



Workforce
Foresighting
Hub

Driving Sustainability in Medicines Manufacturing.

**Transforming Existing API Manufacturing
Processes and Facilities to Enable the
Transition to Sustainable Medicines
Manufacturing**

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Acknowledgements

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

Skills England (formerly IfATE – Institute for Apprenticeships and Technical Education, England)

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

ONet – Occupational Networks Online, USA

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

This report was produced following workshops undertaken October 2025-February 2026 using the data set and tools available at that time.

Executive Summary

This report outlines findings from the Workforce Foresighting cycle focussing on ***Transforming Existing API Manufacturing Processes and Facilities to Enable the Transition to Sustainable Medicines Manufacturing***. This study was conducted by the Centre for Process Innovation (CPI) in collaboration with the Workforce Foresighting Hub, an Innovate UK initiative.

Workforce foresighting is a systematic 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.

Strategic context and purpose for Workforce Foresighting

The pharmaceutical sector must rapidly decarbonise active pharmaceutical ingredient (API) manufacturing to meet the UK's Net Zero Strategy (HM Government, 2022), Industrial Decarbonisation Strategy (HM Government, 2021), UK Life Sciences Vision (HM Government, 2021) and NHS Net Zero targets (NHS England., 2025). Current processes rely heavily on fossil-based solvents and outdated technologies, making solvent use one of the most carbon-intensive aspects of medicine production.

Regulatory momentum has been building fast to address this: from April 2027, mandatory carbon reduction plans and full product carbon footprints must be published by pharmaceutical suppliers, as part of the NHS Carbon Foot Printing Guidelines (NHS England, 2020). Additionally, the MHRA has started to promote sustainable manufacturing practices, and environmental, social and governance (ESG) reporting continues to push companies to embed sustainability across operations—from energy use to waste management.

As a result, industry has begun to adopt bio-based solvents, closed-loop recovery systems, and digital sustainability tools—technologies with the potential to substantially reduce emissions and waste while improving resource efficiency. These solutions are technically viable and advancing toward Horizon 2 (2028–2030), where they are expected to be deployed at scale within existing GMP facilities. However, successful adoption requires significant upskilling across green chemistry, regulatory change management, process optimisation, lifecycle analysis, and the integration of new digital tools.

The sector knows it must change—but lacks the tools to do so. There's a growing awareness of sustainability, but current efforts are fragmented. Training exists in areas like Life Cycle Assessment and carbon accounting, but it is not tailored to the unique challenges of pharmaceutical manufacturing.

This cycle therefore aims to understand and define the future organisational capabilities, workforce roles, and skills required to transition existing API manufacturing toward sustainable solvent systems. Through Workforce Foresighting, the goal was to get ahead of the skills curve—ensuring that the UK has a prepared, capable workforce ready to enable this technological and environmental transformation across the medicines manufacturing ecosystem.

Participants and Stakeholders

This research reflects a collaborative effort across a diverse group of stakeholders who each play a vital role in shaping the transition toward sustainable solvent adoption in API manufacturing. Contributors and Cycle Sponsors included organisations involved in technology development, pharmaceutical manufacturing, regulatory and policy influence, and skills and education provision. Their collective insights, expertise, and evidence have been instrumental in shaping the findings of this cycle.

We extend our thanks to all participating organisations for their time, commitment, and valuable contributions, which will help support meaningful progress across the sector.

Technology Participants	Industry Participants	Skills Participants
CPI	Johnson & Johnson	CPI
Johnson & Johnson	AstraZeneca	Skills Development Scotland
AstraZeneca	GSK plc	
GSK plc		
Office for Life Sciences		
Celtic Renewables		
Syngenta		

Table 1 Participants and Stakeholders

Summary of Findings

This Workforce Foresighting cycle identified the critical organisational capabilities, workforce roles and skills required to enable the transition of existing API manufacturing processes and facilities towards more sustainable medicines manufacturing. A total of 107 future capabilities were identified and incorporated into 15 Future Occupational Profiles (FOPs) spanning the full skills value chain, from biobased solvent development through to regulatory assurance and digital enablement.

Employers: Sustainable API manufacturing represents a system level transformation. Organisations will need to strengthen knowledge and skills across solvent substitution and recovery, ESG-aligned decision making, regulatory compliance, digital manufacturing; and most importantly, how these capabilities interact and influence each other. The analysis highlighted four key occupations that are influential in this collaboration, which are currently underserved by existing training provision. Employers are therefore encouraged to prioritise targeted upskilling, invest in cross-functional capability development, and engage early with technology providers and regulators to reduce adoption risk and accelerate implementation.

Educators: Current apprenticeship, degree and postgraduate programmes provide a strong technical foundation, but do not consistently address interdisciplinary capabilities such as green chemistry in regulated environments, solvent recovery and circularity, lifecycle assessment, and GMP digital validation. The findings indicate a need for enhanced curriculum content and flexible continuous professional development (CPD) provision that supports both new entrants and the existing workforce. Embedding these foresighting insights into curriculum design will enable educators to deliver training that addresses industry gaps, ensuring learners are equipped to enter the workforce with the knowledge and skills to support the transition to sustainable medicines manufacturing at scale.

To summarise, the findings demonstrate that while many of the enabling technologies already exist to a certain extent, widespread adoption will be constrained without parallel investment in workforce capability and upskilling in the following sectors: regulatory compliance, solvent recovery and circularity, digital validation, and sustainability led leadership. Executive level roles, in particular, are paramount in influencing strategic investment, skills development priorities and cross-sector collaboration.

Next Steps

The next phase following this Workforce Foresighting cycle should focus on translating insight into coordinated action across industry, education and regulatory bodies. Priority should be given to addressing the most significant workforce capability gaps through curriculum enhancement, while learning maintenance packages can be developed in the longer term.

Employers: Inform strategic workforce planning, investment decisions and capability building initiatives that support the adoption of sustainable API manufacturing technologies within existing GMP environments. Engagement with regulators, standards bodies and supply chain partners should be strengthened to align evidence generation, clarify regulatory expectations and reduce adoption risk.

Educators: Guide curriculum evolution and the development of flexible, applied learning provision. Short-course CPD, modular training and updates to existing apprenticeship and degree pathways should be prioritised to address high industry demand and neglected capability areas. Ongoing collaboration with industry will be essential to ensure provision remains relevant, applied and aligned with sector-wide implementation challenges.

Maintenance: Continued workforce foresighting and monitoring will be critical. As technologies mature and regulatory frameworks evolve, capability requirements will continue to change. Regular review of workforce needs, education provision and adoption progress will help ensure that skills development remains aligned with sector transformation, enabling the delivery of compliant, scalable and sustainable medicines manufacturing over the long term.

Glossary

Term	Definition
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
EMA	European Medicines Agency
ESG	Environmental, Social and Governance
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
GMP	Good Manufacturing Practice
ISO	International Organization for Standardization
Map and Gap Analysis	A combined expert and automated process that maps the Future Competency Set against a selected reference framework
MHRA	Medicines and Healthcare products Regulatory Agency.
National Challenge (Industry / Sector / Region)	A recognised technological or socio-political threat or opportunity for which there is consensus that workforce action is necessary
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
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

Table 2 Glossary

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1. Introduction



1. Introduction

1.1 Introduction to Workforce foresighting

Workforce foresighting is essential in addressing the skills challenge, by aligning the skills value chain—from early education through to advanced training—with the demands of emerging technologies. By identifying FOPs and the capabilities required for new roles, foresighting enables educators, employers, and policymakers to proactively adapt curricula, qualifications, and training pathways. This ensures the workforce is not only prepared for technological change but also equipped to drive innovation and productivity. In doing so, it transforms the skills gap from a reactive challenge into a strategic opportunity for national growth and resilience.

This report outlines findings from a Workforce Foresighting cycle focused on **Transforming Existing API Manufacturing Processes and Facilities to Enable the Transition to Sustainable Medicines Manufacturing**. The study was conducted by Centre for Process Innovation (CPI), in collaboration with the Workforce Foresighting Hub, an Innovate UK initiative. This report was designed to support strategic decision making and inform the next steps on the Skills Value Chain.

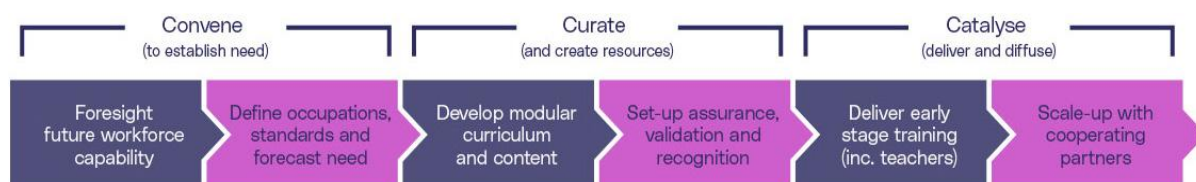


Figure 1 Skills Value Chain

1.2 Defining the Workforce Foresighting Topic

This workforce foresighting topic focused on the capabilities required to transition existing API manufacturing to sustainable solvent systems, including bio-based solvents, closed-loop recovery technologies and supporting digital sustainability tools.

Delivery of this transition was assessed based on coordinated capability across five key supply chain partners: bio-based solvent manufacturers developing renewable solvent alternatives; solvent recovery system providers engineering closed-loop recycling solutions; pharmaceutical manufacturers integrating these technologies into GMP facilities; digital technology providers enabling data-driven optimisation and lifecycle analysis; and regulatory and standards bodies updating guidance to support safe and compliant adoption.

This cycle explored how roles, skills and interfaces across these partners must evolve to enable scalable, future-ready implementation.

2. Findings & Insights



2. Findings and Insights

This report outlined a three-step foresighting process to understand how emerging technologies were expected to reshape supply chain capabilities and workforce needs.

- **Industry:** First, it explored how organisational capabilities must evolve to enable the adoption/deployment of new and emerging technology, identifying which supply chain partner and functions will be most impacted.
- **Workforce:** Next, these capabilities were grouped into FOPs, which show the occupations that will need to change.
- **Provision:** Finally, the FOPs were compared against current education and training provision—using Skills England occupational standards as a benchmark—to identify where existing programmes align and where gaps exist.

The report summarised priority capabilities, FOPs, and knowledge, skills, and behaviours (KSBs). Full details of the data and findings are available in the appendix and visualisation tool.

Introduction to 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 identify existing standards which align to 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 was generated by the foresighting cycles, integrating the expertise of technologists/domain specialists, employers, and educators. The data can be used to inform the development of future curricula 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.

Links to the [Workforce Foresighting Visualisation Tool](#)

Detailed instructions on how to use the Visualisation Tool¹ can be found in the appendix ([Appendix A Visualisation tool and instructions for use](#)).

¹ Visualisation tool <https://hvmcatapultforesighting.retool.com/embedded/public/e869283b-4b8a-437c-973e-64ab292e5b87?token=97f32699b61bd02b863f006b3dbc6e28>

2.1 Industry - Identified Organisational Capabilities

Capabilities Identified

Exploration of organisational changes provided insights into how organisations would need to adapt their existing capabilities to implement the solutions that responded to the challenge addressed by the foresighting project.



Insight:

During the data gathering and analysis phase, 107 unique future organisational capabilities were identified. These capabilities were then used as the basis of further analysis through the research approach. Majority of the capabilities followed eight themes that are listed below. These themes indicate potential areas of focus. But detailed analysis of the individual capabilities is always encouraged for decision making.

The eight themes identified are as follows:

1. Process and Technology Development

Approximate coverage: 74 capabilities

This theme encompassed the design, optimisation and continuous improvement of manufacturing routes and associated technologies. It includes the development of bio-solvents, the application of biocatalysis, and the integration of membrane purification and recovery technologies. A strong emphasis was placed on embedding sustainability principles directly into process and technology design to support efficient scale-up and operational performance.

2. ESG, Sustainability and Environmental Impact

Approximate coverage: 69 capabilities

Capabilities within this theme addressed environmental performance, sustainability strategy and compliance with ESG-related expectations. Key areas included lifecycle assessment, environmental monitoring, emissions tracking and resource-efficiency optimisation. The theme also covered solvent recovery, substitution and recycling practices aimed at reducing the environmental footprint of pharmaceutical manufacturing.

3. Digital, Data and Artificial Intelligence

Approximate coverage: 53 capabilities

This theme related to the deployment of digital technologies, data analytics and AI-enabled tools to enhance process understanding and decision-making. It covered the use of digital twins, predictive maintenance methods and advanced analytical models for forecasting and optimisation. Additionally, it included digital governance frameworks and dashboards to support operational, quality and sustainability outcomes.

