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Training provision in Scotland's **onshore wind and solar industries**

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1 Executive summary

1.1 Aims

Achieving Scotland's net zero goals by 2045 will require significant expansion of the renewable energy workforce. This is especially true in the rapidly growing onshore wind and solar energy sectors. Forecasts indicate a dramatic increase in workforce demands by 2030. This emphasises the need for enhanced, well-aligned training programmes to develop a skilled labour pool.

This study assesses the current training provision for the onshore wind and solar energy sectors in Scotland, identifying gaps, barriers and opportunities for improvement. It analyses existing programmes and their alignment with industry needs, exploring future workforce demands and strategies to address skills shortages.

1.2 Findings

We conducted desk research, data analysis and stakeholder consultations. The skills needed in the solar and onshore wind sectors can be divided into sector-specific, allied STEM (from broader disciplines such as mechanical and electrical engineering) and other skills (Figure 2). Although some critical training provision is needed for solar and onshore wind separately, the majority of roles are shared by the sectors requiring allied STEM and other skills. Siloed approaches for skills governance in solar and onshore wind could be counterproductive as the sectors compete for many of the same skillsets.

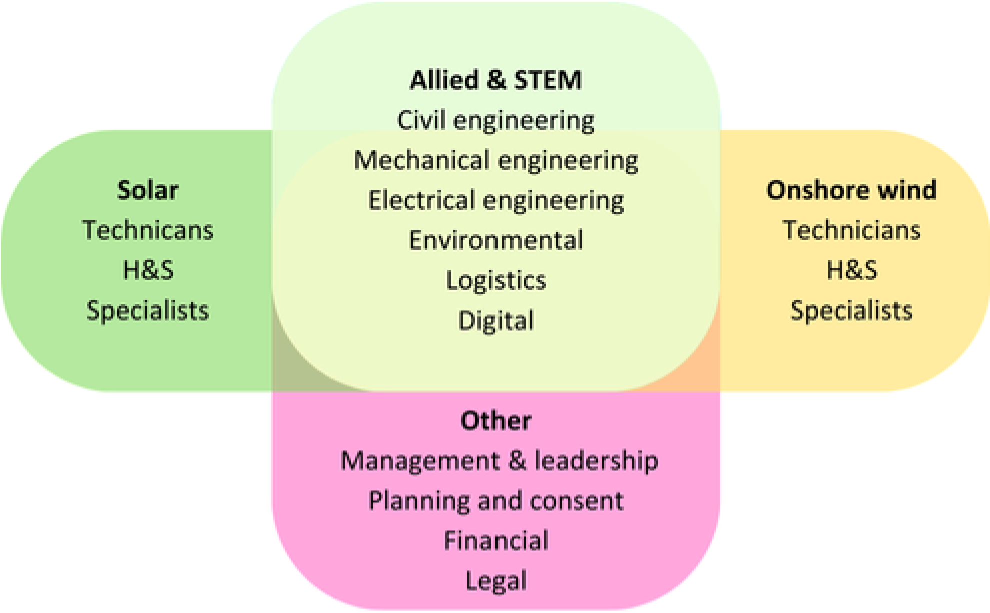

Figure 1. Conceptual framework of skill types relevant to solar and onshore wind industries.

We found that:

- There is a strong breadth of allied STEM training provision in Scotland, with skills that are highly sought across multiple sectors. A siloed approach to STEM workforce planning is a threat, as several industries draw from the same talent pool. Stakeholders highlighted poor visibility of careers, as well as low job attractiveness, as major barriers to the development of solar and onshore wind sectors at the accelerated pace required.
- There is a shortage of specialised training provision providing essential skills for the construction and operational phases of solar and onshore wind projects. The solar sector, in particular, suffers from a lack of training specific to large-scale or ground-mounted solar installations.
- The majority of targeted training provision relevant to solar and onshore wind sectors is largely theory-based, with insufficient emphasis on practical, hands-on experience. Industry leaders are concerned that graduates often lack real-world skills and are not "work-ready" upon entering the workforce. Practical training opportunities, such as industry partnerships and on-site apprenticeships, are limited.
- Funding constraints are a significant barrier to the expansion and modernisation of training programmes. High-cost courses, such as those involving high-voltage systems and specialised certifications, require substantial investment in equipment and facilities. Many colleges and training providers struggle to secure adequate resources to enhance the training delivery.
- Industry uncertainty, driven by a lack of clear and stable policy directives, complicates long-term planning for workforce development. Industry is hesitant to invest in apprenticeships and workforce training without concrete indications of project pipelines and future market stability.
- The competition for technically skilled workers is fierce across various industries. Renewable energy companies compete among themselves and with other sectors for these workers. This high level of competition complicates talent acquisition and retention.

1.3 Lessons learnt

The content and delivery principles of training programmes needs to be updated to better equip trainees with practical, hands-on experience. Deeper collaborations between industry stakeholders and educational institutions would ensure curricula content is relevant and meets current and future sector needs. Educational institutions and training providers should integrate work-based learning modules, internships and apprenticeship opportunities into their curricula. Modular and more flexible courses as a core mechanism for training delivery would facilitate targeted, intensive upskilling or reskilling. Such flexibility would enable faster and more efficient transitions into the workforce.

There is a pressing need for increased and targeted funding to support technical training programmes to enable these updates.

To attract and retain a skilled workforce, the onshore wind and solar sectors must become more visible and appealing to job seekers. Development of career pathway maps would illustrate how individuals can progress from entry-level roles to senior positions. This would provide a clearer picture of the long-term opportunities available in the sector, making it more attractive to potential recruits.

An **integrated perspective** is necessary to consider the requirement for a STEM workforce across all infrastructure projects of national importance and overall installed capacity ambitions. A comprehensive map that details the scale, timelines and workforce demands of major infrastructure projects has the potential to inform the total scale of skilled workforce needs, including for the onshore wind and solar sectors.

1.4 Next steps

Effective workforce development will require close collaboration between government, industry and educational institutions, and workforce representative groups. A coordinated approach will ensure that training programmes are aligned with sector demands. To address the workforce and training challenges outlined in this report, a detailed, comprehensive action plan should be developed. This plan should include timelines, assigned responsibilities, and measurable outcomes to ensure progress is tracked and accountability is maintained.

With workforce demand projected to peak by 2027, the action plan must be implemented swiftly. Initiatives should be launched before the start of the 2025/2026 academic year to allow training providers time to adapt and scale. This proactive approach will enable the industry to meet pressing needs and support for the Scottish Government to deliver its renewable energy commitments.

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2 Glossary / Abbreviations table

CESAP	Climate Emergency Skills Action Plan
ESP	Energy Skills Partnership
FPE	Full person equivalents - a standardised unit that quantifies the number of people enrolled in a course
FTE	Full time equivalents - a standardised unit that quantifies workload equivalence to full-time hours
GWO	Global Wind Organisation
NESA	National Energy Skills Accelerator
NESCoL	North-East Scotland College
NOS	National Occupational Standards
OPITO	Offshore Petroleum Industry Training Organisation
SCGJ	Skills Council for Green Jobs
STEM	Science, technology, engineering, and mathematics
UHI	University of Highlands and Islands

3 Introduction

3.1 Scale of skills demands in solar and onshore wind

The achievement of Scotland's net-zero commitment by 2045 relies heavily on expanding the renewable energy sector, including the onshore wind and solar energy sectors. Both the wind and solar sectors are expanding rapidly, creating an urgent need to train a larger skilled workforce. Two recent studies published by the ClimateXChange have estimated the workforce needs for both these sectors.

In the onshore wind sector, the workforce could need to increase from around 6,900 full-time equivalent (FTE) jobs in 2024 to an estimated around 20,500 FTEs by 2027 (Morrison, et al., 2024). Most of these new jobs will focus on constructing and installing wind farms. Key areas such as the Highlands and Dumfries and Galloway will need a large share of the workforce, but recruitment challenges already exist in these regions. Critical skills shortages include high-voltage engineers and wind turbine technicians. If these gaps are not filled, it could slow down the sector's growth and reduce its economic and environmental benefits.

The solar sector faces similar challenges. Its workforce could need to grow from around 800 FTEs in 2023 to an estimated over 11,000 by 2030, with over 80% of these roles estimated to be related to construction, especially for large ground-mounted solar projects (Creamer *et al*, 2024). Solar projects will require key tradespeople, such as electricians, grid connection engineers, and high-voltage technicians. Many of the large solar installations will be in rural parts of Scotland, which makes workforce distribution a challenge.

Both sectors already have skilled workers, but they must attract and train more people to meet their installed capacity ambitions. While current training programmes can address some of these needs, there is a clear requirement to upskill and reskill workers from other sectors. Previous research (Morrison *et al*, 2024; Creamer *et al*, 2024) has shown that a large part of the additional workforce required for solar and onshore wind sectors will require education at Higher National Certificate, Higher National Diploma and degree levels. Furthermore, the industry strongly prefers trainees who have real-world experience in these sectors. As such, apprenticeships are expected to play a significant role in the delivery of the future skilled workforce.

Based on the findings of these studies, we argue that the timelines for intervention towards increased training provision are urgent. To illustrate, the onshore wind sector forecasts a peak of workforce demand as early as 2027, leaving only two academic years for intervention and subsequent training to be delivered.

This follow-on study focuses on the analysis of the existing and planned training provision, profiling its alignment with the industry needs, and exploring potential avenues for optimisation of training provision based on insights from sector stakeholders.

3.2 Conceptualisation of relevant training provision

The skills needed in the solar and onshore wind sectors can be divided into **sector-specific**, **allied STEM,** and **other skills** (Figure 2).

Sector-specific skills focus on the installation, maintenance, and safe operation of the unique infrastructure in each sector. For example, solar projects require expertise in setting up and maintaining solar panels, while wind projects demand skills in handling large wind turbines, often in challenging environments such as working at heights. Health and safety knowledge is critical in both sectors, as they each present different risks—solar work involves concerns like heat stress, while wind energy can involve working at height and operation of heavy equipment. Additionally, site design in both sectors requires highly specialised skills. Wind projects, for example, need knowledge of geology and land use to optimise turbine placement, whereas solar projects focus on efficient land use for arrays.

More detail on sector-specific skills and job roles can be found in the ClimateXChange publications by Creamer *et al* (2024) and Morrison *et al* (2024) (solar and onshore wind, respectively). These skills are often acquired through the apprenticeship routes, as well as first degrees and private training provision programmes.

Allied STEM skills include those adapted from broader disciplines such as civil, structural, mechanical and electrical engineering. These disciplines are essential for building and connecting renewable energy infrastructure to the grid. Engineers play a vital role in constructing foundations for wind turbines or solar supports and managing and balancing electrical systems. Further, skills from environmental sciences and logistics help ensure that projects comply with environmental regulations and manage supply chains effectively. Similar to sector-specific skills, allied STEM skills are acquired through apprenticeships, as well as first degrees and postgraduate training.

In addition to technical skills, **other skills**, such as finance, planning, and management expertise are critical for the success of renewable energy projects. These professionals may not have hands-on involvement in infrastructure development but are key in overseeing projects, securing funding, navigating regulations, and managing teams. Understanding the specifics of solar and wind energy is essential in these roles, as managers and leaders must handle complex projects, from permitting and financing to project delivery. These skills are a combination of theoretical sector understanding that could be achieved, for example, through first degree or postgraduate specialisation, in addition to extensive work experience in the sector. Albeit these skills are not the main focus of the current study, it is important to acknowledge their involvement in the sectoral skills ecosystem, and in particular in context of their position in career pathways for mid-career and senior professionals.

