Advancing Manufacture of Blades for Offshore Wind Turbines

Interim Report: Workforce Foresighting Cycle Output

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

- IfATE – Institute for Apprenticeships and Technical Education, England
- ESCO – European Skills, Competencies, Qualifications & Occupations, EU
- ONet – Occupational Networks Online, USA

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

- The IfATE data used contains public sector information licensed under the Open Government Licence v1.0.
- The ESCO data is used in accordance with the EUROPEAN UNION PUBLIC LICENCE v. 1.2 EUPL © the European Union 2007, 2016
- The ONet data used is under CC BY 4.0 license. (O*NET® is a trademark of USDOL/ETA.) The Workforce Foresighting Hub team has modified all or some ONet information. USDOL/ETA has not approved, endorsed, or tested these modifications.

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

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

This report was produced following workshops undertaken 2025 Q1 using the data set and tools available at that time.

EXECUTIVE SUMMARY

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

This interim report outlines findings from the second phase - 'Carrying Out' - of a workforce foresighting study on "Advancing Production of Blades for Offshore Wind Turbines". The study is sponsored by RenewableUK and conducted by the Offshore Renewable Energy Catapult in collaboration with the Workforce Foresighting Hub, and the National Composite Centre.

The study considers the organisational capabilities needed in an alternative production methodology where manual lay-up and preparation of wind turbine blades is augmented or replaced by robotics and automation.

Within this report, participants and stakeholders can review the developed capability sets and Future Occupational Profiles ('FOPs') before the next phase of work. The appendices provide further information about workforce foresighting, selection of the topic, and provide links to an online visualisation tool for exploration of data generated during this study.

Participants and Stakeholders

The following organisations participated in the carrying-out phase of this foresighting cycle:

Organisation	Technologist Group	Employer Group
The Offshore Renewable Energy Catapult	o	o
Vestas Wind Systems A/S	o	o
Siemens Gamesa Renewable Energy	o	o
Loop Technology	o	o
The National Composite Centre (NCC)	o	o
University of Hull – Energy and Environment Institute	o	
Bristol Composites Institute – University of Bristol	o	

Key stakeholders in the foresighting cycle are:

Role	Purpose	Stakeholder
Challenge Sponsor	Person or organisation requiring the outputs of the foresighting process to support decisions to act on education and training.	RenewableUK: Jane Cooper, Director of Offshore Wind
Challenge Convener	Organisation that identifies and brings together stakeholders to define the Challenge, Sponsor and take part in foresighting.	ORE Catapult: Tony Quinn, Operations Director
Foresighting Champion	Person with authority and influence to convene foresighting interest within the organisation and with its stakeholder and partner bodies.	ORE Catapult: Danielle Portsmouth, Future Skills Manager
Foresighting Coordinator	Person who will manage the acquisition of project information, facilitate topic selection, recruit and organise participants, and author reports.	Paul Hatchett Consulting Limited

Results of the "Carrying Out" Phase

The workforce foresighting workshops and surveys identified 145 capabilities relevant to the topic. Of these capabilities:

- 64 capabilities were adopted from the Workforce Foresighting Data Cube[1];
- 10 capabilities were adapted (modified) from the Workforce Foresighting Data Cube; and
- 71 capability statements were newly defined by the study and added to the Data Cube.

The capabilities are grouped into fifteen future occupational profiles ('FOPs') in the following areas of practice:

- Direction and management of change;
- Developing and designing blades suitable for automated / advanced production methods;
- Implementation of equipment that will carry out automated production;
- Operation of the equipment and production of the wind turbine blades;
- Development of the composite material system suitable for automated production;
- Supporting functions – getting the right things to the right place, at the correct quality.

The purpose of the FOPs is to indicate coherent groups of capabilities that can be used as a basis in skills analysis, job design, and education / training curricula. The FOPs are not job descriptions, and it is possible that one job may encompass parts of several FOPs or specialise into part of only one FOP. These resulting FOPs now form the basis for ongoing discussions and the "causing action" phase of workforce foresighting.

[1] These could either be IfATE standards, or capabilities added to the Data Cube in a previous cycle.

Next Steps

In the next phase of the foresighting cycle ORE Catapult will work with stakeholders to identify and initiate actions to close the potential future skills gaps identified through foresighting, considering the volume of likely roles determined by forecasting. This work will include:

1. Issuing a preliminary survey for feedback on the 'differentiating capabilities' within each future occupational profile [complete].
2. Incorporating feedback from industrial participants and other reviewers of the future occupational profiles and capability sets.
3. Developing forecasts that help to understand component volumes and the expected role numbers.
4. Initiating a working group including UK-based blade manufacturers and their skills partners, to focus on the future of advanced manufacture for blades, including:
    a. Working with further and higher education partners, as well as industry training organisations, to identify potential course module content – based on foresighting and forecasting, and relevant Knowledge, Skills and Behaviours.
    b. Encouraging a champion for development of skills in advanced wind turbine blade manufacture.
5. Evaluating the opportunity for further foresighting studies in composites manufacture for offshore wind.

NOMENCLATURE

Term	Definition
AI	Artificial intelligence (in the case of foresighting, the 'GPT4' large language model, used to analyse and match capability statements and standards).
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
CPD	Continuing Professional Development
Data Cube	The database and framework developed by the Workforce Hub to hold, compare and analyse organisational capabilities against occupational standards. For further detail, see Appendix 1 .
DESNZ	The UK Government's Department for Energy Security and Net Zero.
Fit Factor (FF)	The degree to which the capability statements within an Existing Provision definition fit to a given future occupational profile (from foresighting). A higher Fit Factor indicates a closer match.
FOP	Future Occupational Profile.
GW	Gigawatts
IfATE	the Institute for Apprenticeships and Technical Education, see https://www.instituteforapprenticeships.org/
LCoE	Levelised cost of energy
ORE Catapult	The Offshore Renewable Energy Catapult, part of the UK Catapults network of research and technology organisations, established and funded by Innovate UK to accelerate technology and capability in key industrial sectors, and act as a bridge between academic research and industry.
OWIGP	The UK's Offshore Wind Industrial Growth Plan (RenewableUK, 2024)
R&D	Research and development
RTO	Research and technology organisation (e.g. ORE Catapult)
SF Surplus Factor	The degree to which the capability statements within an Existing IfATE course definition are not contained within a given future occupational profile (from foresighting). A lower Surplus Factor indicates a closer match.
WFH, WF Hub	The Workforce Foresighting Hub provides the process, insight and recommendations for industry, policymakers and educators to adapt to continuing change, helping UK businesses to adopt innovation and succeed in the dynamic global marketplace. The central team is based at the Manufacturing Technology Centre (part of the High Value Manufacturing Catapult).

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1. Introduction

1 INTRODUCTION

1.1 Purpose of the Interim Report

This interim report is a summary of output from Phase 2 ('Carrying Out') of a workforce foresighting study on "Advancing Manufacture of Blades for Offshore Wind Turbines". The study is sponsored by RenewableUK and conducted by the Offshore Renewable Energy Catapult, with the Workforce Foresighting Hub facilitating the foresighting process through structured workshops and detailed analysis.

The report is intended principally for participants and interested stakeholders to review and access the capability sets and prototype future occupational profiles ('FOPs') developed by the study so far. This provides an opportunity for comment, before the "causing action" phase of the study. FOPs are intended to support industry and the training / education sector in the design of roles and course content, but they are not intended as prescriptions for job descriptions or specific course modules.

The report briefly summarises the foresighting topic and its selection, presents the future occupational profiles, and provides the capability sets within the Appendices. The appendices to the report also contain further information about the workforce foresighting process, and links to an online visualisation tool, where the generated data can be viewed in various ways.

1.2 Background to Workforce Foresighting

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

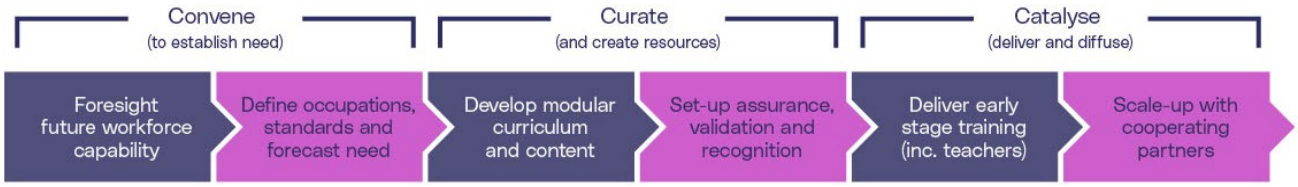


Figure 1 - The Skills Value Chain

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

1.3 Workforce Foresighting - Process Overview

The core of workforce foresighting is convening groups of relevant specialists to conduct Delphi-style[2] workshops to capture and discuss the set of organisational capabilities that will be required to respond to and exploit technology innovation.

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

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

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

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

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

Preparing – The convening of specialists and scheduling of workshops

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

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

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

[2] Delphi-style workshops are structured to gather insights and reach consensus on complex topics, using anonymous feedback and iterative rounds. The term derives from the ancient Greek oracle at Delphi, and the workshop approach is attributed the RAND Corporation.

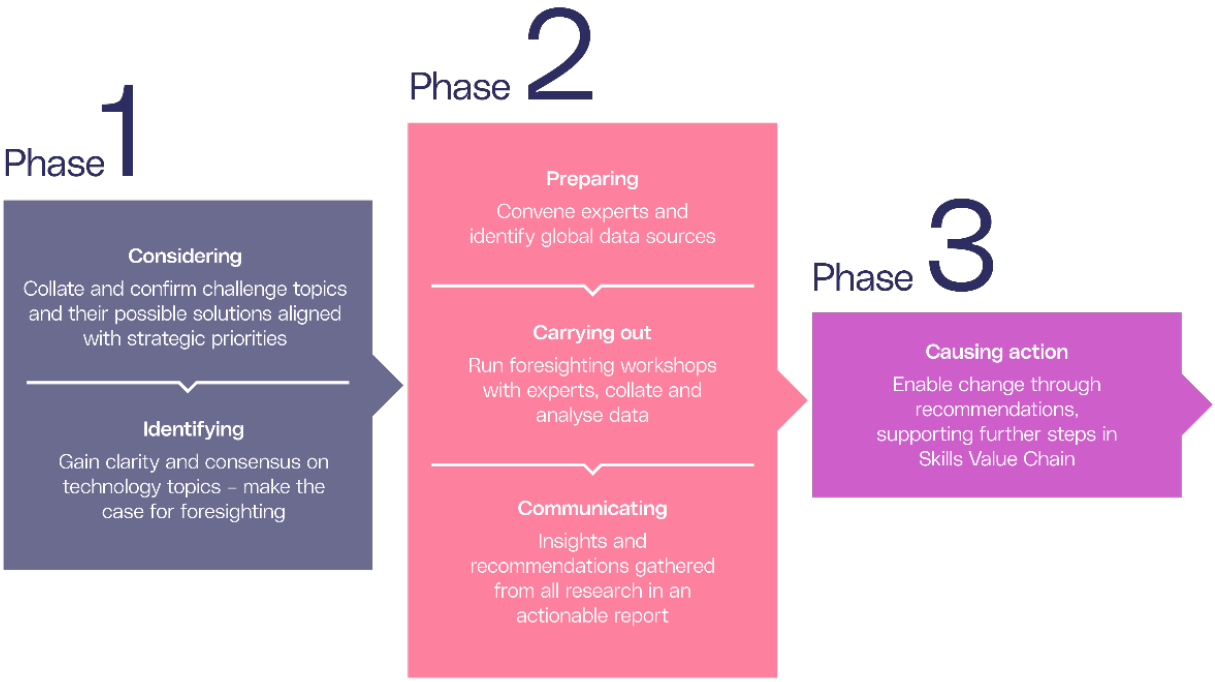


Figure 2 - The workforce foresighting process

1.4 Foresighting vs Forecasting

Although this study is focussed on workforce foresighting (capabilities required) it is important to keep in mind parallel findings from forecasting (required capacities and numbers). ORE Catapult is working with the Department for Energy Security and Net Zero ('DESNZ') and Innovate UK to make assessments and maintain thought leadership around offshore wind installation targets and the implications on educators, industry, and sector bodies. Forecasting, alongside foresighting, provides vital input to the sector, feeding into recruitment and development targets for employers, and consideration of economic class sizes and recruitment targets for educators. However, it is beyond the scope of the foresighting study to carry out independent forecasting, and as such readers should refer to other studies for detail on forecasting.

1.5 Introducing the Visualisation Tool

The Workforce Foresighting Hub's Visualisation Tool is a powerful, innovative system, which will enable the reader to explore and analyse foresighting data to determine the capabilities required for future roles. Some instructions on how to use the Visualisation Tool can be found in Appendix 2 .

2. Defining the Foresighting Challenge

2 DEFINING THE FORESIGHTING CHALLENGE

The foresighting challenge, technologies and topics were identified during a combined 'consider-identify-prepare' phase[3].

2.1 Positioning and National Context

According to the UK's Clean Power Action Plan 2030 (Department for Energy Security and Net Zero, 2024), power generation from offshore wind is a vital part of the UK's future energy security and achievement of CO_2 reduction targets. The UK has a target of 43-50GW of power from offshore wind by 2030. Alongside nuclear, this is seen as the backbone of a clean electricity system in the UK. The gap between current installed capacity and future targets is illustrated in Figure 2 below.

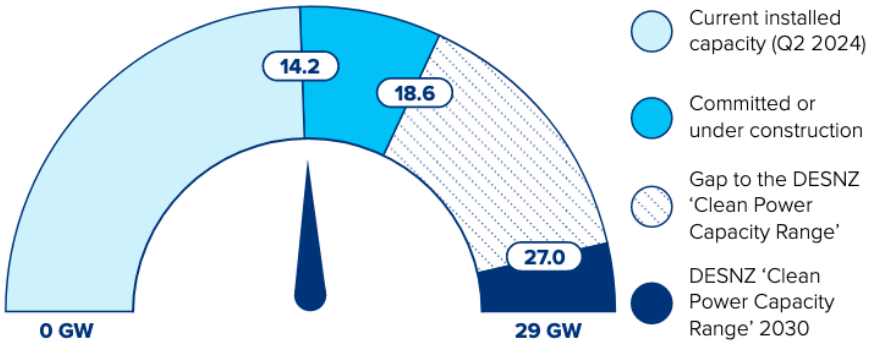


Figure 2 - Offshore Wind installed capacity vs 'Clean Power Capacity Range' in 2030 (Department for Energy Security and Net Zero, 2024)

The need for new technologies and capabilities to support this increase in the UK's installed offshore wind generating capacity, is the top-level challenge being addressed through ORE Catapult's workforce foresighting studies.

2.2 Topic Selection Approach

The foresighting topic of "Automated Welding for Offshore Wind Flotation Structures" has been selected through the following approach:

1. A detailed review of the UK's "Offshore Wind Industrial Growth Plan" (RenewableUK, 2024) to identify focal technology areas for foresighting.
2. Review of the UK's "Clean Power 2030 Action Plan" (Department for Energy Security and Net Zero, 2024) and the Energy Skills supplement to better understand the strategic landscape.
3. Review and shortlisting workshops with lead technologists from the Offshore Renewable Energy Catapult ('ORE Catapult').

[3] A summary of the approach is provided here, but greater detail is set out in the report "Future Skills Needs in UK Offshore Wind: Workforce Foresighting Cycles 3-5 Activity Zero" (Hatchett, 2025).

2.2.1 Overview of the Offshore Wind Industrial Growth Plan

The Offshore Wind Industrial Growth Plan ('OWIGP') is a recommendation by industry bodies to government, for investment in the growth of UK offshore wind and strengthening of the industrial sector. The report sets out an aim to expand the UK's offshore wind supply chain and grow its market share, domestically and internationally. The plan targets £25 billion in gross value added through a focus on key technologies, leveraging the UK's existing strengths in the sector.

The OWIGP emphasises the need for a strategic approach, with a focus on technologies vital to domestic supply and those where the UK can establish a competitive advantage through innovation. The document sets priorities, objectives, and actions for key technologies, future trends, and innovation.

According to the report, progress will be supported by a new delivery body which will own the growth plan, report against and refresh the plan at intervals, align stakeholders, and champion the UK as a leading destination for investment.

The OWIGP acknowledges that the development of a skilled workforce is a critical factor in making the UK a top employment destination within the offshore wind sector. Workforce Foresighting is referenced within the OWIGP as an approach to identify future workforce capability requirements; however, the plan itself is light on workforce planning and skills development needs.

2.2.2 Overview of the Clean Power 2030 Action Plan

The Clean Power 2030 Action Plan was published by the Department for Energy Security and Net Zero ('DESNZ') in December 2024. The Action Plan describes the UK's transition to clean energy by 2030. The plan sets goals including that:

- Clean energy should comprise 95% of Great Britain's overall generating capacity *(currently 60%);*
- Clean energy should produce as much power as Great Britain consumes *(currently 56%);* and,
- Great Britain's CO_2 emissions intensity should be below 50g per KWh by 2030 *(currently 171g CO_2 / KWh).*

The plan reiterates the UK's target of 50GW of offshore wind generating capacity by 2030, although in certain scenarios this target is reduced to 43GW of offshore wind, with a renewed focus on onshore wind and the introduction of low-carbon dispatchable power, such as biomass with carbon capture and storage. Batteries (both domestic, and as large-scale grid-attached storage) also play a significant role, with an increase from 4.5GW current installed capacity up to 23-27GW by 2030.

