Wales Centre for Public Policy
Canolfan Polisi Cyhoeddus Cymru

Net zero skills: Insights and evidence from emissions sectors in Wales

Greg Notman, Josh Coles-Riley, Helen Tilley, Jack Price

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Summary

- This report focuses on the skills that will be needed as Wales transitions to a net zero economy. It provides an overview of future skills needs, how likely these are to be met, and what support might be needed from the Welsh Government and other actors.
- The current skills mix differs in some important ways from the skills that will be needed for the transition. Adjusting the skills profile will involve reskilling existing staff, and ensuring that those entering the workforce possess the right skills.
- Pathways to net zero are clearer for some emissions sectors than others. There is particular uncertainty about the future role of key emerging technologies, making future skills needs challenging to assess for surface transport, electricity and heat generation, heavy industry and steel sectors in particular.
- There is a need for a wide range of technical skills, notably electricians and software engineers in steel, construction, road and rail transport, and renewable energy. Product specific training and training to support the transfer of skills between sectors; such as planning, manufacturing, installation, and maintenance skills from existing oil and gas workers to offshore wind farms; and petrochemical workers skills to marine energy projects.
- As well as technical skills, there is a need for transversal skills which are not job-specific, including digital skills, carbon literacy and management and leadership, as businesses prepare to transition to net zero.
- There are common cross cutting issues across sectors. These have an impact on current and future skills demand and include ensuring a just transition, the circular economy, digitalisation and the Welsh language. The diversification of workers involving cultural change within industries will be important to ensure there are sufficient skilled employees to enable the transition.
- A social partnership approach that brings together government, businesses, trades unions and workers, will be essential to supporting the skills transition - along with funding, long term planning and coordination of the education and skills system.
- It is important that the Welsh Government and other actors within the skills system consider implications on the whole system when considering what action to take to ensure Wales has the right skills mix for the transition to net zero.

Introduction

The transition to net zero presents opportunities and challenges for workers, employers and government. There is broad agreement that skills needs will change as the transition advances. The economic changes likely to accompany the ongoing transition will result in shifts in employment as new employers, industries and roles emerge and others close down.

Following its commitment in *Net Zero Wales*, the Welsh Government has published S*tronger, Fairer, Greener Wales: Net Zero Skill Action Plan* (Welsh Government, 2023). The Scottish Government have also published a similar Climate Emergency Skills Plan, exploring opportunities and skills implications, and priority areas for skills action (Skills Development Scotland, 2020). This rapid evidence review is a background paper to help to inform the Welsh Government's Net Zero Skills Action Plan. The Action Plan summarises the current net zero skills position in Wales, against the backdrop of each of the eight emission sectors, and sets out key actions to support businesses and learners to develop a skilled workforce to achieve a just transition to net zero working in collaboration with internal and external stakeholders and partner organisations (Welsh Government, 2023).

This rapid review aims to contribute to the evidence base and discussion by providing an overview of evidence on future skills needs for the emissions sectors presented in *Net Zero Wales*. It provides a review of the literature, synthesising existing evidence and publicly available data. We supplement this with additional evidence from semi-structured interviews with 20 sector representatives from key emissions sectors and those involved in skills training and development. Practical constraints mean this review is not able to present a comprehensive analysis of each sector; instead, it summarises the evidence available to us and the views of those available for interview at the time of research. These vary by sector and industry.

The review considers the following questions:

1. To what extent is it known what the future skills needs will be across different economic and emissions sectors in Wales?
2. To what extent are these skills needs being met at present, and are they expected to be met in the future?
3. What support from the Welsh Government or other actors could best allow for the development of skills to reach net zero?

The report is structured around the emissions sectors, discusses cross cutting themes, and then concludes with a set of consolidated recommendations for the Welsh Government and other actors.

Net zero skills by emissions sector

This section provides an overview of the evidence from the desk review, integrated with findings from interviews with sector representatives. For each sector we consider: the background and the anticipated changes in technology and corresponding skills needs; the skills mix within the current workforce and the changes likely to be needed as the transition progresses; and recommendations for the Welsh Government and other actors.

Electricity and heat generation

The electricity and heat generation sector covers the production of electricity in Wales from fossil fuel, low carbon, and renewable sources. It also includes the generation and supply of heat, for example through heat networks.

Globally, the burning of fossil fuels for electricity and heat generation is the predominant source of greenhouse gas emissions. Decarbonising the energy system is therefore critical to Wales' net zero ambitions and will require widespread changes to both energy supply and demand over several decades. Currently 56% of Wales' energy needs are met from renewable sources, against a target of 70% by 2030, indicating that there is still a substantial amount of adjustment to be made (Welsh Government, 2022b). Much uncertainty exists around the pathways to decarbonisation including the future mix of sources for electricity and heat generation; and the optimum emphasis on reducing the demand for energy and intensity of energy services, or reducing the carbon content of energy (Freeman and Ekins, 2021).

This uncertainty notwithstanding, any viable pathways to the energy transition will involve significant changes to skills needs and employment in the electricity and heat generation sector. The National Grid (2020) highlights four strategic challenges that must be overcome to build a UK-wide net zero energy workforce: i) losing existing talent; ii) retention of graduates; iii) encouraging young people to undertake STEM based apprenticeships and qualifications; and iv) the lack of diversity in the sector.

Existing roles in the oil and gas industry are expected to gradually become redundant as energy production shifts towards renewables and other low-carbon energy sources. Conversely, there will be more demand for roles associated with the production, installation and maintenance of renewable energy generation including offshore wind, as well as other roles related to the production and storage of

hydrogen. More qualified grid engineers may also be needed to ensure the electricity transmission and distribution network can support changes in how electricity is generated. Across the sector, the National Grid estimates that Wales will need around 25,000 roles in the net zero workforce for electricity and heat generation, of which around 65% will be new roles (National Grid, 2020). Sector representatives commented that many of the short to medium term skills needed are already present within the electricity and heat generation sector, but not in sufficient numbers given current labour shortages. Therefore, there is currently significant demand not only for engineering and technical roles, but also project management and scientific skills. Similarly, sector experts told us that many of the specialist skills required to support changes to the energy transmission and distribution network already exist in the supply chain, but engaging and mobilising these skills is likely to prove a challenge.

It has been suggested that workers in the oil and gas sector may possess the skills needed for planning, manufacturing, installation, and maintenance of offshore wind farms (Deloitte, 2021). Similarly, in their submission to the Welsh Affairs Committee, Marine Energy Wales (2021) state that workers in carbon-intensive industries such as petrochemicals are also likely to have transferable skills relevant to the marine energy sector, and that these skills are already located in close proximity to marine energy projects in South West Wales.

Beyond jobs in renewable energy, feedback from sector representatives indicated that jobs in hydrogen production will likely require skills similar to those existing in chemical and oil and gas industries. Oil and gas workers could also work in jobs relating to carbon capture and storage with minor reskilling, however Wales has less opportunity for carbon storage than other parts of the UK (ECITB, 2020; Welsh Government, 2021a). For some medium-to-long term technologies, such as hydrogen storage in salt caverns, and the synthesis of fuel from captured carbon dioxide, the exact skills needed are unclear, as the technology is not yet proven at scale.

The UK Government has recognised the need for transferable skills across the electricity and heat generation sector in its Offshore Wind Sector Deal, committing to developing an Offshore Training Passport to facilitate job mobility between the oil and gas and renewables sectors, which is currently difficult due to a lack of standardisation and mutual recognition between training schemes (Department for Business, Energy, and Industrial Strategy, 2019). However, there are ongoing concerns about who is responsible for the cost of reskilling between carbon intensive sectors and jobs in renewable energy and hydrogen: government, industry, or workers themselves (Jeliazkov et al., 2020; Deloitte, 2021).

Some schemes are in place to facilitate the development of skills required to work within the nuclear and offshore renewables sectors, with a particular focus on supporting firms operating within the supply chain for these sectors. Fit for Nuclear, organised by Nuclear AMRC, offers a business improvement programme to help English businesses find work within the nuclear sector (Nuclear AMRC, n.d.). Fit for Offshore (with ORE Catapult) provides a similar programme for the offshore renewables industry, and 'Fit For' programmes are also in development for hydrogen and carbon capture, usage and storage (Nuclear AMRC, n.d.). The Welsh Government and Welsh public services could provide support for extending these programmes to Wales.

Interviewees from the sector were confident that the complex infrastructure projects required to decarbonise the electricity and heat generation sector can be completed to reach net zero by 2050, though cautioned that large parts of the design process are likely to be outsourced to overseas branches of international engineering companies as they already hold the requisite expertise. Developing and retaining a workforce skilled in conducting feasibility studies and designing complex engineering projects may reduce the amount of overseas expertise needed and provide opportunities to export these skills in the future (ECTIB, 2020).

Recommendations for Welsh Government and other actors

- Further and higher education courses should take a renewables focus and incorporate examples from the renewables industry into existing curricula; there are examples of this in Wales already, with Pembrokeshire College launching a new programme focused on renewables co-designed and co-delivered with industry (Pembrokeshire College, 2022).
- Sector representatives highlighted that apprenticeships require employment from the outset, making it difficult to recruit apprentices if infrastructure projects are in the planning stage. More flexible models of funding would allow for the industry to develop their workforce so that skills are available in the right place at the right time.
- Forming an Energy Skills Partnership, as exists in Scotland, could encourage collaborative working between education providers and industry partners (RenewableUK Cymru, unpublished). This would help to increase capacity to deliver the right skills to meet industry demand.
- To help aid the transition between the oil and gas and renewables sectors, a government-funded job transition scheme could be implemented to aid a just transition, providing practical secondments and wage support while allowing workers to reskill (Storey, 2020).

- The Welsh Government and Welsh public services could provide support for extending ‘Fit For’ programmes to Wales.

Surface transport

In this paper we have focussed on rail and road surface transport and have excluded aviation and marine transport from the broader transport emissions sector, due to the rapid nature of this review, the evidence which was available to us, and the greater ability for Welsh Government to act within the surface transport sector.

Most of the emissions associated with rail and road surface transport are from petrol and diesel in road transport (Department for Business, Energy, and Industrial Strategy, 2022).