This report uses the framework outlined in Figure 2 for a comprehensive discussion of training provision that enables solar and onshore wind industries. This is in alignment with the precursor studies, which identified that the highest skilled workforce demands are likely to be within the allied sectors. This report discusses solar, onshore wind, and allied STEM skills training provision in parallel, as the skills needs across solar and onshore wind sectors have high levels of convergence. Any differences between the sectors are highlighted in the text and summarised in the Conclusions.

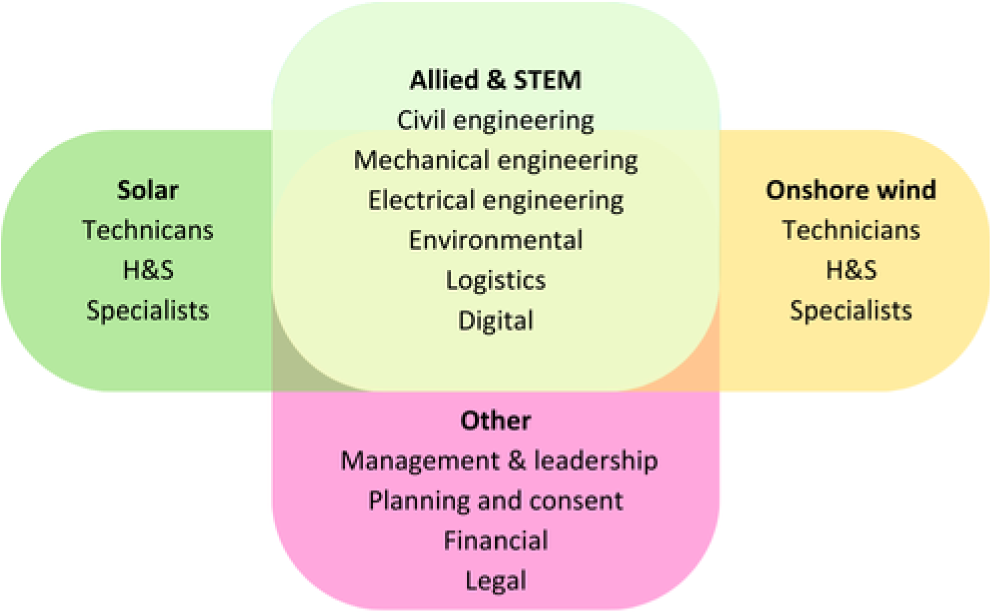

Figure 2. Conceptual framework of skill types relevant to solar and onshore wind industries.

4 Methodology

We carried out extensive desk based research, reviewing national and international policies and initiatives related to training provision for solar and onshore wind sectors and the renewable energy sector overall. This included the review of the precursor studies, literature regarding the EU Pact of Skills, International Energy Agency reports, and others.

Following this, we conducted a comprehensive landscape analysis of training provision in Scotland for solar, onshore wind, and other relevant STEM sectors. This process included profiling all training providers in Scotland's higher and further education institutions, gathering course names and qualifications offered, and analysing course content to understand the themes and topics. We also mapped the geographic distribution of training provision sites to visualise the regional availability of skills provision.

To understand how the training provision aligns with industry needs, we reviewed national occupational standards (NOS) and explored future training initiatives. Additionally, we extracted and analysed student enrolment data from the Scottish Funding Council (SFC) to assess the number of students enrolled in relevant STEM disciplines and compared this with solar and onshore wind workforce demand forecasts from previous studies.

Our stakeholder engagement programme involved consulting a broad range of participants, including those from policy, training providers, supporting organisations, industry, and the supply chain (21 participants) between July and September 2024. Through semi-structured one-to-one interviews via Microsoft Teams, we gathered insights on how current policies affect training provision, the competition for talent, and talent retention. We also explored stakeholders' views on the barriers and motivations individuals face when pursuing careers in solar and onshore wind sectors. These discussions helped us identify potential actions to address current and future skills gaps, as well as suggestions for improving the targeting, timing, and enhancement of training provisions. A complete list of the organisations we consulted is included in Appendix A.

5 Key relevant training provision policy and initiatives

5.1 Scotland

5.1.1 Policy activity

In Scottish national policy, onshore wind and solar sectors are covered under the umbrella of green jobs / skills and renewables. Scotland's National Strategy for Economic Transformation (The Scottish Government, 2022) places significant emphasis on building a skilled workforce to drive future economic prosperity. This publication outlines, in general terms, that the skills related to the net zero transition, including renewable energy, will be critical. It emphasises lifelong learning mechanisms such as continuous reskilling and upskilling as key to adapting to fast-paced technological changes. The Climate Emergency Skills Action Plan (CESAP) (Skills Development Scotland, 2020) is a document that outlines key initiatives to equip Scotland's workforce for the transition to a net zero economy. The Green Jobs Workforce Academy was launched as a service aimed to help the workforce with training, upskilling, and job seeking in the emerging green sectors. The National Transition

Training Fund (NTTF) was introduced in 2020 as a direct response to the economic impact of the Covid-19 pandemic. In its second and final year, the fund’s scope expanded and included a more significant emphasis on supporting individuals and employers in the transition to net zero. This followed a commitment within CESAP. Further, CESAP’s original publication indicated the ambition to launch the Green Jobs Skills Hub to provide insights into the skills needed over the next 25 years, working with businesses and educational institutions to ensure training aligns with the demand for green jobs

Additionally, CESAP indicates that sector-specific initiatives, such as the Energy Skills Alliance (now led by the Offshore Petroleum Industry Training Organisation OPITO) and Offshore Wind Skills Group, will map out skills requirements in renewable energy, such as hydrogen production and carbon capture. At a policy level, there is no equivalent regionally targeted working group aimed at solar or onshore wind.

CESAP set an ambition to work with educational institutions to realign curricula with industry needs and offer work-based learning to ensure individuals acquire the skills needed for Scotland’s green economy. Much of this work was carried out through Pathfinder activity under the remit of the Skills Alignment Assurance Group, now Shared Outcomes Assurance Group of the Scottish Government. Lastly, CESAP indicates that a place-based approach will target regional needs, with agencies like Highlands and Islands Enterprise leading efforts in rural areas to promote green job opportunities.

The CESAP Pathfinder Work Package 1 (Skills Development Scotland, 2023) aimed to understand the demand for skills driven by the transition to net zero and to map existing skills provision across apprenticeships, further education, higher education, upskilling, and reskilling. The report revealed that 27% (32,300) of college enrolments are in courses aligned with CESAP sectors. Additionally, around 16% of Scottish university graduates were working in a CESAP sector 15 months after graduation. In terms of apprenticeships, 29% (7,400) of Modern Apprenticeship (MA) starts and 38% (400) of Graduate Apprenticeship (GA) starts were in sectors aligned with CESAP. However, CESAP WP1 report indicates that there is evidence of leakage from this potential skills supply pipeline. Of the university graduates who entered a CESAP sector as their first destination, about 40% took jobs outside of Scotland. CESAP WP1 also highlighted the gap in knowledge of the future destinations of college students.

5.1.2 Future training provision initiatives in Scotland

Stakeholders across Scotland are engaging in a range of initiatives towards optimising future training provision for the whole renewables sector, many of which are targeted at offshore wind. We note that offshore wind skills are often directly applicable to onshore wind, and these are reviewed below. The Scottish Government, as part of its NSET strategy, prioritises a “Skilled Workforce” with a focus on future skills needs, including the net zero transition.

OPITO has introduced credit-rated qualifications in Hydrogen, Oil and Gas, and Wind Power to enhance workforce mobility across sectors. The Energy Skills Partnership (funded by Scottish Funding Council) supports key technical skills across Scotland's colleges through various Training Networks. National Energy Skills Accelerator (NESA) has secured £1 million from the Just Transition Fund to pilot training programmes, including Performing

Engineering Operations – Renewables, Electrical Systems for Renewable Energy, Project Management Fundamentals, and Energy Data Management.

Hosted by the North East Scotland College (NESCol) and funded by the Just Transition Fund, Energy Transition Zone/NESA is also developing an Energy Transition Skills Hub, which will include demonstration and teaching facilities for energy transition technologies and a state-of-the-art welding and fabrication academy. The Engineering Construction Industry Training Board has launched Energy Scholarships to address workforce shortages in roles such as Wind Transfer Technician and Energy Transfer Technician, with trainees receiving training in core engineering skills, new technologies, and digital competencies. RenewableUK and Energy & Utility Skills have partnered to create training and assessment standards for the UK's renewable energy workforce, including national occupational standards (discussed below) and apprenticeship frameworks.

5.2 UK

In July 2024, the UK Government announced a mission to increase onshore wind development. This was marked by the launch of the Onshore Wind Industry Taskforce (UK Government, 2024). One of their key working groups is specifically focused on supply chains, skills and the workforce. The Taskforce will run for up to 6 months and culminate in the publication of a final report, setting out their commitments, and transition into the delivery body.

In May 2023, the UK Government launched the Solar Taskforce (UK Government, 2023) with terms of reference including skills governance for the solar sector. A 'Draft Solar Roadmap' was last discussed in the taskforce meeting in March 2024, and the final publication is pending.

5.3 European Union

In the European Union (EU), achieving the REPowerEU targets across all renewables sectors is predicted to create over 3.5 million jobs by 2030. In response to this rapid increase in STEM workforce demands, the EU has launched several initiatives to develop a skilled workforce for the renewable energy sector.

One of the flagship efforts as a part of the European Skills Agenda is the Pact for Skills (European Commission, 2020), aimed at upskilling and reskilling the workforce in various industries. One of the themes of the Pact of Skills is the Renewable Energy Ecosystem. This ecosystem is a series of strategic partnerships between the industry and policymakers to ensure sectoral cooperation for the development of skilled workforce in sufficient numbers. Examples of partnerships include Renewable Energy Skills Partnership, Large-Scale Partnership on the Digitalisation of the Energy Value Chain, and Skills Partnership for Offshore Renewable Energy. These initiatives are supported through consistent and sustained funding mechanisms such as Horizon Europe and Erasmus+ funding programmes. This capacity building is strengthened through international cooperation, facilitating the exchange of best practices and expertise, and harmonisation activities in training content.

Another relevant EU policy initiative is the BUILD UP Skills programme (European Climate Infrastructure and Environment Executive Agency, 2011), which has been active since 2011 and focuses on increasing skills in the construction sector, particularly for energy efficiency and renewable technologies. It provides national roadmaps to tackle skills shortages and works through EU funding programmes like Horizon 2020 and LIFE CET to support training for green energy jobs. This highlights that the EU is taking a broad approach to renewable energy workforce development and recognises the allied STEM skills role in it.

Overall, while these strategies aim to effectively transition workers and communities to renewable energy sectors, their success can be difficult to measure as the energy transition is ongoing. The long-term impact of workforce transition and reskilling is yet to be seen. In addition to the skills governance, broader economic conditions, like market fluctuations and supply chain disruptions, also affect outcomes. The transition's success ultimately relies on sustained political will, consistent funding, and strong collaboration among governments, industry, and communities.

