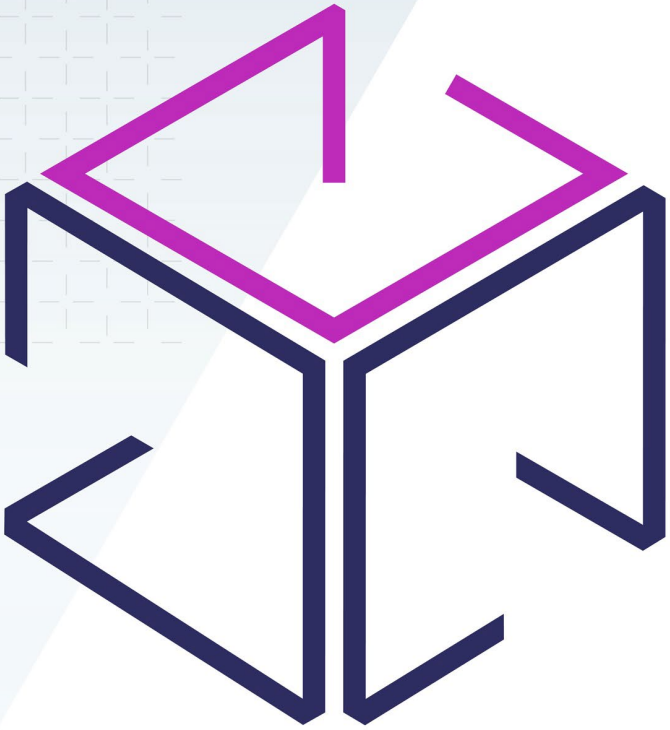
Workforce Foresighting Hub



Hydrogen Tanks for bulk storage, distribution and commercial use.

Including the design, installation and commissioning of tanks and ongoing inspection, maintenance and operation.

A Workforce Foresighting Hub report.

Authors: National Composites Centre, working with the Tank Storage Association.

Date: June 2024

UKRI Innovate UK

Right skills, right time, right place

Attributions - The Workforce Foresighting process integrates data from the following international data sets:

IfATE – Institute for Apprenticeships and Technical Education, England

ESCO – European Skills, Competencies, Qualifications & Occupations, EU

ONet – Occupational Networks Online, USA

In accordance with licence and publishing requirements of these organisations for the use of their data sets, the Workforce Foresighting Hub team states that –

The IfATE data used contains public sector information licensed under the Open Government Licence v1.0.

The ESCO data is used in accordance with the EUROPEAN UNION PUBLIC LICENCE v. 1.2 EUPL © the European Union 2007, 2016

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Any errors, omissions and incorrect data are the responsibility of the Workforce Foresighting Hub team and all queries should be addressed to info@iuk.wf-hub.org

The method and process used in the Workforce Foresighting process is under development and there may be errors and omissions in the data provided.

This report was produced following workshops undertaken October – December 2023 using the data set and tools available at that time.

Foreword

Increasing the use of hydrogen as a zero-carbon fuel source is key to the government's Net Zero strategy and one which will mobilise additional public and private investment of £20-£30 billion into the hydrogen sector. In the British Energy Security Strategy, the government has set a target, to deliver up to 10GW of hydrogen production capacity by 2030, with at least half of this coming from electrolytic hydrogen.

To meet these government targets and deliver on the outlined plans to increase hydrogen production, action is needed to improve the skills of our workforce. The latest Workforce Foresighting report carried out by the National Composites Centre (NCC), alongside the Tank Storage Association (TSA) and the Hydrogen Skills Alliance (HSA), set out to evaluate issues and concerns about the future skills availability to meet the challenge of hydrogen take-up, specifically regarding above-ground cryogenic and pressurised hydrogen storage tanks.

Bulk storage tanks are widespread throughout the UK, installed both at dedicated storage terminals and consumer facilities. These tanks are critical in all aspects of storage, distribution and commercial use and are appliable across many sectors. Skills gaps in design, installation, maintenance, and operation threaten to impede progress and scale up in this critical area.

The report identified that very few of the current occupational standards are suitable for wholesale adoption to deliver the skills needed for the roll-out of hydrogen storage tanks. The findings illustrate that both organisational and occupational changes are needed to meet the demands of the evolving hydrogen landscape. A detailed analysis revealed areas where current training provisions does not meet the future needs, urging stakeholders to take immediate action to address this.

Overall, the report emphasised the need for a sustained effort to update existing training provisions and develop new standards to ensure a skilled workforce capable of driving innovation and growth in the hydrogen sector. Without urgent action the UK will not be able to exploit the key role hydrogen can play in reaching the government's Net Zero goals.

The Workforce Foresighting Hub activity represents the initial step in a broader Skills Value Chain. The NCC and TSA (as the convener and the sponsor), together with the Hydrogen Skills Alliance are then responsible for taking the findings and driving action to deliver future skills. This working group should bring together various stakeholders to support the process and implement the recommended short- and mid-term actions outlined in the report, which are needed to develop a skilled workforce to meet the government's hydrogen targets.

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0.0 Executive Summary

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0.1 Foresighting cycle summary

The Workforce Foresighting Challenge stems from the government's Net Zero Strategy, which aims to boost hydrogen adoption and meet specific targets, including:

- Creating up to 10,000 jobs by 2030 in fuel supply.
- Start to mobilise additional public and private investment of £20-30 billion, in line with 2037 delivery pathway.
- Deliver 10GW of low carbon hydrogen production capacity by 2030, subject to affordability and value for money, with at least half of this from electrolytic hydrogen.

The National Composites Centre (NCC) and the Hydrogen Skills Alliance (HSA), engaged industry and government stakeholders during 2023 to assess future skills needs across key categories:

- Hydrogen Generation
- Storage and Distribution
- Transport
- Power and Industrial Use
- Domestic Heating

Comprehensive stakeholder engagement took place to determine the most relevant and impactful topics across various industrial sectors. The selection process identified several critical areas with broad applications.

Storage tanks, both gaseous and cryogenic, were prioritised due to their critical role in hydrogen storage and distribution. This choice was supported by a motivated sponsor, the Tank Storage Association (TSA), who recognised the importance of addressing future skills needs promptly and ensuring sufficient participation in foresighting workshops.

The workshops and analysis provided key insights into the future organisational and occupational changes necessary to meet the evolving demands of the hydrogen economy. The findings highlighted the need for enhanced design, implementation, and logistics functions, as well as the identification of future occupational profiles for various roles within the value chain. These roles include maintenance technicians, operations technicians, design specialists, compliance and risk management specialists, and several senior engineering positions.

Overall, the foresighting process emphasised the importance of aligning future workforce capabilities with strategic priorities and industry requirements. It also underscored the need for ongoing collaboration among stakeholders to ensure that training and education programs evolve to meet the emerging demands of the hydrogen sector.

A range of stakeholders were engaged from across technology, academia, industry and government to ensure the process comprehensively addressed the future needs of the hydrogen sector.

0.2 Organisational change

The findings of the workshops and analysis provide key insights into the future organisational and occupational changes required.

The future organisational capabilities suggest an increased requirement for design, implementation, and logistics function requirements compared to current functions.

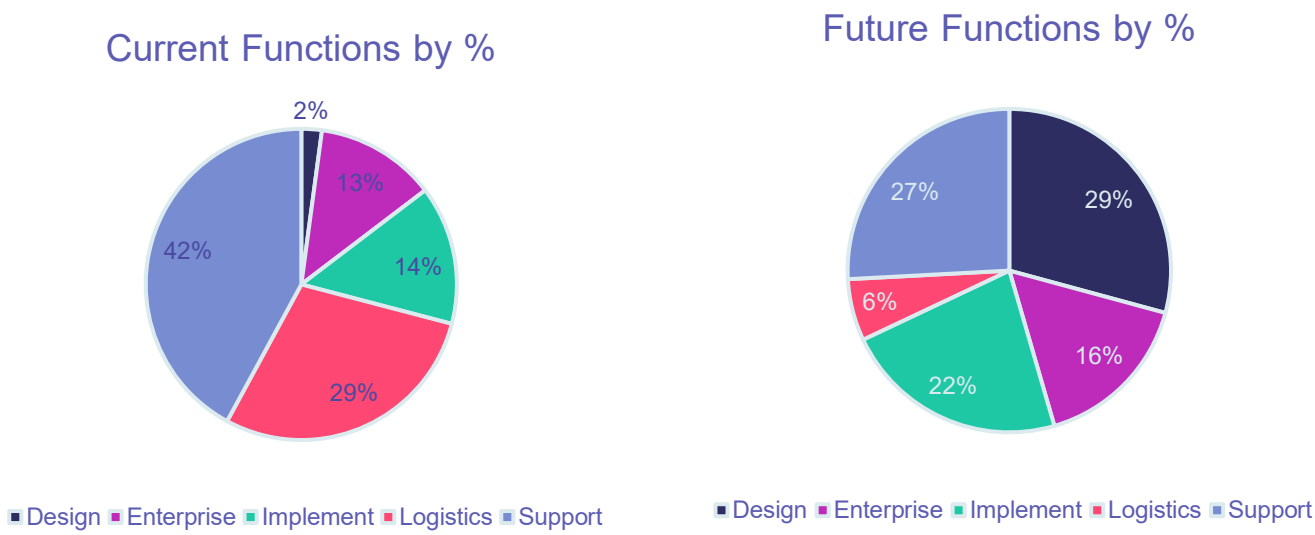


Figure 1: Current and Future Supply Chain - Capability Functions summary by %

0.3 Future Occupational Profile Highlights

Working with inputs from the expert groups and global data, the workforce foresighting process intelligently outlines a range of **Future Occupational Profiles** (FOPs) for each role family, describing the duties and Knowledge, Skills and Behaviours (KSBs) of potential future occupations.

This table outlines an example of how the visualisation tool can identify the specific actions or areas to prioritise.

Value Chain Partners affected	Role Family Description	Proposed Future Occupational Profile	Commentary
Site Operator	Operators and Maintainers of plant and equipment during its lifecycle	Maintenance Technician Operations Technician Revised – Project Engineer	Good alignment by existing standard (plus an additional new standard has been created in parallel to the report generation)
Design Specialists	Designers of these systems	Industrial Control Systems Specialist	The initial analysis has identified a lack of Design Specialists

Sub System Specialist	Implementers of these systems	Compliance and Risk Management Specialist	Initial analysis indicates that needs will increase as the National Strategy develops and the value chain emerges
		Safety Technician	
		Revised - H2 Storage Systems Project Engineer	
		Risk and Compliance Engineer	
		Senior Engineer - Quality and Risk Management	

0.4 Specific areas of concern

The table below highlights the FOPs that have:

- Good Suitability Scores – where the FOPs are well provided for by the current IfATE standards.
- Low Suitability Scores – the FOPs need development as the capabilities identified cannot be met by the current IfATE standards.

FOPs Comparison with current IfATE standards	
Good Suitability Scores	**Low Suitability Scores**
1. Maintenance Technician 2. Safety Technician 3. Revised Safety Specialist 4. Senior Engineer - Quality and Risk Management	1. Compliance and Risk Management Specialist 2. Industrial Control Systems Technician 3. Process Engineer 4. Design Engineer 5. Revised - H2 Storage Systems Project Engineer 6. Senior Safety Engineer 7. Senior Engineer - Environmental Remediation Projects 8. Senior Engineer - Hydrogen Storage Systems 9. Senior Engineer - Cryogenic Systems 10. Revised - Senior Design Engineer 11. Senior Engineer - Quality and Risk Management

To Summarise:

- Only 1 out of 23 future profiles have adequate coverage in the current IfATE training standards, requiring minimal adjustments.
- 19 out of 23 future profiles have partial coverage in the current IfATE standards, necessitating additional content.
- 3 out of 23 future profiles lack sufficient coverage in the current IfATE standards, indicating the need for new standards or major revisions.

0.5 Recommended actions

Use the Future Occupational Profiles to:

- To address skills gaps, leverage Future Occupational Profiles (FOPs) to update standards and provide CPD courses for current and transitioning workers.
- Advocate for revised standards aligned with future workforce needs.

Given the focus on hydrogen storage, most FOPs target this area, highlighting the lack of relevant standards. Failure to address these gaps will risk shortages in skilled workers, hindering the UK's overall hydrogen adoption and infrastructure goals.

The recommendations in this report emphasise the importance of immediate and coordinated efforts by educators, employers, and other stakeholders to address the anticipated skills gap in the hydrogen sector. The actions are divided into short-term and mid-term strategies to ensure a smooth transition towards a hydrogen-based economy.

	Topic	Actions	Who	When	Result
Short term actions	Reskilling and upskilling current workforce	Tailor course content to match new capabilities with existing occupational standards, focusing on design and other early lifecycle activities.	Educators, Awarding Bodies, Employers	Prepare ahead of the scale-up need	Availability of short-term training for the current workforce to meet immediate technology demands.
	Recruitment from other industries	Identify and reskill individuals with transferable skills from other sectors, particularly for high-demand roles such as Maintenance and Operations Engineering Technicians.	Employers, Training Providers	Immediate	Mitigation of workforce shortages in high-demand areas through targeted recruitment and training initiatives.
Medium term actions	Integration of future skills training	Formalise changes to occupational standards and training programs for new entrants, integrating future skills requirements defined by the Future Occupational Profiles (FOPs).	Educators, Awarding Bodies, Employers	As soon as possible for prioritised FOPs	Develop training programs that meet both current and future skills needs, reducing lead time for new workforce entrants.

	Modular approach to course updates	Implement modular changes to existing courses rather than complete redesigns, facilitating quicker adaptation to evolving skills requirements.	Educators, Training Providers	Ongoing	Flexibility in educational programs, enabling rapid response to industry needs.
General actions for educators	Assessment and feedback	Review Institute for Apprenticeships and Technical Education (IfATE) standards and relevant qualifications with employers, providing feedback and identifying gaps.	Educators, Employers	Ongoing	Comprehensive understanding of current training provisions and identification of areas for improvement.
	Commissioning new Continuing Professional Development (CPD) courses	Evaluate existing CPD provisions, commission new courses where necessary, and facilitate collaboration to maintain a unified approach.	Educators, Training Providers	Short-term	Enhanced CPD offerings to upskill current workforce members across all role families.

Table of abbreviated recommendations leading to action:

A Dissemination of Findings	Convener and Sponsor to set up working group to take the recommendations and create an action plan and advance through the Skills Value Chain to cause action. It is essential to share the findings widely among stakeholders, industry groups, and local skills bodies. This will promote access to the insights gained and influence the strategic direction of workforce development initiatives.
B Short-term action	As part of the working group, educators and employers should collaborate to deliver timely short term training solutions for the future workforce. This includes developing and offering Continuing Professional Development (CPD) courses that address immediate skills gaps and ensure workers are equipped with the necessary competencies.
C Mid-term actions	The ongoing working group mid-term action planning should include a concerted effort to integrate new skills and knowledge into existing training programs. Educators and employers need to update curricula and training standards to reflect the evolving demands of the hydrogen sector, ensuring that both current employees and new entrants are adequately prepared.
D Enabling action	Employers and educators must work together to review and influence the update of IfATE standards and relevant qualifications. This involves using the insights from the foresighting process to inform the development of new standards and qualifications that align with future workforce needs. This will contribute to the working group skills framework.
E Further foresighting subjects	The working group should seek additional sponsors and propose further subjects for foresighting. This continuous cycle of foresighting will help to stay ahead of emerging trends and technologies, ensuring the workforce remains adaptable and prepared.
F Lesson Learnt	The working group, supported by the Workforce Foresighting Hub should promote the value gained from participation in workshops. Sharing lessons learned will help to refine the foresighting process and enhance the quality of future outputs

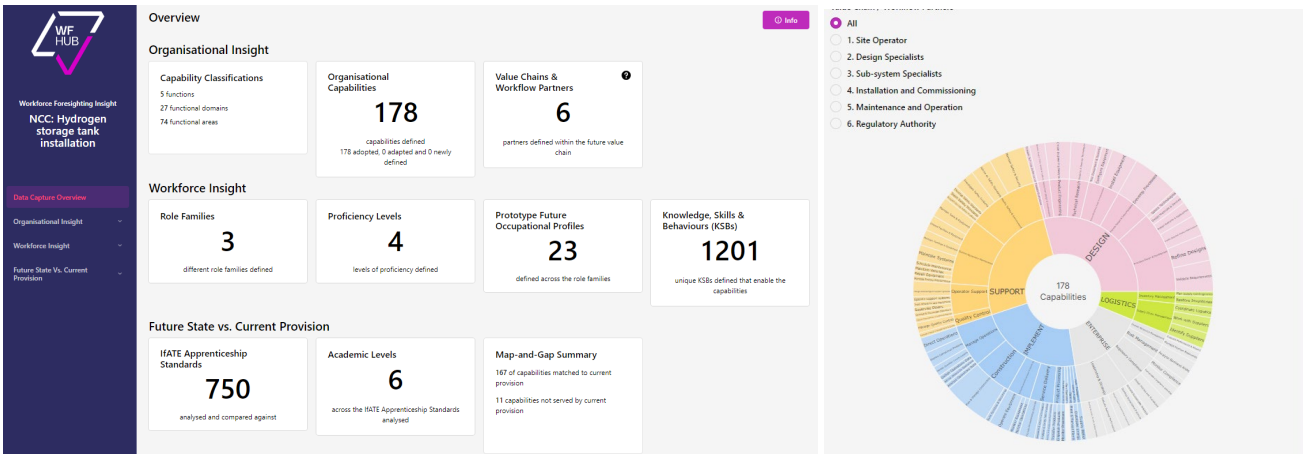
By implementing these recommended next steps, stakeholders can ensure that the hydrogen storage tanks sector is supported by a skilled and adaptable workforce, capable of meeting the challenges and opportunities of a rapidly evolving industry.

0.6 Introducing the Visualisation Tool

The Workforce Foresighting Hub's Visualisation Tool is a powerful, innovative system, which will enable the reader to explore and analyse foresighting data to determine the capabilities required for future roles. Links throughout this report make it easy to identify existing standards which meet the needs of these future roles and pinpoint where new standards are necessary to develop a skilled workforce equipped to adopt new technologies.

The data is generated by the foresighting cycles, integrating the expertise of technologists/domain specialists, employers and educators. The data informs the development of future curriculum and course content as determined by the action plan. Using AI tools validated by human oversight, and by linking to external data sources, the tool identifies differences at the level of occupation/role as well as detailed changes required to knowledge, skills and behaviours thus delivering insights for learners, providers, creators and assurers of skills.

Detailed instructions on how to use the Visualisation Tool can be found in the appendix.



1.0 The Mission – Providing foresight for future change

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1.1 Addressing future workforce challenges

The global marketplace is changing at a rapid pace and the continued development of innovative technologies is creating opportunities for growth in all sectors.

Whilst we are well placed to take advantage in the UK, the Government and industry have identified that we need a workforce able to adapt to new capabilities that require different and often higher skill sets. The 'Manufacturing the Future Workforce' report, published in 2020, states: "Failure to address the workforce development challenge will mean missing out on opportunities to build the UK's manufacturing base and to take market leading positions."

Developing this workforce and preventing a skills shortfall will provide future-thinking organisations with the capabilities to successfully adopt innovation and enable the UK to build a prosperous economy.

1.2 The Skills Value Chain

A Skills Value Chain (SVC) approach promotes connectivity between upstream UK innovation and downstream skills systems, as well as enabling better co-operation within education and training provider eco-systems. It aligns and integrates innovation and skills strategies with a common purpose.

The SVC approach was proposed in the 'Manufacturing the Future Workforce' report, which examined global best practice and convened UK pioneers to explore how the UK can develop skills to exploit innovative technologies.

And it starts with workforce foresighting.

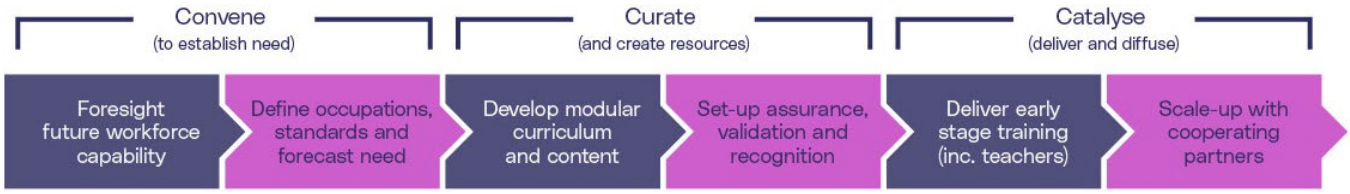

Figure 1: The Skills Value Chain

1.3 Workforce foresighting

Using the Skills Value Chain approach, the UK can start building the skilled workforce required by tomorrow's industries and employers, and understanding what these future needs will be is where workforce foresighting comes in.

Workforce foresighting is a systemic approach to identifying the organisational capabilities and workforce skills necessary to enable industry to adopt and exploit innovative technologies which respond to global, national and sector challenges.

The Workforce Foresighting Hub, initiated and funded by Innovate UK, and built in collaboration with the Catapult Network, provides the processes and data that inform insight and support the recommendations required for industry, policymakers and educators to respond to continuing change.

Our Vision: To foster the organisational capabilities and workforce skills required to adapt to continuing change and enable adoption of innovative technologies to enable a prosperous UK industry.

Our Mission: To provide the process, insight and recommendations required to identify and address future skills demands to enable the UK to adopt innovation and succeed in the dynamic global marketplace.