With its significant dependence on oil as a source of fuel, the surface transport sector is currently the largest carbon-emitting sector of the UK economy, accounting for 22% of greenhouse gas emissions. As emissions in other sectors have reduced, surface transport has increased its share of overall emissions, with no net reduction since 1990. Similarly, despite multiple policy strategies in the last ten years, very little progress has been made to date in reducing surface transport emissions in Wales (UK Climate Change Committee, 2020). Any possibility of meeting emissions targets therefore requires significant changes to the transport system as a whole, likely to involve a combination of a shift to lower-emission vehicles and other technical solutions for decarbonising transport, policies to reduce demand for travel, and a permanent long-term increase in the proportion of journeys made via the most sustainable forms of transport (public transport, cycling, walking, and wheeling). However, there is considerable debate about the optimum balance between an emphasis on technical solutions for decarbonising the transport system versus policies focusing on influencing the demand for travel and modal shift. There are also varying levels of certainty about the future mix of technologies that will be required to decarbonise different forms of surface transport.

Beyond this uncertainty about policy options and technical solutions, what remains clear is that pathways to net zero for the surface transport sector will involve significant changes to skills and employment. As previously noted, the decarbonisation of surface transport may bring opportunities for workforce growth, including a potential expansion from 170,000 to 220,000 employed in automotive and electric vehicle battery manufacture across the UK by 2040 (Broome et al, 2022). However, this would require retraining existing staff as well as new recruitment. There is also likely to be increased demand for specialist skills in maintenance and engineering in the sector, although there is a risk that an emphasis on new qualifications (the cost of which may fall on workers) and a shift in task focus could

have negative employment effects for the younger, working-class men who have traditionally made up much of the workforce in the industry (Watkins, 2022).

Achieving a modal shift away from emitting forms of transport will also require new or higher numbers in roles associated with designing and managing active travel and public transport systems. For example, changing transport planning away from a road-traffic-centric model may require integrating transport with spatial and town planning (Powell et al., 2021).

Road

There is ongoing uncertainty about the future roles of electrification and hydrogen fuel cells in the decarbonisation of road transport. While the sale of new petrol and diesel cars and vans in the UK is due to end by 2030, and hybrids from 2035 (Department for Business, Energy and Industrial Strategy, 2020), concerns remain about the scale of change required to support this, with widespread electrification so far proving to be a very incremental process (Brand et al., 2020).

In the light duty vehicle category, battery electric vehicles are likely to be comparable in cost and customer experience to vehicles powered by internal combustion engines by 2030, with hydrogen fuel cells only becoming comparable in cost by 2040 (Advanced Propulsion Centre, 2021a). In the heavy duty vehicle category, the technology is much more uncertain. The majority of urban-based service vehicles, such as delivery vans, are likely to be battery powered by 2030 (Advanced Propulsion Sector, 2021b), but sector experts highlighted that the size and weight of electric batteries are likely to limit the cargo load of heavy goods vehicles.

The roll out of battery electric vehicles will require significant numbers of new electricians, as well as the reskilling of existing electricians in the workforce, many of whom currently do not have the right skills to install electric vehicle charging equipment (Minio-Paluello and Markova, 2021). As well as being specifically skilled in working with charging points, many manufacturers require individuals to complete a manufacturer approved training course to repair and maintain their charging points, providing an additional barrier for electricians interested in reskilling (Transport Scotland, 2020). Sector representatives also highlighted a need for software engineers on the manufacturing side, specifically in relation to electric motors and how vehicles utilise battery power.

The decarbonisation of road transport will also require repair and maintenance workers to develop skills in servicing and maintaining new powertrains, including the knowledge and understanding of electric motors and battery packs, possibly also extending to hydrogen fuel cells. However, research in Scotland highlights that a small minority of existing vehicle staff already have recognised qualifications in

working safely on hybrid or electric vehicles (Transport Scotland, 2020). Feedback from sector representatives indicates that this likely extends to Wales, with colleges starting to offer courses; although representatives from the education sector highlight current uptake is low as the small and medium-sized enterprises (SMEs) supporting maintenance and repair continue to be busy maintaining vehicles powered by internal combustion engines. According to sector experts, digital and electronic skills will be increasingly significant in maintenance and repair, particularly in relation to diagnostics and servicing for electric motors. Roadside assistance and recovery will also require similar skills relating to new powertrains (Transport Scotland, 2020).

It is challenging to estimate the overall effects of the transition to net zero on employment in the road transport sector in Wales. While there are opportunities for job creation in automotive and electric vehicle battery manufacture, these would require significant new investment in Wales, given the existing regional distribution of the industry across the UK. On this basis, recent estimates from the Institute of the Motor Industry (2022) predict a net loss of jobs in the sector in Wales between 2021-2031, and estimates are that around 5,000 jobs may be required to offset a retiring workforce. Feedback from sector experts indicates that bus companies who have invested in battery vehicles are already reporting less demand for staff working in maintenance and repair.

While Wales is not currently forecast to benefit significantly in terms of jobs from the UK-wide expansion of automotive and electric battery manufacturing, there may be growth opportunities in the wider supply chain. These could be optimised by building links with existing involvement of Welsh businesses in innovation and manufacturing of vehicle parts, both those specific to the automotive industry and in other areas, such as the compound semiconductor cluster.

Rail

The rail industry has a clearer path to net zero than road transport. To a large extent the technology is already proven and in existence: electrification will be the default mode of decarbonisation, with battery or hydrogen powered trains where electrification is not feasible, although there remains some degree of uncertainty about what combination of electrification, battery operation and hydrogen operation will be optimal.

The Rail Delivery Group (2021) estimates that decarbonising the railway will directly create around 600 jobs in Wales. In fact, Wales is seen to be a net beneficiary of the move to a net zero railway, with the existing assembly plant in Newport benefitting from increased demand for electric- or hydrogen-powered trains (Rail Delivery Group, 2021). Alongside these jobs which are predominantly in manufacturing, there will also be a need for jobs in infrastructure, with electrical engineers, maintenance

technicians, project managers, and jobs relating to operations and signalling (Minio-Paluello and Markova, 2021; Department for Transport, 2022). Forecasting from the Rail Delivery Group (2021) suggests that the majority of these jobs are likely to require Level 2 (equivalent to a GCSE), or Level 5 (equivalent to an HND) qualifications, though apprenticeships remain a key route into the sector.

Alongside new roles, there will also be a challenge in replacing workers who retire or leave the industry, as 28% of the workers are aged 51 or over, and there is already a high rate of unfilled vacancies within the industry (City & Guilds Group and NSAR, 2020). Many major infrastructure projects rely on workers with short fixed-term contracts (City & Guilds Group and NSAR, 2020); however, there is an opportunity for those who have worked on major infrastructure projects (such as the South Wales Metro), to obtain fair and permanent work within the railway industry when these projects begin to wind down, providing an opportunity to fill the projected vacancies arising from natural attrition (Rail Delivery Group, 2021). As a substantial proportion of jobs will be related to rail infrastructure and in Wales this is (apart from parts of the Valley lines in south Wales) largely the responsibility of the UK government, it could make it more difficult for the Welsh Government to provide support for the rail industry.

Active travel

Encouraging active travel will be crucial in developing a modal shift and net zero journeys. However, transport planning is frequently characterised by traditional approaches in which cars are the primary actors and road capacity must be developed to meet demand (Powell et al., 2021). Expert feedback suggests that these views dominate thinking within the sector and are typically passed down to younger entrants, meaning that a widespread change in attitudes is required. Active travel is considered only a minor part of many planning jobs and a new generation of planners need to focus on achieving modal shift. This will require some new skills, including carbon assessment, communications and behaviour change, as well as inclusive design and public engagement (Future Generations Commissioner, 2020).

Recommendations for Welsh Government and other actors

- Establishing good links between academia and industry will be key to harnessing opportunities for research and development across the automotive supply chain, especially when considering the strength of engineering expertise within the Welsh higher education sector and the compound semiconductor cluster. Regional Skills Partnerships could help establish these links and contribute to further innovation and investment in Wales.

- Encouraging automotive companies in Wales who pay an apprenticeship levy to transfer funds to SMEs in their supply chain would help develop capacity and capability and retain investment in Wales.
- Higher and further education could help foster a change in attitudes towards active travel in the industry by engraining behaviour change, modal shift, and inclusive design into appropriate courses, such as planning and civil engineering.

Residential buildings

The residential buildings sector covers emissions from energy usage in homes, as well as efforts to reduce embodied carbon in constructing and retrofitting residential properties.

The Welsh Government's decarbonisation strategy, Net Zero Wales, calls for a reduction in carbon emissions arising from Welsh homes by 80% by 2050, compared to 1990 levels (Welsh Government, 2021c). Currently, approximately 80% of energy use in housing in Wales is due to space heating and domestic hot water use, mainly using gas fired central heating systems (Robinson et al., 2023). This suggests a substantial retrofit programme with supporting skills, which addresses the challenge of increasing the energy efficiency of building stock through insulation and other measures and switching away from fossil-fuel based heat. These average figures mask the significant energy efficiency gains to be made (and associated challenge) from upgrading pre-1900 and 1919-1929 dwellings mainly constructed with solid walls which fall significantly short of targets, with median EPC ratings of 51 and 55 respectively. Of the 28% of properties in Wales constructed of solid walls, some 82% are uninsulated; compared to just 32% of dwellings with cavity walls (Robinson et al., 2023; Welsh Government, 2019). Of the 1.44 million dwellings in Wales, approximately 70% are owner-occupied, with the remainder being split between private rental (14%), social (10%) and local authority (6%) housing providers (Stats Wales, 2020, cited in Robinson et al., 2023). There is however varying engagement with net zero across the housing sector, with homeowners considered to be lagging behind private and public landlords, respectively, in their awareness of measures necessary to decarbonise homes.

Skills needs in this area therefore primarily revolve around the broader need to decarbonise housing, including improving the energy efficiency of housing and retrofitting existing stock with more efficient heating sources (Jofeh, 2019). It will also be important to ensure that new build houses are as low emission as possible, which will intersect with the Welsh Government's social housing strategy which emphasises modern methods of construction (Welsh Government, 2020).

