Workforce Foresighting Hub

Elimination, substitution, reduction and recycling of fossil-based solvents through the development of Active Pharmaceutical Ingredient (API) manufacturing processes.

Driving sustainability in medicines manufacturing.

Workforce Foresighting Hub findings report in collaboration with CPI, HVMC.

March 2025

Acknowledgements

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 –

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 November 2024 – February 2025 using the data set and tools available at that time.

Contents

Executive summary

Executive summary

This report outlines findings from the Workforce Foresighting cycle focussing on the elimination, substitution, reduction and recycling of fossil-based solvents through the development of Active Pharmaceutical Ingredient (API) manufacturing processes. This industry challenge was identified by the Medicines Manufacturing Industry Partnership Sustainability Group and study conducted by CPI in collaboration with the Workforce Foresighting Hub, an Innovate UK initiative.

Workforce foresighting is a systemic approach to planning ahead and anticipating future skills and capability needs associated with new technologies and government transformation targets. It involves identifying and understanding the skills required for tomorrow's jobs, ensuring our education and training systems are prepared so that our workforce is ready to adopt new technologies and support future industrial growth.

This report sets out the findings of the workforce foresighting study and suggests the next recommended actions required by various Stakeholders to ensure a workforce is created that is prepared to effectively implement these new technologies in the sector.

Workforce Foresighting focus

Life sciences is a priority for future UK economic growth, as outlined in the UK Life Sciences Vision[1]. To harness the sector's potential for driving growth in the UK economy, it is projected that up to 70,000 new jobs will be needed by 2035. Additionally, approximately 75,000 employees will be required to replace those exiting the workforce during the same period. Around half of this workforce will be needed within the Biopharma sector[2].

As the sector evolves and new technologies emerge, a wide range of educational and training pathways are required to create opportunities for individuals at all stages of their career to address skills gaps and maintain global competitiveness.

Innovative technologies relating to environmentally sustainable medicines manufacturing provide an opportunity for the UK to maximise its participation in the global life sciences sector. Environmentally sustainable medicines manufacturing is critically important to preserve natural resources, reduce harmful waste and reduce carbon emissions and help the UK, the NHS and companies meet Net Zero targets.[3] The global medicines manufacturing industry is a significant contributor to climate emissions, accounting for 4-5% of total global emissions.

The industry must adopt a whole-systems approach to significantly improve sustainability within manufacturing processes to adapt to global and UK market demand. Approximately one quarter of emissions from pharmaceutical companies can be attributed to the manufacture of active pharmaceutical ingredients (APIs)[4]—the active component of medicines that produce the intended therapeutic effect on the body. Therefore, focussing on the development of more sustainable API manufacturing processes presents a significant opportunity. The adoption of bio-based and low-impact solvents to replace harmful traditional fossil-based solvents, and development of manufacturing processes which reduce or recycle solvents are essential to deliver more sustainable API production. Industry does not yet have the capabilities to deliver change at the scale and pace necessary.

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[1] https://www.gov.uk/government/publications/life-sciences-vision
[2] https://cogentskills.com/wp-content/uploads/2025/03/Life-Sciences-2035_Main-Report.pdf
[3] https://www.abpi.org.uk/publications/follow-the-green-high-tech-road/
[4] https://www.mckinsey.com/industries/life-sciences/our-insights/decarbonizing-api-manufacturing-unpacking-the-cost-and-regulatory-requirements

As a trusted partner of industry, academia, government, entrepreneurs, and the investment community, CPI connect the dots within the innovation ecosystem, to look beyond the obvious to transform healthcare and drive towards a sustainable future. In collaboration with the Medicines Manufacturing Industry Partnership Sustainability Group, CPI convened stakeholders relevant to this industry challenge, to explore the future workforce requirements through workforce foresighting. The findings from this initiative are outlined in the following report.

Participants and Stakeholders

Industry Participants	Skills Participants	Technology Participants
GSK	Heriot-Watt University	CPI
High Force Research	Scottish Colleges Science Group	Heriot-Watt University
Industry Consultant	Skills Development Scotland	Pharmaceutical Environment Group (PEG)
Johnson & Johnson	University of Leeds	University of Leeds
Medicines Manufacturing Industry Partnership	University of Strathclyde	University of Strathclyde
Pfizer	University of York	University of York
Sterling Pharma Solutions	IfATE	Office for Life Sciences

Findings and next steps

This study found that to deliver industry transformation and enable adoption of new solvent technologies which deliver more sustainable API manufacturing, the workforce will require 138 capabilities across a range of functions. There is an anticipated increase in demand for capabilities relating to sustainability strategy, life cycle analysis, sustainability by design within drug development, including the evaluation of solvent technologies and process optimisation.

These capabilities will be distributed across 22 different job roles, detailed through the future occupational profiles (FOPs) outlined in this report and accessible within the Workforce Foresighting Hub data visualisation tool. The roles or FOPs which will be critical to the delivery of this transformation include Senior Leader; Senior Process Engineer; Senior Process Chemist; Process Leader; Equipment Design Engineer and Sustainability Officer.

It is recommended that employers review the new capabilities required for these roles to shape future workforce development plans. Then partner with education and training providers to develop appropriate provision.

The UK Biopharma workforce is highly skilled with roles typically requiring advanced qualifications including degrees and postgraduate training. This study identified a requirement for additional education and training provision at qualification levels 4 to 7 (SQCF levels 6-11). Therefore, the findings of this report will have relevance to Further Education, Higher Education, and Independent Training Providers.

To deliver the workforce capabilities required to enable more sustainable medicines manufacturing, flexible continuing professional development (CPD) courses are essential to upskill the existing workforce and reskill those transferring skills from other industries. It is recommended that Educators review the existing education qualifications relevant to this field including the Science Industry Plant and Process Engineer, Senior Leader and Process

Leader IfATE apprenticeship standards and Scottish Modern Apprenticeship frameworks in Scientific, Technical and Formulation Processing. Then compare the capabilities required with the current curriculum to identify opportunities for development to meet future industry needs. A comparison of the priority FOPs with existing education provision is detailed in section 3.4 of this report with full detail of the 41 new capabilities required within the workforce listed in section 3.5.

To enable adoption of new solvent technologies to drive sustainability in medicines manufacturing and maintain UK competitiveness in this sector, continuing collaboration is imperative. Limited knowledge of technology implementation, unclear regulatory pathways, and inconsistent business investment in this field present potential barriers to change. Therefore cross-industry collaboration, partnering with industry and regulatory bodies is essential. Building the relevant skills and expertise within the workforce provides a foundation to drive change.

1. Introduction

1. Introduction

Section	Title
1.1	Background to workforce foresighting
1.2	Workforce foresighting - process overview
1.3	Foresighting vs forecasting
1.4	Visualisation tool

1.1 Background to Workforce Foresighting

The report "Manufacturing the Future Workforce" (Collier et al., 2020) recommended the Skills Value Chain as an approach to avoid shortfalls in workforce capabilities relating to future innovations (see Figure 1). This is the genesis of the workforce foresighting programme, which is sponsored by Innovate UK and delivered through the Innovate UK Catapult Network.

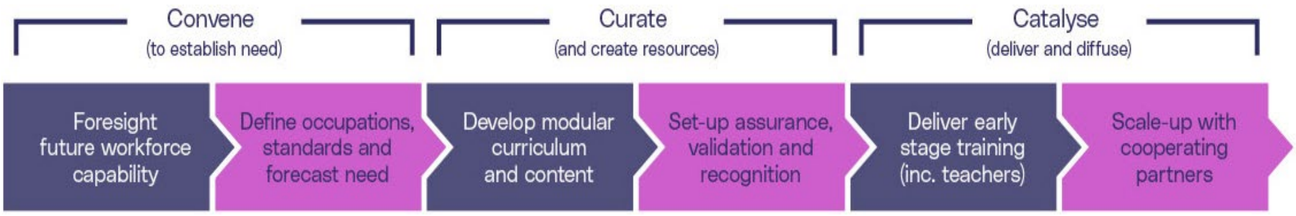


Figure 1: The Skills Value Chain

The first step of the skills value chain is to "Foresight future workforce capability": This calls for technology, industry, education, and training partners to convene using government as a focal point, to "foresight and articulate future skills needs, standards and qualifications associated with emerging technologies" (Collier et al., 2020).

1.2 Workforce Foresighting - process overview

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.

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. The 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 artificial intelligence (AI) and Large Language Model (LLM) 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 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

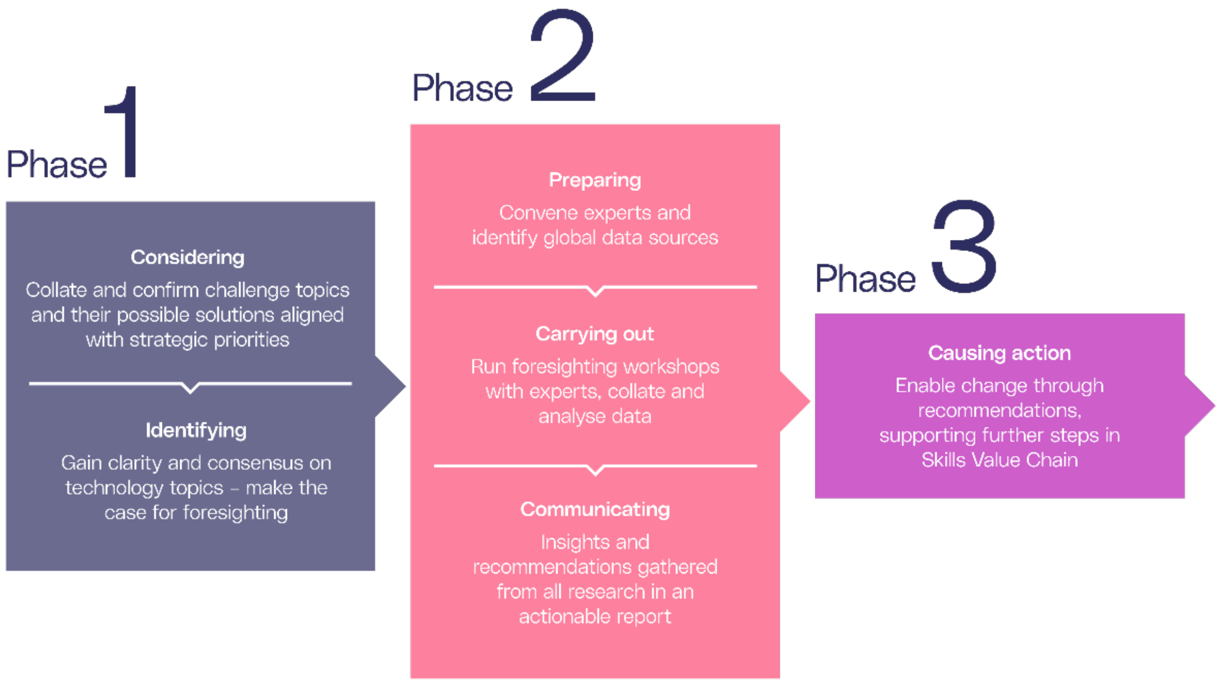


Figure 2 - The workforce foresighting process

1.3 Foresighting vs forecasting

Although this study is focussed on workforce foresighting (capabilities required) it is important to keep in mind parallel findings from forecasting (required capacities and numbers). Forecasting, alongside foresighting, provides vital input to the sector, feeding into recruitment and development targets for employers, and consideration of economic class sizes and recruitment targets for educators. However, it is beyond the scope of the foresighting study to carry out independent forecasting, and as such readers should refer to referenced studies for detail on forecasting.

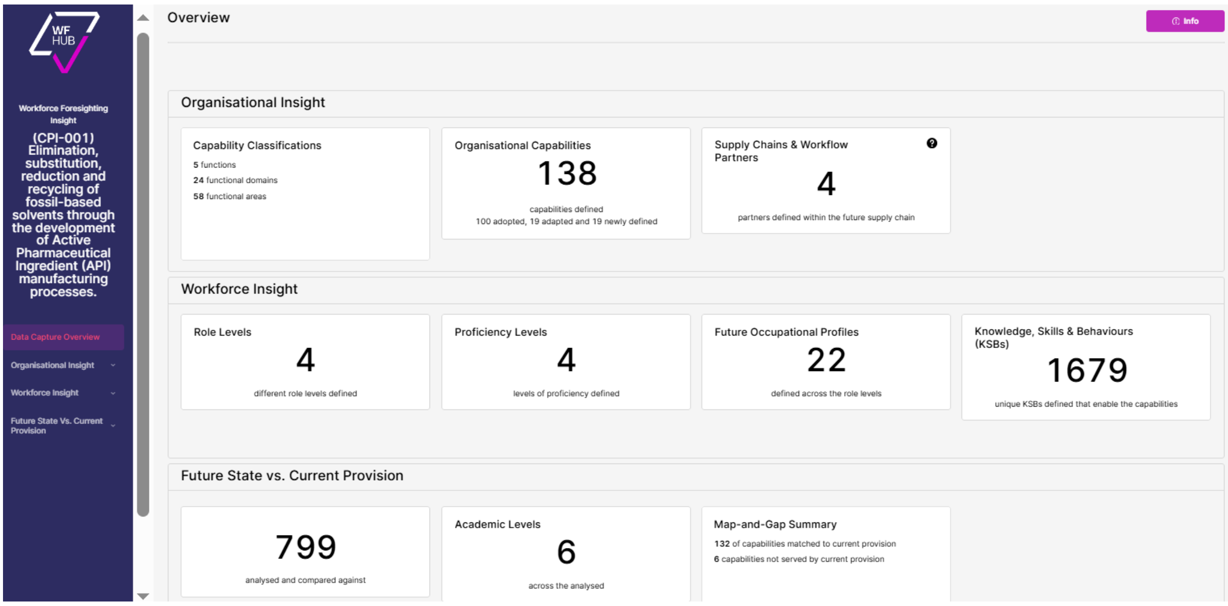
1.4 Introducing the Visualisation Tool

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 curriculums 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 help update/refresh 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.

