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Building a 'Fair and Fast' energy transition? Renewable energy employment, skill shortages and social licence in regional areas

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A B S T R A C T

Within techno-economic models for climate and energy scenarios, labour is assumed to be available just-in-time – even as cost-optimisation electricity system modelling typically generates development profiles with sharp peaks and troughs which would make labour supply and management very challenging. Local job creation is often framed as a key benefit for regional communities and important for building social licence in host regions to enable rapid, large-scale renewable energy development. Yet, whilst there is a large body of studies projecting employment volumes under climate and energy transition scenarios, there has been limited empirical research on the challenges, opportunities and solutions for labour supply and workforce development within local and regional labour markets.

Through a study of five renewable energy zones being established within an electricity system dominated by coal generation in New South Wales (Australia), our study contributes to the understanding of the employment constraints that could emerge and need to be addressed for a 'fair and fast' energy transition. As the global transition to renewable energy accelerates, local workforce development will become more important as competition for labour intensifies. However, significant barriers to building a regional workforce for renewable energy are identified including 'boom-bust' development cycles, the depth of regional labour markets in key occupations, competition for labour across inter-connected sectors, the concentration of socially disadvantaged communities in under-employed populations and demographic changes, especially population ageing.

Based on the case study, four key policy implications are identified for other jurisdictions. Firstly, 'smoothing' the development profile to avoid boom-bust cycles can be implemented consistent with renewable energy targets aligned with the Paris Climate agreement. Secondly, there needs to be a coordinated approach between government, industry and training providers to build training capacity – market-led approaches are unlikely to work for renewable energy in regional areas. Thirdly, training and employment pathways need to be built for diverse labour market segments to develop a regional workforce, including disadvantaged groups outside the workforce. Fourthly, renewable energy should be managed as part of an 'ecosystem' to develop a workforce that can move between renewable energy and adjacent sectors such as resources, infrastructure and manufacturing.

1. Introduction

Rapid decarbonisation of national energy systems is required to achieve greenhouse emission reductions in line with the Paris Agreement. Scenarios for rapid, large-scale decarbonisation and 100% renewable energy usually focus on technological pathways, examining physical, technological and market constraints or sensitivities to the optimal development pathway(s) [1,2]. Alongside the techno-economic scenario modelling, there is now widespread recognition of the importance of a 'just transition' to prevent less developed nations, low-income households and carbon-intensive regions bearing the costs of energy transition – both as a matter of equity but also to build social and political support for a rapid transition. The principles of just transition were incorporated into the Paris Agreement [3] and are an increasingly common feature of international instruments and national policy (e.g. [4]).

Employment and labour markets are central to the achievement of a 'fast but fair' energy transition. In nations and regions with significant

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coal generation, the transition to 100% renewable energy requires a spatial reorganisation of energy infrastructure from regionally concentrated coal-fired power stations to the rapid build-out of renewable energy generation, transmission and storage in new regions [5,1]. The rapid build-out of renewable energy and transmission requires the development of a workforce across regions which often have limited existing energy infrastructure - with risks of skill shortages, delays and cost over-runs which could impact on the speed and cost of the energy transition. For regional areas which host energy infrastructure, economic benefits including increased local employment are an important component to building social licence for future developments. However, employment practices that emerge to meet the challenges of a rapidly developing, cost-competitive industry in new regions may negatively impact on the renewable energy sector's social licence. For example, rapid construction schedules reduce the time for local workforce development (increasing the use of 'fly-in, fly-out' workers) and opportunity for investment in local manufacturing and supply chains. Support for renewable energy may be undermined if regional communities experience the negative impacts of short-term construction booms, such as local housing price surges, without the benefits of on-going local employment. Consequently, the development of a local and regional workforce is important to minimise the tension and conflicts between rapid industry development and social licence for renewable energy.