In order to reach net zero by 2050, 12,000 additional full-time equivalent workers will be required in Wales across the sector; this includes around 2,800 plumbers and heating, ventilation, and air conditioning workers (CITB, 2021). Alongside skills relating to installation, maintenance and repair, sector experts highlighted that there will also be demand for a variety of additional pre- and post-construction skills, including surveying, design, energy assessment, and retrofit coordination.

Moreover, the use of modern methods of construction will alter the profile of jobs in construction, as off-site manufacturing will offer the potential to produce higher quality and more efficient homes (Welsh Government, 2020). This shift away from construction on-site will create more demand for manufacturing jobs and offer the potential for other workers to enter the sector. Interviewees told us that those who previously worked in other manufacturing jobs may, in fact, have more appropriate skills for those jobs than those currently working in the residential buildings sector.

Some challenges in the residential buildings sector are already well-understood: for instance, there is a shortage of qualified heat pump engineers, with 50,000 heat pump engineers needed to meet the UK government's target of installing 600,000 heat pumps a year (Watkins, 2022). However, skills needs are not solely confined to repair, maintenance and installation, and skills will also need to be developed across the retrofit process - including energy evaluation, surveying, and customer engagement - at the same rate. The scale of these needs is largely unknown and often overlooked, yet a shortage of supply in skills for retrofit design, assessment, advice, management, and evaluation may result in lower levels of consumer knowledge and confidence, making the transition more difficult.

Weak levels of consumer demand historically feed into and compound these difficulties, as installers are less likely to pursue retraining for retrofit when there is little demand from customers for these measures (Energy Systems Catapult, 2021a). This is one reason why there is little appetite within the sector for retraining, especially within SMEs. Feedback from sector experts additionally suggests that SMEs remain busy with work on existing technologies and rely on small margins from cost sensitive clients; they therefore require a business case and incentivisation to encourage reskilling (Construction Leadership Council, 2021).

Sector experts highlighted that the majority of new technology involved in decarbonising residential buildings will predominantly require adaptations of existing skills, meaning that existing workers can be trained to install, maintain, and repair new technologies fairly easily, once they are familiar with the products. Currently, manufacturers are a key training provider for new products like heat pumps, although this is only provided to those with existing links to the company, such as those installing the company's products. Interviewees also stated that they believe further

education colleges do not currently have the expertise or resources to deliver courses in new technologies at the scale required. However, this in part reflects a lack of demand from suppliers, as colleges will be less likely to deliver courses that they do not believe are in demand (Energy Systems Catapult, 2021a).

A lack of skills in suppliers does not only mean that work is unable to be carried out, but also that, where work is carried out, it is not always of sufficiently high quality (Energy Systems Catapult, 2021a). Interviewees told us that there is significant variation in the quality of work done by tradespeople and that this is an impediment to decarbonising homes as energy efficiencies can only be maximised if products are fitted correctly. Also, customers are likely to be deterred from further improvements if the outcomes delivered do not meet expectations.

Sector experts stated that quality control largely resides with the consumer as certification from training courses does not necessarily translate into competency, as workers may struggle to apply their knowledge to more challenging real-world scenarios. Additionally, compliance with certification schemes can be evidenced by paperwork alone which is no guarantee of quality, and even evaluation programmes do not always pick up faults (Energy Systems Catapult, 2021a). Robust evaluation and audit could help to improve quality control but could also drive skills improvement across the sector (Energy Systems Catapult, 2021a).

A place-based approach to residential decarbonisation might be a good way to develop skills through the whole supply chain in particular areas or regions, embedding good practice and allowing larger-scale initiatives such as district heat networks (Energy Systems Catapult, 2020). Building place-based capacity could also increase capacity within the skills system to train installers in other regions and accelerate residential decarbonisation.

Recommendations for Welsh Government and other actors

- The Welsh Government should provide a clear and joined-up strategy and incentives for decarbonising homes to encourage workers and employees to invest in retraining and adjust the skills provided.
- Incentives for workers leaving the sector (for example, due to poor health) to move into jobs in the further education sector where extra capacity is needed. Incentives would be needed to compensate for perceived lower pay and conditions, but these could include the removal of barriers to labour market participation such as travel to work or childcare incentives.
- Train-the-trainer programmes can help to familiarise workers with new technologies, with buddy schemes allowing workers to practice on real-world

examples a way of maintaining quality. Representatives also stated that the reviewing of National Occupational Standards (TRACER, 2022) provide an opportunity to also address gaps in quality during the transition, potentially by adding performance criteria to address variations in quality of work across the sector.

- Competency schemes could be used to ensure quality and instil confidence in consumers to decarbonise their homes by ensuring that work is completed to a satisfactory standard. The Welsh Government could encourage the uptake of competency schemes through public procurement processes by requiring bidding contractors to participate in a well-audited competency scheme.
- Place-base initiatives could be trialled to embed improvement and good practice across the supply chain, boosting capacity across the whole skills system.

Industry and business

The Welsh Government's definition of the industry and business sector includes 'manufacturing, construction, operation of machinery, food processing and the extraction and production of fossil fuels' (Welsh Government, 2021c: 118). Therefore, many key Welsh economic sectors fall within the industry and business emissions sector and there is a substantial diversity of skills needs and gaps according to the specific industry and role in question. In our research, we focused particularly on heavy industry and steel, which is a high-emission sector that needs to rapidly decarbonise; and SMEs, which predominate in the Welsh economy. However, we recognise that this captures only a subset of the skills which will be required in the transition to net zero.

In 2019 the sector accounted for 38% of Welsh emissions (Welsh Government, 2021c: 118). The main emitters within the sector are iron and steel production (accounting for 37% of the sector's emissions) and petroleum refining (15%). Other substantial emitters are 'manufacturing and construction, solid fuel production, cement, gas production and distribution, operation of machinery, minerals and mines, chemical production, the processing and manufacture of food and drink as well as paper and pulp' (Welsh Government, 2021c: 120).

Heavy industry and steel

Within heavy industry future skills needs are likely to be determined by the technological solutions for decarbonisation in the various subsectors. These include 'fuel switching, carbon capture and storage, low-carbon hydrogen, and engineered emissions removals' (Welsh Government, 2021c: 118).

Interviewees noted that businesses are trying to work out what technological changes are likely to work for them, including options for electrification, hydrogen power, and carbon capture, utilisation and storage (CCUS). Although electrification is considered to be costly and time-consuming, there is currently less of a perceived business case for hydrogen as the technology is not yet seen to be as advanced. However, sector experts told us that some businesses may wait to decarbonise until hydrogen is more feasible. A particular challenge for the steel industry will be meeting interim 2035 emissions targets, ahead of many low-carbon processes coming online (Antonazzo et al., 2021).

Compared to other parts of the UK, Wales has a higher proportion of job roles at risk of change, or which are likely to experience reduced demand from the net zero transition. For example, around 10% of employment in the Bangor and Holyhead, Rhyl and Newport travel to work areas are in so-called ‘brown’ jobs, occupations that are particularly prevalent in sectors with high emissions and which will require the biggest transition to reach net zero (Broome et al., 2022).

Interviewees indicated they are reluctant to invest in skills until there is more certainty about the technology that will be used. There will be a need both to retrain the existing workforce and to support those at risk of redundancy to reskill in other areas, however future technologies will determine the size and composition of the workforce and ultimately the nature and scale of this adjustment. For example, electric arc furnaces in the steel industry require fewer workers than alternative technologies such as carbon capture or hydrogen (Green Jobs Taskforce, 2021; UK Steel, 2022). Another example concerns the emerging CCUS and hydrogen technologies. As these are in their infancy, there is limited evidence surrounding the skills and qualifications that are likely to be needed for industries transitioning to these options (Green Jobs Taskforce, 2021). There are indications that jobs and skills needs are likely to evolve with these new technologies, for example with hydrogen requiring burn specialists; and certain job-based skills evolutions catering to the specific technologies, including pipefitters, electricians, and engineers (SWIC, forthcoming). However, this is likely to be an evolution rather than replacing ‘old’ skills with ‘new’ ones: it is more likely that new skills will sit alongside existing skill sets (Antonazzo et al., 2021).

Existing qualifications will need to be updated to respond to these needs. Interviewees pointed out that, like some other sectors, there were concerns that current apprentices are lacking in the sufficient technical skills, such as maintaining water circuits. Upskilling is likely to be required within the education sector to deliver qualifications related to new technologies at the required scale; carbon capture was identified as an area where experts may need to be brought into Wales from elsewhere. Higher education will likely play a much larger role in the heavy industry

sector than in other sectors, as around 65% of the technical workforce in the UK steel industry are educated to degree level, with around 40% holding a postgraduate degree (UK Steel, 2022). The retirement of large parts of the workforce in the next 10-20 years (estimated at 50% within twenty years in steel) means that it will also be necessary to ensure a continued pipeline for skills such as welding which will be needed in the future as well as currently (Antonazzo et al., 2021).

Across industry there is a need for transversal skills (which are not job-specific but can be applied across a number of roles) including project management, environmental awareness, and digital skills, and ensuring that these become engrained in work practices (Antonazzo et al., 2021; Green Jobs Taskforce, 2021; SWIC, forthcoming). One interviewee emphasised that the transition to net zero will involve managing change and that business leaders will need to be equipped with the capabilities to steer this process.

A fundamental consideration for firms in heavy industry and steel manufacturing will be to ensure that any interventions — whether in skills or in decarbonising processes — also increase productivity, so that firms remain competitive internationally, while mitigating job losses (McDonald et al., 2021).

However, like many other sectors, interviewees highlighted current labour shortages, which limit the ability for employers to send their staff on training courses. Employers who are early adopters of new technology may also be reluctant to invest in training due to concerns about headhunting, therefore presenting the risk that investment in training does not guarantee a highly skilled workforce. Taking measures to reduce the direct cost of retraining for businesses could help to counteract this (Green Alliance, 2022).

Small businesses, including food and drink

SMEs make up over 99% of businesses in Wales and contribute approximately 62% of private sector employment (ap Gareth, 2021).