Data Capture Overview



2. 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 solutions to 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

2.1 Positioning and context of national challenge

Government sector target related to national challenges

The UK government has set a target for the National Health Service (NHS) to achieve Net Zero emissions by 2045. This ambitious goal is part of the broader UK Life Sciences Vision, which aims to stimulate growth in the life sciences sector while addressing significant healthcare challenges[5]. With the wider Healthcare sector accounting for 5% of global greenhouse gas (GHG) emissions, this Life Sciences vision will ensure that sustainability becomes an integral part of the industry's growth and innovation.

Context of the sector

The pharmaceutical sector itself accounts for approximately 4.4% of the greenhouse gas (GHG) emissions, with active pharmaceutical ingredient (API) manufacture accounting for approximately, 25% of these emissions. An API is the active component of a medicine that produces the intended therapeutic effect on the body.

It is estimated that the pharmaceutical industry emits more GHG than the automotive industry[6]. Small-molecule APIs, which are chemically synthesised, tend to have a higher carbon footprint compared to biologic APIs derived from cell cultures or microorganisms[7]. Efforts to decarbonise API manufacturing are underway, with potential reductions of up to 90% through innovations like green chemistry and process efficiency improvement.

Environmentally sustainable medicines manufacturing is critically important to preserve natural resources, reduce harmful waste and reduce carbon emissions and help the UK, the NHS and companies meet Net Zero targets. There is a strong value proposition associated with transitioning to Net Zero medicines manufacture in the UK across all three pillars: Environmental, Social and Governance (ESG). By integrating Net Zero strategies into ESG frameworks, companies not only contribute to global climate goals but also gain a competitive edge, improve stakeholder relationships, and ensure long-term resilience with employees and business economics.

A Net Zero approach will provide an opportunity for the UK to be a world leader and therefore an exporter of low carbon footprint medicines, lowering the Scope 3 emissions of health system purchasers worldwide, enabling them to meet their decarbonisation goals and contribute to the decarbonisation of healthcare globally[8].

The industry must adopt a whole-systems approach to significantly improve sustainability within manufacturing processes to adapt to global and UK market demand. Industry does not currently have the capabilities to deliver change at the scale and pace necessary, creating a risk that targets may not be achieved.

While there is some knowledge of sustainability at industrial level, there is not the broad understanding across the workforce of how to deliver sustainability within medicines manufacturing with a coordinated whole systems approach, nor how each department and individual can make an impactful contribution to drive sustainability. Only by adopting this

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[5] https://www.gov.uk/government/publications/life-sciences-vision
[6] https://www.statnews.com/pharmalot/2023/07/21/climate-change-emissions-carbon-roche-gsk-sanofi-astrazeneca-merck-samsung-novo-nordisk-pollution/
[7] https://www.mckinsey.com/industries/life-sciences/our-insights/decarbonizing-api-manufacturing-unpacking-the-cost-and-regulatory-requirements
[8] https://www.abpi.org.uk/publications/follow-the-green-high-tech-road/

approach, similar to existing industry practices in quality and regulatory affairs, can the sector implement the necessary changes to achieve sustainability and Net Zero goals.
Within drug development, sustainability by design must be central to both research and development teams, including the evaluation of solvent feedstocks and the use of green chemistry principles. Process design includes not only the raw materials being used, but also the extraction and reuse of raw materials within the process, promoting a genuine circular economy.

Historically, this focus has often been deprioritised due to limited knowledge, regulatory approval challenges, with the emphasis on advancing the science, resulting in the frequent reliance on outdated and environmentally harmful technologies.

Regardless of the complexity of the process, it is essential the workforce possesses the necessary skills and tools to make informed decisions that minimise environmental impact. Without strong justification, early decisions made during pharmaceutical development are difficult to reverse after the process is transferred to commercial manufacturing.

The UK government has been addressing solvent use as part of its broader sustainability and environmental goals, so a focus on the development of more sustainable API manufacturing processes presents a significant sustainability opportunity.

Technological changes and future outlook

The industry is undergoing a paradigm shift driven by the need for sustainability, technological advancements, and changing market demands. Key technological changes include:

- **Sustainable Feedstocks**: Utilising biomass, CO_2, and waste materials.
- **Green Chemistry**: Reducing or eliminating hazardous substances.
- **Circular Economy**: Designing products and processes for reuse and recycling.
- **Digitalisation**: Leveraging AI, machine learning, and advanced analytics[4].

2.2 Potential and prioritised technology solutions to the challenge

Evaluating technology solutions

The process of evaluating technology solutions involves assessing their feasibility, impact on sustainability, and alignment with regulatory requirements.

This includes life cycle assessments (LCA) and carbon accounting, although current methodologies face challenges such as data availability and Supply Chain complexity[5].

Technology solution options

Technology Solution	Description	Relevance to Challenge	Current State	Timing Considerations
Sustainable Feedstocks	Use of renewable resources	Reduces dependence on fossil fuels	Emerging	Medium-term
Green Chemistry	Minimises hazardous substances	Enhances safety and sustainability	Developing	Short-term
Circular Economy	Reuse and recycling of materials	Maximises resource efficiency	Early stages	Long-term
Digitalisation	AI and machine learning for optimisation	Accelerates innovation and efficiency	Growing	Short-term

Case for each solution

- **Sustainable Feedstocks**: Essential for reducing the carbon footprint of raw materials. This solution is in the emerging stage but holds significant potential for long-term sustainability.
- **Green Chemistry**: Critical for minimising environmental impact and improving safety. This approach is already being developed and can be implemented in the short term.
- **Circular Economy**: Focuses on designing processes that minimise waste and promote recycling. This is in the early stages but is crucial for long-term resource efficiency.
- **Digitalisation**: Enhances process optimisation and innovation through AI and machine learning. This technology is rapidly growing and can be adopted in the short term[9].

Review of current state and Supply Chain impact

The current state of the industry shows some awareness of the need for sustainability, but there is a lack of comprehensive understanding and coordinated efforts across the workforce. The Supply Chain is complex, and improvements in data collection and standardised reporting are necessary to manage Scope 3 emissions effectively.[10]

Timing considerations

- **Short-term**: Green Chemistry and Digitalisation can be implemented relatively quickly due to their current development stages.
- **Medium-term**: Sustainable Feedstocks require more time to become fully viable but are essential for long-term sustainability.
- **Long-term**: Circular Economy practices will take longer to establish but are crucial for maximising resource efficiency and achieving sustainability goals.

[9] https://www.gov.uk/government/publications/life-sciences-industrial-strategy
[10] Life Sciences Industrial Strategy Update - GOV.UK

2.3 Workforce Foresighting for chosen prioritised technology solutions

Fossil based solvents are a critical raw material for API manufacture in the pharmaceutical industry. Reducing the reliance on fossil-based solvents through their elimination, substitution, reduction and recycling represents a transformative step towards a sustainable future and the achievement of Net Zero targets in the pharmaceutical industry.

Process development of any new API should be done in such a way that solvent use is either eliminated fully with the use of newer manufacturing techniques and innovations or substituted by using non-fossil-based solvents, for example biobased or aqueous based chemistries. For manufacturing processes where solvent removal is not feasible, it is essential to incorporate solvent recovery and recycling into the design. Recovered solvents should either be reintegrated into the same process or repurposed as feedstock for other processes.

Solvent recovery and recycling systems are a valuable investment for various industries, offering cost reduction, operational efficiency, and contributing to the attainment of sustainability goals.

Whilst it is challenging to predict when a solvent supply crisis will occur, often due to fossil fuel resource depletion or geopolitical instability, moving to alternative options and re-using what is available will have a wide-reaching sustainability impact.

The future Supply Chain workforce, within the following 4 key industry areas, will require new capabilities and skills to adapt to this innovation area:

- Medicines Manufacturers
- CDMOs and CROs
- Equipment manufacturers
- Fine chemical and solvent manufacturers

Investing and upskilling the workforce involved in technological innovation is crucial to ensure a stable supply for API manufacture.

2.4 Current and predicted scale of technology deployment in UK

To improve the sustainability of API manufacturing, various approaches for managing the use of fossil-based solvents should be carefully evaluated during the process development stage.

Collaboration must exist throughout the end-to-end Supply Chain, ensuring the correct capability is available to allow transition away from fossil-based solvents. This requirement includes the availability of new equipment, raw materials, scientific methodologies, with an understanding of the economic cost benefit to ensure adoption of the change etc:

Action	Some examples of current technological options
Elimination	Utilise different green chemistries e.g. aqueous Utilise new manufacturing technologies e.g. mechanochemistry
Substitution	Biobased alternatives
Reduction	Digital technology for process design, minimising solvent required Process intensification e.g. flow chemistry, continuous manufacturing
Recycling	Distillation Membrane separation

As the transition away from fossil fuels becomes increasingly critical for the industry, there is significant momentum to evaluate the full product impact and implement technologies that enable the "Elimination, substitution, reduction, and recycling of fossil-based solvents" in the development of active pharmaceutical ingredient (API) manufacturing processes.

The UK requires the current and future workforce to be skilled and prepared to drive this change, to deliver a substantial impact on sustainability.

2.5 Key Stakeholders in industry and government

The NHS Net Zero targets are driving the adoption of sustainable practices across the pharmaceutical industry. Decarbonising solvent use in API manufacturing requires collaboration across multiple Stakeholders to ensure a comprehensive and effective approach.

Key Stakeholders encompass the pharmaceutical industry, including both pharmaceutical companies and associated contract organisations, fine chemical and solvent manufacturers, regulatory bodies, academic and research institutions, and technology and equipment providers.

All these Stakeholders play a role in driving the necessary changes, however demand is often led by patients and end users such as the NHS, driven by government policy, who increasingly expect more sustainable pharmaceuticals from the industry. End users and patients will strongly influence business economics and profitability within the pharmaceutical and life sciences industry.

3. Findings and results

3. Findings and results

Section	Title
3.1	Methodology and findings
3.2	Step One – How will the Supply Chain change - *Organisational changes insight*
3.3	Step Two – How will the workforce change - *Occupational change insight*
3.4	Step Three – How the current education provision meets the future need - Highlighted changes for future provision

3.1 Methodology and findings

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. The report is aligned to the needs of those responsible for workforce planning – employers, educators, and skills providers.

Step One – How will the Supply Chain change - *Organisational changes*

Exploration of organisational changes provides insights into how organisations will need to adapt their current capabilities to implement the solutions that respond to the challenge addressed by the foresighting project.

Typically, organisational changes will also require the adoption of new capabilities and a change in the distribution of these capabilities across Supply Chain partners. The change in capabilities within an organisation as well as their Supply Chain partners will determine the changes knowledge and skill changes required by the role groups within the workforce of each Supply Chain partner.

Step Two – How will the workforce change - *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 levels, function, proficiency and capability similarity. As part of the foresight process the generated FOPs are reviewed, revised and distilled by the Employer group. The 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) apprenticeship standards; to assess which current training and education provision could be used in the future.

For this cycle, the agreed set of FOPs are additionally compared to selected Scottish Vocational Qualification (SVQs) and Scottish apprenticeship frameworks, across a range of SCQF (Scottish Credit and Qualifications Framework) levels and degree programmes relevant to current industry.

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.

Step Three – How the current education provision meets the future need - *Highlighted changes to future provision*

The report identifies suggested changes to education and training provision – principally apprenticeship 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

CPD to upskill the current workforce to meet future needs. Additionally, foresighting outputs can be used to develop programmes, qualifications, and apprenticeship 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, apprenticeship 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.

3.2 Step One – How will the Supply Chain change - *Organisational changes insight*

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.

The functional structure is developed to levels of detail that enable the foresight process to reference external data sets including ONET (US) Occupational Information Network[11], ESCO – European Skills, Competences, Qualifications and Occupations[12], IfATE (UK) Institute for Apprenticeships and Technical Education[13].

The five root functions comprise around 40 domains which are broken down to around 140 functional areas. The architecture is used to position ~ 25,000 capability statements which are

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

the building blocks used in the workforce foresight process. Each capability statement has several attributes - some are static and reflect the position of the capability statement in the architecture, whilst 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 large language models (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 (API manufacturing Supply Chain) in the future. The pie-charts reflect the distribution of capabilities across the five functions of the capability classification. The future state data is captured in three technology focused workshops. The current state data is derived from information collected on apprenticeship standards used across current Supply Chain partners. This latter information is not as detailed as that produced by the workshops but is indicative and used to provide a point of comparison.

These initial pie charts (Figure 3) summarise the changes that will be required by the whole Supply Chain, across the five organisation functions.

- There is an indication of a future increase in the capabilities required within the ‘Design’ and ‘Enterprise’ functions of organisations, as industry transitions to more sustainable solvents and manufacturing processes. To meet environmental goals, companies must develop effective sustainability strategies, integrate sustainability into the design of API manufacturing processes, and collaborate with regulatory agencies to define a path to regulatory approval for new solvents and processes. Design of equipment to deploy new API manufacturing processes is required, particularly for processes which eliminate or recycle solvents.

- Although the comparison in Figure 3 suggests a decrease in the need for 'Implement' and 'Support' function capabilities, it is important to note that this cycle primarily focussed on the development, scale-up, and intensification of new API manufacturing processes within the process development phase. It did not consider any change being integrated into existing commercial manufacturing processes, where ‘Implement’ and ‘Support’ functions would undoubtedly play a significant role.