This paper undertakes an analysis of the challenges, opportunities and policy options for developing regional level employment in renewable energy and transmission through a case-study of Renewable Energy Zones (REZs) in the state of New South Wales (NSW), Australia. NSW is developing five renewable energy zones in regional areas to facilitate a transition from an energy-system dominated by coal-fired power. In the first section, the context and methodology are described. In the second section, employment projections for the REZs are detailed as context for the regional study. In the third section, barriers and challenges to growing local employment within five REZs are analysed. In the fourth section, policy implications and options for addressing barriers to growing a local and regional workforce for renewable energy are outlined.

2. Context and methodology

To date, there has been limited empirical research on the challenges, opportunities and solutions for developing local employment within renewable energy at the level of regional labour markets. For techno-economic models, labour is generally assumed to be available on-demand as required for energy infrastructure construction and operation. Cost-optimisation within energy models is based on just-in-time construction to minimise finance and build costs, producing large peaks and troughs in employment which in practice exacerbate the risks of constraints and shortages. With rare exceptions (e.g. Mallon & Hughes [6]), the risks of labour constraints are not considered in energy models. There is a body of literature on 'just transition' which primarily focusses on how to manage transition in declining coal regions, but rarely on the development of renewable energy infrastructure and workforce in new regions [5,7,8]. There is also a significant body of studies collecting data and modelling the quantity of employment for renewable energy at an international and national level (see [9]: 3; [10]) and sometimes regional level (see [11]). Whilst there is an emerging literature on structural and institutional barriers to the rapid scale-up of renewable energy incorporating supply chains, labour, and skills shortages (Ford & Hardy, 2020; Devine-Wright, 2011; Perlaviciute et al., 2018; Bergman and Eyre, 2011; Batel and Devine-Wright, 2015; Ambrose, 2020; Parag and Janda, 2014; Kuzemko and Britton, 2020), these are mostly national studies which do not undertake detailed analysis of regional and local labour market dynamics (del Río & Burguillo, 2008; Essletzbichler, 2012). Consequently, there is limited research at the regional level where the tensions between rapid energy transition and local job creation are played out. Policy-makers, industry and regional stakeholders need a better understanding of regional dynamics to inform their approach to local renewable energy workforce development.

NSW (Australia) is a good case to study the regional dynamics of renewable energy employment. In the 2020 Integrated System Plan (ISP) for Australia's National Electricity Market, the Australian Energy Market Operator (AEMO) outlines a series of scenarios for energy transition which all end in an electricity system with at least 85–90 per cent renewable energy in the mid-2030s.[1] A series of Renewable Energy Zones in regional areas have been identified by AEMO as the best locations for large-scale renewable energy generation and storage. In the three largest states, the New South Wales (NSW), Queensland and Victorian Governments are each currently developing programs to implement REZs.

The empirical research for this paper was undertaken within NSW. The NSW Government has developed an Electricity Infrastructure Roadmap ('the Roadmap'). Under the *Electricity Infrastructure Investment Act 2020*, there is a minimum target of 12 Gigawatts (GW) of new renewable energy generation and 2 GW of long-duration storage to be constructed by 2030 [12]. To achieve these targets, REZs have been established in five regions (Central-West Orana, New England, South-West, Hunter-Central Coast and Illawarra). The Hunter-Central Coast and Illawarra are regions in transition from fossil fuel production with a manufacturing base. Most of the new renewable energy and transmission infrastructure will be constructed in the three inland REZs of the Central-West Orana, New England and South-West. Both the New England and South-West regional economies are dominated by agriculture. The Central-West Orana REZ also has a strong agricultural sector but a more mixed economy including resources, manufacturing and public sector operations (see [13]).

Employment projections in this study were modelled using employment factors (Appendix A) mostly derived from surveys undertaken by the authors commissioned by the leading Australian renewable energy peak body, the Clean Energy Council [14] and Infrastructure Australia [15]. The Clean Energy Council study included large-scale surveys of the Australian wind, solar, hydro, and battery industries (see [16]), which led to reduced employment factors for wind and solar compared to previous work [17]. The Infrastructure Australia study derived employment factors for transmission construction of new lines and the associated infrastructure based on an industry survey [15].