Interviewees in the sector noted that although there is an awareness of net zero, it is not a priority for businesses given other current challenges and cost pressures including the prices of energy and raw materials and labour shortages. While 73% of small businesses surveyed by FSB Wales agreed they had a responsibility to achieve climate change targets, less than a quarter of these said they knew enough about environmental policy in Wales (ap Gareth, 2021). Some interviewees also noted that in many cases smaller businesses are actively engaged in the circular economy, though they often did not realise they were.

Cost pressures facing small businesses have increased their focus on the need to improve energy efficiency, one of the changes anticipated in the Welsh Government's Carbon Budget 2, along with the need to 'incorporate….resource efficiency and new low carbon technologies into their work spaces and manufacturing facilities and develop new ways of working' (2021c: 119). It remains important to consider the emissions throughout manufacturing processes, for instance within food and drink and other industries within Wales and beyond, to ensure that a reduction of emissions in Wales does not simply offshore emissions somewhere else. Longer supply chains for imported materials make it more difficult to trace origins and influence change (Food and Drink Federation, 2021).

Interviewees noted that there is not necessarily only one pathway to decarbonisation in the food and drink industry making it hard to determine specific skills needs. Some businesses will face a choice between electrification or changing to hydrogen power, so will require skills relating to the specific technology when it becomes available at an affordable cost.

As equipment may be tailored for specific businesses (especially in the food and drink sector), it needs to be designed and fitted before skills needs can be understood and training can take place. In response to this, interviewees outlined a need for transversal skills, similar to those needed by heavy industry and other sectors. These include carbon accounting, basic IT skills and environmental awareness, although they noted that these would be best targeted at middle managers and SME owners, rather than frontline workers. Carbon accounting would be particularly important for the food and drink industry given that ingredients and imports account for the majority of the industry's emissions. Also, changes in production processes and products may need to be adjusted to reflect emissions as the Food and Drink Federation (2021) advocates that businesses in the industry measure ingredient emissions, price carbon internally and incorporate carbon targets into product reformulations. The Future Food Movement (2021) also highlights the need for general environmental awareness and the application of skills within procurement and packaging teams to ensure that emissions are reduced throughout the supply chain.

Recommendations for Welsh Government and other actors

- Given the need to retrain and reskill the workforce, industry and local skills providers will need support to manage this transition. There is a need for a joint dialogue between government, trades unions and the private sector and the Social Partnership and Procurement (Wales) Bill introduced in June 2022 is an important vehicle for this process (Silva et al., 2022).

- The challenge in ensuring that green jobs are available and accessible in Wales will form an important part of a just transition strategy, but other factors like automation and a reduction in the labour demand of some industries will also need to be considered to ensure that existing inequalities are not perpetuated or increased.
- Business Wales could take a signposting role to raise awareness of net zero policy in Wales and its relevance for SMEs, similar to the role it played during the COVID-19 pandemic.
- The Welsh Government could support networks and educate business owners to strengthen networks that are relevant for decarbonisation. In particular raising awareness of the circular economy would be welcome, by framing it in a way which portrays it as viable and beneficial to businesses.

Agriculture

Agricultural emissions are associated with emissions from machinery, soil (including the use of fertiliser), and livestock (Department for Business, Energy, and Industrial Strategy, 2022). Cattle and sheep farming is the most common farm type in Wales (Devenish, 2022), and has been coming under pressure to reduce greenhouse gas emissions, notably carbon dioxide, methane and nitrous oxide. Interviewees highlighted the need to balance reducing greenhouse gas emissions from agriculture with the important role of Welsh farmers in ensuring food security.

The future skills base for agriculture interacts with the skills needs for those in the land use, land use change and forestry (LULUCF) sector, particularly as current proposals for new agricultural subsidies consist of payments for afforestation and biodiversity promotion (Welsh Government, 2022a). In addition, changes to farm management including regulatory frameworks on the use of nitrogen-based fertilisers will require a change in approach. Other changes will depend, to some extent, on how farming evolves in the future: if the current, predominantly pasture-based livestock model continues in some form, it will require fewer skills changes than if a more mixed farm system involving more crop production is adopted. Interviewees told us that they foresee minor adaptations to existing practices, however some intensive arable and intensive dairy farms may find it more difficult to transition.

Financial viability is a fundamental determinant of how farming and land use practices evolve. Farmers are price-takers and operate on small margins, so ensuring that the agriculture sector remains competitive is important in determining how the sector evolves as it transitions towards net zero (Farmers Union of Wales, 2021; Royal Agricultural Society of England, 2021). Along with efforts to encourage the use of the Welsh language (explored in the Welsh language section), a survey of farmers found

that two-thirds of farmers identified land use change as a threat (NFU Cymru, 2020). Sector representatives highlighted that this extended beyond fears about long-run profitability and included the potential for large carbon offsetting companies to purchase farms within local communities for afforestation.

Skills for sustainable land management are intrinsically linked to decarbonising the agriculture sector. The NFU (2021) suggests that the wholesale take-up of productivity improvements, mostly consisting of improved agronomic practices, could remove up to 25% of the sector's emissions. Such practices may include utilising fertilisers more effectively, improving manure management and improving the digestibility of feed for livestock (Ortiz et al., 2021). There is also scope for reducing agricultural emissions through expanding awareness and take-up of innovations in horticultural practice, for example in the use of waste heat and energy sources from industrial activities for horticulture and capturing and storing energy from renewable sources to warm protected cropping units. Cattle breeders may also benefit from using genetic data to select for lower methane-emitting animals (UKRI, 2022). Sector representatives stated that improved skills in animal health and welfare would improve the yield of meat or milk per unit of greenhouse gas, as healthy animals are more productive. Soil management skills will also be required, to ensure that carbon released into the atmosphere from the soil is minimised.

Previous research has also identified improving farmers' forestry and woodland management skills to facilitate increased afforestation (Beauchamp and Jenkins, 2020). If farmers are paid for afforestation under new subsidy schemes, as has been proposed (Welsh Government, 2022), the demand for these skills would increase given the reliance of Welsh farmers on subsidies. Interviewees also highlighted the role of farmers in habitat and species management as tailoring farming practices to benefit wildlife can both increase biodiversity and have positive effects on production yield (Stiles, 2017).

Beyond changes to farming practices, representatives also stated that carbon auditing and assessment skills will be needed to ensure farmers understand their current level of emissions and how they might set about decarbonising their land. This will become even more important if such data is required to receive subsidies.

Representatives from the agriculture sector told us that they were unsure whether concepts related to net zero were given sufficient weight in agricultural qualifications at a further and higher education level. There were similar concerns among stakeholders in Scotland about the quality of agricultural qualifications, based on the perception that courses focus on maximising short-term production rather than longer term sustainability (Hirst and Lazarus, 2020).

Previous research also identifies gaps in management and leadership skills, which are considered essential for day-to-day operations (Nye and Lobley, 2021). Interviewees also highlighted that business management was not something that farmers tended to obtain formal training in, but that they would seek out guidance and advice related to new legislation, for example the forthcoming changes in subsides. Sector representatives told us that developing carbon assessment and accounting skills will be necessary to ensure that farmers are able to measure emissions from their farms and evaluate potential decarbonisation options; this aligns with findings presented to the House of Lords Science and Technology Committee (2022).

Recommendations for Welsh Government and other actors

- Education providers should ensure that agricultural courses generate an understanding of net zero and reflect the challenges facing the industry.
- The Welsh Government should encourage improved agronomic practices and consider future support for the sector.
- Support networking and collaboration between farmers and ecologists could encourage the sharing of best practice in species and habitat management.

Land use, land use change and forestry (LULUCF)

Emissions in the LULUCF sector relate to emissions based on forest land, grassland, crops, settlements and harvesting of wood, and the impact of changes to how land is used (Department for Business, Energy and Industrial Strategy, 2022). It also includes negative emissions, as forests, salt marshes, and some other land uses act as carbon sinks. More broadly, afforestation is a stated aim of the Welsh Government (Welsh Government, 2021c). In order to meet the Climate Change Commission's 'balanced pathway', Wales needs to plant 43,000 hectares of woodland by 2030, and 180,000 hectares by 2050 (Welsh Government, 2021d), however, it is already falling behind, having planted only 290 hectares in 2020.

The Forestry Skills Forum (2021) predict that the forestry industry in Wales will need a 63% increase in workers by 2030, both to cope with increased demand and to compensate for those retiring from the workforce. Beyond the forestry sector, there is a need for environmental and conservation professionals to restore peatland and meadows and support rewilding (Minio-Paluello and Markova, 2021). Natural Resources Wales (2020) are currently running the National Peatland Action Programme, which is helping to restore peatlands on publicly owned land and provide coordination and funding to encourage peatland restoration on private land.

Interviewees told us that there were few new skills required in the sector, and an increase in demand for existing roles is the main anticipated change during the transition. Few school pupils are however currently aware of potential opportunities in forestry and arboriculture (Welsh Government, 2018),

The forestry sector faces the challenge of few higher and further education programmes that are specific to the sector and a competitive job market that reflects such qualification and skills shortages. There is a lack of provision of forestry qualifications, which are concentrated in North Wales: Bangor University is one of few institutions in the UK offering an accredited forestry degree and Coleg Cambria is the sole provider of Level 2 and Level 3 courses at a further education level. Forestry graduates are considered to lack some specific skills, including mensuration, soil management and geographical information systems (Forestry Skills Forum, 2019), as well as lacking certification for the spraying of pesticides and operating relevant machinery. The sector has experienced a shift in the way skills are provided. Whereas previously skills programmes in the sector were coordinated and supported by European funding, now a lot of training for new entrants is informal and conducted by employers and other providers within the sector. The Forestry Skills Forum (2021) highlights the opportunity for a coordinated accreditation scheme that allows employees in forestry to accrue credits towards a qualification by completing informal courses as part of their continuing professional development.

Combined with an increasing awareness that the technical skills can be taught to graduates without a forestry background, the sector is increasingly recruiting graduates with degrees other than forestry and land management, such as geography, business studies and other humanities subjects (Forestry Skills Forum, 2021).

Alongside these challenges, Interviewees from the forestry sector told us that the job market for graduates in the sector is very competitive, with several private sector companies providing highly popular graduate training programmes. This competitive job market has meant that the public sector, which does not offer a graduate scheme, is struggling to fill vacancies.