Our Goals:

Define future capabilities required across a sector in response to a challenge, or technology innovation and consequently define the skill sets of the workforce of the future.
Understand and explain gaps between technology adoption, organisational capability and workforce profiles that could hamper innovation.
Identify and communicate insights, future requirements and the action required by industry and educators.
Enable and deliver a consistent approach to workforce foresighting.

Outcomes:

The process integrates insight from experts in three categories – domain specialists/technologists, employers, and educators. Using a structured and facilitated series of collaborative information-gathering workshops, combined with data from open-source global data sets, the workforce foresighting process can produce a wealth of detailed quantitative data to inform action.

At the heart of the foresighting process are working groups consisting of the industry sponsor and centre of innovation, with support from the Workforce Foresighting Hub team, who undertake detailed analysis to report and summarise key data insights and recommendations for action. This report details future supply chain capabilities, prototype future occupational profiles and identifies changes required to current training provision for the sponsor to take forward and address skills challenges relating to the specific topic.

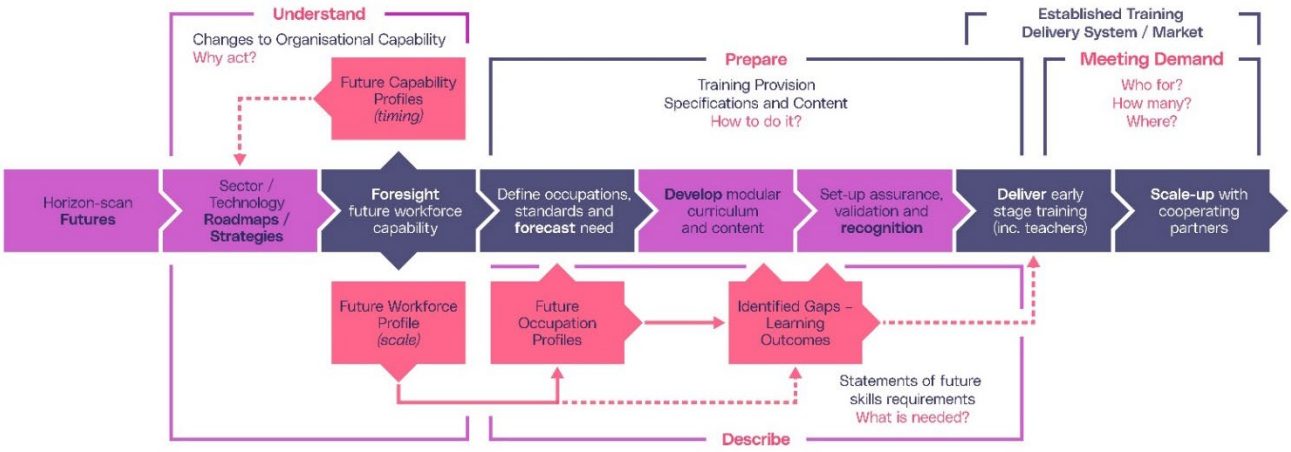

Figure 2: Workforce Foresighting & Skills Value Chain

1.4 Approach used - principles and implementation

The core of workforce foresighting is convening three groups of relevant specialists to conduct structured, Delphi-style, facilitated workshops to capture and discuss the set of organisational capabilities that will be required to respond to and exploit technology innovation. Lists of workshop participants are provided in Section 5.1

Organisational capabilities are captured using a bespoke classification that has been developed by the Workforce Foresighting Hub. The classification uses a structured common language to enable cross sector and cross centre collaboration and integration of data. Additionally, the classification enables data from a number of other national and international open-source workforce datasets to be integrated through the same common language. This data is held in a cloud based "data-cube" that is dynamically growing as each workforce foresighting cycle adds to the shared data relating to future workforce capabilities.

Using cutting edge AI and Large Language Model data tools, the data-cube is used to undertake detailed analysis to 'map' future workforce capability requirements against the current education and training provision to identify where existing provision can be used and where new provision, CPD or qualifications are required.

As an agile development project, the Workforce Foresighting Hub team are constantly evolving and improving the detailed workshop process and workshop approach, but essentially always consists of the following stages:

Considering – Clarifying the Challenge to be met (the 'what' and the 'when') and collating solutions (the 'how') as foresighting topic suggestions align with strategic priorities

Identifying – Gain clarity and consensus about the solutions to be put forward – make the case for foresighting

Preparing – The convening of specialists and scheduling of workshops

Carrying out – Run foresighting workshops with experts, collate and analyse data

Communicating – Insights, findings and recommendations gathered from all research in report

Causing action – The driving of action based on the recommendations (promoting progress down the rest of the skills value chain) built on the findings and recommendations of foresighting

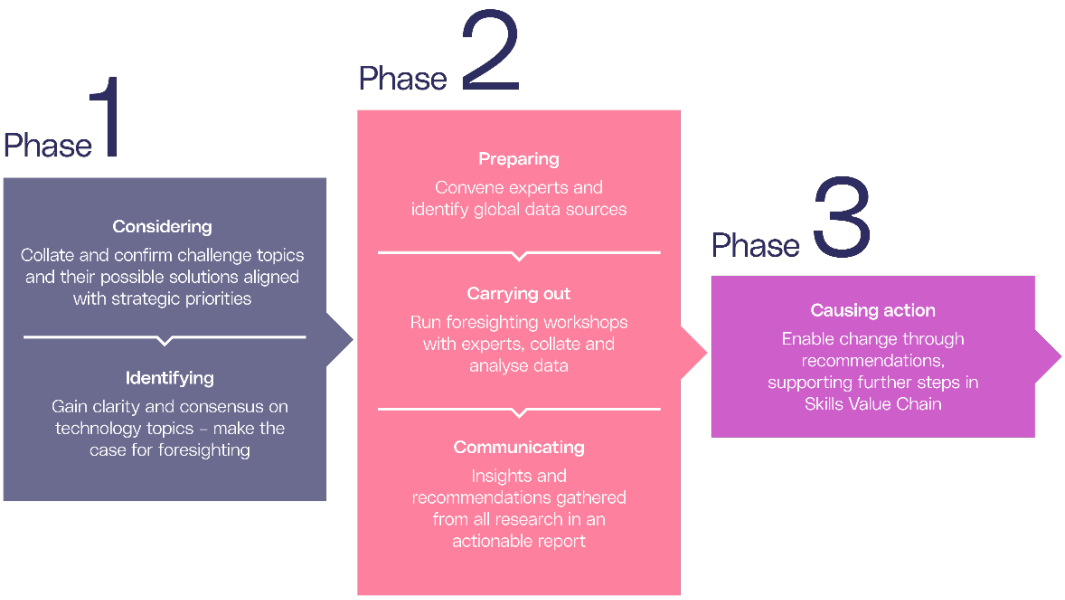

Figure 3 - The workforce foresighting process

1.5 Forecasting and Foresighting

The result of workforce foresighting is understanding why skills requirements will need to change to enable the adoption of innovative technologies, and to define what this change is likely to be in terms of future occupations and shorter-term skills gaps. Forecasting of demand can then take these future focused findings and work with industry and government stakeholders to estimate the quantity of workers necessary for an industry to fulfill emerging skill demands at a given time and place. The two approaches are linked in that workforce foresighting identifies the requirements and forecasting can then determine the quantity needed, the people needing the skills and therefore prepare programmes to deliver them.

1.6 Outcomes - insights and recommendations

Workforce foresighting is a data intensive approach that can provide sponsors, stakeholders and participants with detailed insight about future workforce requirements. A dynamic data set is provided for each cycle to allow all stakeholders and participants to freely access and interrogate the data. Additionally, the Workforce Foresighting Hub team will support the production of a report that provides targeted recommendations that require action to address gaps in training and education provision relevant to the challenge and planned technology solution.

The dynamic data portal provides a range of standard data sets and visualisations. Additionally, users can download data to undertake their own more detailed interrogation of data to guide and inform subsequent actions.

The key aspect is to provide insight about gaps – which capabilities required in the future are not addressed by aspects of current provision – apprenticeship standards, qualifications or other provision. Gaps represent:

Short term CPD – topics required across the workforce to upskill members of current workforce
Medium term – topics to be included as current provision / standards are reviewed and updated
Longer term – new qualifications and standards that may be needed to equip new entrants

The insight produced by a workforce foresighting cycle provides:

Technologists and technical leads with insight of the organisational capability sets required across future supply chain partners in response to the identified challenge.

Employers with insight about possible future roles and occupations that may be required across the whole workforce, operators to researchers, to ensure they are equipped and ready.

Educators with details of the gaps to be addressed by short-course training to upskill the existing workforce and also insight about qualifications and provision that will be required to support new entrants in the future.

2.0 Aligning the Challenge and Solutions with national priorities

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Section	Title
2.1	Positioning and context of challenges
2.2	Potential and prioritised technology solutions to the challenge
2.3	Workforce foresighting for chosen prioritised technology solution
2.4	Current and predicted scale of technology deployment in UK
2.5	Key stakeholders in industry and government
2.6	Sponsors, conveners, and participating organisations
2.7	Background information and references

2.1 Positioning and context of national challenge

The drive towards the use of hydrogen as a zero-carbon fuel source is central to government policy and strategy. The High Value Manufacturing Catapult is leading and supporting initiatives such as Hydrogen Innovation Initiative and the Hydrogen Skills Alliance (HSA).

National Strategy

The Challenge defined by the government's Net Zero Strategy states that growth of hydrogen take-up should:

- Creating up to 10,000 jobs by 2030 in fuel supply
- Start to mobilise additional public and private investment of £20-30 billion, in line with 2037 delivery pathway
- Deliver 10GW of low carbon hydrogen production capacity by 2030, subject to affordability and value for money, with at least half of this from electrolytic hydrogen.

This is further broken down as more detailed Missions to allow the UK to commit to:

- A pipeline of new projects, totaling 1.3GW in the construction and late development phase by 2023
- Producing 1GW hydrogen by Electrolysis by 2025
- Generating 20MW of green hydrogen at Port of Immingham by 2025
- Generating 10GW hydrogen production (5GW green) by 2030

And this will enable:

- 2,000 km of backbone pipeline (Project Union) by 2030
- Pilot solution of first salt cavern by 2030
- National distribution networks to be in place by 2035
- Hydrogen or ammonia-powered marine vessels in operation by 2035
- Net Zero Highways: 100% hydrogen or EV by 2035
- Jet Zero Target - UK domestic flight to be Net Zero by 2040

Developing Solutions

With this background, the National Composites Centre, working with the Hydrogen Skills Alliance, convened discussions with a wide range of industry and government stakeholders during 2023 to help them evaluate issues and concerns about future skills availability to meet challenges for hydrogen production (make), distribution and storage (move) as well as use.

The objectives were to:

- Establish Challenges focusing on 'Make it, Move it, Use it' and suggest potential Technologies and Solutions responding to the Challenges
- Prioritise Challenges, with their enabling technologies and Solutions, to inform future Foresighting Cycles
- Identify additional industry stakeholders to be approached using structured interviews
- Enable workshop participants to gain a better understanding of the Workforce Foresighting approach

The outputs identified that Make-it, Move-it, and Use-it should be refined for clarification to become:

- Hydrogen Generation
- Hydrogen Storage and Distribution
- Hydrogen Transport
- Hydrogen Power and Industrial
- Hydrogen Domestic Heating

Through developing and analysing the data, feedback from discussions was identified as being either:

- Challenges and / or solutions that could be developed for future workforce foresighting analysis
  or
- Issues that will need to be reviewed and considered by HSA in future discussions and not taken forward as workforce foresighting subjects (some being short term)

Further analysis (PESTLE) helped to focus on the Challenges and corresponding technological Solutions for which future skills would be necessary. Initial sector interest was applied to the Challenges and although many may be cross-sectoral, this approach enables the sector with a more pressing need to be identified.

2.2 Potential and prioritised technology solutions to the challenge

The following table lists ranges of technology Solutions related to Challenges:

	Technology Solutions
Generation	• electrolysers • compressors (high volume) • conditioning
Distribution and Storage	• conversion technology: liquefiers compressors (pos. displacement) hydrogen pipeline • static storage tanks • moving storage tanks • metering • conversion technology: carriers ammonia solid materials • large storage (e.g., salt cavern) • pipes • balance of plant and balance of system: filtration valves pumps compressors heat exchangers electrical systems • carbon capture
Transport	• fuel cells • moving storage tanks • refuelling station • liquid hydrogen use: hydrogen fuelled ICE hydrogen fuelled gas turbine • power: fuel cells internal combustion engines
Power and Industrial	• conditioning • fuel cells • hydrogen fuelled gas turbine

Domestic Heating	• metering • sensors • safety systems • leak detection
Key Enablers	• sensors, metering, monitoring, and inspection • hydrogen science fundamentals – how does hydrogen behave under different conditions • hydrogen safety – safe handling, fire • hydrogen system design • business case development • sustainability assessment e.g., life cycle analysis • electrical, electro-chemical, electro-mechanical • maintenance and inspection • materials • digital e.g., simulation, analytics, connectivity, distributed ledger technologies • manufacturing technologies • through life (maintenance, inspection, and recycling) technologies

The selection of the initial foresighting topic by industry stakeholders was carried out by stakeholder interview and discussion to select the most appropriate subjects with wide application across the six groups in the table above.

This led to a concise list drawn from the table:

- Storage tanks – Gaseous and Cryogenic Hydrogen
- Aero gas turbines
- Distributed and mobile applications (Fuel systems / Internal Combustion Engines)
- Design, Manufacture, Install and Maintenance of Compressors / Loading Arms, pipelines, and propulsion systems

Storage tanks were selected after further consultation and included both gaseous and cryogenic tanks. This was supported by a motivated sponsor who recognised the risks of failing to take prompt action to identify future skills needs as well as an assessment that sufficient participants would wish to contribute to foresighting workshops.

2.3 Workforce foresighting for chosen prioritised technology solution

Based on this selection, the rest of this report now considers above ground cryogenic and pressurised tanks for hydrogen storage as the workforce foresighting cycle topic covering hydrogen bulk storage, distribution, and commercial use. This includes the design, installation and commissioning of tanks and ongoing inspection, maintenance, and operation. The scope of this workforce foresighting cycle excludes cavern storage of hydrogen and the wider gas distribution network.

Use of static, above ground cryogenic and pressurised storage tanks for hydrogen will be critical in all aspects of bulk storage, distribution, and commercial use to support this commitment and to address the opportunities that are well aligned to the Innovate UK Impact Domain targets. This will apply across many industrial sectors, including:

- Aero Manufacture
- Aviation
- Energy Networks
- Hydrogen Production
- Infrastructure
- Maritime Infrastructure Operations
- Off Road Plant
- Power Generation
- Rail Vehicles
- Road Vehicles
- Marine, Land Transport, etc.

Early feedback from UK tank supply chain businesses reveal that skills gaps may already be adding risk to current activities and that they will further increase across future roles in the design, installation, commissioning of tanks and their ongoing inspection, maintenance, and operation.

In choosing to focus on smaller scale pressurised and cryogenic storage, a tighter and more clearly defined scope for the first of the workforce foresighting cycles and subsequent analysis was able to be defined. This provided the opportunity to review, and where necessary, build on the known skill sets that were already in existence for similar storage solutions.

2.4 Current and predicted scale of technology deployment in UK

The hydrogen economy in the UK continues to evolve, and with it the technologies and infrastructure that will be needed to connect hydrogen as an energy carrier to commercial and domestic users. The primary mechanism for storage and transportation of hydrogen will be via dedicated pipelines (potentially also blended with existing gaseous energy carriers such as natural gas), with atmospheric storage provided in underground caverns.

However, smaller scale storage, either under pressure or cryogenically, will be required at production and storage facilities, and for commercial users, particularly those not connected to any future hydrogen network (i.e., those consumers considered to be ‘off-grid’).

Bulk storage tanks are widespread throughout the UK, installed both at dedicated storage terminals and consumer facilities. Terminals provide an essential interface between sea,

road, rail, and pipeline logistics for a diverse range of essential products, including transport and heating fuels, chemicals, animal feed and foodstuffs.

The UK has over 12 million cubic meters of storage capacity at terminals and depots across the UK in over 3,600 tanks. These tanks come in many different configurations, including atmospheric, pressurised and cryogenic, depending on the product stored. Because of the nature of hydrogen as an energy carrier, much greater energy density can be achieved by storing it either under pressure or cryogenically.

This storage methodology, and the technology required to achieve it, has been in use in the UK for many years – however not at the scale that will be required to develop hydrogen as an energy carrier to help achieve the UK's Net Zero ambitions. Hence it is important to understand what skills are needed, which are already in place, and the scale of workforce that will be required to design, install, operate, and maintain pressurised and cryogenic storage facilities in a future hydrogen economy.

Whilst storage and transportation of gaseous hydrogen in tanks is a mature technology (already being manufactured worldwide), there are numerous innovation opportunities to reduce mass and cost and improve sustainability of the pressure vessels. The UK can pivot on globally renowned expertise in designing and manufacturing of composite tanks/vessels for new applications of hydrogen in land and sea mobility, material handling machinery and off-road vehicles.

The design of new lightweight materials and components that can withstand the harsh cryogenic environment for fuel tank in the aerospace sector (business jet, regional and mid-size aircrafts) can exploit the strong network of academia and RTOs in the UK, and similarly a thriving aerospace supply chain.

2.5 Key Stakeholders in industry and government

Participating stakeholders collectively ensure that the output from the foresighting cycle on hydrogen tanks for bulk storage, distribution and commercial use is comprehensive, integrating perspectives from innovation, education, industry, and policy-making to address the future needs. This included:

- National Composites Centre (NCC): Lead organisation coordinating discussions and efforts around hydrogen skills and workforce foresighting.
- Hydrogen Skills Alliance (HSA): Collaborative entity working with NCC to address the future skills needs in the hydrogen sector.
- Tank Storage Association: Sponsor - Provides industry specific expertise in storage solutions.
- High Value Manufacturing Catapult: Leads and supports hydrogen-related initiatives and policy development.
- Hydrogen Innovation Initiative (HII) – Represents a group of organisations that bring together industry, government, and academia to create an investible, globally competitive hydrogen technology and services sector, here in the UK.
- Industry stakeholders: Various industry participants involved in hydrogen production, storage, distribution, and usage who provided input and feedback during discussions and interviews.
- Academic and Research Institutions: Entities conducting research on hydrogen innovations, providing critical technological insights.
- Government stakeholders: Government bodies and agencies that are part of the strategic initiatives and policy-making processes related to hydrogen technology and workforce development.
- Workshop participants: Individuals from various sectors who participated in foresighting workshops to provide insights and help refine the challenges and solutions related to hydrogen technology.
- Institute for Apprenticeships and Technical Education (IfATE): Provides valuable insights into educational standards and future skills needs.

2.6 Sponsors, conveners, and participating organisations

Tank Storage Association – sponsor

The Tank Storage Association represents the interests of over 70 companies who operate more than 390 terminals and distribution hubs in the UK or provide equipment and services to the sector. Working on their behalf, Peter Davidson is the Executive Director responsible for all aspects of advocacy and lobbying on behalf of the sector, and is also tasked with promoting process safety leadership, helping members achieve excellence in this area and work toward becoming high reliability organisations. Peter works in close collaboration with the UK Government and Regulators and is a leading member of cross-industry committees, Process Safety groups and the Federation of European Tank Storage Associations

National Composite Centre, High Value Manufacturing Catapult – Convener

The National Composites Centre (NCC) is a world leading UK research and development facility that provides access to state-of-the-art engineering capabilities and technology. Collaborating to address complex engineering challenges, to accelerate the development of new products across advanced materials, digital engineering, sustainability, and hydrogen. Delivering innovation to drive industrial transformation, working across a diverse range of sectors to deliver benefits to the UK.

As part of the High Value Manufacturing Catapult, the NCC collaborates with innovators to SMEs, the supply chain, and OEMs, providing businesses with a de-risked environment to design, develop, test, and scale their ideas and get to market fast.

Hydrogen Skills Alliance

The Hydrogen Skills Alliance was set up in March 2023 by the High Value Manufacturing Catapult and Cogent Skills. The purpose of the alliance is to work with a large and diverse group of stakeholders to identify and address the skills challenges involved in meeting the UK's Net Zero targets for hydrogen. The Hydrogen Skills Alliance engages with groups from industry, academia, Catapult centres, and government, to understand their needs, capabilities, and challenges.

2.7 Background information and references

https://assets.publishing.service.gov.uk/media/6194dfa4d3bf7f0555071b1b/net-zero-strategy-beis.pdf
https://assets.publishing.service.gov.uk/media/5fb5513de90e0720978b1a6f/10_POINT_PLAN_BOOKLET.pdf
HSA workshop 3rd May updated (002).pdf
Hydrogen Strategy: Update to the market, August 2023 (publishing.service.gov.uk)

3.0 Results – Findings, Data and Insight

3.0 Results – Findings, Data and Insight

3.1 Findings, methodology and presentation

This section describes the future organisational capabilities that will be required to meet the Challenge using the proposed Solution(technology) and which occupations are likely to change to deliver these capabilities.

Summary information is provided with a narrative based on the underlying data which is also provided using bespoke visualisations to enable greater insight and access to detail. This section of the report is aligned to the needs of those responsible for workforce planning – employers, educators, and skills providers.

The two parts interpret the data findings and contain links to the relevant visualisation elements.

Actions necessary to meet the skills and training requirements for the changed occupations are considered in Section 4 with recommendations to be considered by the foresighting sponsor, convener, and others on behalf of the stakeholder and participant groups.

