact

Comments on skills and industry similarities

| | | | | | |
|--|---|---------------|---|---|---|
| Coal power plants switch to biomass | Refitting coal plants for biomass use | ● ● ● ● ● ● ● | ● | ● | Existing skills from previous experience on converting Drax from coal to biomass |
| Nuclear decommissioning | Fuel handling, storage, final disposal, dismantling systems or components, site cleaning up | ● ● ● ● ● ● ● | ● | ● | Minor reskilling for different treatment and processing of nuclear facilities and waste |
| Small nuclear reactors | Modular building, cooling installation, maintenance, hazardous material handling | ● ● ● ● ● ● ● | ● | ● | Upskilling/retraining for some skills (e.g. welding); skills shortages expected due to aging of current workforce |
| Waste-to-energy | Waste management, separation, energy recovery process, gasification | ● ● ● ● ● ● ● | ● | ● | Minor reskilling for different treatment and processing |

Industry Sector Key



Timeframe



Impact



Relevant industrial sectors to each technology are shown as full purple dots. This infographic only includes the impacts of deploying individual technologies. Other impacts, such as the requirement for cross-industry collaboration, are discussed in the main report

Impact on project phases

The technologies discussed above are expected to affect the full life-cycle of future projects.

- Early project phases, prior to winning the work, focussing on bid writing and commercial activities, will require personnel with a full understanding of the decarbonisation technologies, technical and commercial risks associated with each technology, and a knowledge of key partners and contractors required. Building this awareness of low carbon technology will require upskilling training for office workers.
- Later project phases, post project award, such as FEED and detailed design phases are considered key phases that require significant expertise. With extensive expertise in the sector, the UK industry is confident in terms of conducting feasibility studies for oil and gas, nuclear, and CCS projects, and it is thus expected to be disrupted lightly.
- On-site project phases, such as construction, generally require medium and highly skilled workers. However, the unprecedented levels of ambition in deploying different technologies in the short to medium term, especially hydrogen and CCS, might lead to a skills shortage and may require significant recruitment of new talent.

3.3 Decarbonising industrial clusters will bring additional complexities

Under the current UK Industrial Strategy and net zero legislation, industrial clusters must decarbonise by 2050. It is expected that deployment of decarbonisation technologies within industrial clusters will start in the 2020s, with the first low-carbon cluster becoming operational by 2030, and the first net zero cluster by 2040. Decarbonising clusters will require the deployment and integration of many of the technologies described in section 2.2. However, the tight timescale and the wide variety of technologies required will add another layer of complexity to the skills gaps and shortages the ECI sectors may face.

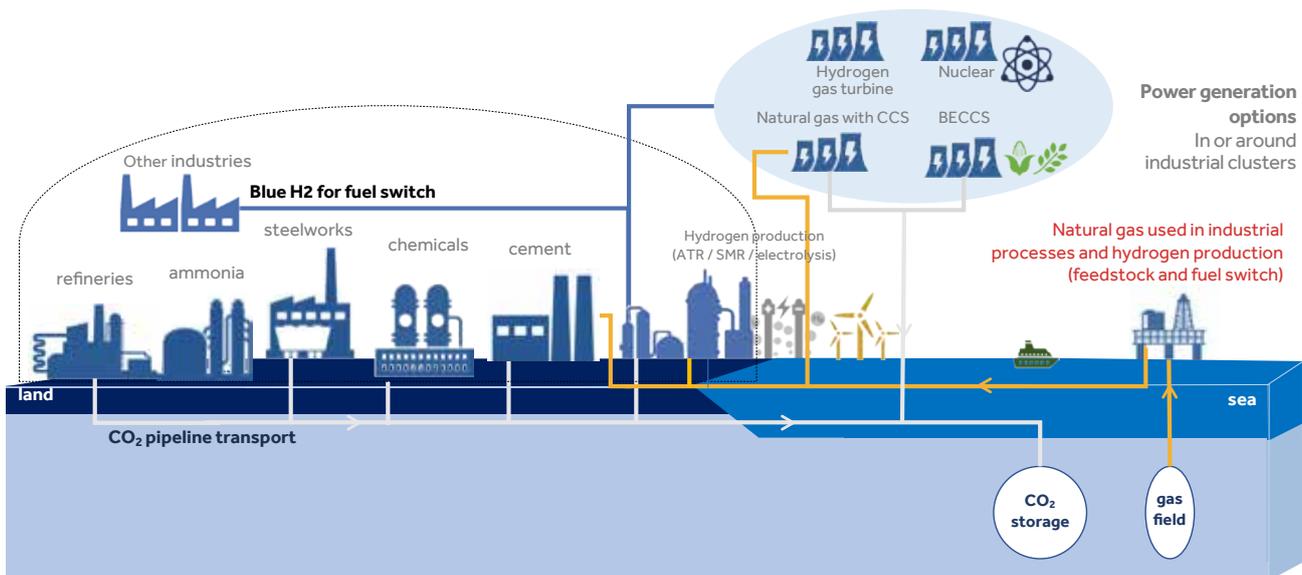


Figure 10: Illustrative example of an industry cluster⁴⁸

⁴⁸ Adapted from Hy-Impact Series – Study 1: Hydrogen for Economic Growth, Element Energy for Equinor, 2019