6 Review of existing training provision

6.1 Targeted training programmes

6.1.1 List of targeted training provision

To identify targeted training provision that is relevant to solar and onshore wind sectors, we profiled course lists available on the websites of training providers (Scotland-based universities and colleges) and collated a list of courses that include renewable energy (general), wind, or solar in their title or public description. For private training provision, we carried out a Google search using keywords such as "Scotland solar PV training courses" and "Scotland onshore wind training courses" and profiled course lists available through private providers (remote training options were excluded from the analysis).

Our analysis of training provision identified a total of 57 courses relevant to solar and onshore wind sectors in Scottish colleges and universities being delivered in 2024/2025. We analysed the course content available in the public description on training providers' websites and found:

- 23 courses that include content on renewable energy and energy systems (without specifying wind (onshore and offshore) or solar in the public description)
- 11 courses that include wind (onshore and offshore)- and solar-themed modules
- 5 courses that include solar-specific modules
- 18 courses that include wind-specific modules (onshore and offshore).

Figure 3 illustrates the levels of qualifications offered by the identified relevant courses. This data shows that most solar and wind sector courses are at postgraduate level specialism (25 total). This is in comparison to only 8 courses at the first-degree level, and two courses at SCQF L4. The highest number of targeted skills provision courses were hosted at the University of Strathclyde (10) and NESCol (7). The full list of courses identified as directly relevant to solar and onshore wind sectors is included in Appendix B.

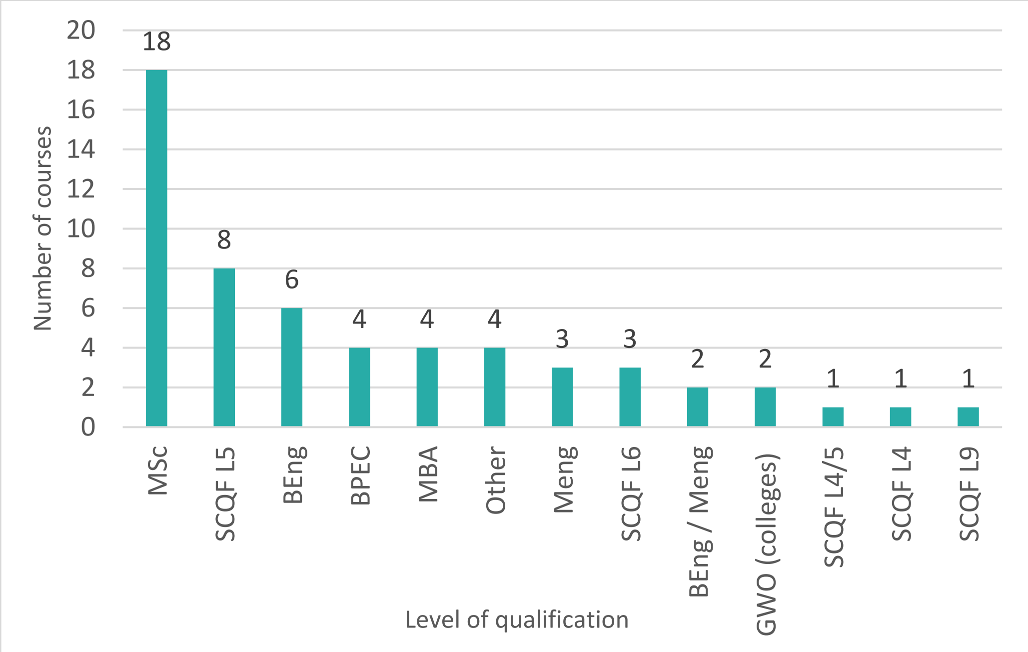

Figure 3. Levels of qualifications of courses targeted to solar and onshore wind sectors available through Scottish public education providers.

We note that the numbers outlined above are a high-level estimation of training provision for solar and wind. Other courses, particularly at BEng and BSc levels in electrical engineering and other allied sectors, might include further content relevant to solar and onshore wind. This analysis, therefore, focuses on courses where solar and/or onshore wind forms the major component of the course content.

In addition to training provision available through Scottish colleges and universities, we identified 110 short courses available through private training providers:

- Solar: 5
- Wind: 105 (specialist skill training, Global Wind Organisation (GWO) basic safety courses and other safety certifications).

These short courses are typically 1-6 days in duration and include certifications that are critical for safe working on solar and wind sites, as well as highly specialist technical skills and use of highly specialised equipment. The full list of identified relevant course private provision is included in Appendix B, Table 2.

6.1.2 Thematic analysis of course content

We reviewed publicly available information on the contents of college and university courses identified as directly relevant to onshore wind and solar sectors and identified nine key thematic trends. All module names and themes are extracted from STEM course descriptions.

Theme 1: Fundamental engineering and electrical principles.
Module titles: Engineering Mathematics; Electrical & Mechanical Systems; Thermodynamics and Fluids; Electrical Engineering Principles; Core Maths; Electrical Systems; Fluid Mechanics & Thermodynamics.

Description: These modules provide the foundational engineering knowledge crucial for understanding and applying more advanced concepts in renewable energy. Mastery of these basic principles is essential for anyone entering the energy sector, as they underpin much of the work in system design, operation, and maintenance.

Theme 2: Renewable energy technologies and systems.
Module titles: Wind Turbine Technology; Solar Energy Systems; Marine and Wind Energy; Energy Conversion and Storage; Renewable Energy Integration to Grid; Wind, Solar, Hydro, and Marine Electricity Generation; Future Energy; Renewable Energy Technologies.
Description: This theme includes modules that focus on specific renewable energy technologies and systems. Students learn the principles, operations, and applications of various renewable energy sources, including wind and solar, as well as hydro, geothermal, and marine energy. These courses are most directly applicable to the onshore wind and solar sectors.

Theme 3: Power systems and grid integration.
Module titles: Electrical Power Systems; Power Electronics for Energy & Drive Control; High Voltage Technology & Electromagnetic Compatibility; Distributed Energy Resources and Smart Grids; Renewable Energy Integration to Grid; Power Systems Engineering and Economics; Power System Design, Operation & Protection.
Description: Modules under this theme cover the complexities of integrating renewable energy sources into existing power grids. Students are taught the technical and economic aspects of power systems, including high-voltage technology, power electronics, and grid management. This knowledge is essential for ensuring that renewable energy can be effectively and efficiently incorporated into the larger energy infrastructure.

Theme 4: Practical skills and hands-on experience.
Module titles: Assembling and Testing Fluid Power Systems; Operation and Maintenance of Wind Turbine Systems; Basic Hydraulics.
Description: Practical experience is a critical aspect of training in the renewable energy sector. These modules focus on hands-on learning, where students gain direct experience with the operation, maintenance, and troubleshooting of renewable energy systems. This practical knowledge is crucial for developing the skills needed to work effectively in the field.

Theme 5: Health, safety, and industry-specific certifications and standards.
Module titles: Health and Safety Passport (CCNSG); GWO BTT Course (Electrical, Mechanical, Hydraulics); ECITB Mechanical Joint Integrity Training; Solar and energy storage system design and installation modules recognised by Microgeneration Certification Scheme (MCS).
Description: Industry-specific certifications and skills are vital for professionals in the renewable energy sector. This theme includes modules that provide the necessary certifications and specialized training required by the industry. These qualifications are crucial for meeting industry standards and ensuring that professionals are fully prepared for their roles.

Theme 6: Sustainable energy and environmental impact.

Module titles: Basic Evaluation of the Impact of Energy Generation on the Environment; Sustainable Energy Management; Environmental Impact Assessment.
Description: Modules in this theme explore the environmental aspects of energy production and the importance of sustainability. Students learn about the environmental impacts of different energy sources, strategies for sustainable energy management, and how to reduce emissions and pollution. These modules are critical for understanding the broader environmental implications of energy projects.

Theme 7: Project management and strategic planning.
Module titles: Strategic Technology Management; Stakeholder Management and Governance; Project Management.
Description: Effective management and strategic planning are crucial for the successful execution of renewable energy projects. These modules equip students in STEM courses with the skills needed to manage complex projects, plan strategically, and navigate the economic and regulatory landscapes. This theme prepares students for leadership roles within the industry.

Theme 8: Innovation and advanced technologies.
Module titles: Data Analytics & AI for Energy Systems; 3D Printing and Inventor Programmable Logic Controllers (PLCs); Advanced Control Engineering; Digital Signal Processing Principles; Renewable Technology Commercialisation
Description: Innovation drives progress in renewable energy, and this theme covers the latest technologies and methodologies that are transforming the industry. Courses in this category focus on advanced technologies like AI, IoT, and programmable logic controllers, which are crucial for developing new solutions and improving existing systems in the renewable energy sector.

Theme 9: Energy economics and sustainability policy.
Module titles: The Economics of Community Wealth Building; Net Zero Society; Transition to Net Zero; Understanding Sustainability Discourses; Energy Resources & Policy
Description: This theme covers the economic, policy, and sustainability aspects of the energy sector. Modules in this category focus on the financial and regulatory frameworks that influence renewable energy projects, as well as the broader societal impacts of transitioning to a net-zero economy. Understanding these factors is essential for anyone involved in the strategic planning and implementation of renewable energy projects.

Based on these desk research findings, we conclude that the overall scope of current training courses has the potential to equip trainees with a wide range of skills suitable for various roles in the solar and onshore wind sectors, from technical and practical positions to environmental and project management. The courses also cover important areas like health and safety, policy, economics, and innovation, providing a solid foundation of knowledge for these industries. Stakeholders expressed a difference in opinion on the suitability of the content of current training provision for the industry. This is discussed in detail in Section 8.1.

6.2 Training provision alignment with industry needs

6.2.1 National Occupational Standards

National Occupational Standards (NOS) describe the skills, knowledge and understanding required to undertake a particular job to a nationally (UK-wide) recognised level of competence. NOS are proposed, developed and updated in response to industry needs. The process is usually led by the relevant industry skills association, that works with employers and sector experts to collectively refine NOS through a process of consultation. The NOS are then approved by UK government regulators to ensure that they meet industry requirements. NOS are the foundation for vocational qualifications, including apprenticeships. Learners are assessed against NOS to ensure that they have achieved the necessary competencies to be employed in that occupational role.

NOS are grouped into business sectors. There are 22 NOS that are grouped in the wind turbine sector, although only two are specific to wind turbines. There are 16 that are grouped in the solar PV sector, all but two of which are specific to solar PV. These NOS are listed in Appendix C, Table 3. As of the time of the creation of this report, a review of the NOS is ongoing (Energy and Utility Skills, 2024).

6.2.2 Activity towards aligning curricula and industry needs

Based on intelligence received from industry, ESP previously created a Wind Training Network for the College sector. The Colleges were strategically located in areas where there was a demand for onshore wind turbine technicians. The network has grown from the original 3 colleges and now consists of 11 throughout Scotland to meet forecasted demands.

The curriculum content is co-created by colleges and industry and continues to evolve with direct industry input from companies such as Natural Power, that have sponsored wind turbine technician courses at Dumfries & Galloway College with direct routes to employment offered. This model is forecast to be rolled out to other areas where demand exists and can be duplicated and adapted by additional industry partners.