Organisational changes

Providing insight into organisational changes – this indicates how organisations will need to adapt their current capabilities to implement the Solutions that respond to the Challenge addressed by this foresighting project.

Typically, this will also require the adoption of new capabilities and a change in the distribution of these capabilities across value chain partners. This change in capabilities within an organisation as well as their supply chain partners will determine skill changes required by the role families within the workforce of each supply chain partner.

Occupational changes

A set of 'Future Occupational Profiles' (FOPs) is produced by the foresight process that demonstrates how current occupations may need to change in the future. FOPs are generated using a combination of attributes from the underlying capability classification and from data collected in the workshops. The FOP generation algorithm works to group capabilities into logical sets reflecting role families, function, proficiency and capability similarity. As part of the foresight process the generated FOPs are reviewed, revised and distilled by the Employer group. This agreed set of FOPs are then compared with selected current education provision; the default reference is the set of Institute for Apprenticeships and Technical Education (IfATE) occupational standards; to assess which current training and education provision could be used in the future. Two bespoke metrics, match and surplus are used to evaluate the alignment of current provision with the set of FOPs proposed. Summaries are presented of the key findings related to each supply chain partner.

Findings are aimed at both Employers and Education and Training Providers and identify matches and gaps in future training needs compared with current provision to guide further detailed investigation.

Recommended actions for future provision

The outputs from workforce foresighting identify recommended changes to education and training provision – principally occupational standards that will deliver the knowledge, skills and behaviours required by future occupations. In some cases, this will include the development of short courses and continued professional development (CPD) to upskill the current workforce to meet future needs. Additionally, foresighting outputs can be used to

develop programmes, qualifications, and occupational standards for new entrants to the workforce joining via apprenticeship, taught qualification, or other training programme.

The insight and data in this part of the report are primarily aimed at educators training providers, occupational standards bodies and awarding organisations. Combined with insight arising from the supply chain capability changes, the provision insight offers an effective way for employers to identify training opportunities that align to their future needs.

Method

The workforce foresighting process uses a series of structured workshops and surveys to capture and summarise input from relevant sector experts – covering technology, workforce development and education. At a number of points in the workshop and analysis sequence the foresighting process utilises large language models (LLM) and artificial intelligence (AI) tools to parse and assist in the analysis of the content generated by workshop participants. For example, the AI model can compare capability statements with existing occupational standards more thoroughly and rapidly than human comparison. All AI derived outputs are reviewed and validated by the participant groups through the workshops and the integral quality assurance reviews of the foresight process.

3.2 Insight into organisational changes

Organisational insight indicates how diverse types of organisations in the supply chain will need to make functional changes to align their future capabilities to those required to respond to the Challenge being addressed. This provides useful insight for these organisations and in turn, provides a data rich and well-founded basis to understand how future occupations and their skillsets may need to change to meet that challenge. This is developed in section 3.3 of this report.

Organisation functions

The workforce foresighting process uses an information architecture built on five functional areas which are common to any business:

Design	The function of an organisation that focuses on activities relating to product, service, or solution design.
Implement	The function of an organisation that focuses on activities relating to producing / making / providing its products or services.
Logistics	The function of an organisation that focuses on activities relating to procurement, delivery, materials, or services necessary for operations – service / manufacturing, etc.

Support	The function of an organisation that focuses on activities relating to users, in-service support, repair / maintenance, recycling, end of life disposal.
Enterprise	Core functions of an organisation e.g., strategic planning, leadership and management, human resources. Digital backbone and data systems. Integration of relevant statutory / regulatory requirements and compliance.

This functional structure is developed to levels of detail that enable the foresight process to reference external data sets including ONET (US) Occupational Information Network [1], ESCO – European Skills, Competences, Qualifications and Occupations[2], IfATE – (UK) Institute for Apprenticeships and Technical Education[3] .

The five root functions comprise ~ 40 Domains which are broken down to ~ 140 Functional Areas. This architecture is used to position ~ 25,000 capability statements which are the building blocks used in the workforce foresighting process. Each capability statement has several attributes. Some are static and reflect the position of the capability statement in the architecture, others are dynamic and are assigned values through a cycle and set of workshops.

The data-architecture is implemented in a bespoke 'data-cube' which underpins the foresight process, workshops, and enables extensive use of LLM and AI tools. Additionally, a key feature of the data-cube is that the data from each foresight topic cycle is added into the data set and can then be used, where relevant, in future cycles. This ensures that the capabilities of the system are dynamic and up to date.

Identifying the Future Supply Chain Capabilities.

The following charts and graphs summarise the changes in the set of capabilities that will be required by the supply chain in the future. The pie-charts reflect the distribution of capabilities across the five functions. The future state data is captured in three Technologist workshops and the current state data is generated using information collected about current occupational standards used across the existing supply chain. This latter information is not as detailed as that produced by the workshops and is indicative and used to provide a point of comparison.

These initial pie charts illustrate the changing proportions of the five functions between the current and future. This indicates an overall relative:

- Increase of Design, Enterprise and Implement
- Decrease of Logistics and Support

[1] ONET - Occupational Information Network - https://www.onetcenter.org/
[2] ESCO - European Skills, Competences, Qualifications and Occupations - https://esco.ec.europa.eu/en
[3] IfATE – Institute for Apprenticeships and Technical Education - https://www.instituteforapprenticeships.org/

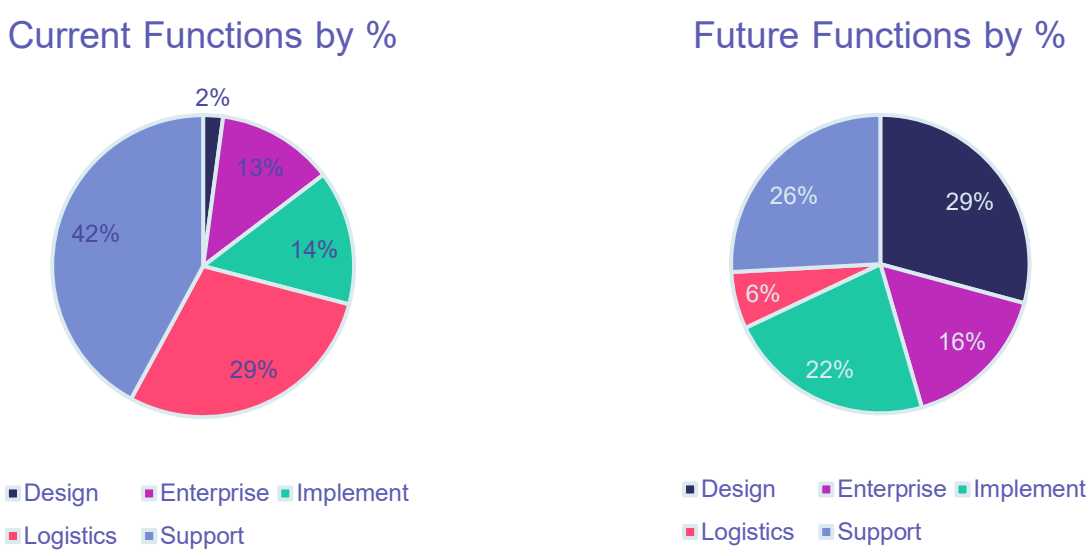


Figure 2: Current and Future Supply Chain - Capability Functions summary by %

This information is useful to indicate relative changes, but the underlying change will be a result of future scale as well as how functions change relative to each other. To gain more detailed insight, these overall comparisons of functional areas are analysed using the current and future capability counts within each function using the next level of classification architecture – Functional Domain.

The graphs show the change in capabilities at domain level within each of thew five main functions. The domain data is ranked with greatest change at top of the list. These graphs provide insight into both the relative importance of each domain and scale of the changes that will be required from the current state.

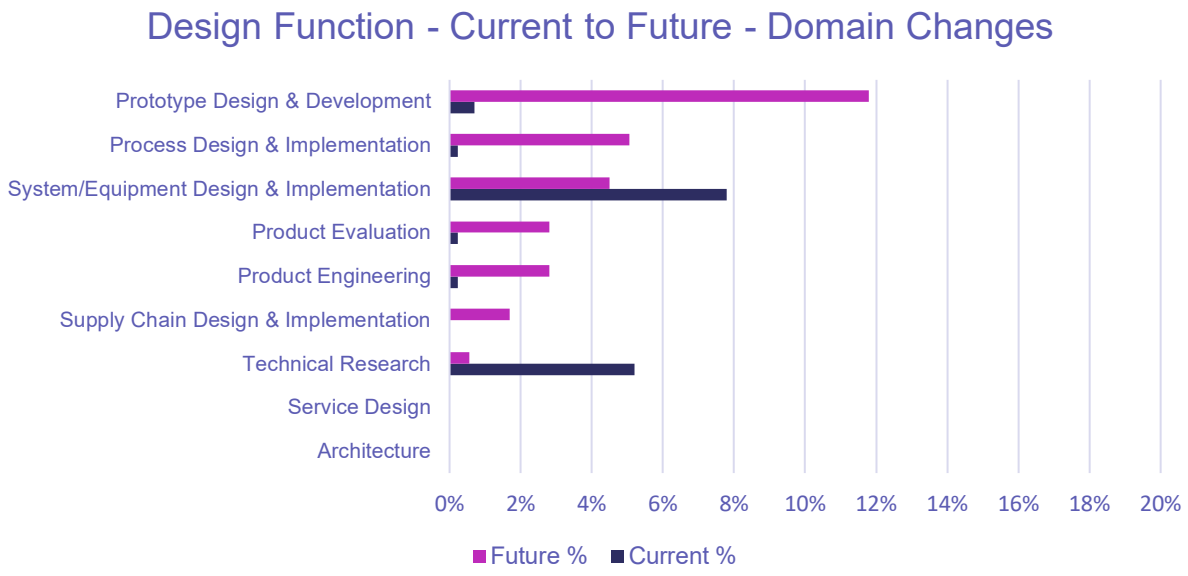


Figure 3: Design Function - Current to Future - Domain changes

The current / future comparison for Design reflects the foresighted transition to an increase in new products, engineering and evaluation ahead of the development and implementation phase.

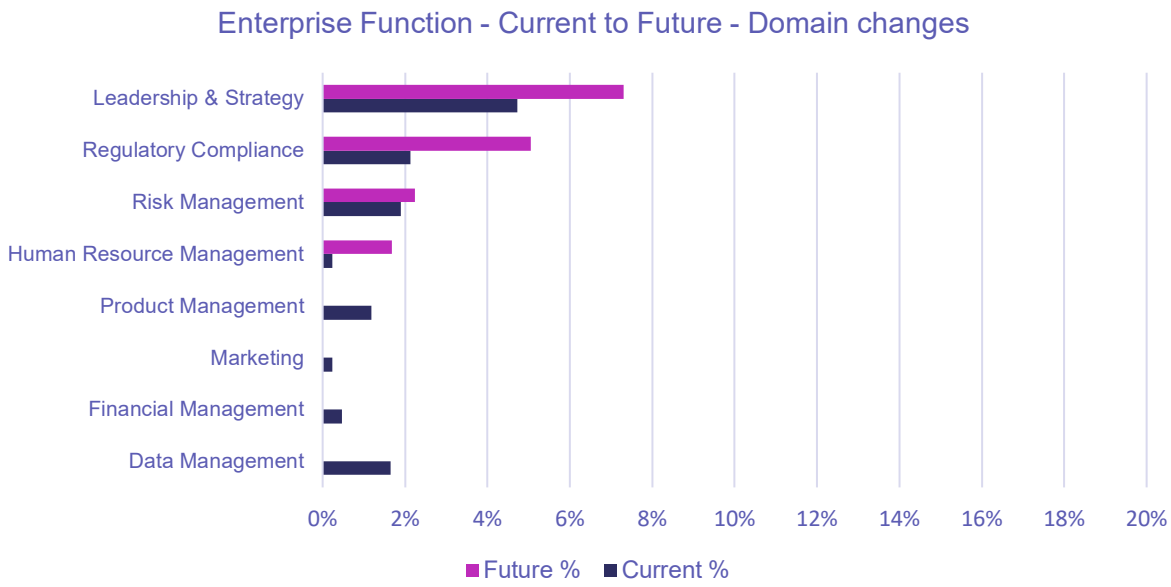


Figure 4: Enterprise Function - Current to Future - Domain changes

The current / future comparisons in the Enterprise area show the increased need associated with a maturing and competitive regulated market and the need to increase human resources.

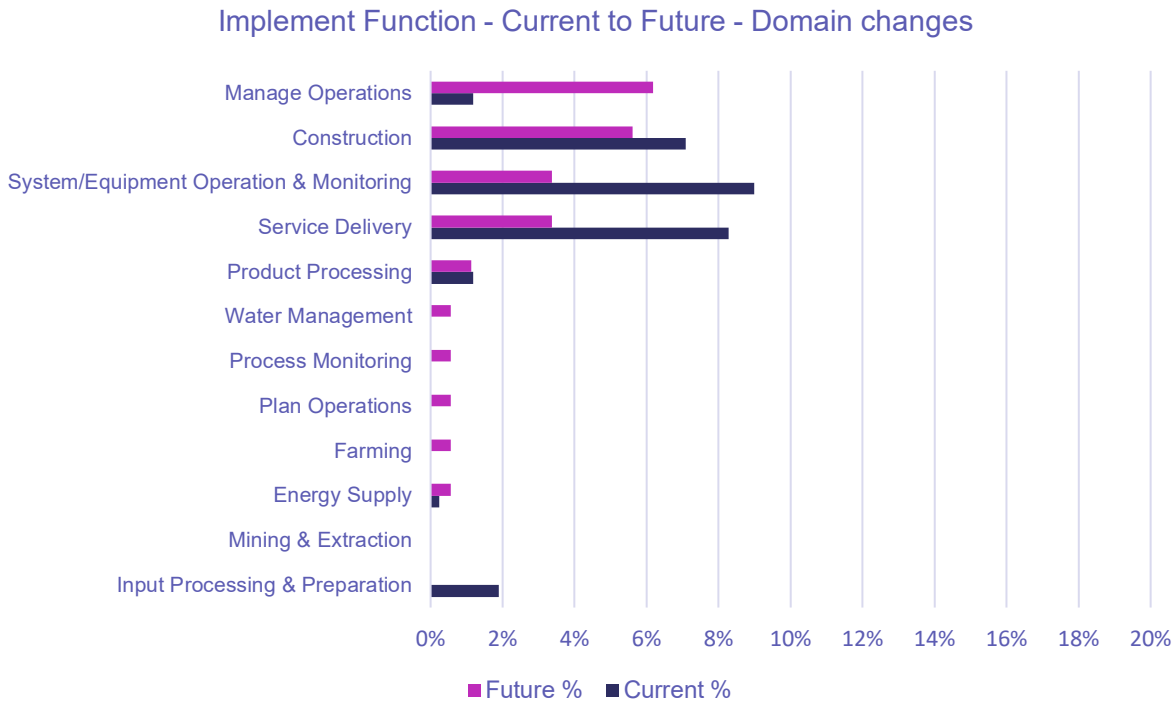


Figure 5: Implement Function - Current to Future - Domain changes

The current / future comparison of implementation functions reflects the changes associated with greater adoption and product sales volume.

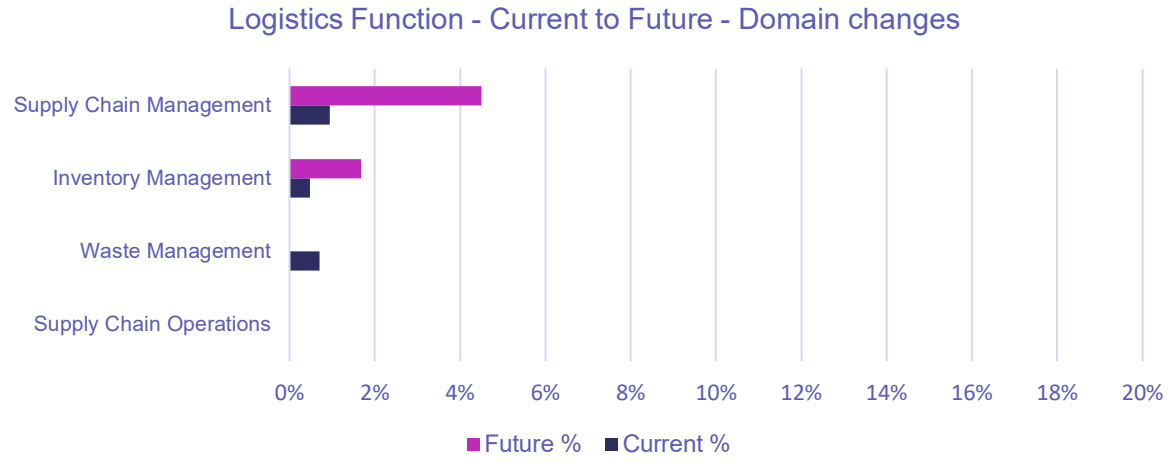


Figure 6: Logistics Function - Current to Future - Domain changes

The current and future comparison for logistics is as expected for organisations gearing up to work at a higher scale of production.

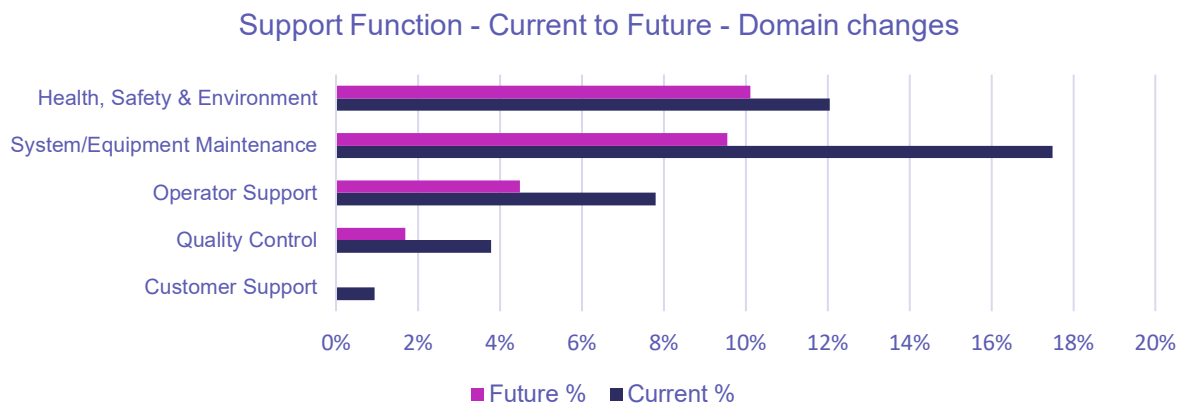


Figure 7: Support Function - Current to Future - Domain changes

The current and future support comparison reflects the current prominent levels of Health and Safety – reducing proportions may be due to omissions during the data gathering and analysis.

Visualisation Instructions

Detailed instructions can be found in the appendix.

Visualisation Data Link	What is it and what can it be used for?
Organisational Capabilities	Generally, the data presented here can provide an indication of how well served the sector is. This page provides a high-level summary of each capability statement generated in the cycle. The capability statement describes the depth and nature of each capability within an Organisation against a defined reference. The page also provides a way of reviewing the capabilities through the lens of the Capability Classification Framework (Design/ Implement/ Logistics/ Support/ Enterprise). This information can be used to provide insight about the types of capabilities and their distribution across the classification framework. This can be used to identify which capabilities may be supported by existing provision, and where there may be gaps that require new development to support.

3.3 Occupational change insight

This insight into occupational change uses the understanding of how capabilities will change across business functions (section 3.2) to inform proposals for how occupations and their associated skillsets for each supply chain partner may need be revised to reflect change for each role family within that Partner.

Supply chain partner organisation types

The workforce foresighting process recognises that different partners in a supply chain will require appropriate capabilities and these are determined and agreed in the initial workshops.

In this cycle, the following Supply Chain Partners were identified and then used during participant workshops and data analysis to determine the organisational needs:

1. Site Operator
2. Design Specialists
3. Sub System Specialists
4. Installation and Commissioning
5. Maintenance and Operation
6. Regulatory Authority

This categorisation enables the analysis and reporting of the major areas of occupational change by business function for each partner, recognising that each will have distinctive characteristics and requirements.