Skills are a significant consideration in the Clean Power 2030 Action Plan – the only addendum to the report focusses on this issue ("Assessment of the Clean Energy Skills Challenge"). The Skills Challenge Assessment notes that the offshore wind sector has reported persistent skills gaps in high-level electrical, digital, and consenting skills; for roles like Senior Authorised Persons, data analysts and scientists, and regulators. It also notes that there are workforce shortages in the areas of project management, on- and off-shore logistics, and construction resources for floating wind projects. According to the plan, Government will be exploring targeted skills interventions to reskill and upskill workers across the economy. Workforce Foresighting is referenced as a component in resolving the skills challenge, citing ORE Catapult's study on Dynamic Cable Systems.

2.2.3 Topic Longlisting Approach

The OWIGP recommends the UK should be a global leader in five areas of offshore wind:

- Advanced Turbine Technology

- Industrialised Foundations & Substructures
- Future Electrical Systems & Cables
- Smart Environmental Services, and
- Next Generation Installation, Operations & Maintenance

For each of these areas, the plan outlines "Respond, Expand, and Disrupt" programs. The "Respond" programs are focused on addressing immediate infrastructure needs and supply constraints, the "Expand" programs aim to build capacity for emerging export markets, and the "Disrupt" programs seek to establish the UK as a leader in offshore wind advancements through innovation and commercialisation. The plan highlights the need for the UK to increase its manufacturing capabilities in key areas like blades, towers, foundations, and cables, and to enhance its skills in areas like installation, and operations & maintenance ('O&M'). In addition to the list of initiatives, the OWIGP identifies some key technology trends which further inform potential areas for skills foresighting.

Thirteen potential foresighting topics were identified through review of the OWIGP:

- Novel manufacturing processes and bonding methods for WTG blade leading edge protection.
- 3D printing of WTG blade leading-edge parts.
- Design of composite WTG blades to enable production with advanced techniques.
- Automating composite manufacturing techniques for blades, e.g. VARTM, ATL, soluble mandrels etc.
- Use of alternative materials to reduce steel weight (towers, foundations) in FoW.
- Use of alternative and synthetic materials for anchors and moorings in FoW.
- Use of synthetic ropes for mooring lines in FoW Development of hybrid energy offshore wind farm solutions.
- Incorporation of power-to-x and energy storage systems in offshore wind farms.
- Development of autonomous windfarm environmental and site inspection survey RAS (hardware).
- Survey algorithm & autonomous controls for RAS environmental and site inspection (software).
- Batteries & energy storage for autonomous survey systems.
- ML analysis of Survey Data (for species monitoring, habitat monitoring).
- Generate solutions for next-generation drive train technologies.

2.2.4 Topic Shortlisting

The shortlisting exercise involved gathering input from lead technologists and senior managers at the Offshore Renewable Energy Catapult:

- Dr. Thomas Wildsmith, Head of Commercial
- Deri Galvin, Head of Industrialisation
- Michael Smailes, Principal Development Engineer.
- Andrew Esson, Future Skills Lead
- Danielle Portsmouth, Future Skills Manager
- Paul Hatchett, Future Skills Consultant (facilitator)
- Andrew Stormonth-Darling, Principal Portfolio Manager – Floating Offshore Wind
- Jack Paterson, Team Leader – Floating Offshore Wind
- Alex Neumann, Chief Engineer – HV Electrical
- Tony Quinn, Director – Technology Development

Participants screened the longlist considering the fit with workforce foresighting methodology, ease of scoping the topic, likely skills needs, and maturity of the technology (i.e. achieving 'horizon 2' around 2030-2032). Topics were challenged and adjusted for suitable scope (neither too broad nor too niche). The group also considered potential collaborations with other Catapults and RTOs, favouring those where there might be some beneficial overlap.

After a check for omissions, including comparison to the European Technology & Innovation Platform on Wind Strategy (ETIPWind, n.d.), the group carried out a prioritisation exercise considering the level of future skills challenge, and ability to convene an effective working group. This resulted in two clusters of foresighting topics:

Cluster 1

- **Structures – automated welding**: The development and application of automated welding solutions [and assembly methods] for foundations, transition structure and tower sections.
- **Advanced production methods in WTG blades**: Design and production of WTG blades to utilise advanced techniques such as 3d printing / ceramic leading edges, automated production methods.
- **HVDC Cable Systems**: Development and production of high voltage direct current (HVDC) cables in the UK, potentially including novel polymers, and associated equipment.

Cluster 2

- **Smoothing power delivery to grid from Offshore Wind**: Power-to-x (e.g. electrolyser), hybrid and large-scale energy storage systems for offshore wind; also possibly considering system including application of grid forming control in WTG invertors.
- **Autonomous survey**: RAS application for autonomous subsea environmental, site and geotechnical survey (pre-construction).
- **Alternative materials for Floating Offshore Wind moorings / structures**: Use of synthetic ropes, alternative and synthetic materials for mooring lines in floating offshore wind /or/ Use of advanced / novel concrete materials and forming for floating offshore wind foundations, structures.

2.3 Topic Selection and Description

Deriving from the second shortlisted topic, this workforce foresighting cycle addresses "Advancing Manufacture of Blades for Offshore Wind Turbines" and relates to the development and application of production automation equipment and robotics to reduce the cost, cycle time and improve quality of wind turbine blade production.

The title of 'advancing manufacture' rather than 'automating manufacture' was chosen to reflect the fact that automation is one of several ways of advancing manufacture. Other methods of advanced manufacture might include innovations such as sectional blades (see section 2.3.4), bonding ceramic leading edges to reduce in-service wear, or separately manufactured trailing edges bonded to a flat-edged central blade box. In practice however, the workshop cycle focussed predominantly on the automation of production. This may be a function of the participants in the cycle, and the relative maturity or confidentiality of emerging methodologies.

The following paragraphs explore some relevant developments and technologies to provide context, but this is not intended as a detailed technology review or forecast[4].

2.3.1 Drivers for Automation in Blade Production

The principal drivers for automating the production of wind turbine blades include:

- **Increasing production capacity**: By 2030, European offshore wind deployment is expected to reach around 8-9GW per year. Siemens Gamesa Renewable Energy, General Electric, and Vestas (the main wind turbine blade suppliers into this market) can supply around 6.5 – 8 GW of nacelle and blade capacity per year. At these capacities, supply would just be able to support an anticipated European offshore wind deployment of 8–9 GW/year by 2030 (Telsnig et al., 2022). This is without taking export market demand into account.
  Additional blade production capacity is needed to meet worldwide demands for wind energy (Huth, 2024), which means that further factories could be added (potentially, hitting labour supply limits), and / or some degree of automation is needed to increase the output capacities of current facilities.
  Within the UK and in the near-term, Siemens Gamesa Renewable Energy are expected to produce around 250 blades per year at the new blade factory in Hull, and Vestas have a capacity of around 125 blades per year from the Isle of Wight facility.

- **Reducing costs**: The UK has a high labour cost base, and automating production can be a way to offset these costs. As well as lowering labour costs, automation can increase production efficiency and optimise material usage. Blades comprise around 22% of the overall cost of the wind turbine (Franke et al., 2019) . The 'Blademaker' project finds that reduction in costs of between 8% and 14% may be possible with automation (Dörsch et al., 2015), and further savings may be possible by adapting blade designs for automation.

- **Improving quality**: More consistent processing and repeatability in wind turbine blade production can be achieved through automation, compared to manual production (Dörsch et al., 2015). This can also lead to the inclusion of tolerances in designs, so automation can also allow for reduction of tolerances and improve the overall structural performance and safety of the blades (Wang et al., 2015).

- **Larger blades**: As wind turbine sizes increase to reduce the overall cost of energy produced, manufacture of the larger wind turbine blades becomes more challenging with manual processes (Dörsch et al., 2015; Engemann et al., 2021).

- **Improving worker safety and ergonomics**: Automating the production process can improve worker ergonomics (Nixon-Pearson et al., 2022) and help to ensure the health and safety of workers.

2.3.2 Examples of Automation

There is a spectrum for automation from partial or assisted automation in parts of the production process (such as inspection and non-destructive testing), through to a full "lights-off" production model. Newer humanoid robotic and "co-botic" production solutions might also offer ways to advance production in ways that differ to a traditional automated production line. The full-spectrum

[4] For a more detailed discussion of current and future blade manufacture, see (Nixon-Pearson et al., 2022) at https://cms.ore.catapult.org.uk/wp-content/uploads/2023/01/CFAR-OC-020-31032022-Wind-Turbine-Blades-Design-and-Manufacturing-Literature-ReviewFinal.pdf

automation and lights-off facility may not be economically feasible for turbine blade production, but current production models are unlikely to meet future capacity and unit cost requirements. It is thought to be likely within the horizons of workforce foresighting, that production will be partially rather than fully automated. This in turn may have some impacts on the design of turbine blades.

The main areas where automation is being implemented or developed for blade production include:

- **Textile handling and lay-up** (Ohlendorf et al., 2020)
  - Automated pick and placement of pre-cut fabric layers by robots with specialised grippers.
  - Direct textile placement (DTP) – laying up the textile directly into molds.
  - Automated tape lay (ATL), and Automated fibre placement (AFP) are both methods used in aerospace manufacture and can automatically lay down fibre material for complex structures.
  - Automated preforming – forming the stack of 2D textiles before these are placed into the correct 3D geometry in the mold.

- **Core material processing**, such as in-situ forming processes for the polyurethane (PU) core. This involves automated application of liquid PU into the mold using a CNC-controlled gantry system, and replaces manual positioning of foam kits (Wang et al., 2015).

- **Post-mold processing,** including measurement, CNC trimming and grinding of the blade for better shape and surface quality, and other forms of automated surface processing (Dörsch et al., 2015).

- **Inspection**, such as the use of autonomous mobile manipulators to accurately inspect structures (Engemann et al., 2021), and the use of vision systems for assuring lay-up and core or ply placement (de Kruijk, 2018).

2.3.3 The ALMA Project

The ALMA project seeks to develop an “Automated Preforming Robotics System (APRS)” to replace the manual process of laying up pre-form plies during blade production. The key hardware components are a fabric dispensing system, an end-effector and robot, which are mounted on a moving gantry system. Sophisticated inspection systems can detect wrinkles in the fabric placement. ALMA commenced in 2023 and will run until 2026, operating with a budget of just under 29M DKK (about £3.3M) of which 56% is funded by the Danish state.

2.3.4 Sectional and Modular Blade Concepts

The drive to reduce the levelised cost of energy (LCoE) has led to longer blades, to increase the generating capacity of each wind turbine and realise economies of scale. Blade lengths have been steadily increasing, now exceeding 125m. This has created challenges particularly for transportation and handling, but also in manufacture.

One of the approaches to address these challenges is to segment the blade, instead of producing a traditional monolithic blade. The segments are chordwise ‘slices’ of the turbine blade, which are then assembled into the complete blade. The assembly can take place at the site of the turbine, which significantly reduces the difficulties of transporting long blades (Peeters et al., 2017). Sections can be joined using mechanical fasteners or bonded at lap joints. It is possible that by designing similar segments, the apparent unit volume increases, which in turn may make segmented blades more suitable for automated production.

Whether or not sectional blades end up cheaper overall than monolithic blades depends on the balance of factors such as capital expenditure for manufacturing tooling and equipment, transport costs, manufacturing and assembly costs. Manufacturing cost may increase due to the additional features and complexity of parts, compared to a monolithic blade. Similarly, if on-site assembly and installation are complex this may also increase the cost of segmented blades compared to monolithic. On the other hand, transportation costs will decrease as the size of the blade increases.

Modular blade concepts have similar drivers and benefits, but rather than chordwise segments, the modules may comprise key parts of the blade such as spar boxes, leading / trailing edges, tips and roots, which are manufactured separately and then bonded together (see Figure 3).

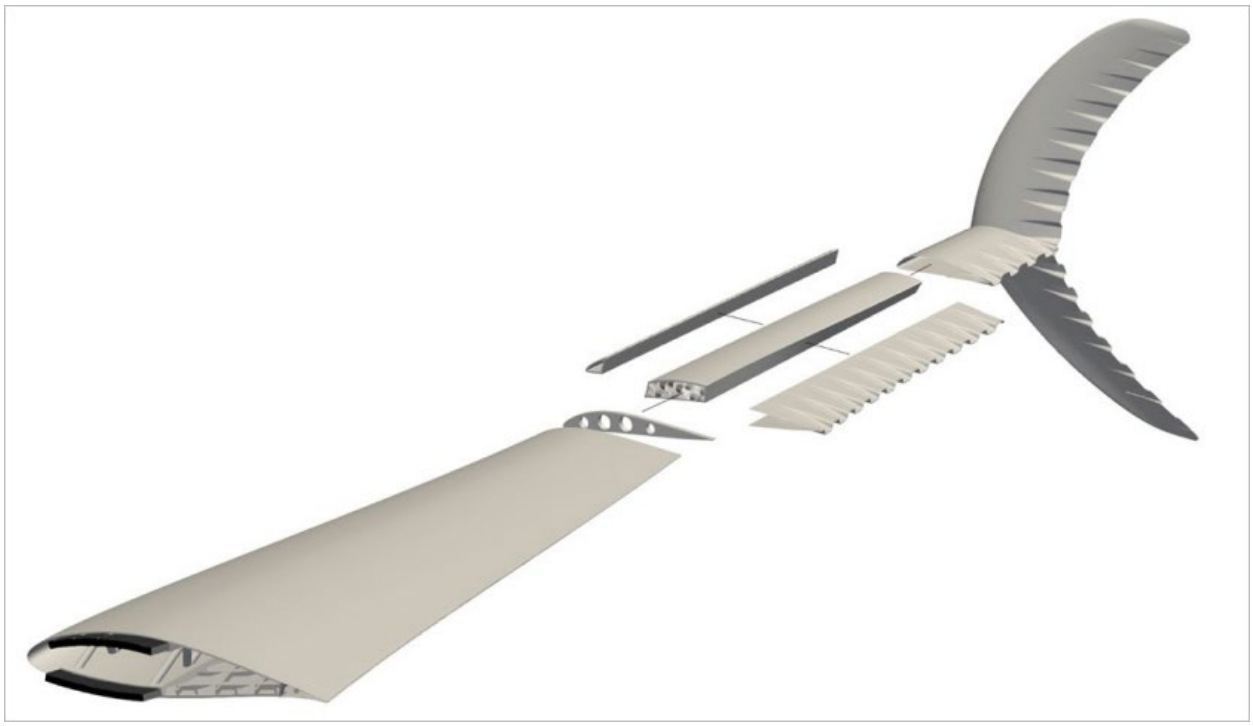


Figure 3 - Illustration of a Modular Blade Concept (ORE Catapult & National Composites Centre, 2022)

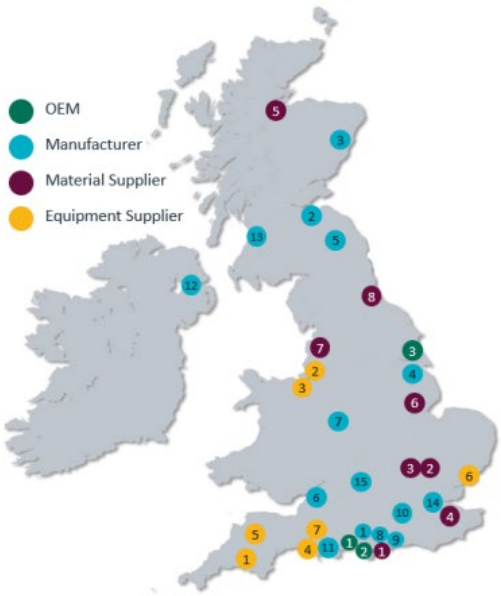
2.3.5 Humanoid Robots

An emerging alternative to traditional fixed- or gantry-mounted production robots are humanoid robots. These are currently at low technology-readiness levels and their design, production and implementation for blade manufacture may not be impactful in the next five years or so (the 'horizon 2' timescales defined for the workforce foresighting process). However, it is possible that progress accelerates rapidly in the coming years, so it is worth mentioning these systems. For example, Airbus have carried out tests on the use of humanoid robots for airframe assembly and non-value add tasks – noting that in 2014 humanoid robots were not thought to be stable enough for such tasks, but by 2019 there was significant progress (Kheddar et al., 2019).Implications from the perspective of this study may well be around human-robot or 'cobot' interfaces and interactions, particularly in terms of safe operation and degrees of automation.

2.3.6 UK-based Supply Chain for Blade and Composite Production

The two current manufacturers of wind turbine blades within the UK are Siemens Gamesa Renewable Energy and Vestas. These have respective UK capacities for around 250 and 125 blades per year (Telsnig et al., 2022). Suppliers into these facilities include manufacturers of

composite fabric and resin material systems, such as Gurit and Hexcel. Production automation equipment manufacturers within the UK are limited at this time, comprising Loop Technology, with others such as Broetje Automation working with manufacturers in Europe. There is overlap with the aerospace sector, and previous work by ORE Catapult and the National Composites Centre identified various manufacturers and equipment suppliers in composites within the UK (see Figure 4). This supply chain assessment was noted as being “non-exhaustive” (ORE Catapult & National Composites Centre, 2022).