The NSW Department of Planning, Industry and Environment commissioned research on the barriers and opportunities for local employment [13] as an input to an industry plan being developed by the NSW Renewable Energy Sector Board (RESB) for the Minister for Energy (the *'Baseline and Opportunities Study')*. Under the *Baseline and Opportunities Study,* a multi-method research methodology was used including:

- Supply chain mapping for renewable energy technologies (solar farms, wind farms, pumped hydro storage, battery storage and transmission construction).
- An online survey of regional businesses in renewable energy supply chains (200 complete responses and 57 partial responses).
- Economic and labour market profiling of the REZs.
- Qualitative research within each of the five REZs including 27 semi-structured interviews with 42 stakeholders and renewable energy sector experts and workshops (70 participants) to collect data on the opportunities, barriers and actions to support local industry development and employment.

This paper builds upon the empirical research undertaken for these

[1] At the time of writing (December 2021), the AEMO released the draft 2022 ISP. This analysis is based on the 2020 ISP. Whilst the 2020 scenarios are revised in the 2022 ISP – primarily including accelerated projections for the development of renewable energy – the fundamental trends are comparable.

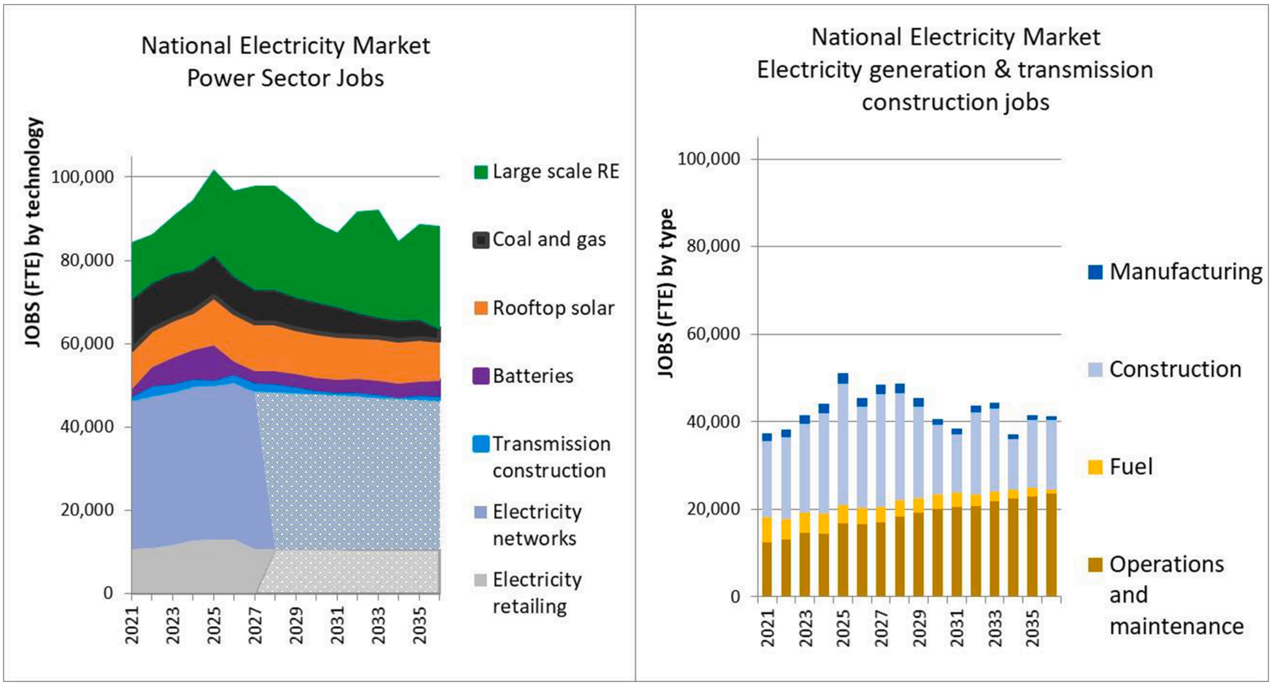

Fig. 1. Power Sector Jobs, all sectors (left) and Electricity Generation and Transmission Construction (right). Note: the employment projections for utility-scale renewable energy, coal and gas, rooftop solar, batteries and transmission construction are authors' calculations. The source for employment in the operation of the transmission and distribution network and electricity retailing until the mid-2020s is [19–21], after which employment is assumed to decline in line with trend for each sub-sector at the average rate for the preceding decade (−0.7% p.a. for electricity distribution, −0.3% p.a. for transmission and −0.1% for electricity retailing). The focus of the study was on electricity generation and transmission employment but network operation and electricity retailing employment was included to give a full estimate of employment in the electricity sector.