4. Solvent and Materials Science

Approximate coverage: 46 capabilities

Capabilities in this theme focused on solvent selection, validation and performance assessment, with particular emphasis on bio-based alternatives. It also included membrane design and purification technologies that support solvent recovery and purity requirements. The theme reflected the fundamental materials science considerations necessary for advancing solvent innovation in pharmaceutical applications.

5. Quality, GMP and Compliance

Approximate coverage: 40 capabilities

This theme covered regulatory compliance, quality assurance and GMP-aligned operational practices. It included system and equipment validation, adherence to regulatory standards (e.g., ISO, MHRA, EMA), and the preparation of comprehensive documentation to support compliant manufacturing activities. Digital system validation also formed part of the capability landscape.

6. Facilities, Equipment and Infrastructure

Approximate coverage: 30 capabilities

This theme related to the design, construction and management of manufacturing facilities and equipment. It covered equipment selection, acceptance testing, and compliance with pharmaceutical and GMP requirements. Capabilities also included the operation and maintenance of recovery systems and other critical infrastructure necessary for safe and sustainable manufacturing operations.

7. Training, Documentation and Change Management

Approximate coverage: 12 capabilities

This smaller but strategically important theme focused on supporting organisational change through training, documentation and communication. It included workforce development, the creation of standard operating procedures (SOPs) and manuals, and the development of certification and awareness building materials to ensure consistent adoption of new or updated processes.

8. Supply Chain, Sourcing and Suppliers

Approximate coverage: 6 capabilities

This theme encompassed strategic sourcing, supplier qualification and broader supply chain planning and collaboration. Capabilities included aligning suppliers with sustainability and regulatory expectations, ensuring availability of bio-based solvents, and anticipating future material and capacity needs to support long-term operational resilience.

2.1.1 Future Supply Chain

To understand how supply chains were expected to evolve in response to emerging technologies, a forward-looking view of what future supply chain operations was created and compared to how they function today. This comparison helped to highlight the areas where change was required to meet new demands and opportunities.

Throughout the process, engagement with participants supported the identification of which **supply chain partners** would be affected by the technology in question. This ensured that the analysis was grounded in real-world contexts and reflected the full ecosystem of organisations involved. The supply chain partners related to the analysis are as follows:

Bio-Based Solvent Manufacturers

These partners develop and supply renewable, pharmaceutical-grade solvents designed to replace fossil-based alternatives. In Horizon 2, they are responsible for scaling production, ensuring consistent GMP-compliant quality, and generating analytical and safety data needed to support regulatory acceptance. They also provide documentation, certification, and technical insight to enable manufacturers to validate, qualify and adopt bio-solvents in existing processes.

Solvent Recovery System Providers

These partners design, manufacture, and install closed-loop solvent recovery and recycling systems—such as distillation units and membrane-based purification solutions—tailored for multi-product GMP environments. They support contamination control, system validation, operator training, and generation of economic, environmental, and regulatory evidence demonstrating that recovered solvents meet specifications and are safe for reuse.

Pharmaceutical Manufacturers

These partners enable data-driven decision-making for solvent substitution, contamination control, and recovery efficiency. These deliverables are guided by AI optimisation tools, lifecycle analysis platforms, sustainability dashboards, and process simulation technologies. Their tools support modelling, real-time analytics, regulatory reporting, and integration of digital workflows with plant systems to improve process control, sustainability performance, and transparency.

Regulatory & Standards Bodies

These partners shape the regulatory landscape required for sustainable solvent adoption. They update GMP guidance, define sustainability compliance expectations, approve process changes, and establish bio-solvent specifications and impurity requirements. They also provide the frameworks that determine the evidence needed for solvent changes, harmonise standards to enable sector-wide adoption, and train inspectors in sustainable manufacturing practices.

2.1.2 Functional Cycle Capabilities Currently Not Served

Of the 107 future capabilities identified for this cycle, **23 were found to have no suitable match within the duty statements of current apprenticeship standards.**

This highlighted potential gaps across existing education and training provision, indicating a need to develop both immediate and longer-term learning solutions to equip the current workforce and future entrants with the skills required for sustainable solvent adoption.

The 23 unmatched capabilities are listed below, mapped to their relevant supply chain partners.

Table Key: Supply chain partners

1. Bio-Based Solvent Manufacturers
2. Solvent Recovery System Providers
3. Pharmaceutical Manufacturers
4. Digital Technology Providers
5. Regulatory & Standards Bodies

Function	Capability statement	1	2	3	4	5
DESIGN	Use cost-performance data to guide decisions on solvent substitution and process changes			✓	✓	
DESIGN	Create lifecycle analysis models to support sustainable practices in API production.				✓	
DESIGN	Validate biocatalytic methods to achieve stereoselective synthesis of chiral intermediates.	✓				
DESIGN	Develop bio-based solvents to expand the portfolio of renewable alternatives for pharmaceutical applications.	✓				
DESIGN	Evaluate financial viability of sustainable technologies to support adoption in pharmaceutical manufacturing			✓	✓	
DESIGN	Design membranes to purify biosolvents to specification.		✓			
DESIGN	Define acceptance criteria for recycled solvents used in pharmaceutical manufacturing.		✓	✓		✓
IMPLEMENT	Treat and supply excess recovered water to external users.			✓		
IMPLEMENT	Utilise suitable membranes to purify biosolvents and meet defined quality specifications.	✓	✓	✓		
IMPLEMENT	Approve new feedstocks through supply agreements.	✓				
IMPLEMENT	Utilise pervaporation membranes to efficiently remove water and methanol from solvents during API manufacturing.		✓	✓		
LOGISTICS	Establish partnerships with technology providers to integrate sustainable manufacturing processes into existing API production lines.	✓	✓	✓	✓	
LOGISTICS	Establish guidance on supplier qualification for reprocessed solvents.		✓	✓		✓
LOGISTICS	Build supplier awareness of qualification programme requirements to support quality and compliance in biologics manufacturing.	✓	✓			✓
SUPPORT	Define qualification requirements for solvent recycling and recovery equipment to ensure regulatory compliance.					✓
SUPPORT	Establish biosolvent standards to facilitate seamless substitution in existing manufacturing processes.	✓		✓		✓
ENTERPRISE	Conduct analytical studies to demonstrate performance equivalence of bio-based solvents with fossil-based solvents.	✓		✓	✓	
ENTERPRISE	Implement solvent substitution strategies to meet updated MHRA and EMA guidelines for sustainable API manufacturing.			✓	✓	

Function	Capability statement	1	2	3	4	5
ENTERPRISE	Provide detailed solvent property data with emphasis on safety characteristics to support sustainable medicines manufacturing.	✓				✓
ENTERPRISE	Scale production of bio-based solvents.	✓		✓		
ENTERPRISE	Establish working groups to address specific sustainability challenges in pharmaceutical manufacturing.			✓		✓
ENTERPRISE	Communicate alternative solvent options to customers to support informed selection.	✓			✓	
ENTERPRISE	Establish public-private partnerships to accelerate the adoption of sustainable technologies in API manufacturing.	✓		✓		

Table 3: Functional Cycle Capabilities Currently Not Served

Links: Link to [supply chain capability view](#)²

² Supply chain partner capability

<https://hvmcatapultforesighting.retool.com/embedded/public/3573002a-ab48-4fad-9765-bee00876a42e?token=97f32699b61bd02b863f006b3dbc6e28>

2.1.3 Prioritised Capability Themes

In total, 107 unique organisational capabilities were identified across the cycle (see Appendix 4.4 for full detail). Following review and validation with expert participants, a subset of these capabilities was prioritised as critical for the successful adoption of sustainable API manufacturing technologies. This prioritisation was based specifically on the capabilities voted as essential within Survey B, which asked participants across all stakeholder groups to assess the importance of each capability for future implementation readiness.

From this analysis, five priority capability themes were derived. These themes brought together individual essential capabilities into broader areas of strategic importance for the transition to sustainable API manufacturing and the wider adoption of bio-based and circular solvent systems. Each theme represented a cluster of related technical, regulatory, or organisational competencies that would require strengthening in order to remove barriers to adoption, support regulatory confidence, and enable operational excellence.



Insight:

These themes are ranked according to their criticality for enabling the adoption of sustainable API manufacturing technologies. Additionally, the ranking highlights the order in which gaps must be addressed to ensure both regulatory confidence and practical feasibility.

1. Regulatory Compliance, Standards & Assurance

This is the highest-priority theme because regulatory alignment is the most significant barrier to implementation. Without validated methods, acceptance criteria, compliant documentation, and robust quality frameworks, organisations cannot introduce new solvent systems or sustainability-driven process changes. Ensuring regulatory readiness underpins every other theme: it enables market approval, maintains product quality, and de-risks innovation.

2. Bio-based Solvent Development, Validation & Scale-Up

Industry cannot transition away from fossil-derived solvents without scalable, high-quality alternatives. Essential capabilities in performance testing, feedstock approval, contamination control, and commercial-scale production place this theme second. Strength in this area provides the technical foundation for sustainable solvent adoption and ensures that new materials can be integrated into regulated environments without compromising process robustness.

3. Solvent Recovery, Circularity & Process Efficiency

This theme supports environmental impact reduction and efficiency improvements across manufacturing. Capabilities such as recovery system design, membrane purification, equipment qualification, and contamination control make solvent circularity achievable. Ranking third reflects its importance in reducing operational costs and waste, but also its dependence on the regulatory and solvent-development themes above it.

4. Sustainability Leadership, Partnerships & Strategic Implementation

Sector-wide adoption requires strong strategic coordination. Working groups, public–private partnerships, technoeconomic analysis, sustainability planning, and ESG frameworks ensure organisations can justify investment and align on shared goals. This theme ranks fourth because it becomes truly effective once the technical and regulatory foundations are in place.

5. Communication, Documentation & Knowledge Transfer

Effective communication ensures that sustainability-related changes are consistently implemented, understood, and maintained across organisations. While essential, it ranks fifth because communication supports rather than drives the technical and regulatory changes required. Nonetheless, capabilities such as producing guidance documents, training operators, and communicating solvent options are vital for embedding new practices into everyday operations.

2.2 Workforce Insight

2.2.1 Future Occupational Profiles

FOPs indicated how roles in the industry were expected to evolve as the sector becomes more productised, systemised, and technology driven. The profiles defined the key responsibilities and the knowledge, skills, and behaviours required for each role, ensuring alignment with the industry's transformation.

The FOPs defined for this cycle did not represent the full extent of a current or future job role. Instead, the workforce foresighting approach identified new capabilities and changes required within an occupation required in the future to allow technology adoption.

Links [Click the link to explore the FOP Matrix³](#)

2.2.2 Role Levels

Organisations were observed to rely on structured role levels to manage talent, drive performance and support sustainable growth. A clear hierarchy from entry level to executive leadership ensures responsibilities are well defined and expectations aligned. Each level builds on the last in terms of complexity, autonomy and impact, enabling effective collaboration and accountability.

Workforce Foresighting uses a common way of defining role levels across supply chain partners but adapts it to each technology and sector. This shared framework supports consistency, while still reflecting the specific capabilities and workforce needs for each challenge

Role Levels selected for this cycle are:

- 1. Professional and Delivery**
Analysis, Execution and Tactical Delivery within defined systems.
- 2. Strategic & Operational Management**
Lead teams, assess systems, design solutions and manage resources.
- 3. Enterprise / Strategic Leader**
Integrate foresight, policy, collaboration, and enterprise-wide strategy.

³ FOP Matrix <https://hvmcatapultforesighting.retool.com/embedded/public/f99a913f-8827-4730-8893-d618d489bc84?token=97f32699b61bd02b863f006b3dbc6e28>

2.2.3 Future Occupational Profiles results

To support the transition towards sustainable solvent systems in API manufacturing, a total of 15 FOPs were identified. These profiles represented the key roles required across the value chain to enable the adoption of bio-based solvents, implement circular solvent practices, and ensure regulatory-compliant process transformation. The FOPs were presented below by Role Level and mapped across the relevant supply chain partners.