OEM	
1	LM Wind
2	MHI Vestas
3	Siemens Gamesa

Manufacturer	
1	AC Marine
2	ACT Blade
3	Balmoral Group
4	Flocktons TVP
5	Forbes Technologies
6	GKN Aerospace
7	GKN Automotive
8	Magma Structures
9	Marine Concepts
10	McLaren
11	Norco Composites
12	SiloTank
13	Spirit Aerosystems
14	Technobell
15	Unipart Manufacturing

Material Supplier	
1	Gurit
2	Hexcel
3	Huntsman Advanced Materials
4	INEOS Composites
5	SGL Carbon
6	SHD Composites
7	Sigmatex
8	Solvay

Equipment Supplier	
1	Composites Integration
2	Cygnet TexKimp
3	Electro Impact
4	Loop Technology
5	Pipex
6	Pultrex
7	VFE – Autoclaves & Ovens

Figure 4 - UK Supply Chain for Composite Production (ORE Catapult & National Composites Centre, 2022)

2.4 Cycle Scope and Boundaries

The scope of the foresighting topic was further explored during the verification workshops by mapping key tasks against supply chain and lifecycle (see Table 1) and constrained by considering specific topics that would be outside of scope (see Table 2).

Agreeing the scope boundary is a process of discovery and requires some flexibility through the workshops; for example, the scope can be a function of which organisations engage and supply participants. The goal is to find a 'goldilocks' zone which is neither so broad that it is impossible to cover all the organisational capabilities needed, nor so specialist or niche such that the findings will be of very limited applicability.

Supply Chain	Devise, Design	Make, Manufacture	Install, Commission	Operate, Maintain
Partner 1 – Design Authority	- Design of the WTG and blade - DFMA - Proof of concept - Development	- Prototyping	-	-
Partner 2 – Blade Manufacturers	- Factory layout - Production system design	- Manufacture blade - Inspection - Rework		-
Partner 3 – Material Suppliers	- Design material system - Resin system	- Supply components	-	-
Partner 4 & 5 – Production Equipment Suppliers	- Design production systems - Safety, degrees of automation - Tooling design	- Supply robotics and production / automation equipment	-	-
Partner 6 – Others	- Type testing, certification	-	- Shipping, marshalling - Installation	- Inspection, repair and maintenance

Table 1 - Key Activities in the Supply Chain

STUDY SCOPE	ACTIVITIES
In-Scope	- Blade design / Design for manufacture and assembly (DFMA) / Design for automated manufacture (collaboratively, across the supply chain) - Reducing the levelised cost of energy (LCoE) - Progressive automation, automated production systems (considering degrees of automation) - Material systems, material science - Digital manufacturing - Optimising production: Cost reduction, Cycle time reduction, reducing non-conformances, lean manufacture

	- Production operations: lay-up, curing, blade finishing - Digital twins - Co-bot operations - Quality control; “right first time” / Process monitoring and inspection / Repair and rework within the factory - Training operators - Production and factory design - Tooling design - Operability and safety
Out of Scope	- Certification bodies - Type testing / type approvals - External logistics [i.e. transportation outside the factory] - Windfarm on-site installation - Operations and maintenance [of the blades in service] - Procurement of sub-components

Table 2 - Study Scope Boundaries

2.5 Participant expectations

During the initial ‘all hands’ briefing, participants recorded the following expectations for Workforce Foresighting:

- Building a collaborative / cross-industry approach to looking at future skills needs
- Understand viewpoints from other areas of the industry
- To understand sources of skills that we otherwise may not have considered
- Gaining a better understanding of future needs / challenges so we can focus our work and technology / skills development to solve
- Help to plan new courses – at various levels – to meet future demand
- Provide Developer input and understand skills needed in more detail
- To gain insight to future capabilities and skills required to focus our development
- Insight into range of view of manufacturing demand and approach / differences created.

3. Findings and Results

3 FINDINGS AND RESULTS

3.1 Capabilities

The technologist and employer workshops in this foresighting study identified an initial set of 145 capabilities[5] relevant to the topic. Of these capabilities:

- 64 capabilities were adopted from the Workforce Foresighting Data Cube;
- 10 capabilities were adapted (modified) from the Workforce Foresighting Data Cube; and
- 71 capability statements were newly defined by the study and added to the Data Cube.

The newly created and adapted capabilities are listed in Appendix 3 on page 48.

3.1.1 Sensemaking and FOP Guiding Principles

When developing Future Occupational Profiles, it is useful to define a set of guiding principles within the framework of the Workforce Foresighting Employer workshops. These help to understand what a particular group of occupational profiles are designed to achieve. The guiding principles help participants to make sure that a profile title is descriptive of its intent and then help to determine whether a capability belongs in a profile. The guiding principles for defining the future occupational profiles within this cycle were:

- Strategy and change
- Develop and design blades for advanced production
- Design, build and implement production equipment
- Develop composite / material systems for advanced production
- Manufacture wind turbine blades
- Supporting functions (getting the right things to the right place, right time & quality)

[5] An organisational capability is defined in workforce foresighting as a specific activity that enables or improves organisational performance. A capability is likely to be performed by or involve multiple employees and might use specific tools or methods. An example capability statement is “Design policies and procedures for robotic and autonomous systems-based operations in offshore wind.”

3.2 Resulting Future Occupational Profiles

The Future Occupational Profiles are fully stated in Appendix 5 .

Table 3 on the following page summarises the titles of the profiles by role family, against each of the guiding principles defined.

The role families indicate the general level of qualification or equivalent experience that might be expected for a given profile:

- Role Family 1 (RF1) profiles are at an entry grade technician or operator level.
- Role Family 2 (RF2) profiles are intended for senior technicians and operators.
- Role Family 3 (RF3) profiles are graduate / junior engineer level.
- Role Family 4 (RF4) profiles are pitched for senior engineering levels, specialist scientists or equivalent.

Guiding Principle	RF1 FOPs	RF2 FOPs	RF3 FOPs	RF4 FOPs
Strategy and Change	-	-	-	- Production Senior Manager
Develop and design blades for advanced production	-	-	- Blade Design Engineer	- Senior R&D Engineer
Design, build and implement production equipment	-	-	- Robotics & Industrialisation Engineer - Equipment Installation & Support Engineer - Mechanical / Tooling Engineer	- Senior Robotics & Industrialisation Engineer
Develop material systems	-	-	-	- Senior Materials Engineer
Manufacture Wind Turbine Blades	- Blade Production Technician	- Senior Blade Production Technician	- Manufacturing Engineer	-
Supporting functions	- Blade Production Inspector	-	- Supply Chain & Logistics - Quality Control Engineer	- Digital, Data & Technology

Table 3 - Guiding Principles and Future Occupational Profiles

The capabilities within one FOP could be relevant to another stage of work or part of the supply chain. Table 4 considers the FOPs by role family and indicates where in the supply chain such a role might sit primarily (P) or additionally (+). Ultimately industry will determine how and where capabilities are deployed but the FOPs and alignments should provide a basis for role design and skills development.

RF	FOP	Design Authority / RTO	Blade Production	Automation Equipment Suppliers	Material Suppliers
1	Blade Production Technician		P		
	Blade Production Inspector		P		
2	Blade Production Senior Technician		P		
3	Blade Design Engineer	P	+		+
	Manufacturing Engineer		P	+	
	Equipment Installation & Support Engineer		+	P	
	Mechanical / Tooling Engineer		+	P	
	Quality Control Engineer		P	+	
	Supply Chain & Logistics		P	+	+
	Robotics & Industrialisation Engineer	+		P	
4	Senior Robotics & Industrialisation Engineer	+		P	
	Production Senior Manager		P		
	Senior R&D Engineer	P	+		
	Senior Materials Engineer / Scientist		+		P
	Digital, Data & Technology	+	P	+	

Table 4 - Applicability of Future Occupational Profiles to Supply Chain Tiers

3.3 Potential Pathways to the Future Occupational Profiles

The following table shows the closest fitting existing standards to each of the FOPs identified. The fit factor (FF) shows the percentage of capabilities assessed by the large language model to be a 'match'[6]. The surplus factor (SF) shows the percentage of capabilities in the foundation standard, that do not match into the FOP. The delta count (Δ) shows the number of capabilities in the FOP that are not matched within the foundation standard (in other words, how many capabilities a worker might need training in, if moving from a role in the foundation standard to one based on the future occupational profile).

An existing provision is considered a 'fair' or 'good candidate' for adoption if it has a fit factor above 50% - in other words, 50% or more of the capabilities in the FOP show a match with the capabilities in an existing provision. Where there is a 'fair' or 'good' candidate for adoption, the list of extra capabilities compared to the standard is given in Appendix 3 on page 48. These standards may therefore provide 'pathways' for development of the FOP roles – but as discussed in the table, the Data Cube does not alone give reliable guidance.

The pathways indicated by the Data Cube are a steer for educators and industry to develop new learning provision or CPD. They are by no means the only pathways, and the absence of an identified pathway tends to indicate that the role has a higher proportion of new or adapted capabilities. Domain-specific language within a capability naturally reduces the degree of matching. These factors mean it is difficult for the AI to match it to an existing standard. The language model cannot distinguish between capabilities that are typically trained or taught, versus those that are learned 'on the job'.

[6] The match is based on a system threshold setting of 0.49.

During the workshops, there was a noticeable emphasis on future differentiating capabilities, rather than on capabilities used for current processes and technologies. This focus on the future requirements contributes to the low fit factor observed against the current IfATE.

Therefore, at its current level of maturity the matching process is considered as the basis for an informed approach, and an appropriate starting point.

RF	FOP	Foundation standard	FF	SF	Δ	Comment
1	Blade Production Technician	Furniture Making Operative	35%	50%	13	There are no particularly good matches to this profile, and only the more generic capabilities are matched. Most of the capabilities relating to composite blade production are unmatched because they are not well provided for within IfATE. Alternative pathways might include automotive technicians, or CNC machining where operation of automated production equipment takes place.
		Science Industry Maintenance Technician	35%	40%	14	
	Blade Production Inspector	Food Industry Technologist	78%	45%	3	One of the stronger fits from this set. The delta capabilities are those that specifically mention blade surface or add-ons. There are no 'inspector' or 'quality' titled matches, which is most likely because of the focus on differentiating capabilities. However, the role requirements for assessment and inspection are captured within the aligned standards.
2	Senior Blade Production Technician	Battery Manufacturing Technician	41%	44%	14	In practice the most likely pathway to this FOP is via experience in the junior technician role.
3	Robotics & Industrialisation Engineer	Robotics Engineer	25%	59%	14	Again, no good fits to this profile, with low FF and high SF. In part this reflects some differentiating and domain-specific capabilities in the FOP, but a high number of relatively generic unmatched capabilities suggests that the design and development of industrialisation equipment is not well covered in IfATE.
	Supply Chain & Logistics	Supply Chain Leadership Professional	21%	56%	15	Poor matching here may reflect the merger of small FOPs to meet an acceptable size, and the collation of capabilities on a functional rather than occupation level – waste and environmental capabilities are unmatched, alongside some domain-specific capabilities. In practice, this standard or 'Senior Procurement and Supply Chain Professional' should provide good foundations for the profile, with additional experiential interventions.

RF	FOP	Foundation standard	FF	SF	Δ	Comment
	Blade Design Engineer	Materials Science Technologist (degree)	30%	58%	14	The material technologist fit is a 'red herring' arising from strong matching on a small number of capabilities. 27 of the capabilities of in this FOP, which have limited alignment to a specific IfATE standard, were new additions to the Data Cube in this cycle. In practice, likely pathways to this role might include mechanical, structural, aeronautical or aerodynamic engineering; however Aerospace Engineer shows only a 5% FF here.
	Manufacturing Engineer	Food and drink advanced engineer (integrated degree)	70%	30%	7	A Manufacturing Engineer degree (FF 35%) might, in practice, be a more likely pathway into a manufacturing engineering role - by dint of numbers if nothing else. Higher matches are achieved by the two roles shown here, as well as Aerospace Engineer (FF 52%), Food and Drink Engineer (FF 47%) and Dairy Technologist (FF 39%).
		Science industry process and plant engineer (degree)	52%	20%	11	
	Equipment Installation and Support Engineer	Control systems engineer (degree)	47%	73%	10	Moderate alignment with some logic. There is an absence of standards that relate explicitly to designing or manufacturing production equipment.
		Robotics engineer (degree)	42%	41%	11	
	Mechanical / Tooling Engineer	Manufacturing engineer (degree)	55%	60%	5	Both standards make sense as pathways. That both achieve only around 50% fit factors is partly due to the low number of total capabilities in the FOP (11), (WF-hub guidance is for 15 – 20 capabilities within a FOP). In practice this might be combined with another FOP to make a complete role.
		Tool process design engineer	46%	67%	6	
	Quality Control Engineer	Control systems engineer (degree)	64%	64%		While having a reasonably good FF score, there is still a high SF. The word 'control' appears to skew results. There are no 'quality' standards appearing in the match list because the education band for this role was set at Level 6-7. There is a Quality Practitioner standard at Level 4, but under the present methodology it is filtered out based on the education level. If the education filter is relaxed, then the Quality practitioner shows a FF 45.5% and SF 41.7%
		Aerospace engineer	55%	67%	10	
4	Senior R&D Engineer	Digital manufacturing engineering leader	42%	0%	10	This standard has only 10 capabilities, resulting in the unusual 0% SF score. The unmatched capabilities here include all the domain-specific and differentiating capabilities relating to offshore wind.
		Material science technologist (degree)	32%	50%	13	Practically this would seem a good potential route to a composites R&D role. The unmatched duty/capability statements relevant to the role could inform appropriate development opportunities.

RF	FOP	Foundation standard	FF	SF	Δ	Comment
	Production Senior Manager	Digital manufacturing engineering leader	52%	0%	11	Capabilities referencing 'digital' and other modern manufacturing terms in this standard drive a reasonable match.
	Senior Robotics & Industrialisation Engineer	Digital Manufacturing Engineering Leader	50%	0%	10	As above, the reason for the matches is evident, but the Advanced robotics engineer standard appears a more likely pathway.
		Advanced robotics engineer	45%	35%	11	The second highest ranking match, this is probably a more likely pathway for the role – but it doesn't capture the industrialisation or production engineering parts.
	Senior Materials Engineer	Materials science technologist (degree)	58%	50%	5	A logical match, and the unmatched capabilities in this case all relate to domain-specifics – composites, blades or renewable energy.
	Digital, Data & Technology	Digital Manufacturing Engineering Leader	79%	0%	4	Another showing for this standard, although in this case a more logical match.

Table 6 - Comparison of Future Occupational Profiles with Existing Standards

4. Conclusions and Next Steps

4 CONCLUSIONS AND NEXT STEPS

4.1 Ongoing Process Improvement

Workforce Foresighting – as a process – seeks to balance development and stability across multiple cycles. This carrying-out phase included several adjustments to process and workshops, compared to earlier cycles. Some of the points for consideration identified during this cycle include:

- It would be useful to see all capabilities and occupational profiles 'in one view', as part of the sensemaking activity around QA4 / Workshop 2B stages. This would allow for better visual comparisons and assignment of capabilities within and between FOPs.
- Focussing participants' attention on differentiating capabilities (future state versus current state), seems to be an important part of foresighting. The 'map and gap' approach / algorithm may benefit from some refinement to deal with FOPs that have a high proportion of these types of capability.
- Broadening the qualification level filter may help to identify matching standards, if there are few returns within a presumed FOP qualification level.
- Additional work by the Workforce Foresighting Hub facilitator between workshops was very helpful, in particular, disambiguation of capabilities, pre-matching standards, and testing for match thresholds.
- Replacement of AI generation of the occupational profiles with a workshop approach is a significant improvement. Use of the 'guiding principles' here also helps with clarity and understanding.

4.2 "Carrying Out" Phase Recommendations

Broadly, the existence of the energy skills assessment within the Clean Power Action Plan 2030 (Department for Energy Security and Net Zero, 2024) – and its reference to foresighting – is encouraging. Planned and current national developments including the Skills England set up, regional skills initiatives, the industry Skills Passport project, and the forthcoming Office for Clean Energy Jobs, all point towards a growing focus on getting the right talent in place – and the awareness that timing grows tight.

The principal recommendation is to continue this foresighting study into the 'causing action' phase. Validating the FOPs with industry is the first step in that journey. At this stage there is no prioritisation between FOPs, and the foresighting process implies that all capabilities are required within the industry by 2030, with equal focus, to support successful deployment of RAS and growth of offshore wind. It is also necessary to consider foresighting alongside forecasting and current course provision, to build a comprehensive picture in the early part of the next phase.

The Clean Power Action Plan 2030 notes that "Most of the workforce we need for 2030 is already employed, so retraining, upskilling and increasing the transferability of workers between sectors is essential." In terms of foresighting this is an interesting assertion, as it *suggests the focus should be on professional training delivery rather than apprenticeship and degree provision*. At the same time, the energy skills assessment also considers the "pressing need to train the younger generation to ensure long-term talent supply" in STEM skills. It cites findings by WorldSkills UK that

63% of 16–24-year-olds have never heard of ‘green skills’, and that only 27% of those who have heard of ‘green jobs’ could explain what the term means.

4.3 Next Steps – “Causing Action”

In the joint ‘All Hands Briefing’ at the start of the cycle, participants recorded the following intent for carrying the findings of workforce foresighting forward:

- Using the information to better inform next steps and understand some commonalities where we can support each other.
- Using the information and insight gained to plan – both internal capability development but also working with university network to inform future needs.
- Understand areas that Developers can support skills in this area.
- Put in place a more strategic rather than reactive thinking skills building process.
- Think through future technologies and the route to deploy them.