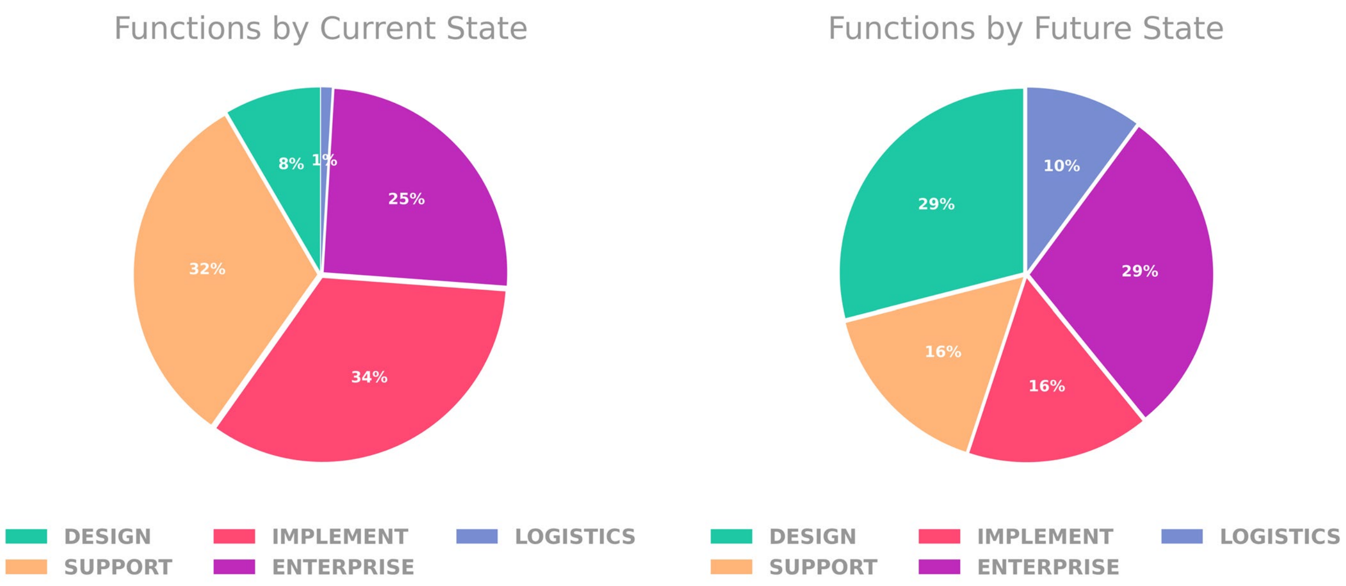


Figure 3: Current and Future – Whole Supply Chain - Capability Function Distribution %

Whilst the information on current and future Supply Chain capabilities is useful to indicate relative changes, factors such as volume of activity will also determine which functions may have greater future significance.

Visualisation Instructions

Visualisation Data Link	What is it and what can it be used for?
Organisational Capabilities	*The page provides details of the capabilities required by each Supply Chain partner and the Supply Chain as whole. The information is presented using the Capability Classification Framework, Design / Implement / Logistics / Support / Enterprise and can be interrogated and then exported to suit specific user requirements and interest.* *The information provided also identifies capabilities supported by existing provision, and also where there may be gaps that require new development to support to equip the future workforce.*

3.3 Step Two – How will the workforce change - *Occupational change insight*

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 skills sets for each Supply Chain partner may need to be revised to reflect change for each role level 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. Medicines Manufacturers
2. Contract Development Manufacturing Organisations (CDMOs) & Contract Research Organisations (CROs.)
3. Fine Chemical & Solvent Manufacturers
4. Equipment Manufacturers

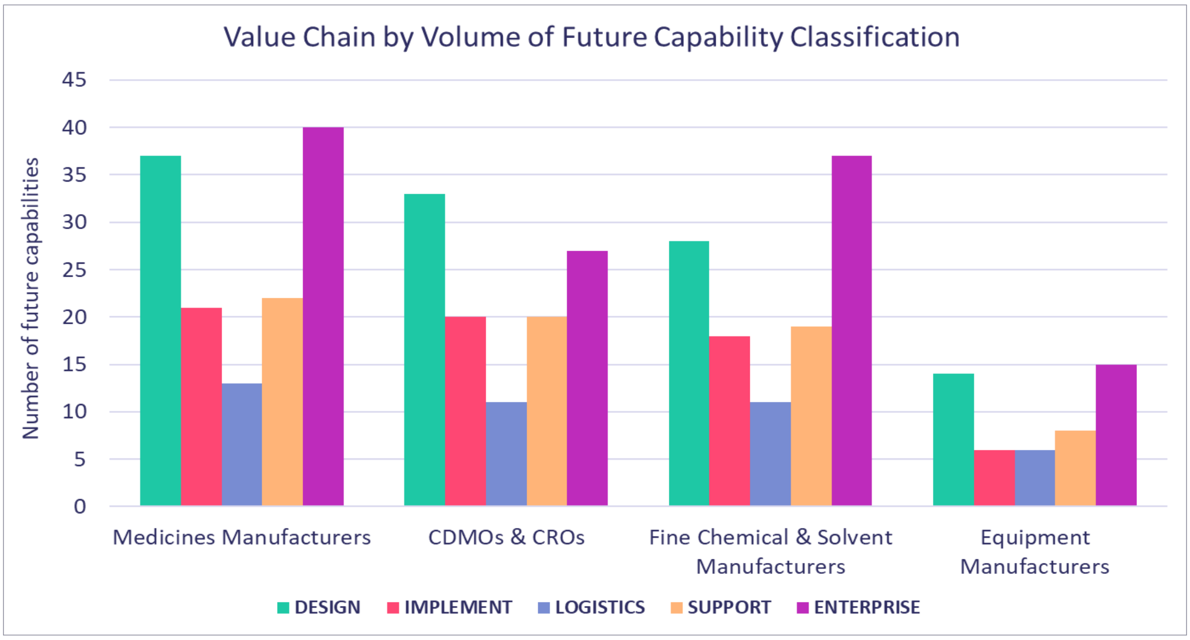


Figure 4: Distribution of Functions across each Supply Chain partner

Figure 4 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 level. This occupational change insight indicates that to adopt the required technological innovations, the greatest workforce change will be required within medicines manufacturers, CDMOs &CROs, and solvent manufacturers.

Visualisation Instructions

Detailed instructions can be found in the appendix.

Visualisation Data Link	What is it and what can it be used for?
Supply Chain Capabilities	*This page provides an overview of the identified capabilities at a Supply Chain partner level.* *By selecting/deselecting each Supply Chain partner you can review the capabilities identified as required in that area of the Supply Chain.* *This can be used to generate organisational capability profiles for each area of the 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 Levels

The foresighting process uses the concept of Role Levels to represent future occupations. Utilising this approach acknowledges that the workforce is not homogeneous, there will be varying levels of proficiency required across a workforce and require different types of vocational or academic qualifications. Additionally, the role level approach seeks to avoid presuming that the future workforce will be operating at a different level to the current state.

Role Levels determined through workshops:

1. Apprentices/ Technicians
2. Scientists/ Engineers
3. Senior Managers/ Managers
4. Senior Scientists/ Senior Technical Leads

Proficiencies

Each of these role levels will require proficiency that reflects their role and the needs of each Supply Chain partner. The foresight process uses a three-point scale to capture and differentiate the proficiencies required. This information is used both in the generation of the FOPs, and to assist the definition of training needs identified. Within the workforce foresight process proficiency is defined as:

> **Awareness (A)** - Has a foundational knowledge of tools, technology, techniques relevant to sector, industry, or organisation. 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. A Practitioner 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. An Expert can implement improvements personally or direct and guide others.

During the workshops participants applied their insight to assign proficiency for each role group to each capability. Individual responses were aggregated by the system to arrive at a consensus.

A summary of the distribution of required proficiency for the capabilities at each role level in this cycle are:

	Apprentices / Technicians	Scientists / Engineers	Senior Managers / Managers	Senior Scientists / Senior Technical Leads
Awareness	2	8	12	0
Practitioner	23	82	20	7
Expert	15	62	67	52

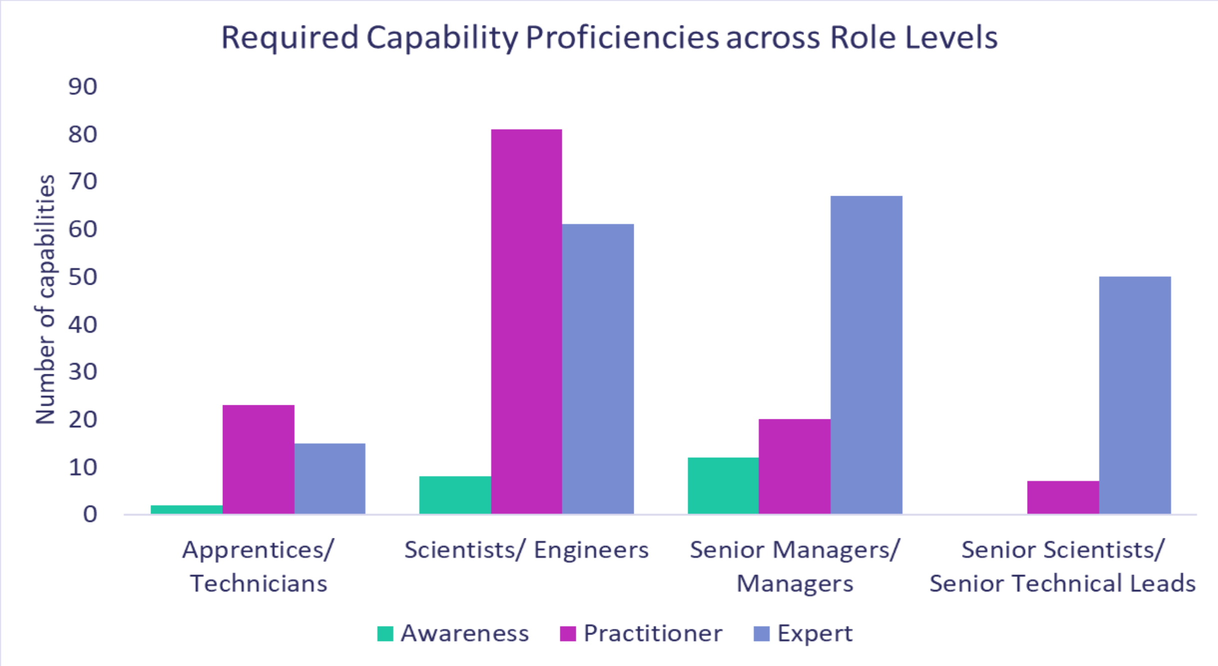


Figure 5: Proficiency details by Role Level

Future Occupational Profiles

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 apprenticeship 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 evaluate changes required to develop effective workforce development plans and consider existing apprenticeship standards and additional provision required to upskill their workforce to meet the requirements of a particular FOP.

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 Group to deliver future capabilities.

Apprentices/ Technicians Role Level FOPs

In this cycle the Apprentices/ Technicians role level was defined as occupations and roles requiring a minimum Level 2 qualification or apprenticeship, or equivalent industry experience.

While most FOPs identified by this cycle are at higher skill levels, there will be some impact on the workforce capabilities required at this level. To enable the adoption of solvent technologies to deliver more sustainable API manufacturing, Laboratory Technicians will require eight new capabilities at practitioner level and six new capabilities at expert level, predominantly relating to new equipment and systems operation and maintenance. Therefore, it could be beneficial for employers with these roles within their workforce to focus workforce development plans on these FOPs.

Full details of the new capabilities required for these roles can be found within the *FOP Detail* in the data visualisation tool

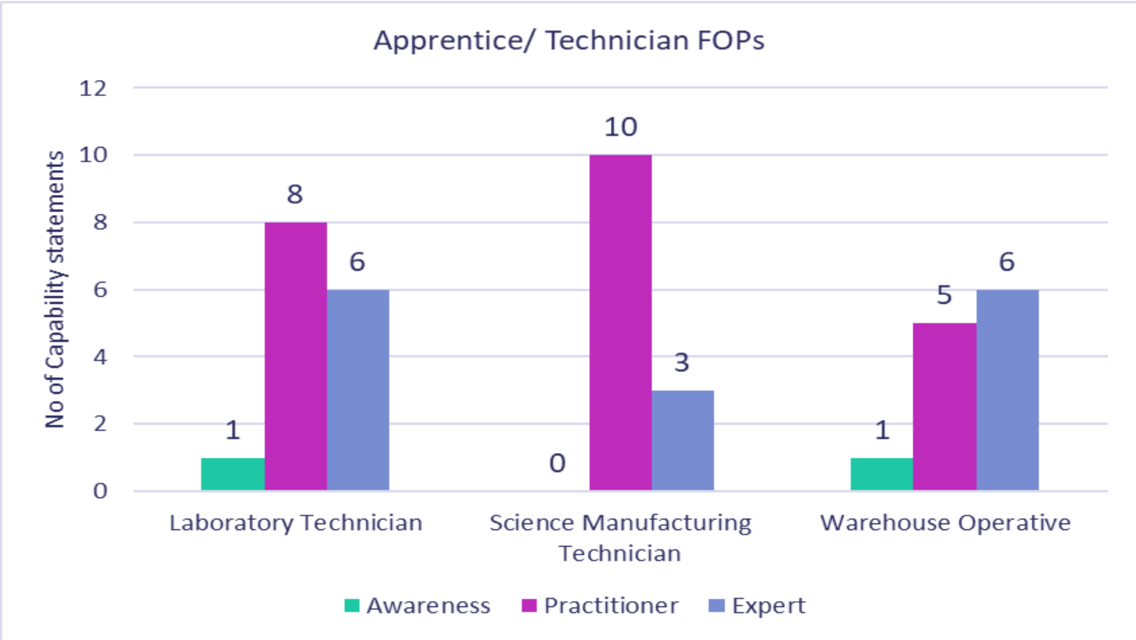


Figure 6: Apprentice/ Technicians Level Future Occupational Profiles

Scientists/ Engineers Role Level FOPs

In this cycle the Scientists/ Engineers role level was defined as occupations and roles requiring a minimum Level 4 qualification or apprenticeship, or equivalent industry experience.

A significant proportion of the new capabilities will be delivered across technical roles at this level within the future workforce. Key roles to prioritise for workforce development include Process Leader, Equipment Design Engineer and Process Development Chemist. Delivering new capabilities relating to new process development, design of equipment to deliver new solvent technologies, and evaluation of processes and raw materials for environmental impact.