Colleges are collaborating with industry partners to deliver short technical courses for wind turbine technicians that include GWO BTT qualifications. The teaching materials are shared resources within the network and a collaborative approach to delivery is used. To date, the solar sector has not had the same level of interest, but as demand increases a similar college training network model can be implemented to increase capability and capacity to meet this growing demand, both strategically and sustainability. We note that there is minimal activity towards future training provision for the solar sector, especially in the context of large ground-mounted projects. One stakeholder noted that the minimal activity of ground-mounted projects in the planning pipeline has led to a lack of clear indication from the industry about its skills needs for these projects, making it challenging for training providers to respond.

6.3 Allied sector STEM skills provision

6.3.1 Overview

As illustrated in Figure 2, both onshore wind and solar sectors are further enabled by a skills base drawn from allied sectors. These skills are fundamentally rooted in non-energy-focused disciplines such as engineering (electrical, mechanical, civil, and structural), and applied disciplines such as construction, welding, electrical installation and others.

We have identified a total of 389 courses available through Scottish universities and colleges that are aligned with these topics (Figure 4). These courses are distinct from the courses identified in the section above. In this STEM training provision, we identified 10 Foundational Apprenticeships, 16 Modern Apprenticeships, 8 Graduate Apprenticeships and 14 pre-apprenticeship courses. Many of these apprenticeships are provided via the apprenticeship frameworks (listed in Appendix D). Additionally, apprenticeships are also available through private companies, and typically these would not be advertised through training providers' course lists and websites.

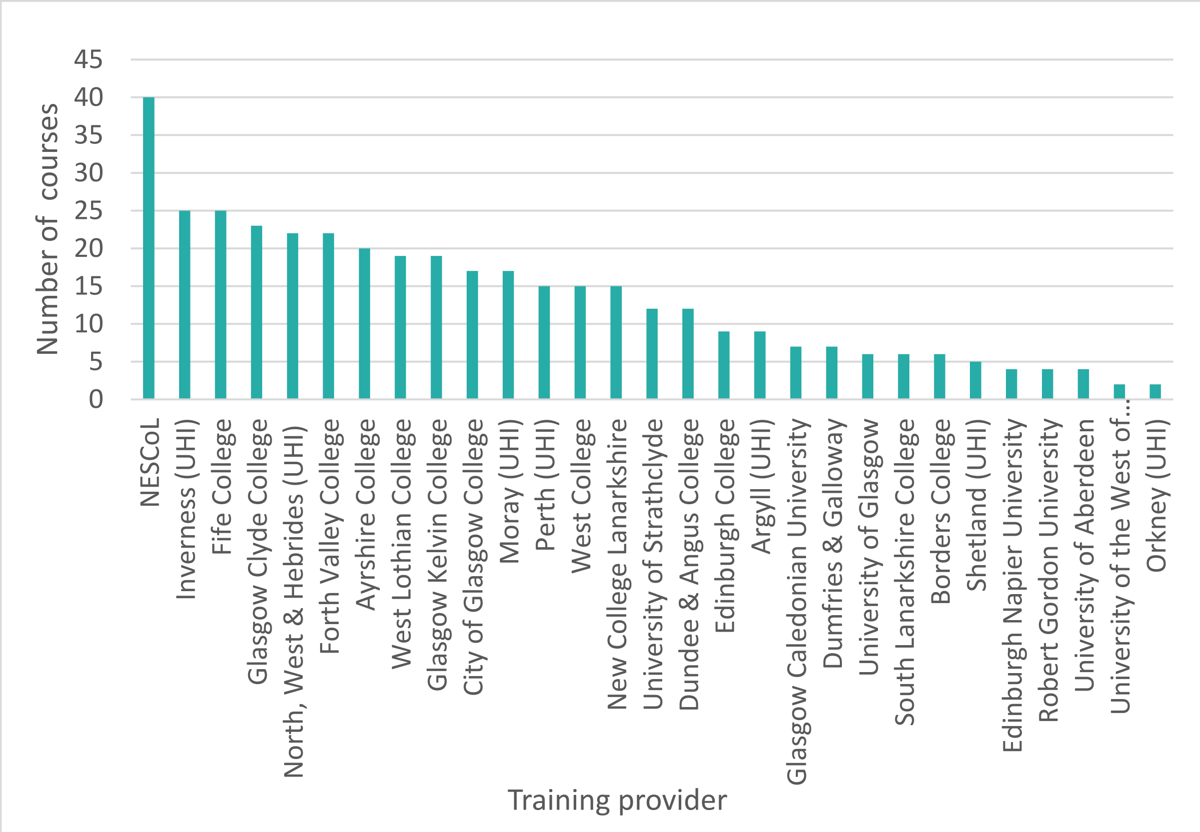

Figure 4. The number of courses in the allied sectors relevant to solar and onshore wind per provider.

6.3.2 Thematic analysis

A thematic analysis of the course content reveals broad provision across core engineering disciplines, particularly in structural, mechanical, civil, and electrical engineering. Key areas such as structural mechanics, geotechnical engineering, fluid mechanics, thermodynamics, and power electronics demonstrate comprehensive training in fundamental engineering topics. The curricula also place significant emphasis on computational techniques, with modules such as computer-aided engineering design, mathematical modelling, and finite element analysis providing students with essential design and analysis skills.

Environmental and sustainability topics are well-represented, with courses such as environmental engineering, water resource management, and sustainability, reflecting the growing importance of sustainable practices in engineering. Some of the curricula further include emerging technologies, such as artificial intelligence, machine learning, and Internet-of-Things as interdisciplinary data science fields. Additionally, modules in project management, risk management, and engineering innovation and management offer robust professional skills development, preparing students for leadership roles in managing engineering projects.

However, there are potential gaps. Emerging technologies, such as artificial intelligence, machine learning, and Internet-of-Things generally remain under-represented. The curricula could also benefit from expanded coverage of specific renewable energy subsectors, including solar and onshore wind; the current course content only mentions "wind" three times and "solar" two times.

In summary, while the course content provides a strong foundation in traditional and modern engineering disciplines, there is room to enhance the curricula by incorporating more emerging technologies and renewable energy topics. This would better prepare students for the evolving challenges of the engineering profession. It would also encourage students from engineering backgrounds to further specialise in solar and onshore wind sectors, particularly considering the lack of targeted solar and onshore wind coverage at undergraduate levels.

6.4 Geographic distribution of training provision

6.4.1 Locations of training provision

Research shows that future onshore wind farm developments will be in remote and rural areas of Scotland such as the Highland and parts of Dumfries and Galloway, resulting in a sharp increase in skills requirements in these geographies (Morrison *et al*, 2024). In comparison, commercial rooftop solar projects in Scotland are mainly based around densely populated areas, including the central belt, Borders, Dumfries and Galloway, the east, north-east, and Inverness. Ground-mounted solar projects will be primarily situated in rural areas like Aberdeenshire, Angus, Fife, and Tayside (Creamer *et al*, 2024), where there is ample land for larger systems.

We have created a map that shows where the targeted training provision is available (Figure 5). Most of these locations are aligned with the locations of higher and further education institutions, and it has been supplemented with locations of the private training provision company sites. It shows that the training provision is located within the central belt of Scotland, as well as Aberdeen and Inverness. There is an obvious disparity between the locations of training providers and the geographic regions where the solar and onshore wind workforce will be in the highest demand.

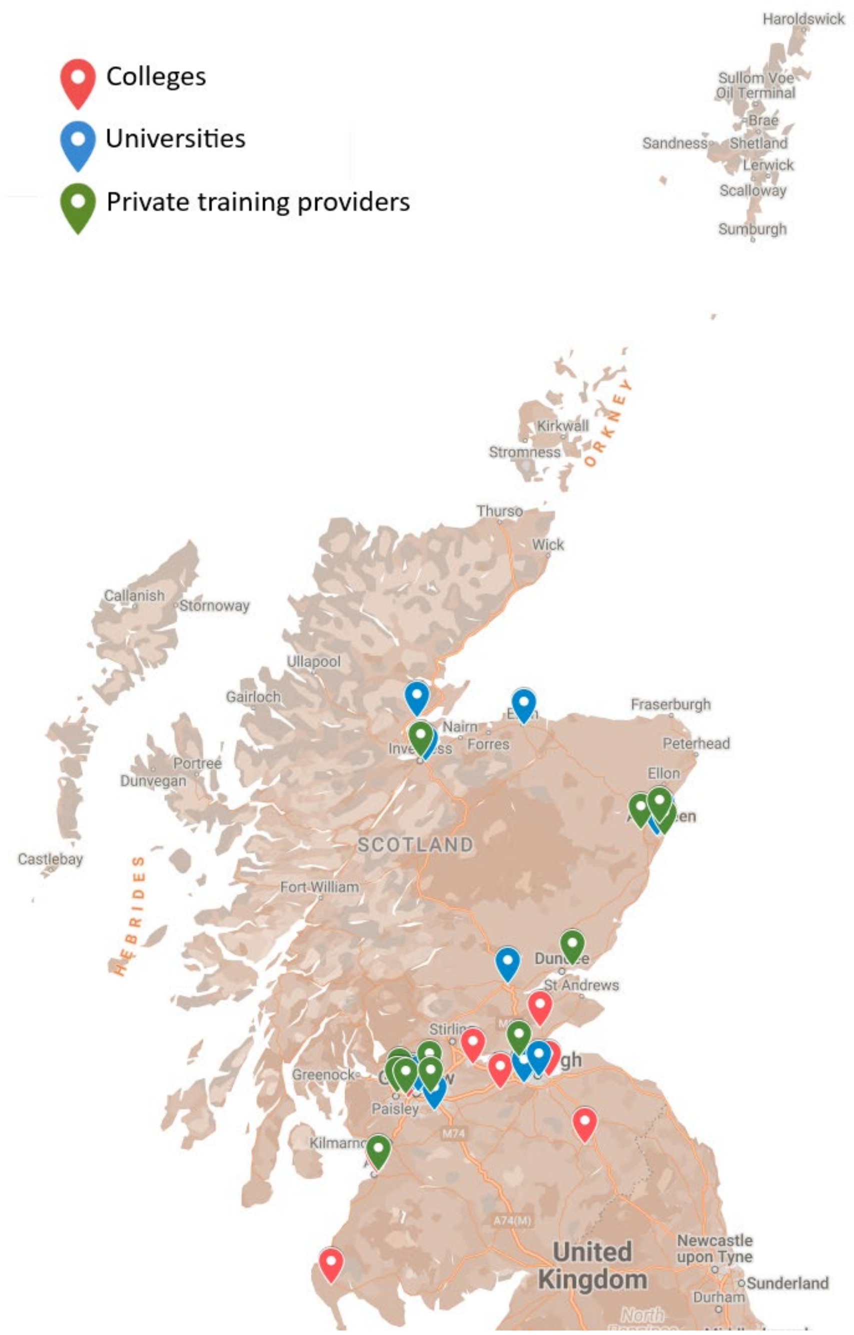

Figure 5. Geographic locations of Scottish training providers (colleges, universities, and private companies) offering courses relevant to solar and onshore wind sectors.