Expansive hydrogen and CCS infrastructure will be needed in a short timeframe

Hydrogen production facilities will be near industrial clusters, since industry will be the largest single consumer of hydrogen under the CCC scenario. CCS will be required to capture emissions from hydrogen production, as well as industrial sites with process emissions (e.g. cement), and nearby power stations. It is thus expected that CCS infrastructure will be installed across all major clusters. Whilst all industrial clusters will require carbon capture plants for separating emissions from processes and flue gases, the transport and storage infrastructure requirements will differ depending on the location of the cluster. Clusters close to storage sites in the North and Irish seas, such as Humber, Teesside, Grangemouth, and Merseyside will require on-shore and off-shore T&S infrastructure. However, clusters with limited storage nearby, such as South Wales and Southampton will require additional infrastructure of compression and liquefaction, and subsequent transport (e.g. by tanker or ship) to storage sites.

There is uncertainty around the exact cluster configurations

Whilst it is generally accepted that hydrogen and CCS will play a major role in the decarbonisation of each industrial cluster, there are still many uncertainties about the exact types of the technologies and their scale of deployment within each cluster. For example, there are a variety of hydrogen production methods (e.g. SMR, ATR, electrolysis and biomass gasification), any of which could front-run by 2050. This uncertainty, if not clarified in due course, could create a gap in the skills and number of personnel required to deploy a certain technology in a given area.

Geography may pose challenges but also bring opportunities for collaboration

The wide geographic distribution of industrial clusters and concentration in industrial areas, with community issues such as an aging population, could lead to local workforce shortages. This could be accentuated by a lower willingness among younger generation to relocate for work, especially to industrial areas⁴⁹. The wide variety of technologies deployed will also require the expertise of multiple companies covering several ECI sectors, opening new opportunities for cross-company collaboration to bridge the gaps in expertise and workforce.

Project FEED and detailed design may face the lowest disruption

Whilst later project phases, such as construction, which require on-site work will face the biggest disruption, FEED and project design could be conducted remotely. Although such studies could be staffed by employees in the overseas offices of major engineering companies, especially in the short term, it is expected that a large number of studies will be commissioned between 2020 and 2050, providing the UK with the opportunity to build expertise and diversify into a new range of low carbon services.

⁴⁹ Millennials want purpose over paychecks. So why can't we find it at work?, The Guardian, September 2016

⁵⁰ What is the Industrial Clusters mission?, UK Government, 2019

⁵¹ Leading energy companies announce new zero-carbon UK partnership, Drax press release, 27th May 2019

3.4 Case study: Decarbonising the Humber Cluster

The Government's Industrial Strategy is aiming to boost the competitiveness of key industrial regions and drive inward investment, creating and protecting jobs for a low-carbon global economy with growing low-carbon export markets. This brings financial support and incentives for industry to decarbonise and achieve net zero goals by 2050. Whilst all industrial clusters are expected to decarbonise by 2050, with several project proposals already existing, this case study focuses on one of the largest industrial cluster in the UK.

The Humber cluster, located in the Yorkshire and Humber region, is the UK's largest cluster by industrial emissions

(~12 MtCO₂/year in 2018⁵⁰, Figure 3), and its prompt decarbonisation is critical to the UK economy as it hosts a diverse range of industrial sites and power generation plants. In 2019, Drax Group, Equinor and National Grid Ventures announced a strategic partnership to explore how a large-scale CCS network and a hydrogen production facility could be constructed in the Humber industrial cluster in the mid-2020s⁵¹ - the Zero Carbon Humber partnership. The decarbonisation efforts would be centred on the Drax power plant site and would expand within the surrounding industrial area, helping decarbonise industrial sites and other power stations by a combination of hydrogen and carbon capture and storage technologies.



Figure 11: Overview of the Humber Zero Carbon project concept in the Yorkshire and Humber region

Large-scale hydrogen production would be achieved via natural gas reformation in ATRs. This would also require the construction of an associated value chain comprising transport, storage, and use across the Yorkshire and Humber region. Hydrogen will be used for the production of ammonia as a new 'clean' commodity, as well as by 40 large industrial sites with strong opportunities for hydrogen use, such as chemicals, glass manufacturing, steel making, and refineries⁵². A significant hydrogen demand may also come from nearby power plants either blending hydrogen with natural gas or undergoing a complete turbine conversion to hydrogen. In addition, hydrogen produced within the cluster could fuel the nearby H21 North of England (H21 NoE) deployment which is aiming to decarbonise domestic and commercial heating in Yorkshire and the Humber region and further beyond. The availability of hydrogen would also enable and support the uptake of hydrogen mobility in the region. In total, ~114 TWh/year of hydrogen could be produced in the region by 2050⁵³.