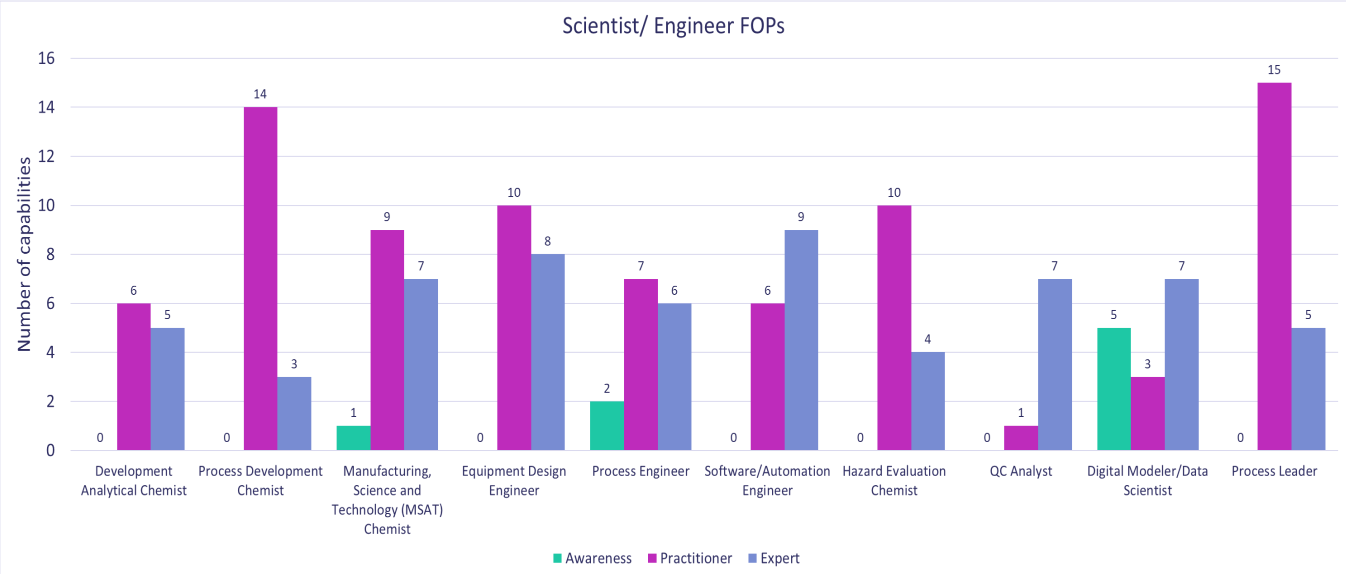


Figure 7: Scientist/ Engineer Future Occupational Profiles

Senior Managers/Managers Role Level FOPs

In this cycle the Senior Managers/Managers role level was defined as occupations and roles requiring a minimum Level 4 qualification or apprenticeship, or equivalent industry experience.

Senior Leaders and Supply Chain Managers must develop new capabilities, with Sustainability Officers playing a crucial role in the future workforce to drive the technological transformation. These roles require capabilities to define sustainability strategy, lead cross-industry collaboration to define and agree new industry standards and regulatory guidelines, and analyse changes designed to improve the environmental performance of complex systems to avoid unintended negative consequences.

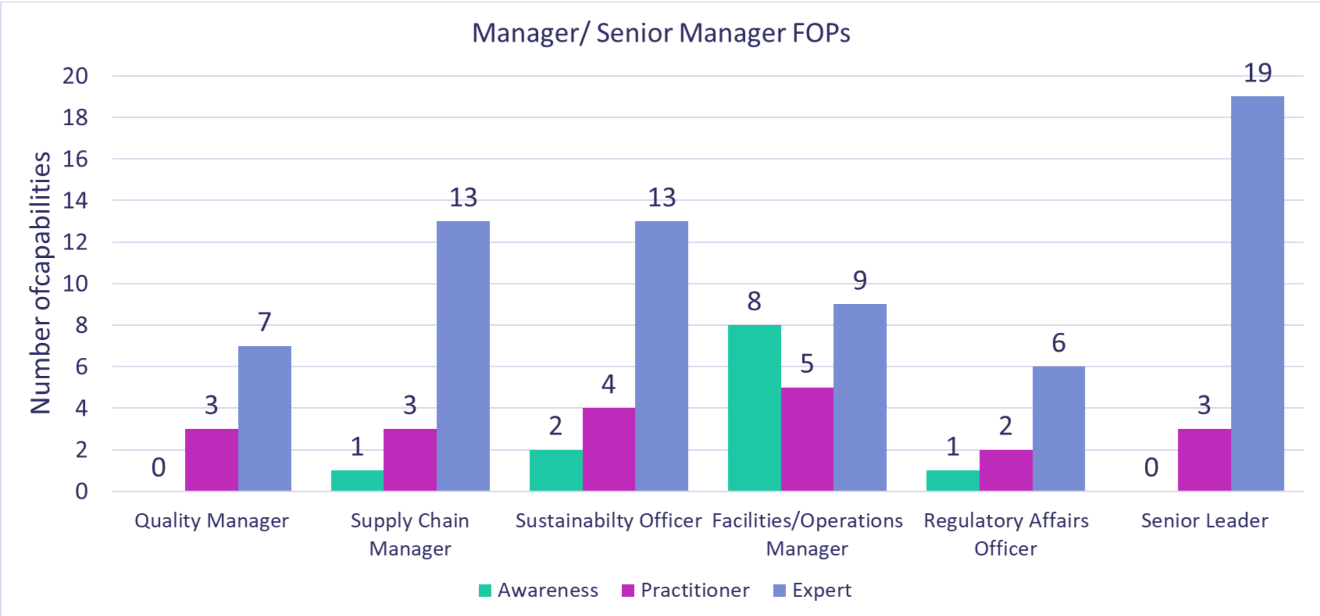


Figure 8: Manager/ Senior Managers Future Occupational Profiles

Senior Scientists/ Senior Technical Leads Role Level FOPs:

In this cycle the Senior Scientists/ Senior Technical Leads role level was defined as occupations and roles requiring a minimum Level 6 qualification or apprenticeship, or equivalent industry experience.

At this level, Senior Process Engineers and Chemists are crucial for enabling the adoption of new solvent technologies, requiring advanced capabilities, particularly at an expert proficiency level. In the future workforce, these roles will demand expertise in conducting and overseeing life cycle analyses to guide process changes, as well as researching green production and recycling techniques to innovate more sustainable API manufacturing processes.

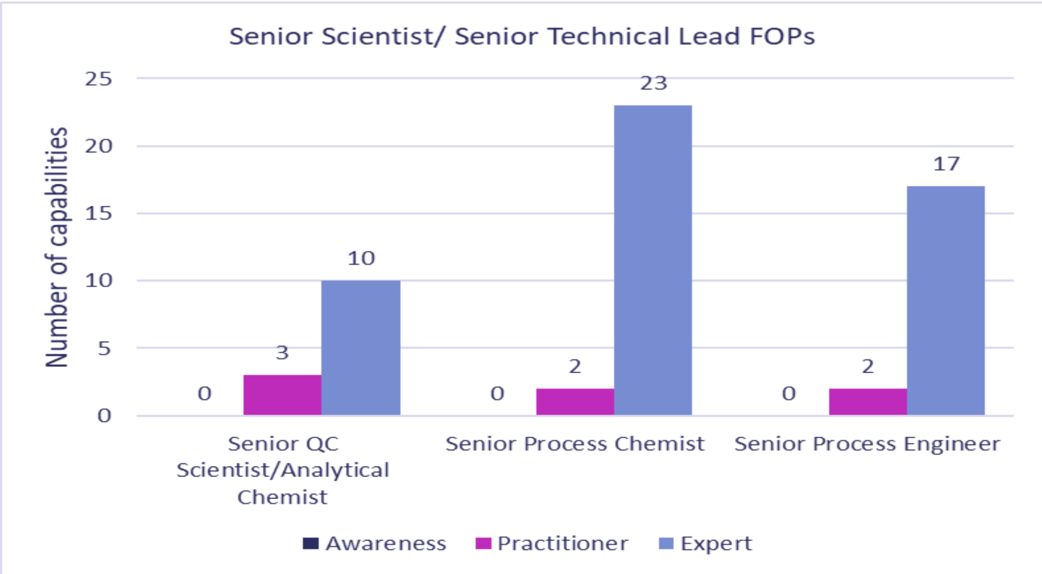


Figure 9: Priority FOPs - Senior Scientists/Senior Technical Leads Role Level

Visualisation Instructions

Detailed instructions can be found in the appendix.

Visualisation Data Link	What is it and what can it be used for?
FOP Matrix	*This page provides a detailed breakdown of FOP's 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 FOPs in a role level by selecting one (or more) of these from the drop down. This will then allow you to select the FOPs aligned to that role level.* *The populated table allows you review and compare different FOPs within or across role levels. You can view the capabilities in each FOP and the assigned proficiency levels.*

3.4 Step Three – How the current education provision meets the future need - *Highlighted changes for future provision*

The FOPs outlined below have been identified as key roles within the future workforce, essential for delivering the capabilities required to drive industry transformation, enabling the adoption of new solvent technologies within the manufacturing of APIs. Although there is some alignment with existing education and training programmes, certain emerging capabilities are not adequately addressed by current educational offerings. As such, these areas represent priority opportunities for innovation and the development of new education and training provision.

A detailed comparison of how current education and training provision meets the requirements of the FOPs identified through this workforce foresighting cycle is available within the data visualisation tool: [FOP vs Provision link]

Priority Future Occupational Profiles (FOPs)

1. Senior Leader
2. Senior Process Engineer
3. Senior Process Chemist
4. Process Leader
5. Equipment Design Engineer
6. Sustainability Officer

Existing education and training provision relevant to these FOPs, recommended for review and adaptation to deliver required workforce capabilities:

	Qualification level 4 (SCQF level 6)	**Level 5**	**Qualification level 6 (SCQF level 10)**	**Qualification level 7 (SCQF level 11)**
Process Development	Process Leader MA in Scientific, Technical and Formulation Processing at SCQF level 6	No provision identified as required at this level	Science Industry Plant and Process Engineer/BEng in Chemical Engineering Product design and development engineer	
Leadership and Quality			Sustainability business specialist (integrated degree)	Senior Leader

Below is a comparison for each priority FOP with existing education programmes, highlighting the additional capabilities required within the future workforce. These capabilities could form the basis of a curriculum for future education and training provision, to be delivered through adaptation of existing education programmes or as short continuing professional development (CPD) courses to upskill the current workforce.

Senior Leader

Senior Leaders play a pivotal role in the future workforce to facilitate the adoption of more sustainable solvents in API manufacturing processes. Achieving industry transformation will require thought leadership and clear strategy relating to sustainability, as well as cross-industry collaboration to develop new solvent databases, Supply Chains, and regulatory pathways.

A comparison between the capabilities required in senior leadership within the future workforce and current education provision reveals a notable gap. Below is a detailed list of capabilities not met by existing education programmes, identifying areas where new training provision could support the future workforce needs. These capabilities could provide the foundation for a curriculum for new CPD courses.

FOP vs Provision	**18.2% fit with IfATE Senior Leader apprenticeship standard**
Capability ID	**Unmatched FOP capabilities**
6610	Analyse the financial impacts of sustainable manufacturing processes or sustainable product manufacturing.
74770	Identify or develop strategies or methods to minimise the environmental impact of industrial production processes.
182033	Select and implement appropriate technology to deliver the people strategy, policy and practices, taking into account the risks, opportunities, impact and value of technology. Seek out, critically evaluate and utilise technologies to drive a continuous improvement approach.
183300	Identify and analyse Stakeholders impacted by a proposed change, understand their perspectives and assess how their interests are best managed
188185	Promote a climate change focussed approach that upholds the organisations climate change and net carbon zero policies and promote sustainable approaches in delivery.
205726	Establish and implement systems for the management, sharing and storage of product information in line with required protocols throughout the value/Supply Chain
206677	Supporting the organisation's environmental and sustainability plans and targets. Consider sustainable use of resources, equipment and supplies for the facilities management service.
213944	Establish collaborative procedures for sharing lessons, reviewing failures, and analysing root causes to benefit the industry.
213988	Evaluate how policies and legislation impact activities and assist in achieving United Nations Sustainable Development Goals (UNSDG) and Net Zero carbon emissions
213990	Develop sustainable practices through effective communication and stakeholder engagement
213991	Collaborate in setting sustainability KPIs for the wider organisation and understand their purpose
214005	Develop a sustainability strategy focused on solvents within Active Pharmaceutical Ingredient (API) manufacturing.
214008	Define and agree on data sharing protocols, collaboration agreements, and data standardisation between industry Stakeholders.
214208	Create business models to enable sustainable solvent production, ensuring economic viability and environmental responsibility.

Senior Process Engineer

The future workforce will require relevant technical expertise to design, optimise, and scale manufacturing processes utilising sustainable solvent technologies. While the core knowledge and skills in Process Engineering will remain relevant, Process Engineers will require new capabilities to conduct life cycle analyses to assess the environmental impact of various solvent technologies. This will be essential when developing and scaling new API manufacturing processes.

Furthermore, these engineers will need to translate such processes into the design of new plant facilities, enabling the adoption of sustainable solvent technologies, including the recovery and recycling of waste to enhance manufacturing efficiencies.

To equip the future workforce with these capabilities, additional modules could be integrated into existing Science Industry Process and Plant Engineer degree apprenticeship or BEng Chemical Engineering programmes. Alternatively, CPD courses could be developed to upskill the current workforce and build the necessary knowledge and skills in sustainable solvent technologies and process optimisation.

FOP vs Provision	**45% fit with IfATE Science industry process and plant engineer (degree) apprenticeship standard (Equivalent to BEng in Chemical Engineering)**
Capability ID	**Unmatched FOP capabilities**
5020	Analyse changes designed to improve the environmental performance of complex systems and avoid unintended negative consequences.
25410	Communicate with suppliers regarding the design or specifications of bioproduction equipment, instrumentation, or materials.
29840	Conduct or oversee the conduct of life cycle analyses to determine the environmental impacts of products, processes, or systems.
63830	Evaluate current or proposed manufacturing processes or practices for environmental sustainability, considering factors such as greenhouse gas emissions, air pollution, water pollution, energy use, or waste creation.
74770	Identify or develop strategies or methods to minimise the environmental impact of industrial production processes.
188217	Focus on sustainability, research and develop green production techniques, processes and the use of recycled materials.
209982	Devise tools to ensure effective, ethical, and sustainable lifecycle plans, from demand identification, through creation, and operation and maintenance, to disposal, of the assets and systems of assets with the overall asset portfolio
210784	Develop ways to repurpose and recycle waste to improve cost efficiencies in manufacturing process.
214003	Design solvent capability into plant facilities, including recycling and Atmosphere Explosible (ATEX) ratings, to enhance safety and operational efficiency.
214009	Assess physical space conditions to ensure safety, compliance, and inform retrofit and facility design.