In the next phase of the foresighting cycle ORE Catapult will work with stakeholders to identify and initiate actions to close the potential future skills gaps identified through foresighting, considering the volume of likely roles determined by forecasting. Actions will include:

1. Issuing a preliminary survey for feedback on the ‘differentiating capabilities’ within each future occupational profile [complete].
2. Incorporating feedback from industrial participants and other reviewers of the future occupational profiles and capability sets to prioritise key FOPs and capabilities.
3. Developing forecasts that help to understand component volumes and the expected role numbers.
4. Initiating a working group including UK-based blade manufacturers and their skills partners, to focus on the future of advanced manufacture for blades, including:
    a. Working with further and higher education partners, as well as industry training organisations, to identify potential course module content – based on foresighting and forecasting, and relevant Knowledge, Skills and Behaviours.
    b. Encouraging a champion for development of skills in advanced wind turbine blade manufacture.
5. Evaluating the opportunity for further foresighting studies in composites manufacture for offshore wind.

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6. Appendices

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APPENDIX 1 ABOUT WORKFORCE FORESIGHTING

A1.1 The purpose of workforce foresighting

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.

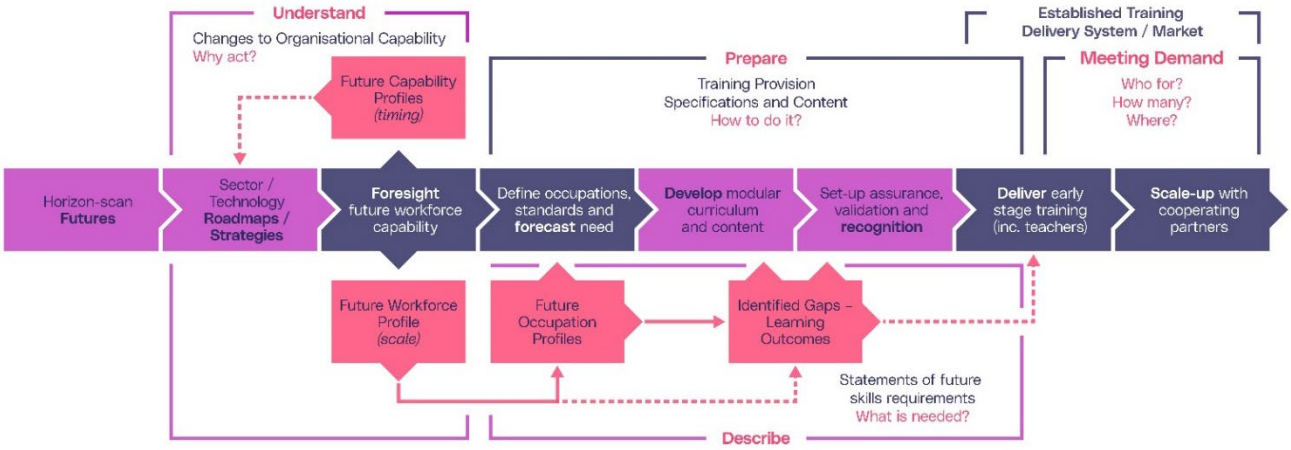
Identify and communicate insights, future requirements and the action required by industry and educators.

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.



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 insight about qualifications and provision that will be required to support new entrants in the future.

A1.2 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.

Organisational capabilities are captured using a bespoke classification that has been developed by the Workforce Foresighting Hub. The classification uses a structured common language to enable cross sector and cross centre collaboration and integration of data. Additionally, the classification enables data from several 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 innovative AI and Large Language Model data tools, the Data Cube is used to undertake detailed analysis to 'map' future workforce capability requirements against the current education and training provision to identify where existing provision can be used and where new provision, CPD or qualifications are required.

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

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

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

Preparing – The convening of specialists and scheduling of workshops

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

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

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

A1.3 Capability Classification and The Data Cube

During the 'carrying out' phase, capabilities are defined and articulated using a classification system developed by the Workforce Foresighting Hub. This classification builds upon Existing published and widely used national and international frameworks including the Occupational Information Network (ONet) US[7]; European Skills, Competences, Qualifications and Occupations (ESCO)[8]; National Occupational Standards, UK[9]; and the Institute for Apprenticeships and Technical Education (IfATE)[10], England.

This classification has been used to build a data repository, referred to as the 'Data Cube' – see figure below – which underpins the workshops and related activities of the carry out phase. Data is input using a common language, which means that any centre conducting similar activities can describe capabilities in a consistent format and vocabulary. The Data Cube integrates information from ONet, ESCO, NOS, IfATE and other open-source databases, again, using the same common

[7] https://www.onetcenter.org/
[8] https://esco.ec.europa.eu/en
[9] https://www.gov.uk/government/publications/national-occupational-standards
[10] https://www.instituteforapprenticeships.org/

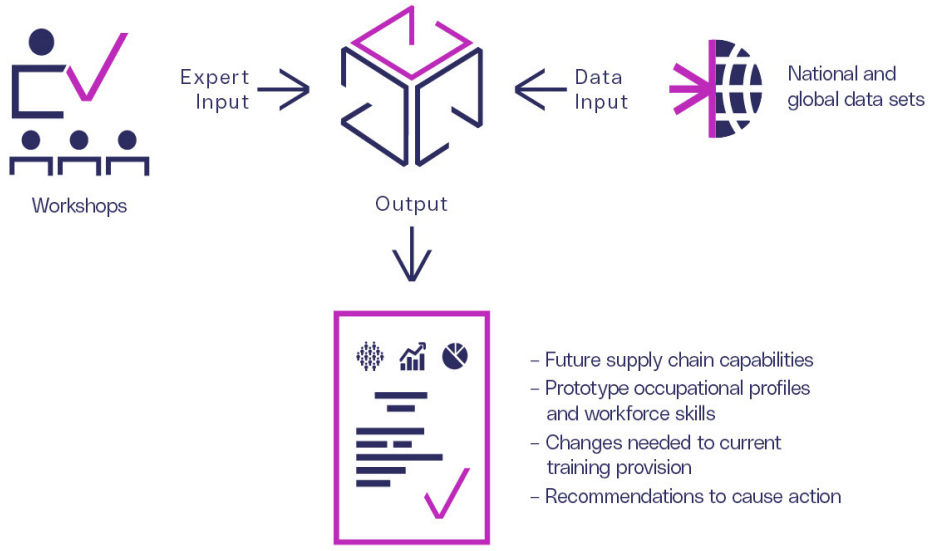
language. The result being a database that is exponentially growing with rich data relating to future workforce capabilities.

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

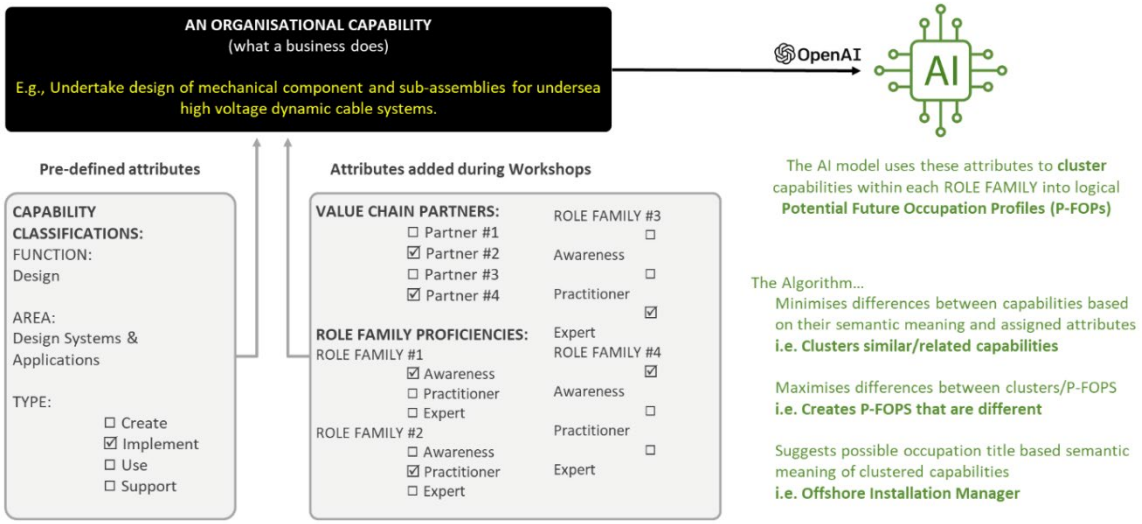
Design	The function of an organisation that focuses on activities relating to product, service or solution design.
Implement	The function of an organisation that focuses on activities relating to producing / making / providing its products or services.
Logistics	The function of an organisation that focuses on activities relating to procurement, delivery, materials, or services necessary for operations – service / manufacturing, etc.
Support	The function of an organisation that focuses on activities relating to users, in-service support, repair / maintenance, recycling, end of life disposal.
Enterprise	Core functions of an organisation - e.g., strategic planning, leadership and management, human resources, digital backbone and data systems, integration of relevant statutory / regulatory requirements and compliance.

The five root functions comprise around 40 domains which are broken down to around 140 functional areas. The architecture is used to position ~ 30,000 capability statements which are the building blocks used in the workforce foresight process. Each capability statement has several attributes - some are static and reflect the position of the capability statement in the architecture, whilst others are dynamic and are assigned values through a cycle and set of workshops.

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



OpenAI / ChatGPT large language models are used to analyse workshop input in terms of capability statements, compare these to Existing capabilities in the Data Cube, and generate clusters of similar capabilities as potential future occupation profiles.



In the final workshop sessions and output, the Data Cube is used to 'map' the future workforce capability requirements (FOPs) against the current education and training provision, providing a 'map and gap' analysis combining automated processing with expert input.

A1.4 Overview of Workforce Foresighting Methodology

A1.4.1 Step One – How Will the Supply Chain Change? Organisational Changes

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

Typically, organisational changes will also require the adoption of new capabilities and a change in the distribution of these capabilities across supply chain partners. The change in capabilities within

an organisation as well as their supply chain partners will determine the changes knowledge and skill changes required by the role groups within the workforce of each Supply Chain partner.

A1.4.2 Step Two – How Will the Workforce Change? - Occupational Changes

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

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

A1.4.3 Step Three – Highlighting Changes to Future Educational Provision

The report identifies suggested changes to education and training provision – principally apprenticeship standards that will deliver the knowledge, skills and behaviours required by future occupations. In some cases, this will include the development of short courses and continued professional development (CPD) to upskill the current workforce to meet future needs. Additionally, foresighting outputs can be used to develop programmes, qualifications, and apprenticeship standards for new entrants to the workforce joining via apprenticeship, taught qualification, or other training programme.

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

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

> **Fit** – expressed as a %, it is a measure of the proportion of a FOP that is covered by an existing standard or qualification.
>
> **Surplus** – expressed as a %, it is a measure of the not relevant material in an existing standard that is not required for a FOP.

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

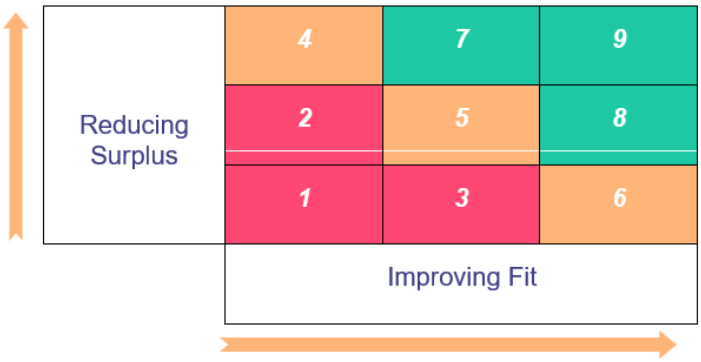
Our (Workforce Hub) interpretation is represented by a simple nine-box model to position the suitability of a given current occupational standard to a future occupational profile:

Factor scores

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

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

Suitability Grid



Fit Factor scores and Suitability Grid

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

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

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

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

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

APPENDIX 2 ONLINE DATA VISUALISATION TOOL

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[11]. 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	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.
Supply Chain Capabilities	Provides an overview of the identified capabilities at a Supply Chain / Workflow Partner level. By selecting/deselecting each Supply Chain / Workflow Partner you can review the capabilities identified as required in that area of the Supply Chain / Workflow. This can be used to generate organisational capability profiles for each area of the workflow /supply chain to help prioritise and focus the acquisition of new capabilities that will be required in the future. It can also be used to generate combined organisational profiles, where an organisation may be involved in more than one area of the supply chain.
FOP Detail	This page allows you to review a specific Occupational Profile, including the capabilities contained within it and the Knowledge, Skills & Behaviour (KSB) tags associated with the capability. You can select an individual Role Family and linked FOP in the two available dropdowns. The table in the lower section of the page will then be populated with all relevant capabilities. The search control above the table allows you to filter content of any of the columns of data. A key piece of functionality in this table is the presence of the KSB tags associated with the capabilities.
FOP Matrix	Provides a detailed breakdown of future occupational profiles that could be required in the future workforce. These were generated using a combination of attributes collected through the workshops and an algorithm. These suggested profiles were then reviewed and ratified by small groups of employers who were able to add/remove capabilities and uprate/downrate proficiency levels required. You can view all the 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. 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. 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.
Future KSBs Summary	Not yet completed in this cycle.

[11] The URL to access the visualisation tool is https://hvmcatapultforesighting.retool.com/embedded/public/e869283b-4b8a-437c-973e-64ab292e5b87?_environment=production&token=6186fdd36b27d4c94af69d54dd1d118d

	Provides a view of the complete set of capabilities within the cycle along with all of the associated KSB tags which are linked to them. It is, essentially, the superset of all details displayed on the FOP detail page. This is used to: • To review the identified Knowledge, Skill and Behaviour tags for a given capability, to support development of future education and learning material. • To review the requirements from a capability level, rather than a role family/occupational profile grouping.
FOP Distribution	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. Clicking the "View FOPs" button alongside each capability will provide a list of the proficiencies (EPA) with the FOPs that fall into them. The exported version of this data will include a full breakdown of the FOP IDs which contain the capability within a specific proficiency. This is used to: • understand the levels/volumes of common/crossover Capabilities, to support prioritisation of Capability Development • identify which Occupational Profiles contain these common/crossover capabilities, and so which may be prioritised for development activity
Capabilities Matched to Current Provision	This page allows you to review and compare individual capabilities against 'Duty' statements in an Apprenticeship / Occupational Standard. You can select individual capabilities to review their specific matches. These matches are shown in the bottom panel, including the Standard, the Level and the Duty Statement this is matched to. You can filter in several ways to focus your review: • By the Capability Classification Framework (left-hand panel). • By capabilities that **are** served by the reference mapping framework – the default is Institute for Apprenticeships and Technical Education (IfATE) provision. By capabilities that **are not** served by the reference mapping framework, e.g., IfATE provision – these are capabilities required in the future that may require new/bespoke training and CPD materials to be developed to upskill/re-skill the workforce. This page can be used to identify where existing provision may exist across the broad spectrum of Occupational Standards, and not just within a narrow range of sector-specific Standards. The data also allows you to identify where provision may already exist to support specific capabilities.
Fit & Surplus Factors	This page allows you to review the 'Fit' and 'Surplus' of Prototype Future Occupation Profiles (FOP) against existing training provision e.g. Institute for Apprenticeships and Technical Education (IfATE). It is possible for the 'Fit' and 'Surplus' comparison to total over 100%, as they are two separate calculations based on a two-way comparison.
Fit & Surplus Matrix	This page is a visual representation of the 'Fit and Surplus Factor' insight. You can visually review 'Fit' and 'Surplus' of Future Occupation Profiles (FOP) against

	existing training provision e.g. Institute for Apprenticeships and Technical Education (IfATE). This can help you identify which provision may align strongest, or which may require adaptation, to provide the suitable provision fit for each future role. It will help you focus in on which provision to focus your attention for analysis.
FOP Capability Matches	This page allows you to view the matches between Capabilities and Institute for Apprenticeships and Technical Education (IfATE) Duty Statements. Clicking the arrow next to a number in the 'Matches' column will open a popup with more detail for each Capability. Each capability also includes Knowledge, Skill and Behaviour Tags, to support with scaffolding future education provision. You can review individual Future Occupational Profiles (FOPS) or review all FOPs under a Role Family, to give a more holistic view of Capabilities and Matches Where a future capability has been matched to existing provision (currently, by default, IfATE apprenticeship standards) it is possible to interrogate the data and identify specific statements in standards that align to enable identification of existing training materials and activities that could be used or adapted to meet future requirements. This can be used to review the capability requirements for Role Families and FOPs, from Job / Occupation level through to Knowledge, Skill and Behaviour level
FOP vs Provision	This page allows you to compare FOPs against existing IfATE Standards. The information here allows you to prioritise effort or action over the short, medium or long-term. This is displayed as a Matched/Not Matched Capability, comparing the Capability in a FOP to the Duties in a Standard. 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 IfATE Standards for that Occupational Profile. Where a future capability has been matched to existing provision (currently, by default, IfATE apprenticeship standards) it is possible to interrogate the data and identify specific statements in standards that align to enable identification of existing training materials and activities that could be used or adapted to meet future requirements.
FOP Priorities	Provides a list of all the FOPs within the selected cycle with details of their fit and surplus factors. The information here allows you to prioritise effort or action over the short, medium or long-term.