Role Level	FOP	Bio-Based Solvent Manufacturers	Solvent Recovery System	Pharmaceutical Manufacturers	Digital Technology Providers	Regulatory & Standards Bodies
Enterprise / Strategic Leader	Chief Transformation Officer	✓	✓	✓	✓	✓
Strategic & Operational Management	Commercial Partnerships Lead	✓	✓		✓	
	Process Design Specialist	✓		✓	✓	
	Digital Manufacturing Transformation Lead			✓	✓	
	Supply Chain Strategist	✓	✓	✓		✓
	Environmental Compliance Manager	✓	✓			✓
	Regulatory Policy & Standards Officer (Regulator/Standards Body)					✓
	Supply Chain Strategist		✓			
Professional and Delivery	Scientist (Bio-Solvent Development)	✓	✓	✓		
	Regulatory Compliance Officer (Manufacturing)	✓	✓	✓		
	Circular Economy Engineer	✓	✓	✓		
	Sustainability Data Analyst	✓		✓	✓	✓
	GMP Digital Validation Specialist		✓	✓	✓	
	Analytical Quality & Risk Specialist	✓	✓	✓		✓
	Quality & Contamination Control Specialist		✓	✓		

Table 4 Future Occupational Profiles across supply chain partners by role level

2.2.4 Priority FOPs

The FOPs were reviewed by our expert cycle participants against the context of importance to the sector, demand and mapping against current provision. As part of our strategic workforce planning, FOPS were assessed and prioritised for initial action and further analysis, based on a defined set of key criteria.

A **Priority FOP** was identified as a critical role within the future workforce, and essential for delivering the capabilities needed to drive industry transformation and enable the widespread adoption of sustainable solvent technologies across API manufacturing.

These roles were prioritised because they:

- Were strategically important to the sector's long-term transition to sustainable solvent systems
- Faced current or emerging capability gaps that could limit adoption
- Had high impact across multiple manufacturing, regulatory and supply-chain functions
- Required early talent planning and proactive workforce pipeline development
- Needed to be ready within a defined timeframe to support upcoming process, regulatory and sustainability shifts



Insight:

Each FOP reflects a combination of strategic relevance, essential capability requirements, and current gaps in educational provision. These roles will play a defining part in enabling organisations to transition to bio-based, recyclable, and circular solvent systems while maintaining regulatory compliance and operational performance.

1. Chief Transformation Officer

Leads organisation-wide transformation by setting strategic direction, shaping innovation pathways, and aligning partners across the supply chain. This role ensures the organisation can respond effectively to new sustainable solvent technologies, changing regulatory landscapes and evolving market expectations. It also drives cross-industry collaboration, a critical enabler of system-level change.

2. Scientist (Bio-Solvent Development)

Develops, validates and characterises bio-based solvents, ensuring their performance, compatibility and compliance with regulatory standards. This knowledge-driven capability is central to reducing reliance on fossil-derived solvents and enabling a robust pipeline of safe, effective and commercially scalable sustainable solvent alternatives.

3. Regulatory Policy & Standards Officer (Regulator/Standards Body)

Defines and interprets regulatory policy and standards relating to sustainable manufacturing. This role removes barriers to adoption by developing certification programmes, defining acceptance criteria, enabling post-approval change frameworks and convening stakeholders. Strong regulatory leadership was identified as essential to providing clarity and confidence as sustainable solvent technologies mature.

4. Regulatory Compliance Officer (Manufacturing)

Translates regulatory expectations into compliant operational practices within organisations. This role ensures GMP/GxP alignment, prepares documentation, supports audits, and embeds safe and compliant processes, during the transition to solvent recovery, reuse and bio-based solvent systems. Without strong compliance capability, sustainable process changes cannot be implemented at scale.

Links: Link to [FOPs versus provision](https://hvmcatapultforesighting.retool.com/embedded/public/d9f485a2-6d23-45dd-ab48-4c4c87ced0c7?token=97f32699b61bd02b863f006b3dbc6e28)⁴ and for [Future Occupational Profiles](https://hvmcatapultforesighting.retool.com/embedded/public/81d272f0-ad80-421c-8926-86655913acdf?token=97f32699b61bd02b863f006b3dbc6e28)⁵

⁴ FOP vs Provision <https://hvmcatapultforesighting.retool.com/embedded/public/d9f485a2-6d23-45dd-ab48-4c4c87ced0c7?token=97f32699b61bd02b863f006b3dbc6e28>

⁵ FOP Detail <https://hvmcatapultforesighting.retool.com/embedded/public/81d272f0-ad80-421c-8926-86655913acdf?token=97f32699b61bd02b863f006b3dbc6e28>

2.3 Education & Training provision insights

2.3.1 Provision Analysis of FOPs and Capabilities

Below is a comparison of each priority FOP against highest scoring existing education provision. The tables highlighted the highest-scoring standard for each and identified capabilities that were not addressed by the existing selected standard. These unmet capabilities indicated areas that could inform the development of future education and training provision, either by adapting existing programmes or through the development of short CPD courses aimed to upskill the current workforce.

Please note that whilst the FOPs mentioned below were mapped to Skills England apprenticeships, thirteen Scottish Provision standards (SDS, SQA and SCQF) were also included in this cycle.

Links Click the link for the [full list of FOP capabilities against Provision](#)⁶

Priority FOPs

- Chief Transformation Officer
- Scientist (Bio-Solvent Development)
- Regulatory Policy & Standards Officer (Regulator/Standards Body)
- Regulatory Compliance Officer (Manufacturing)

⁶ Full list of FOP capabilities against Provision

<https://hvmcatapultforesighting.retool.com/embedded/public/d9f485a2-6d23-45dd-ab48-4c4c87ced0c7?token=97f32699b61bd02b863f006b3dbc6e28>

Chief Transformation Officer

Role Summary

The Chief Transformation Officer plays a critical strategic leadership role, steering the organisation through the transition to sustainable solvent systems. They shape long-term innovation pathways, align internal and external stakeholders, and ensure the organisation responds effectively to regulatory shifts, market expectations, and technological opportunities. This role operates at the highest level of influence, orchestrating collaboration across the supply chain to accelerate solvent substitution, recovery, and sustainability-driven process change.



Key Tasks: Leads organisation-wide transformation to enable the adoption of sustainable solvent technologies, aligning strategy, stakeholders, and regulatory pathways while driving collaborative action across the supply chain.

Aligned to supply chain partners:

- Bio-Based Solvent Manufacturers
- Solvent Recovery System Providers
- Pharmaceutical Manufacturers
- Digital Technology Providers
- Regulatory & Standards Bodies

In the FOP vs Provision analysis, there was a 57.1% fit with the Skills England apprenticeship ‘Digital Manufacturing Engineering Leader’. The remaining unmet capabilities indicate areas not currently addressed by existing training provision.

Function Area	Capability Statement
ENTERPRISE	Establish public-private partnerships to accelerate the adoption of sustainable technologies in API manufacturing.
ENTERPRISE	Establish working groups to address specific sustainability challenges in pharmaceutical manufacturing.
ENTERPRISE	Facilitate dialogue to identify regulatory barriers to sustainability.

Table 5 Chief Transformation Officer capabilities not served by existing Skills England provision

Education & Provision Implications

Because the unmatched capabilities relate to **strategic collaboration**, **policy alignment**, and **regulatory barrier removal**, current provision lacks training for senior leaders tasked with driving systemic sustainability change. New provision could include:

- Executive-level CPD modules on **cross-sector partnership building**, **regulatory engagement for sustainable technologies**, and **strategic environmental governance**
- Leadership courses on **facilitating and maintaining multi-stakeholder dialogue** and **managing sustainability transitions in regulated environments**

Insight

The unmatched capabilities for this FOP centre on **strategic convening**, **policy influence**, and **cross-industry coordination**, which are all essential for accelerating the adoption of sustainable solvent technologies. Progress towards bio-based, circular and low-impact solvent systems will remain slow and fragmented, without senior leaders capable of unblocking regulatory challenges, aligning diverse organisations, and championing cross-supply-chain collaboration. These gaps highlight a clear need for **specialised leadership training** that prepares strategic decision-makers to guide the sector through complex sustainability transitions.

Scientist (Bio-Solvent Development)

Role Summary

This role creates the scientific and engineering foundation for sustainable solvent adoption. It integrates green chemistry, biocatalysis, membrane science, and analytical characterisation to deliver bio-based solvents that perform equivalently to fossil-derived options, can be purified to pharmaceutical grade, and are scalable within regulated API environments.



Key Tasks: Develops, validates, and characterises bio-based solvents and purification approaches, ensuring they meet performance, quality, and regulatory requirements for use in API manufacturing. Supports scale-up, membrane-based purification, analytical evaluation, and the development of standards to enable safe and effective adoption of sustainable solvent technologies.

Aligned to supply chain partners:

- Bio-Based Solvent Manufacturers
- Solvent Recovery System Providers
- Pharmaceutical Manufacturers

In the FOP vs Provision analysis, there was a 30.8% fit with the Skills England apprenticeship 'Scientist'. The remaining unmet capabilities indicate clear training gaps requiring targeted CPD or curriculum enhancement.

Function Area	Capability Statement
DESIGN	Validate biocatalytic methods to achieve stereoselective synthesis of chiral intermediates.
DESIGN	Assess starting materials to understand their impact on product quality and performance.
DESIGN	Design membranes to purify biosolvents to specification.
DESIGN	Develop bio-based solvents to expand the portfolio of renewable alternatives for pharmaceutical applications.
IMPLEMENT	Utilise pervaporation membranes to efficiently remove water and methanol from solvents during API manufacturing.
IMPLEMENT	Utilise suitable membranes to purify biosolvents and meet defined quality specifications.
SUPPORT	Establish biosolvent standards to facilitate seamless substitution in existing manufacturing processes.
ENTERPRISE	Scale production of bio-based solvents.
ENTERPRISE	Provide detailed solvent property data with emphasis on safety characteristics to support sustainable medicines manufacturing.

Table 6 Scientist (Bio-Solvent Development) capabilities not served by existing Skills England provision

Education & Provision Implications

To equip the future workforce with these capabilities, providers could:

- Integrate targeted modules into **BEng Chemical Engineering, Chemistry, and Science Industry Process & Plant Engineer** degree-apprenticeship pathways (e.g., **membrane separations, biocatalysis for API synthesis, bio-solvent characterisation, solvent-recovery design & validation**).
- Develop **CPD short courses** on bio-solvent development and performance equivalence testing, membrane-based purification for GMP environments, and generation of solvent property/safety dossiers aligned to regulatory expectations.

Insight

The gaps for this FOP cluster around **biocatalysis, membrane purification, standards creation, and scale-up**—all pivotal to moving from promising lab-scale options to **regulatory-compliant, plant-ready solutions**. Closing these gaps will accelerate substitution away from fossil-derived solvents, reduce environmental impact through efficient recovery and reuse, and ensure safe, consistent manufacturing performance in API production.

Regulatory Policy & Standards Officer (Regulator/Standards Body)

Role Summary

This role ensures that sustainable solvent technologies can be safely and confidently adopted by industry. The Regulatory Policy & Standards Officer creates, interprets, and evaluates regulatory requirements related to bio-based solvents, solvent recycling, and circular manufacturing practices. They collaborate with stakeholders to establish clear specifications, acceptance criteria, and post-approval change pathways. By producing case studies and harmonised standards, they provide the regulatory certainty needed to accelerate innovation and reduce barriers to sustainable transformation in API manufacturing.



Key Tasks: Defines and shapes the regulatory frameworks, standards, and approval pathways needed to enable sustainable solvent adoption in API manufacturing. Leads policy development, removes regulatory barriers, and ensures industry has clear, evidence-based guidance to support compliant implementation of new solvent technologies.

Aligned to supply chain partners:

- Regulatory & Standards Bodies

In the FOP vs Provision analysis, there was a 28.6% fit with the Skills England apprenticeship 'Regulatory Affairs Specialist'. The remaining unmatched capabilities indicate areas not currently addressed by existing training provision and highlight specialised regulatory knowledge gaps.

Function Area	Capability Statement
DESIGN	Define acceptance criteria for recycled solvents used in pharmaceutical manufacturing.
SUPPORT	Establish biosolvent standards to facilitate seamless substitution in existing manufacturing processes.
ENTERPRISE	Facilitate dialogue to identify regulatory barriers to sustainability.
ENTERPRISE	Develop frameworks for post-approval adoption of bio-solvents to facilitate regulatory compliance.
ENTERPRISE	Develop case studies of successful regulatory pathways for sustainable innovations to guide future API manufacturing transformations.

Table 7 Regulatory Policy & Standards Officer (Regulator/Standards Body) capabilities not served by existing Skills England provision

Education & Provision Implications

The unmet capabilities highlight a shortage of training that integrates **sustainable chemistry, solvent recovery standards, and emerging regulatory science**. To fill these gaps, providers could develop:

- Targeted CPD modules on **green regulatory frameworks, standards development, and evidence expectations for solvent-related submissions**
- Specialist training for regulators on **post-approval change management, bio-solvent evaluation, and harmonising sustainability practices across jurisdictions**
- Workshops and short courses on **regulatory barrier identification, stakeholder consultation, and case study development for sustainable technologies**

Insight

The unmatched capabilities reflect the growing need for regulatory leadership that understands both the science and the policy implications of sustainable solvent systems. As organisations adopt bio-based, recycled, and circular solvents, regulators must define clear acceptance criteria, establish robust standards, and create predictable pathways for post-approval change. Without these frameworks, innovation slows, compliance risks increase, and industry hesitates to transition away from fossil-derived solvents.