6.4.2 Stakeholder commentary on the development of local talent

Attraction, development, and retention of local talent pools in remote and rural areas was highlighted as an area of high concern by 9 of 21 stakeholders. The Highlands, in particular, faces substantial challenges in attracting and retaining local talent and developing a skilled regional workforce. Two regional stakeholders expressed an opinion that the Highlands is an emerging industrial cluster and predicted a sharp increase in demand for technical talent. This is an area of concern because the region has a rapidly ageing population (Highlands and Islands Enterprise, 2019).

> “We don't actually have enough (...) people for all the jobs that are going to be available.”

The temporary nature of jobs in the construction stages of solar and onshore wind projects further exacerbates the issue with the development of local talent. Construction and commissioning stages of projects in solar and onshore wind industries are marked by a sharp increase in workforce requirement. However, this demand is temporary as the construction stage of project development takes 2-3 years and is seasonal. As such, the industry is heavily dependent on a mobile skilled workforce. One stakeholder highlighted that the current reliance on bringing an external workforce to the region is, in effect, a barrier to the development of a stable, local talent pool for solar and onshore wind sectors. This is due to the fact that, from an industry perspective, skilled regional workforce development takes a significant investment of time that is not aligned with timelines of a typical project. From the workforce perspective, these temporary job roles might not serve as a basis for a life-long career and, therefore, make the sectors less attractive to new entrants.

> “The reliance on transient workforce [*means*] there's no real demand from developers to try and develop a workforce locally.”

In addition, two stakeholders indicated that the planned acceleration in onshore wind activity in England is a potential threat to maintaining a stable technical talent pool in Scotland. They explained that this acceleration is likely to drive a rapid increase in demand for skilled workers in England, where there is an anecdotal shortage of talent, prompting the industry to potentially draw from the Scottish workforce. Additionally, remuneration in England is perceived as higher, which could further incentivise talent migration.

> “There is a concern that Scotland could lose a significant chunk of its skilled workforce to England.”

7 Addressing the future skilled workforce demands

7.1 Analysis of SFC data

To understand analyse the scale of skills being delivered against the projected future skilled workforce demands, we extracted data in relation to the total number of enrolments in all STEM-related courses identified as relevant to onshore wind and solar sectors. This was done in collaboration with the Scottish Funding Council.

The analysis of enrolment numbers on a course level was not possible as the data request could not be fulfilled in the timelines of this study. Therefore, the datasets discussed below are assessing combined annual enrolment numbers in both targeted and broader STEM training provision courses.

In the most recent available dataset (2021/2022), the total full person equivalent (FPE) enrolment in first degree, postgraduate taught and postgraduate research courses broadly identified as relevant to the sectors was 53,585 (Figure 6). The transferability of skills from these courses into solar and onshore wind is illustrated in Appendix D, Table 5.

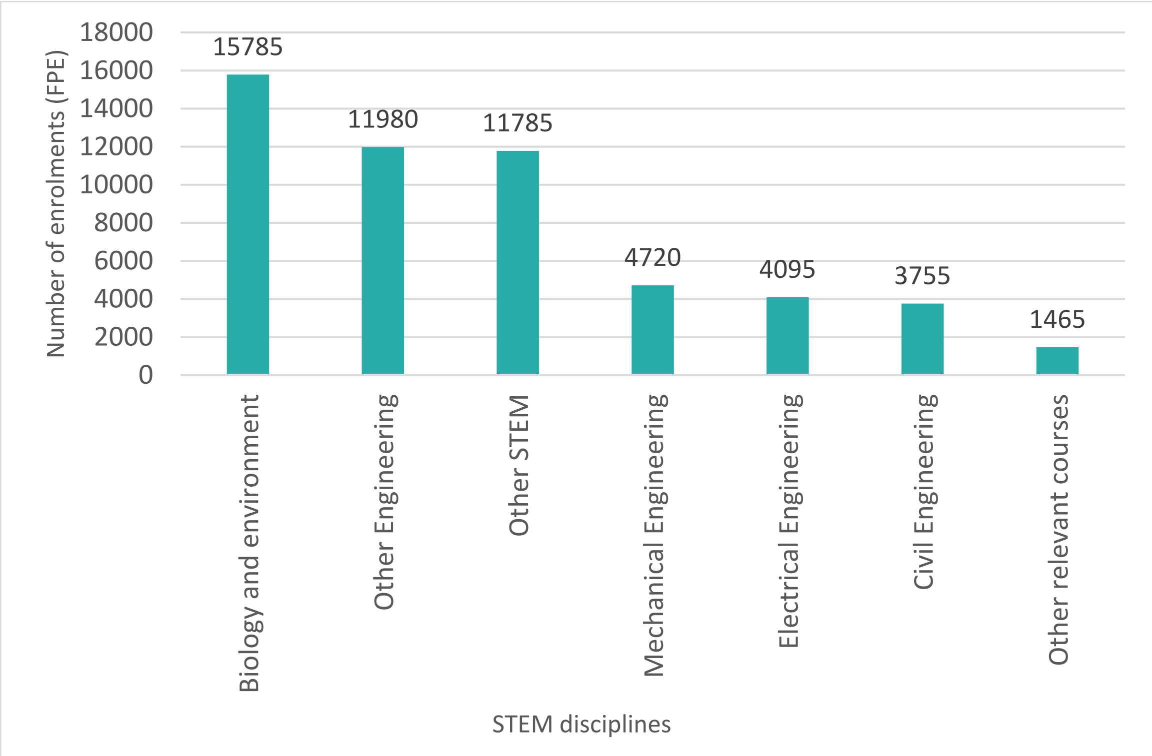

Figure 6. Number of enrolments (full person equivalents) in courses relevant to solar and onshore wind sectors in Scottish higher education institutions (2021/2022).

In the most recent available dataset (2022/2023) the total FPE enrolment in Scottish college courses that are engineering-focused and identified as relevant to solar and onshore wind and allied sectors was 14,890 (Figure 7).

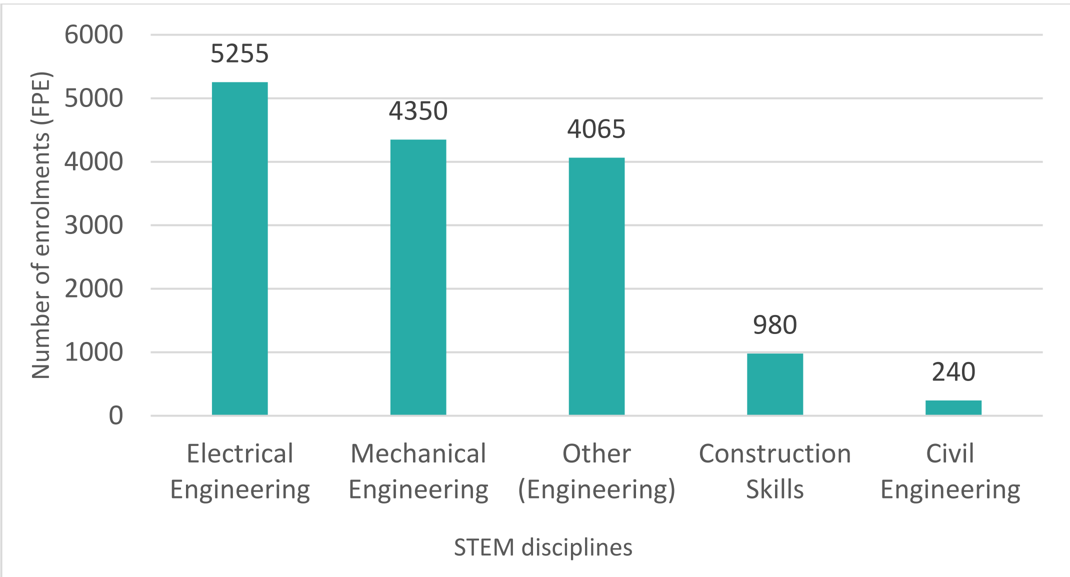

Figure 7. Number of FPE enrolments in engineering courses identified as relevant to solar and onshore wind sectors in Scottish colleges (2022/2023).

To reiterate, previous studies have estimated the peak total workforce requirement for solar and onshore wind sectors as 11,000 and 20,500 respectively. The FPE numbers of the current training provision have been provided as an illustration of the training capacity of further and higher education institutions in Scotland in courses relevant to solar and onshore wind. However, it is critically important to note that the total FPE numbers illustrated in Figure 6 and Figure 7 above do not imply that Scotland's skilled workforce needs are being addressed by the existing training provision. People from these courses enter a range of different industries, and this is explored further in Section 7.2. Additionally, annual FPE enrolments in the relevant courses do not equal the number of individuals completing the training, or the number of graduates that are entering the workforce. For example, the number of graduates in a four-year training programme could be 25% of the total FPE number (the 4th year trainees).

Further, the data on the future destinations of students undergoing the training is fragmented, and this has already been flagged by CESAP Work Package 1 report (Skills Development Scotland, 2023). The recent SDS Apprentice Voice publication states that 71% of modern apprentices are still working for the employer with which they completed their modern apprenticeship 15 months after completion (SDS, 2024). Further research could explore the demographics, interests, and future career pathways of students in training to clarify the true number of entrants into the renewables sector and identify their subsector preferences.

7.2 Competition for talent

Due to the short timeline for meeting the 2030 installed capacity ambitions, addressing future skilled workforce demands in solar and onshore wind sectors will rely on cross-sector skills transfer. Interviews highlighted that one dominant sector that provides technically skilled talent to renewables, in particular onshore and offshore wind, is ex-service personnel (6 of 21 stakeholders).

Technically skilled talent is in high demand across many sectors, including other renewables (hydrogen and offshore wind), manufacturing, construction, the utility companies, and others. The competition for talent within the onshore wind and solar sectors is also fierce. As a consequence, workforce retention is an issue. This was highlighted as a critical challenge by 14 of 21 stakeholders consulted. Stakeholders highlight that a siloed approach to skilled workforce planning is a potential threat to the renewables sector as a whole.

> "We're competing with so many other sectors for the same skill sets... it's a very competitive marketplace."

In addition to problems in attracting talent from other industries, solar and onshore wind sectors face significant challenges in retaining skilled workers within their roles (14 of 21 stakeholders).

> "We did go through a period... where there was very high turnover and lots of people leaving."

Talent mobility is high, with workers often moving on to more lucrative or appealing opportunities after a short period. This disincentivises the industry to invest in workforce development via traditional pathways.

> "The investment of spending three years training them [*apprentices*] [is significant]. At the end of it, a lot of them were literally staying in the role for six months, then looking to the next thing."

The ageing workforce in parts of the solar and onshore wind sectors represents an additional challenge in training and developing talent.

> "We're losing a lot of our real experienced people that would normally mentor those coming in straight from uni... that's where the struggle is."

> "The ageing workforce and impending retirements are exacerbating these challenges, as there are not enough experienced workers to mentor new entrants."

The limited talent pool can result in solar and onshore wind companies headhunting suitably trained technical talent within their supply chains, with potentially detrimental consequences to these suppliers.

> "When we've got good people... the developers come and use us as a recruitment location (..) clearly you can't restrict people's careers but (..) that's a challenging area for us."

The industry indicates that more innovative training mechanisms will be required to address the issues with training and retention, and these are discussed in Section 8.