APPENDIX 3 ADAPTED AND ADDED CAPABILITIES

The following capabilities have been created (or adapted from others) as part of this workforce foresighting cycle:

ID	Capability Statement	Function
227049	Design production facilities to accommodate the parallel manufacturing of wind turbine blade segments.	DESIGN
227054	Review engineering and/or manufacturing methods to determine the most effective, economical and sustainable methods whilst meeting specifications	DESIGN
227043	Develop specifications for automated manufacturing of wind turbine blades to enhance production rate, reduce costs, and improve product quality.	DESIGN
227535	Implement standards for nameplating in wind turbine components, e.g. materials, masses, design life, circularity	DESIGN
227538	Develop cross-industry standards for component interfaces, such as blade root and mount configurations, to ensure compatibility and efficiency.	DESIGN
227050	Implement additive manufacturing techniques to create tools, molds, fixtures and jigging for in-flight components and/or manufacturing support materials	DESIGN
227051	Develop humanoid robotic systems to assist in wind turbine blade production.	DESIGN
227074	Create wind turbine blade designs to enhance the circularity and recyclability, thereby reducing environmental impact	DESIGN
227081	Design wind turbine blade add-ons such as vortex generators, spoilers, serrations, and gurney flaps, for improved performance.	DESIGN
227531	Develop segmented blade designs to enable parallel production of multiple, similar blade sections	DESIGN
227532	Develop wind turbine blade designs that support assembly-based production (rather than mold-based production)	DESIGN
227543	Develop composite material systems for WTB to enhance properties e.g. snap curing, low temperature performance, low viscosity, high strength-to-weight ratio, self-healing capabilities.	DESIGN
227544	Develop materials to streamline the transformation of raw materials into blades, reducing the number of production steps.	DESIGN
227545	Develop wind blade-compatible smart materials to enhance durability and performance in renewable energy applications.	DESIGN
227546	Develop Materials to prevent leading edge erosion over blade life	DESIGN
227547	Develop material systems to eliminate specific finishing operations in final production.	DESIGN
227548	Implement additive manufacturing techniques to create tools, molds, fixtures and jigging for in-flight components, and direct production of in-flight components (e.g. leading edges)	DESIGN

ID	Capability Statement	Function
227084	Deploy additively-manufactured direct mold manufacturing processes to streamline the introduction of new products.	DESIGN
227087	Design robotic and automation systems suitable for wind turbine blade production	DESIGN
227529	Implement design-for-automation in the design phase to reduce manual labour tasks in production.	DESIGN
227534	Devise design solutions that allow for production efficiencies from additive manufacture	DESIGN
227542	Implement automation and robotics systems to precisely execute and manage repair and rework processes in a manufacturing environment.	DESIGN
227075	Design wind turbine blades using advanced composite materials and engineering to enhance their structural performance, specifically in terms of weight, strength, and durability.	DESIGN
227076	Design blade segmentation and modularization systems to support industrialization to reduce production time and enhance product quality	DESIGN
227078	Select materials for wind turbine blades that enhance circularity and sustainability to minimise their lifecycle environmental impact.	DESIGN
227052	Develop flexible manufacturing infrastructure to integrate new composite manufacturing processes and technologies	DESIGN
227077	Develop processes for joining segmented blades	DESIGN
227055	Operate robotic equipment to perform green production applications, including testing and maintaining specific components.	DESIGN
227080	Refine manufacturing processes to integrate advanced sensors with prognostics systems, thus enhancing product quality and minimizing waste.	DESIGN
227086	Apply specific modern design techniques like design-for-automation and design-for-X to wind turbine blade design, enhancing their suitability for automated production methods.	DESIGN
227537	Implement data-sharing protocols to benchmark manufacturing capabilities and enhance performance metrics across different manufacturers.	ENTERPRISE
227058	Review targeted training programs to enhance employee skills in adapting to new technologies and flexible work schedules.	ENTERPRISE
227540	Implement data sharing and benchmarking initiatives to compare manufacturing capabilities and enhance overall performance.	ENTERPRISE
227057	Verify the capabilities of new supply chain companies to ensure compliance with operational standards.	ENTERPRISE
227056	Develop specific partnership agreements to directly support technological advancements in product development.	ENTERPRISE
227059	Develop product specifications to incorporate specific new production techniques and processes.	ENTERPRISE
227104	Assemble prefabricated parts into kits for the next production stage.	IMPLEMENT

ID	Capability Statement	Function
227088	Manage production of prototype systems and components to validate performance of wind turbine products.	IMPLEMENT
227541	Implement production operations to assembly-based final stages with subsection components manufactured by the supply chain.	IMPLEMENT
227020	Consolidate mat using suitable end effectors mounted on a robotic system to produce a laminate devoid of wrinkles.	IMPLEMENT
227110	Gather operational data to inform decision making in the development of product variants and derivatives.	IMPLEMENT
227094	Implement digital twin technology to simulate and enhance manufacturing and design operations	IMPLEMENT
227089	Program robots to execute precise assembly tasks for complex composite components and integrate robotics systems to enhance production efficiency.	IMPLEMENT
227111	Implement lean manufacturing principles to streamline the production process and reduce cycle time.	IMPLEMENT
227048	Monitor layup of fabric in composite systems to ensure accurate placement and no wrinkles	IMPLEMENT
227112	Capture monitoring data to inform specific analyses on quality, time, and cost.	IMPLEMENT
227113	Monitor add-on placements to ensure compliance with specific installation specifications.	IMPLEMENT
227114	Monitor resin infusion and curing to ensure full infusion and minimise cycle time	IMPLEMENT
227099	Inspect blade surface for defects	IMPLEMENT
227100	Install leading-edge protection and vortex generators on blades to enhance aerodynamic performance.	IMPLEMENT
227101	Automate installation of leading-edge protection and vortex generators on blades to enhance aerodynamic performance.	IMPLEMENT
227102	Produce technical specifications for the finished Wind Turbine Blades to ensure compliance with industry standards.	IMPLEMENT
227530	Design blade and material systems to eliminate or automate the finishing processes.	IMPLEMENT
226983	Lay up composite materials on turbine blades to ensure structural integrity and optimal performance.	IMPLEMENT
227103	Place dry glass fabrics into shell molds to ensure precision in composite material shaping.	IMPLEMENT
227105	Assemble blade components by adding webs and specific prefabrications to build turbine blade.	IMPLEMENT
227107	Implement automated systems to assist in preparing and loading specific machinery and tools for designated operational tasks.	IMPLEMENT
227108	Prepare machinery and tools for specific operational tasks such as setting up production lines or performing maintenance procedures.	IMPLEMENT
227109	Load machinery and tools for operational tasks	IMPLEMENT
227106	Monitor compliance of operational activities with specific industry standards to ensure they meet quality and safety requirements.	IMPLEMENT

ID	Capability Statement	Function
227010	Fabricate and dismantle parts, equipment, and machines using robotic and automated systems.	IMPLEMENT
227063	Optimise logistics processes to ensure that all materials are utilised before their expiration date.	LOGISTICS
227068	Manage and co-ordinate delivery of composite materials including resins, consumables, and cores to supply an advanced production line	LOGISTICS
227071	Utilise digital and automated inventory control systems in automated composite production lines	LOGISTICS
227064	Standardise production materials to mitigate the impact of supply chain disruptions.	LOGISTICS
227065	Promote awareness of specific automation opportunities in the offshore wind sector to enhance targeted production capabilities.	LOGISTICS
227066	Identify potential suppliers with relevant expertise to provide automated and advance composite production equipment into the Wind industry	LOGISTICS
227069	Investigate alternative material supply formats to improve compatibility with automated and advanced production methods	LOGISTICS
227060	Develop roadmaps for potential suppliers to outline specific technical requirements and expected production volumes.	LOGISTICS
227061	Provide suppliers with detailed specifications and data for materials to enhance processes	LOGISTICS
227067	Adjust kits and material supply formats to suit automation in production	LOGISTICS
227062	Improve factory layout to support automation and ensure more efficient movement	LOGISTICS
227070	Utilise automated factory logistic systems to move material to production lines within specified timeframes.	LOGISTICS
227044	Integrate robots to perform practical tasks in the production of complex composite components.	SUPPORT
227046	Operate support systems for cobotics in Wind Turbine component manufacture	SUPPORT
227095	Integrate design process with digital twin systems to enhance project accuracy and efficiency.	SUPPORT
227097	Develop specific digital tools to ensure adherence to defined operational processes.	SUPPORT
227091	Ensure correct placement of 'add-ons' such as vortex generators, spoilers, serrations, and gurney flap during wind turbine blade production, to minimise rework.	SUPPORT
227093	Manage resin infusion processes to ensure full infusion, to minimise cycle time and achieve product specifications	SUPPORT
227539	Implement cross-industry standards for component interfaces to standardize blade root and mount configurations across different sectors.	SUPPORT
227090	Conduct predictive maintenance of processing and equipment using condition-based monitoring	SUPPORT

APPENDIX 4 FOPS vs EXISTING STANDARDS

The following tables show the additional capabilities that would need to be added to an **existing standard** in IfATE, to approximate the capability content with in the **future occupational profiles**.

A4.1 Senior Engineer / Role Level 4

DIGITAL DATA & TECHNOLOGY vs DIGITAL MANUFACTURING ENGINEERING LEADER

FF 79%
SF 0%

ID	Additional Capabilities Needed
227112	Capture monitoring data to inform specific analyses on quality, time, and cost.
189903	Develop advanced materials simulations using computational modelling tools
227110	Gather operational data to inform decision making in the development of product variants and derivatives.
213841	Gather operational data using relevant collection methods to inform system performance evaluations.

SENIOR MATERIALS ENGINEER vs MATERIALS SCIENCE TECHNOLOGIST (DEGREE)

FF 58%
SF 50%

ID	Additional Capabilities Needed
227530	Design blade and material systems to eliminate or automate the finishing processes.
227543	Develop composite material systems for WTB to enhance properties e.g. snap curing, low temperature performance, low viscosity, high strength-to-weight ratio, self-healing capabilities.
227546	Develop Materials to prevent leading edge erosion over blade life
227545	Develop wind blade-compatible smart materials to enhance durability and performance in renewable energy applications.
227061	Provide suppliers with detailed specifications and data for materials to enhance processes

SENIOR ROBOTICS & INDUSTRIALISATION ENGINEER vs ADVANCED ROBOTICS ENGINEER

FF 45%
SF 35%

ID	Additional Capabilities Needed
227101	Automate installation of leading-edge protection and vortex generators on blades to enhance aerodynamic performance.
201349	Define and devise systems to support rapid redeployment of automation equipment in response to changing business requirements.
227052	Develop flexible manufacturing infrastructure to integrate new composite manufacturing processes and technologies
213144	Develop new automated manufacturing processes that generate real time data for enhancing process/product characterisation
227077	Develop processes for joining segmented blades
227043	Develop specifications for automated manufacturing of wind turbine blades to enhance production rate, reduce costs, and improve product quality.
209122	Implement advanced material handling automation for efficient sorting and preparation.

227107	Implement automated systems to assist in preparing and loading specific machinery and tools for designated operational tasks.
213160	Implement digital and automated quality control systems to ensure product compliance and minimise defects.
227080	Refine manufacturing processes to integrate advanced sensors with prognostics systems, thus enhancing product quality and minimising waste.
183818	Undertake complex forming simulation trials where the new component is "formed" from a series of process steps

SENIOR ROBOTICS & INDUSTRIALISATION ENGINEER vs DIGITAL MANUF. ENGINEERING LEADER

FF 50%
SF 0%

ID	Additional Capabilities Needed
227101	Automate installation of leading-edge protection and vortex generators on blades to enhance aerodynamic performance.
188086	Build, integrate and test functional robot systems.
201349	Define and devise systems to support rapid redeployment of automation equipment in response to changing business requirements.
205888	Develop advanced control algorithms for real-time coordination of co-botic support systems using machine learning
227051	Develop humanoid robotic systems to assist in wind turbine blade production.
227077	Develop processes for joining segmented blades
209122	Implement advanced material handling automation for efficient sorting and preparation.
227044	Integrate robots to perform practical tasks in the production of complex composite components.
227046	Operate support systems for cobotics in Wind Turbine component manufacture
227054	Review engineering and/or manufacturing methods to determine the most effective, economical and sustainable methods

SENIOR R&D ENGINEER vs DIGITAL MANUF. ENGINEERING LEADER

FF 42%
SF 0%

ID	Additional Capabilities Needed
201313	Design product and process verification and validation procedures that utilise rapid prototyping technologies
227538	Develop cross-industry standards for component interfaces, such as blade root and mount configurations, to ensure compatibility and efficiency.
227077	Develop processes for joining segmented blades
227059	Develop product specifications to incorporate specific new production techniques and processes.
227531	Develop segmented blade designs to enable parallel production of multiple, similar blade sections
227056	Develop specific partnership agreements to directly support technological advancements in product development.
227532	Develop wind turbine blade designs that support assembly-based production (rather than mold-based production)
227539	Implement cross-industry standards for component interfaces to standardise blade root and mount configurations across different sectors.
227535	Implement standards for name plating in wind turbine components, e.g. materials, masses, design life, circularity
227088	Manage production of prototype systems and components to validate performance of wind turbine products.

227065	Promote awareness of specific automation opportunities in the offshore wind sector to enhance targeted production capabilities.

A4.2 Engineer / Role Family 3

QUALITY CONTROL ENGINEER vs CONTROL SYSTEMS ENGINEER

FF 64%
SF 64%

ID	Additional Capabilities Needed
227112	Capture monitoring data to inform specific analyses on quality, time, and cost.
196862	Conduct condition monitoring.
227097	Develop specific digital tools to ensure adherence to defined operational processes.
227542	Implement automation and robotics systems to precisely execute and manage repair and rework processes in a manufacturing environment.
227099	Inspect blade surface for defects
209588	Operate robotic inspection systems for blade surface inspection
155740	Select, calibrate, or operate equipment used in the non-destructive testing of products or materials.
227057	Verify the capabilities of new supply chain companies to ensure compliance with operational standards.

QUALITY CONTROL ENGINEER vs AEROSPACE ENGINEER

FF 55%
SF 67%

ID	Additional Capabilities Needed
227112	Capture monitoring data to inform specific analyses on quality, time, and cost.
196862	Conduct condition monitoring.
227090	Conduct predictive maintenance of processing and equipment using condition-based monitoring
227097	Develop specific digital tools to ensure adherence to defined operational processes.
227542	Implement automation and robotics systems to precisely execute and manage repair and rework processes in a manufacturing environment.
227099	Inspect blade surface for defects
188907	Observe the operation of machinery or equipment to diagnose malfunctions
209588	Operate robotic inspection systems for blade surface inspection
155740	Select, calibrate, or operate equipment used in the non-destructive testing of products or materials.
227057	Verify the capabilities of new supply chain companies to ensure compliance with operational standards.

MECHANICAL / TOOLING ENGINEER vs TOOL PROCESS DESIGN ENGINEER

FF 46%
SF 67%

ID	Additional Capabilities Needed
227108	Prepare machinery and tools for specific operational tasks such as setting up production lines or performing maintenance procedures.
227107	Implement automated systems to assist in preparing and loading specific machinery and tools for designated operational tasks.

182330	Contributing to continuous improvement in component production or assembly.
227084	Deploy additively manufactured direct mold manufacturing processes to streamline the introduction of new products.
227109	Load machinery and tools for operational tasks
227091	Ensure correct placement of 'add-ons' such as vortex generators, spoilers, serrations, and gurney flap during wind turbine blade

MECHANICAL / TOOLING ENGINEER vs MANUFACTURING ENGINEER

FF 55%
SF 60%

ID	Additional Capabilities Needed
227107	Implement automated systems to assist in preparing and loading specific machinery and tools for designated operational tasks.
189753	Develop new tooling and equipment for enhancing product processing efficiency
227109	Load machinery and tools for operational tasks
227091	Ensure correct placement of 'add-ons' such as vortex generators, spoilers, serrations, and gurney flap during wind turbine blade production, to minimise rework.

EQUIPMENT & INSTALLATION ENGINEER vs ROBOTICS ENGINEER

FF 42%
SF 41%

ID	Additional Capabilities Needed
227062	Improve factory layout to support automation and ensure more efficient movement
227090	Conduct predictive maintenance of processing and equipment using condition-based monitoring
227046	Operate support systems for cobotics in Wind Turbine component manufacture
204136	*Implement and maintain efficient and reliable maintenance procedures to prevent equipment failures and optimise asset performance
225749	*Manage and maintain digital manufacturing systems and equipment
227108	Prepare machinery and tools for specific operational tasks such as setting up production lines or performing maintenance procedures.
100120	Monitor functioning of equipment to ensure system operates in conformance with specifications.
205739	Maintain predictive maintenance techniques to optimise equipment performance and prevent breakdowns
181400	plan and maintain all schedules for upgrade, upkeep and maintenance to reduce downtime production loss.
43650	Design layout of equipment or workspaces to achieve maximum efficiency.

EQUIPMENT & INSTALLATION ENGINEER vs CONTROL SYSTEMS ENGINEER

FF 48%
SF 73%

ID	Additional Capabilities Needed
227062	Improve factory layout to support automation and ensure more efficient movement
227089	Program robots to execute precise assembly tasks for complex composite components and integrate robotics systems to enhance production efficiency.
227542	Implement automation and robotics systems to precisely execute and manage repair and rework processes in a manufacturing environment.
227044	Integrate robots to perform practical tasks in the production of complex composite components.