Senior Process Chemist

Similar to Process Engineers, Process Chemists will deliver critical technical expertise in the future workforce to integrate sustainable solvent technologies into the design, optimisation, and scale-up of API manufacturing processes. Within drug development, sustainability by design must be central to research and development teams, including the evaluation of solvent feedstocks and the application of green chemistry principles.

Process design will encompass not only the selection of raw materials but also the extraction and reuse of materials within the process, fostering a genuine circular economy. A focus on sustainability, the research and development of green chemistry techniques, and an understanding of regulatory, technical, or market issues related to sustainability will be essential to ensure new API manufacturing processes are efficient, safe, sustainable, and compliant with regulatory requirements.

Furthermore, life cycle assessment capabilities within the context of these technologies and the industry will be a key component of the future workforce.

A comparison with existing education provision indicates a gap in these capabilities, listed below, therefore a focus on the development of additional modules integrated into the existing Science Industry Process and Plant Engineer degree apprenticeships or BEng Chemical Engineering programmes, or new CPD courses could be beneficial.

FOP vs Provision	**61.5% fit with IfATE Science industry process and plant engineer (degree) apprenticeship standard (Equivalent to BEng in Chemical Engineering)**
Capability ID	**Unmatched capabilities**
5020	Analyse changes designed to improve the environmental performance of complex systems and avoid unintended negative consequences.
6120	Analyse potential environmental impacts of production process changes and recommend steps to mitigate negative impacts.
29840	Conduct or oversee the conduct of life cycle analyses to determine the environmental impacts of products, processes, or systems.
63830	Evaluate current or proposed manufacturing processes or practices for environmental sustainability, considering factors such as greenhouse gas emissions, air pollution, water pollution, energy use, or waste creation.
182337	Utilise detailed product formulations and characterisations in production process and maintain formulation and costing databases.
188217	Focus on sustainability, research and develop green production techniques, processes and the use of recycled materials.
210784	Develop ways to repurpose and recycle waste to improve cost efficiencies in manufacturing process.
212626	Understand regulatory, technical, or market issues related to sustainability
213989	Develop green chemistry methods to synthesise Active Pharmaceutical Ingredients (API)

Process Leader

Process Leaders will play a key role within the future workforce. Leveraging existing capabilities in operational delivery, such as ensuring effective project execution, maintaining safety, documentation, and process efficiency, as well as fostering positive relationships across multidisciplinary teams to successfully transfer and operate projects.

New capabilities required for Process Leaders in the future workforce include analysing environmental impact, adopting continuous manufacturing technologies, and implementing digitalisation of equipment to optimise API manufacturing processes. These new capabilities go beyond current education provision and could be integrated into the Process Leader apprenticeship or a CPD curriculum.

FOP vs provision	**15% fit with IfATE Process Leader apprenticeship standard or 40% fit with Modern Apprenticeship in Scientific, Technical and Formulation Processing at SCQF level 6**
Capability ID	**Unmatched FOP Capabilities**
213976	Implement new processes, methodologies, and plant equipment to support product development and scale-up manufacturing
203681	Follow procedures in line with environmental and sustainability regulations, standards, and guidance. Segregate resources for reuse, recycling and disposal.
204344	Adapt manufacturing operations to reduce environmental impact and promote waste reduction and recycling
210645	Utilise machine learning algorithms to monitor and optimise operations
201355	Develop and implement equipment maintenance protocols using modern technology
214002	Operate automated equipment using Human-Machine Interfaces (HMI) and machine programming.
173740	Troubleshoot problems with chemical manufacturing processes.
209960	Implement in-process analysis during manufacture.
194436	Utilise advanced process control software for continuous manufacturing
213944	Establish collaborative procedures for sharing lessons, reviewing failures, and analysing root causes to benefit the industry.
6120	Analyse potential environmental impacts of production process changes, and recommend steps to mitigate negative impacts.
188217	Focus on sustainability, research and develop green production techniques, processes and the use of recycled materials.
213978	Select equipment based on manufacturing requirements to allow recycling and recovery of solvents.
203017	Operate a manufacturing batch or continuous process following Standard Operating Procedures

Equipment Design Engineer

The design of new equipment to support the adoption of sustainable solvent technologies is crucial for industry transformation. Equipment incorporating digital technologies for process design, minimising solvent use, process intensification (such as flow chemistry and continuous manufacturing), and solvent recycling will facilitate the shift away from fossil-based solvents.

To meet these industry needs, Equipment Design Engineers will require new capabilities to evaluate current or emerging technologies, considering sustainability and factors such as cost, portability, compatibility, and usability. They will need to design equipment that delivers a full range of in-process analytics for optimising monitoring and control, as well as cost-effective continuous manufacturing equipment for lab-scale investigations and process development.

These specific industry requirements are not currently addressed in existing education programmes. Therefore, the inclusion of relevant modules or industry-specific CPD programmes focusing on these capabilities could be beneficial for future education and training initiatives.

FOP vs provision	**22% fit with IfATE Product design and development engineer (degree) apprenticeship standard or BEng (Hons) Engineering: Design and Manufacture**
Capability ID	**Unmatched capabilities**
63820	Evaluate current or emerging technologies to consider factors such as cost, portability, compatibility, or usability.
63830	Evaluate current or proposed manufacturing processes or practices for environmental sustainability, considering factors such as greenhouse gas emissions, air pollution, water pollution, energy use, or waste creation.
194488	Develop capability for in-line monitoring and control of critical quality attributes using real-time process analytical tools (PAT) such as Raman spectroscopy.
201355	Develop and implement equipment maintenance protocols using modern technology
205735	Create reconfigurable, agile and flexible production systems to enable rapid changes to production pathways/processes as products change
210414	Utilise Artificial Intelligence (AI) tools for design, manufacturing, and planning support.
210784	Develop ways to repurpose and recycle waste to improve cost efficiencies in manufacturing process.
213994	Confer with research, quality, and manufacturing personnel to ensure the compatibility of design and production.
214003	Design solvent capability into plant facilities, including recycling and Atmosphere Explosible (ATEX) ratings, to enhance safety and operational efficiency.
214207	Evaluate batch and continuous manufacturing options within process design to optimise sustainability and cost effectiveness.
214210	Design equipment to isolate and purify products in continuous manufacturing processes, optimising reactions for scalability and efficiency.
214211	Design equipment to deliver a full range of in-process analytics to optimise monitoring and control.
214212	Design cost-effective continuous manufacturing equipment for lab-scale investigations and process development.
214213	Install continuous manufacturing equipment to optimise Active Pharmaceutical Ingredient (API) manufacturing processes.

Sustainability Officer

Sustainability Officers could become central figures in the future workforce, driving the adoption of sustainable practices across industries enabling the three pillars of sustainability: Economy, Society, and Governance (ESG.) In adopting sustainable solvent technologies, Sustainability Officers will shape strategies to support the transition to greener production methods, managing data and helping to analyse changes designed to improve the environmental performance of complex systems to avoid unintended negative consequences.

They will also help to facilitate cross-industry collaboration to overcome challenges in regulatory systems and Supply Chain issues, ensuring new technologies are economically viable and compliant.

While the Sustainability Business Specialist apprenticeship standard has some suitability to deliver the knowledge and skills required, capabilities relating to sustainable solvent technologies, regulatory compliance, and Supply Chain integration are required. These gaps could form the basis of future education and training programmes.

The capabilities outlined below are not currently included in the Sustainability Business Specialist apprenticeship standard, therefore could provide the basis of a curriculum for an industry specific CPD course.

FOP vs Provision	**57.9% fit with IfATE Sustainability business specialist (integrated degree) apprenticeship standard**
Capability ID	**Unmatched capabilities**
183300	Identify and analyse Stakeholders impacted by a proposed change, understand their perspectives and assess how their interests are best managed
214005	Develop a sustainability strategy focused on solvents within Active Pharmaceutical Ingredient (API) manufacturing.
210414	Utilise Artificial Intelligence (AI) tools for design, manufacturing, and planning support.
213704	Collaborate with research and development teams to integrate sustainable practices into medicine manufacturing.
206608	Enable the 3 pillars of sustainability (Economy, Society and Governance) and social value relating to sustainable solvent technologies.
214208	Create business models to enable sustainable solvent production, ensuring economic viability and environmental responsibility.
5020	Analyse changes designed to improve the environmental performance of complex systems and avoid unintended negative consequences.

3.5 New workforce capabilities required

The table below lists the 41 new challenge-specific future workforce capability statements defined through this foresighting cycle, with an overview of the number of FOPs which require these capabilities. This data highlights the anticipated demand for specific capabilities within the future workforce and overlap in skills across future job roles, providing valuable insights for the development of future education and training programmes.

Further details on the FOPs these capabilities correspond to can be found within the visualisation tool. [FOP Distribution link]

Capability ID within Visualisation tool	Organisational Function	Capability Statement	Total capability count across 22 FOPs
213979	DESIGN	Use computer software to ensure product specification and consistent testing, analysis, and results reporting.	5
213975	DESIGN	Develop processes or identify equipment needed for manufacturing production.	4
213976	DESIGN	Implement new processes, methodologies, and plant equipment to support product development and scale-up manufacturing	4
213996	DESIGN	Interpret technical and regulatory requirements to support new process development.	4
213973	DESIGN	Design bench or pilot production experiments to optimise product yield and minimise production costs	3
214207	DESIGN	Evaluate batch and continuous manufacturing options within process design to optimise sustainability and cost effectiveness.	3
213997	DESIGN	Identify criteria for product evaluation to ensure consistency, quality, and support decision-making.	3
213974	DESIGN	Conduct research to develop sustainable chemical engineering processes or production techniques	2
213977	DESIGN	Select equipment for continuous manufacturing processes to enhance efficiency using engineering design principles.	2
213989	DESIGN	Develop green chemistry methods to synthesise Active Pharmaceutical Ingredients (API)	2
213978	DESIGN	Select equipment based on manufacturing requirements to allow recycling and recovery of solvents.	2
213998	DESIGN	Redesign processes to reduce solvent volumes using continuous flow chemistry or microreactors.	2
214211	DESIGN	Design equipment to deliver a full range of in-process analytics to optimise monitoring and control.	2

Capability ID within Visualisation tool	Organisational Function	Capability Statement	Total capability count across 22 FOPs
214212	DESIGN	Design cost-effective continuous manufacturing equipment for lab-scale investigations and process development.	2
214007	DESIGN	Select appropriate solvents using the latest solvent guides to enhance sustainable manufacturing process design.	2
214210	DESIGN	Design equipment to isolate and purify products in continuous manufacturing processes, optimising reactions for scalability and efficiency.	1
213995	ENTERPRISE	Understand the foundations of the regulatory submission process to ensure effective conduct and documentation of planned trials or studies	4
213992	ENTERPRISE	Develop robust manufacturing processes by implementing data analytics techniques	3
213990	ENTERPRISE	Develop sustainable practices through effective communication and stakeholder engagement	2
213991	ENTERPRISE	Collaborate in setting sustainability KPIs for the wider organisation and understand their purpose	2
213987	ENTERPRISE	Select biodegradable, non-toxic, or other environmentally friendly raw materials for manufacturing processes.	2
214208	ENTERPRISE	Create business models to enable sustainable solvent production, ensuring economic viability and environmental responsibility.	2
214005	ENTERPRISE	Develop a sustainability strategy focused on solvents within Active Pharmaceutical Ingredient (API) manufacturing.	2
213988	ENTERPRISE	Evaluate how policies and legislation impact activities and assist in achieving United Nations Sustainable Development Goals (UNSDG) and Net Zero carbon emissions	1
214004	ENTERPRISE	Define and lead technology strategy to deliver the people plan, policy, and practices, considering risks, opportunities, impact, and value.	1
214008	ENTERPRISE	Define and agree on data sharing protocols, collaboration agreements, and data standardisation between industry Stakeholders.	1
213986	IMPLEMENT	Mix , pour, or use raw materials and gases according to safety standards or established operating procedures	4
213982	IMPLEMENT	Analyse data from experiments using alternative solvents to assess impact on water cycle, solvent extraction, and recovery processes.	3

Capability ID within Visualisation tool	Organisational Function	Capability Statement	Total capability count across 22 FOPs
213999	IMPLEMENT	Implement a technical decision-making framework to guide manufacturing process development.	3
214009	IMPLEMENT	Assess physical space conditions to ensure safety, compliance, and inform retrofit and facility design.	3
213984	IMPLEMENT	Develop lab-scale models of industrial-scale Active Pharmaceutical Ingredient (API) processes.	2
213985	IMPLEMENT	Mix raw materials and solvents in defined quantities in a controlled process operation.	2
214000	IMPLEMENT	Follow guidelines for the movement of goods and services to ensure efficient operations.	2
214213	IMPLEMENT	Install continuous manufacturing equipment to optimise Active Pharmaceutical Ingredient (API) manufacturing processes.	2
214214	IMPLEMENT	Qualify continuous manufacturing equipment to optimise Active Pharmaceutical Ingredient (API) manufacturing processes.	2
213994	LOGISTICS	Confer with research, quality, and manufacturing personnel to ensure the compatibility of design and production.	4
214006	LOGISTICS	Develop advanced models for recycling processes to separate solvents from complex waste streams.	1
214209	LOGISTICS	Identify new Supply Chains to ensure sustainable and reliable production of bio-solvents.	1
214002	SUPPORT	Operate automated equipment using Human-Machine Interfaces (HMI) and machine programming.	5
214003	SUPPORT	Design solvent capability into plant facilities, including recycling and Atmosphere Explosible (ATEX) ratings, to enhance safety and operational efficiency.	4
214001	SUPPORT	Manage control systems, including Human Machine Interfaces (HMI) and IT data systems to ensure operational efficiency.	2