By building capability in this role, the sector strengthens the regulatory foundation required for confident, safe, and scalable adoption of sustainable solvent technologies.

Regulatory Compliance Officer (Manufacturing)

Role Summary

The Regulatory Compliance Officer ensures that sustainable manufacturing changes—such as solvent substitution, recovery, and digital system implementation—are introduced in a compliant, controlled, and auditable manner. The role provides specialist interpretation of regulatory expectations, supports validation and documentation activities, and ensures both internal teams and suppliers meet quality, environmental, and GMP/GxP requirements. As sustainable solvent systems increase in complexity, this role becomes central to enabling compliant adoption and maintaining product quality and operational integrity.



Key Tasks: Ensures manufacturing processes comply with evolving sustainability-aligned regulatory requirements, translating standards into operational practice, preparing compliant documentation, and supporting the integration of solvent recovery, reuse, and bio-based solvent systems within GMP environments.

Aligned to supply chain partners:

- Bio-Based Solvent Manufacturers
- Solvent Recovery System Providers
- Pharmaceutical Manufacturers

In the FOP vs Provision analysis, there was a 45.5% fit with the Skills England apprenticeship ‘Compliance and Risk Officer’. The remaining capabilities not covered by existing provision highlight specific regulatory-compliance skills gaps linked to sustainable solvent technologies.

Function Area	Capability Statement
DESIGN	Provide guidance on validation requirements for digital systems to ensure compliance with regulatory standards.
SUPPORT	Facilitate dialogue to identify regulatory barriers to sustainability.
SUPPORT	Develop documentation packages to support regulatory submissions for recovery systems.
SUPPORT	Advise on analytical approaches that support quality assurance and regulatory compliance in sustainable manufacturing.
ENTERPRISE	Establish guidance on supplier qualification for reprocessed solvents.
ENTERPRISE	Ensure compliance with regulatory requirements by integrating ISO 14001 standards into API manufacturing operations.

Table 8 Regulatory Compliance Officer (Manufacturing) capabilities not served by existing Skills England provision

Education & Provision Implications

Because the unmet capabilities related to **sustainable manufacturing compliance**, **digital validation**, and **supplier qualification for reprocessed solvents**, current provision was found not to fully prepare compliance professionals for sustainability-driven API process changes. Analysis of this gap indicated that targeted education and training provision could be required including:

- CPD modules on **ISO 14001 integration**, **supplier qualification for circular materials**, and **ESG-linked compliance frameworks**
- Specialist training focused on **documentation for recovery systems**, **GMP-aligned digital validation**, and **regulatory expectations for solvent reuse**
- Workshops addressing **cross-functional engagement** to identify and address regulatory barriers to sustainability initiatives

Insight

The unmatched capabilities highlight a growing need for compliance professionals who can navigate the regulatory implications of sustainable solvent technologies. As organisations adopt bio-based solvents, reprocessed materials, and digital recovery systems, ensuring validated, well-documented, and standards-aligned implementation becomes critical. This role ensures that sustainability innovations do not introduce compliance risks, and that regulatory submissions—covering recovery systems, solvent reuse, and environmental performance—are robust and defensible. Strengthening this capability is therefore essential for enabling safe, compliant, and scalable transformation across API manufacturing.

Link to [*full list of FOP capabilities against Provision*](#)⁷

⁷ FOP capabilities against Provision

<https://hvmcatapultforesighting.retool.com/embedded/public/d9f485a2-6d23-45dd-ab48-4c4c87ced0c7?token=97f32699b61bd02b863f006b3dbc6e28>

FOPs with the biggest Education provision gaps

The table below listed the total FOPs defined for this foresighting cycle. It highlighted provision gaps by showing the best fit current apprenticeship standard, based on Maximum Fit Factor. The Maximum Fit Factor was combined with the Surplus Factor to determine the Apprenticeship Suitability score of Low, Medium or High.

A detailed comparison of current apprenticeship provision against the capability requirements of the identified FOPs was provided in the data visualisation tool: [FOP vs Provision](#).

Table Key: Supply Chain Partners

1. Bio-Based Solvent Manufacturers
2. Solvent Recovery System Providers
3. Pharmaceutical Manufacturers
4. Digital Technology Providers
5. Regulatory & Standards Bodies

Role Level	FOP Title	Required for Supply Chain Partners	Best Fit Apprenticeship Standard/s	Apprenticeship Suitability
Enterprise/ Strategic Leader	Chief Transformation Officer	1,2,3,4,5	Digital manufacturing engineering leader	MEDIUM
Strategic Operational Management	Digital Manufacturing Transformation Lead	3,4	Digital manufacturing engineering leader	HIGH
Strategic Operational Management	Environmental Compliance Manager	1,2,5	Sustainability business specialist (integrated degree)	MEDIUM
Strategic Operational Management	Regulatory Policy & Standards Officer (Regulator/Standards Body)	5	Regulatory affairs specialist	LOW
Strategic Operational Management	Process Design Specialist	1,3,4	Digital manufacturing engineering leader	LOW
Strategic Operational Management	Commercial Partnerships Lead	1,2,4	Procurement and supply chain practitioner	LOW
Strategic Operational Management	Supply Chain Strategist	1,2,3,5	Supply chain leadership professional (integrated degree)	LOW
Professional Delivery	Quality & Contamination Control Specialist	2,3	Science manufacturing technician 2023	HIGH
Professional Delivery	Analytical Quality & Risk Specialist	1,2,3,5	Scientist	MEDIUM
Professional Delivery	Scientist (Bio-Solvent Development)	1,3	Scientist	LOW
Professional Delivery	Sustainability Data Analyst	1,3,4,5	Energy manager	LOW
Professional Delivery	Circular Economy Engineer	1,2,3	Mineral products technician	LOW
Professional Delivery	Regulatory Compliance Officer (Manufacturing)	1,2,3	Compliance and risk officer	LOW
Professional Delivery	GMP Digital Validation Specialist	3,4	MSc Pharmaceutical Quality & Good Manufacturing Practice	LOW

Table 9 FOPs with the biggest Education provision gaps

Note: this cycle focused on new, future capabilities, and omitted current capabilities, which was why the apprenticeship suitability was low for existing courses that appear to share a lot

of common ground with their paired FOP. If existing capabilities were added to this analysis, the course suitability would naturally be much higher.

2.3.2 Knowledge, Skills, and Behaviour tags and its observations.

For each capability in a foresighting cycle, a team of expert educators have determined the relevant knowledge, skills, and behaviours (KSBs) required by the workforce to deliver the capability. This approach supported two key use cases:

- 1. Informing / Guiding understanding of the alignment between future-state capability requirements and current educational provision.**
- 2. Driving action by equipping educators to embed these capabilities into their curriculum.**

While capabilities defined what organisations need to thrive in the future, KSBs provided a practical framework for how education would need to evolve to support that transformation. Tags associated with capabilities that align well with current educational provisions may have also revealed shifts in KSBs. Capabilities introduced during the cycle were assigned relevant tags to support educators in effectively integrating those capabilities into curriculum.

This intersection between capability relevance and KSB evolution was critical for identifying where curriculum updates are needed to keep pace with industry transformation.

Application

The complete list of KSBs associated with each capability was made available within the visualisation tool,⁸ alongside all other relevant contextual information.

The application of this data can be broadly divided into two key areas:


- 1. Macro Trend Analysis**
By examining KSB tags at an aggregate level across all capabilities, educators can identify major shifts in demand. This high-level view helps narrow the focus to areas where change is most significant or emerging.
- 2. Detailed Research**
Once priority areas are identified through the macro lens, educators can drill down into specific capabilities or explore the detailed KSBs linked to a particular tag. This supports more targeted curriculum development and informed decision-making.

This report presented a selection of aggregated insights intended to illustrate potential use cases. Readers are strongly encouraged to explore the visualisation tool for a more detailed and interactive engagement with the data. The tool provided deeper context, flexible filtering, and access to the full range of capabilities and KSB tags, enabling users to tailor their exploration to specific interests or needs.

⁸ Future KSB Summary https://hvmcatapultforesighting_retool.com/embedded/public/8634650f-9700-4627-8431-068b4b764222?token=97f32699b61bd02b863f006b3dbc6e28

2.3.3 Most frequent tags

The following graphic highlighted the most frequently used tags across all capabilities in the foresighting cycle. These tags revealed macro trends that can guide the focus of training provisions.

 **Insight:**

The dominant KSB themes identified below indicate that sustainable solvent adoption is being driven by the need to embed environmental performance within regulated manufacturing practice:

- **Green Chemistry**
- **Regulatory Compliance**
- **GMP and Environmental Compliance**

Additionally, the emergence of tags linked to sustainability compliance, lifecycle assessment, digital validation and sustainable procurement reflects new or under-represented capability areas that are not yet consistently embedded within existing curricula. These tags align strongly with capabilities related to solvent substitution, recovery and circularity, regulatory assurance, and sustainability-led implementation, demonstrating that future roles require integrated capability across sustainability science, regulatory confidence and GMP delivery.

Most frequent Knowledge Tags

Tag	Tag Frequency
Green Chemistry	19
Regulatory Compliance	18
Environmental Compliance	13
Good Manufacturing Practices	11
Corporate Sustainability	8
Pollution Prevention	8
Process Engineering	8
Analytical Chemistry	6
Bioprocess Engineering	6
Process Analytical Technology (PAT)	6
Quality Control	6
Vacuum Distillation Processes	6
Waste Reduction	6

Table 10 Most frequent Knowledge Tags

Most frequent Skills Tags

Tag	Tag Frequency
Monitor and evaluate pharmaceutical manufacturing processes	11
Monitor manufacturing compliance with industry regulations	11
Develop sustainable procurement practices	10
Prepare regulatory or compliance documentation	10
Promote sustainable practices	10
Provide advice on sustainability	8
Develop waste management technologies	7
Maximise product yield from raw materials	7
Review operational compliance with regulatory requirements	7

Table 11 Most frequent Skills Tags

This data served as a starting point for identifying emerging knowledge and skill areas that may not be traditional within the industry but were gaining traction due to the adoption of new technologies. It also highlighted expected tags that rank lower than anticipated, potentially indicating a decline in demand.

Using this insight, readers can explore the visualisation tool to examine the knowledge, skills, and behaviours (KSBs) unique to a specific capability or FOP, enabling more informed decision-making.⁹

Priority evaluation of underserved and high demand capability themes

Educators conducted a targeted review of capability statements and FOPs to identify areas where there is:

- High forecasted demand for specific capabilities in the future workforce, and
- Low current curriculum coverage, meaning these capabilities are not adequately addressed in existing educational programmes.

By focusing on this intersection—high demand but underserved provision—educators were able to pinpoint critical capability gaps that may hinder workforce readiness if left unaddressed.

This approach supports strategic curriculum development by highlighting which capabilities should be prioritised for inclusion or enhancement in training programmes.

⁹ Capability distribution across FOPs

<https://hvmcatapultforesighting.retool.com/embedded/public/ce67cca1-5beb-4557-8482-8a0b6e174933?token=97f32699b61bd02b863f006b3dbc6e28>

2.4 Discussion on Noteworthy Observations

A number of themes emerged from the clustering of capability statements with high demand and low provision. These themes reflect areas where current educational offerings may not sufficiently prepare learners for future roles, particularly in sectors undergoing rapid transformation. The following clusters represent key capability gaps:

1. **Foundations of Sustainable & Bio-based Solvents**
2. **Solvent Purification, Recovery & Circularity**
3. **Sustainable Manufacturing Strategy & Sector Collaboration**
4. **Advanced Green Synthesis & Feedstock Innovation**

Collectively, these clusters signal a clear shift in workforce capability requirements toward sustainable chemistry, circular manufacturing practices, and system-level thinking across regulated environments. The gaps identified reflect not only emerging technical needs, such as bio-based solvent design, purification and recovery, but also a growing requirement for strategic capability in sustainability leadership, cross-sector collaboration, and regulatory-aware innovation. Addressing these gaps will require coordinated action between educators, industry partners and standards bodies to evolve curricula, develop targeted CPD, and embed interdisciplinary learning that equips the workforce to deliver compliant, scalable and environmentally sustainable medicines manufacturing.