227046	Operate support systems for cobotics in Wind Turbine component manufacture
201349	Define and devise systems to support rapid redeployment of automation equipment in response to changing business requirements.
227108	Prepare machinery and tools for specific operational tasks such as setting up production lines or performing maintenance procedures.
43650	Design layout of equipment or workspaces to achieve maximum efficiency.
227107	Implement automated systems to assist in preparing and loading specific machinery and tools for designated operational tasks.
188086	Build, integrate and test functional robot systems.

MANUFACTURING ENGINEER vs SCIENCE INDUSTRY PROCESS & PLANT ENGINEER

FF 52%
SF 20%

ID	Additional Capabilities Needed
213460	Model assembly processes and systems using digital tools.
227540	Implement data sharing and benchmarking initiatives to compare manufacturing capabilities and enhance overall performance.
227062	Improve factory layout to support automation and ensure more efficient movement
227084	Deploy additively manufactured direct mold manufacturing processes to streamline the introduction of new products.
209939	Optimise process development using Modelling and Simulation (M&S) and Digital Twin Technologies
227044	Integrate robots to perform practical tasks in the production of complex composite components.
227548	Implement additive manufacturing techniques to create tools, molds, fixtures and jigging for in-flight components, and direct production of in-flight components (e.g. leading edges)
182330	Contributing to continuous improvement in component production or assembly.
212764	Identify opportunities to improve manufacturing processes, products or to reduce costs using e.g. knowledge of fabrication processes, tooling and production equipment, assembly methods, quality control standards, or product design, materials and parts.
227052	Develop flexible manufacturing infrastructure to integrate new composite manufacturing processes and technologies
205735	Create reconfigurable, agile and flexible production systems to enable rapid changes to production pathways/processes as

MANUFACTURING ENGINEER vs FOOD & DRINK ADVANCED ENGINEER (INTEGRATED DEGREE)

FF 70%
SF 30%

ID	Additional Capabilities Needed
213460	Model assembly processes and systems using digital tools.
227540	Implement data sharing and benchmarking initiatives to compare manufacturing capabilities and enhance overall performance.
227062	Improve factory layout to support automation and ensure more efficient movement
227084	Deploy additively manufactured direct mold manufacturing processes to streamline the introduction of new products.
227044	Integrate robots to perform practical tasks in the production of complex composite components.
227548	Implement additive manufacturing techniques to create tools, molds, fixtures and jigging for in-flight components, and direct production of in-flight components (e.g. leading edges)
227052	Develop flexible manufacturing infrastructure to integrate new composite manufacturing processes and technologies

A4.3 Senior Technician / Role Family 2

SENIOR BLADE PRODUCTION TECHNICIAN vs BATTERY MANUFACTURING TECHNICIAN

FF 42%
SF 44%

ID	Additional Capabilities Needed
227010	Fabricate and dismantle parts, equipment, and machines using robotic and automated systems.
227071	Utilise digital and automated inventory control systems in automated composite production lines
226983	Lay up composite materials on turbine blades to ensure structural integrity and optimal performance.
227109	Load machinery and tools for operational tasks
227091	Ensure correct placement of 'add-ons' such as vortex generators, spoilers, serrations, and gurney flap during wind turbine blade production, to minimise rework.
227100	Install leading-edge protection and vortex generators on blades to enhance aerodynamic performance.
227048	Monitor layup of fabric in composite systems to ensure accurate placement and no wrinkles
227020	Consolidate mat using suitable end effectors mounted on a robotic system to produce a laminate devoid of wrinkles.
227114	Monitor resin infusion and curing to ensure full infusion and minimise cycle time
227103	Place dry glass fabrics into shell molds to ensure precision in composite material shaping.
227093	Manage resin infusion process to ensure full infusion, to minimise cycle time and achieve product specifications
227105	Assemble blade components by adding webs and specific prefabrications to build turbine blade.
40480	Cure materials by letting them set at room temperature, placing them under heat lamps, or baking them in ovens.
99890	Monitor equipment to ensure proper operation.

A4.4 Technician / Role Family 1

BLADE PRODUCTION INSPECTOR vs FOOD INDUSTRY TECHNOLOGIST

FF 79%
SF 49%

ID	Additional Capabilities Needed
209588	Operate robotic inspection systems for blade surface inspection
227099	Inspect blade surface for defects
227113	Monitor add-on placements to ensure compliance with specific installation specifications.

APPENDIX 5 THE FUTURE OCCUPATIONAL PROFILES

This Appendix presents the capability sets defined through the foresighting process to date. Capabilities are grouped into 'future occupational profiles' (FOPs) within four role families:

- Role Family 1 (RF1) roles are at an entry grade technician or operator level.
- Role Family 2 (RF2) roles are intended for senior technicians and operators.
- Role Family 3 (RF3) roles are graduate / engineer level.
- Role Family 4 (RF4) roles are pitched for senior engineering levels or equivalent.

Where a FOP has a progression within the subgroup then the two roles are tabulated together (e.g. engineer / senior engineer, or operator / supervisor).

Each capability is identified as (A) Awareness, (P) Practitioner or (E) Expert level for the FOP. In general, the Awareness level capabilities are presented only where there is a corresponding Practitioner or Expert level identified for a progression role (in other words, capabilities where only the Awareness level is present, are omitted here for brevity).

The FOPs are presented here in full. The previous section provided the 'delta', or additional capabilities compared to existing standards. This may be of use to educators and trainers in terms of developing modular or conversion course content.

A5.1 Role Families 1 and 2 – (Senior) Technician / Operator Level

A5.1.1 Blade Production Technician

ID	15212: Blade Production Technician	Function	Functional Domain	Functional Area	RF1 Level
213460	Model assembly processes and systems using digital tools.	DESIGN	Process Design & Implementation	Model Processes	A
181992	Identify ways to improve processes by monitoring production process and end product.	DESIGN	Process Design & Implementation	Develop Processes	P
227055	Operate robotic equipment to perform green production applications, including testing and maintaining specific components.	DESIGN	System/Equipment Design & Implementation	Test Equipment & Systems	P
227104	Assemble prefabricated parts into kits for the next production stage.	IMPLEMENT	Input Processing & Preparation	Prepare Work Areas	P
227541	Implement production operations to assembly-based final stages with subsection components manufactured by the supply chain.	IMPLEMENT	Manage Operations	Direct Operations	P
227020	Consolidate mat using suitable end effectors mounted on a robotic system to produce a laminate devoid of wrinkles.	IMPLEMENT	Manage Operations	Gather Operations Data	P
227048	Monitor layup of fabric in composite systems to ensure accurate placement and no wrinkles	IMPLEMENT	Process Monitoring	Monitor Processes	P
227114	Monitor resin infusion and curing to ensure full infusion and minimise cycle time	IMPLEMENT	Process Monitoring	Monitor Processes	P
227100	Install leading-edge protection and vortex generators on blades to enhance aerodynamic performance.	IMPLEMENT	Product Processing	Finish Products	P
226983	Lay up composite materials on turbine blades to ensure structural integrity and optimal performance.	IMPLEMENT	Product Processing	Join Components	P
227103	Place dry glass fabrics into shell molds to ensure precision in composite material shaping.	IMPLEMENT	Product Processing	Join Components	P
227105	Assemble blade components by adding webs and specific prefabrications to build turbine blade.	IMPLEMENT	Product Processing	Join Components	P
40480	Cure materials by letting them set at room temperature, placing them under heat lamps, or baking them in ovens.	IMPLEMENT	Product Processing	Transfer Products	P

ID	15212: Blade Production Technician	Function	Functional Domain	Functional Area	RF1 Level
227109	Load machinery and tools for operational tasks	IMPLEMENT	System/Equipment Operation & Monitoring	Load Equipment	P
168460	Tend and observe equipment and machinery to verify efficient and safe operation.	IMPLEMENT	System/Equipment Operation & Monitoring	Monitor Equipment	P
99890	Monitor equipment to ensure proper operation.	IMPLEMENT	System/Equipment Operation & Monitoring	Monitor Equipment	P
227010	Fabricate and dismantle parts, equipment, and machines using robotic and automated systems.	IMPLEMENT	System/Equipment Operation & Monitoring	Operate Equipment	P
227071	Utilise digital and automated inventory control systems in automated composite production lines	LOGISTICS	Inventory Management	Monitor Inventories	P
227091	Ensure correct placement of 'add-ons' such as vortex generators, spoilers, serrations, and gurney flap during wind turbine blade production, to minimise rework.	SUPPORT	Quality Control	Evaluate Product Characteristics & Quality	P
227093	Manage resin infusion¬†process to ensure full infusion, to minimise cycle time and achieve product specifications	SUPPORT	Quality Control	Manage Quality Control	P

A5.1.2 Blade Production Inspector

ID	15215: Blade Production Inspector	Function	Functional Domain	Functional Area	RF1 Level
150230	Review existing manufacturing processes to identify opportunities for yield improvement or reduced process variation.	DESIGN	Technical Research	Research & Develop Technologies	A
227057	Verify the capabilities of new supply chain companies to ensure compliance with operational standards.	ENTERPRISE	Leadership & Strategy	Identify New Business Partnerships	A
227097	Develop specific digital tools to ensure adherence to defined operational processes.	SUPPORT	Operator Support	Train others to use equipment	A
188331	Review engineering and maintenance procedures identifying potential improvements to processes, materials, resources or planning. For example, improvements on costs, efficiencies and quality.	SUPPORT	Quality Control	Manage Quality Control	A
227112	Capture monitoring data to inform specific analyses on quality, time, and cost.	IMPLEMENT	Process Monitoring	Monitor Processes	E

ID	15215: Blade Production Inspector	Function	Functional Domain	Functional Area	RF1 Level
227099	Inspect blade surface for defects¬†	IMPLEMENT	Product Processing	Finish Products	E
227113	Monitor add-on placements to ensure compliance with specific installation specifications.	IMPLEMENT	Process Monitoring	Monitor Processes	P
182330	Contributing to continuous improvement in component production or assembly.	IMPLEMENT	Product Processing	Join Components	P
100120	Monitor functioning of equipment to ensure system operates in conformance with specifications.	IMPLEMENT	System/Equipment Operation & Monitoring	Monitor Operations	P
196862	Conduct condition monitoring.	IMPLEMENT	System/Equipment Operation & Monitoring	Monitor Operations	P
227106	Monitor compliance of operational activities with specific industry standards to ensure they meet quality and safety requirements.	IMPLEMENT	System/Equipment Operation & Monitoring	Monitor Operations	P
209588	Operate robotic inspection systems for blade surface inspection	IMPLEMENT	System/Equipment Operation & Monitoring	Operate Equipment	P
213139	Operate within an automated, digitalised quality-controlled environment, performing technical quality checks and peer reviews in line with standard operating procedures.	SUPPORT	Quality Control	Manage Quality Control	P
222181	*Inspect materials using advanced NDT methods to identify faults and imperfections	SUPPORT	System/Equipment Maintenance	Inspect Facilities & Equipment	P

A5.1.3 Senior Blade Production Technician

ID	15213 - Senior Blade Production Technician	Function	Functional Domain	Functional Area	RF2 Level
181992	Identify ways to improve processes by monitoring production process and end product.	DESIGN	Process Design & Implementation	Develop Processes	P
150230	Review existing manufacturing processes to identify opportunities for yield improvement or reduced process variation.	DESIGN	Technical Research	Research & Develop Technologies	P
227111	Implement lean manufacturing principles to streamline the production process and reduce cycle time.	IMPLEMENT	Plan Operations	Plan Operations	P

ID	15213 - Senior Blade Production Technician	Function	Functional Domain	Functional Area	RF2 Level
188907	Observe the operation of machinery or equipment to diagnose malfunctions	IMPLEMENT	System/Equipment Operation & Monitoring	Monitor Equipment	P
227010	Fabricate and dismantle parts, equipment, and machines using robotic and automated systems.	IMPLEMENT	System/Equipment Operation & Monitoring	Operate Equipment	P
227068	Manage and co-ordinate delivery of composite materials including resins, consumables, and cores to supply an advanced production line	LOGISTICS	Inventory Management	Monitor Inventories	P
227071	Utilise digital and automated inventory control systems in automated composite production lines	LOGISTICS	Inventory Management	Monitor Inventories	P
212889	Develop and apply Lean Manufacturing principles to streamline manufacturing processes and reduce waste generation.	LOGISTICS	Waste Management	Manage Waste	P
227055	Operate robotic equipment to perform green production applications, including testing and maintaining specific components.	DESIGN	System/Equipment Design & Implementation	Test Equipment & Systems	E
227104	Assemble prefabricated parts into kits for the next production stage.	IMPLEMENT	Input Processing & Preparation	Prepare Work Areas	E
227541	Implement production operations to assembly-based final stages with subsection components manufactured by the supply chain.	IMPLEMENT	Manage Operations	Direct Operations	E
227020	Consolidate mat using suitable end effectors mounted on a robotic system to produce a laminate devoid of wrinkles.	IMPLEMENT	Manage Operations	Gather Operations Data	E
227048	Monitor layup of fabric in composite systems to ensure accurate placement and no wrinkles	IMPLEMENT	Process Monitoring	Monitor Processes	E
227114	Monitor resin infusion and curing to ensure full infusion and minimise cycle time	IMPLEMENT	Process Monitoring	Monitor Processes	E
227100	Install leading-edge protection and vortex generators on blades to enhance aerodynamic performance.	IMPLEMENT	Product Processing	Finish Products	E
226983	Lay up composite materials on turbine blades to ensure structural integrity and optimal performance.	IMPLEMENT	Product Processing	Join Components	E
227103	Place dry glass fabrics into shell molds to ensure precision in composite material shaping.	IMPLEMENT	Product Processing	Join Components	E
227105	Assemble blade components by adding webs and specific prefabrications to build turbine blade.	IMPLEMENT	Product Processing	Join Components	E

ID	15213 - Senior Blade Production Technician	Function	Functional Domain	Functional Area	RF2 Level
40480	Cure materials by letting them set at room temperature, placing them under heat lamps, or baking them in ovens.	IMPLEMENT	Product Processing	Transfer Products	E
227109	Load machinery and tools for operational tasks	IMPLEMENT	System/Equipment Operation & Monitoring	Load Equipment	E
168460	Tend and observe equipment and machinery to verify efficient and safe operation.	IMPLEMENT	System/Equipment Operation & Monitoring	Monitor Equipment	E
99890	Monitor equipment to ensure proper operation.	IMPLEMENT	System/Equipment Operation & Monitoring	Monitor Equipment	E
227091	Ensure correct placement of 'add-ons' such as vortex generators, spoilers, serrations, and gurney flap during wind turbine blade production, to minimise rework.	SUPPORT	Quality Control	Evaluate Product Characteristics & Quality	E
227093	Manage resin infusion¬†process to ensure full infusion, to minimise cycle time and achieve product specifications	SUPPORT	Quality Control	Manage Quality Control	E

A5.2 Role Families 3 and 4 – (Senior) Engineer Level

A5.2.1 Production Manager

ID	15214 - Production Manager	Function	Functional Domain	Functional Area	RF4 Level
181992	Identify ways to improve processes by monitoring production process and end product.	DESIGN	Process Design & Implementation	Develop Processes	P
181862	Leads process improvement activities associated with new and existing manufacturing processes utilising latest techniques and practices by the collection and analysis of data using standard SPC analytical techniques	DESIGN	Process Design & Implementation	Develop Processes	P
182335	Solve internal and external materials production problems utilising experiential or innovative solutions.	DESIGN	Prototype Design & Development	Design Materials & Devices	P
212764	Identify opportunities to improve manufacturing processes, products or to reduce costs using e.g. knowledge of fabrication processes, tooling and production equipment, assembly methods, quality control standards, or product design, materials and parts.	DESIGN	Prototype Design & Development	Refine Designs	P
227052	Develop flexible manufacturing infrastructure to integrate new composite manufacturing processes and technologies	DESIGN	System/Equipment Design & Implementation	Design Equipment	P
227540	Implement data sharing and benchmarking initiatives to compare manufacturing capabilities and enhance overall performance.	ENTERPRISE	Leadership & Strategy	Evaluate Business Performance	P
205761	Direct operations by coordinating robotic systems	IMPLEMENT	Manage Operations	Direct Operations	P
194441	Implement advanced process control techniques to improve operational efficiency.	IMPLEMENT	Manage Operations	Manage Operation Control Systems	P
223891	*Lead and oversee the implementation of digital manufacturing technologies	IMPLEMENT	Service Delivery	Create & Process Digital Media	P
227539	Implement cross-industry standards for component interfaces to standardise blade root and mount configurations across different sectors.	SUPPORT	Quality Control	Manage Quality Control	E