Link to full data set - Visualisation Instructions

<table>
<tr><th>Visualisation Data Link</th><th>What is it and what can it be used for?</th></tr>
<tr><td>FOP Detail</td><td> 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 Level and linked FOP in the two available dropdowns. 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. </td></tr>
<tr><td>Future KSBs Summary</td><td> 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 FOP_detail page. This is used to: To review the identified Knowledge, Skill and Behaviour tags for a given capability, to support development of future education and learning material.
To review the requirements from a capability level, rather than a role level/occupational profile grouping.</td></tr>
<tr><td>Capabilities Matched to Current Provision</td><td> This page allows you to review and compare individual capabilities against 'Duty' statements in an Apprenticeship / Occupational Standard or equivalent Scottish Vocational Qualification (SVQs). 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. For this cycle, the agreed set of FOPs are additionally compared to selected Scottish Vocational Qualification frameworks (SVQs) and current go-to MSc and BSc degrees.
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 Apprenticeship 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. </td></tr>
</table>

Visualisation Data Link	What is it and what can it be used for?
Fit & Surplus Factors	*This page allows you to review the 'Fit' and 'Surplus' of Prototype Future Occupation Profiles (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 & 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 (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.*
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 (FOPs) or review all FOPs under a Role Level, 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 Levels and FOPs, from Job / Occupation level through to Knowledge, Skill and Behaviour level*

4. Conclusion and next steps

4. Conclusions and next steps

Section	Title
4.1	Summary of key insights
4.2	What this means for industry and the workforce
4.3	What this means for education
4.4	Recommended next steps

4.1 Summary of key insights

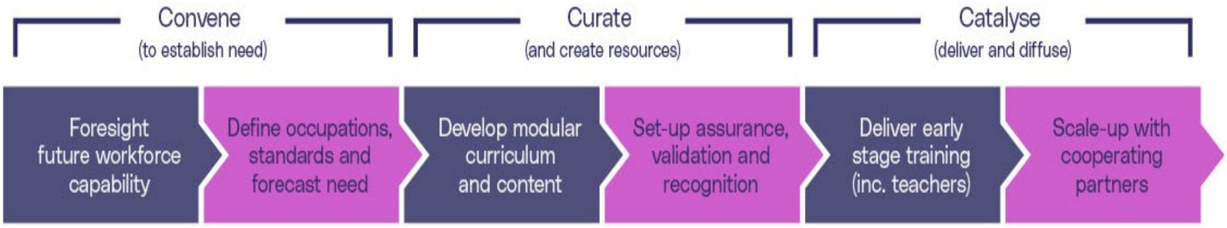
Achieving industry transformation to eliminate fossil-based solvents in API manufacturing requires strong leadership, consistent and strategic business investment, a deep understanding of solvent innovations, and the integration of sustainability throughout the design and development process. The foresighting analysis highlights the need to adapt particular apprenticeship and degree programmes and develop flexible CPD courses to equip the workforce with the necessary knowledge and skills for future demands.

- **Strong leadership:** Senior leaders within medicines manufacturing will need enhanced knowledge of solvent innovations and sustainability to assess financial and regulatory impacts, then lead the transition to sustainable medicines manufacturing. Modifying Supply Chains may result in unintended negative consequences for other industries, emphasising the need for skill-building and informed decision-making.
- **Cross-Sector Collaboration:** Collaboration across industry, centres of innovation, education and regulatory agencies, is crucial to deliver the required updates to solvent guides, navigate regulatory pathways, address workforce gaps and align curricula with industry needs.
- **Upskill the existing technical workforce:** There is a need to upskill existing employees, particularly Process Engineers and Chemists, in areas relating to solvent selection, continuous manufacturing and digital technologies, and life cycle analyses to deliver sustainability by design, which is essential to support the transition to greener production methods.
- **Key Roles:** Senior leaders, Process Chemists and Engineers, and Sustainability Officers will be instrumental in driving industry-wide change by facilitating informed decision-making and ensuring the compliance and economic viability of new technologies.
- **Technology Adoption:** The industry must prioritise the development and availability of suitable equipment for sustainable solvent technologies and process intensification, ensuring engineers are equipped to design and implement these innovations effectively. Digitalisation, AI, continuous manufacturing, and solvent recovery technologies will be key drivers of change and process optimisation.
- **Education Focus:** Education providers should adapt existing apprenticeship and degree programmes to incorporate knowledge and skills relating to sustainability and new solvent technologies, particularly in institutions serving API manufacturing clusters, develop flexible CPD curricula and foster knowledge-sharing across industry networks.

These conclusions emphasise the importance of building expertise within the workforce, engaging in cross-sector collaboration, and integrating sustainability into the core of drug development and manufacturing processes to drive industry transformation. Recommended actions include revising educational programmes, developing tailored CPD courses, and fostering cross sector collaboration, to ensure regulatory and Supply Chain challenges are overcome and the workforce is prepared for future challenges and deliver sustainability goals.

4.2 What this means for industry and the workforce

Foresighting has been developed to provide insight and the detailed information required to enable action by relevant Stakeholders but is the first step of the Skills Value Chain. Collective action will be required by all Stakeholders to ensure that the changes identified by foresighting – to the Supply Chain, the workforce and education provision are implemented.



This section summarises the actions required as a result of this foresight cycle.

Achieving the transformation of the medicines manufacturing industry to enable the elimination, substitution, reduction and recycling of fossil-based solvents through the development of API manufacturing processes requires strong leadership, clear sustainability strategy, and industry-wide collaboration. Leaders within the sector must gain expertise in solvent innovations and sustainability to assess the financial and regulatory implications of sustainable API manufacturing, to develop effective strategy and lead industry collaboration to minimise the environmental impact of production processes. The demand for sustainable solvent technologies will be primarily driven by medicines manufacturers seeking innovative solutions within solvent Supply Chains. However, modifying these Supply Chains may lead to unintended negative consequences for other industries, emphasising the need to build skills and expertise to support informed decision-making.

Effectively managing the regulatory process from the design stage will also be critical to ensure that new processes remain both compliant and efficient. Ongoing collaboration and communication with relevant regulatory agencies throughout this industry transformation is recommended.

Sustainability Officers could play a key role in the future workforce, promoting sustainable practices and facilitating collaboration across industries. By providing data to support leaders to analyse changes aimed at improving the environmental performance of complex systems, they enable informed decisions to drive the transition to sustainable production methods.

New capabilities in solvent selection, alongside digital technologies and AI, are essential to optimise production and support the economic viability of technological change. Process Engineers and Chemists must be skilled in life cycle analyses to assess the environmental impact of solvent technologies and incorporate these insights into new processes and facilities. The development of updated solvent guides will provide a helpful tool to inform this. Providing Process Engineers with the skills and knowledge to translate solvent recovery and recycling systems into the design of new plant facilities will enable the adoption of sustainable solvent technologies.

To further optimise manufacturing and enhance efficiencies, integrating continuous manufacturing technologies and digitalisation is key. However, these technologies are not widely used in API manufacturing, creating a gap in capabilities. Prioritising workforce upskilling or reskilling those with transferrable skills, to build this expertise could drive necessary advancements in the sector.

The availability of suitable equipment for sustainable solvent technologies presents a potential barrier to industry transformation. Equipment incorporating digital technologies for process design, minimising solvent use, and process intensification, such as continuous flow manufacturing or solvent recovery, is key to reducing reliance on fossil-based solvents. Equipment designers must develop new solutions. Engineers require new capabilities to evaluate emerging technologies with sustainability in mind, designing equipment for in-process analytics, solvent recovery, recycling, and elimination. These skills, combined with a focus on effective cross-industry collaboration to tackle regulatory and Supply Chain issues, will help deliver the industry's transition to greener production methods.

In summary, while some sustainability knowledge exists at the industrial level, there is a lack of understanding across the workforce to implement sustainability in a coordinated, whole-systems approach. To meet sustainability and Net Zero goals, each organisational function must be equipped with the skills to assess their role, similar to established industry practice in quality and regulatory affairs. To enable this, new capabilities must be developed across the workforce to empower organisations to develop effective sustainability strategies, integrate sustainability into the design of API manufacturing processes, and collaborate with regulatory agencies to define a path to regulatory approval for new solvents and processes. The design of equipment to deploy these new processes, particularly those that eliminate or recycle solvents, is also required. Specific roles within the workforce will drive these changes and should be prioritised in workforce development plans. It is recognised that the FOPs identified through this cycle may be delivered through one role in some employers, however in other organisations several FOPs may be delivered by one employee, depending on the size of the organisation.

Workforce development should focus on upskilling existing staff, particularly senior leaders, process chemists, and engineers, as well as exploring opportunities to recruit and reskill talent from other sectors with experience in continuous flow manufacturing and solvent recovery. Integrating these skills into education programmes is essential to building the future talent pipeline and making sustainability standard practice across the sector.

Employers should review the recommendations in this report and collaborate with education partners and apprenticeship groups to revise existing programmes, incorporating sustainable solvent technologies. This should include the development of short, flexible Continuing Professional Development (CPD) courses to upskill the workforce. Additionally, increasing the number of Sustainability Officers, particularly in larger organisations, should be considered.

Investing in building the necessary knowledge and skills now is critical to facilitating industry transformation and the adoption of new solvent technologies. Cross-industry collaboration across the entire Supply Chain, including regulatory agencies, will be essential to achieve these goals.

4.3 What this means for education

The analysis of capabilities and FOPs derived from this foresighting cycle reveals that adaptation of existing apprenticeship programmes and degrees, alongside the development of short, flexible CPD courses, is required to meet future workforce demands. It is recommended insights are incorporated into the curriculum for the identified apprenticeship standards. While education and training providers which serve relevant industry clusters should engage with industry partners, to explore opportunities to incorporate the recommended knowledge and skills into identified programmes, expand delivery, and develop specific CPD programmes to meet industry needs. The FOPs and education programmes identified in section 3.4 of this report are recommended as an area for particular focus and provider review. However it is recommended that educators also review the full FOP detail within the data visualisation tool, to inform plans.

The UK Biopharma workforce is highly skilled with roles typically requiring advanced qualifications including degrees and postgraduate training. This study identified a requirement for additional education and training provision at qualification levels 4 to 7 (SQCF levels 6-11). Therefore, the findings of this report will have relevance to Further Education, Higher Education, and Independent Training Providers.

To develop the capabilities outlined in the future occupational profiles for Process Engineers and Process Chemists, it is recommended that a review be conducted of both the Science Industry Process and Plant Engineer (degree) apprenticeship standard and the BEng Chemical Engineering degree programmes. Recognising that not all providers of BEng Chemical Engineering may be positioned to implement curriculum changes, it is advisable to prioritise those institutions serving API manufacturing industry clusters. For these providers, the integration of modules focused on the identified capability gaps listed in section 3.4, is advised, either incorporated into existing programmes or offered as industry-specific short courses.

In addition to formal education programmes, educators should consider developing short, flexible CPD courses to upskill the existing workforce or reskill individuals with transferrable skills from other industries. Specific leadership development programmes should be created to deepen understanding of sustainability in this context and solvent innovations. These courses should equip leaders with the necessary knowledge to evaluate the financial and regulatory impacts of sustainable API manufacturing processes, empowering them to formulate strategy and lead collaborative efforts to transform the industry to reduce the environmental impact of production processes.

Furthermore, CPD courses targeting technical staff should focus on the application of sustainable solvent technologies and process intensification, including continuous flow manufacturing and solvent recovery, during the design and development of API manufacturing processes. These courses should also equip learners with the knowledge required to conduct and apply learnings through life cycle analyses and foster skills relating to digitalisation and human-machine interfaces. These initiatives will play a crucial role in preparing the workforce for the challenges and opportunities of a more sustainable future in API manufacturing. The insights presented in Section 3.5 of this report can serve as a valuable foundation for developing course curricula.

Educators should proactively engage with industry networks to facilitate knowledge sharing, particularly relating to equipment design for sustainable API manufacturing. This collaboration can enable design of equipment which incorporates a full range of in-process analytics, enabling the optimisation of monitoring and control. Through building knowledge to empower equipment manufacturers to develop cost-effective continuous manufacturing equipment suitable for lab-scale investigations and API manufacturing process development, academic and industry Stakeholders can be aligned to advance sustainable manufacturing practices.

Educators are encouraged to review the detailed insights within this report and the accompanying data visualisation tool to inform plans and identify opportunities to more closely align education and training provision with industry requirements.

4.4 Recommended next steps

To ensure the sector remains competitive and can meet future workforce demands, the following actions are recommended in response to this report:

1. **Dissemination of Findings:**
    - Share the findings of this skills report with relevant industry strategy groups to determine priorities. These groups can support to map out demand, focus areas, and timelines for industry developments to guide the scale and pace of change.
2. **Industry-Education Partnerships:**
    - Establish partnerships between industry and education providers to deliver the recommendations of this report to address skills gaps within the sector.
3. **Integration into Apprenticeship Standards:**
    - Explore opportunities to incorporate insights from the report into the review of the Science Industry Process and Plant Engineer degree apprenticeship standard and inform the updated curricula.
4. **Engagement with Relevant Programme Providers:**
    - Engage with providers of relevant degree programmes, such as BEng Chemical Engineering, particularly those serving relevant industry clusters, to incorporate the identified insights into existing and future courses.
5. **Development of CPD Programmes:**
    - Use capabilities identified through this cycle, and supporting data within the data visualisation tool to develop tailored CPD programmes to upskill the current workforce and reskill individuals transitioning from other industries. Collaborate with industry partners to identify priority areas and scale of demand.
6. **Expansion of Technical Education Delivery:**
    - Identify opportunities to expand the delivery of relevant technical education, particularly in the devolved nations, ensuring that skills are delivered at the right time and place to meet industry demand. Utilise insights from data visualisation tool to shape curriculum.
7. **Knowledge Sharing with Industry Networks:**
    - Encourage educators to engage with industry networks to share knowledge, particularly regarding equipment design for sustainable API manufacturing. Industry collaboration should also address updating current solvent guides to incorporate sustainable solvents, and partnership with regulatory bodies to avoid barriers to the adoption of new technologies.
8. **Additional Workforce Foresighting**
    - This cycle primarily concentrated on the development, scale-up, and intensification of new API manufacturing processes within the process development phase. It did not consider any change being integrated into existing commercial manufacturing processes. Further investigation into the workforce implications of this technology change is recommended.

Through continuing collaboration and delivery of these actions, the sector will be better positioned to address future workforce needs, support ongoing innovation to deliver more sustainable medicines manufacturing, and maintain UK competitiveness in this sector.