This decarbonisation project would be underpinned by the deployment of CCS to enable decarbonisation of power and industry, with the cluster's proximity to the Southern North Sea, an ideal area for CO₂ storage, a key regional advantage. Carbon capture and storage infrastructure would also allow capture of emissions from hydrogen production. The Drax Power Station has already partially converted to biomass, and connection to CCS infrastructure would also enable negative emissions through the world's first BECCS (bio-energy with carbon capture and storage) plant. Other users of the CCS infrastructure would include industrial sites or power stations in the cluster. It is estimated that by 2030, 15 MtCO₂/year would be captured from the region, reaching 53 MtCO₂/year in 2050.

⁵² Hy-Impact Series – Study 4: Hydrogen in Yorkshire & the Humber, Element Energy for Equinor, 2019

⁵³ Zero Carbon Humber, The Impacts of Decarbonising Yorkshire and the Humber, Element Energy for the Zero Carbon Humber Consortium, 2019

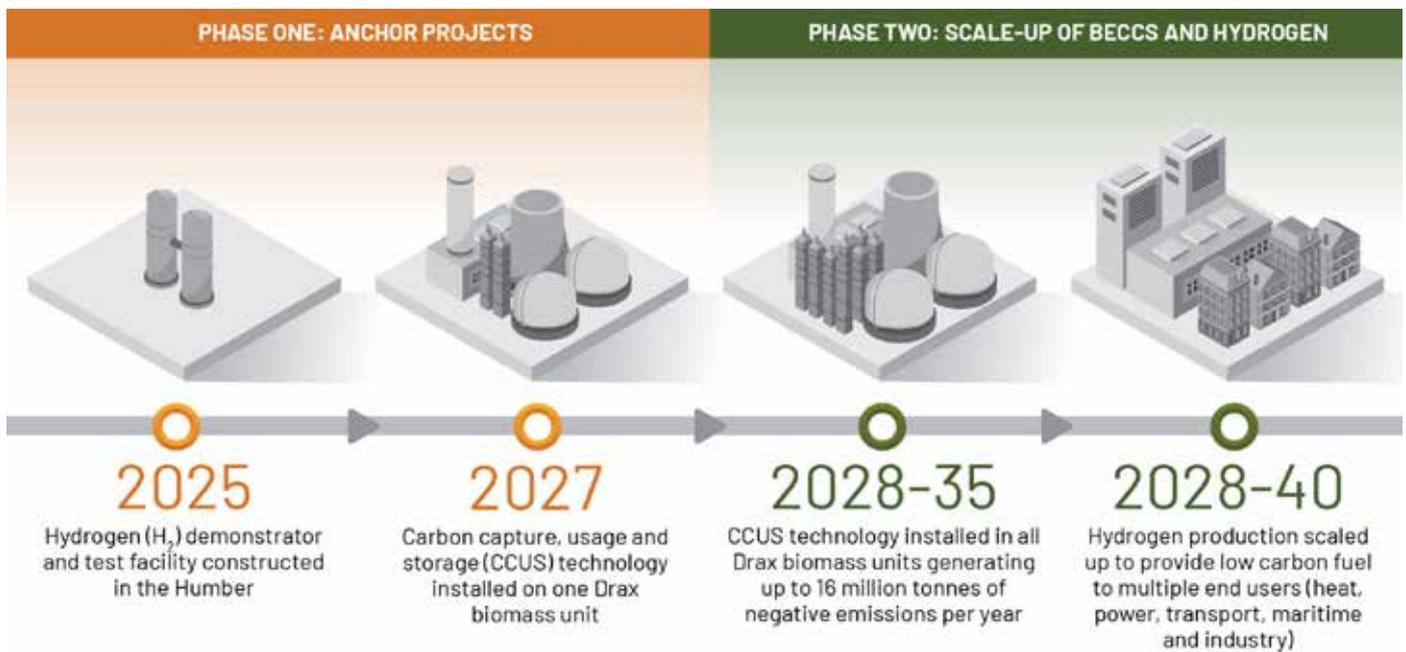


Figure 12: Zero Carbon Humber Projects Timeline⁵⁴

The impressive scale of this deployment could bring significant opportunities for the engineering construction industry both in the short and long term. The proposed development of decarbonisation infrastructure would be a continuous process. The project plans outline two main phases:

- Phase I:** by the end of 2027 the carbon capture facilities would be installed at one of the four Drax biomass units, while modular ATRs would be installed for hydrogen production. Hydrogen would be supplied to a small number of industrial users as well as used for ammonia production. In addition, the CO₂ transport and storage infrastructure will be built, capturing emissions from the Drax plant and the ATR and storing them in the Southern North Sea. This phase would drive a high short-term demand for design and FEED services, as well as for the construction of the associated infrastructure. Hydrogen and ammonia generation and carbon capture plants would require skills similar to those in the chemical industry, whilst the CCS value chain will rely on skills specific to the oil and gas industry.
- Phase II** would focus on the consolidation of deployed assets and aims to continue until the 2040s and beyond. This would include a scale-up of hydrogen production facilities (reaching 13.7 GW installed ATR capacity by 2050), installation and conversion of the industrial appliances at around 40 industrial sites, and connection of all four units of Drax and other industrial sites (including chemical plants, refineries, and iron and steel production) to the CCS network. Whilst this phase would be characterised by further developing the technologies deployed during Phase I and would require similar skills, the implementation scope, scale, geography, and timeframe would be much wider and would require a larger workforce. Partial or complete conversion to hydrogen of nearby power plants would also require workforce specialised in the energy and electricity generation sector. Additional operations and maintenance services would be required within this timeframe to cater for the needs of infrastructure in operation.