In nature-based jobs, there is a high availability of graduates with suitable skills (Hirst and Lazarus, 2020). However, sector representatives told us that there are a lack of qualifications and courses providing environmental restoration skills to contractors on-the-ground, in particular relating to peatlands. In Scotland, the publicly funded Peatland Action Project is currently helping to fill these gaps and provide training in peatland restoration techniques for both contractors and land managers (Rowse, n.d.). Hirst and Lazarus (2020) also highlight the potential for apprenticeships within nature-based jobs, which are suited to work-based learning; though there are

concerns over the cost for, and capacity within, SMEs to supervise learners undertaking apprenticeships. Scotland has developed a rural skills modern apprenticeship qualification at Levels 2 and 3 to develop skills for nature-based jobs, including environmental surveying and habitat conservation; these qualifications have clear progression routes into nature-based jobs, as well as with other further and higher education courses (Lantra, 2016). Developing contractor training courses is a key action within the Welsh National Peatland Action Programme (Natural Resources Wales, 2020) and evidence from Scotland recommends using blended learning to deliver these courses in a palatable manner to rural SMEs.

Recommendations for Welsh Government and other actors

- A coordinated accreditation scheme where employees in forestry and the nature sector can accrue credits towards a qualification by completing informal courses would increase access to training and enhance skills.
- Blended learning provision would also increase access and support SMEs.
- Providers of courses in agriculture may be able to deliver courses in forestry, given overlaps in core skills; and agricultural qualifications should be broadened to include forestry skills.

Waste management

Waste management emissions are those associated with landfill, waste-water treatment, and incineration of waste (Department for Business, Energy, and Industrial Strategy, 2022). The UK Climate Change Committee (2020) has highlighted Wales as leading the way on the net zero transition for the waste management sector, with waste sector emissions now 55% below the 1990 baseline and continuing to decline. Wales has a target of a 92% reduction in waste emissions by 2030 compared to 1990 levels, linked to a series of ambitious waste separation, recycling and food waste reduction policy goals as part of the Welsh Government's circular economy strategy 'Beyond Recycling' (Welsh Government, 2021b). These include a 'zero waste' goal for 2050, aiming to phase out residual waste to landfill and incineration, and a range of targets relating to re-use of materials (Welsh Government, 2021b).

Delivering on the linked zero waste and net zero ambitions is likely to have a positive impact on employment in the sector, for example with a likely increase in refuse collection arising from the separation of materials at source (CIWM, 2022). Research commissioned by WRAP highlights a net growth of over 600 net jobs within waste management in Wales by 2030 (James and Mitchell, 2021), though jobs relating to residual waste, such as energy from waste plants, will decline in the long term given the planned phase out.

Although there is little evidence that training needs are routinely assessed to ensure skills and training are in place to meet future challenges (WLGA, 2016), feedback from sector experts indicates that most of the technical skills required are present in the existing workforce. Minor reskilling is however needed in relation to changes in materials handled, for example, or for maintenance of an electrified fleet. Beyond technical skills, sector representatives consider the transition to net zero as an opportunity for reskilling or additional jobs focused on consumer engagement and behaviour change, involving the promotion of the circular economy. Behaviour change in particular forms part of a package of 'soft skills' which will be increasingly required in the sector, including project management, contract management and systems thinking (CIWM, 2022). Sector experts also raised the need for courses in carbon literacy and accounting, especially among middle managers. However, training within the sector is not highly valued, with the perception that most skills can be learned 'on the job', alongside a lack of time and budget for undertaking formal courses.

Achieving the targets in Beyond Recycling will require skills changes outside the waste management workforce including incentivising further re-use or 'remaker' spaces, as well as support for business and industrial sectors to develop more resource-efficient processes. Achieving the goals in Beyond Recycling requires that materials which are collected in Wales are processed in Wales, to derive the maximum possible added value from materials, and to create jobs within the foundational economy (Welsh Government, 2021b). However, it is important to ensure that skills requirements are considered when developing this processing capacity. One sector representative highlighted the example of a procurement exercise where no bidders had a market ready solution. Ensuring that enough local people are equipped with the requisite skills forms a key part of this, especially given the common perception that jobs within the sector require little or no skills development (CIWM, 2022). Reuse and repair are also areas for skills development, including technical skills such as electrical testing, carpentry and sewing; and skills relating to the practice of reuse and repair, such as reverse logistics and auditing (ibid).

In 2019, recycling was a larger employer than reuse or repair in the circular economy, making this a key growth area in Wales (James and Mitchell, 2021). Research by the Green Alliance (2021) highlights the growth potential in the circular economy, particularly in areas other than recycling such as reuse and remanufacturing, which is considered further below.

Recommendations for Welsh Government and other actors

- Regular assessment of training needs by industry bodies and increased coordination between industry and skills providers would support the tailoring of educational courses in response to employers' needs and would ensure that labour market intelligence informs skills development.
- Developing networks with academia and private sector innovators could form the basis for forward planning and generate better collective sector knowledge.
- Encouraging forward planning and improved carbon literacy from public and private sector business leaders within the industry will assist with the integration of new technologies at an operational level (e.g., electric vehicles), and a strategic level (e.g., innovations in recycling composite materials).

Public sector

Public sector emissions are those associated with buildings and operations across the Welsh public service. Therefore, many of the key skills challenges will be similar to those in other sectors including residential and buildings and transport. However, the Welsh public sector also has a leadership role in promoting decarbonisation, including an advanced ambition of net zero emissions by 2030 (Welsh Government, 2021c). It additionally has influence over other organisations through procurement, and can develop and implement tools to, for example, measure the emissions and resource impact of decisions (Welsh Government, 2021c).

In addition to skills required to decarbonise residential, transport or land use-based emissions for example, there will need to be a significant focus on skills relating to climate leadership; procurement and supply chain management; and ensuring that climate change is considered in everyday decision-making.

The Welsh Government has convened a Climate Strategy Panel to co-ordinate and provide strategic direction for public sector decarbonisation. Part of this work includes working on a toolkit and training programme directed at local authorities, intending to build capacity in areas like emissions reporting or technical carbon literacy. There is a recognised need to make in-house expertise available and to adopt a consistent approach across Wales, to ensure data are comparable and to facilitate the sharing of best practice. However, to ensure that the programmes have the greatest possible impact, they will need to be designed to reflect the differing level of capacity and understanding across public bodies in Wales.

Recommendations for Welsh Government and other actors

- Carry out a skills audit or deep dive to understand existing skills, knowledge and capacity within Welsh public bodies, to identify where skills gaps exist and to shape support programmes.
- Facilitate information sharing and upskilling across the Welsh public sector, developing formal and informal networks to do so.
- Ensure that skills are considered as part of public sector climate change strategies.

Cross-cutting themes

Cross-cutting issues, grouped here into themes, arise in most of the sectors, and are important to consider in the route to net zero. While these are broadly shared across sectors, inevitably they are more prevalent in certain sectors and roles than others. We explore the implications of these below.

Just transition

Prior WCPP work on just transitions (Price et al., 2021) and skills for a just transition (Silva et al., 2022) consider how changes in the economy and society might be managed to ensure that the transition 'protects the rights and opportunities of those who are made vulnerable under the existing economic order, or who may become vulnerable as part of the transition' (Price, 2019). Net Zero Wales defines a just transition as 'how we ensure we leave no-one behind as we move to a cleaner, stronger, fairer Wales' (Welsh Government, 2021c: 6).

Ensuring that a just transition framework is central to the skills development context, as called for in Net Zero Wales, will therefore be important (Welsh Government, 2021c). This will require clear communication of what is meant by a just transition and how it applies in the skills development context, as interviewees had different understandings. In particular, the extent to which a just transition is a question of reskilling and redeployment of the existing workforce will need to be balanced with understanding the potential for the transition to broaden and diversify characteristics of new entrants into the workforce. This theme should however not be considered in isolation as specific challenges will arise from the interaction of the transition with other factors shaping the workforce such as automation, precarious work and digitalisation. In Wales, the Social Partnership and Procurement (Wales) Bill 2022 also forms part of the legislative agenda shaping perceptions of fair work.

Reskilling and redeployment

Sector representatives told us that reskilling may pose less of a challenge for the transition than is sometimes assumed. There was a feeling across sectors that existing skills could be developed relatively quickly or through practical, on-the-job training where job roles are at risk of change in the transition. Understanding where this can be achieved and, conversely, where more formal or rigorous training will be needed will allow for better targeting of interventions, particularly where workforce demographics may make informal training a preferred option (see below).

Redeployment of workers from sectors vulnerable to the transition to 'greener' jobs is a more sensitive area. There is a general recognition that the transition may involve a phase-out of some jobs within high-emitting industries or their replacement by other job roles. Given Wales' economic geography, this is likely to be concentrated in certain geographical areas. For instance, 8.7% of workers in Neath Port Talbot are employed in emissions-intensive heavy industry – the highest proportion in the UK (Wallace-Stephens, 2021). High proportions of workers are also employed in fossil fuels in parts of Wales, such as in oil refineries and the LNG terminal in Pembrokeshire.

Previous UK experience suggests that site or industry closures have been treated as stand-alone events rather than planned for, with transition and redundancy packages being negotiated on a case-by-case basis (Coats, 2020). This means that decisions may not be made in the context of a just transition and more strategic planning is therefore necessary.

It will be important to recognise where larger numbers of workers will be affected and, where necessary, have sector- or area-specific plans which look to mitigate negative impacts of transitions. Structural adjustment policies, for instance, could be used to support areas and sectors in particular need (Silva et al., 2022). Workers could be supported to transition into new jobs with similar skills requirements: some stakeholders argued that the skills requirements for fossil fuel industry workers could very easily be adapted for marine energy. Other stakeholders stressed the importance of ensuring that displaced workers are provided with clear and accessible options for retraining or redeployment within the workforce, building on baseline skills where possible. Consulting workers as skills are (re)designed will be important to ensure that the needs of affected groups are met and that the most effective support is provided.