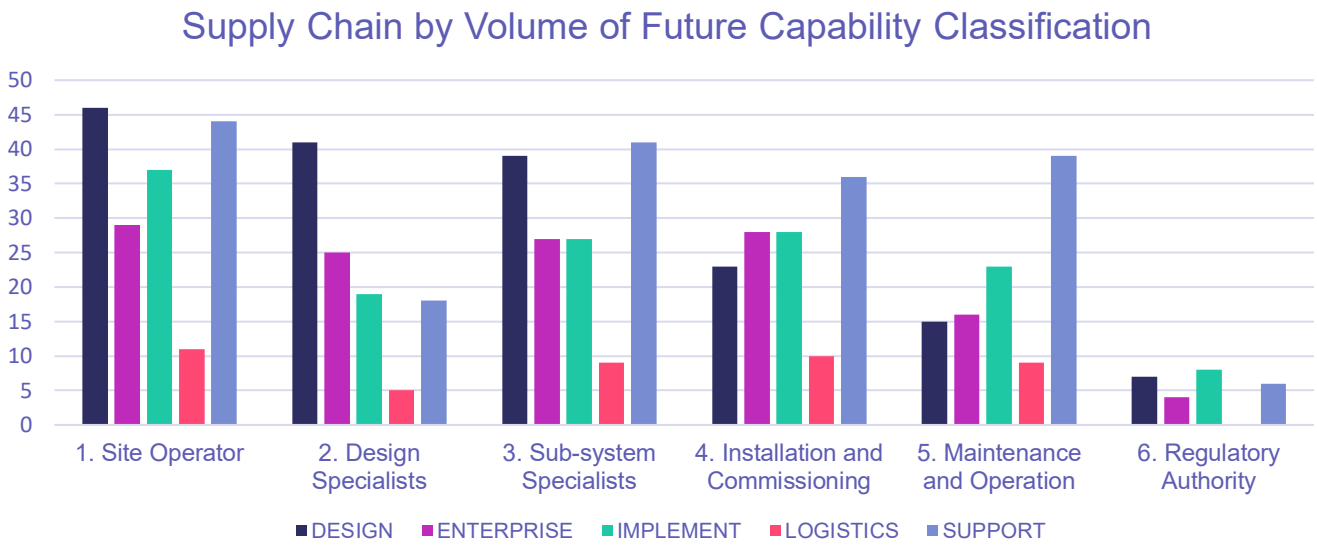


Figure 8: Supply Chain by Volume of Future Capability Classification

This graph illustrates the distribution of capabilities by function across the Supply Chain Partners. These capability sets are used to form the set of Future Occupational Profiles within each Role Family.

Visualisation Instructions

Detailed instructions can be found in the appendix.

Visualisation Data Link	What is it and what can it be used for?
Supply/Value Chain Capabilities	This page provides an overview of the identified capabilities at a Supply Chain / Workflow Partner level. By selecting/deselecting each Supply Chain / Workflow Partner you can review the capabilities identified as required in that area of the Supply Chain / Workflow. This can be used to generate organisational capability profiles for each area of the workflow /supply chain to help prioritise and focus the acquisition of new capabilities that will be required in the future. It can also be used to generate combined organisational profiles, where an organisation may be involved in more than one area of the supply chain.

Role Families

The foresighting process uses the concept of Role Families to represent future occupations. This approach acknowledges that the workforce is not homogeneous, there will be varying levels of proficiency required across a workforce and qualifications and training may be aligned/require different types of vocational or academic qualifications. Additionally, the role family approach seeks to avoid presuming that the future workforce will be "current state plus."

For this cycle, the following Role Families were determined through the workshops:

1. Technician / Operator
2. Engineer
3. Senior Engineer

Proficiencies

Each of these role families will require proficiency that reflects their role and the needs of each Supply Chain Partner. The foresighting process uses a three-point scale to capture and differentiate the proficiency required. This information is used in the generation of the Future Occupational Profiles and also to assist the definition of training needs identified. Within the workforce foresighting process Proficiency is defined as:

Awareness (A) - Has a foundational knowledge of tools, technology, techniques relevant to sector, industry, and company. Sufficient comprehension to know where to seek further information/details as necessary for a particular issue.

Practitioner (P) - Has the ability to apply and use independently a tool, system, or process. Understands the implications, consequences, and impact for their role/function. Knows what key actions are required and in what context.

Expert (E) - Has detailed knowledge of process, system, tool, or technology. Can support others and identify improvements required for a process, system, or tool. Can implement improvements personally or direct and guide others.

In the workshops, participants apply their insight to assign proficiency for each role family to each capability. Individual responses are aggregated by the system to arrive at a consensus.

A summary of the distribution of required proficiency for the role families in this cycle are:

	Operator / Technician	Engineer	Senior Engineer
Awareness	4%	5%	4%
Practitioner	38%	58%	18%
Expert	57%	37%	78%

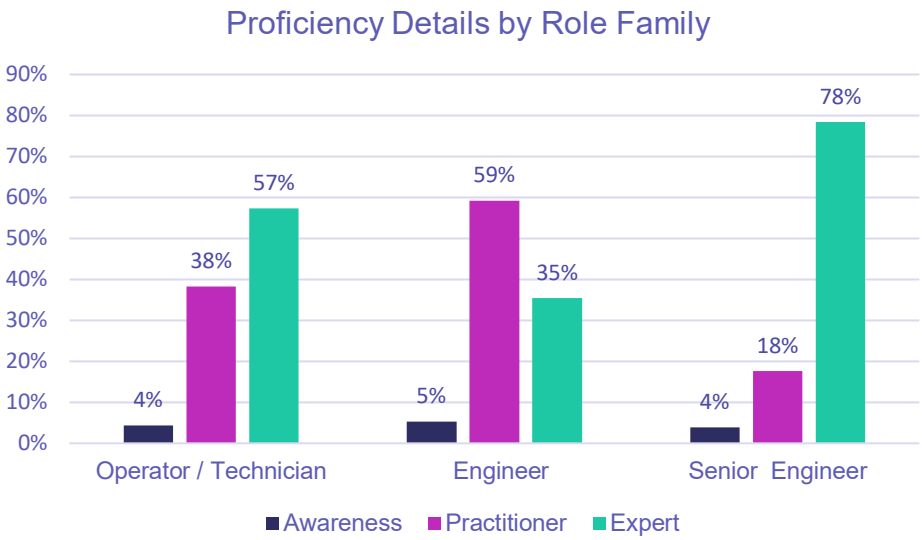


Figure 9: Proficiency details by Role Family

Future Occupational Profiles

The FOPs (Future Occupational Profiles) are a construct created and used during workforce foresighting workshops and analysis to capture future skills needs in a form that may be compared with current occupation definitions – typically occupational standards.

The familiar nature and structure of FOPs assists with their evaluation and validation by employers and educators and enables the analytical comparison that results in useful indications of matches, surplus and gaps of future skills needs compared with current state. This then allows recommendations for action to be made based on future need and current fit to those needs.

FOPs are used to describe and suggest occupations, or roles, that may be required in the future and provide a framework to indicate capabilities and related duties. They can be used to review the impact on current roles and the adaptation that may be required in the future.

Educators can review current occupational standards against the requirements of the FOPs and interpret which need to be changed to fill the gaps between the current and future state.

Employers can consider existing apprenticeship standards and make a judgement on adapting an existing apprenticeship standard to upskill their workforce to meet the requirements of a particular FOP.

Educators may react to these specified skill requirements from industry by editing, adapting, or creating new content.

FOPs and indicative skills need

Combining proficiency with the identified FOPs, the following graphs indicate the priority needs across the supply chain for each Role Family to deliver future capabilities.

Technician / Operator Role Family FOPs:

In this cycle the Technician / Operator role family was defined as occupations and roles requiring Level 3 qualifications or apprenticeships.

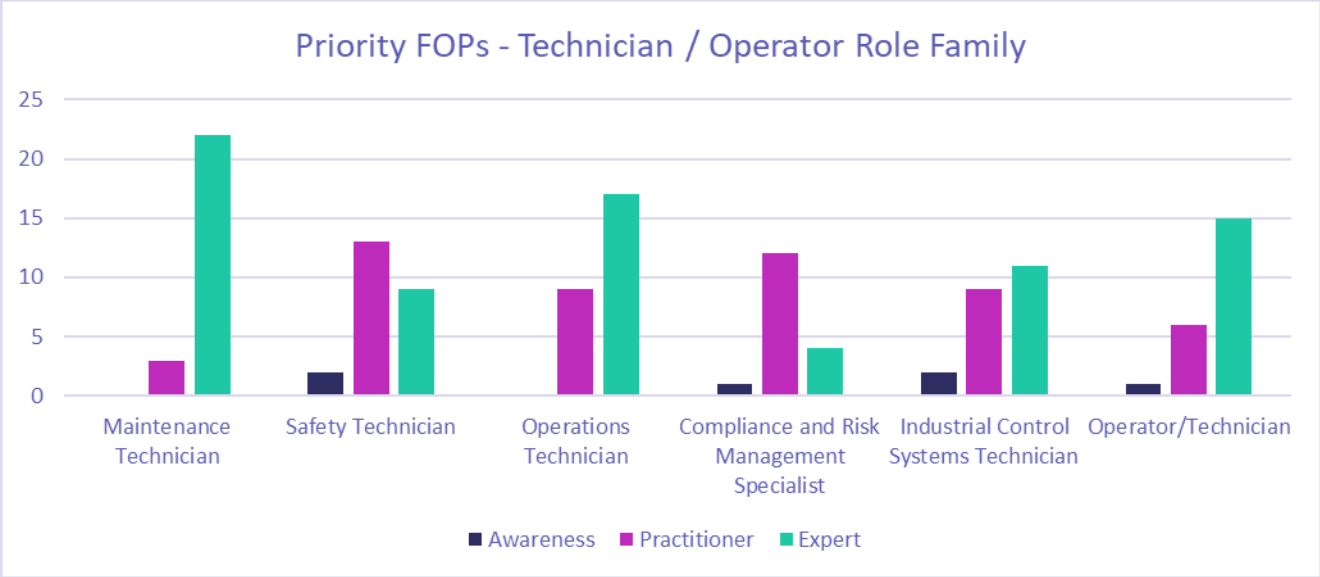


Figure 10: Priority FOPs - Technician / Operator Role Family

Engineer Role Family FOPs:

In this cycle, the Engineer role family was defined as occupations and roles requiring Level 4/5 qualifications or apprenticeships.

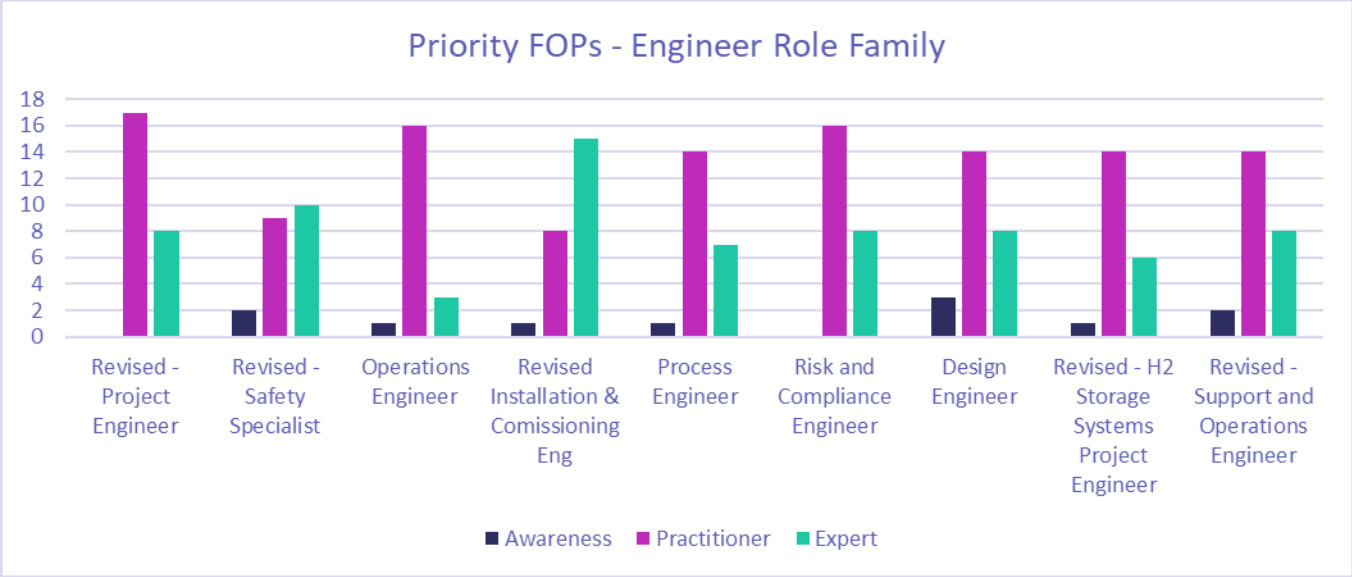


Figure 11: Priority FOPs – Engineer Role Family

Senior Engineer Role Family FOPs:

In this cycle the Senior Engineer role family was defined as occupations and roles requiring Level 5/6 qualifications or apprenticeships.

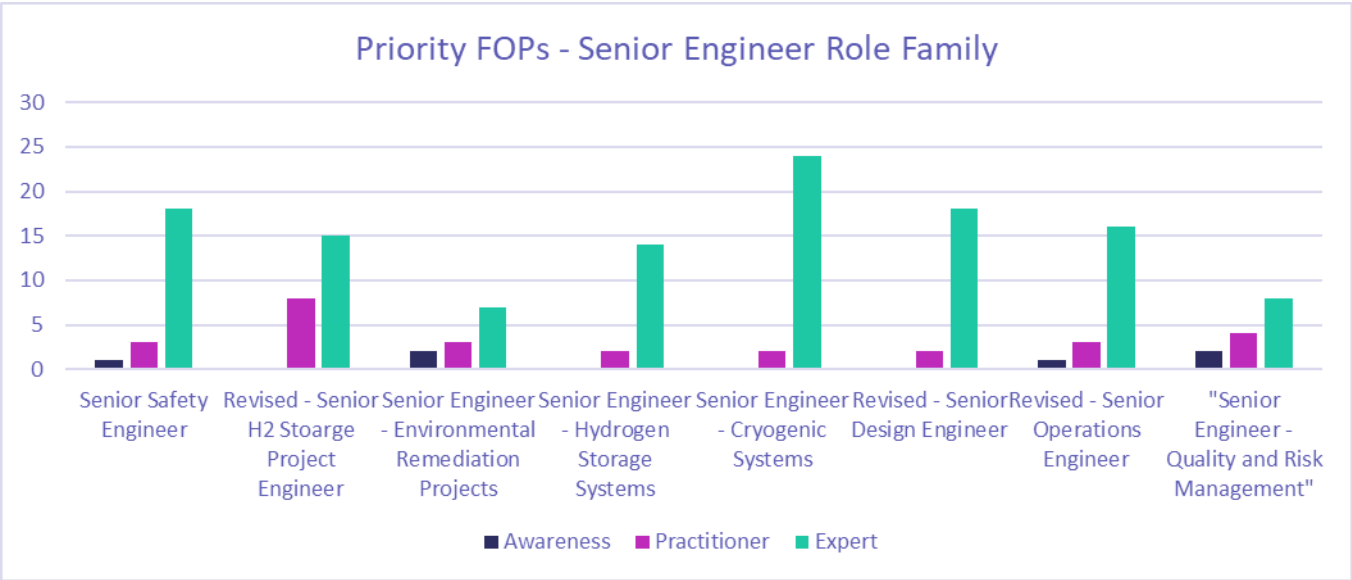


Figure 12: Priority FOPs - Senior Engineer Role Family

Visualisation Instructions

Detailed instructions can be found in the appendix.

Visualisation Data Link	What is it and what can it be used for?
Prototype Occupational Profiles (PFOP Matrix)	This page provides a detailed breakdown of future occupational profiles that could be required in the future workforce. These were generated using a combination of attributes collected through the workshops and an algorithm. These suggested profiles were then reviewed and ratified by small groups of employers who were able to add/remove capabilities and uprate/downrate proficiency levels required. You can view all the P-FOPs in a role family by selecting one (or more) of these from the drop down. This will then allow you to select the P-FOPs aligned to that role family. The populated table allows you review and compare different P-FOPs within or across role families. You can view the capabilities in each P-FOP and the assigned proficiency levels. You can also toggle 'Hide Empty Capabilities' on/off to reduce the view down to only those capabilities included in the role family you are reviewing.

Comparison with current state

The workforce foresighting process has developed two metrics to quantify the alignment between a FOP and a current standard or qualification:

Fit – expressed as a %, it is a measure of the proportion of a FOP that is covered by an existing standard or qualification.

Surplus – expressed as a %, it is a measure of the not relevant material in an existing standard that is not required for a FOP.

An ideal existing qualification or standard would have a high fit and low surplus – this implies good coverage of the FOP but with little material that is not relevant to the FOP. Conversely a poor candidate would have a low fit and high surplus. Using these two metrics it is possible to quantitively evaluate, rank, and compare a range of existing provisions against a set of FOPs describing future needs.

By looking at how current occupational standards fit the Future Occupational Profiles, the most suitable and efficient route for change can be determined, e.g. a fit factor of less than 33% probably indicates that the current standard is unlikely to a good candidate for change, however a fit factor of 66% suggests that less adaptation will be necessary to meet future needs.

This interpretation is represented by a simple nine-box model to position the suitability of a given current occupational standard to a future occupational profile:

Factor scores

Fit Factor	Fit score	Surplus Factor	Surplus score
0 - 32%	1	81-100%	1
33-65%	2	51-80%	2
66-100%	3	0 - 50%	3

(Multiplying the Fit score by the Surplus score gives a Suitability Grid score of 1-9 as below)

Suitability Grid

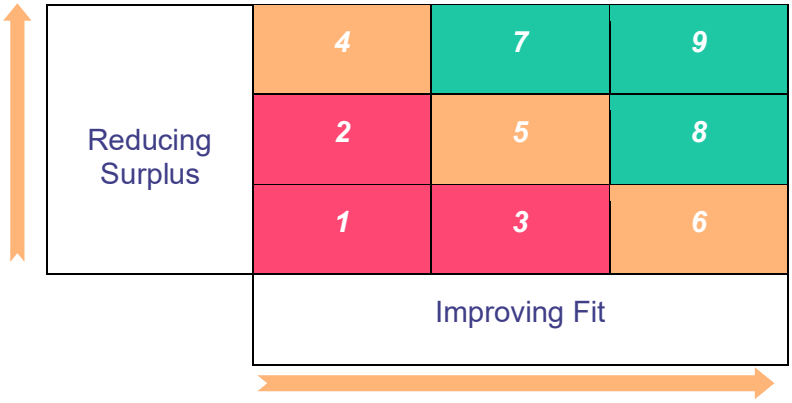


Figure 13: Fit Factor scores and Suitability Grid

For this foresighting cycle, it was found that a higher threshold on surplus factor is more useful in filtering out the less relevant IfATE standards, whilst a slightly lower threshold on fit factor is useful to ensure relevant standards might be included.

Using this score and indicated 'RAG status' the following interpretation can be made:

Good Suitability – 7,8,9 – for standards that have good coverage of FOPs.
Represents good candidates from current occupational standards used as the basis of development to meet FOP requirements and inform elements of short course and CPD provision.

Some Suitability– 4,5,6 – for standards that have only partial coverage of FOPs.
These are likely to require extended work to meet FOP requirements, further review of the data may be necessary. They are likely to contain some useful information to inform elements of short course and CPD provision.

Low Suitability – 1,2,3 – for standards that have poor coverage of FOPs.
These are unlikely to be adaptable to meet future needs but may contain some useful information to inform elements of short course and CPD provision. This can be assessed using the data visualisation tools.

FOP findings compared with current standards

Using the approach described above and applying the 'RAG' scores to each FOP indicating the suitability of current occupational standards selected from the IfATE set, the following table begins to identify areas of action and concern for the provision of future skills for each Supply Chain Partner to respond to the Challenge.

Using Site Operator as an example, all three role families are represented, and from looking at the data extracted we can identify that there is good coverage of Future Occupations in the roles of Maintenance Technician based on the current IfATE standards.

As expected, the IfATE standards provision is stronger for the Operator/ Technician role groups than for Engineer/ Senior Engineer, and this is reflected in the suitability findings for Design Specialists.