Depending on funding decisions, FEED work is expected to start within a year or two. Although cost estimates for the region are not published, typical FEED for large-scale projects would be >£100 million. This would then lead to construction until the end of Phase I (2026/27), and beyond. The UK engineering construction industry is expected to play an important role during all phases of this project, with tangible potential opportunities starting in the near future.

⁵⁴ Reproduced from the Zero Carbon Humber website - <https://www.zerocarbonhumber.co.uk/>

4.

CONCLUSIONS AND RECOMMENDATIONS



Analysis in this study and input from industry indicates that we have the foundation skills required to deploy these different decarbonisation technologies. With no significant skills gaps envisaged in the short term, we expect minimal reskilling in the engineering construction industry. However, caution should be exercised as skills will need to be transferred from other sectors and there may be significant workforce shortages. Whilst skills needed for some technologies are present in more sectors than others, the major change will be related to different ways of work, execution and project delivery requiring a more collaborative approach to ensure synergies between different industries. In terms of project phases, the UK based companies could deliver the FEED and detailed design required, although the staffing may not necessarily be in the same region as the project site. Earlier project phases will suffer less disruption compared to later stages, which will require workforce to be present on-site for construction, operation and maintenance-related activities.

Unlocking the full potential for the sector and ensuring timely deployment of technologies required for net zero will require actions from the both industry and policy stakeholders in three main areas. Identifying and closing any skills gaps will be crucial, especially in the context of meeting the low-carbon cluster milestone in the short term. As the roll-out of key decarbonisation technologies will accelerate in the medium and long term, actions should focus on addressing any skills shortages promptly. Collaboration between industry and government on policy and adoption of innovative technologies will also be required to ensure the UK industry develops well-rounded expertise within the UK and to ensure the workforce will be readily available in areas at the epicentre of the infrastructure deployment.

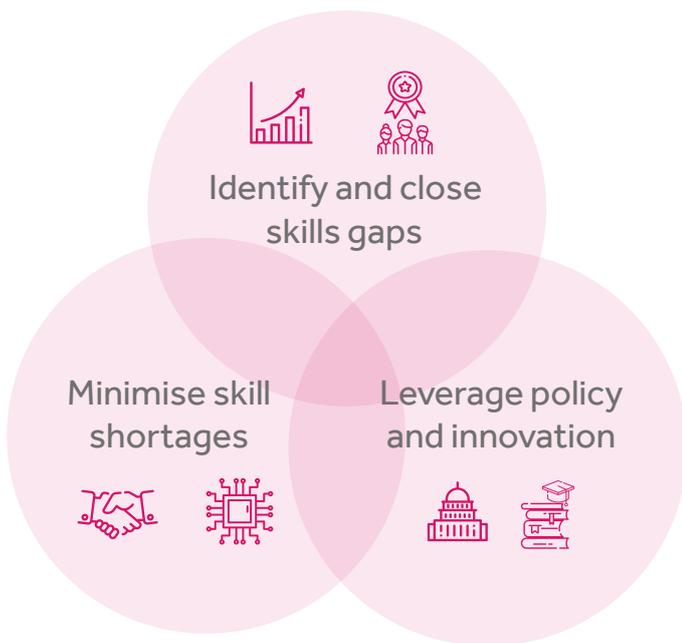


Figure 13: Key areas of action

Identify and close skills gaps

This study has already identified areas of retraining and upskilling needed for the deployment of the main decarbonisation technologies. Whilst the foundation skills needed are available, upskilling will be required in the short, medium and long term.

Address any skills gaps with transferable skills

A variety of projects, such as hydrogen production, CCS, and BECCS, are expected to be commissioned in the 2020s, with FEED and detailed engineering design to be contracted within the next few years. This would mean that a skilled workforce will be required within the next few years. To ensure timely delivery and mitigate any risks, retraining of the current workforce, focusing on the short term and highly disruptive technologies, will be needed.

The ECITB has already embarked on work in this area, for instance by retraining operators for the now-closed Cottam coal power station for jobs in the nuclear sector through an Accelerated Experienced Learning Programme⁵⁵. A similar approach could be taken for some of the new technologies expected to be deployed in the short term. The oil and gas workforce represents a good target for retraining, due to the synergies with the work required for the carbon capture and storage infrastructure value chain.