Diversifying the workforce

The transition also affords the opportunity to diversify the demographic makeup of the workforce through attracting a broader range of people to enter particular sectors. According to feedback from sector representatives, the workforce in many sectors is

predominantly white and predominantly male (see also Parken et al., forthcoming). Several interviewees also highlighted that the challenges of an ageing workforce create a need to replace retiring workers as well as prepare for the transition. Box 1 presents data from variety of industries, highlighting how these problems exist across the majority of sectors featured in this report.

Box 1: Workforce demographics of relevant sectors

- Within the **engineering construction industry,** around 86% of workers are male, and 96% of the workforce is white. (von Blumenthal and Boyer Fantini, 2021)
- Across the UK, 84% of the **rail industry** workforce is male, with 28% of workers aged 51 or over (City and Guilds Group and NSAR, 2020).
- UK-wide figures indicate that the **construction workforce** is also overwhelmingly white and male: 87% of the workforce are male and only around 5% come from Black, Asian and Minority Ethnic communities. Around 35% of workers in the construction sector are over the age of 50 (Watkins and Hochlaf, 2021).
- As of 2016, 85% of **UK farm holders** were male, and the median age of farm holders across the UK was 59 (Department for Environment, Food and Rural Affairs, 2019).
- 90% of the **Welsh municipal waste workforce** is comprised of men, and 95% of the workforce is white (WLGA, 2016)

Sector respondents identified the transition as an opportunity to increase diversity, with some representatives emphasising that without a more diverse pool of applicants, they will be unable to develop a workforce large enough to deliver change at the scale required to transition to net zero. This risk is notable in some sectors such as rail, the automotive industry and forestry, where the high proportion of older workers will see large numbers retiring, discussed below. One expert from the waste management sector stated that the existing lack of diversity may be reinforced by perceptions of workplaces as insular and cliquey. Moreover, apprenticeships, which were mentioned by interviewees in almost every sector as a route into industry, are more common pathways for white males than other groups (British Academy, 2021).

Progress has been made towards redressing the gender imbalance in some sectors, however. While agriculture remains a male dominated industry, women now make up the majority of students studying agriculture at Aberystwyth University (Aberystwyth University, 2021). In schools, there is now a fairly balanced split of boys and girls entering A Level Chemistry, and an increasing number of girls are entering A Level

Physics (Arad Research 2020a). Research from within the transport sector has also examined the ways in which girls in schools respond to a career in engineering, noting that girls in particular respond positively when the social value of engineering is highlighted (Department for Transport, 2016). Engagement with role models in primary school can also positively impact girls' attitudes towards STEM (Arad Research 2020b).

Interaction with broader labour market trends

While equality in terms of gender and race was recognised as a challenge, there was more focus from interviewees on the need to reskill ageing workforces. Several sector experts stated that without careful management, many of the existing workforce could choose to retire or leave the workforce during the transition rather than engage in reskilling. Older workers may prefer practical on-the-job training as opposed to classroom-based learning, and there is already a perception that companies do not want to invest in retraining older workers (Christie-Miller and Luke, 2021). This subject was often linked by interviewees to the lack of interest by young people in many of these industries; however, survey data highlights that 55% of young people feel inspired to develop skills allowing them to pursue a career tackling climate change (White et al., 2022). It may therefore be the case that a perceived lack of interest instead reflects young people not being aware of opportunities within these industries to work in climate-focused roles.

Precarious working arrangements have been growing and now affect a substantial share of employees in many sectors, including those in the industry and business sector and agriculture. One in nine workers in Wales are in insecure work and 2.8% of the Welsh workforce (42,000 people) are on zero-hours contracts (Future of Devolution and Work Commission, 2022). These workers are particularly likely to be affected by the barriers to training and reskilling which include associated costs and loss of income, time pressures, caring responsibilities and insufficient essential skills (Pember et al., 2021).

Sector representatives from the industry and business sector stated that the current labour shortages are encouraging many employers to invest in skill development as a means of retaining their staff; and that improved terms and conditions, including moving away from zero-hour contracts, is likely to also form part of this. However, overcoming the above barriers is likely to be challenging. For example, in the residential buildings and industry and business sector many self-employed people find it difficult to retrain as they are busy and reskilling would cause them to lose income. Therefore, consideration should be given to how self-employed workers can access support in the transition to net zero, especially in some areas where there is already high demand such as heat pumps installation and retrofitting.

New jobs which are created need to be sustainable. Some jobs will likely require a high volume of workers in the short-term, mainly to support the installation of new infrastructure, such as charging points for electric cars. However, these workers may then need to retrain as demand for installing these technologies tapers off. It is therefore important to ensure that younger workers do not lose out from the transition and are able to obtain skills that allow them to transfer into a variety of careers related to net zero, rather than simply being trained to meet short term demands. Without changes to existing workforce demographics this problem is more likely to affect lower-class white males who tend to work in sectors with the most immediate demand for jobs installing new infrastructure, such as in road transport and residential buildings.

Recommendations for Welsh Government and other actors

- Active planning will be needed to ensure a coherent and relevant skills offer is in place for workers vulnerable to the effects of the transition. Structural adjustment programmes and other forms of area- or sector-specific intervention could be useful, and affected workers should be involved in planning the programmes.
- Consideration should be given to how the understanding of net zero in the new Curriculum for Wales can be developed in a way which does not reinforce existing inequalities, especially since girls are more likely than boys to say they find the prospect of a green career interesting (White et al., 2022)
- Messaging surrounding reskilling will require careful management and coordination between actors to avoid older workers, who make up a significant portion of the workforce in many relevant sectors, retiring en masse.
- Encouraging retiring workers with skills that are relevant for net zero to move into the education sector will support the development of training and reskilling capacity.
- Planning for future skills needs in collaboration with industry will allow greater understanding of the gaps and insight into how qualifications could enable skilled individuals to move between jobs and aid different areas of the transition without long periods of retraining. For example, a wind turbine technician is likely to possess electrical skills that would qualify them for other jobs in the energy sector with only minor retraining.
- Improved labour market intelligence, gathered for example through routine surveys, would facilitate understanding of current skills needs and comparisons between sectors as well as informing projections of future needs.

The education and skills system

Gaps in qualification provision are equally as important as skills gaps, and often do not receive equivalent attention. Interviewees from a number of sectors, including further and higher education, discussed the limited capacity of education and skills providers to deliver the skills and qualifications needed to transition to net zero.

The current education and skills system was described by interviewees as demand-driven, with providers on the supply side only delivering courses if there is sufficient uptake, meaning that provision is limited by current lack of demand. Further education colleges and training providers told us that funding occurs in short-term cycles, based on predicted uptake of courses, making them reluctant to invest in areas with emerging and uncertain technologies that are often critical for net zero but where likely uptake numbers now are insufficient to make courses viable.

Sector representatives also told us that there is a lack of provision of key qualifications which will be required to reskill existing workforces and prepare new entrants to take up net zero related roles, especially in the residential buildings, road transport, and electricity and heat generation sectors. Several sector experts pointed out that while some relevant courses have recently been developed, these should have been in place earlier to meet existing demands in the sector. Interviewees also stated that there were not always clear progression routes, meaning that candidates with sufficient industry knowledge and experience were not able to progress to a higher-level qualification due to prerequisites.

To respond to the training needs outlined above requires long-term support, local access to courses, and support at work. A multi-pronged strategy that increases awareness, encourages learners, and incentivises educational institutions and employers to accommodate students is necessary. This will involve reviewing the fees and payments systems to ensure access and including paid leave or study allowances; supporting educational institutions to deliver flexible programmes to accommodate life commitments; and measures to overcome other barriers such as the absence of childcare provision and insufficient essential skills (Pember et al. 2021).

Education providers need to act in partnership with businesses, government, trades unions and other actors to base decisions on labour market intelligence: interviewees highlighted that colleges in particular are well placed to find out what local employers need and understand how local people are likely to engage with education. A coordinated approach to reskilling requires that these actors come together. The Social Partnership and Procurement (Wales) Bill and the Commission for Tertiary Education and Research (CTER) as established in the Tertiary Education and

Research (Wales) Act 2022 provide frameworks for such coordination (Pember et al., 2021; Silva et al. 2022).

Moreover, coordination will be required from within the Welsh Government itself. Several sector experts highlighted that the transition to net zero is currently thought about in policy silos, with skills needs and sector-related issues (such as technology) discussed, planned for, and funded, separately. Sector experts stated that they often had held similar conversations around net zero and skills with several teams of officials in the Welsh Government (for example with skills, climate change, and agriculture teams). Interviewees also suggested that clear and joined-up messaging from across the Welsh Government would likely provide a valuable signal to industry about plans for the transition and how they can develop skills in their workforce.

The role of funding was also raised by several sector representatives, who stated that EU funds had previously been wholly or partially responsible for several key skills initiatives and training programmes. They were worried about the future of this funding, and where new external funding for skills development may emerge from. One representative stated that businesses often need direction in accessing funding for skills development, and that there was concern over accessing funds through new decentralised funds from the UK Government.

Recommendations for Welsh Government and other actors

- Longer-term planning is needed to ensure an adequate provision of qualifications that can be accessed locally, with the new CTER bringing together education providers, businesses, government, trades unions and other actors to make decisions on qualification provision based on appropriate labour market intelligence. Ensuring that appropriate funding structures are in place to support long-term planning will be essential, as it is largely the current short-term funding arrangements which incentivise short term planning.
- Supporting the development of educational capacity by encouraging retiring workers to move into the education sector where learners would directly benefit from their industry experience.
- Measures to overcome barriers to reskilling should be considered including reviewing the fees and payments systems to include paid leave or study allowances; supporting educational institutions to deliver flexible programmes to accommodate life commitments; and childcare provision and measures to develop essential skills where they are insufficient.
- Flexible courses for reskilling existing workers and courses for those leaving pre-16 education should be provided. These could incorporate accreditation for short courses, designed to enable credit accumulation towards

qualifications and a variety of entry and exit routes that allow learners to obtain the skills most appropriate to their role (High Value Manufacturing Catapult, 2021). Clear signposting and links between qualifications is also essential to support engagement from both learners and industry (SWIC, forthcoming).

- Encouraging increased coordination from teams within the Welsh Government would help to deliver a clear message to industry and others in the skills system. Experts from several sectors indicated they are already having discussions with officials in the Welsh Government: integrating these conversations and encouraging joint planning would be beneficial.