Supply Chain Partner - Site Operator

Role Family	Selected Future Occupational Profiles	Current Suitability Summary
Operator / Technician	Maintenance Technician	
	Operations Technician	
Engineer	Revised - Project Engineer	
	Process Engineer	
Senior Engineer	Senior Safety Engineer	
	Senior Engineer – H2 Storage Systems	

Detailed breakdown:

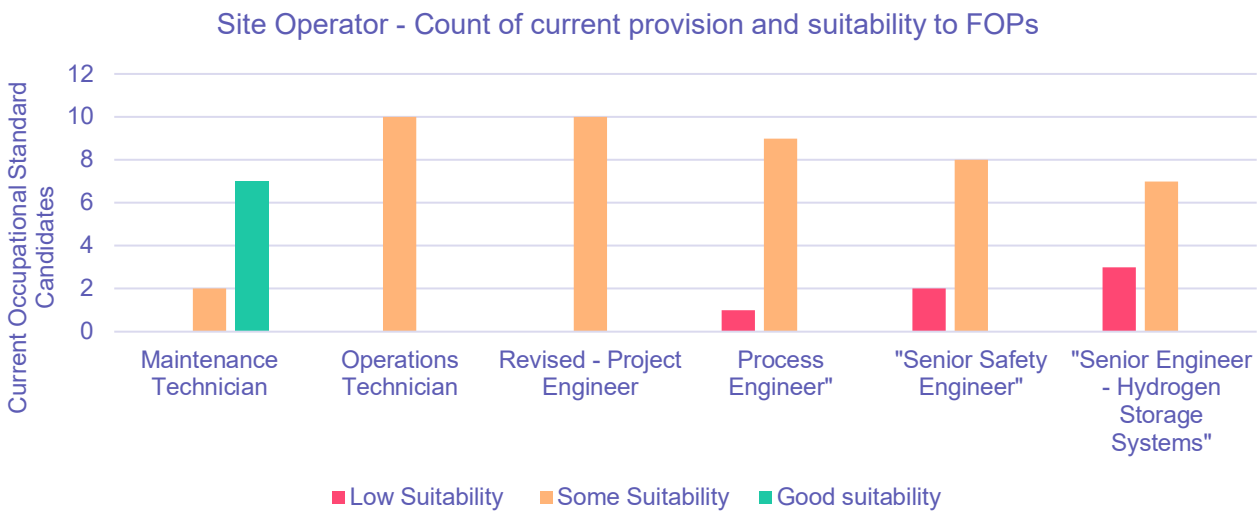


Figure 14: Site Operator - Count of current provision (IfATE Standards) and suitability to FOPs

Supply Chain Partner - Design Specialist

Role Family	Selected Future Occupational Profiles	Current Suitability Summary
Operator / Technician	Industrial Control Systems Technician	
Engineer	Design Engineer	
Senior Engineer	Revised - Senior Design Engineer	

Detailed breakdown:

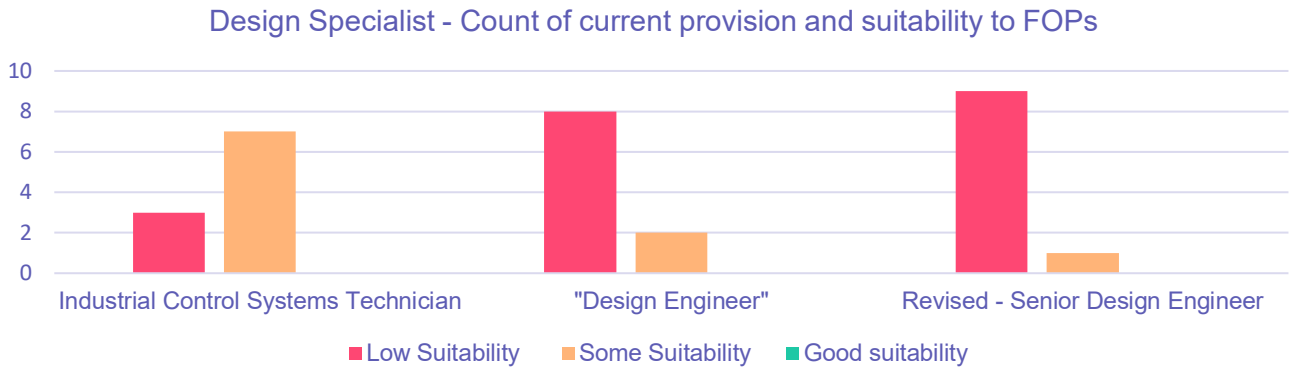


Figure 15: Design Specialist - Count of current provision (IfATE Standards) and suitability to FOPs

Supply Chain Partner - Sub-systems Specialist

Role Family	Selected Future Occupational Profiles	Current Suitability Summary
Operator / Technician	Safety Technician	
	Compliance and Risk Management Specialist	
	Operator/Technician	
Engineer	Revised - Safety Specialist	
	"Risk and Compliance Engineer"	
	Revised – H2 Storage Systems Project Engineer	
Senior Engineer	"Senior Engineer - Quality and Risk Management"	
	Revised - Senior H2 Storage Project Engineer	

Detailed breakdown:

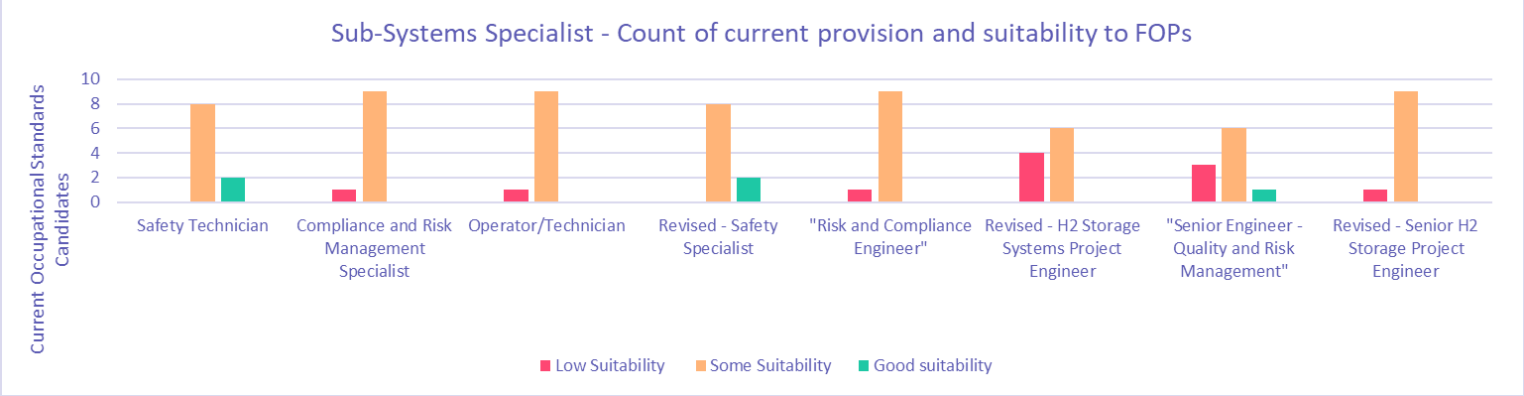


Figure 16: Sub-Systems Specialist - Count of current provision (IfATE Standards) and suitability to FOPs

Supply Chain Partner - Install and Commissioning

Role Family	Selected Future Occupational Profiles	Current Suitability Summary
Senior Engineer	Senior Engineer – Environmental Remediation Projects	
	Senior Engineer - Cryogenic Systems	

Detailed breakdown:

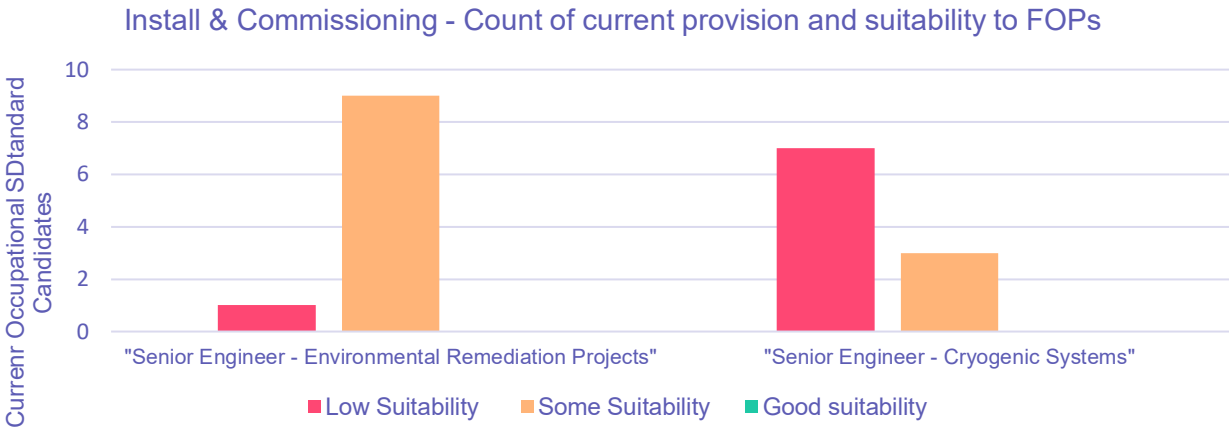


Figure 17: Install & Commissioning - Count of current provision (IfATE Standards) and suitability to FOPs

Supply Chain Partner - Maintenance and Operation

Role Family	Selected Future Occupational Profiles	Current Suitability Summary
Engineer	Operations Engineer	
	Revised - Support and Operations Engineer	
	Revised Installation and Commissioning Engineer	
Senior Engineer	Revised - Senior Operations Engineer	

Detailed breakdown:

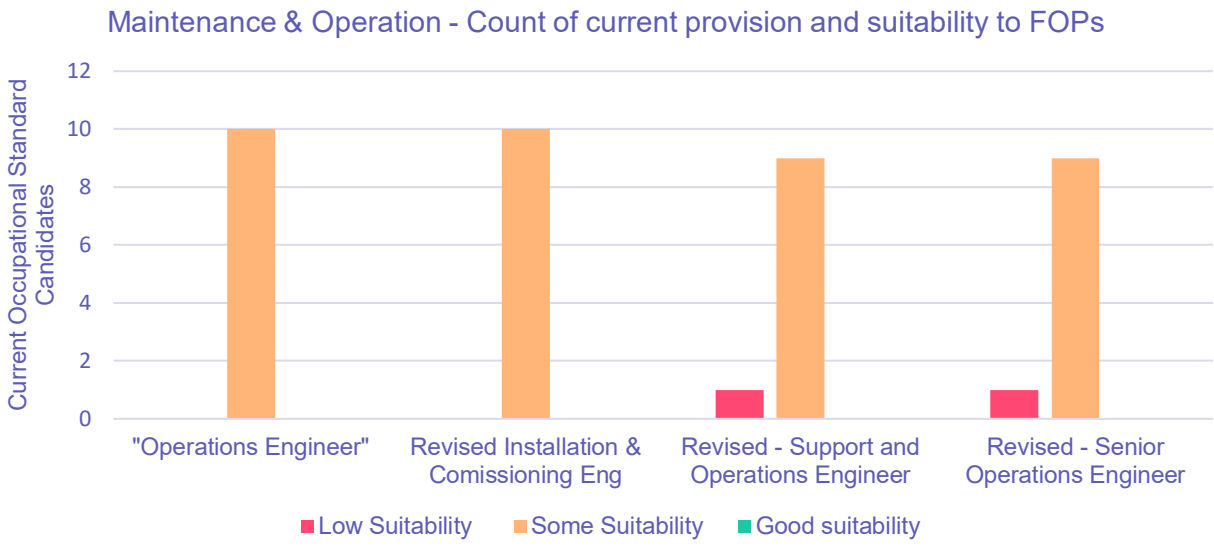


Figure 18: Maintenance & Operation - Count of current provision (IfATE Standards) and suitability to FOPs

3.4 Summary of findings

The below table counts the number of IfATE standards by Suitability score for each FOP.

Role Family	Primary Supply Chain / Workflow Partner	Future Occupation Profiles	Low Suitability	Some Suitability	Good Suitability	Overall Suitability RAG
Operator / Technician	1. Site Operator	Maintenance Technician	0	2	7	
Operator / Technician	1. Site Operator	Operations Technician	0	10	0	
Engineer	1. Site Operator	Revised - Project Engineer	0	10	0	
Engineer	1. Site Operator	Process Engineer	1	9	0	
Senior Engineer	1. Site Operator	Senior Safety Engineer	2	8	0	
Senior Engineer	1. Site Operator	Senior Engineer - Hydrogen Storage Systems	3	7	0	
Operator / Technician	2. Design Specialists	Industrial Control Systems Technician	3	7	0	
Engineer	2. Design Specialists	Design Engineer	8	2	0	
Senior Engineer	2. Design Specialists	Revised - Senior Design Engineer	9	1	0	
Operator / Technician	3. Sub-system Specialists	Safety Technician	0	8	2	
Engineer	3. Sub-system Specialists	Revised - Safety Specialist	0	8	2	
Senior Engineer	3. Sub-system Specialists	Senior Engineer - Quality and Risk Management	3	6	1	
Operator / Technician	3. Sub-system Specialists	Compliance and Risk Management Specialist	1	9	0	
Operator / Technician	3. Sub-system Specialists	Operator/Technician	1	9	0	
Engineer	3. Sub-system Specialists	Risk and Compliance Engineer	1	9	0	
Senior Engineer	3. Sub-system Specialists	Revised - Senior H2 Storage Project Engineer	1	9	0	
Engineer	3. Sub-system Specialists	Revised - H2 Storage Systems Project Engineer	4	6	0	
Senior Engineer	4. Installation and Commissioning	Senior Engineer - Environmental Remediation Projects	1	9	0	
Senior Engineer	4. Installation and Commissioning	Senior Engineer - Cryogenic Systems	7	3	0	
Engineer	5. Maintenance and Operation	Operations Engineer	0	10	0	
Engineer	5. Maintenance and Operation	Revised Installation and Commissioning Eng	0	10	0	
Engineer	5. Maintenance and Operation	Revised - Support and Operations Engineer	1	9	0	
Senior Engineer	5. Maintenance and Operation	Revised - Senior Operations Engineer	1	9	0	

Top Fits

From a FOP perspective and utilising the suitability grid we can determine which of the groups of current occupational standards are more applicate than others.

The FOPs with a good suitability score resulting from their comparison with current IfATE standards and provision are:

1. Maintenance Technician
2. Safety Technician
3. Revised Safety Specialist
4. Senior Engineer - Quality and Risk Management

Suitable standards are listed in the table below:

Role Family	Future Occupation Profiles	IfATE Apprenticeship Standard	Suitability
Operator / Technician	Maintenance Technician	Property maintenance operative	
Operator / Technician	Maintenance Technician	Water industry network technician	
Operator / Technician	Maintenance Technician	Maintenance and operations engineering technician	
Operator / Technician	Maintenance Technician	Utilities engineering technician	
Operator / Technician	Maintenance Technician	Food and drink maintenance engineer	
Operator / Technician	Maintenance Technician	Aircraft maintenance technician	
Operator / Technician	Maintenance Technician	Multi-skilled mechatronics maintenance technician	
Operator / Technician	Safety Technician	High speed rail and infrastructure technician	
Operator / Technician	Safety Technician	Cellular network field engineer	
Engineer	Revised - Safety Specialist	High speed rail and infrastructure technician	
Engineer	Revised - Safety Specialist	Aircraft certifying technician	
Senior Engineer	"Senior Engineer - Quality and Risk Management"	Risk and safety management professional (degree)	

This is a wide-ranging field so use of the data visualisation tool is recommended to access the next layer of detail and review the specific standards that have been identified as having Good Suitability / Some Suitability or Low Suitability.

As a comparison we can also list the standards that score lowest against the required FOPs. This suggests that little suitability in the IfATE standards to support these Future Role Profiles.

FOPs with the lowest scores are:

- Compliance and Risk Management Specialist
- Industrial Control Systems Technician
- Process Engineer
- Design Engineer
- Revised - H2 Storage Systems Project Engineer
- Senior Safety Engineer
- Senior Engineer - Environmental Remediation Projects
- Senior Engineer - Hydrogen Storage Systems
- Senior Engineer - Cryogenic Systems
- Revised - Senior Design Engineer
- Senior Engineer - Quality and Risk Management

Visualisation Instructions

Detailed instructions with illustrations can be found in the appendix.

Visualisation Data Link	What is it and what can it be used for?
P-FOP Detail	This page allows you to review a specific Occupational Profile, including the capabilities contained within it and the Knowledge, Skills & Behaviour (KSB) tags associated with the capability. You can select an individual Role Family and linked P-FOP in the two available drop-downs. The table in the lower section of the page will then be populated with all relevant capabilities. The search control above the table allows you to filter content of any of the columns of data. A key piece of functionality in this table is the presence of the KSB tags associated with the capabilities.
Future KSBs Summary	This page provides a view of the complete set of capabilities within the cycle along with all of the associated KSB tags which are linked to them. It is, essentially, the superset of all details displayed on the P-FOP detail page. This is used to: • review the identified Knowledge, Skill and Behaviour tags for a given capability, to support development of future education and learning material. • review the requirements from a capability level, rather than a role family/occupational profile grouping.
P-FOP Distribution	This page allows provides a breakdown of the Capabilities within the selected Cycle and how they are distributed across the P-FOPs with the addition of a distribution chart showing the required proficiency across those P-FOPs. Clicking the “View P-FOPs” button alongside each capability will provide a list of the proficiencies (EPA) with the P-FOPs that fall into them. The exported version of this data will include a full breakdown of the FOP IDs which contain the capability within a specific proficiency. This is used to: • understand the levels/volumes of common/crossover Capabilities, to support prioritisation of Capability Development. • identify which Occupational Profiles contain these common/crossover capabilities, and so which may be prioritised for development activity.
Capabilities matched to Current Provision	This page allows you to review and compare individual capabilities against ‘Duty’ statements in an Apprenticeship / Occupational Standard. You can select individual capabilities to review their specific matches. These matches are shown in the bottom panel, including the Standard, the Level and the Duty Statement this is matched to. You can filter in several ways to focus your review: • by the Capability Classification Framework (left-hand panel). • by capabilities that **are** served by the reference mapping framework – the default is Institute for Apprenticeships and Technical Education (IfATE) provision. • by capabilities that **are not** served by the reference mapping framework, e.g., IfATE provision – these are capabilities required in the future that may require new/bespoke training and CPD materials to be developed to upskill/re-skill the workforce.

	This page can be used to identify where existing provision may exist across the broad spectrum of Occupational Standards, and not just within a narrow range of sector-specific Standards. The data also allows you to identify where provision may already exist to support specific capabilities.
Fit and Surplus Factors	This page allows you to review the 'Fit' and 'Surplus' of Prototype Future Occupation Profiles (P-FOP) against existing training provision e.g. Institute for Apprenticeships and Technical Education (IfATE). It is possible for the 'Fit' and 'Surplus' comparison to total over 100%, as they are two separate calculations based on a two-way comparison.
Fit and Surplus Matrix	This page is a visual representation of the 'Fit and Surplus Factor' insight. You can visually review 'Fit' and 'Surplus' of Prototype Future Occupation Profiles (P-FOP) against existing training provision e.g. Institute for Apprenticeships and Technical Education (IfATE). This can help you identify which provision may align strongest, or which may require adaptation, to provide the suitable provision fit for each future role. It will help you focus in on which provision to focus your attention for analysis.
P-FOP Capability Matches	This page allows you to view the matches between Capabilities and Institute for Apprenticeships and Technical Education (IfATE) Duty Statements. Clicking the arrow next to a number in the 'Matches' column will open a popup with more detail for each Capability. Each capability also includes Knowledge, Skill and Behaviour tags, to support with scaffolding future education provision. You can review individual Prototype Future Occupational Profiles (P-FOPs) or review all P-FOPs under a Role Family, to give a more holistic view of Capabilities and Matches. Where a future capability has been matched to existing provision (currently, by default, IfATE apprenticeship standards) it is possible to interrogate the data and identify specific statements in standards that align to enable identification of existing training materials and activities that could be used or adapted to meet future requirements. This can be used to review the capability requirements for Role Families and P-FOPs, from Job / Occupation level through to Knowledge, Skills and Behaviour level.

4.0
Recommendations

4.0 Recommendations

4.1 Use of the findings

Naturally some FOPs (Future Occupational Profiles) are generic, while others are tailored to the hydrogen challenge and storage tank technologies. Employers should communicate specific role requirements to educators for targeted training. This report's data and visualisations will aid in this process.

Real-world jobs may blend multiple occupational profiles, and courses can adapt to cover various profiles. FOPs offer a framework for designing future roles and guiding course development.

Few existing standards directly address skills for hydrogen storage tanks. Two IfATE standards, Property Maintenance Operative (ST 0171) and Construction Assembly and Installation Operative (ST0265), show potential. Property Maintenance Operative could be a candidate for standard revision, while Construction Assembly and Installation Operative might better serve as a source for CPD modules due to its surplus factor.

In summary, FOPs can be used to:

- Highlight where roles related to a current occupational standard require updating. For incumbent or transferring workers this could be met by short course and CPD events
- Influence and inform changes to occupational standards used to define the education and training of new entrants to the future workforce.

The adoption of the following recommendations is critical to ensure the solutions to the Challenge can be delivered. The Hydrogen Skills Alliance will work to provide a framework to highlight the different knowledge, skills and behaviours required by future occupations and identify as well as pursue the actions required to deliver those.

4.2 Summary of Findings

The Future Occupational Profiles are the major output of the process and are used to evaluate the need for action. Further work to adapt combinations of FOPs to better fit emerging roles is anticipated as employers plan for future needs. Findings are categorised by supply chain partners to focus on core role requirements of each.

Organisational change

Supply Chain Partner	Core Role Requirements
1. Site Operator	• Meet safety requirements for hydrogen cryogenic tank systems, analyse inventory levels to identify risks and develop mitigation strategies alongside applying natural language processing techniques for compliance monitoring. • Collaborate with suppliers for specialised equipment maintenance, conduct risk assessments, and provide employee training on risk management practices. • Implement IoT sensors, using industry best practices for safety standards and risk assessment frameworks, and integrate predictive maintenance systems using IoT technology are important measures. • Explore advanced technologies like drones and AI for safety inspections, surveillance, and maintenance, stay updated on regulatory trends, and utilise data analytics are also key to ensure efficient and effective operation of hydrogen storage tanks.
2. Design Specialists	• Meet the requirements for hydrogen cryogenic tank systems, adapt safety protocols and analyse inventory levels to identify risks and develop mitigation strategies. • Utilise natural language processing techniques which can enhance compliance monitoring accuracy and efficiency. • Repairs, calibration, and maintenance must be conducted as specified, with tools and equipment cleaned post-use to prevent contamination, and collaboration with suppliers for specialised services. • Commission equipment and regular training on risk management practices. • Thorough risk assessments, IoT technology integration, and collaboration with renewable energy consultants are necessary steps, along with comprehensive maintenance training programs and quality control measures. • Implement real-time monitoring systems, utilise advanced technologies like drones and blockchain, and stay informed about regulatory trends and new technologies which are crucial for maintaining compliance, efficiency, and safety.
3. Sub-system Specialists	• Adapt safety protocols for hydrogen cryogenic tank systems, analyse inventory levels, develop mitigation strategies, and use natural language processing techniques for compliance monitoring. • Ensure repairs, calibration, and maintenance are carried out, along with cleaning tools and equipment.