In addition to oil and gas industry synergies with CCS, skills can be imported from the coal and other engineering industries to plug a shortage in the growing nuclear industry in the UK through professional conversion programs. These programmes could provide a quick and efficient way to upskill the current workforce for certain tasks in the short term. Specific high integrity or confined spaces welding certification is an example of this kind of training.

⁵⁵ Nuclear Skills Strategy Group, Case Study: Coal staff find new roles, ECITB 2018

⁵⁶ Building Nuclear Skills: A workforce for the future, Balfour Beatty

Attract new talent by making ECI sectors more attractive employment environments

The wide range of new technologies, with medium to high impact, such as hydrogen production and storage, will require a new generation of talent in the 2030s. This will be especially important in the context of a large proportion of the current workforce expected to retire in the medium term. In addition, the rise of infrastructure projects in the UK, such as the High Speed 2 (HS2) and new nuclear projects, will require a sizeable workforce⁵⁶. As the ECI competes with these sectors in attracting new talent, it should consider how to remain a desirable alternative. This could be achieved by repositioning the engineering construction industry as a sector that is critical to tackling climate change. There is evidence⁴⁹ that younger generations are looking for careers with a positive impact on society and the environment. The ECITB could help the industry position itself as a key driver in decarbonising the UK and fighting climate change by updating its training standards and aligning them with trends in the decarbonisation agenda and the use of data-driven innovative technologies. This will help the ECI attract and retain younger talent and position itself as a competitive sector.

Minimise skills shortages

The CCC's ambitious target to achieve net zero by 2050, in addition to the Industrial Strategy clusters milestones by 2030 and 2040, will require new entrants to join the industry. Whilst repositioning and making the sector more attractive will certainly help, the industry will need to act to overcome several other challenges.

Industry should develop a proactive attitude towards collaboration

Decarbonisation of industrial clusters will require multi-sector involvement, with a wide range of technologies deployed within a small geographic area and a tight timeframe. Cross-industry collaboration will help improve efficiency and share skills. However, the engineering construction industry may not be fully aware of the need for collaboration. The industry should ensure that companies' leadership teams are aware of the potential opportunities from the industrial clusters and the need for cross-sectoral collaborative work. This could be achieved through research deep-dives on industrial clusters, understanding the needs of each region and engagement with industry to increase awareness about the types of skills potential partners could bring in each cluster. This process could be conducted in the near future, providing some certainty in the short term. However a similar exercise should be conducted again in the future (e.g. in 5 years' time) to account for any changes in the regional

landscape.

Harness the transformative impact of digitalisation to improve workforce efficiency, productivity and utilisation

The anticipated digital transformation of the energy industry will bring new ways of working. Digital technologies will enable remote operations, data sharing, and automated maintenance, by using digital twins⁵⁷ for failure and reliability forecasts. The ECITB has already investigated the impacts of innovative technologies and of Industry 4.0 to the engineering construction industry¹⁰. Applied in industry, in the context of the decarbonisation agenda, these lessons will help to maximise workforce productivity and enable better utilisation of resources, mitigating the impacts of shortages in the workforce and skills gaps. In the CCS value chain, digital technologies could be used for monitoring CO₂ capture and transport infrastructure and the associated pipelines by robots, replacing manual inspection of pipes (pigging), diver inspection offshore, and corrosion monitoring. Storage sites could become unmanned installations, monitored by various subsurface sensors tracking the integrity of the storage sites and detecting any CO₂ leakage. Similarly, digital and analytic solutions can be employed to reduce workforce shortages within the hydrogen supply, ranging from managing electrolyser houses and aligning production and storage availability based on projected hydrogen demand (e.g. based on the wind forecast). Investment in training on digital technologies and close collaboration with the developers of digital technologies with a focus of their applicability in driving the decarbonisation agenda, should thus continue.

⁵⁷ A digital twin is a digital replica of physical assets (e.g. wind farms, oil and gas platforms, or a distribution network) acting as a live model to help in remaining life calculations, failure diagnosis, and reliability forecasts.

Leverage policy and innovation

A wider collaboration of multiple stakeholder including policymakers will be required to ensure the actions previously listed will be implemented with success.

Work closely with government to ensure the UK develops a comprehensive skills base required for industrial decarbonisation; skills that the UK could export in the future

Some services provided by the ECI, such as FEED and detailed engineering design, can be provided off-site. Our consultations with industry suggested that whilst UK industry is confident that the initial projects needed to initiate the decarbonisation agenda in the 2020s could be conducted in time, these would be outsourced to the overseas offices of international engineering companies. This represents a risk mitigation measure to ensure timely deployment to meet early milestones. However, left uncontrolled, it may lead to a long-term skill shortage in the UK. It is in the UK's best interest to develop appropriate skills in feasibility study and design of decarbonisation technologies. This is particularly important in the context of the large number of projects which will be commissioned in the medium and long term. In addition, this represents a potential for the UK to export new green skills in the future. The European Parliament recently declared a climate emergency and urged member states to set net zero targets by 2050⁵⁸, meaning that other European countries will likely set ambitious climate targets in the near future. Industry should work with government to make sure a full range of skills and expertise is built within the UK, including work on early project phases. Providing clarity and certainty on the Government's decarbonisation agenda will help the ECI sector with the certainty needed to invest in rounded skills training and portfolio diversification within the UK.