7.3 Sector visibility and attractiveness

Due to the overall high demand for a technically skilled workforce, stakeholders highlighted that improving the visibility and attractiveness of the sector is a key element in ensuring that the future skills demands are met (11 of 21 stakeholders). They suggest that one strategy for ensuring optimal communication of sector attractiveness is by clearly describing the opportunities for life-long, diverse careers in these sectors. This can be achieved, for example, through the development of clear career pathway maps by building on the sectoral overlap matrix conceptualised in Figure 2, for example by illustrating career paths from technical roles into leadership, management, and planning (other skills).

> "People want to see, okay, where can I go next? They want to see that career path... that's where we need to be to attract people."

> "We need visibility of career pathways... there will be a lot more interest if there's more visibility of how they can go about obtaining those roles."

> "The biggest challenge is that they don't know how to progress within the sector."

One stakeholder indicated that some companies in the onshore wind sector use career mapping internally as a tool for increasing employee retention within the organisation.

> "We're doing a lot of that internally now... developing a career path map so people can see the visibility of where they can go."

One stakeholder, actively engaged with skilled individuals looking to transition to onshore renewable energy, indicated that the overall levels of visibility and clarity about the requirements and opportunities in solar and onshore wind are relatively low.

> "They [*skilled individuals seeking to transfer to renewables*] need to understand the route to becoming a fully qualified electrician to get into solar installation.
>
> For solar, we're not seeing the volume of opportunities.
>
> We're talking a lot about the opportunities but they're just not visible... we don't see the wind turbine technician roles coming up that often.

8 Training provision gaps, barriers, and opportunities for improvement

8.1 Gaps and barriers

8.1.1 Gaps in training provision and alignment with industry needs

Stakeholders (16 of 21) consistently highlighted a significant gap between the content and capacity of existing training programs and the specific needs of the solar and onshore wind sectors. This gap is particularly evident in specialised, role-specific training, such as for wind turbine technicians and ground-mounted solar project development specialists. This is in contrast to the findings outlined in the Section 6 above, suggesting suboptimal levels of communication between the education providers and the industry in tailoring course content to the industry's specific needs.

> "We have generic degree courses in electrical engineering... it's probably more the specialisms that we're lacking just now."
>
> "There is no single qualification in solar. Generally, qualifications are part of a wider training provision."
>
> "I've got engineers at the moment that I need to get up-skilled in solar... the closest training course I can find is in the south of England."

The mismatch between academic offerings and industry requirements creates challenges in producing a workforce that is ready to contribute effectively from day one. Stakeholders highlighted that training provision is reactive rather than proactive and does not anticipate the industry's needs to meet the 2030 installed capacity ambitions.

> "The qualifications available in Scotland are very generic... we need a much more work-ready solution so that when people come out of training, they have a much better insight into the specifics."

> “Most training providers at the moment are looking to provide training for current demand. And there's no foresight as to what that's going to look like in the next two, three years.”

A few stakeholders (3/21) indicated that skills provision for solar sector, and especially large-scale commercial rooftop and ground mounted solar, is limited in Scotland. This opinion is supported by the desk based research findings that showed that most solar-targeted training provision is specialised on domestic rooftop installations. There is a clear deficit in targeted training for the more complex and technically demanding aspects of large solar projects.

> “Solar is lagging behind – all on awareness level, not competence-based... solar farms are less catered for.”

> “There is very limited experience on these types of projects [*large commercial and ground-mounted projects*]”.

8.1.2 Barriers to increased training provision

A recurring theme that was highlighted by 15 of 21 stakeholders as a critical issue is the lack of targeted funding for training provision, which has become a significant barrier to expanding and adapting training programmes.

> “Funding is the main issue... the absolute allocation to individual Modern Apprenticeships has not increased for 10 years.”

> “Colleges are struggling to provide [*relevant training provision*] without external support.”

The financial constraints are compounded by the high costs of the necessary infrastructure and materials, leaving institutions to rely on limited general budgets.

> “These are very expensive courses to cover in comparison with other courses.”

> “My understanding is that there's only one college right now that has the equipment to deliver high-voltage training.”

Stakeholders indicated the need for ring-fenced funding to support the development and delivery of courses that are specific to solar and onshore wind sectors. This has become particularly important after the termination of the National Transition Training Fund in 2022. One stakeholder further indicated the need for ringfenced funding for safety certifications to ensure that the skilled workforce is certified to work in solar and onshore wind environments.

> “We have nothing... all of that ring-fenced funding is now gone.”

> “The funding available is often for higher-level qualifications, but it doesn’t apply to safety tickets or other certifications, which can be a barrier.”

8.1.3 Stakeholder commentary on policy

Stakeholders (10 of the 21 consulted) highlighted that policy has a central role in market certainty and, therefore, future skills needs planning and training provision. Uncertainty, particularly concerning the future pipeline of projects, complicates long-term workforce planning. Companies are hesitant to invest in long-term workforce development initiatives without clearly understanding future project demand. At the conclusion of this study, the upcoming Energy Strategy and Just Transition Plan had not been published. Stakeholders highlighted that industry has interpreted this as a signal of market uncertainty, which by extension complicates their future workforce planning.

> "We need confidence that there's a long-term pipeline of projects... that gives us the green light to look at investment and ramping up the workforce."

> "If you're recruiting an apprentice, you're planning three or four years out... that's challenging to do without certainty."

Stakeholders also indicate that the skills governance and policy for solar and onshore wind currently lack certainty and strategic direction. This is in contrast to offshore wind skills governance, which was seen as substantially more mature, despite the lower levels of sector maturity compared to onshore wind. In addition, it was highlighted that the ongoing post-school education reform complicates future workforce development planning. In this context it is challenging for education providers to allocate resources to critical skills areas and delays the alignment of curricula with emerging industry needs, affecting the preparedness of trainees.

> "The problem within my space at the moment is all our policy is up in the air... we're waiting for (...) the funding review."

> "Without a clear directive from the government, the training provision will continue to be reactive rather than strategic."

Overall, stakeholders called for a more strategic, top-level intervention from a policy perspective that would involve industry, training providers, and funding bodies.

8.2 Opportunities for enhancement

8.2.1 Modular and flexible training programs

The need for modular, flexible training programs that can quickly upskill individuals with relevant but incomplete experience is a recurring theme that was highlighted as the opportunity for training enhancement (14 of 21 stakeholders). These programs should be designed to provide targeted, condensed training that aligns with industry needs, allowing workers to become productive more quickly.

> "They have the base skills and they just need a little top-up to actually enable them to move into the sector. We need to condense [training

> provision] into something intense, something that people can do in short courses."
>
> "If we [*the industry*] could fund modular type activities... that would really suit us."
>
> "We could take a more modular approach... train you to do [*a certain task*] and then upskill you as needed, but in the meantime, you're productive much more quickly."

The main idea behind modular training provision is to identify areas where a worker requires additional support while using their existing skills within the workforce. Two stakeholders described this process as skills "*top-up*", as opposed to full retraining of already skilled workers that would remove them from the workforce for an extended period. This could be integrated into the existing training provision, with apprenticeships highlighted as one of the most important mechanisms for the delivery of a skilled workforce to the solar and onshore wind sectors.

> "The perfect mix is where you have [*modular training within*] degree apprenticeships. They're learning the fundamentals while getting operational experience."

In addition, one stakeholder indicated that modular training provision could also support increased levels of training of trainers, expanding the skillset that can be passed on through existing training provision mechanisms. This highlights that the modular training provision could benefit different stakeholder groups and be synergistic for the development of skilled workforce.

8.2.2 Strategic collaboration between stakeholders

Effective workforce development in the renewable energy sector requires a coordinated effort between industry, government, educational institutions, and training providers. Stakeholders (18 of 21) consistently highlighted the need for improved communication and partnership that can lead to more effective training and recruitment efforts. This collaboration should focus on not only bringing together stakeholders from solar and onshore wind but also other relevant sectors.

> "Employers need to work with training providers... to put together a training piece that's going to assist [*workforce that is looking to transfer*] based on topping up their skills."
>
> "We just need to get that communication from industry... they [*training providers*] will absolutely ramp up and align their courses with it and we [*a networking organisation*] can support them to flex what they offer as well."
>
> "Government, industry, and training providers should be working more closely to develop a much more modular approach to the delivery of training."

One stakeholder highlighted that, whilst the relevant people are “often in the same room…” they are “…speaking different languages”. This comment relates to the fact that policymakers, industry, education providers, and other stakeholders often tend to have different and occasionally conflicting priorities. As such, the solar and onshore wind sectors could benefit from more strategic and mediated conversations and relationship-building activities to ensure synergy between stakeholders.

8.2.3 Importance of practical training and on-the-job experience

There is a strong emphasis on the need for practical, hands-on experience in training programs. Many stakeholders (12 of 21) believe that current training programs are too theoretical and do not provide the real-world skills needed for success in the solar and onshore wind sectors.

> “The practical element... is fairly limited, so we're going to do more of that in-house now to meet the needs.”
>
> “We’re still going to need months, if not years, of training them on our products... they have good general electrical engineering knowledge, but not the specifics.”

Two stakeholders indicated that, currently, qualifications alone do not guarantee competency to work in the sector.

> “Just because someone is a qualified electrician, it doesn’t make them competent.”

Stakeholders also noted that the academic environment cannot prepare the future workforce for all required job roles in the industry, especially in mid-management. This relates to the previous insights associated with the ageing workforce; as the sector relies heavily on existing career professionals to upskill newcomers, mentorship and guidance must remain available to those entering the sector. This also applies to skilled workers transferring from other sectors to solar and onshore wind.

> “The academic environment... doesn't equip them as project managers. A lot of it realistically... where you get the real training is on the job.”
>
> “We’ve been much more focused on... are they the right person culturally to fit the organisation... then we can train them from an experience point of view.”

9 Lessons learnt

The findings of our study suggest a series of key themes that could be used for future consideration in developing training provision for the onshore wind and solar sectors.

Although our analysis of current solar and wind sector courses found a theme of ‘**practical skills and hands-on experience**’ in the descriptions, industry stakeholders did not feel that this is sufficiently represented in the training available. Training providers need to ensure that the course content is relevant to industry needs, in particular regarding hands-on training and close collaboration with industry partners, including through apprenticeships. Access to internationally recognised, accredited training, such as GWO Health & Safety, should be prioritised to ensure that workers receive industry-standard qualifications.

Currently, most solar and wind sector courses are at postgraduate level of specialism. A shift towards a more **flexible, modular approach** to upskilling and reskilling the workforce is needed. This would allow individuals to tailor their training to specific needs rather than undergoing full retraining programmes. This has the potential to enable faster movement of individuals from training into the workforce which would benefit the industry.

Improved **collaboration and communication between stakeholders** is another critical lesson. The important role of government in creating clear market signals and strategic skills governance has been highlighted. Establishing more formal partnerships and regular cross-industry and education forums could help foster greater coordination and break down the siloed approach to workforce development. It would also benefit the SMEs in the solar and onshore wind sectors that cannot carry out substantial skills development programmes on their own.

To support the above points, there is a need **to enhance and modernise existing funding mechanisms**. This includes re-establishing targeted funding streams, encouraging industry investment in training, and exploring new funding models to support specialised programmes such as modular training options. In particular, there needs to be significant investment in practical infrastructure to support hands-on training.