ID	15214 - Production Manager	Function	Functional Domain	Functional Area	RF4 Level
227082	Design production facilities to accommodate the parallel manufacturing of wind turbine blade segments.	DESIGN	Supply Chain Design & Implementation	Develop Supply Chain Models & Systems	E
182030	Assess both current and future workforce needs, building future capability and talent and actively contribute to the organisation's strategic workforce planning or talent management processes for example, they may need to analyse the transferability of skills in the current workforce and devise strategies that enable a just transition for staff into the green economy.	ENTERPRISE	Human Resource Management	Manage Human Resources	E
201063	Implement strategic workforce planning	ENTERPRISE	Human Resource Management	Manage Human Resources	E
227058	Review targeted training programs to enhance employee skills in adapting to new technologies and flexible work schedules.	ENTERPRISE	Human Resource Management	Manage Human Resources	E
189304	*Lead and facilitate organisational change management, preparing teams and individuals for transitions and promoting the acceptance of change.	ENTERPRISE	Leadership & Strategy	Manage Change & Transformation Programmes	E
202588	*Manage change in the organisation, ensuring smooth transitions and minimal disruption.	ENTERPRISE	Leadership & Strategy	Manage Change & Transformation Programmes	E
227111	Implement lean manufacturing principles to streamline the production process and reduce cycle time.	IMPLEMENT	Plan Operations	Plan Operations	E
227065	Promote awareness of specific automation opportunities in the offshore wind sector to enhance targeted production capabilities.	LOGISTICS	Supply Chain Management	Identify Suppliers	E
227062	Improve factory layout to support automation and ensure more efficient movement	LOGISTICS	Supply Chain Operations	Move Supplies	E
212889	Develop and apply Lean Manufacturing principles to streamline manufacturing processes and reduce waste generation.	LOGISTICS	Waste Management	Manage Waste	E
213019	Create ways to repurpose and recycle waste to improve cost efficiencies in manufacturing process.	LOGISTICS	Waste Management	Manage Waste	E

ID	15214 - Production Manager	Function	Functional Domain	Functional Area	RF4 Level
205735	Create reconfigurable, agile and flexible production systems to enable rapid changes to production pathways/processes as products change	DESIGN	Process Design & Implementation	Develop Processes	A
227541	Implement production operations to assembly-based final stages with subsection components manufactured by the supply chain.	IMPLEMENT	Manage Operations	Direct Operations	A

A5.2.2 Senior Research & Development Engineer

ID	15206 – Senior Research & Development Engineer	Function	Functional Domain	Functional Area	RF4 Level
194412	Apply additive manufacturing technology to prototype and produce complex product designs	DESIGN	Prototype Design & Development	Design Materials & Devices	P
227094	Implement digital twin technology to simulate and enhance manufacturing and design operations	IMPLEMENT	Manage Operations	Manage Operation Control Systems	P
194397	Develop new manufacturing processes using advanced process control (APC) technology.	DESIGN	Process Design & Implementation	Develop Processes	E
201537	Devise design evaluation and optimisation processes using Design Of Experiments, Design For Manufacture And Assembly (DFMA) and Design for X (DFX) approaches to create robust and resilient designs	DESIGN	Product Engineering	Create Engineering Designs	E
227535	Implement standards for name plating in wind turbine components, e.g. materials, masses, design life, circularity	DESIGN	Prototype Design & Development	Create Detailed Product Specification	E
227538	Develop cross-industry standards for component interfaces, such as blade root and mount configurations, to ensure compatibility and efficiency.	DESIGN	Prototype Design & Development	Create Detailed Product Specification	E
227531	Develop segmented blade designs to enable parallel production of multiple, similar blade sections	DESIGN	Prototype Design & Development	Design Materials & Devices	E
227532	Develop wind turbine blade designs that support assembly-based production (rather than mold-based production)	DESIGN	Prototype Design & Development	Design Materials & Devices	E

ID	15206 – Senior Research & Development Engineer	Function	Functional Domain	Functional Area	RF4 Level
227534	Devise design solutions that allow for production efficiencies from additive manufacture	DESIGN	Prototype Design & Development	Design Systems & Applications	E
201313	Design product and process verification and validation procedures that utilise rapid prototyping technologies	DESIGN	Prototype Design & Development	Develop Prototypes	E
227076	Design blade segmentation and modularisation systems to support industrialisation to reduce production time and enhance product quality	DESIGN	Prototype Design & Development	Develop Prototypes	E
227077	Develop processes for joining segmented blades	DESIGN	System/Equipment Design & Implementation	Install Equipment	E
227056	Develop specific partnership agreements to directly support technological advancements in product development.	ENTERPRISE	Leadership & Strategy	Negotiate Business Agreements	E
227059	Develop product specifications to incorporate specific new production techniques and processes.	ENTERPRISE	Product Management	Develop Specifications	E
227088	Manage production of prototype systems and components to validate performance of wind turbine products.	IMPLEMENT	Manage Operations	Direct Operations	E
227530	Design blade and material systems to eliminate or automate the finishing processes.	IMPLEMENT	Product Processing	Finish Products	E
183818	Undertake complex forming simulation trials where the new component is formed" from a series of process steps"	IMPLEMENT	Product Processing	Join Components	E
227065	Promote awareness of specific automation opportunities in the offshore wind sector to enhance targeted production capabilities.	LOGISTICS	Supply Chain Management	Identify Suppliers	E
227539	Implement cross-industry standards for component interfaces to standardise blade root and mount configurations across different sectors.	SUPPORT	Quality Control	Manage Quality Control	E

A5.2.3 Blade Design Engineer

ID	15220 - Blade Design Engineer	Function	Functional Domain	Functional Area	RF3 Level
201537	Devise design evaluation and optimisation processes using Design Of Experiments, Design for Manufacture and Assembly (DFMA) and Design for X (DFX) approaches to create robust and resilient designs	DESIGN	Product Engineering	Create Engineering Designs	P
227535	Implement standards for name plating in wind turbine components, e.g. materials, masses, design life, circularity	DESIGN	Prototype Design & Development	Create Detailed Product Specification	P
227538	Develop cross-industry standards for component interfaces, such as blade root and mount configurations, to ensure compatibility and efficiency.	DESIGN	Prototype Design & Development	Create Detailed Product Specification	P
227531	Develop segmented blade designs to enable parallel production of multiple, similar blade sections	DESIGN	Prototype Design & Development	Design Materials & Devices	P
227532	Develop wind turbine blade designs that support assembly-based production (rather than mold-based production)	DESIGN	Prototype Design & Development	Design Materials & Devices	P
227529	Implement design-for-automation in the design phase to reduce manual labour tasks in production.	DESIGN	Prototype Design & Development	Design Systems & Applications	P
227076	Design blade segmentation and modularisation systems to support industrialisation to reduce production time and enhance product quality	DESIGN	Prototype Design & Development	Develop Prototypes	P
227078	Select materials for wind turbine blades that enhance circularity and sustainability to minimise their lifecycle environmental impact.	DESIGN	Prototype Design & Development	Select Technologies	P
227059	Develop product specifications to incorporate specific new production techniques and processes.	ENTERPRISE	Product Management	Develop Specifications	P
227094	Implement digital twin technology to simulate and enhance manufacturing and design operations	IMPLEMENT	Manage Operations	Manage Operation Control Systems	P
227539	Implement cross-industry standards for component interfaces to standardise blade root and mount configurations across different sectors.	SUPPORT	Quality Control	Manage Quality Control	P
205670	Apply tools used for the optimisation of product and production processes - e.g. Design for X tools and systems	DESIGN	Process Design & Implementation	Develop Processes	E

ID	15220 - Blade Design Engineer	Function	Functional Domain	Functional Area	RF3 Level
227074	Create wind turbine blade designs to enhance the circularity and recyclability, thereby reducing environmental impact	DESIGN	Prototype Design & Development	Design Materials & Devices	E
227081	Design wind turbine blade add-ons such as vortex generators, spoilers, serrations, and gurney flaps, for improved performance.	DESIGN	Prototype Design & Development	Design Materials & Devices	E
210844	Incorporate existing design techniques from other industries, e.g., DFX (Design For X) or concurrent engineering.	DESIGN	Prototype Design & Development	Design Systems & Applications	E
227075	Design wind turbine blades using advanced composite materials and engineering to enhance their structural performance, specifically in terms of weight, strength, and durability.	DESIGN	Prototype Design & Development	Develop Prototypes	E
201534	Design and implement systems and tools to support design for assembly/disassembly and recycling	DESIGN	System/Equipment Design & Implementation	Design Equipment	E
227086	Apply specific modern design techniques like design-for-automation and design-for-X to wind turbine blade design, enhancing their suitability for automated production methods.	DESIGN	Technical Research	Research & Develop Technologies	E
227102	Produce technical specifications for the finished Wind Turbine Blades to ensure compliance with industry standards.	IMPLEMENT	Product Processing	Finish Products	E
227095	Integrate design process with digital twin systems to enhance project accuracy and efficiency.	SUPPORT	Operator Support	Prepare Informational or Reference Materials	E

A5.2.4 Quality Control Engineer

ID	15216 - Quality Control Engineer - Engineer	Function	Functional Domain	Functional Area	RF2 Level
181862	Leads process improvement activities associated with new and existing manufacturing processes utilising latest techniques and practices by the collection and analysis of data using standard SPC analytical techniques	DESIGN	Process Design & Implementation	Develop Processes	P

ID	15216 - Quality Control Engineer - Engineer	Function	Functional Domain	Functional Area	RF2 Level
150230	Review existing manufacturing processes to identify opportunities for yield improvement or reduced process variation.	DESIGN	Technical Research	Research & Develop Technologies	P
182330	Contributing to continuous improvement in component production or assembly.	IMPLEMENT	Product Processing	Join Components	P
227097	Develop specific digital tools to ensure adherence to defined operational processes.	SUPPORT	Operator Support	Train others to use equipment	P
188331	Review engineering and maintenance procedures identifying potential improvements to processes, materials, resources or planning. For example, improvements on costs, efficiencies and quality.	SUPPORT	Quality Control	Manage Quality Control	P
227090	Conduct predictive maintenance of processing and equipment using condition-based monitoring	SUPPORT	System/Equipment Maintenance	Manage Facility Maintenance	P
181992	Identify ways to improve processes by monitoring production process and end product.	DESIGN	Process Design & Implementation	Develop Processes	E
227542	Implement automation and robotics systems to precisely execute and manage repair and rework processes in a manufacturing environment.	DESIGN	Prototype Design & Development	Design Systems & Applications	E
212764	Identify opportunities to improve manufacturing processes, products or to reduce costs using e.g. knowledge of fabrication processes, tooling and production equipment, assembly methods, quality control standards, or product design, materials and parts.	DESIGN	Prototype Design & Development	Refine Designs	E
155740	Select, calibrate, or operate equipment used in the non-destructive testing of products or materials.	DESIGN	System/Equipment Design & Implementation	Select Equipment	E
227057	Verify the capabilities of new supply chain companies to ensure compliance with operational standards.	ENTERPRISE	Leadership & Strategy	Identify New Business Partnerships	E
189829	Coordinate compliance activities across different departments to streamline processes and ensure consistent adherence to regulations.	ENTERPRISE	Regulatory Compliance	Coordinate Compliance activities	E

ID	15216 - Quality Control Engineer - Engineer	Function	Functional Domain	Functional Area	RF2 Level
227112	Capture monitoring data to inform specific analyses on quality, time, and cost.	IMPLEMENT	Process Monitoring	Monitor Processes	E
227099	Inspect blade surface for defects¬†	IMPLEMENT	Product Processing	Finish Products	E
188907	Observe the operation of machinery or equipment to diagnose malfunctions	IMPLEMENT	System/Equipment Operation & Monitoring	Monitor Equipment	E
196862	Conduct condition monitoring.	IMPLEMENT	System/Equipment Operation & Monitoring	Monitor Operations	E
227106	Monitor compliance of operational activities with specific industry standards to ensure they meet quality and safety requirements.	IMPLEMENT	System/Equipment Operation & Monitoring	Monitor Operations	E
209588	Operate robotic inspection systems for blade surface inspection	IMPLEMENT	System/Equipment Operation & Monitoring	Operate Equipment	E
213160	Implement digital and automated quality control systems to ensure product compliance and minimise defects.	SUPPORT	Quality Control	Manage Quality Control	E
213138	Digitise and automate quality control of raw and production materials to ensure compliance with regulatory specifications.	SUPPORT	Quality Control	Manage Quality Control	E
213139	Operate within an automated, digitalised quality-controlled environment, performing technical quality checks and peer reviews in line with standard operating procedures.	SUPPORT	Quality Control	Manage Quality Control	E
222181	*Inspect materials using advanced NDT methods to identify faults and imperfections	SUPPORT	System/Equipment Maintenance	Inspect Facilities & Equipment	E

A5.2.5 Manufacturing Engineer

ID	15217 - Manufacturing Engineer	Function	Functional Domain	Functional Area	RF3 Level
181992	Identify ways to improve processes by monitoring production process and end product.	DESIGN	Process Design & Implementation	Develop Processes	P
213460	Model assembly processes and systems using digital tools.	DESIGN	Process Design & Implementation	Model Processes	P
209939	Optimise process development using Modelling and Simulation (M&S) and Digital Twin Technologies	DESIGN	Process Design & Implementation	Model Processes	P
227548	Implement additive manufacturing techniques to create tools, molds, fixtures and jigging for in-flight components, and direct production of in-flight components (e.g. leading edges)	DESIGN	Prototype Design & Development	Design Materials & Devices	P
227084	Deploy additively manufactured direct mold manufacturing processes to streamline the introduction of new products.	DESIGN	Prototype Design & Development	Design Systems & Applications	P
205626	*Utilise advanced data analytics tools to analyse manufacturing data and identify areas for improvement	ENTERPRISE	Data Management	Perform Data Analysis	P
227540	Implement data sharing and benchmarking initiatives to compare manufacturing capabilities and enhance overall performance.	ENTERPRISE	Leadership & Strategy	Evaluate Business Performance	P
227111	Implement lean manufacturing principles to streamline the production process and reduce cycle time.	IMPLEMENT	Plan Operations	Plan Operations	P
223891	*Lead and oversee the implementation of digital manufacturing technologies	IMPLEMENT	Service Delivery	Create & Process Digital Media	P
225744	*Collaborate with cross-functional teams to identify and implement digital solutions for manufacturing challenges	IMPLEMENT	Service Delivery	Create & Process Digital Media	P
227044	Integrate robots to perform practical tasks in the production of complex composite components.	SUPPORT	Operator Support	Design and configure support systems	P
225749	*Manage and maintain digital manufacturing systems and equipment	SUPPORT	System/Equipment Maintenance	Maintain Systems	P

ID	15217 - Manufacturing Engineer	Function	Functional Domain	Functional Area	RF3 Level
181862	Leads process improvement activities associated with new and existing manufacturing processes utilising latest techniques and practices by the collection and analysis of data using standard SPC analytical techniques	DESIGN	Process Design & Implementation	Develop Processes	E
205735	Create reconfigurable, agile and flexible production systems to enable rapid changes to production pathways/processes as products change	DESIGN	Process Design & Implementation	Develop Processes	E
182335	Solve internal and external materials production problems utilising experiential or innovative solutions.	DESIGN	Prototype Design & Development	Design Materials & Devices	E
212764	Identify opportunities to improve manufacturing processes, products or to reduce costs using e.g. knowledge of fabrication processes, tooling and production equipment, assembly methods, quality control standards, or product design, materials and parts.	DESIGN	Prototype Design & Development	Refine Designs	E
227052	Develop flexible manufacturing infrastructure to integrate new composite manufacturing processes and technologies	DESIGN	System/Equipment Design & Implementation	Design Equipment	E
213015	Adapt equipment for continuous manufacturing processes using Engineering and Engineering Design Process	DESIGN	System/Equipment Design & Implementation	Design Equipment	E
150230	Review existing manufacturing processes to identify opportunities for yield improvement or reduced process variation.	DESIGN	Technical Research	Research & Develop Technologies	E
194441	Implement advanced process control techniques to improve operational efficiency.	IMPLEMENT	Manage Operations	Manage Operation Control Systems	E
182330	Contributing to continuous improvement in component production or assembly.	IMPLEMENT	Product Processing	Join Components	E
227062	Improve factory layout to support automation and ensure more efficient movement	LOGISTICS	Supply Chain Operations	Move Supplies	E
212889	Develop and apply Lean Manufacturing principles to streamline manufacturing processes and reduce waste generation.	LOGISTICS	Waste Management	Manage Waste	E

A5.2.6 Supply Chain & Logistics Manager

ID	15218 - Supply Chain & Logistics Manager	Function	Functional Domain	Functional Area	RF3 Level
194412	Apply additive manufacturing technology to prototype and produce complex product designs	DESIGN	Prototype Design & Development	Design Materials & Devices	P
227541	Implement production operations to assembly-based final stages with subsection components manufactured by the supply chain.	IMPLEMENT	Manage Operations	Direct Operations	P
227064	Standardise production materials to mitigate the impact of supply chain disruptions.	LOGISTICS	Inventory Management	Plan Supply Contingencies	P
227065	Promote awareness of specific automation opportunities in the offshore wind sector to enhance targeted production capabilities.	LOGISTICS	Supply Chain Management	Identify Suppliers	P
213019	Create ways to repurpose and recycle waste to improve cost efficiencies in manufacturing process.	LOGISTICS	Waste Management	Manage Waste	P
227078	Select materials for wind turbine blades that enhance circularity and sustainability to minimise their lifecycle environmental impact.	DESIGN	Prototype Design & Development	Select Technologies	E
227540	Implement data sharing and benchmarking initiatives to compare manufacturing capabilities and enhance overall performance.	ENTERPRISE	Leadership & Strategy	Evaluate Business Performance	E
227057	Verify the capabilities of new supply chain companies to ensure compliance with operational standards.	ENTERPRISE	Leadership & Strategy	Identify New Business Partnerships	E
227068	Manage and co-ordinate delivery of composite materials including resins, consumables, and cores to supply an advanced production line	LOGISTICS	Inventory Management	Monitor Inventories	E
227071	Utilise digital and automated inventory control systems in automated composite production lines	LOGISTICS	Inventory Management	Monitor Inventories	E
227063	Optimise logistics processes to ensure that all materials are utilised before their expiration date.	LOGISTICS	Inventory Management	Monitor Inventories	E
227066	Identify potential suppliers with relevant expertise to provide automated and advance composite production equipment into the Wind industry	LOGISTICS	Supply Chain Management	Identify Suppliers	E