Drive strong links between industrial clusters and local education institutions to accelerate workforce inflow

Most of the UK's decarbonisation infrastructure will be deployed around industrial clusters. However, our conversations with industry representatives have indicated that younger workers may be less willing to relocate for work in industrial areas. If this is the case, there will be greater onus on recruiting local talent rather than relying on workforce mobility. Government, at both national and regional levels, will need to do more to ensure that the education provided locally matches the regional needs of UK industry. Industrial clusters pose an invaluable opportunity for the ECITB and the industry to start influencing and driving the delivery of education programmes by colleges and universities located in cluster zones. The ECITB should drive the delivery of education programmes tailored for the future⁵⁹. Partnerships with local education institutions should focus on identifying the workforce requirements in the region and how current learning programmes could be aligned with the occupations of the future workforce. By doing this, the industry will be better placed to attract well-trained talent. The availability of talent around industrial clusters will not only help the ECI to overcome the mobility problem, but also will enhance the competitiveness of the industry.

⁵⁸ The European Parliament declares climate emergency, European Parliament press release, November 2019

⁵⁹ In compliance in with the Industrial training act (1982) and the ECITB Levy order (2017) No. 485

5.
APPENDIX:
METHODOLOGY
FOR QUANTITATIVE
ANALYSIS

The bottom left corner of the page features three overlapping, semi-transparent, light red abstract shapes. These shapes are rounded and elongated, creating a modern, graphic design element that contrasts with the solid red background.

This study is based on a top-down assessment of different decarbonisation technologies. It examines the applicability of each key decarbonisation technology within different sectors (e.g. industry, power, etc). We examined in closer detail technologies related to the ECI sectors as well as the components constituting each technology. Such components could include different pieces of equipment and infrastructure, such as compressors, electrical stations, pipelines, iron structures or absorption columns. We then looked at each technology across the project lifecycle focusing on the design, construction, and

maintenance capabilities of the engineering construction industry. In cases where key technology components were similar to the type of infrastructure deployed by today's industry, a low disruption potential was assigned. However, in cases where the key decarbonisation technology is completely new or uncertain, a medium or high disruption potential was assigned. The original assessment was conducted by Element Energy, based on literature review, and the validated by over 20 industry representatives.