2.5 Summary of Key Recommendations

To address these capability gaps, educators and industry participants identified the following recommendations, which are structured around the four high-demand, low-provision capability clusters emerging from the cycle:

- **Develop foundational education and CPD in Sustainable & Bio-based Solvents**
Introduce introductory and intermediate learning provision that builds core understanding of bio-based solvent systems, their scale of application, and the facilities required for implementation within GMP environments.

This provision should integrate **analytical performance, cost-effectiveness and scalability considerations**, equipping early-career professionals and those transitioning roles with a practical grounding in sustainable solvent adoption.

- **Create bridging provision focused on Solvent Purification, Recovery & Circularity**
Develop targeted courses and CPD programmes that equip learners in academia and industry with the practical skills and applied knowledge required to implement solvent purification, recovery and reuse techniques.

This includes **membrane technologies, recovery system operation, contamination control and quality assurance**, enabling direct application within existing API manufacturing processes.

- **Embed Sustainable Manufacturing Strategy & Sector Collaboration into leadership and management training**
Introduce leadership-level provision that supports strategic thinking, collaboration and systems-level decision-making.

This should focus on **cross-sector alignment**, embedding sustainability into process and project design, and equipping individuals with the knowledge to assess alternatives, demonstrate value, and articulate **cost, risk and regulatory trade-offs** associated with sustainable manufacturing transitions.

- **Strengthen Advanced Green Synthesis & Feedstock Innovation within science and engineering curricula**
Expand curricula and CPD to take a more holistic view of green synthesis routes, biocatalysis and feedstock diversity, emphasising the importance of continuous innovation.

Provision should address **feedstock variability, supply resilience and performance equivalence**, areas that are often underrepresented but critical to long-term sustainable API manufacturing.

Taken together, these recommendations reflect a clear shift toward interdisciplinary, sustainability-driven education that combines technical depth with strategic, regulatory and economic awareness. They highlighted the need for closer collaboration between industry, educators and standards bodies to ensure learning provision was applied, scalable and aligned with real-world implementation challenges.

Addressing these gaps will be critical to preparing a workforce capable of delivering compliant, circular and environmentally sustainable medicines manufacturing at scale.

3. Conclusion & Next Steps



3. Conclusions and Next Steps

Strong leadership, targeted investment, and a clear understanding of emerging innovations are essential to drive meaningful transformation across the sector. This cycle's foresighting shows that aligning workforce development with future demand—through adaptation of apprenticeship and degree programmes, complemented by flexible, role-relevant CPD—will be decisive. Doing so will ensure people have the knowledge and skills to introduce bio-based solvents, implement recovery and circularity, and maintain GMP-aligned compliance as technologies and operating practices evolve.

3.1 Key Findings & Conclusions

From the Workforce Foresighting Cycle, the following data points were identified and focus areas were developed.

Key Findings

Future Capabilities & Roles:

107 future organisational capabilities were identified in this cycle. These informed 15 FOPs mapped across five supply-chain partners:

- Bio-based Solvent Manufacturers
- Solvent Recovery System Providers
- Pharmaceutical Manufacturers
- Digital Technology Providers
- Regulatory & Standards Bodies)

Priority Capabilities Themes:

These themes have been prioritised because they directly address the most pressing challenges and opportunities for transforming existing API manufacturing processes and facilities towards sustainable medicines manufacturing:

- Regulatory Compliance, Standards & Assurance for Sustainable Manufacturing
- Bio-based Solvent Development, Validation & Scale-Up
- Solvent Recovery, Circularity & Process Efficiency
- Sustainability Leadership, Partnerships & Strategic Implementation
- Communication, Documentation & Knowledge Transfer for Sustainable Practices

High-Priority Roles:

The following roles are pivotal to enabling sector-wide change—combining scientific and engineering advances with regulatory assurance, operational integration, and strategic leadership:

- **Chief Transformation Officer**
- **Scientist** (Bio-Solvent Development)
- **Regulatory Policy & Standards Officer** (Regulator/Standards Body)
- **Regulatory Compliance Officer** (Manufacturing)

Education provision gaps:

Provision analysis indicates material gaps for priority roles, with low best-fit alignment for several FOPs (e.g., Scientist (Bio-Solvent Development); Regulatory Policy & Standards Officer) and 23 capability statements currently not matched to apprenticeship duty statements—pointing to immediate CPD needs and curriculum enhancement opportunities.

Key Conclusions

This Workforce Foresighting cycle demonstrates that the transition to sustainable API manufacturing is not constrained by technological readiness alone, but by the availability of aligned organisational capability, leadership capacity, and workforce skills across the supply chain. The findings show that progress will depend on organisations' ability to integrate scientific innovation, regulatory assurance and operational change within existing GMP environments. Leadership capability therefore emerges as a critical enabler, providing the strategic direction, coordination and confidence required to move from pilot-scale innovation to routine, compliant implementation.

A central conclusion of this report is the strong interdependency between supply-chain capability, education provision and regulatory frameworks. Bio-based solvent developers, recovery system providers, manufacturers, digital technology suppliers and regulators must evolve in parallel. Gaps in any one part of this system—such as the absence of clear acceptance criteria for recycled solvents, insufficient workforce capability in recovery system validation, or limited education provision in green synthesis and circularity—create friction across the whole ecosystem. Effective transformation will therefore require coordinated action rather than isolated interventions.

The analysis highlights a clear and urgent need for upskilling and reskilling. Many of the 107 future capabilities identified—particularly those related to solvent recovery, digital validation, lifecycle assessment, regulatory documentation and sustainability leadership—are only partially addressed, or not addressed at all, by current education and training provision. Without targeted CPD and curriculum adaptation, organisations risk relying on informal learning or external expertise, slowing adoption and increasing compliance risk. Workforce development must therefore be treated as a near-term priority, not a long-term aspiration.

Technology adoption and digitalisation are shown to be powerful enablers of sustainable manufacturing, but only when accompanied by appropriate workforce capability. Digital tools such as lifecycle analysis platforms, sustainability dashboards, process modelling and AI-enabled optimisation have the potential to significantly improve decision-making, efficiency and environmental performance. However, the cycle findings make clear that these technologies introduce new demands around data governance, GMP-aligned digital validation and regulatory confidence. Building competence in both the use and assurance of digital systems will shape how future API manufacturing practices evolve.

Finally, the report reinforces the need for education reform to support long-term transformation. Traditional discipline-based training is no longer sufficient on its own. Future provision must be more interdisciplinary, integrating green chemistry, process engineering, regulatory science, digital systems and strategic sustainability thinking. This will require closer collaboration between educators, industry and regulators to ensure curricula, apprenticeships and CPD are not only technically robust, but also grounded in real-world implementation challenges. Without this reform, the sector will struggle to build the workforce required to deliver compliant, circular and environmentally sustainable medicines manufacturing at scale.

3.2 What this means for Industry

For industry stakeholders, the findings of this foresighting cycle translate into a clear requirement to treat sustainable API manufacturing as a strategic transformation programme, rather than a series of isolated technical upgrades. Senior leadership teams must embed sustainability, circularity and regulatory readiness into organisational strategy, ensuring that solvent substitution, recovery and digital optimisation are aligned with long-term business objectives, capital planning and regulatory risk management. Immediate action is required to prioritise investment decisions that support scalable deployment within existing GMP facilities.

Leaders have a central role in setting direction and enabling delivery. This includes establishing clear ownership for sustainability-driven transformation, often through enterprise-level roles responsible for coordinating technical, regulatory and commercial decision-making across functions and supply-chain partners. Senior leaders must also create the conditions for collaboration, both internally between engineering, quality, digital and sustainability teams, and externally with technology providers, solvent manufacturers and regulators. Without this coordination, organisations risk fragmented implementation and slower adoption.

Engineering and technical teams will be critical to operationalising change. Process engineers, chemists and equipment specialists will need to integrate bio-based solvents, recovery systems and digital tools into live production environments while maintaining product quality and compliance. This places increased importance on workforce capability in process redesign, validation, contamination control and lifecycle assessment. Organisations should therefore invest in targeted upskilling, enabling technical staff to confidently evaluate new technologies, understand cost-performance trade-offs and generate the evidence required for regulatory approval.

The business case for innovation is closely tied to workforce development. While equipment investment in recovery systems, membranes and digital platforms is essential, these assets will only deliver value if organisations have the skills to operate, optimise and assure them. Investment in people—through structured CPD, cross-functional training and new specialist roles—should be viewed as a risk-mitigation strategy that accelerates adoption, reduces compliance uncertainty and supports long-term competitiveness.

Finally, industry must actively engage with regulatory bodies and standards organisations. Early dialogue, shared evidence generation and participation in working groups can help streamline approvals, clarify expectations and reduce duplication of effort. Partnerships across the supply chain, including public–private collaborations, will be essential to managing operational risk and ensuring that sustainable manufacturing solutions can be implemented at pace and at scale.

3.3 What this means for Educators

For educators, this cycle highlights the need to evolve provision in response to a rapidly changing industrial context. Existing apprenticeship, degree and postgraduate programmes provide a strong foundation in science and engineering, but they do not yet consistently address the interdisciplinary capabilities required for sustainable API manufacturing. Curriculum updates are therefore needed to better integrate green chemistry, solvent recovery and reuse, regulatory science, and digital manufacturing practices.

Apprenticeship and degree programmes should be adapted to include applied learning in areas such as bio-based solvent selection, membrane-based purification, lifecycle assessment and GMP-aligned digital validation. Embedding these topics within existing pathways—rather than treating them as optional add-ons—will help ensure that new entrants are prepared for the realities of sustainable manufacturing environments. Practical case studies, industry-led projects and exposure to regulatory requirements will be particularly important.

CPD provision has a critical role to play in upskilling and reskilling the existing workforce. Many of the priority capabilities identified in this cycle are most urgently needed by professionals already working in industry, including engineers, scientists, quality specialists and sustainability leads. Modular, flexible CPD—designed to fit alongside employment—will enable individuals from adjacent sectors or traditional roles to transition into emerging areas such as solvent circularity, sustainability data analysis and regulatory compliance for new technologies.

The findings also underline the importance of leadership education. As sustainability becomes embedded within strategic decision-making, educators have an opportunity to support the development of leaders who can operate across technical, regulatory and commercial domains. Executive education and leadership-focused CPD should therefore address topics such as systems thinking, cross-sector collaboration, regulatory engagement and evidence-based investment decision-making.

Finally, educators are encouraged to make greater use of workforce foresighting data and tools. By using foresighting insights to inform curriculum planning, educators can ensure that provision remains aligned with future demand rather than reacting retrospectively to skills shortages. Close collaboration with industry partners will be essential to validating relevance, maintaining impact and ensuring that education provision supports real-world implementation.

3.4 Summary of next steps:

The next phase following this report should focus on translating insight into coordinated action across industry, education and the wider ecosystem. In the short term, priority should be given to addressing the most significant workforce capability gaps identified in this cycle, particularly those linked to regulatory compliance, solvent recovery, digital validation and sustainability leadership. Targeted CPD and curriculum enhancement can provide rapid impact while longer-term reforms are developed.

Key stakeholders each have a distinct role to play. Industry should lead on implementation, investment and demand signalling, articulating clear skills requirements and supporting workforce development initiatives. Educators should respond by adapting provision, developing new modules and collaborating with industry to ensure relevance and application. Regulators and standards bodies should continue to engage with both groups to clarify expectations, support capability development and reduce uncertainty around sustainable manufacturing adoption.

Effective collaboration mechanisms will be essential to success. These may include cross-sector working groups, shared pilot projects, joint curriculum design initiatives and open knowledge-sharing forums. Such mechanisms can help align evidence generation, reduce duplication and accelerate learning across the sector. Dissemination of findings—through industry networks, education providers and policy forums—will also be important to ensure the insights influence strategy and investment decisions.

Finally, the sector should commit to ongoing workforce foresighting and monitoring. As technologies mature and regulatory frameworks evolve, workforce requirements will continue to change. Regular review of capability needs, education provision and adoption progress will help maintain alignment, ensuring that the workforce remains prepared to support emerging technologies and long-term transformation toward sustainable medicines manufacturing.

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4. Appendix



Appendices

Appendix A Visualisation tool and instructions for use

Appendix B List of full FOPs by Role Level including Capabilities

Appendix C Background to Workforce Foresighting Hub

Appendix A Visualisation tool and instructions for use

The interested reader may wish to access the online data visualisation tool which provides several different ways to view the cycle data. Links to relevant parts of the tool are given with brief guidance below. This content is provided and maintained by the Workforce Foresighting Hub.