	• Collaborate with suppliers, manufacturers, and renewable energy consultants who can provide specialised services, training, and sustainable solutions. • Safety inspections, risk assessments, and equipment monitoring using AI, thermography, and IoT technology are key to identify failures and ensure regulatory compliance. • Implement maintenance training and assessment programs, compliance management software, and industry best practices are essential for maintaining safety standards. • Utilise IoT sensors, robotics, artificial intellence, and cloud platforms to monitor, maintain, and optimise hydrogen storage operations can enhance efficiency and safety.
4. Installation and Commissioning	• In order to meet the requirements for hydrogen cryogenic tank systems, current safety protocols need to be adapted by analysing inventory levels and developing mitigation strategies. • Natural language processing techniques can improve compliance monitoring accuracy, while repairs, calibration, and maintenance should be carried out as specified. • Collaborate with suppliers and manufacturers for specialised services, commission equipment, and regular training sessions for employees on risk management practices. • Safety inspections using artificial intelligence image recognition software and thermography could identify potential equipment failures, while risk assessments should be conducted using industry frameworks and methodologies. • Collaborate with renewable energy consultants to integrate sustainable energy solutions into construction projects, and IoT technology could be used to monitor and control hydrogen storage tank operations. • Develop and implement risk assessment frameworks, quality control measures, safety procedures for workers, and competency management systems ensure safety and compliance, along with utilising emerging technologies like drones and robots for inspections and surveillance.
5. Maintenance and Operation	• Manage hydrogen cryogenic tank systems, safety protocols must be adapted, inventory levels analysed, and mitigation strategies developed. • Implementing natural language processing techniques for compliance monitoring, collaborate with suppliers for specialised equipment services, and commission pneumatic/vacuum equipment. • Training on risk management, safety inspections using AI image recognition software, and implement IoT technology for monitoring operations. • Develop maintenance training programs, risk assessment frameworks, and quality control measures, as well as incorporating emerging technologies like drones and robots for safety inspections and surveillance. • Ensuring compliance, maintenance, and technological advancement.

6. Regulatory Authority	• Meet the requirements for hydrogen cryogenic tank systems, it is crucial to adapt current safety protocols and analyse inventory levels to identify potential risks and develop mitigation strategies. • Utilise natural language processing techniques for compliance monitoring and carry out repairs, calibration, and maintenance as specified. • Collaborate with suppliers and manufacturers for specialised equipment repair, commission installed equipment, and conduct safety inspections using AI image recognition software. • Configure equipment with IoT technology for monitoring hydrogen storage tank operations, coordinate with renewable energy consultants, and implement a risk assessment framework using compliance management software. • Utilise data visualisation tools, AI, machine learning, and IoT sensors for real-time monitoring and control. • Implement safety procedures, maintenance schedules, and quality control measures, stay informed about regulatory trends.

From these findings we can assist understanding of how the supply chain organisations' workforce structure needs to change to deliver the required capabilities, Initial examples provided below, for further information see the Appendices 5.6 Supply Chain Capabilities.

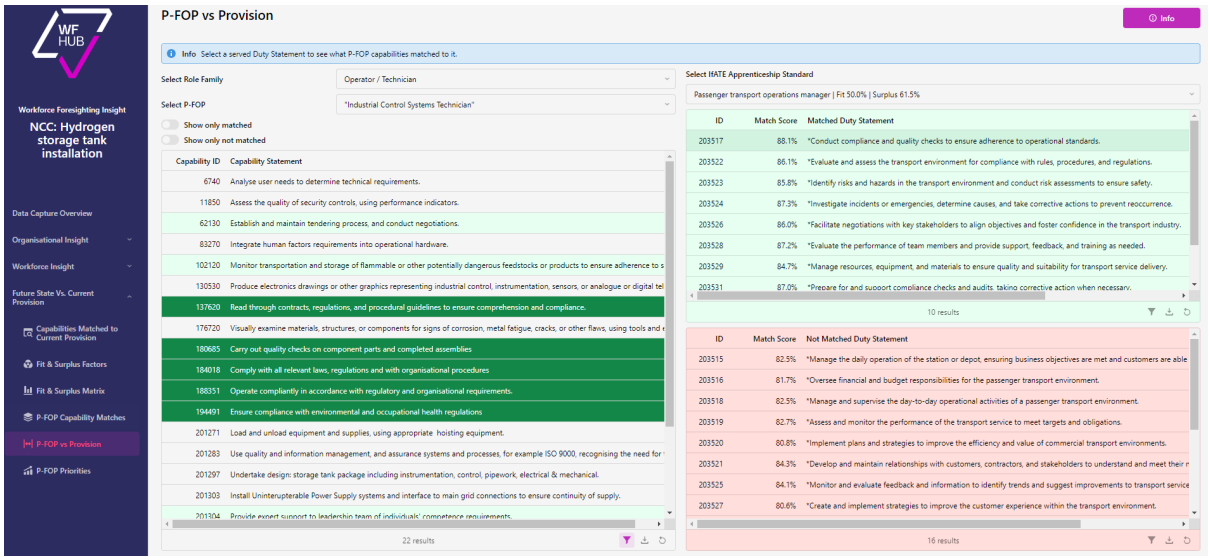
Occupational Change

Supply Chain Partner	Example of required change to deliver capabilities
1. Site Operator	Manage operations by coordinating and overseeing all activities to ensure efficient and effective operation of hydrogen storage tanks.
2. Design Specialists	Review designs for materials requirements and feed through to technical research.
3. Sub System Specialists	Conduct repairs, calibration, and maintenance of specialised equipment for hydrogen storage tank systems as specified by manufacturers.
4. Installation and Commissioning	Skill in utilising blockchain technology for transparent tracking and auditing of maintenance records.
5. Maintenance and Operation	Complete review to ensure only suitably qualified and competent persons are appointed and those persons maintain their professional currency (this applies to both permanent and contract hires). Maintain appropriate competency management system (including CPD).

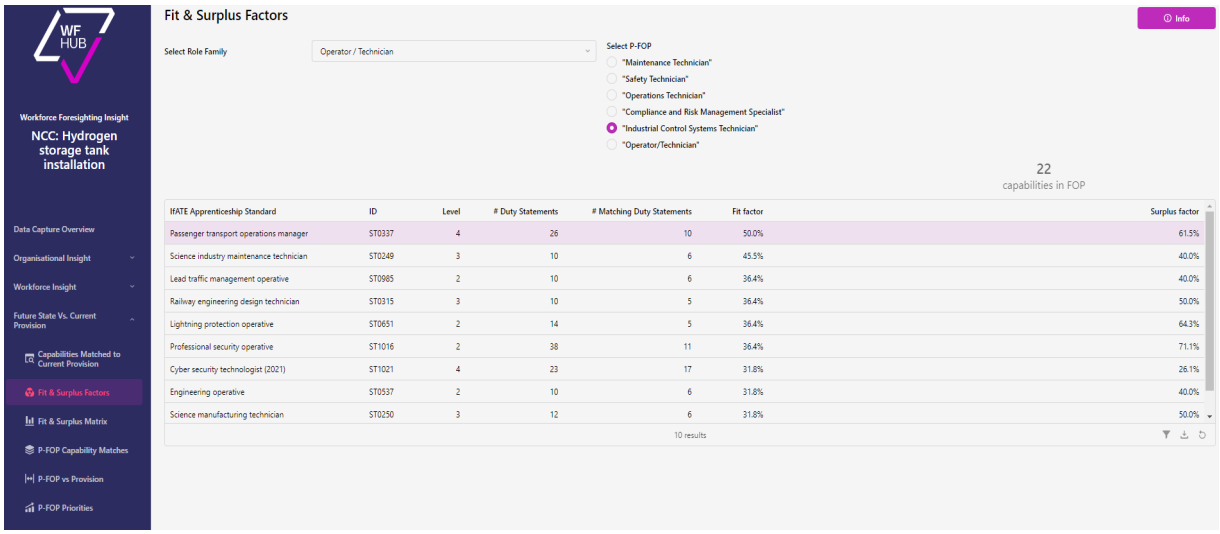
The capabilities that make up the Future Occupational Profiles can be reviewed in the FOP vs Provision tab in the visualisation.

Worked Example

In this example the FOP is preselected as **Industrial Control Systems Technician** – this view enables the capabilities matched / not matched by the IfATE standards to be reviewed.



The Fit & Surplus Factors view (illustrated below) shows the fit and surplus factor against the matched standards to the to the future required capability.



This enables the convening partner to identify where the gaps in the training provision are, and through utilising organisations like the Hydrogen Skills Alliance to identify the shape of the demand from industry.

This could then support the potential requirement for new CPD courses curation.

The FOPs (Future Occupational Profiles) not only require the capabilities to be understood but also the Knowledge Skills and Behaviours required by the future workforce.

Therefore, the training and education provision needs to change delivery of these Knowledge, Skills and Behaviours.

Knowledge, Skills and Behaviours

KBS's	Summary of the Changes
Knowledge	To achieve the necessary knowledge bases for the inspection and testing of tanks in material testing, training and education providers need to revamp their existing programs to cover all the essential topics mentioned above. This might involve updating their curriculum to include courses on Visual Tank Testing, End of Life, and Tank Inspection, as well as other relevant subjects necessary for regulatory compliance and effective project management. Additionally, training providers should consider offering specialised courses or certifications in areas such as bid writing, systems monitoring, grid connections, and buyer knowledge to ensure that individuals have the necessary skills to effectively manage tank installation projects from start to finish. Furthermore, training providers should also focus on hands-on practical training and engagement with industry professionals to ensure that students have real-world experience and are prepared to tackle the challenges they may encounter in the field. Overall, by adapting their programs to include these crucial knowledge bases and ensuring that students are well-equipped to handle all aspects of tank installation and management, training and education providers can help promote safety, efficiency, and compliance in the hydrogen storage industry.
Skills	Training and education providers need to adapt to the rapidly evolving field of AI and machine learning by offering specialised courses and programs that focus on the skills and knowledge required for developing these technologies. This includes courses on digital twins, IoT/Industry 4.0 systems, predictive data analysis, hazard prediction and prevention, and machine learning algorithms. Providers should also offer hands-on training and practical experience opportunities to students, allowing them to apply their knowledge in real-world scenarios. Collaboration with industry partners and businesses can also help ensure that students are learning the most up-to-date and relevant skills. Moreover, training and education providers should stay current with the latest advancements in AI and machine learning technologies, updating their curriculum and adapting their programs accordingly. This may involve incorporating new tools, technologies, and best practices into their courses to ensure that students are prepared for the demands of the industry. Overall, training and education providers need to be proactive in responding to the changing landscape of AI and machine learning, providing students with the skills and knowledge they need to succeed in this rapidly growing field.
Behaviours	To achieve these desired behaviours in individuals, training and education providers need to revamp their programs to focus more heavily on developing skills in risk assessment, problem-solving, mathematical and data-driven methods, and leadership in health and safety culture

	promotion. They should incorporate practical scenarios and case studies that allow individuals to practice these skills in real-world situations. Furthermore, training and education providers should emphasise the importance of collaboration, innovation, and compliance in their programs, encouraging individuals to work effectively with others, think outside the box to improve processes, and adhere strictly to regulations. This can be achieved through group projects, simulations, and workshops that challenge individuals to apply their knowledge and skills in a team setting. Moreover, training and education providers should also prioritise personal accountability and transparency in their programs, teaching individuals the importance of taking responsibility for their actions and promoting a culture of honesty and openness in the workplace. They can do this through ethics training, communication skills development, and discussions on the impact of safety breaches and non-compliance. Overall, by updating their curricula and teaching methods to focus on these key behaviours and traits, training and education providers can better prepare individuals to excel in their roles with a logical, methodical, and health and safety-focused approach.

Future State vs Current State

750 IfATE standards across all 6 academic levels were used for comparison with the derived FOPs.

Educators can use the Suitability Grid and visualisation tools to find relevant IfATE standards for further examination. While this does not automatically create requirement statements or a fully defined curriculum, it does helps educators work more efficiently, by accessing clear and consistent skills data, aligned with employers' actual future needs.

Sponsor Comment

The IfATE standards identified in the table below are the ones the sponsor has reviewed and recommends being most relevant and which should have the most impact if amended to align with future demand.

This sponsor's perspective is a further refinement to guide educators towards appropriate source occupational standards. As well as the sponsor's preference, immediate alternatives are highlighted.

The **Revised Project Engineer** role has a 'Low Suitability' fit with the Material Process Engineer standard. Industry can use this report as evidence to drive change such as developing a new standard.

The 'Call to Action' for educators is to look at what else is available.

An example could be the Operations Technician - IfATE Standard typically used is the Maintenance and Operations Engineering Technician Standard.

However, there is a benefit to reviewing and potentially utilising the Building Services Engineering Service and Maintenance Engineer IfATE standard as this may reduce the anticipated skills gap.

As a general comment, the current project management skills gap lies in technology integration, leaving a significant skills need in managing projects within existing or new facilities. Tackling the challenge of change management could become crucial in addressing this gap.

Visualisation Instructions

Detailed instructions can be found in the appendix.

Visualisation Data Link	What is it and what can it be used for?
Fit and Surplus Revised Project Engineer	This page allows you to review the 'Fit' and 'Surplus' of the Revised Project Engineer Profile against existing training provision e.g. Institute for Apprenticeships and Technical Education (IfATE).

For the Revised Project engineer the areas for educators to focus on are:

For the Revised Project Engineer, educators should emphasise understanding the properties of hydrogen and its behaviour when stored cryogenically at low temperatures. Site operators currently face significant gaps regarding project engineers working on-site.

The focus should also extend to design specialists. Where these specialists come from and how their knowledge can be interconnected. It's essential to understand whether it is the lack of input from required design engineers in the foresighting cycle highlighting this issue, or if there is a wider shortage of design engineers.

Future Occupational Profile versus Provision

Primary Supply Chain	Proposed FOP	Sponsor preference - IfATE (Institute for Apprenticeships and Technical Education) Apprenticeship Standard	Suitability Grid Rating and Commentary
Site Operator	Maintenance Technician	Maintenance and Operations Engineering Technician (ST0154) Fit 76.0% Surplus 10.0%	9 - Good rating, potential candidate for Occupational Change
	Operations Technician	Maintenance and Operations Engineering Technician (ST0154) Fit 61.5% Surplus 20.0%	6 - There is a benefit to reviewing and utilising this information – potential for CPD unit development. Other IfATE Standards could also be reviewed such as Building Services Engineering Service and Maintenance Engineer ***Potential New Standard to be reviewed in relation to this FOP - Bulk Storage Terminal Technician – This new Apprenticeship standard is with IfATE for approval. Within this standard focuses on Transitional Fuels.***
	Revised – Project Engineer	Materials Process Engineer (degree) (ST0659) Fit 44.4% Surplus 70.6%	2 - Foresighting cycle has identified a review is required by educators as this is a role that is not fulfilled by the IfATE standard it is matched to.
Design Specialists	Industrial Control Systems Specialist	Science Manufacturing Technician (ST0250) Fit 31.8% Surplus 50.0%	3 - Review required by educators to see if there is a better fit for this proposed FOP. The Science Industry Maintenance Technician (with a suitability score of 4) to be reviewed to see what could be extracted for CPD development.
Sub System Specialist	Compliance and Risk Management Specialist	Regulatory Compliance Officer (ST0430) Fit 55.6% Surplus 50.0%	4 - There is a benefit to reviewing and utilising this information – potential for CPD unit development – other Standards that might provide relevant information for CPD development could be Security First Line manager, or Cyber Security Technologist (2021).
	Safety Technician	Safety, Health and Environment Technician (ST0550) Fit 65.4% Surplus 10.0%	6 - We can see that there is a benefit to reviewing and utilising this information – potential for CPD unit development. Educators can also review other standards identified such as High-Speed rail and infrastructure technician standards.

Primary Supply Chain	Proposed FOP	Sponsor preference - IfATE (Institute for Apprenticeships and Technical Education) Apprenticeship Standard	Suitability Grid Rating and Commentary
Sub system specialist	Revised - H2 Storage Systems Project Engineer	Materials Process Engineer (degree) (ST0659) Fit 28.6% Surplus 70.6%	1 - Further review required by the other educators to see if there is a better fit for review. An example of this could be the Lead Engineering maintenance technician.
	Risk and Compliance Engineer	Risk and safety management professional (degree) (ST0465) Fit 48.0% Surplus 10.0%	6 - We can see that there is a benefit to reviewing and utilising this information – potential for CPD unit development Educators may also benefit from reviewing Senior compliance and risk specialist
	Senior Engineer - Quality and Risk Management	Risk and safety management professional (degree) (ST0465) Fit 66.7% Surplus 30.0%	9 - Good preference – Potential candidate for Occupational Change. Another Standard worth a review would be the Senior Compliance and risk specialist

Visualisation Instructions

Detailed instructions can be found in the appendix.

Visualisation Data Link	What is it and what can it be used for?
P-FOP vs Provision	This page allows you to compare P-FOPs against existing IfATE Standards. The information here allows you to prioritise effort or action over the short, medium or long-term. This is displayed as a Matched/Not Matched Capability, comparing the Capability in a P-FOP to the Duties in a Standard. The left-hand side allows you to select the Role Family and P-FOP, while the right-hand modal allows you to compare against the top 10 matched IfATE Standards for that Occupational Profile. Where a future capability has been matched to existing provision (currently, by default, IfATE apprenticeship standards) it is possible to interrogate the data and identify specific statements in standards that align to enable identification of existing training materials and activities that could be used or adapted to meet future requirements.
P-FOP Priorities	This page provides a list of all the P-FOPs within the selected cycle with details of their fit and surplus factors. The information here allows you to prioritise effort or action over the short, medium or long-term.

4.3 Recommended next steps

These recommendations highlight the short and mid-term actions needed by employees and educators. Collaboration is essential to ensure future skills are available for implementing innovative technologies to address identified challenges.

A potential shortage of skilled technicians, engineers, and senior engineers could significantly hinder the UK's ambition to advance towards using hydrogen as a zero-carbon fuel source, a core focus of government policy and strategy.

The findings in section 3 have been through a review by those involved in the process, and the data acquisition and analysis were quality assured during the workshops this has led to the following insights and recommendations.

A. Dissemination of Findings

Convener and sponsor to set up “Cause Action” working group to take the findings and recommendations and create an action plan and advance through the Skills Value Chain. It is essential to share the findings widely among stakeholders, industry groups, and local skills bodies. This will promote access to the insights gained and influence the strategic direction of workforce development initiatives.

These findings indicate where there are likely to be future gaps in skills which, if not addressed, will cause delays in:

Technology development and deployment

- Lack of capacity and capability in the sector will hinder early lifecycle technology design and development work.
- Delays in testing and proving will impede innovative technology uptake in a risk-averse sector.
- Working group led by the HSA to be established to review gaps identified and prioritise in a way that aligns with the emerging skills frameworks.
- Educators to review design figures with technologists.

Scaling-up production

- Scaling up production of innovative technologies requires time.
- Process involves developing at-scale production methodologies, investing in and installing capital equipment, and recruiting and training the workforce.

Project delivery

- Shortage of skilled workers will act as a major supply chain bottleneck.
- Increased costs and future delivery inefficiency.

Current (as listed in Section 2) and future stakeholders in both aspects should be made fully aware of the foresighted gaps and the workforce skills and training actions necessary to mitigate the risk. The sponsor can play a key role in this.

The “Cause Action” working group should engage the Workforce Foresighting Hub Steering Board members to identify scope for departmental support for actions.

What	Dissemination of Findings
Who	NCC, TSA, HSA, Stakeholders, Industry and Sector groups, Government and Regions
When	Following publication
Result	Web hosted reports and traffic

B. Short term actions

The understanding gained from the proposed FOPs enables short-term re-skilling and upskilling of the current workforce, which is crucial for meeting emerging technology demands, particularly in early lifecycle activities like design. As part of the working group, educators can tailor course content to match specific new capabilities with existing provisions found in various occupational standards.

Some roles may see high demand, surpassing opportunities for current workforce development, but there is potential for recruiting individuals with transferrable skills from other industries. For instance, the 'Maintenance and Operations Engineering Technician' FOP presents a viable option, given its versatility across industries. Reskilling recruits with hydrogen storage-specific training, as indicated by the FOPs, offers promising opportunities. Further investigation is needed for the Engineer/Senior Engineer roles, as they appear less aligned with current provisions.

What	Short term action
Who	Educators, Awarding Bodies, Employers (working group)
When	Prepare ahead of scale-up need
Result	Timely availability of short-term training for current workforce

Short term recommendations to cause action.

KSB	Possible next step to cause action
Knowledge	1. Develop a training program for employees on the knowledge bases essential for inspecting and testing tanks in Material Testing, focusing on Visual Tank Testing, End of Life, and Tank Inspection. 2. Implement regular workshops and seminars to update employees on the latest information and best practices in tank inspection and testing. 3. Create a checklist or guide for project managers to ensure they are aware of the timescales for permits, site protocols, emergency plan diagrams, and other important regulatory compliance measures. 4. Establish a communication plan with emergency services, government agencies, site management, and key stakeholders to ensure everyone is informed and prepared for any potential issues. 5. Provide training on bid writing, systems monitoring, grid connections, and buyer knowledge to improve communication and coordination with stakeholders during the installation process.