5. Appendix

5. 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
5.6	Visualisation tool Fit & Surplus factor process details

5.1 List of Participants

Industry Participants	Skills Participants	Technology Participants
GSK	Heriot-Watt University	CPI
High Force Research	Scottish Colleges Science Group	Heriot-Watt University
Industry Consultant	Skills Development Scotland	Pharmaceutical Environment Group (PEG)
Johnson & Johnson	University of Leeds	University of Leeds
Medicines Manufacturing Industry Partnership	University of Strathclyde	University of Strathclyde
Pfizer	University of York	University of York
Sterling Pharma Solutions	IfATE	Office for Life Sciences

5.2 Cycle timeline

Workforce Foresighting cycle started the Carry Out phase in November 2024. The Carry Out phase concluded in February 2025. The Findings report was prepared following the data validation period and published in March 2025.

5.3 Access to output data - link and authorisation

Data Capture Overview

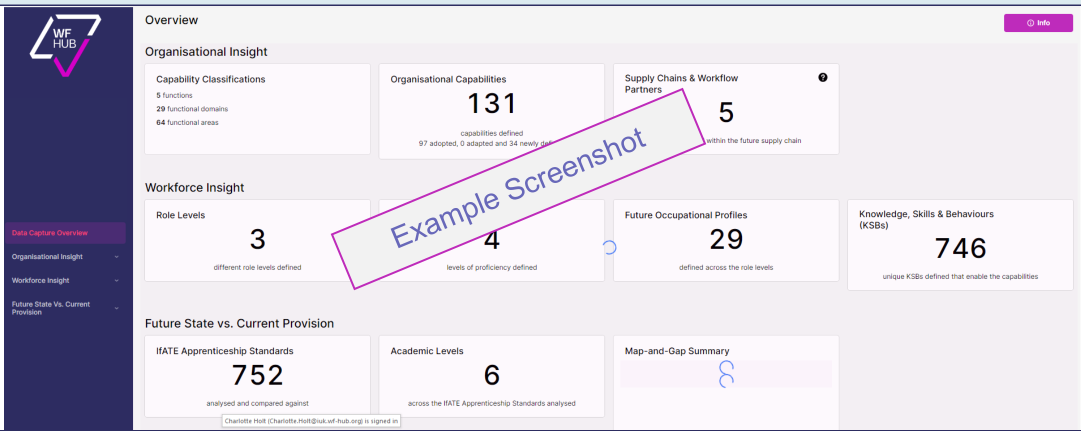
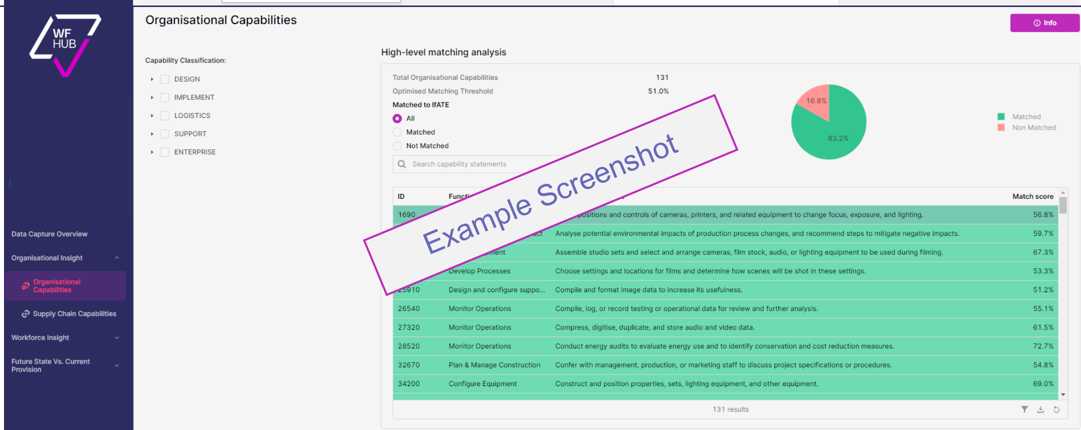
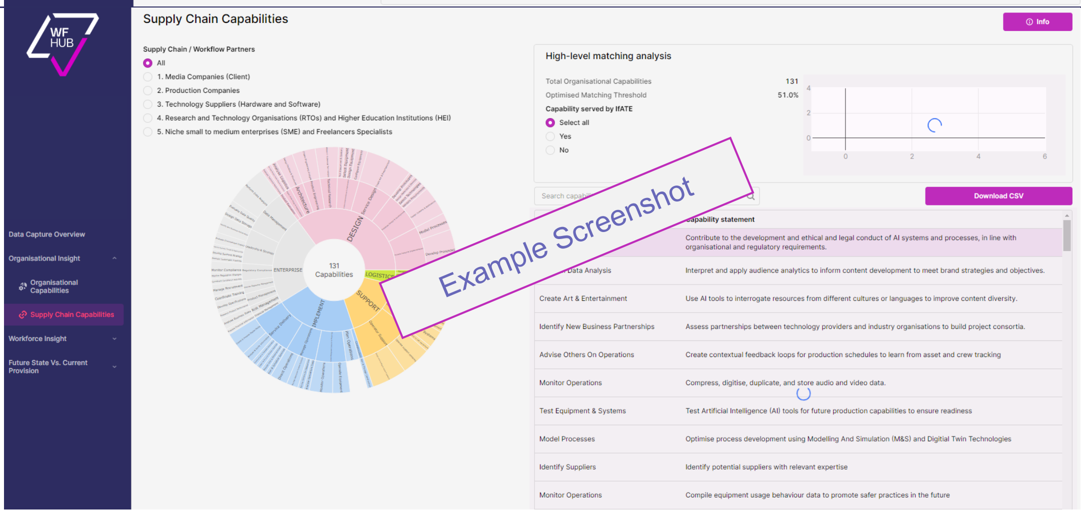
5.4 Glossary

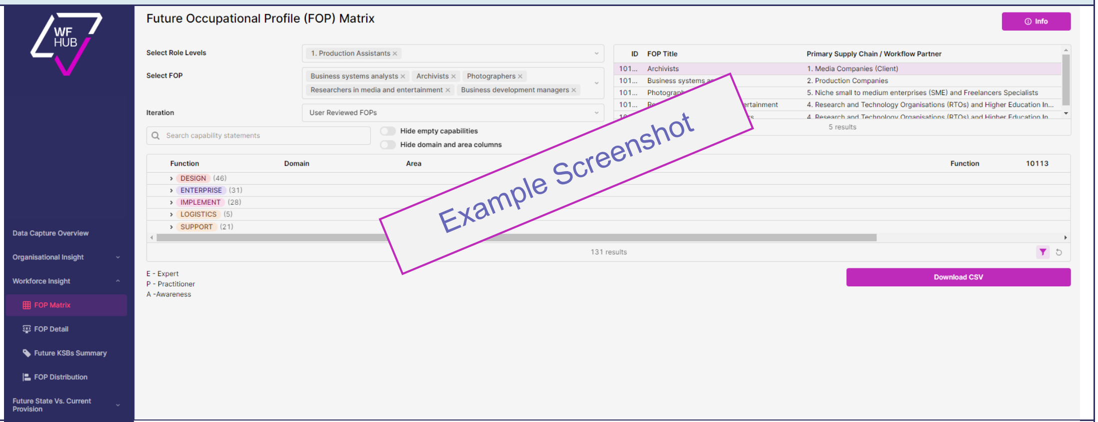
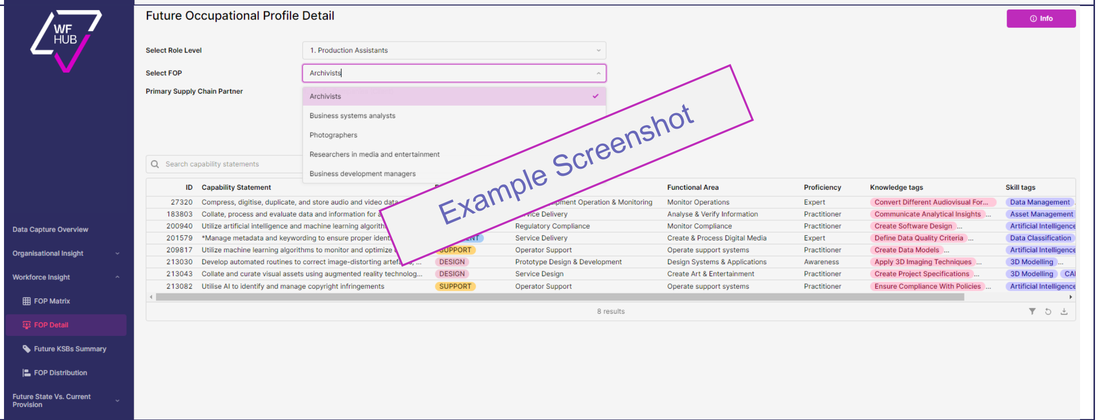
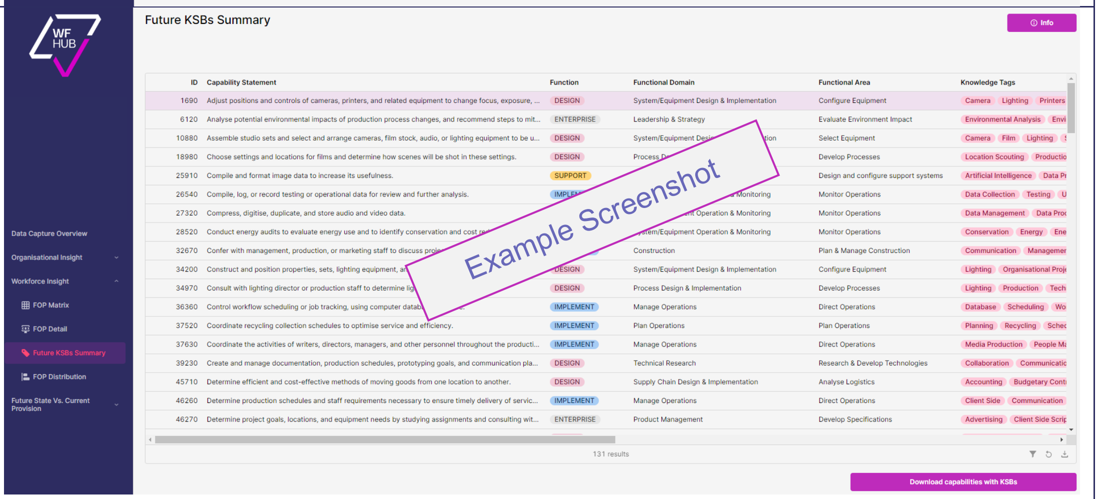
Term	Definition
Active Pharmaceutical Ingredient (API)	The primary substance in a pharmaceutical drug that is responsible for its therapeutic effect on the body
Challenge Response	Specific intervention aimed at the challenge
Capability (Organisation)	The collective abilities, and expertise of an organisation 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
Carbon Accounting	The process of measuring, tracking, and reporting greenhouse gas emissions produced by an organisation or activity
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
CPD	Continued Professional Development
Delphi Process	Foresighting takes a Delphi approach which has come to represent consulting expert opinion. (Harking back to the Delphic Oracle of ancient Greece)
Environmental, Social and Governance (ESG)	Criteria used to evaluate an organisation's operations and impact, focusing on environmental practices, social responsibility, and governance structure to promote sustainability and ethical business behaviour
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 KSB output from the Educator workshop for each Role Group
Green Chemistry Principles	Guidelines for designing chemical processes and products that reduce or eliminate the use of hazardous substances, minimise waste, and have a lower environmental impact.
Greenhouse Gas (GHG)	Gases that trap heat in the Earth's atmosphere, contributing to global warming and climate change, including carbon dioxide, methane and nitrous oxide
Impact Domains	Innovate UK domains used as Strategic Categories to assist setting and monitoring priorities
Life Cycle Assessment (LCA)	A method used to evaluate the environmental impact of a product or service throughout its entire life cycle, from raw material extraction to production, use, and disposal or recycling