Visualisation Tool Section	What is it and what can it be used for?
Data Capture Overview	<p>Provides a summary of the data captured across the foresight cycle, bringing together the work of the Technologists / Domain Specialists, Employers and Educators into one overview.</p> <p>Full URL https://hvmcatapultforesighting.retool.com/embedded/public/e869283b-4b8a-437c-973e-64ab292e5b87?environment=production&token=97f32699b61bd02b863f006b3dbc6e28</p>
Supply Chain Capabilities	<p>Provides an overview of the identified capabilities at a Supply Chain / Workflow Partner level.</p> <p>By selecting/deselecting each Supply Chain / Workflow Partner you can review the capabilities identified as required in that area of the Supply Chain / Workflow.</p> <p>This can be used to generate organisational capability profiles for each area of the workflow /supply chain to help prioritise and focus the acquisition of new capabilities that will be required in the future.</p> <p>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.</p> <p>Full URL https://hvmcatapultforesighting.retool.com/embedded/public/3573002a-ab48-4fad-9765-bee00876a42e?token=97f32699b61bd02b863f006b3dbc6e28</p>
FOP Detail	<p>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.</p> <p>You can select an individual Role Family 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.</p> <p>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.</p> <p>Full URL https://hvmcatapultforesighting.retool.com/embedded/public/81d272f0-ad80-421c-8926-86655913acdf?token=97f32699b61bd02b863f006b3dbc6e28</p>

Visualisation Tool Section	What is it and what can it be used for?
FOP Matrix	<p>Provides a detailed breakdown of future occupational profiles that could be required in the future workforce. These were generated using a combination of attributes collected through the workshops and an algorithm. These suggested profiles were then reviewed and ratified by small groups of employers who were able to add/remove capabilities and uprate/downrate proficiency levels required.</p> <p>You can view all the FOPs in a role family by selecting one (or more) of these from the drop down. This will then allow you to select the FOPs aligned to that role family.</p> <p>The populated table allows you review and compare different FOPs within or across role families. You can view the capabilities in each FOP and the assigned proficiency levels.</p> <p>You can also toggle 'Hide Empty Capabilities' on/off to reduce the view down to only those capabilities included in the role family you are reviewing.</p> <p>Full URL https://hvmcatapultforesighting.retool.com/embedded/public/f99a913f-8827-4730-8893-d618d489bc84?token=97f32699b61bd02b863f006b3dbc6e28</p>
Future KSBs Summary	<p>Not yet completed in this cycle.</p> <p>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.</p> <p>This is used to:</p> <ul style="list-style-type: none"> • 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 family/occupational profile grouping. <p>Full URL https://hvmcatapultforesighting.retool.com/embedded/public/8634650f-9700-4627-8431-068b4b764222?token=97f32699b61bd02b863f006b3dbc6e28</p>
FOP Distribution	<p>This page allows provides a breakdown of the Capabilities within the selected Cycle and how they are distributed across the FOPs with the addition of a distribution chart showing the required proficiency across those FOPs.</p> <p>Clicking the "View FOPs" button alongside each capability will provide a list of the proficiencies (EPA) with the FOPs that fall into them.</p> <p>The exported version of this data will include a full breakdown of the FOP IDs which contain the capability within a specific proficiency.</p> <p>This is used to:</p> <ul style="list-style-type: none"> • understand the levels/volumes of common/crossover Capabilities, to support prioritisation of Capability Development • identify which Occupational Profiles contain these common/crossover capabilities, and so which may be prioritised for development activity <p>Full URL https://hvmcatapultforesighting.retool.com/embedded/public/ce67cca1-5beb-4557-8482-8a0b6e174933?token=97f32699b61bd02b863f006b3dbc6e28</p>

Visualisation Tool Section	What is it and what can it be used for?
Capabilities Matched to Current Provision	<p>This page allows you to review and compare individual capabilities against 'Duty' statements in an Apprenticeship / Occupational Standard.</p> <p>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.</p> <p>You can filter in several ways to focus your review:</p> <ul style="list-style-type: none"> • 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 (Skills England Occupational Standards) provision. <p>By capabilities that are not served by the reference mapping framework, e.g., Skills England Occupational Standards provision – these are capabilities required in the future that may require new/bespoke training and CPD materials to be developed to upskill/re-skill the workforce. This page can be used to identify where existing provision may exist across the broad spectrum of Occupational Standards, and not just within a narrow range of sector-specific Standards.</p> <p>The data also allows you to identify where provision may already exist to support specific capabilities.</p> <p>Full URL https://hvmcatapultforesighting.retool.com/embedded/public/219ff6af-36ea-4b5e-bda1-b0b989c0e3f0?token=97f32699b61bd02b863f006b3dbc6e28</p>
Fit & Surplus Factors	<p>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 (Skills England Occupational Standards).</p> <p>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.</p> <p>Full URL https://hvmcatapultforesighting.retool.com/embedded/public/c699e504-3f64-45a0-b52e-ad44a95f9aa4?token=97f32699b61bd02b863f006b3dbc6e28</p>
Fit & Surplus Matrix	<p>This page is a visual representation of the 'Fit and Surplus Factor' insight. You can visually review 'Fit' and 'Surplus' of Future Occupation Profiles (FOP) against existing training provision e.g. Institute for Apprenticeships and Technical Education (Skills England Occupational Standards).</p> <p>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.</p> <p>It will help you focus in on which provision to focus your attention for analysis.</p> <p>Full URL https://hvmcatapultforesighting.retool.com/embedded/public/1c4e204b-3927-4226-9f8e-2f62ce0643c5?token=97f32699b61bd02b863f006b3dbc6e28</p>

Visualisation Tool Section	What is it and what can it be used for?
FOP Capability Matches	<p>This page allows you to view the matches between Capabilities and Institute for Apprenticeships and Technical Education (Skills England Occupational Standards) Duty Statements. Clicking the arrow next to a number in the 'Matches' column will open a popup with more detail for each Capability.</p> <p>Each capability also includes Knowledge, Skill and Behaviour Tags, to support with scaffolding future education provision.</p> <p>You can review individual Future Occupational Profiles (FOPs) or review all FOPs under a Role Family, to give a more holistic view of Capabilities and Matches</p> <p>Where a future capability has been matched to existing provision (currently, by default, Skills England Occupational Standards) it is possible to interrogate the data and identify specific statements in standards that align to enable identification of existing training materials and activities that could be used or adapted to meet future requirements.</p> <p>This can be used to review the capability requirements for Role Families and FOPs, from Job / Occupation level through to Knowledge, Skill and Behaviour level</p> <p>Full URL https://hvmcatapultforesighting.retool.com/embedded/public/6a205e7e-8f33-4765-b39b-82f1f549217a?token=97f32699b61bd02b863f006b3dbc6e28</p>
FOP vs Provision	<p>This page allows you to compare FOPs against existing Skills England Occupational Standards.</p> <p>The information here allows you to prioritise effort or action over the short, medium or long-term.</p> <p>This is displayed as a Matched/Not Matched Capability, comparing the Capability in a FOP to the Duties in a Standard.</p> <p>The left-hand side allows you to select the Role Family and FOP, while the right-hand modal allows you to compare against the top 10 matched Skills England Occupational Standards for that Occupational Profile.</p> <p>Where a future capability has been matched to existing provision (currently, by default, Skills England Occupational Standards) it is possible to interrogate the data and identify specific statements in standards that align to enable identification of existing training materials and activities that could be used or adapted to meet future requirements.</p> <p>Full URL https://hvmcatapultforesighting.retool.com/embedded/public/d9f485a2-6d23-45dd-ab48-4c4c87ced0c7?token=97f32699b61bd02b863f006b3dbc6e28</p>
FOP Priorities	<p>Provides a list of all the FOPs within the selected cycle with details of their fit and surplus factors.</p> <p>The information here allows you to prioritise effort or action over the short, medium or long-term.</p> <p>Full URL https://hvmcatapultforesighting.retool.com/embedded/public/ad0f6dcb-9535-4239-96a7-c8d0e005477a?token=97f32699b61bd02b863f006b3dbc6e28</p>

Table 12 Visualisation tool and instructions for use

Appendix B List of full FOPs by Role Level including Capabilities

Scientist (Bio-Solvent Development)

Role Level – Professional & Delivery

Required for supply chain partners: Bio-Based Solvent Manufacturers, Pharmaceutical Manufacturers

ID	Capability Statement – Scientist (Bio-Solvent Development)	Function	Functional Domain	Functional Area	Type	RL Proficiency
321033	Develop purification technologies to ensure bio-based solvents meet pharmaceutical-grade specifications.	DESIGN	Technical Research	Research & Develop Technologies	Create	Practitioner
321412	Develop analytical methods to evaluate solvent properties for recovery and reuse.	DESIGN	Technical Research	Research & Develop Technologies	Create	Practitioner
321357	Develop bio-based solvents to expand the portfolio of renewable alternatives for pharmaceutical applications.	DESIGN	Technical Research	Research & Develop Technologies	Create	Expert
321442	Assess starting materials to understand their impact on product quality and performance.	DESIGN	Prototype Design & Development	Design Materials & Devices	Create	Practitioner
321043	Develop new solvent manufacturing processes to specification.	DESIGN	Process Design & Implementation	Develop Processes	Create	Practitioner
321394	Operate recovery units to monitor solvent purity and ensure contamination control.	IMPLEMENT	System/Equipment Operation & Monitoring	Operate Equipment	Use	Practitioner
321044	Select and validate bio-based solvents; perform compatibility and stability testing.	SUPPORT	Quality Control	Evaluate Product Characteristics & Quality	Create	Practitioner
321380	Conduct analytical studies to demonstrate performance equivalence of bio-based solvents with fossil-based solvents.	ENTERPRISE	Product Management	Research Product Performance	Create	Practitioner

Table 13 Scientist (Bio-Solvent Development) FOP

Circular Economy Engineer

Role Level – Professional & Delivery

Required for supply chain partners: Bio-Based Solvent Manufacturers, Solvent Recovery System Providers, Pharmaceutical Manufacturers

ID	Capability Statement – Circular Economy Engineer	Function	Functional Domain	Functional Area	Type	RL Proficiency
321389	Create lifecycle analysis models to support sustainable practices in API production.	DESIGN	Technical Research	Research & Develop Technologies	Create	Practitioner
321433	Integrate economic modelling with environmental metrics to inform strategic sustainability planning.	DESIGN	Technical Research	Research & Develop Technologies	Implement	Practitioner
321408	Conduct technoeconomic analysis alongside lifecycle assessment to support informed decisions on sustainable manufacturing investments.	DESIGN	Technical Research	Research & Develop Technologies	Use	Practitioner
321360	Define acceptance criteria for recycled solvents used in pharmaceutical manufacturing.	DESIGN	Prototype Design & Development	Validate Requirements	Create	Expert
197022	Develop processes that enable recovery of high value raw materials during the manufacturing process.	LOGISTICS	Waste Management	Manage Waste	Create	Expert
321468	Integrate solvent recycling systems to improve operational efficiency and reduce hazardous waste.	LOGISTICS	Waste Management	Manage Waste	Create	Practitioner
321469	Develop solvent recovery systems to reduce hazardous waste through solvent reuse.	LOGISTICS	Waste Management	Manage Waste	Create	Expert
321066	Enhance solvent recycling rates to reduce environmental impact and improve process efficiency.	ENTERPRISE	Leadership & Strategy	Promote Sustainable Practices	Create	Practitioner

Table 14 Circular Economy Engineer (FOP)

Sustainability Data Analyst

Role Level – Professional & Delivery

Required for supply chain partners: Bio-Based Solvent Manufacturers, Pharmaceutical Manufacturers, Digital Technology Providers, Regulatory & Standards Bodies

ID	Capability Statement – Sustainability Data Analyst	Function	Functional Domain	Functional Area	Type	RL Proficiency
321414	Track and report sustainability metrics to meet internal goals and external disclosure standards.	IMPLEMENT	Process Monitoring	Monitor Processes	Use	Practitioner
321413	Monitor emissions and resource use to support transparent ESG reporting and meet regulatory requirements.	IMPLEMENT	Process Monitoring	Monitor Processes	Maintain	Practitioner
321422	Analyse sustainability data to identify efficiency gains and guide strategic planning.	ENTERPRISE	Leadership & Strategy	Evaluate Business Performance	Use	Practitioner
321423	Generate ESG reports to inform stakeholders and support continuous improvement.	ENTERPRISE	Leadership & Strategy	Evaluate Business Performance	Create	Practitioner
321458	Support regulatory submissions to Environmental Regulators with verified environmental data and ESG performance evidence.	ENTERPRISE	Leadership & Strategy	Evaluate Business Performance	Use	Awareness
321459	Design digital dashboards and lifecycle assessment tools to monitor, evaluate, and reduce environmental impact.	ENTERPRISE	Leadership & Strategy	Evaluate Environment Impact	Create	Practitioner
321462	Monitor performance using data analytics to support sustainability compliance and continuous improvement.	ENTERPRISE	Data Management	Monitor Data Governance	Implement	Practitioner