ID	15218 - Supply Chain & Logistics Manager	Function	Functional Domain	Functional Area	RF3 Level
227069	Investigate alternative material supply formats to improve compatibility with automated and advanced production methods	LOGISTICS	Supply Chain Management	Identify Suppliers	E
227060	Develop roadmaps for potential suppliers to outline specific technical requirements and expected production volumes.	LOGISTICS	Supply Chain Management	Work with Suppliers	E
227067	Adjust kits and material supply formats to suit automation in production	LOGISTICS	Supply Chain Management	Work with Suppliers	E
227070	Utilise automated factory logistic systems to move material to production lines within specified timeframes.	LOGISTICS	Supply Chain Operations	Move Supplies	E
188072	Implement best practice in environmental and waste management	LOGISTICS	Waste Management	Manage Waste	E
194470	Develop and implement a closed-loop waste management system to minimise waste generation and promote resource recovery.	LOGISTICS	Waste Management	Manage Waste	E
227104	Assemble prefabricated parts into kits for the next production stage.	IMPLEMENT	Input Processing & Preparation	Prepare Work Areas	A
209122	Implement advanced material handling automation for efficient sorting and preparation.	IMPLEMENT	Input Processing & Preparation	Sort Materials	A

A5.2.7 Equipment Installation & Support Engineer

ID	15209 - Equipment Installation & Support Engineer	Function	Functional Domain	Functional Area	RF3 Level
227089	Program robots to execute precise assembly tasks for complex composite components and integrate robotics systems to enhance production efficiency.	IMPLEMENT	Plan Operations	Plan Operations	P
188907	Observe the operation of machinery or equipment to diagnose malfunctions	IMPLEMENT	System/Equipment Operation & Monitoring	Monitor Equipment	P
227062	Improve factory layout to support automation and ensure more efficient movement	LOGISTICS	Supply Chain Operations	Move Supplies	P

ID	15209 - Equipment Installation & Support Engineer	Function	Functional Domain	Functional Area	RF3 Level
227044	Integrate robots to perform practical tasks in the production of complex composite components.	SUPPORT	Operator Support	Design and configure support systems	P
188086	Build, integrate and test functional robot systems.	SUPPORT	Operator Support	Design and configure support systems	P
227046	Operate support systems for cobotics in Wind Turbine component manufacture	SUPPORT	Operator Support	Design and configure support systems	P
225749	*Manage and maintain digital manufacturing systems and equipment	SUPPORT	System/Equipment Maintenance	Maintain Systems	P
227542	Implement automation and robotics systems to precisely execute and manage repair and rework processes in a manufacturing environment.	DESIGN	Prototype Design & Development	Design Systems & Applications	E
201349	Define and devise systems to support rapid redeployment of automation equipment in response to changing business requirements.	IMPLEMENT	Manage Operations	Manage Operation Control Systems	E
227108	Prepare machinery and tools for specific operational tasks such as setting up production lines or performing maintenance procedures.	IMPLEMENT	System/Equipment Operation & Monitoring	Load Equipment	E
100120	Monitor functioning of equipment to ensure system operates in conformance with specifications.	IMPLEMENT	System/Equipment Operation & Monitoring	Monitor Operations	E
43650	Design layout of equipment or workspaces to achieve maximum efficiency.	SUPPORT	Operator Support	Design and configure support systems	E
188331	Review engineering and maintenance procedures identifying potential improvements to processes, materials, resources or planning. For example, improvements on costs, efficiencies and quality.	SUPPORT	Quality Control	Manage Quality Control	E
204136	*Implement and maintain efficient and reliable maintenance procedures to prevent equipment failures and optimise asset performance	SUPPORT	System/Equipment Maintenance	Maintain Facilities & Equipment	E
205739	Maintain predictive maintenance techniques to optimise equipment performance and prevent breakdowns	SUPPORT	System/Equipment Maintenance	Maintain Facilities & Equipment	E

ID	15209 - Equipment Installation & Support Engineer	Function	Functional Domain	Functional Area	RF3 Level
194484	Develop and implement a proactive maintenance strategy to minimise downtime.	SUPPORT	System/Equipment Maintenance	Maintain Systems	E
227090	Conduct predictive maintenance of processing and equipment using condition-based monitoring	SUPPORT	System/Equipment Maintenance	Manage Facility Maintenance	E
181400	plan and maintain all schedules for upgrade, upkeep and maintenance to reduce downtime production loss.	SUPPORT	System/Equipment Maintenance	Schedule Maintenance	E
227107	Implement automated systems to assist in preparing and loading specific machinery and tools for designated operational tasks.	IMPLEMENT	System/Equipment Operation & Monitoring	Load Equipment	A

A5.2.8 Mechanical / Tooling Engineer

ID	15210 - Mechanical / Tooling Engineer	Function	Functional Domain	Functional Area	RF3 Level
213460	Model assembly processes and systems using digital tools.	DESIGN	Process Design & Implementation	Model Processes	P
182330	Contributing to continuous improvement in component production or assembly.	IMPLEMENT	Product Processing	Join Components	P
227108	Prepare machinery and tools for specific operational tasks such as setting up production lines or performing maintenance procedures.	IMPLEMENT	System/Equipment Operation & Monitoring	Load Equipment	P
227107	Implement automated systems to assist in preparing and loading specific machinery and tools for designated operational tasks.	IMPLEMENT	System/Equipment Operation & Monitoring	Load Equipment	P
189753	Develop new tooling and equipment for enhancing product processing efficiency	DESIGN	Process Design & Implementation	Develop Processes	E
227548	Implement additive manufacturing techniques to create tools, molds, fixtures and jigging for in-flight components, and direct production of in-flight components (e.g. leading edges)	DESIGN	Prototype Design & Development	Design Materials & Devices	E

ID	15210 - Mechanical / Tooling Engineer	Function	Functional Domain	Functional Area	RF3 Level
227050	Implement additive manufacturing techniques to create tools, molds, fixtures and jigging for in-flight components and/or manufacturing support materials	DESIGN	Prototype Design & Development	Design Materials & Devices	E
227084	Deploy additively manufactured direct mold manufacturing processes to streamline the introduction of new products.	DESIGN	Prototype Design & Development	Design Systems & Applications	E
212764	Identify opportunities to improve manufacturing processes, products or to reduce costs using e.g. knowledge of fabrication processes, tooling and production equipment, assembly methods, quality control standards, or product design, materials and parts.	DESIGN	Prototype Design & Development	Refine Designs	E
227109	Load machinery and tools for operational tasks	IMPLEMENT	System/Equipment Operation & Monitoring	Load Equipment	A
227091	Ensure correct placement of 'add-ons' such as vortex generators, spoilers, serrations, and gurney flap during wind turbine blade production, to minimise rework.	SUPPORT	Quality Control	Evaluate Product Characteristics & Quality	A

A5.2.9 (Senior) Robotics & Industrialisation Engineer

ID	15207 - Robotics & Industrialisation Engineer 15208 - Senior Robotics & Industrialisation Engineer	Function	Functional Domain	Functional Area	RF3 Level	RF4 Level
213460	Model assembly processes and systems using digital tools.	DESIGN	Process Design & Implementation	Model Processes	P	
227089	Program robots to execute precise assembly tasks for complex composite components and integrate robotics systems to enhance production efficiency.	IMPLEMENT	Plan Operations	Plan Operations	P	P
227054	Review engineering and/or manufacturing methods to determine the most effective, economical and sustainable methods whilst meeting specifications	DESIGN	Product Engineering	Create Engineering Designs	P	E

ID	15207 - Robotics & Industrialisation Engineer 15208 - Senior Robotics & Industrialisation Engineer	Function	Functional Domain	Functional Area	RF3 Level	RF4 Level
227043	Develop specifications for automated manufacturing of wind turbine blades to enhance production rate, reduce costs, and improve product quality.	DESIGN	Prototype Design & Development	Create Detailed Product Specification	P	E
227051	Develop humanoid robotic systems to assist in wind turbine blade production.	DESIGN	Prototype Design & Development	Design Materials & Devices	P	E
227052	Develop flexible manufacturing infrastructure to integrate new composite manufacturing processes and technologies	DESIGN	System/Equipment Design & Implementation	Design Equipment	P	E
213144	Develop new automated manufacturing processes that generate real time data for enhancing process/product characterisation	DESIGN	Technical Research	Research & Develop Technologies	P	E
227080	Refine manufacturing processes to integrate advanced sensors with prognostics systems, thus enhancing product quality and minimising waste.	DESIGN	Technical Research	Research & Develop Technologies	P	E
209122	Implement advanced material handling automation for efficient sorting and preparation.	IMPLEMENT	Input Processing & Preparation	Sort Materials	P	E
205888	Develop advanced control algorithms for real-time coordination of cobotic support systems using machine learning	IMPLEMENT	Manage Operations	Manage Operation Control Systems	P	E
183818	Undertake complex forming simulation trials where the new component is formed" from a series of process steps"	IMPLEMENT	Product Processing	Join Components	P	E
227107	Implement automated systems to assist in preparing and loading specific machinery and tools for designated operational tasks.	IMPLEMENT	System/Equipment Operation & Monitoring	Load Equipment	P	E
205735	Create reconfigurable, agile and flexible production systems to enable rapid changes to production pathways/processes as products change	DESIGN	Process Design & Implementation	Develop Processes	P	
189753	Develop new tooling and equipment for enhancing product processing efficiency	DESIGN	Process Design & Implementation	Develop Processes	P	

ID	15207 - Robotics & Industrialisation Engineer 15208 - Senior Robotics & Industrialisation Engineer	Function	Functional Domain	Functional Area	RF3 Level	RF4 Level
194397	Develop new manufacturing processes using advanced process control (APC) technology.	DESIGN	Process Design & Implementation	Develop Processes	P	
201313	Design product and process verification and validation procedures that utilise rapid prototyping technologies	DESIGN	Prototype Design & Development	Develop Prototypes	P	
227087	Design robotic and automation systems suitable for wind turbine blade production	DESIGN	Prototype Design & Development	Design Systems & Applications	E	E
182335	Solve internal and external materials production problems utilising experiential or innovative solutions.	DESIGN	Prototype Design & Development	Design Materials & Devices	E	
227533	Design For Safety in production and construction	DESIGN	Prototype Design & Development	Design Materials & Devices	E	
227531	Develop segmented blade designs to enable parallel production of multiple, similar blade sections	DESIGN	Prototype Design & Development	Design Materials & Devices	A	
227529	Implement design-for-automation in the design phase to reduce manual labour tasks in production.	DESIGN	Prototype Design & Development	Design Systems & Applications	A	
227542	Implement automation and robotics systems to precisely execute and manage repair and rework processes in a manufacturing environment.	DESIGN	Prototype Design & Development	Design Systems & Applications		P
227077	Develop processes for joining segmented blades	DESIGN	System/Equipment Design & Implementation	Install Equipment		P
201349	Define and devise systems to support rapid redeployment of automation equipment in response to changing business requirements.	IMPLEMENT	Manage Operations	Manage Operation Control Systems		E
227101	Automate installation of leading-edge protection and vortex generators on blades to enhance aerodynamic performance.	IMPLEMENT	Product Processing	Finish Products		E
227044	Integrate robots to perform practical tasks in the production of complex composite components.	SUPPORT	Operator Support	Design and configure support systems		E

ID	15207 - Robotics & Industrialisation Engineer 15208 - Senior Robotics & Industrialisation Engineer	Function	Functional Domain	Functional Area	RF3 Level	RF4 Level
188086	Build, integrate and test functional robot systems.	SUPPORT	Operator Support	Design and configure support systems		E
227046	Operate support systems for cobotics in Wind Turbine component manufacture	SUPPORT	Operator Support	Design and configure support systems		E
213160	Implement digital and automated quality control systems to ensure product compliance and minimise defects.	SUPPORT	Quality Control	Manage Quality Control		E

A5.2.10 Senior Materials Scientist

ID	15211 - Senior Materials Scientist	Function	Functional Domain	Functional Area	RF4 Level
182335	Solve internal and external materials production problems utilising experiential or innovative solutions.	DESIGN	Prototype Design & Development	Design Materials & Devices	P
189903	Develop advanced materials simulations using computational modelling tools	DESIGN	Prototype Design & Development	Design Materials & Devices	E
182331	Provide materials science advice utilising advanced practical, conceptual and technological expertise to key departments such as, but not limited to, innovation, production, and engineering design teams.	DESIGN	Prototype Design & Development	Design Materials & Devices	E
227543	Develop composite material systems for WTB to enhance properties e.g. snap curing, low temperature performance, low viscosity, high strength-to-weight ratio, self-healing capabilities.	DESIGN	Prototype Design & Development	Design Materials & Devices	E
227544	Develop materials to streamline the transformation of raw materials into blades, reducing the number of production steps.	DESIGN	Prototype Design & Development	Design Materials & Devices	E
227545	Develop wind blade-compatible smart materials to enhance durability and performance in renewable energy applications.	DESIGN	Prototype Design & Development	Design Materials & Devices	E
227546	Develop Materials to prevent leading edge erosion over blade life	DESIGN	Prototype Design & Development	Design Materials & Devices	E

ID	15211 - Senior Materials Scientist	Function	Functional Domain	Functional Area	RF4 Level
227547	Develop material systems to eliminate specific finishing operations in final production.	DESIGN	Prototype Design & Development	Design Materials & Devices	E
227078	Select materials for wind turbine blades that enhance circularity and sustainability to minimise their lifecycle environmental impact.	DESIGN	Prototype Design & Development	Select Technologies	E
51910	Develop sustainable manufacturing technologies to reduce greenhouse gas emissions, minimise raw material use, replace toxic materials with non-toxic materials, replace non-renewable materials with renewable materials, or reduce waste.	DESIGN	System/Equipment Design & Implementation	Design Equipment	E
227530	Design blade and material systems to eliminate or automate the finishing processes.	IMPLEMENT	Product Processing	Finish Products	E
227061	Provide suppliers with detailed specifications and data for materials to enhance processes	LOGISTICS	Supply Chain Management	Work with Suppliers	E

A5.2.11 Digital, Data & Technology (Senior Engineer)

ID	15219 - Digital Data & Technology	Function	Functional Domain	Functional Area	RF4 Level
213460	Model assembly processes and systems using digital tools.	DESIGN	Process Design & Implementation	Model Processes	P
189903	Develop advanced materials simulations using computational modelling tools	DESIGN	Prototype Design & Development	Design Materials & Devices	P
201339	Develop , design, and implement tools that will support the design, modelling and optimisation of manufacturing/production systems	SUPPORT	Operator Support	Design and configure support systems	P
209939	Optimise process development using Modelling and Simulation (M&S) and Digital Twin Technologies	DESIGN	Process Design & Implementation	Model Processes	E

ID	15219 - Digital Data & Technology	Function	Functional Domain	Functional Area	RF4 Level
209989	Devise end-to-end process digitisation tools to support enquiry through to final QA reporting using digital technologies and techniques, such as Computer Aided Design (CAD) or Building Information Modelling (BIM)	DESIGN	Product Engineering	Create Engineering Designs	E
194418	Investigate the application of digital twin technology to model and predict process behaviour in real time.	DESIGN	Prototype Design & Development	Design Systems & Applications	E
227537	Implement data-sharing protocols to benchmark manufacturing capabilities and enhance performance metrics across different manufacturers.	ENTERPRISE	Data Management	Manage Data Security	E
205626	*Utilise advanced data analytics tools to analyse manufacturing data and identify areas for improvement	ENTERPRISE	Data Management	Perform Data Analysis	E
227540	Implement data sharing and benchmarking initiatives to compare manufacturing capabilities and enhance overall performance.	ENTERPRISE	Leadership & Strategy	Evaluate Business Performance	E
213841	Gather operational data using relevant collection methods to inform system performance evaluations.	IMPLEMENT	Manage Operations	Gather Operations Data	E
227110	Gather operational data to inform decision making in the development of product variants and derivatives.	IMPLEMENT	Manage Operations	Gather Operations Data	E
194441	Implement advanced process control techniques to improve operational efficiency.	IMPLEMENT	Manage Operations	Manage Operation Control Systems	E
227094	Implement digital twin technology to simulate and enhance manufacturing and design operations	IMPLEMENT	Manage Operations	Manage Operation Control Systems	E
227112	Capture monitoring data to inform specific analyses on quality, time, and cost.	IMPLEMENT	Process Monitoring	Monitor Processes	E
223891	*Lead and oversee the implementation of digital manufacturing technologies	IMPLEMENT	Service Delivery	Create & Process Digital Media	E
225744	*Collaborate with cross-functional teams to identify and implement digital solutions for manufacturing challenges	IMPLEMENT	Service Delivery	Create & Process Digital Media	E

ID	15219 - Digital Data & Technology	Function	Functional Domain	Functional Area	RF4 Level
227095	Integrate design process with digital twin systems to enhance project accuracy and efficiency.	SUPPORT	Operator Support	Prepare Informational or Reference Materials	E
227097	Develop specific digital tools to ensure adherence to defined operational processes.	SUPPORT	Operator Support	Train others to use equipment	E
225749	*Manage and maintain digital manufacturing systems and equipment	SUPPORT	System/Equipment Maintenance	Maintain Systems	E