Circular economy

A circular economy aims to keep resources in use for as long as possible to avoid waste (Welsh Government, 2021b). Moving towards net zero will require an increase in the re-use, repair and recycling of resources, with companies moving away from linear business models that focus on the extraction of resources, production of goods and the disposal of waste. Businesses across a range of sectors will have skills needs related to both incorporating the circular economy into their business models and implementing circular economy principles into their day-to-day operations.

Interviewees stated that many businesses in Wales already participate in the circular economy through their existing business practices, they are just unaware that they do so. Examples of existing circular economy practices highlighted by sector experts included using food waste and by-products of milk production to feed livestock in the agriculture sector; and providing off-cuts from manufacturing businesses to further education colleges.

Businesses in Wales understand their role in the circular economy, although it is often framed around decarbonisation or sustainability more generally (WRAP, unpublished). This aligns with our findings – several sector experts told us that the circular economy was an abstract concept and circular economy principles need to be communicated in a way which directly aligns with business priorities and language. Research in Scotland indicates that Scottish businesses were largely unclear of the business benefits resulting from circular economy practices, and that businesses would likely invest in skills for their workforce to undertake these practices if they were aware that it may benefit the business (Findlay et al., 2021).

There are various skills gaps that are relevant for a range of sectors associated with the circular economy including: data collection and analysis, understanding of materials and collaborative working. There is also the need for awareness of the circular economy as a concept and how it relates to business practices (WRAP, unpublished). There are also technical skills gaps specific to some industries, such

as biomass management in agriculture and design for disassembly in construction (EEA, 2020; WRAP, unpublished). Multiple sector experts told us that existing qualifications remain focused on linear models of the economy and do not adequately focus on waste or the circular economy; a view that aligns with findings from research conducted by WRAP (unpublished).

There is scope for significant growth in jobs for the circular economy if government acts ambitiously. Encouraging methods like reuse, repair and remanufacturing could promote development, particularly in areas where there is an existing skills base in manufacturing to build upon (Green Alliance, 2021). In order to realise this potential, investment in business would need to be matched with job support for workers to retrain and reskill (Green Alliance, 2021).

Recommendations for Welsh Government and other actors

- The circular economy needs to be presented to businesses in language which relates to their business concerns. This may involve framing the circular economy in terms of business efficiency, or sustainability and corporate social responsibility.
- The integration of circular economy principles into qualifications at all levels would help develop awareness of the circular economy for workers entering the sector, as well as those reskilling through formal qualifications.

Digitalisation

Digitalisation, or the use of digital technologies to deliver services or functions, is increasingly important for the Welsh economy and the Welsh Government. The Welsh Government's digital strategy includes a mission on digital skills, giving individuals the capacity to use digital technologies from an early age (Welsh Government, 2021e). It is recognised that digitalisation will also play a role in the transition to net zero: a recent report by the Welsh Government's Centre for Digital Public Services, for instance, looked at how public services could use digital technologies to reach net zero (Centre for Digital Public Services, 2022). Existing digital technologies could help cut 15% of UK emissions by 2030, helping the transition to low-carbon ways of working across several sectors (The Royal Society, 2020).

Digital technology is being increasingly integrated into workplaces, including automated machinery, sophisticated data analysis including digital twins, and artificial intelligence; and the COVID-19 pandemic rapidly accelerated the demand for digitalised technologies (Feijao et al., 2021; Wales TUC, 2021).

Employers are now actively seeking employees with digital skills (Feijao et al., 2021). Interviewees from a variety of sectors highlighted that a range of digital skills will be

needed in the workforce, including data analytics, software engineering and computer-aided design. Several sector experts noted that most of the workforce do not currently have suitable digital skills and that employees require basic digital literacy training. A survey conducted by the Chartered Institute for IT also revealed that 64% of experts did not believe that the UK workforce currently had the right digital skills to achieve net zero (BCS, 2021).

For some projects and use cases, outside specialists or experts could be embedded within organisations within the project, particularly where the project involves data sharing or cross-organisational co-ordination (Energy Systems Catapult, 2021b). This can help to build capacity within organisations, and can benefit providing organisations if it allows them to understand how data is used or access new data sources. Standardisation across organisations and services can also help to ensure expertise can be applied to new contexts (Energy Systems Catapult, 2021b).

Experts stated that overall digitalisation is unlikely to result in job losses, with existing workers either utilising new digital technologies as part of their job or being transferred to other areas of the business to improve efficiencies. Several interviewees stated that digitalisation represented an opportunity for workers to move into higher-skilled jobs, which would in turn result in higher pay and better terms and conditions. Box 2 provides insights from different sectors on digitalisation and its impacts.

Sector representatives stated that SMEs are however often slower in their take up of technology given that their owners suffer from a lack of time and specific expertise. Interviewees also highlighted that as well as lack of understanding about how digital technologies could benefit their business, many SME owners may also benefit from courses targeted at improving their digital skills. SMEs may therefore require further support in order to ensure they are able to utilise digital technology effectively to reduce emissions.

Box 2: Potential for digitalisation across emissions sectors

- Interviewees from the **electricity and heat generation sector** highlighted the use of electronic sensors and big data analytics as examples of digitalisation that was already happening. Digital sensors can now be added to infrastructure such as turbines, power plants and electricity networks at lower costs than before, and can help make operational decisions to improve the efficiency of the system and

detect faults (IEA, 2017). Sector experts noted that digital skills, including data analysis, are going to be needed in increasing numbers across the sector.

- Experts from the **residential buildings sector** highlighted the potential for digitalisation to help meet the demand for retrofit assessment and evaluation, either as an aid to a growing workforce, or forming part of a consumer-led approach utilising artificial intelligence. Interviewees claimed that digitalisation could allow for greater efficiencies and better communication throughout the sector, reducing costs for the consumer and thereby reducing the barriers to uptake of retrofit.

- The **waste management sector** is 'behind the curve on embracing digitalisation' and that business leaders within the sector are largely unaware of how technology could revolutionise their operations (CIWM, 2022: 20). Sector experts stated that there is a perception that work practices would need to change to embrace technology, given the lack of digital literacy across the sector. Collaboration will be required to help support decision making and logistics as the sector moves towards to the circular economy, although a current lack of understanding of what might be possible limits the sector's ability to identify potential partners for collaboration (CIWM, 2022).

- Digitalisation, including the use of IT for training and administrative purposes, is a particular challenge in the **agriculture sector** (Rees, 2016). Sector experts stated that although blended learning had increased in popularity during the COVID-19 pandemic, farmers often still rely on family members or farming unions to comply with regulations that require the completion of online forms and records. Interviewees also noted that even where farmers possess suitable digital skills, issues with broadband connectivity and cost in rural Wales prohibit advantages related to digitalisation.

Recommendations for Welsh Government and other actors

- Efforts to prepare and reskill the workforce to transition to net zero will require a focus on digital skills training and highlighting the links between the two in support programmes will be important.
- In line with the recommendations for ensuring a just transition, including worker voice in the social partnership approach with trades unions and skills providers will likely help ensure that workers do not feel left behind as a result of digitalisation.
- Support and resources for business leaders may help them understand how digital technologies could benefit their business. A dedicated scheme to help

SMEs invest in digital technologies and skills could be beneficial, as current funding structures were unclear.

Welsh language

Changes brought about by decarbonisation have the potential to affect the level of Welsh language use across sectors. For those sectors where customer engagement and behaviour change are important skills, such as residential buildings and waste management, there is a recognition that some customers will want to engage in Welsh.

There are Welsh language concerns specifically related to the agriculture sector. NFU Cymru describes Welsh farming as a 'stronghold for the Welsh language' (2020: 6). The protection of the language therefore requires careful treatment as the structure of the labour market changes. The purchase of farmland for carbon sequestration, for example, changes the use of the land and in turn risks altering the language balance of areas.

Recommendation for Welsh Government and other actors

- The Welsh Government and other actors in the education and skills system should consider the need for local provision of Welsh-medium and Welsh language courses and qualifications, to ensure that both Welsh speaking workers and consumers are supported throughout the transition.

Conclusion

Pathways to net zero are clearer for some emissions sectors than others, largely reflecting different levels of certainty about the role of emergent technologies for decarbonisation, some of which are in competition with each other and are yet to be proven at scale.

Skills needs are difficult to outline in detail in sectors where the technology is not yet proven at scale, or the future mix of different technologies is still unknown. For example in the surface transport sector, modal shift is expected to play a significant role in future technology adaptation. As future pathways and technology mixes become clearer, businesses will be able to respond in a way that is commensurate with the risk involved, adapt and prepare for the transition to net zero.

Some technical skills needs are forecastable. Given that electrification forms the core of decarbonisation in many sectors, more electricians will be needed in industries including steel, construction, road and rail transport, and renewable energy. Software engineers will also be in greater demand. There remains a need for product-specific training as each sector has differing technical requirements.

The agriculture and LULUCF sectors will value skills relating to sustainable land management, including soil husbandry, woodland management and habitat management. As part of the transition to net zero, these sectors will see fundamental changes in how land is used and managed, increasing the sequestration of carbon through forests and peatland, and reducing emissions produced in agriculture.

Some skills can be transferred with support and adaptation to new decarbonised roles. For example planning, manufacturing, installation, and maintenance skills from existing oil and gas workers to offshore wind farms; and petrochemical workers skills to marine energy projects. Concerns remain about whether the responsibility for financing such reskilling falls to government, industry, or workers, highlighting the need for coordination and dialogue.

We found that many sector experts identified a need for transversal skills which can be applied across a number of roles, as well as technical skills as they prepare to transition to net zero. These include project management, digital, managerial and change management skills as well as skills relating to general environmental awareness and carbon literacy which will have to be supplied to both existing workers looking to reskill, as well as new workers entering industry.

Almost all the sectors in this report face the challenge of a homogenous workforce: predominantly middle-aged, white, and male, many of whom will retire within the next ten to fifteen years. Therefore, businesses will require additional workers to transition to net zero and will also need to replace those leaving the workforce. Many of these sectors have traditionally recruited new entrants from the same pool of younger white males, so the diversification of workers entering key industries such as steel, construction, waste management and energy will be necessary to ensure there are enough skilled workers for these sectors to transition. However, if change is not managed carefully those close to retirement may retire earlier, further increasing the need for new workers.