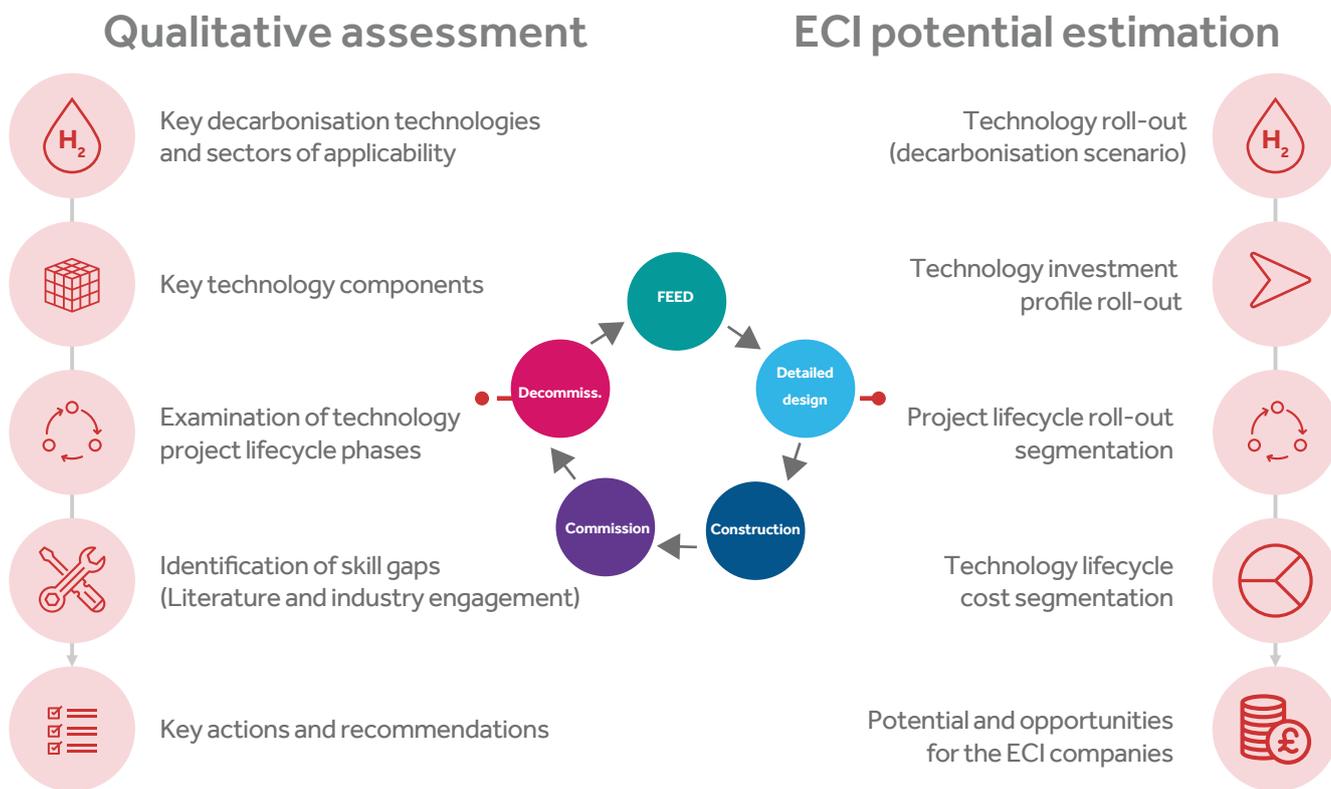


Figure 14: General methodological approach

A face-to-face workshop was arranged to test and refine the findings of the skills assessment matrix. Through more than 20 attendees from 7 different organisations, the results were validated and calibrated to the industry input. The workshop covered the detailed methodology used in the skills matrix assessment and key components underpinning each technology. The workshop also presented targets for Industrial clusters deployment and key milestones guided by the UK Industrial Strategy. This discussion informed the understanding of how ECITB is to deliver the required volume of training, what are the current and expected gaps and shortage in skills, as well as issues such as workforce mobility, demographics and expertise.

We then made an assessment of future business potential for the ECI for certain technologies. These included hydrogen production (both natural gas reformation and electrolysis), industrial decarbonisation both through fuel switch to hydrogen and CCS, and major power

generation technologies, such as use of hydrogen in power or capturing of emissions from biomass (BECCS) and natural gas power stations. This analysis was based on a techno-economic assessment of different decarbonisation scenarios.

Hydrogen demand scenarios

The roll-out of hydrogen technologies modelled in this study was back-calculated based on the envisaged hydrogen demand scenario between 2020 and 2050. The CCC Net zero Future Ambitions was used as a baseline for calculating the hydrogen production infrastructure requirements. In addition, several sensitivities were conducted based on scenarios with a higher hydrogen demand. Those were based on the Hy-Impact Series recently completed by Element Energy for Equinor, and the H21 North of England report, Northern Gas Networks and Equinor, 2018.

Total potential for ECI from hydrogen production technologies Cumulative investment (2020-2050, £bn)

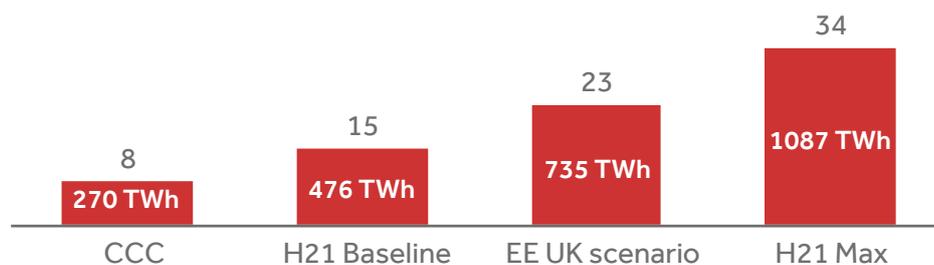


Figure 15: Potential revenues for the ECI under different Hydrogen demand scenarios

The following cost assumptions were used:

Table 1: Cost assumptions for key hydrogen generation technologies

| Level | Component | Cost type | Units | Value | Source |
|---------------------|-----------------------------------|-----------|---------------------------------|-------|---|
| Hydrogen Production | ATR plant and air separation unit | CAPEX | £m/TWh prod. capacity | 80.00 | Hy-Impact series, Study 1, Element Energy for Equinor, 2019 |
| | | OPEX | £m/TWh/year | 2.60 | |
| | Electrolysis | CAPEX | £/KW installed capacity in 2050 | 238 | The future of hydrogen, IEA, 2019 |
| | | OPEX | % of CAPEX | 5% | |

Hydrogen use in industry and CCS infrastructure costs

This study assumes a hydrogen usage in industry of 140 TWh/year in 2050, in line with the CCC Net zero Future Ambitions scenario. Industries using hydrogen are assumed to be non-ferrous metallurgy, chemicals, paper and pulp, mineral processing, and vehicle manufacturing. The costs for the industrial appliances conversion are based on the Hy-Impact series, Study 1: Hydrogen for Economic Growth, Scenario 1 - Decarbonised UK industry, conducted by Element Energy for Equinor, 2019. In addition, CCS would be used to decarbonise sectors such as chemicals, cement, ammonia, steel production, and refineries. The costs of the CCS value chain technologies are based on the Hy-Impact series, Study 1: Hydrogen for Economic Growth, Scenario 2, UK decarbonised Economy, conducted by Element Energy for Equinor, 2019.