	6. Encourage collaboration and knowledge sharing among employees to ensure that everyone is up to date on the latest industry standards and regulations. 7. Regularly review and update documentation and procedures related to the installation, maintenance, and management of hydrogen storage tanks to ensure they reflect current best practices and regulations.
Skills	1. Provide training and upskilling opportunities for individuals interested in developing artificial intelligence and machine learning models. This can include workshops, online courses, certification programs, and on-the-job training. 2. Encourage collaboration and knowledge sharing among professionals in the field. This can be done through networking events, conferences, and industry meetups where individuals can exchange ideas, best practices, and lessons learned. 3. Invest in the development of open-source tools and resources that can help streamline the process of developing AI and machine learning models. This can include libraries, frameworks, and platforms that make it easier for individuals to access and use these technologies. 4. Foster partnerships between academic institutions, industry leaders, and government agencies to promote research and innovation in the field of AI and machine learning. By working together, stakeholders can address common challenges, share resources, and drive progress in the industry. 5. Offer incentives and rewards for individuals and organisations that demonstrate excellence in developing AI and machine learning models for safety hazard prevention and risk identification. This can include grants, awards, and recognition programs that highlight innovative solutions and best practices in the field.
Behaviours	1. Provide regular training and education on risk assessment and data-driven problem-solving methods to reinforce and enhance the skills of individuals with a logical, methodical, and health and safety-focused approach. 2. Encourage and support individuals in actively pre-emptively addressing safety concerns and promoting a safety culture through leadership by recognising and rewarding their contributions to safety and efficiency in the workplace. 3. Foster collaboration and effective communication among individuals with a focus on health and safety by establishing regular meetings, workshops, or safety committees to discuss and address safety issues and opportunities for improvement. 4. Implement advanced techniques and tools for risk assessment and problem-solving, such as software programs or data analytics, to enhance the efficiency and effectiveness of safety practices in the workplace. 5. Monitor and ensure compliance with safety and environmental regulations by regularly auditing and reviewing safety protocols,

	procedures, and practices to identify areas for improvement and implement corrective actions accordingly. 6. Encourage personal compliance with safety protocols by providing resources and support for individuals to adhere to safety guidelines and procedures, such as providing proper equipment and training. 7. Promote transparency and accountability in operational activities by encouraging individuals to report safety concerns and incidents, and actively addressing and resolving them in a timely and effective manner. 8. Foster a culture of safety and efficiency in the workplace by recognising and celebrating individuals who consistently prioritise health and safety in their work and actively contribute to the overall safety and success of the organisation.

C. Mid-term actions

Short-term solutions to address incumbent workforce needs are available within one to two years following analysis and preparation. However, formal changes to occupational standards and training programmes for new entrants requires a considerably longer lead time, typically involving years of review, program development, and individual training.

Efforts aimed at the current workforce and those for new entrants should be integrated to meet the same future needs defined by the FOPs, thereby reducing preparation time. The long lead-time for new entrants demonstrates the importance of incorporating future skills training into programmes from the start.

What	Mid-term actions
Who	Educators, Awarding Bodies, Employers (working group)
When	As soon as possible for prioritised FOPs to update current standards
Result	Take up of programmes meeting future skills needs as well as current

Medium-term recommendations to cause action:

KSB's	Possible next step to cause action
Knowledge	1. Develop a long-term training plan for employees to continue building on their knowledge and skills in tank inspection and testing, incorporating advanced topics such as non-destructive testing methods. 2. Create a certification program for employees who complete the training program, to recognise their expertise in tank inspection and testing and provide them with career advancement opportunities. 3. Consider implementing a mentorship program where experienced employees can guide newer employees in gaining practical experience in tank inspection and testing. 4. Conduct regular audits and evaluations of the training program and workshops to ensure they are meeting the needs of employees and are effective in improving their knowledge and skills. 5. Develop a process for tracking and monitoring the implementation of the checklist or guide for project managers, ensuring that they are consistently following regulatory compliance measures and best practices.

	6. Establish a feedback mechanism for employees to provide input on the training programs, workshops, and documentation, to continuously improve and update them as needed.
Skills	1. Establish a long-term strategy for continuous skills development in AI and machine learning. This could involve creating a structured training program with defined career pathways, mentorship opportunities, and ongoing support for individuals to stay updated on the latest technologies and trends. 2. Create a centralised platform or community for professionals in the field to collaborate, share knowledge, and access resources. This could include a dedicated online forum, a repository of best practices, and regular meetups or webinars to facilitate networking and idea exchange. 3. Support the growth of a robust ecosystem of open-source tools and resources by investing in research and development initiatives, funding projects that aim to improve accessibility and usability of AI and machine learning technologies and fostering partnerships with industry organisations and academic institutions. 4. Establish a long-term collaboration framework between academia, industry, and government to drive innovation and research in AI and machine learning. This could involve setting up joint research programs, funding opportunities for cross-sector collaborations, and establishing advisory boards to guide strategic initiatives in the field.
Behaviours	1. Develop a structured training program that includes advanced risk assessment and problem-solving techniques to further enhance the skills of individuals and ensure continuous improvement in safety practices. 2. Establish a formal recognition and rewards program for employees who consistently demonstrate proactive safety behaviours and actively contribute to creating a safety culture within the organisation. 3. Expand on regular meetings and workshops by implementing cross-functional safety committees to encourage collaboration and communication among different departments and ensure a holistic approach to safety management. 4. Invest in technology and software solutions for advanced risk assessment and data analytics to streamline safety practices and provide real-time insights for better decision-making. 5. Develop a comprehensive audit and review process for safety protocols and practices, including implementing corrective actions and continuous improvement initiatives based on the findings. 6. Provide ongoing support and resources for individuals to maintain compliance with safety protocols, such as refresher training, mentorship programs, and access to the latest safety equipment. 7. Enhance reporting mechanisms and response protocols for addressing safety concerns and incidents promptly and effectively, while also establishing a feedback mechanism for continuous improvement. 8. Incorporate safety and efficiency metrics into performance evaluations and organisational goals to further reinforce the importance of safety as a core value within the workplace culture.

D. General action for educators to support employers' demand for future skills

A modular approach to change is feasible within the timescales, compared to re-designing entire courses to meet FOPs requirements.

Educators can help employers determine their training needs by assessing gaps.

- To inform the Hydrogen Skills Alliance framework and collaborate as part of the "Cause Action" working group.
- Short-term CPD: Topics to upskill current workforce members across all role families.
- Medium-term program updates: Topics to integrate into existing occupational standards through review and incorporation.
- Longer-term changes: New qualifications and standards required to prepare new entrants.

For the short term CPD solutions, educators should:

- Review IfATE standards and relevant qualifications for roles described by the FOPs with employers.
- Assess FOPs data against selected standards and qualifications, providing feedback to employers.
- Evaluate existing CPD provision for possible incorporation.
- Commission new CPD courses if none are available.
- Facilitate collaboration to identify core education needs, maintaining a joined-up approach.

E. Identify further workforce foresighting

Further cycles of foresighting solutions that respond to hydrogen challenge should be identified as technology opportunities become clear. Focusing on cryogenics, fuel cells, gas turbines or cavern storage may be some areas of focus for future skills foresighting.

What	Identify further workforce foresighting
Who	Stakeholders – Hydrogen Skills Alliance
When	3 months after publication
Result	Further FOPs and data uncovering new and common skills needs

F. Lessons learnt

- Data in Table 4.1 and section 3 highlights the need for active participation, evidenced by low engagement in technologist sessions.
- Roles identified in this report will also be affected by considerations of other energy carriers in achieving Net Zero.
- Lack of clear government hydrogen policy is a significant issue in the identified hydrogen storage cycle.
- Clear policies are crucial to drive demand for the hydrogen economy in the UK, as highlighted by the foresighting cycle.

5.0 Appendices

5.0 Appendices

Section	Title
5.1	List of participants
5.2	Cycle timeline
5.3	Access to output data - link and authorisation
5.4	Glossary - common language
5.5	Visualisation links and illustrations
5.6	Supply Chain Capabilities

5.1 List of Participants

Industry Participants	Skills Participants	Technology Participants
Business West	Bath University	ATI
CREO	BEIS	CREO
EDF / Hynamics	Catch UK	Energy Institute
Geopura	Cogent	HSE - Health and Safety
GKN	Cranfield University	Executive
Hydrogen UK	Department of Education	HVMC / HII
Langfields	ECITB	IAPPS
Luxfer	Enginuity	Lloyds Register
MOD	EU Skills	OREC
National Composite Centre	IDRIC - Heriot-Watt University	Tutis Energy
Petrofac	Institute of Technology	ZeroArvia
Protium	Lloyds Register	
Rolls Royce	Loughborough Uni	
Shell	Manchester Metropolitan	
Siemens	University	
Stopford	MTC	
Tank Storage	National Composites Centre	
Techodyne	Nottingham University	
Tower Group	OPITO	
Tutisenergy	Reynolds Training Services	
Wessington Cryogenics	South Devon College	
ZeroArvia	Southampton College	
	Strathclyde University	
	The Blair Project	
	University of Bristol	
	University of the West of England	

5.2 Cycle timeline

This cycle started the workshops as part of the Carry Out phase in October 2023. The Carry Out phase concluded in December 2023. This report was prepared following the data validation period and published in May 2024.

5.3 Access to output data - link and authorisation

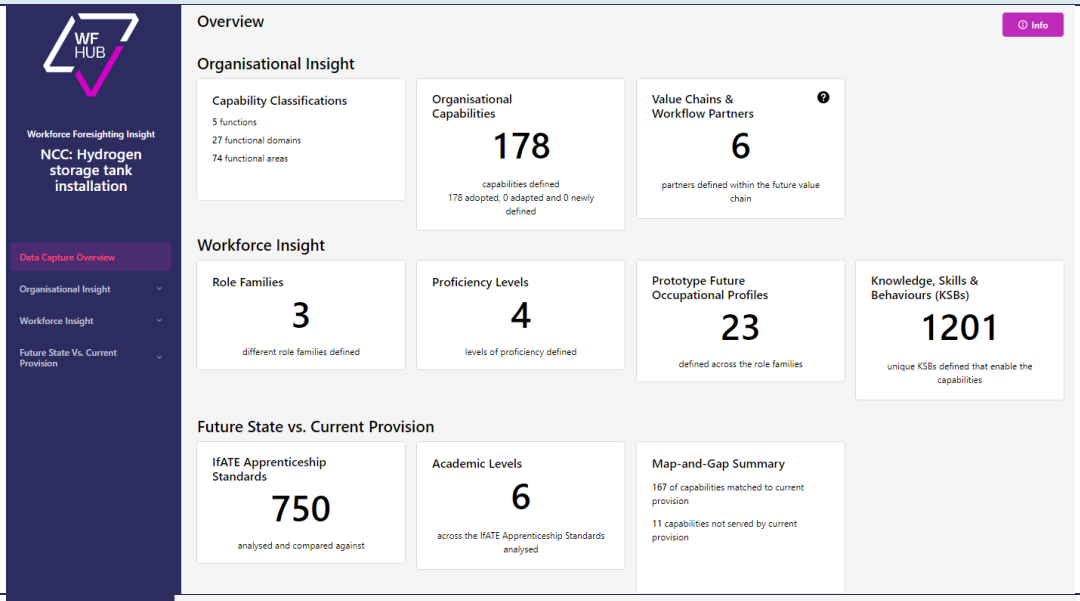
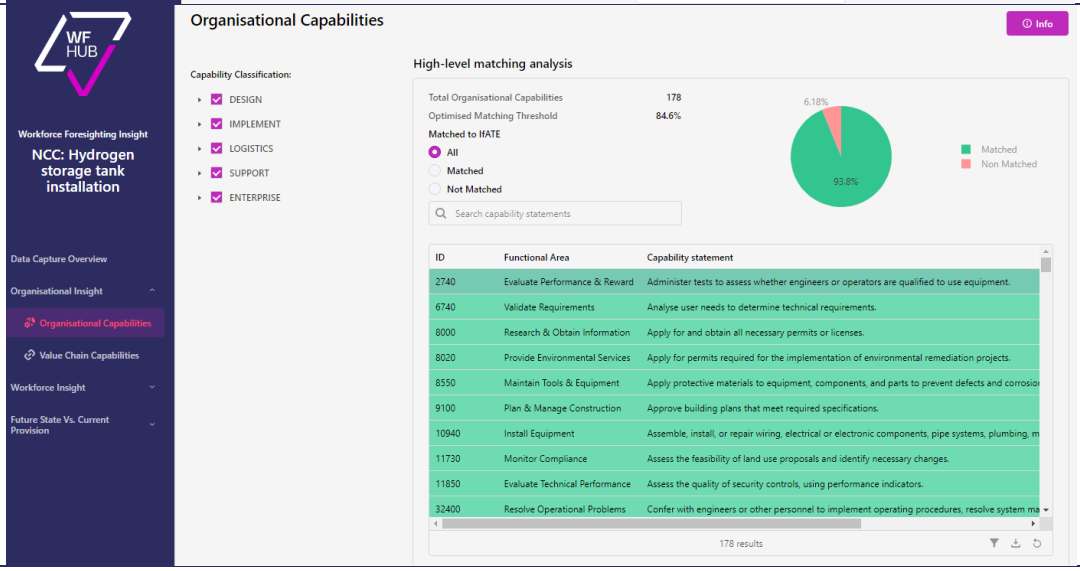
Data Capture Overview | HVMC Foresighting (retool.com)

5.4 Glossary - common language

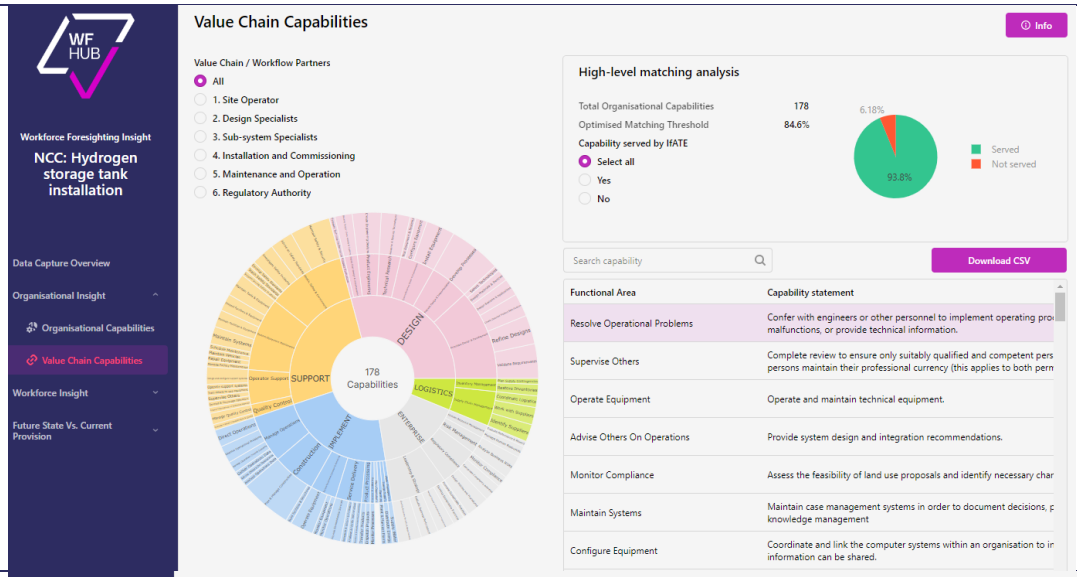
Term	Definition
Impact Domains	Innovate UK domains used as Strategic Categories to assist setting and monitoring priorities
National Challenge (Industry / Sector / Region)	A recognised technological or socio-political threat or opportunity for which there is consensus that workforce action is necessary
Challenge Response	Specific intervention aimed at the challenge
Capability (Organisation)	The collective abilities, and expertise of an organisation to carry out a function, because provision and preparation have been made by the organisation
Capability Classification	Classification provides a common, structured vocabulary to define capability
Capability Statements	Description of the depth and nature of each capability within an organisation
Capability Syntax	Common language to describe each capability application within organisation type
Competencies (Workforce / Individual)	'Proficiency, aptitude, capacity, skill, technique, experience, expertise, facility, fitness related to capability
Competency definition 'KSBs' (Knowledge, Skills and Behaviours)	Knowledge, Skills, and Behaviours are the elements used to express the required competencies for each Role Group
Competency Domain	Used during foresighting analysis to provide focus on existing and emerging competency needs
Delphi Process	Foresighting takes a Delphi approach which has come to represent consulting expert opinion. (Harking back to the Delphic Oracle of ancient Greece)
Foresight Cycle	Set of workshops, analysis and reporting that implements the Foresight Process for each subject
Foresight Process	A series of activities which are convened to understand future competence needs, the opportunities available and actions required to deliver the right skills at the right time and place
Foresighting Champion	An individual nominated within a new user organisation of foresighting to facilitate and lead the use of foresighting processes and tools with the support of the Project Team
Foresighting Subject	The application of specific technologies in the context of a given challenge and which are candidates for foresighting
Future Competency Set	The KBS output from the Educator workshop for each Role Group
Map and Gap Analysis	A combined expert and automated process that maps the Future Competency Set against a selected reference framework
Organisation Type	Simple description of nature of organisation for which capability is required
Proficiencies	Proficiencies differentiate the degree of competencies required from differing Role Groups to support capabilities
Project Sponsor	Typically, a stakeholder in the challenge being successfully met who requires information to under-write plans to act
Role Group	Role groups are a collective of roles that exist in a typical manufacturing business / industrial sector
Syntax	The way in which a statement is phrased to ensure reliable, repeatable and meaningful interpretation

Technologies	The technology that could be used to address the challenge
Working Scenario	To provide further context in relation to the subjects and used to position participants thinking during the detailed identification of future capabilities
Workshops	Online sessions used to undertake each step in the foresight process
Roadmaps	Sector, Industry, Regional view of emerging opportunities and their market entry
Participants	Technologists, Educators, Employers

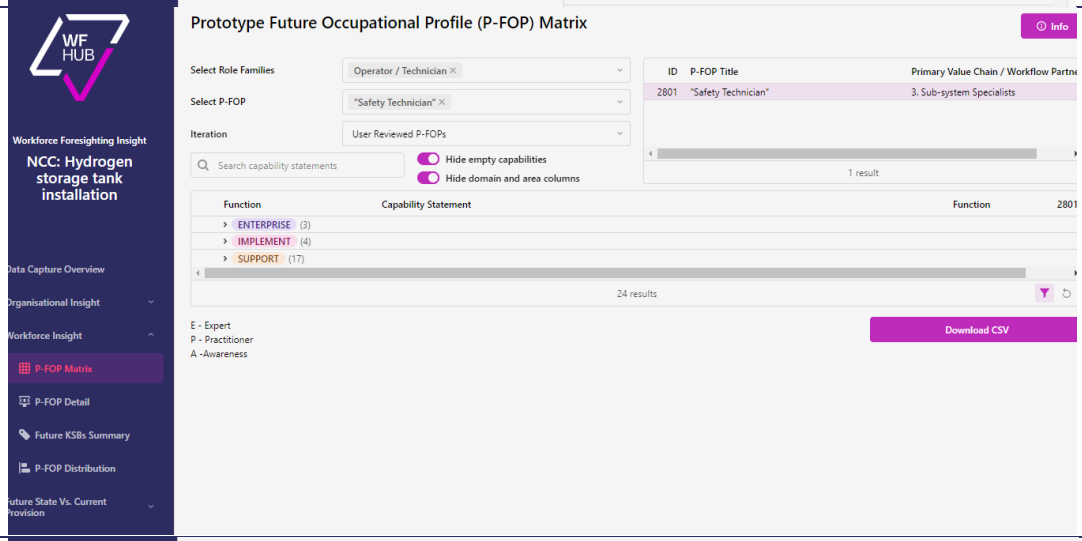
5.5 – Visualisation links and Illustrations

Link to Visualisation	View of data
Data Capture Overview	
Organisational Capabilities	