Table 15: Sustainability Data Analyst

Solvent Recovery Specialist

Role Level – Professional & Delivery

Required for supply chain partners: Solvent Recovery System Providers

ID	Capability Statement – Solvent Recovery Specialist	Function	Functional Domain	Functional Area	Type	RL Proficiency
321396	Develop recovery units to improve solvent purity monitoring and enhance contamination control.	DESIGN	Technical Research	Research & Develop Technologies	Create	Practitioner
213978	Select equipment based on manufacturing requirements to allow recycling and recovery of solvents.	DESIGN	System/Equipment Design & Implementation	Select Equipment	Implement	Expert
321394	Operate recovery units to monitor solvent purity and ensure contamination control.	IMPLEMENT	System/Equipment Operation & Monitoring	Operate Equipment	Use	Practitioner
321402	Utilise suitable membranes to purify biosolvents and meet defined quality specifications.	IMPLEMENT	Mining & Extraction	Mine Liquids & Gases	Implement	Practitioner
321454	Maintain solvent recovery systems to ensure consistent solvent purity and environmental compliance.	SUPPORT	System/Equipment Maintenance	Maintain Systems	Create	Practitioner
321397	Optimise recovery systems to improve solvent purity and minimise environmental impact.	SUPPORT	System/Equipment Maintenance	Maintain Systems	Use	Expert
321382	Develop solvent recovery protocols to enhance sustainability in API manufacturing processes.	ENTERPRISE	Leadership & Strategy	Develop Sustainable Practices	Create	Practitioner

Table 16 Solvent Recovery Specialist (FOP)

GMP Digital Validation Specialist

Role Level – Professional & Delivery

Required for supply chain partners: Pharmaceutical Manufacturers, Digital Technology Providers

ID	Capability Statement – GMP Digital Validation Specialist	Function	Functional Domain	Functional Area	Type	RL Proficiency
321376	Develop validation protocols for digital systems in GMP environments to ensure compliance with regulatory standards.	DESIGN	System/Equipment Design & Implementation	Test Equipment & Systems	Create	Expert
321804	Provide guidance on validation requirements for digital systems to ensure compliance with regulatory standards.	DESIGN	System/Equipment Design & Implementation	Test Equipment & Systems	Implement	Practitioner
321040	Integrate digital twins with existing plant systems to optimize process control and predictive maintenance.	IMPLEMENT	Manage Operations	Manage Operation Control Systems	Create	Practitioner
321390	Use digital twin insights to anticipate equipment failures and schedule timely maintenance.	IMPLEMENT	Manage Operations	Manage Operation Control Systems	Use	Practitioner
321463	Apply automated systems and analytical methods to ensure compliance with regulations.	ENTERPRISE	Regulatory Compliance	Coordinate Compliance Activities	Use	Awareness
321366	Develop user manuals and standard operating procedures to guide operation and maintenance of solvent recovery systems.	ENTERPRISE	Regulatory Compliance	Design Policies and Procedures	Create	Awareness

Table 17 GMP Digital Validation Specialist (FOP)

Environmental Compliance Manager

Role Level – Strategic & Operational Management

Required for supply chain partners: Bio-Based Solvent Manufacturers, Solvent Recovery System Providers, Regulatory & Standards Bodies

ID	Capability Statement – Environmental Compliance Manager	Function	Functional Domain	Functional Area	Type	RL Proficiency
321415	Monitor external manufacturing performance to ensure adherence to quality, safety, and sustainability standards.	IMPLEMENT	Process Monitoring	Monitor Processes	Maintain	Awareness
321413	Monitor emissions and resource use to support transparent ESG reporting and meet regulatory requirements.	IMPLEMENT	Process Monitoring	Monitor Processes	Maintain	Practitioner
321465	Anticipate future demand for materials and locations to guide strategic sourcing and capacity planning.	LOGISTICS	Supply Chain Management	Identify Suppliers	Use	Expert
321464	Align supplier and manufacturer capabilities with sustainability goals and regulatory requirements.	LOGISTICS	Supply Chain Management	Identify Suppliers	Use	Expert
321455	Update waste disposal routes and train operators to reflect process changes.	SUPPORT	Health, Safety & Environment	Teach Safety Standards	Use	Practitioner
321456	Support process design by comparing safety risks and benefits of current versus proposed approaches.	SUPPORT	Health, Safety & Environment	Advise on Safety Standards	Maintain	Practitioner
321457	Support regulatory submissions to medicines regulators with data in line with GMP regulations to justify changes which improve sustainability.	ENTERPRISE	Leadership & Strategy	Evaluate Business Performance	Use	Awareness
321459	Design digital dashboards and lifecycle assessment tools to monitor, evaluate, and reduce environmental impact.	ENTERPRISE	Leadership & Strategy	Evaluate Environment Impact	Create	Practitioner
321302	Develop case studies of successful regulatory pathways for sustainable innovations to guide API manufacturing transformations.	ENTERPRISE	Leadership & Strategy	Develop Sustainable Practices	Create	Practitioner

Table 18 Environmental Compliance Manager FOP

Regulatory Compliance Officer (Manufacturing)

Role Level – Strategic & Operational Management

Required for supply chain partners: Bio-Based Solvent Manufacturers, Solvent Recovery System Providers, Pharmaceutical Manufacturers

ID	Capability Statement – Regulatory Compliance Officer	Function	Functional Domain	Functional Area	Type	RL Proficiency
321806	Advise on analytical approaches that support quality assurance and regulatory compliance in sustainable manufacturing.	SUPPORT	Quality Control	Manage Quality Control	Implement	Awareness
321398	Apply appropriate analytical technologies to support quality assurance and regulatory compliance in sustainable manufacturing.	SUPPORT	Quality Control	Manage Quality Control	Use	Practitioner
321035	Establish biosolvent standards to facilitate seamless substitution in existing manufacturing processes.	SUPPORT	Health, Safety & Environment	Develop Safety Standards	Create	Awareness
321423	Generate ESG reports to inform stakeholders and support continuous improvement.	ENTERPRISE	Leadership & Strategy	Evaluate Business Performance	Create	Practitioner
321457	Support regulatory submissions to medicines regulators with verified environmental data and evidence.	ENTERPRISE	Leadership & Strategy	Evaluate Business Performance	Use	Awareness
321366	Develop user manuals and standard operating procedures to guide operation and maintenance of solvent recovery systems.	ENTERPRISE	Regulatory Compliance	Design Policies & Procedures	Create	Awareness
321014	Ensure compliance with regulatory requirements by integrating ISO 14001 standards into API manufacturing operations.	ENTERPRISE	Regulatory Compliance	Coordinate Compliance Activities	Create	Awareness
321463	Apply automated systems and analytical methods to ensure compliance with regulations.	ENTERPRISE	Regulatory Compliance	Coordinate Compliance Activities	Use	Awareness

Table 19 Regulatory Compliance Officer (Manufacturing) FOP

Supply Chain Strategist

Role Level – Strategic & Operational Management

Required for supply chain partners: Bio-Based Solvent Manufacturers, Solvent Recovery System Providers, Pharmaceutical Manufacturers, Regulatory & Standards Bodies

ID	Capability Statement – Supply Chain Strategist	Function	Functional Domain	Functional Area	Type	RL Proficiency
321369	Implement AI-driven process control systems to enhance efficiency and sustainability in pharmaceutical manufacturing.	DESIGN	Supply Chain Design & Implementation	Develop Supply Chain Models & Systems	Create	Practitioner
321319	Develop predictive modelling tools to assess solvent substitution outcomes for sustainable API manufacturing.	DESIGN	Supply Chain Design & Implementation	Develop Supply Chain Models & Systems	Create	Practitioner
321116	Utilise machine learning algorithms to predict and enhance energy efficiency in production facilities.	DESIGN	Supply Chain Design & Implementation	Develop Supply Chain Models & Systems	Create	Practitioner
322350	Evaluate resource requirements following manufacturing changes to ensure operational efficiency and compliance.	IMPLEMENT	Plan Operations	Plan Operations	Use	Practitioner
321465	Anticipate future demand for materials and locations to guide strategic sourcing and capacity planning.	LOGISTICS	Supply Chain Management	Identify Suppliers	Use	Expert
321416	Develop supply chain strategies to ensure availability and quality of bio-based solvents at commercial scale.	LOGISTICS	Supply Chain Management	Identify Suppliers	Use	Expert
321358	Establish partnerships with technology providers to integrate sustainable manufacturing processes.	LOGISTICS	Supply Chain Management	Work With Suppliers	Create	Expert
321343	Establish public-private partnerships to accelerate sustainable technology adoption.	ENTERPRISE	Leadership & Strategy	Promote Sustainable Practices	Create	Expert

Table 20 Supply Chain Strategist FOP

Analytical Quality & Risk Specialist

Role Level – Professional & Delivery

Required for supply chain partners: Bio-Based Solvent Manufacturers, Solvent Recovery System Providers, Pharmaceutical Manufacturers, Regulatory & Standards Bodies

ID	Capability Statement – Analytical Quality & Risk Specialist	Function	Functional Domain	Functional Area	Type	RL Proficiency
321412	Develop analytical methods to evaluate solvent properties for recovery and reuse.	DESIGN	Technical Research	Research & Develop Technologies	Create	Practitioner
321443	Evaluate new technologies to determine effectiveness and suitability for manufacturing processes.	DESIGN	Product Evaluation	Evaluate Technical Performance	Use	Practitioner
321044	Select and validate bio-based solvents; perform compatibility and stability testing.	SUPPORT	Quality Control	Evaluate Product Characteristics & Quality	Create	Awareness
321224	Utilise advanced analytical technologies to ensure quality and compliance in sustainable manufacturing.	SUPPORT	Quality Control	Manage Quality Control	Create	Expert
321359	Implement contamination control features to ensure solvent purity and system integrity.	SUPPORT	Quality Control	Manage Quality Control	Create	Practitioner
321398	Apply appropriate analytical technologies to support regulatory compliance.	SUPPORT	Quality Control	Manage Quality Control	Use	Practitioner

Table 21 Analytical Quality & Risk Specialist FOP

Quality & Contamination Control Specialist

Role Level – Professional & Delivery

Required for supply chain partners: Solvent Recovery System Providers, Pharmaceutical Manufacturers

ID	Capability Statement – Quality & Contamination Control Specialist	Function	Functional Domain	Functional Area	Type	RL Proficiency
321359	Implement contamination control features to ensure solvent purity and system integrity.	SUPPORT	Quality Control	Manage Quality Control	Create	Practitioner
321398	Apply appropriate analytical technologies to support quality assurance and regulatory compliance in sustainable manufacturing.	SUPPORT	Quality Control	Manage Quality Control	Use	Practitioner
321224	Utilise advanced analytical technologies to ensure quality and compliance in sustainable manufacturing.	SUPPORT	Quality Control	Manage Quality Control	Create	Expert
321806	Advise on analytical approaches that support quality assurance and regulatory compliance.	SUPPORT	Quality Control	Manage Quality Control	Implement	Awareness
321044	Select and validate bio-based solvents; perform compatibility and stability testing.	SUPPORT	Quality Control	Evaluate Product Characteristics & Quality	Create	Awareness
321423	Generate ESG reports to inform stakeholders and support continuous improvement.	ENTERPRISE	Leadership & Strategy	Evaluate Business Performance	Create	Practitioner

Table 22 Quality & Contamination Control Specialist FOP

Digital Manufacturing Transformation Lead

Role Level – Strategic & Operational

Required for supply chain partners: Pharmaceutical Manufacturers, Digital Technology Providers