Power generation scenarios

The following scenarios were used to estimate the potential revenues for the engineering construction industry. This assessment covered the roll-out of new installed capacity as well as decommissioning of aging assets. The assessment focussed on baseline generation technologies, with the following technologies examined: coal, oil, natural gas, nuclear, other thermal, hydrogen gas turbines (H2 GT), natural gas turbines coupled with post-combustion CCS, BECCS, and hydrogen blending in natural gas power plants. This assessment did not examine the potential associated with renewable energy sources (e.g. offshore and onshore wind, solar etc), interconnectors, or storage. The costs of each technology were based on the EIA, Capital Cost Estimates for Utility Scale Electricity Generating Plants, Nov 2016.

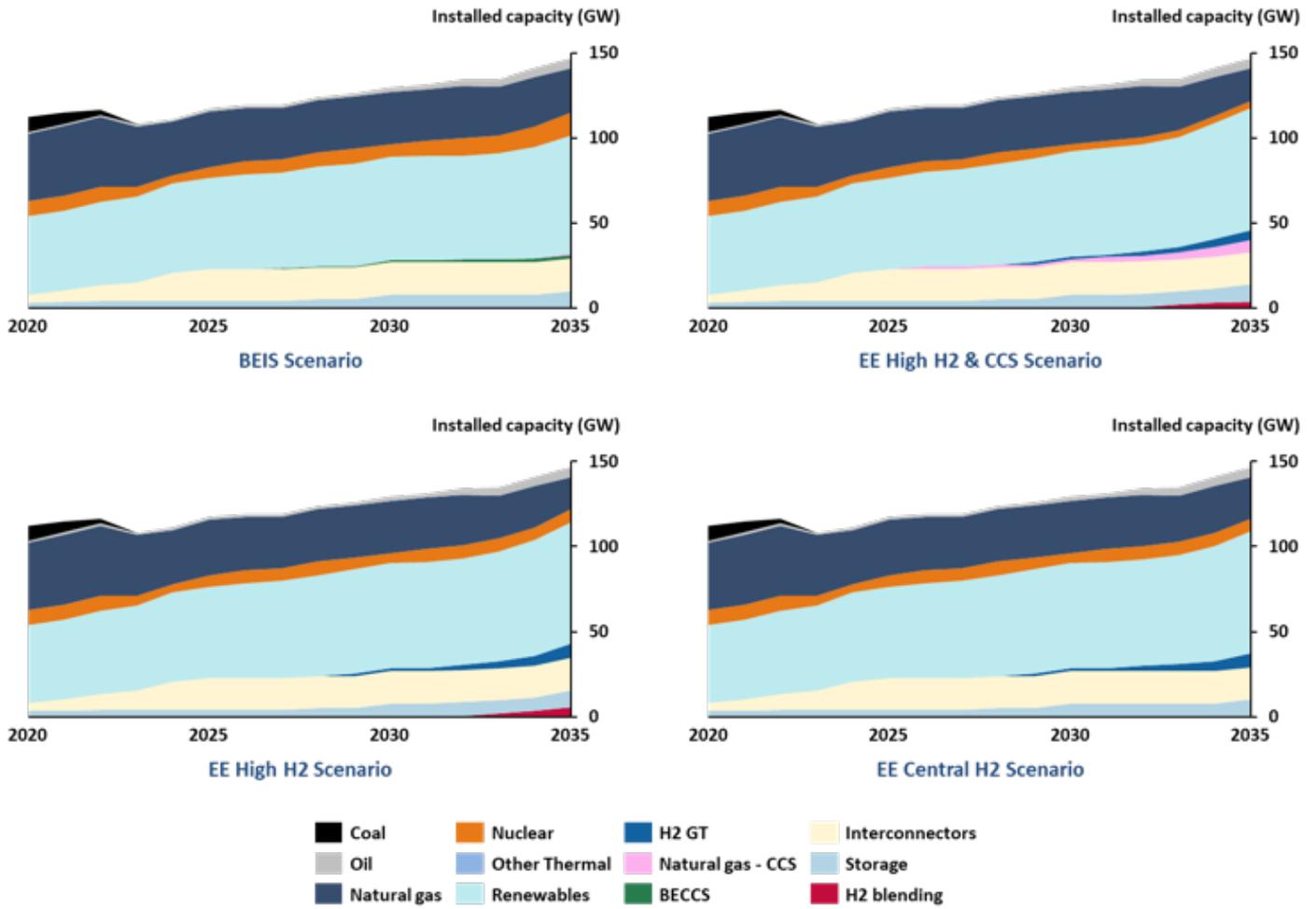


Figure 16: Scenarios used in the revenue potential assessment ⁶⁰

⁶⁰ Based on BEIS Energy Projections (2019) and Hy-Impact Series Study 3: Hydrogen for Power Generation, Element Energy for Equinor (2019).



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