The education and skills system currently lacks the capacity to reskill existing workers and help develop the workforce for the future. While some courses have been introduced to meet some specific net zero skills gaps, including in renewable energy, heat pumps, electric vehicle maintenance and retrofit, sector experts regard these as generally lagging in comparison with the scale and pace of the skills transition required. On the other hand, education and training providers may be reluctant to invest in new courses without sufficient predictable demand. This creates a vicious circle in which skills provision is not available due to a perceived lack of industry demand, but there is a lack of demand from industry because they do not believe that there are qualifications available which can adequately develop the right skills. Partnerships between some industries and education providers are developing in some sectors and some regions, but better coordination could be in place to help both industry and education providers plan their next steps in the transition to net zero. The establishment of CTER offers opportunities to embed partnership working, building on current practices such as regional skills partnerships (Pember et al., 2021). This coordination needs to be supported by more flexible funding for reskilling and apprenticeships, along with financial support to allow employees to participate in retraining.

These challenges represent only part of the problem which means that, at present, the skills needed to transition to net zero are not being developed at the pace and scale required. Without intervention, the market will dictate the changes within industry and in education and skills provision that are needed to reach net zero. However, in this scenario, these changes are unlikely to result in a just transition. Instead, there is likely to be demand for skilled younger workers at the expense of a large proportion of the existing workforce and further marginalisation of vulnerable groups. Moreover, this scenario may increase unsustainable short-term and precarious jobs; for example, skilled workers such as electricians may become unemployed once infrastructure has been installed, and only a small proportion of that workforce required for maintenance.

In identifying what can be done to ensure that Wales has the right skills to reach net zero by 2050, there is a need to consider implications for the whole system. Interventions to support jobs in one sector may come at the expense of progress in other sectors, and other skills needs in project design, management and evaluation must be met as well as focusing on the technical skills required for execution.

Therefore, a successful approach to ensuring that the right skills are available will require long-term collaboration, integrated planning and action from public bodies and other relevant actors in the skills system. This will be essential to avoid negative impacts on the current and future workforce. This needs to take place both within Welsh Government between teams, and also between government, industry, skills providers and trades unions. CTER, as the regulatory body for tertiary education in Wales, can play an active convening role in promoting collaboration and social partnership among and between different actors in the skills system.

Recommendations

Our rapid review of evidence and conversations with sector representatives highlights areas where action from the Welsh Government, education and skills providers, and other stakeholders is seen as having potential to support the skills transition within and across different emissions sectors. The following list replicates in shorter, summary form the recommendations made within the text.

Emissions sectors

Electricity and heat generation

- Support workers in the oil and gas industry to move into careers in renewables with a government-funded job transition scheme, providing practical secondments and wage support while allowing workers to reskill.
- Provide more flexible funding for apprenticeships, to allow industry to develop the required skills in the workforce in the right place at the right time.
- Further and higher education courses should take a renewables focus and incorporate examples from the renewables industry into existing curricula in partnership with industry, for example by forming an Energy Skills Partnership.
- The Welsh Government and Welsh public services could provide support for extending ‘Fit For’ programmes to Wales.

Surface transport

- Enhance links between academia and industry to harness opportunities for research and development across the automotive supply chain.
- Encourage automotive companies in Wales who pay an apprenticeship levy to transfer funds to SMEs in their supply chain to retain investment in Wales.
- Integrate behaviour change, modal shift and inclusive design into higher and further education courses such as planning and civil engineering, to embed active travel.

Residential buildings

- The Welsh Government should provide a clear and joined-up strategy for decarbonising homes, including incentivisation, to encourage the provision and take-up of training.
- Provide incentives for workers leaving the sector to move into jobs in the further education sector where extra capacity is needed. These could include the removal of barriers to labour market participation such as travel to work or childcare incentives.
- Train-the-trainer programmes could help to familiarise workers with new technologies, with buddy schemes allowing workers to practice on real-world examples a way of maintaining quality.
- Consider additional or reviewed performance criteria in National Occupational Standards to address variations in quality of work across the sector.
- Encourage the uptake of competency schemes – to ensure quality and instil confidence in consumers to decarbonise - through public procurement processes requiring companies' participation.

Industry and business

- Use the framework of the Social Partnership and Procurement (Wales) Bill 2022 to support dialogue between government, trades unions, skills providers and the private sector.
- Consider factors like automation alongside the need to ensure 'green' jobs are available, to ensure existing inequalities are not perpetuated or increased.
- Welsh Government, through Business Wales, should raise awareness of net zero policy in Wales and its relevance for SMEs, and of the circular economy.

- Welsh Government should support networks and educate business owners to strengthen their involvement in networks that are relevant for decarbonisation. In particular raising awareness of the circular economy would be welcome, by framing it in a way which portrays it as viable and beneficial to businesses.

Agriculture

- Education providers should ensure that agricultural courses generate an understanding of net zero and reflect the challenges facing the industry.
- The Welsh Government should encourage improved agronomic practices and consider future support for the sector.
- Support networking and collaboration between farmers and ecologists to encourage the sharing of best practice in species and habitat management.

Land use, land use change and forestry (LULUCF)

- Establish a coordinated accreditation scheme for forestry employees to accrue credits towards a qualification by completing informal courses as part of their continuing professional development.
- Providers of agriculture courses consider delivering courses in forestry and agricultural qualifications to include forestry skills.
- Use blended learning to deliver contractor training courses to rural SMEs.

Waste management

- Regular assessment of training needs by industry bodies and increased coordination between industry and skills providers to ensure labour market intelligence informs skills development.
- Develop networks with academia and private sector innovators to inform forward skills planning.
- Encourage forward planning and improved carbon literacy from public and private sector business leaders to integrate new technologies.

Public sector

- Carry out a skills audit or deep dive to understand existing skills, knowledge and capacity across Welsh public bodies, to identify where skills gaps exist and to shape support programmes.
- Facilitate information sharing and upskilling across the Welsh public sector, developing formal and informal networks to do so.

- Ensure that skills are considered as part of public sector climate change strategies.

Cross cutting themes

Feedback from sector experts and existing evidence also raises several issues that cut across emissions sectors:

- The importance of ensuring a just transition framework is central to the skills development context, both addressing the need to reskill and redeploy workers in industries at risk of job changes, and maximising the potential of the transition to broaden and diversify new entrants into the workforce.
- The need to reform aspects of the education and skills system, with long-term planning that brings together education providers, businesses, government, trades unions and other actors to ensure adequate provision of qualifications based on appropriate labour market intelligence.
- The need to support businesses to incorporate the circular economy into their business models and day-to-day operations, and encourage the integration of circular economy principles into qualifications at all levels.
- The importance of recognising both the role digitalisation can play in cutting emissions across sectors, and the related need to ensure efforts to prepare the workforce for the transition to net zero includes a focus on digital skills, as well as support and resources for business leaders.
- The need for sensitivity to the ways in which changes brought about by decarbonisation have the potential to affect the level of Welsh language use across sectors.
- Improved labour market intelligence, gathered for example through routine surveys, would facilitate understanding of current skills needs and comparisons between sectors as well as informing projections of future needs.

There are also some more specific actions which could be taken in each of these areas.

Just transition

- Engage in active planning to ensure a coherent and relevant skills offer is in place for workers vulnerable to the effects of the transition. Structural adjustment programmes and other forms of area- or sector-specific intervention could be useful, alongside the involvement of affected workers in planning.

- Ensure the new curriculum provides young people opportunities to learn about net zero, and does not reinforce existing inequalities.
- Careful messaging around reskilling to encourage older workers to remain in the workforce and to encourage them to move into the education sector to support the development of training and reskilling capacity.
- Joint future skills planning between education providers and industry to encourage transversal skills and smooth reskilling.

The education and skills system

- Long term planning, coordination and funding by the CTER bringing actors together to respond to future skills needs, including increased coordination amongst Welsh Government teams.
- Review the fees and payments system and support to remove financial barriers to training and reskilling.
- Increase the provision of flexible courses and improved signposting of courses.
- Encourage older workers with industry experience to move into the education sector to support the development of training and reskilling capacity.

Circular economy

- Framing the circular economy in terms of business efficiency, or sustainability and corporate social responsibility.
- Integrate circular economy principles into qualifications at all levels.

Digitalisation

- Digital skill training for employees and SME business owners.
- Support for SMEs to invest in digital technology with a dedicated scheme.
- Involve workers in social partnership discussions.

Welsh language

- Enhance the provision of locally provided Welsh language and Welsh medium courses.

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Annex: Sector categorisation

The research is organised according to the emissions sectors in Net Zero Wales (Welsh Government, 2021c). These sectors correspond in definition and scope to those set out by the National Atmospheric Emissions Inventory (NAEI) and adopted across the UK for carbon emissions reporting, with the exception of the 'industry and business' sector in Net Zero Wales which combines two NAEI sectors. **Table A1** sets out our understanding of these correspondences and outlines the sectors for which findings are presented.

Sectoral emissions reporting is based on emissions source rather than end use: for instance, emissions associated with the generation of electricity are accounted for under 'energy supply' rather than with the sectors which ultimately use this electricity (Department for Business, Energy and Industrial Strategy, 2022).

Table A1: NAEI Sectors and Net Zero Wales sectors

NAEI Sector	Net Zero Wales sector
Energy supply	Electricity and heat generation
Transport	Transport
Residential	Residential buildings
Business	Industry and business
Industrial processes	
Land use, land use change and forestry (LULUCF)	LULUCF
Agriculture	Agriculture
Waste management	Waste

Author Details

Greg Notman is a Research Officer at the Wales Centre for Public Policy.

Josh Coles-Riley is a Research Associate at the Wales Centre for Public Policy.

Dr Helen Tilley is a Senior Research Fellow at the Wales Centre for Public Policy.

Dr Jack Price is a Research Associate at the Wales Centre for Public Policy.

For further information please contact:
Dr Jack Price
Wales Centre for Public Policy
+44 (0) 29 2087 5345
info@wcpp.org.uk

Wales Centre
for Public Policy
Canolfan Polisi
Cyhoeddus Cymru