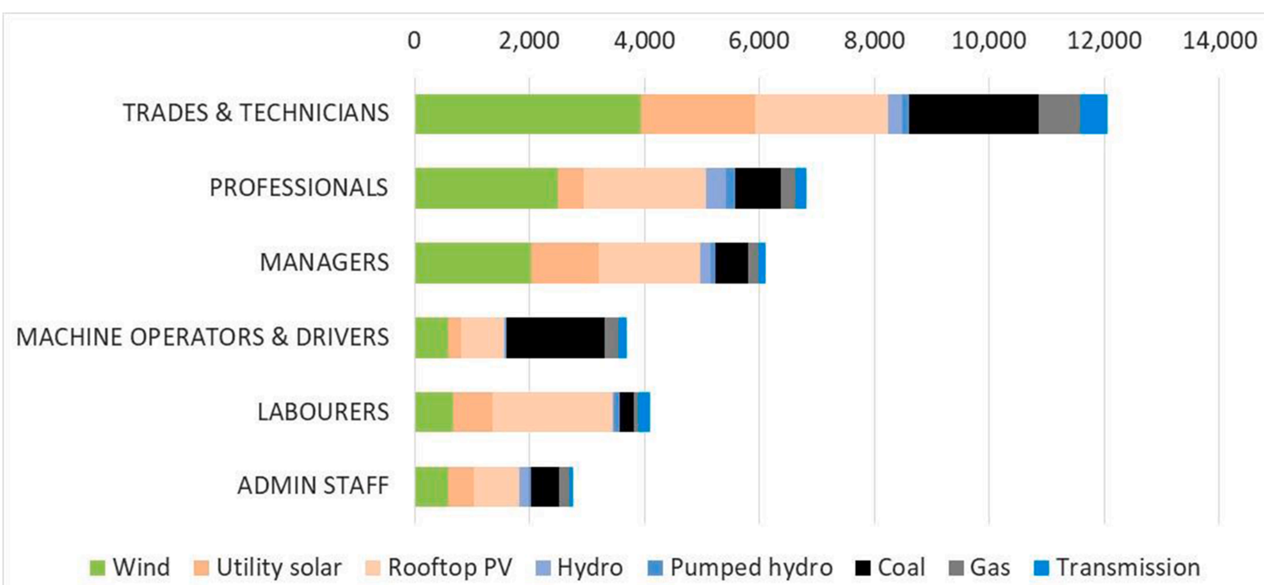

Fig. 2. Average Employment Demand 2021–36, by Occupation (1-digit) and Technology.

studies to analyse the barriers, opportunities and solutions to building a regional workforce for renewable energy.

3. Renewable energy employment demand: growth and volatility

Employment projections were developed by applying the employment factors (Appendix A) to annual renewable energy and transmission infrastructure installations under AEMO's [18] 'Step Change' scenario in the ISP (see Appendix B for capacity projections) . The Step Change scenario was modified to incorporate NSW modelling for the Roadmap undertaken after the 2020 ISP which accelerates the development of renewable energy in the REZs.[2]

[2] For more information on the survey methodology and employment factors, see [16] on renewable energy and storage technologies and Briggs et al. (2021) on transmission construction.