ID	Capability Statement – Digital Manufacturing Transformation Lead	Function	Functional Domain	Functional Area	Type	RL Proficiency
321188	Integrate digital tools into workflows to streamline operations and enhance decision-making in API manufacturing.	DESIGN	Process Design & Implementation	Develop Processes	Create	Practitioner
321087	Implement AI-driven process optimisation tools to enhance efficiency and sustainability.	DESIGN	Process Design & Implementation	Develop Processes	Create	Practitioner
321040	Integrate digital twins with existing plant systems to optimise process control and predictive maintenance.	IMPLEMENT	Manage Operations	Manage Operation Control Systems	Create	Practitioner
321390	Use digital twin insights to anticipate equipment failures and schedule timely maintenance.	IMPLEMENT	Manage Operations	Manage Operation Control Systems	Use	Practitioner
321462	Monitor performance using analytics to support sustainability compliance and continuous improvement.	ENTERPRISE	Data Management	Monitor Data Governance	Implement	Practitioner
321157	Implement digital transformation and automation to streamline API production and improve compliance.	ENTERPRISE	Leadership & Strategy	Manage Change & Transformation Programmes	Create	Expert

Table 23 Digital Manufacturing Transformation Lead FOP

Process Design Specialist

Role Level – Strategic & Operational

Required for supply chain partners: Bio-Based Solvent Manufacturers, Pharmaceutical Manufacturers, Digital Technology Providers

ID	Capability Statement – Process Design Specialist	Function	Functional Domain	Functional Area	Type	RL Proficiency
321043	Develop new solvent manufacturing processes to specification.	DESIGN	Process Design & Implementation	Develop Processes	Create	Practitioner
321188	Integrate digital tools into workflows to streamline operations and enhance decision-making in API manufacturing.	DESIGN	Process Design & Implementation	Develop Processes	Create	Practitioner
321087	Implement AI-driven process optimisation tools to improve sustainability and efficiency.	DESIGN	Process Design & Implementation	Develop Processes	Create	Practitioner
321414	Track and report sustainability metrics following process changes.	IMPLEMENT	Process Monitoring	Monitor Processes	Use	Practitioner
321446	Assess viability of repurposing existing facilities for new plant construction.	IMPLEMENT	Construction	Build Facilities & Structures	Use	Practitioner
321421	Operate technology transfer and knowledge sharing activities with external partners to ensure efficient scale-up.	SUPPORT	Operator Support	Operate Support Systems	Use	Awareness

Table 24 Process Design Specialist FOP

Commercial Partnerships Lead

Role Level – Strategic & Operational

Required for supply chain partners: Bio-Based Solvent Manufacturers, Solvent Recovery System Providers, Digital Technology Providers

ID	Capability Statement – Commercial Partnerships Lead	Function	Functional Domain	Functional Area	Type	RL Proficiency
321426	Develop company-wide strategies and policies to support the transition to sustainable manufacturing practices.	ENTERPRISE	Leadership & Strategy	Identify Business Threats & Opportunities	Create	Awareness
321425	Develop sustainability strategies to minimise environmental impact and align operations with long-term goals.	ENTERPRISE	Leadership & Strategy	Identify Business Threats & Opportunities	Create	Awareness
321343	Establish public-private partnerships to accelerate sustainable technologies in API manufacturing.	ENTERPRISE	Leadership & Strategy	Promote Sustainable Practices	Create	Expert
321066	Enhance solvent recycling rates to reduce environmental impact and improve efficiency.	ENTERPRISE	Leadership & Strategy	Promote Sustainable Practices	Create	Practitioner
321353	Communicate alternative solvent options to customers to support informed selection.	ENTERPRISE	Leadership & Strategy	Promote Sustainable Practices	Create	Awareness
321289	Develop documentation requirements for sustainability-driven process modifications to ensure consistent implementation.	ENTERPRISE	Leadership & Strategy	Develop Sustainable Practices	Create	Practitioner

Table 25 Commercial Partnerships Lead FOP

Chief Transformation Officer

Role Level – Enterprise / Strategic Leader

Required for supply chain partners: Bio-Based Solvent Manufacturers, Solvent Recovery System Providers, Pharmaceutical Manufacturers, Digital Technology Providers, Regulatory & Standards Bodies

ID	Capability Statement – Chief Transformation Officer	Function	Functional Domain	Functional Area	Type	RL Proficiency
321157	Implement digital transformation and automation to streamline production and improve compliance.	ENTERPRISE	Leadership & Strategy	Manage Change & Transformation Programmes	Create	Expert
321426	Develop company-wide strategies to support sustainable manufacturing transition.	ENTERPRISE	Leadership & Strategy	Identify Business Threats & Opportunities	Create	Awareness
321336	Establish working groups to address specific sustainability challenges in pharmaceutical manufacturing.	ENTERPRISE	Leadership & Strategy	Develop Sustainable Practices	Create	Expert
321309	Develop certification programmes for regulatory professionals to ensure compliance with sustainable manufacturing practices.	ENTERPRISE	Leadership & Strategy	Develop Sustainable Practices	Create	Expert
321314	Develop frameworks for post-approval adoption of bio-solvents to facilitate regulatory compliance.	ENTERPRISE	Leadership & Strategy	Develop Sustainable Practices	Create	Awareness
321460	Develop multiparameter optimisation tools to improve efficiency and sustainability in bio-solvent manufacturing.	ENTERPRISE	Leadership & Strategy	Develop Sustainable Practices	Create	Practitioner
321356	Facilitate dialogue to identify regulatory barriers to sustainability.	ENTERPRISE	Leadership & Strategy	Develop Sustainable Practices	Create	Practitioner

Table 26 Chief Transformation Office

Regulatory Policy & Standards Officer (Regulator / Standards Body)

Role Level – Strategic & Operational Management

Required for supply chain partners: Regulatory & Standards Bodies

ID	Capability Statement – Regulatory Policy & Standards Officer	Function	Functional Domain	Functional Area	Type	RL Proficiency
320951	Prepare comprehensive regulatory submissions to document solvent changes and reuse, facilitating approval processes.	ENTERPRISE	Regulatory Compliance	Monitor Regulation Changes	Create	Awareness
321366	Develop user manuals and SOPs to guide operation and maintenance of solvent recovery systems.	ENTERPRISE	Regulatory Compliance	Design Policies & Procedures	Create	Awareness
321014	Ensure compliance with regulatory requirements by integrating ISO 14001 standards into API manufacturing operations.	ENTERPRISE	Regulatory Compliance	Coordinate Compliance Activities	Create	Awareness
321463	Apply automated systems and analytical methods to ensure compliance with regulations.	ENTERPRISE	Regulatory Compliance	Coordinate Compliance Activities	Use	Awareness
321302	Develop case studies of successful regulatory pathways for sustainable innovations to guide future transformations.	ENTERPRISE	Leadership & Strategy	Develop Sustainable Practices	Create	Practitioner
321356	Facilitate dialogue to identify regulatory barriers to sustainability.	ENTERPRISE	Leadership & Strategy	Develop Sustainable Practices	Create	Practitioner
321343	Establish public-private partnerships to accelerate adoption of sustainable technologies in API manufacturing.	ENTERPRISE	Leadership & Strategy	Promote Sustainable Practices	Create	Expert

Table 27 Regulatory Policy & Standards Officer (Regulator / Standards Body) FOP

Appendix C Background to Workforce Foresighting Hub

Addressing future workforce challenges

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

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

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

The Skills Value Chain

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

The SVC approach was proposed in the 'Manufacturing the Future Workforce' [report](#), which examined global best practice and convened UK pioneers to explore how the UK can develop skills to exploit innovative technologies. And it starts with workforce foresighting.

Workforce foresighting

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

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

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

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

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

Our Goals:

Define future capabilities required across a sector in response to a challenge, or technology innovation and consequently define the skill sets of the workforce of the future.

Understand and explain gaps between technology adoption, organisational capability and workforce profiles that could hamper innovation.

Identify and communicate insights, future requirements and the action required by industry and educators.

Enable and deliver a consistent approach to workforce Foresighting.

Outcomes:

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

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

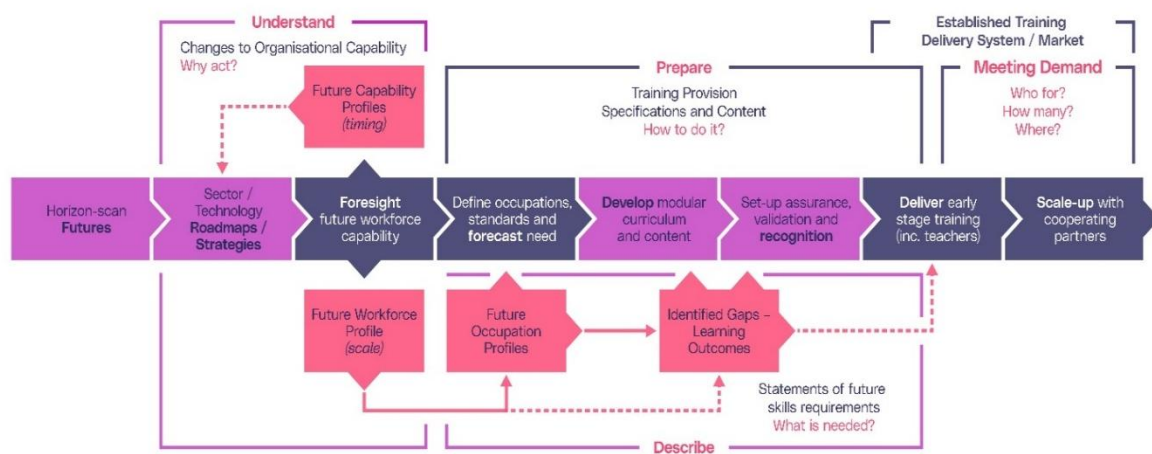


Figure 2 Workforce Foresighting & Skills Value Chain

Approach used - principles and implementation

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

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, classification enables data from a number of other national and international open-source workforce datasets to be integrated through the same common language. This

data is held in a cloud based “data-cube” that is dynamically growing as each workforce Foresighting cycle adds to the shared data relating to future workforce capabilities.

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

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

- Considering** – Clarifying the Challenge to be met (the ‘what’ and the ‘when’) and collating solutions (the ‘how’) as Foresighting topic suggestions align with strategic priorities
- Identifying** – Gain clarity and consensus about the solutions to be put forward – make the case for Foresighting

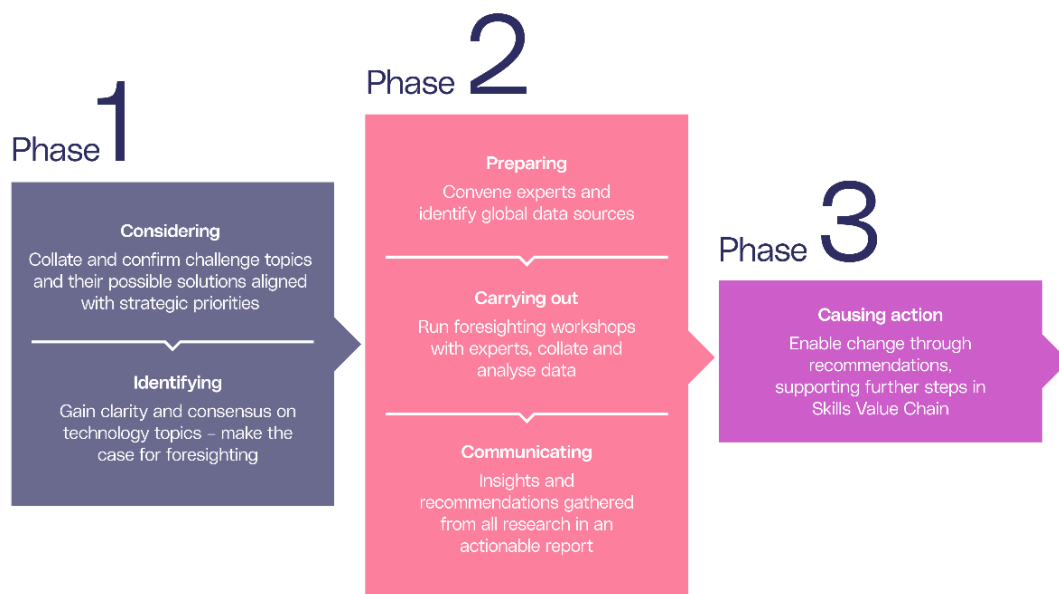


Figure 3 The workforce foresighting process

- 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 an actionable 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

Forecasting and Foresighting

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

Outcomes - insights and recommendations

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

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

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

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

The insight produced by a workforce Foresighting cycle (project) provides:

- **Technologists** and technical leads with insight of the organisational capability sets required across future supply chain partners in response to the identified challenge.
- **Employers** with insight about possible future roles and occupations that may be required across the whole workforce, operators to researchers, to ensure they are equipped and ready.
- **Educators** with details of the gaps to be addressed by short-course training to upskill the existing workforce and also insight about qualifications and provision that will be required to support new entrants in the future.