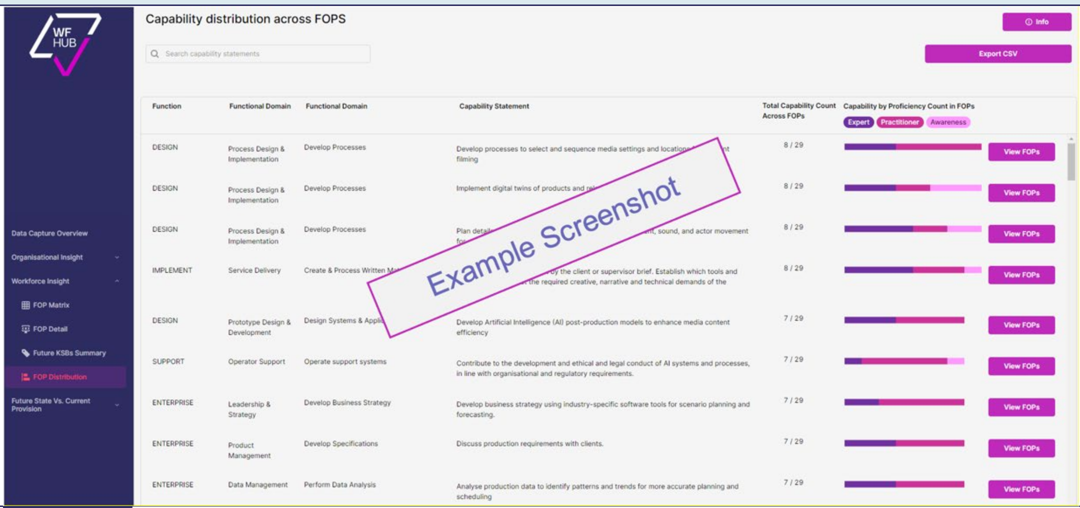
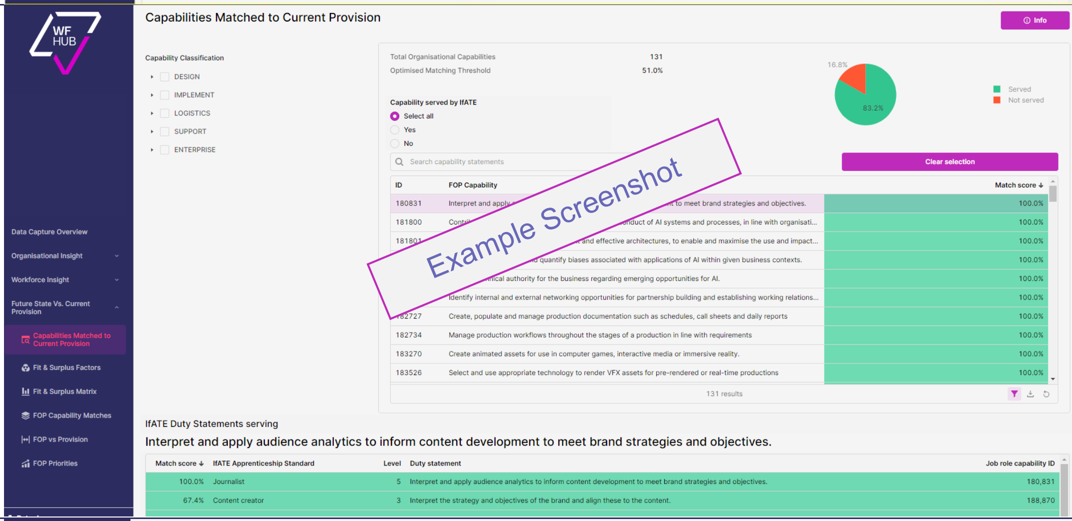
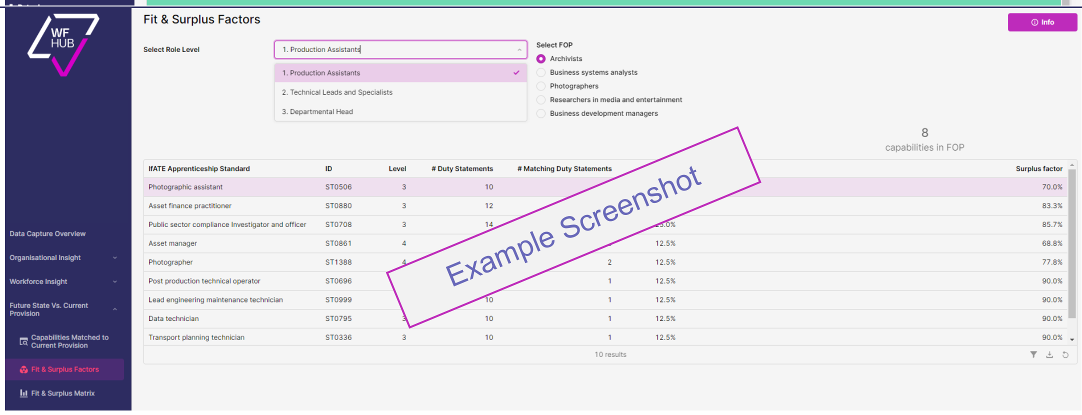
Term	Definition
Map and Gap Analysis	A combined expert and automated process that maps the Future Competency Set against a selected reference framework
National Challenge (Industry / Sector / Region)	A recognised technological or socio-political threat or opportunity for which there is consensus that workforce action is necessary
National Health Service (NHS)	The publicly funded healthcare system in the United Kingdom
Net Zero	The UK's commitment to reducing greenhouse gas emissions to as close to zero as possible by 2050
Organisation Type	Simple description of nature of organisation for which capability is required
Participants	Technologists, Educators, Employers
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
Roadmaps	Sector, Industry, Regional view of emerging opportunities and their market entry
Role Group	Role groups are a collective of roles that exist in a typical manufacturing business / industrial sector
Scottish Credit and Qualifications Framework (SCQF)	The SCQF is the qualifications framework for Scotland. It is used to describe and compare different levels of qualifications
Scope 3 emissions	Indirect greenhouse gas emissions that occur in a company's value chain, including those from suppliers, product use, and disposal
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

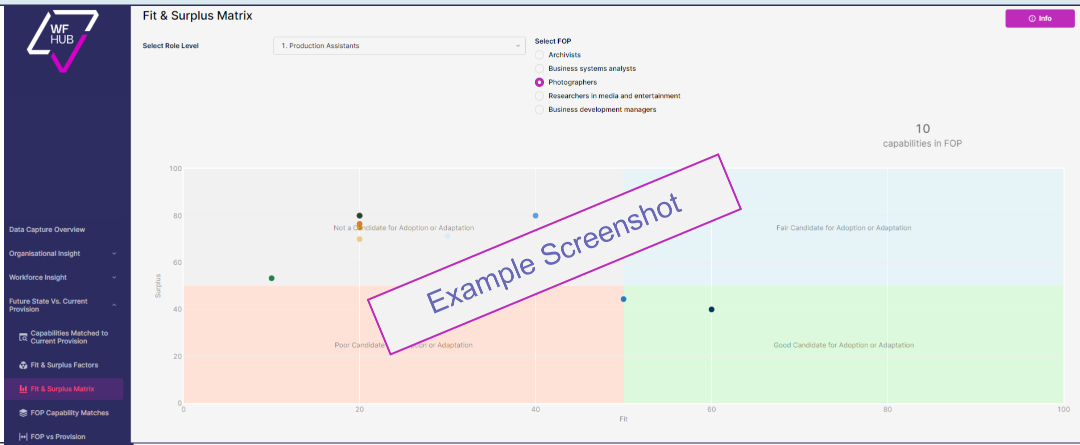
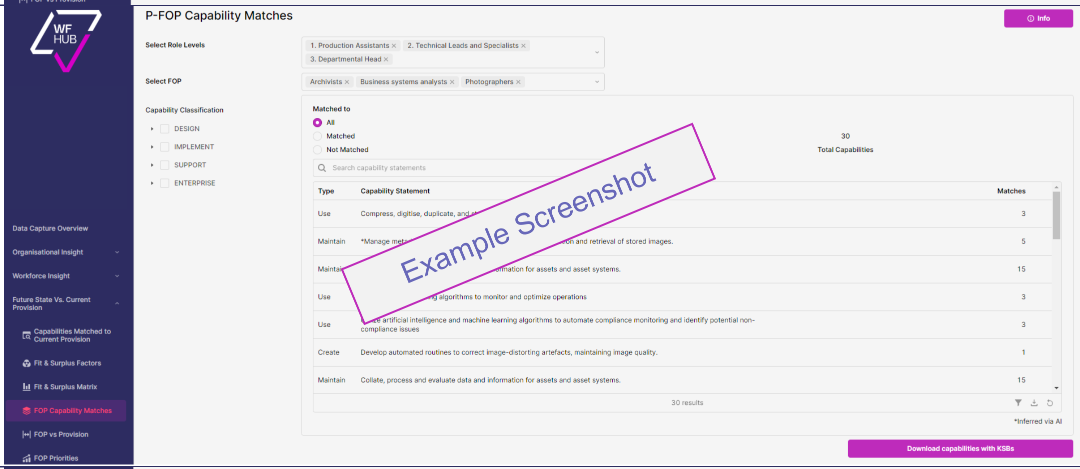
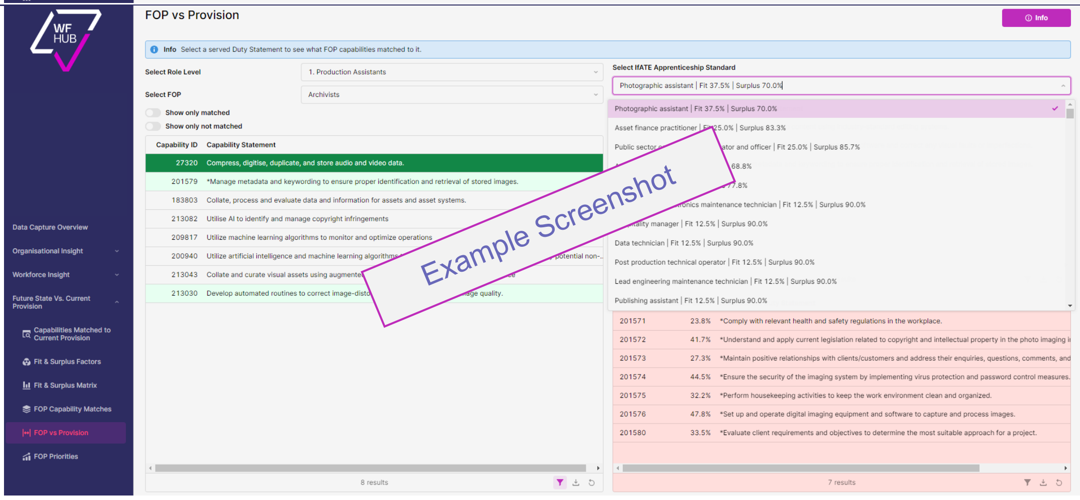
5.5 – Visualisation links and Illustrations

Images are not cycle specific and just for guidance purposes

Link to Visualisation	View of data
[Data Capture Overview]()	
[Organisational Capabilities]()	
[Supply Chain Capabilities]()	

Link to Visualisation	View of data
[FOP Matrix]()	
[FOP Detail]()	
[Future KSBs Summary]()	

Link to Visualisation	View of data
FOP Distribution	
Capabilities Matched to Current Provision	
Fit Surplus Factors	

Link to Visualisation	View of data
[Fit_Surplus Matrix]	
[FOP Capability Matches]	
[FOP vs Provision]	

<table>
<tr><th>Link to Visualisation</th><th>View of data</th></tr>
<tr><td><u>FOP Priorities</u></td><td>
</td></tr>
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5.6 Visualisation tool Fit & Surplus factor process details

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.

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

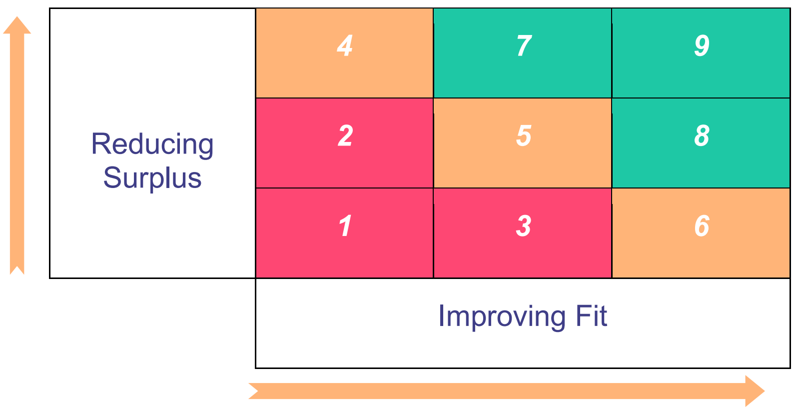

Figure 1: Fit Factor scores and Suitability Grid

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

High Suitability – 7,8,9 – for standards that have good coverage of FOPs.
Represents good candidates from current apprenticeship 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, which 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 apprenticeship 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.

This high-level suitability summary compares the best 10 matching current IfATE qualifications or apprenticeship standards or Scottish equivalent and gives the current suitability summary in the table below.

The below table counts the top 10 best fit IfATE standards or equivalent Scottish Vocational Qualifications (SVQs) by suitability score for each FOP. The table identifies if they have low, some or high suitability and colour-coded their overall suitability.

Role Level	Primary Supply Chain / Supply Chain partner	Future Occupation Profile	Low Suitability	Some Suitability	High Suitability	Overall Suitability RAG
Apprentices/Technicians	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers	Laboratory Technician	1/10	9/10	0/10	Some
Apprentices/Technicians	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers	Science Manufacturing Technician	0/10	6/10	4/10	Some
Apprentices/Technicians	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers, Equipment Manufacturers	Warehouse Operative	2/10	8/10	0/10	Some
Scientists/Engineers	Equipment Manufacturers	Equipment Design Engineer	2/10	8/10	0/10	Some
Scientists/Engineers	Medicines Manufacturers, CDMOs/ CROs, Equipment Manufacturers	Digital Modeler/Data Scientist	5/10	5/10	0/10	Low
Scientists/Engineers	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers	Development Analytical Chemist	3/10	7/10	0/10	Some
Scientists/Engineers	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers	Hazard Evaluation Chemist	4/10	6/10	0/10	Low
Scientists/Engineers	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers	Manufacturing, Science and Technology (MSAT) Chemist	3/10	7/10	0/10	Low

Role Level	Primary Supply Chain / Supply Chain partner	Future Occupation Profile	Low Suitability	Some Suitability	High Suitability	Overall Suitability RAG
Scientists/Engineers	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers	Process Development Chemist	4/10	4/10	2/10	Some
Scientists/Engineers	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers	Process Engineer	2/10	8/10	0/10	Some
Scientists/Engineers	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers	Process Leader	3/10	7/10	0/10	Low
Scientists/Engineers	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers	QC Analyst	3/10	6/10	1/10	Some
Scientists/Engineers	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers Equipment Manufacturers	Software/Automation Engineer	5/10	5/10	0/10	Low
Senior Managers/Managers	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers	Facilities/Operations Manager	7/10	3/10	0/10	Low
Senior Managers/Managers	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers Equipment Manufacturers	Quality Manager	8/10	2/10	0/10	Low
Senior Managers/Managers	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers Equipment Manufacturers	Senior Leader	6/10	4/10	0/10	Low
Senior Managers/Managers	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers Equipment Manufacturers	Supply Chain Manager	6/10	4/10	0/10	Low
Senior Managers/Managers	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers Equipment Manufacturers	Sustainability Officer	5/10	5/10	0/10	Low

Role Level	Primary Supply Chain / Supply Chain partner	Future Occupation Profile	Low Suitability	Some Suitability	High Suitability	Overall Suitability RAG
Senior Managers/Managers	Medicines Manufacturers, Equipment Manufacturers	Regulatory Affairs Officer	1/10	9/10	0/10	Low
Senior Scientists/Senior Technical Leads	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers	Senior Process Chemist	1/10	9/10	0/10	Some
Senior Scientists/Senior Technical Leads	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers	Senior Process Engineer	0/10	10/10	0/10	Some
Senior Scientists/Senior Technical Leads	Medicines Manufacturers, CDMOs/ CROs, Fine Chemical/ Solvent Manufacturers	Senior QC Scientist/Analytical Chemist	0/10	10/10	0/10	Some