This research highlights the centrality of allied STEM and other roles shared by both onshore wind and solar skills development. A siloed approach to STEM workforce planning is a threat as several industries are drawing from the same talent pool, resulting in competition with their vital supply chains. A more **integrated perspective** would consider the requirement for a STEM workforce across all infrastructure projects of national importance and overall installed capacity ambitions. A comprehensive map that details the scale, timelines, and workforce demands of major infrastructure projects has the potential to inform the total scale of skilled workforce needs and alleviate some concerns regarding the temporary nature of some job roles at times of peak demand. Such a map could be used as a signal of the availability of lifelong careers in these diverse sectors. Understanding the flow of skilled workforce amongst solar and onshore wind sectors and between other sectors will be vital to maximising skills and workforce potential.

Another suggestion for policy and the broader stakeholder ecosystem is the need to develop robust and compelling career pathways through **comprehensive career mapping**. Research is needed to outline career progression within the solar and onshore wind, as well as the broader renewable energy sector, and compare it with other major industries to create a comprehensive transferability framework. Identifying key roles, required skills, and potential career progression routes can provide clarity for professionals entering or transitioning within the sector, making it more attractive and accessible. This approach will be essential for addressing both recruitment and retention challenges.

10 Conclusions

In summary, current training provision has the potential to deliver the skilled workforce required for the solar and onshore wind sectors if it is strategically supported through policy certainty, targeted funding and changes in modes of training delivery. The need for intervention is urgent, as research indicates a peak in workforce demand as early as 2027 (Morrison, et al., 2024).

We have conceptualised the sectoral overlap of skills for the onshore wind and solar sectors (Figure 2). This demonstrates that although critical, specialised skills training provision is needed for solar and onshore wind separately, the majority of roles are shared by the sectors requiring allied STEM and other skills. We found that there are gaps for both sectors in specialised, role-specific training aligning to industry needs. However, siloed approaches for skills governance in solar and onshore wind could be counterproductive as the sectors compete for many of the same skillsets.

Allied STEM skills training provision in Scotland is extensive, with a significant number of students enrolling in relevant and transferable courses each year. These programmes equip trainees with foundational skills that can be applied across various sectors, including renewable energy. However, there is a lack of clarity regarding student destinations after completing these courses, making it difficult to track how many trainees are entering the solar and onshore wind sectors in Scotland. Stakeholder engagement highlighted that the onshore wind and solar sectors need to increase their job attractiveness in a highly competitive skills marketplace, including through increased visibility and clear career pathways.

Throughout this report, we have demonstrated the value of an integrated perspective, with the above conclusions being applicable to both sectors. However, our findings also suggest conclusions for the specific sectors, as set out below.

10.1 Sector specific conclusions: Onshore wind

Training provision for the onshore wind industry is available in Scotland but needs better alignment with the sector's specific operational demands, especially with a stronger emphasis on practical, hands-on skills like wind turbine maintenance and site management. While there are few significant barriers preventing individuals from entering the industry, poor sector visibility is an issue. Industry leaders are keen to see training programmes that allow workers to quickly transition into the workforce, building on their existing knowledge while providing opportunities for continued upskilling. Modular training and "topping up" skills are considered vital to ensuring that workers can effectively meet the evolving needs of onshore wind projects and contribute to the industry's success.

10.2 Sector specific conclusions: Solar

The solar industry in Scotland faces several challenges related to training and skills development. Currently, training provision is limited to domestic rooftop installations, which already require an electrical qualification. A major concern is Scotland's lack of expertise in ground-mounted solar, which poses a potential threat to the sector's development. There are no specialist courses available or training providers equipped to deliver the necessary skills. Skills governance for the solar sector is also lagging behind that of other renewable sectors, which further hinders the industry's growth.

Like the onshore wind sector, the solar sector would greatly benefit from increased modular training provision to upskill workers quickly. However, training providers require a clear signal from the industry indicating a need for such courses. Addressing these gaps is essential for ensuring that the solar industry has a skilled workforce capable of supporting its growth.

10.3 Next steps

This study has identified the key barriers, opportunities and needs for intervention to increase training provision for solar and onshore wind sectors in Scotland. The next critical step is to develop a detailed, fast-paced action plan that engages all key stakeholders, including policymakers, industry representatives, training providers and potential talent pool representatives. Given the urgency of workforce demands and a projected peak of skills need as early as 2027, this action plan must establish clear and fast-paced timelines for intervention, with an aim to launch initiatives before the start of the next academic year (2025/2026). Coordinating this effort will be crucial to ensuring that Scotland can support the sectors' rapid growth and deliver its renewable energy commitments.

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12 Appendices

Appendix A

List of consulted stakeholders

Skills Development Scotland
Universities Scotland

Solar Energy UK
Scottish Training Federation
Scottish Funding Council
Gensource
Engineering and Construction Industry Training Board
ITPEnergised
Scotland's Electrical Trade Association (SELECT)
Career Transition Partnership
EVO Energy
Dumfries and Galloway College
Ayrshire College
NMIS/University of Strathclyde
NESCol/Energy Transition Skills Hub
NESCol/National Energy Skills Accelerator
Hitachi Energy
SSE Renewables
Scottish Power Renewables
Highland Council
Energy Skills Partnership (ESP)

Appendix B

Institution	Level	Course name
Ayrshire College	L5 (school)	Skills for Work Introduction to Renewable Energy
Ayrshire College	L5 (pre-apprenticeship)	Electrical Engineering and Renewables
Ayrshire College	SCQF L6	Wind Turbine Systems
Borders College	No formal qualification	Introduction to Renewables Technology SPF
Dumfries & Galloway	NC (SCQF L6)	Natural Power Wind Turbine Technician Trainee
Dumfries & Galloway	NQ (SCQF L4)	Introduction to Engineering and Renewable Energy
Dumfries & Galloway	GWO	Basic Technical Training (BTT)
Dumfries & Galloway	SCQF L5	Renewable Energy Practical Skills
Edinburgh	BEng	Energy and Environmental Engineering
Edinburgh Napier University	BEng	Energy & Environmental Engineering
Fife	GWO	Basic Technician Training
Forth Valley	BPEC (NOS Mapped)	Solar Photovoltaic Systems

Institution	Level	Course name
Glasgow Caledonian University	BEng / MEng	Electrical Power Engineering
Glasgow Clyde	BPEC	Electrical Energy (Battery) Storage Systems (EESS)
Glasgow Clyde	BPEC	Solar Photovoltaic (PV) Systems
Heriot Watt	MSc	Renewable and Sustainable Energy Transition
Heriot Watt	MSc	Renewable Energy Engineering
Inverness (UHI)	BEng (Hons)	Energy Engineering
Inverness (UHI)	MBA	Renewable Energy
Moray (UHI)	MBA	Renewable Energy
Moray (UHI)	BEng (Hons)	Energy Engineering
NESCoL	SCQF 4/5	Automation & Renewables
NESCoL	NC (SCQF L5)	Engineering Systems: Renewables
NESCoL	NC (SCQF L5)	Engineering Systems: Renewables
NESCoL	Skills for Work (SCQF Level 5)	Engineering: Sustainability & Renewables
NESCoL	ECITB (SCQF Level 6)	Engineering: Wind Turbine Technician (WT) Pathway
NESCoL	SCQF Level 5	Girls in Energy
NESCoL	SCQF Level 5	Performing Engineering Operations: Renewables
NESCoL	Online certificate	Principles of Sustainable Energy Management
North West & Hebrides (UHI)	BEng (Hons)	Energy Engineering
North West & Hebrides (UHI)	PDA	Renewable Energy Systems
North West & Hebrides (UHI)	MSc	Sustainable Energy Solutions
North West & Hebrides (UHI)	CPD (SCQF L9)	Sustainable Resource Management
North West & Hebrides (UHI)	MBA	Renewable Energy
Perth (UHI)	BEng (Hons)	Energy Engineering
Perth (UHI)	MBA	Renewable Energy

Institution	Level	Course name
Robert Gordon University	BEng / MEng	Renewable Energy Engineering
SLC	BPEC	Solar PV
University of Aberdeen	MEng	Electrical and Electronic Engineering with Renewable Energy
University of Aberdeen	MEng	Energy Transition Systems and Technologies
University of Aberdeen	MSc	Renewable Energy Engineering
University of Edinburgh	MSc	Advanced Power Engineering
University of Edinburgh	MSc	Electrical Power Engineering
University of Edinburgh	MSc	Sustainable Energy Systems
University of Glasgow	MSc	Sustainable Energy
University of Strathclyde	MSc	Offshore Wind Energy
University of Strathclyde	MEng	Electrical Energy Systems
University of Strathclyde	MSc	Advanced Electrical Power & Energy Systems
University of Strathclyde	MSc	Advanced Mechanical Engineering with Energy Systems
University of Strathclyde	MSc	Electrical Power and Energy Systems
University of Strathclyde	MSc	Energy Systems Innovation
University of Strathclyde	MSc	Renewable Energy & Decarbonisation Technologies
University of Strathclyde	MSc	Sustainable Engineering: Offshore Renewable Energy
University of Strathclyde	MSc	Sustainable Engineering: Renewable Energy Systems & the Environment
University of Strathclyde	MSc	Wind Energy Systems
University of the West of Scotland	MSc	Sustainable Technology and Energy
West Lothian	SCQF Level 5	Electrical Sustainability Through Renewable Technology

Table 1. Training provision relevant to solar and onshore wind sectors available through Scottish colleges and universities in the academic year 2024/2025.

Organisation	Course name
Skills Training Group	Solar PV Installation Course With Battery Storage
BPEC	BPEC Solar Photovoltaic Systems NOS Mapped
TotalSkills	Level 3 Solar PV & Battery Storage Systems EESS - 4 Day course

Energy Technical Academy Group	Solar PV Installer Training (Solar PV & Battery Storage)
IRT Scotland	Roof Safety for Solar Installers
Clyde Training Solutions	GWO Advanced Rescue
Clyde Training Solutions	GWO Wind Basic Technical Straining
Clyde Training Solutions	GWO Enhanced First Aid
Clyde Training Solutions	GWO Sea Survival Training
Clyde Training Solutions	GWO First Aid Training
Clyde Training Solutions	GWO Manual Handling
Clyde Training Solutions	GWO Working at height
Clyde Training Solutions	GWO Basic Safety Training (BST) Package – Offshore
dwpa	Wind Turbine Technology Essentials
dwpa	Advanced Platform Theory
dwpa	Wind Turbine Maintenance
dwpa	Wind Turbine Troubleshooting
dwpa	Maintenance Quality Inspection (MQI)
dwpa	Asset Integrity Inspection (AII)
dwpa	Turbine Operation & Maintenance
dwpa	Gearbox Maintenance & Inspection (GMI)
dwpa	Remote Operations Awareness
dwpa	Operation & Maintenance Awareness
Aurora Energy	GWO Working at Height
Aurora Energy	GWO Manual Handling
Aurora Energy	GWO First Aid
Aurora Energy	GWO Fire Awareness
Aurora Energy	IRATA Rope Access
Aurora Energy	Mechanical Joint Integrity (MJI)
Aurora Energy	Confined Space Entry
Aurora Energy	Working at Height
Aurora Energy	CCNSG Safety Passport
Aurora Energy	ECITB CCNSG LaTS (Leading a Team Safely)
Aset Training	ECITB MJI 10, 18, 19: Mechanical Joint Integrity
Aset Training	ECITB MJI 33: Torque and Tension Wind Turbine Bolted Connections
Aset Training	Flange Make Up and Bolting for Integrity: SCQF Level 6
Aset Training	GWO Basic Technical Training (BTT) Bolt Tightening Module
Aset Training	GWO Basic Technical Training (BTT) Combined
Aset Training	GWO Basic Technical Training (BTT) Electrical Module
Aset Training	GWO Basic Technical Training (BTT) Hydraulics Module
Aset Training	GWO Basic Technical Training (BTT) Mechanical Module
Aset Training	GWO Control of Hazardous Energies (COHE) Basic Safety Module
Aset Training	GWO Control of Hazardous Energies (COHE) Combined
Aset Training	GWO Control of Hazardous Energies (COHE) Combined Refresher
Aset Training	GWO Control of Hazardous Energies (COHE) Electrical Safety Module
Aset Training	GWO Control of Hazardous Energies (COHE) Pressure Fluid Safety Module
Aset Training	GWO Fire Awareness