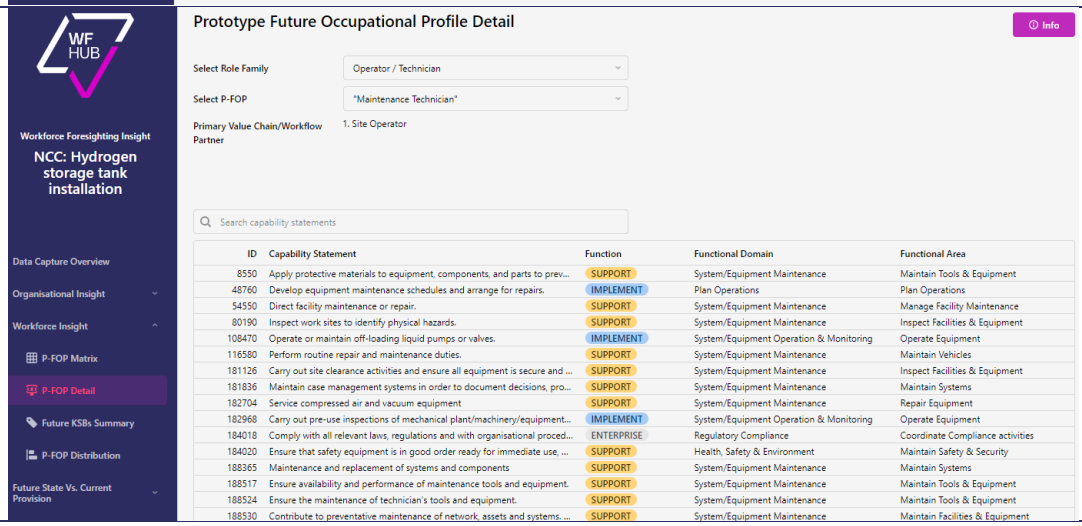
Value Chain Capabilities



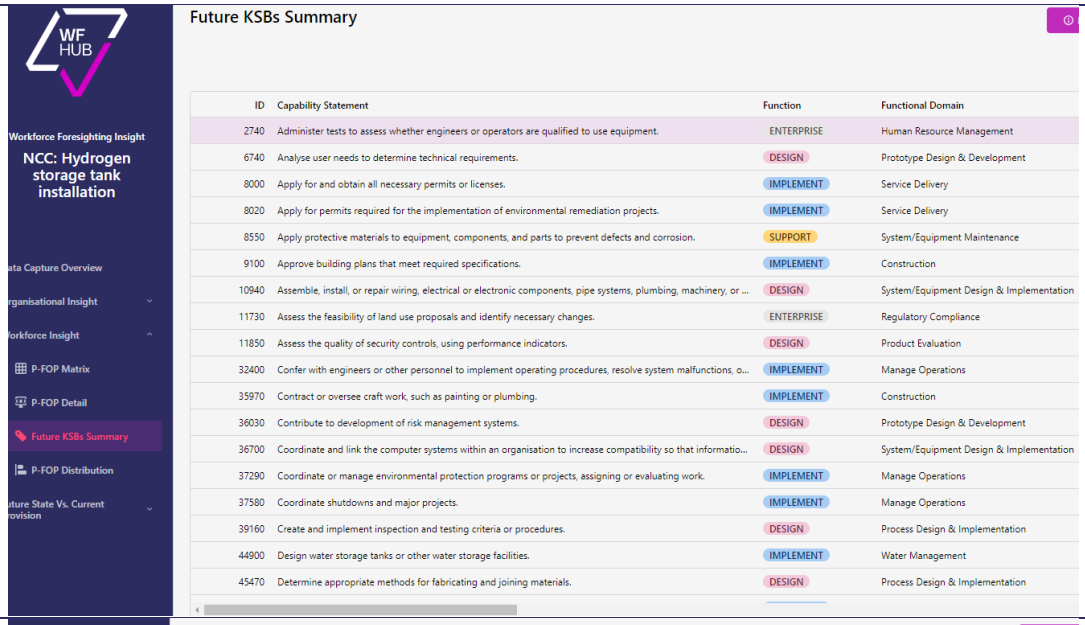
P-FOP Matrix



P-FOP Detail



Future KSBs Summary

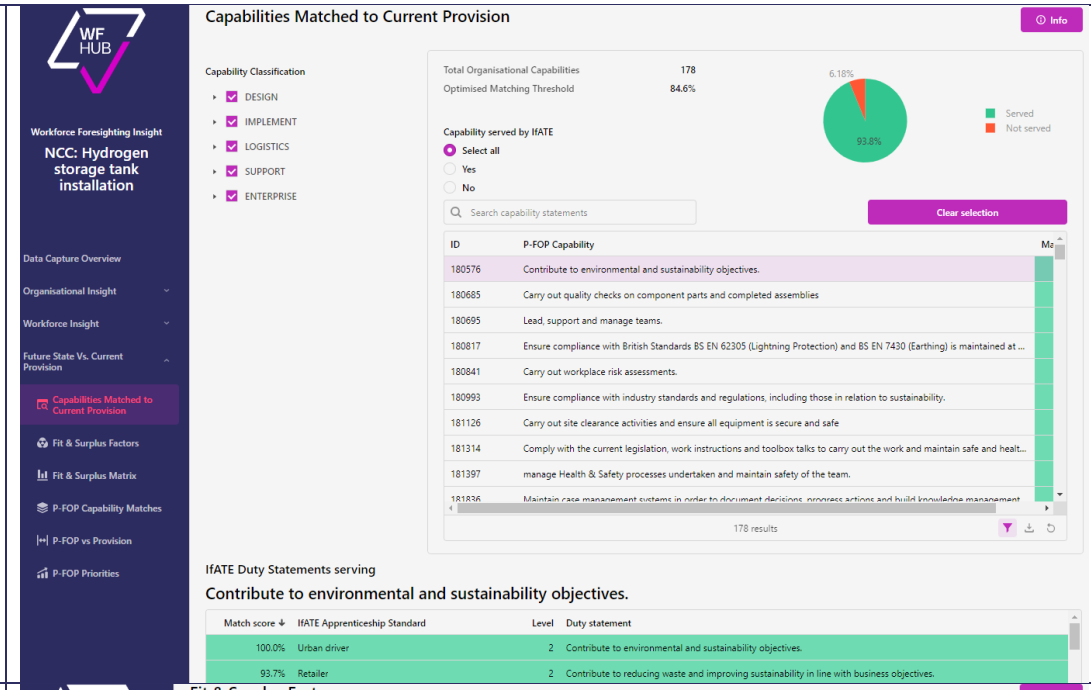


ID	Capability Statement	Function	Functional Domain
2740	Administer tests to assess whether engineers or operators are qualified to use equipment.	ENTERPRISE	Human Resource Management
6740	Analyse user needs to determine technical requirements.	DESIGN	Prototype Design & Development
8000	Apply for and obtain all necessary permits or licenses.	IMPLEMENT	Service Delivery
8020	Apply for permits required for the implementation of environmental remediation projects.	IMPLEMENT	Service Delivery
8550	Apply protective materials to equipment, components, and parts to prevent defects and corrosion.	SUPPORT	System/Equipment Maintenance
9100	Approve building plans that meet required specifications.	IMPLEMENT	Construction
10940	Assemble, install, or repair wiring, electrical or electronic components, pipe systems, plumbing, machinery, or ...	DESIGN	System/Equipment Design & Implementation
11730	Assess the feasibility of land use proposals and identify necessary changes.	ENTERPRISE	Regulatory Compliance
11850	Assess the quality of security controls, using performance indicators.	DESIGN	Product Evaluation
32400	Confer with engineers or other personnel to implement operating procedures, resolve system malfunctions, o...	IMPLEMENT	Manage Operations
35970	Contract or oversee craft work, such as painting or plumbing.	IMPLEMENT	Construction
36030	Contribute to development of risk management systems.	DESIGN	Prototype Design & Development
36700	Coordinate and link the computer systems within an organisation to increase compatibility so that informatio...	DESIGN	System/Equipment Design & Implementation
37290	Coordinate or manage environmental protection programs or projects, assigning or evaluating work.	IMPLEMENT	Manage Operations
37580	Coordinate shutdowns and major projects.	IMPLEMENT	Manage Operations
39160	Create and implement inspection and testing criteria or procedures.	DESIGN	Process Design & Implementation
44900	Design water storage tanks or other water storage facilities.	IMPLEMENT	Water Management
45470	Determine appropriate methods for fabricating and joining materials.	DESIGN	Process Design & Implementation

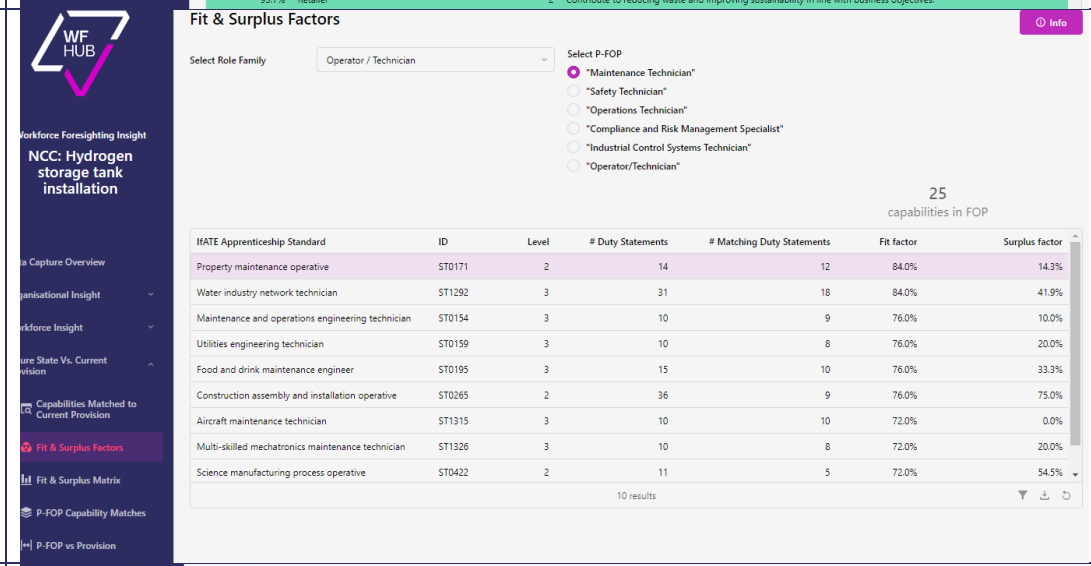
P-FOP Distribution

Function	Functional Domain	Functional Domain	Capability Statement	Total Capability Count Across P-FOPs	Capability by Proficiency Count in P-FOPs (Expert / Practitioner / Awareness)	
SUPPORT	Health, Safety & Environment	Advise on Safety Standards	Work in compliance the Health and Safety at Work Act and relevant regulations.	14 / 23		View P-FOPs
SUPPORT	Health, Safety & Environment	Maintain Safety & Security	Ensure a safe working environment and the adoption of legal working practices including the reviewing of risk assessments.	13 / 23		View P-FOPs
SUPPORT	Health, Safety & Environment	Maintain Safety & Security	Ensure a safe working environment and the adoption of safe working practices.	12 / 23		View P-FOPs
IMPLEMENT	Service Delivery	Provide Environmental Services	Ensure compliance with environmental and occupational health regulations	9 / 23		View P-FOPs
SUPPORT	System/Equipment Maintenance	Maintain Facilities & Equipment	Maintain all required safety & environmental records and documentation.	8 / 23		View P-FOPs
SUPPORT	Health, Safety & Environment	Advise on Safety Standards	Advise on safety standards by conducting risk assessments	8 / 23		View P-FOPs
DESIGN	Technical Research	Research & Develop Technologies	Adapt current safety protocols to meet requirements for H2 cryogenic tank systems.	7 / 23		View P-FOPs

Capabilities Matched to Current Provision

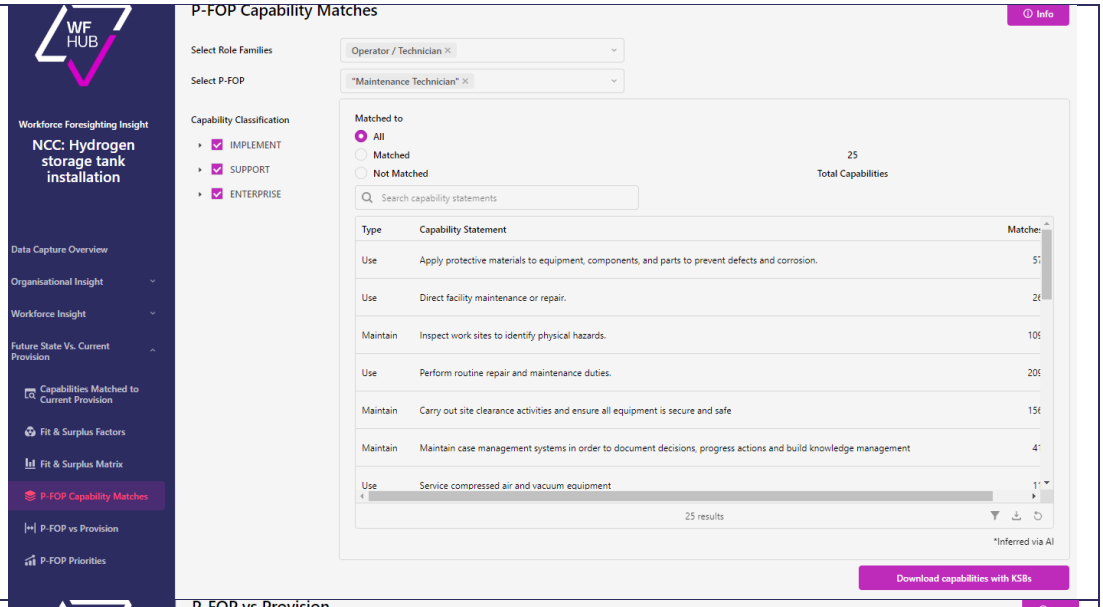


Fit & Surplus Factors

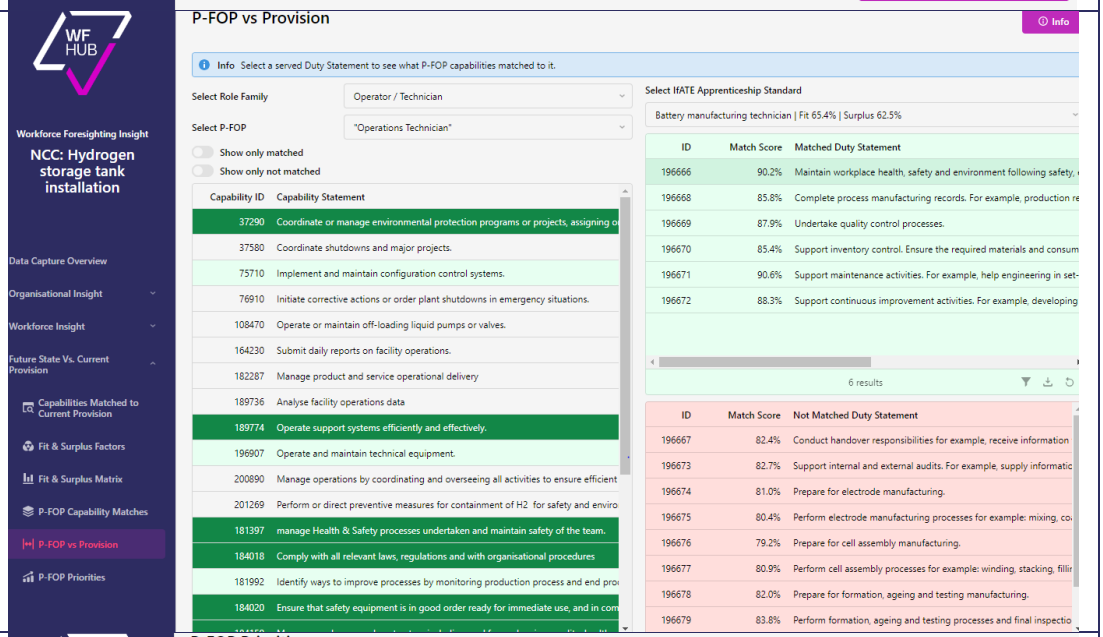


Fit & Surplus Matrix

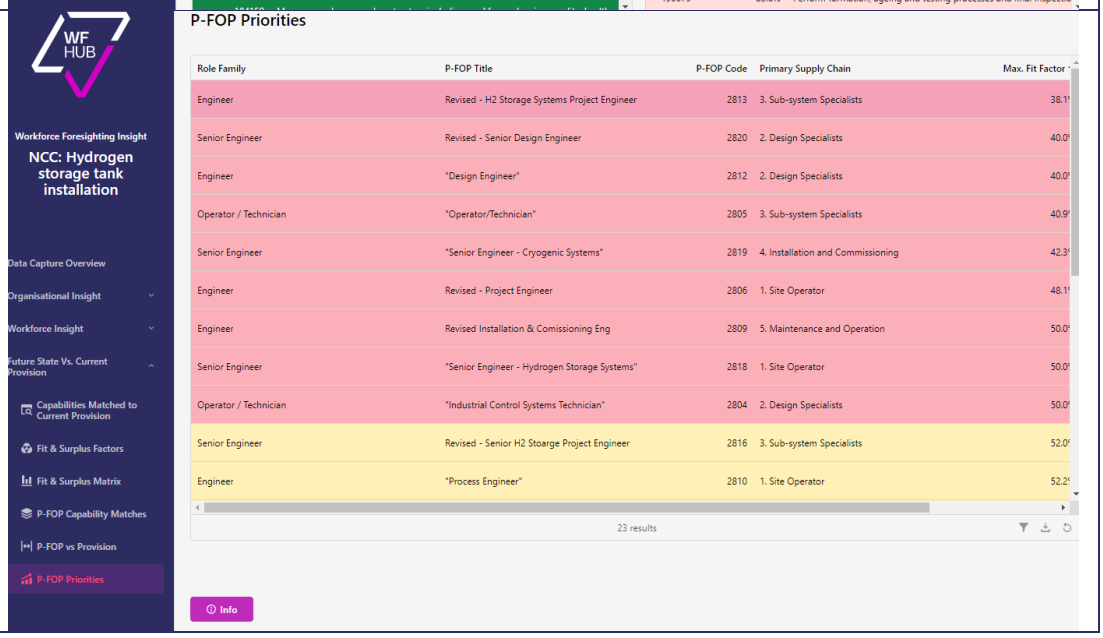
P-FOP Capability Matches



P-FOP vs Provision



P-FOP Priorities



5.6 – Supply Chain Capabilities

This is an overview of the identified capabilities at a Supply Chain / Workflow Partner level and shows how the supply chain organisations' workforce structure needs to change to deliver the required capabilities.

Supply Chain Partner	Example of required change to deliver capabilities
1. Site Operator	Implement digital twinning of storage tank systems using advanced simulation tools - Manage operations by coordinating and overseeing all activities to ensure efficient and effective operation of hydrogen storage tanks - Develop conceptual designs safety and security systems - Develop or evaluate systems or methods of hydrogen storage - Perform or direct preventive measures for containment of hydrogen for safety and environmental protection - Develop safety procedures to be employed by workers operating equipment or working in close proximity to equipment - Manage the procurement products for a specific project - Purchase or requisition supplies and equipment needed to ensure quality and timely delivery of services for a specific project - Inspect and perform maintenance on appropriate plant and equipment to meet operational, regulatory and best practice requirements - Maintain all required safety and environmental records and documentation - Carry out repairs, calibration and maintenance as specified - Develop detailed test methods and specifications to evaluate health and performance of the tank systems - Define process monitoring requirements - input data to be collected - Prepare and issue enquiry documents - Research and identify suppliers - Produce and agree delivery schedules with suppliers - Devise and implement maintenance and inspection management systems
2. Design Specialists	- Review or evaluate site designs for environmental issues - floods, winds, lightning strikes etc - Review or evaluate designs for contaminant control - Load and unload equipment and supplies, using appropriate hoisting equipment - Use quality and information management and assurance systems and processes, for example ISO 9000, recognising the need for these, and their role in continuous improvement

	- Review designs for materials requirements and feed through to technical research - Define digital twin requirements for storage tank package - Creation of Piping and Instrumentation diagram for system - Review and refine system design: storage tank package including instrumentation, control, pipework, electrical and mechanical - Create preliminary design: storage tank package including instrumentation, control, pipework, electrical and mechanical - Model storage tank package performance - Undertake design: storage tank package including instrumentation, control, pipework, electrical and mechanical - Create equipment specifications: storage tank package including instrumentation, control, pipework, electrical and mechanical - Review or evaluate designs for end of life/second life reuse - Install Uninterruptible Power Supply systems and interface to main grid connections to ensure continuity of supply - Provide expert support to leadership team of individuals' competence requirements
3. Sub System Specialists	- Assess current safety protocols and identify gaps in meeting requirements for hydrogen cryogenic tank systems - Implement natural language processing techniques to improve the accuracy and efficiency of compliance monitoring processes within the supply chain - Conduct repairs, calibration, and maintenance of specialised equipment for hydrogen storage tank systems as specified by manufacturers - Clean tools and equipment after use to prevent contamination and ensure proper functionality - Collaborate with suppliers and manufacturers to access specialised equipment repair and maintenance services for hydrogen storage tanks - Commission installed pneumatic/vacuum equipment for efficient operation of hydrogen storage tank systems - Review and ensure that only suitably qualified and competent persons are appointed for supply chain roles and provide regular training sessions on risk management best practices - Conduct safety inspections using artificial intelligence image recognition software to identify potential hazards and ensure compliance with safety standards - Utilise thermography for identifying potential equipment failures in hydrogen storage tank systems - Configure equipment for monitoring and controlling hydrogen storage tank operations using IoT technology for real-time monitoring and optimisation - Coordinate with renewable energy consultants to incorporate sustainable energy solutions, such as solar panels, into construction projects for hydrogen storage tanks - Develop and implement a comprehensive maintenance training and assessment program for workers to ensure proper equipment handling and maintenance

	- Implement IoT sensors for real-time monitoring and control of energy distribution networks for efficient operation of hydrogen storage tanks - Develop quality control measures to ensure accurate labelling of products within the supply chain for hydrogen storage tank systems - Implement real-time tracking systems to monitor inventory levels using IoT devices for efficient inventory management - Manage facility maintenance operations for hydrogen storage tank systems by coordinating repair schedules, allocating resources, and prioritising tasks - Utilise advanced predictive analytics tools to plan supply contingencies and optimise inventory management efficiency within the supply chain - Stay informed about emerging regulatory trends and assess their impact on existing compliance practices for hydrogen storage tank installations - Utilise artificial intelligence and machine learning algorithms to automate compliance monitoring and identify potential non-compliance issues within the supply chain
4. Installation and Commissioning	- Familiarity with artificial intelligence and machine learning algorithms for predictive maintenance - Skill in utilising blockchain technology for transparent tracking and auditing of maintenance records - Familiarity with digital twinning and simulation tools for system design and monitoring
5. Maintenance and Operation	- Define health monitoring frequency to provide required data - Define maintenance schedule based on gathered data and digital twin - Train and assess against relevant internal & external standards - Complete review to ensure only suitably qualified and competent persons are appointed and those persons maintain their professional currency (this applies to both permanent and contract hires) - Maintain appropriate competency management system (including CPD)