Aset Training	GWO Fire Awareness Refresher
Aset Training	GWO Manual Handling
Aset Training	GWO Manual Handling Refresher
Aset Training	GWO Working at Heights
Aset Training	GWO Working at Heights Refresher
Aset Training	HV Switching and System Control (City & Guilds 0672)
Aset Training	HV Switching and System Control Refresher
Aset Training	Hydraulic Engineering Failure Analysis and Troubleshooting - Stage 2: SCQF Level 6
Aset Training	Hydraulic Engineering Fundamentals - Stage 1: SCQF Level 5
Aset Training	Hydraulic Engineering Systems Design and Advanced Troubleshooting - Stage 3
Aset Training	Introduction to PLCs in Programming: SCQF Level 6
Aset Training	Major Emergency Management Initial Response for Renewable Energy (Wind)
Aset Training	OPITO Emergency Coordinator for Renewable Energy
Aset Training	OPITO Introduction to Mechanical and Electrical Engineering in Renewable Energy
Aset Training	Power System Protection (Protection Relays)
Aset Training	Rotating Machinery Alignment Techniques: SCQF: Level 6
Aset Training	Small Bore Tubing and Pipework: SCQF Level 6
Aset Training	Valve Maintenance and Valve Pressure Testing: SCQF Level 6
Heightec	GWO Basic Safety Training – Onshore Package
Heightec	GWO Working at Heights with Manual Handling (WAH & MH)
Heightec	GWO Manual Handling (MH)
Heightec	GWO Fire Awareness (FAW)
Heightec	GWO First AId
Heightec	GWO Slinger Signaller
Heightec	Advanced Hub Rescue for Wind Turbines
Heightec	Wind Turbine Lifting Hoist Operations
Heightec	Evacuation by Descent
Coast Renewables Solutions	GWO Manual Handling
Coast Renewables Solutions	GWO Working at Height
Coast Renewables Solutions	GWO First Aid
Coast Renewables Solutions	GWO Fire Awareness
Coast Renewables Solutions	GWO Advanced Rescue Training (ART)
Coast Renewables Solutions	GWO Hub Rescue
Coast Renewables Solutions	GWO Basic Technical Training (BTT)
MRS Training and Rescue	GWO Wind Turbines Onshore Basic Safety Training (BST)
MRS Training and Rescue	GWO Wind Turbines Onshore Basic Safety Training Refresher (BSTR)
MRS Training and Rescue	GWO Wind Turbines Working at Height with Manual Handling

MRS Training and Rescue	GWO Wind Turbines Working at Height with Manual Handling Refresher
MRS Training and Rescue	GWO Wind Turbines First Aid
MRS Training and Rescue	GWO Wind Turbines First Aid Refresher
MRS Training and Rescue	GWO Wind Turbines Fire Awareness
MRS Training and Rescue	GWO Wind Turbines Enhanced First Aid
MRS Training and Rescue	GWO Wind Turbines Enhanced First Aid Refresher
MRS Training and Rescue	GWO Wind Turbines Advanced Rescue
360 training	Wind Turbine Powered Hoist Operator and Slinger Signaller TICCCS
360 training	Wind Turbine Powered Hoist & Hydraulic Loader Operator and Slinger Signaller TICCCS
360 training	Skyman Service Lift User Training TICCS
360 training	Power Climber SD4 Service Lift User Training TICCCS
360 training	Power Climber RD3 Service Lift User Training TICCCS
360 training	Equipamientos Eolicos Service Lift User Training TICCCS
360 training	GWO Advanced Rescue Training
360 training	GWO Basic Safety Training
360 training	GWO Basic Technical Training
360 training	GWO Basic Technical Training - Electrical
360 training	GWO Basic Technical Training - Hydraulic
360 training	GWO Basic Technical Training - Mechanical
360 training	GWO Fire Awareness
360 training	GWO Manual Handling
360 training	GWO Working at Height
GWT	GWO Five Module Package
Steam Marine Training	GWO Five Module Package
Synergie Training	Wind Turbine Safety Rules+A1:B110 (WTSR)

Table 2. Training provision relevant to solar and onshore wind sectors available through private providers.

Appendix C

NOS	Description	Sector relevance
EUSWT01*	Pre-Assemble Wind Turbine Components	Onshore wind
EUSWT03	Remove plant and apparatus in the electricity power utilities environment	Onshore wind
EUSWT04	Maintain plant and apparatus in the electricity power utilities environment	Onshore wind
EUSWT05	Inspect plant and apparatus in the electricity power utilities environment	Onshore wind
EUSWT06	Configure plant and apparatus in the electricity power utilities environment	Onshore wind
EUSWT07	Diagnose faults on plant and apparatus in the electricity power utilities environment	Onshore wind

NOS	Description	Sector relevance
EUSWT08	Develop yourself in the work role	Onshore wind
EUSWT09	Work with other people	Onshore wind
EUSWT10	Minimise risks to life, property and the environment in electricity power utilities	Onshore wind
EUSWT11*	Install and maintain hydraulic systems on wind turbines	Onshore wind
EUSWT12	Replace plant and apparatus in the electricity power utilities environment	Onshore wind
SEMETS347	Producing technical information for engineering activities	Onshore wind
SEMENG305	Obtain resources for engineering activities	Onshore wind
SEMMAN2302	Using and interpreting engineering data and documentation	Onshore wind
SEMMAN2303	Working efficiently and effectively in engineering	Onshore wind
INSML002	Develop your knowledge, skills and competence to meet the requirements of your work	Onshore wind
INSML024	Build teams and allocate work to team members	Onshore wind
INSML025	Manage and quality assure work in your team	Onshore wind
INSML031	Develop and sustain working relationships with colleagues and stakeholders	Onshore wind
EUSEPUS014	Fault location and diagnosis on plant and apparatus in the electricity power utilities	Onshore wind
EUSEPUS044	Location and identification of underground utility services in the electricity power utilities	Onshore wind
INSEA5	Promote low and zero carbon energy technologies	Onshore wind & solar PV
PROST01*	Prepare the structure for photovoltaic/solar thermal panel installation - existing structure	Solar PV
PROST02*	Fix solar thermal/photovoltaic panels onto a roof structure	Solar PV
PROST03*	Fix solar thermal/photovoltaic panels into a roof structure	Solar PV
PROST04*	Fix solar thermal/photovoltaic panels onto a non-roof structure	Solar PV

NOS	Description	Sector relevance
PROST05*	Solar thermal/photovoltaic panels post installation activities	Solar PV
PROST06*	Identify solar thermal/photovoltaic installation requirements	Solar PV
PROST07*	Produce specifications for solar thermal/photovoltaic installations	Solar PV
BSESPV02*	Install and connect Solar PV and EESS systems	Solar PV
BSESPV03*	Inspect and test Solar PV and EESS Systems	Solar PV
BSESPV04*	Commission Solar PV and EESS systems	Solar PV
BSESPV05*	Identify and rectify faults in Solar PV and EESS systems	Solar PV
BSESPV06*	Maintain Solar PV and EESS systems	Solar PV
BSESPV07*	Develop and agree project designs for Solar PV	Solar PV
BSESPV08	Develop, test and agree project designs for EESS	Solar PV
BSESPV01*	Install assemblies and enclosures for Solar PV and EESS systems	Solar PV

Table 3: National Occupational Standards (NOS) that are relevant to onshore wind and solar PV.

* denotes NOS that are specific to onshore wind and/or solar PV. All others are more general, but still of relevance.

Appendix D

Apprenticeship Type	Framework
Foundation	Civil Engineering
	Engineering
	IT: Hardware and System Support
	IT: Software Development
	Scientific Technologies
	Construction L4/5
Graduate	Civil Engineering
	Civil Engineering: Higher Apprenticeship at SCQF Level 8

	Construction and the Built Environment
	Cyber Security
	Data Science
	Business Management: Project Management
	Engineering: Design and Manufacture
	Engineering: Instrumentation, Measurement and Control
	IT: Software Development
	IT: Management for Business
Modern	Life Sciences and Related Science Industries
	Life Sciences and Related Science Industries Technical
	Maritime Occupations
	Power Distribution
	Industrial Applications
	Process Manufacturing
	Rural Skills: Environmental Conservation
	Construction Technical Apprenticeship: Built Environment,
	Construction Technical Apprenticeship: Contracting Operations
	Construction: Building
	Construction: Civil Engineering
	Construction: Specialist
	Construction: Technical
	Data Analytics: Technical
	Digital Technology
	Electrical Installation
	Engineering: Asset Lifecycle and Maintenance
	Engineering: Manufacturing and Fabrication

	Engineering: Technical Support
	Engineering Construction
	Engineering and Digital Manufacturing Technical Apprenticeship
	Management
	Project Management
	Digital Technology Technical Apprenticeship
	Sustainable Resource Management
	Supply Chain Management

Table 4. List of Apprenticeship Frameworks identified as relevant for the broader STEM skills provision.

Appendix E

University courses	Transferability	Full person equivalents (2021/2022)
Aeronautical and aerospace engineering		980
Agricultural sciences		170
Agriculture		1445
Artificial intelligence		1130
Biology (non-specific)		1070
Biosciences (non-specific)		1820
Biotechnology		460
Building		3470
Chemical, process and energy engineering		2760
Civil engineering		3755
Earth sciences		1750
Ecology and environmental biology		1480
Electrical and electronic engineering		4095
Engineering (non-specific)		3170
Environmental and public health		1055
Environmental sciences		1630
Forestry and arboriculture		150
Geography (non-specific)		220
Information systems		1950
Information technology		2755
Landscape design		255

Maritime technology		40
Materials science		10
Materials technology		10
Mechanical engineering		4720
Microbiology and cell science		1325
Naval architecture		315
Others in engineering		225
Physical and geographical sciences		1865
Physical sciences (non-specific)		150
Planning (urban, rural and regional)		815
Plant sciences		110
Production and manufacturing engineering		1060
Rural estate management		245
Sciences (non-specific)		815
Software engineering		3335
Zoology		1050
Others		1925

Table 5. Scottish university courses and their relative transferability to solar and onshore wind sector. This list is derived from SFC records where courses are ranked in red, amber, and green for their relative transferability to onshore wind and solar sector skills needs. The RAG rating was assigned through qualitative reasoning of the consultants following in-depth thematic analysis of the course content as discussed in Section 6.1.2. The full person equivalent data was provided by the Scottish Funding Council.

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