Across the National Electricity Market, power sector employment is projected to increase slightly, ranging between 80,000 and 100,000 jobs annually until 2036 ([15]: 15). Declining employment in coal and gas throughout the 2020s, and especially the 2030s as more power plants reach the end of their life - is more than offset by growth in transmission construction, battery storage, rooftop solar and especially large-scale renewable energy. Almost half of power sector jobs are in electricity network operation and retailing (Fig. 1). While construction employment in the generation sector dominates in the early peaks, operation and maintenance employment (O&M) grows steadily over time to almost half the projected employment as the renewable generation fleet increases. Notably, if the build-out occurs in line with AEMO scenarios, there will be sharp cycles of employment growth and decline following waves of construction activity..

The largest occupational group in electricity generation and transmission construction is trades and technicians (particularly electricians) (Fig. 2), which average around one third of total employment. Professionals and managers are the next largest groupings, together forming another one-third of the total employment demand.

While this study models employment on the most rapid transition pathway in the 2020 ISP, it is likely to understate both the pace and level of employment demand. For the draft 2022 ISP, AEMO [22] has included a 'hydrogen superpower' scenario with high levels of electrification and the development of a green hydrogen economy to fuel heavy industry, transport and for export. Under the energy superpower scenario, the scale of electricity demand would be almost 4.5 times the current size of the National Electricity Market with flow-on demand for employment. There is a wide range of employment demand scenarios in the electricity sector depending on the transition pathway, and the importance of smoothing the peaks and troughs increases with scale.

4. Barriers to increasing regional employment in renewable energy

The build-out of renewable energy in regional areas creates opportunities for local job creation. However, local employment varies significantly between projects, phases and regions as the renewable energy and transmission sectors source labour at different scales – recruiting from the international, inter-state and capital city workforces as well as local and regional areas. While maximising local employment in renewable energy is often a stated objective for governments, five key challenges were identified to growing local employment in the NSW REZs:

- Renewable energy development characteristics, especially industry volatility and boom-bust cycles;
- Training capacity limitations, especially in regional areas, which reduce the ability to rapidly upskill local workforces and address skill shortages;
- Competition for labour in interconnected supply chains and labour markets between renewable energy and adjacent sectors such as infrastructure construction;
- Regional labour market characteristics which limit the availability of local workforce supply for renewable energy;
- the quality of social and economic infrastructure in regional areas, which can limit the ability to attract and absorb an increased workforce.

4.1. The characteristics of renewable energy development create impediments to local workforce development

Some of the key features typical to renewable energy development create challenges for developing a local workforce. Firstly, once a project has secured finance, contractual requirements for delivery with financial penalties for delays often lead to rapid mobilisation for construction. Secondly, for most individual projects there will be a relatively short employment peak while the project is constructed (with the exception of hydro), followed by a smaller, on-going operations and maintenance employment. Australian survey responses found solar farms are typically twelve months construction projects – and elements of construction can be as short as four months. Wind farm construction typically requires around two-years (Briggs et al. 2019). Thirdly, there is often high uncertainty about the future project pipeline due to factors such as policy uncertainty and intense price competition between developers for government auctions or power purchase agreements with retailers. In Australia – and internationally [23] - renewable energy is prone to 'boom-bust' cycles.

The peaks and troughs in employment can be especially pronounced within regional labour markets, as illustrated by the NSW REZs (Fig. 3). If the development of renewable energy follows the Roadmap, employment would scale up quickly to a peak construction workforce of 3000 in the Central-West REZ and 5000 in the New England REZ before subsiding to a smaller, on-going workforce to maintain infrastructure mainly built in the 2020s. In the Hunter REZ, there are two peaks from the construction of utility battery storage and then wind and solar farms. Employment growth is more moderate in the South-West REZ.

These development characteristics create a range of challenges for developing a local workforce. Firstly, in the absence of a training program ahead of construction, the timeframe to develop a local workforce is tight. Secondly, workforce upskilling for single projects by a developer is a risky investment under conditions of uncertainty. The combination of short-duration projects and uncertainty on forward demand reduces the willingness and ability of the renewable energy sector to invest in local workforce development. As one wind industry firm (a global original equipment manufacturer, project developer and owner) noted in an interview:

> "I'd like to be doing more internships and graduate programs … (but) we've had an off and on-again market for 20 years … you don't have time to build a factory, you need line of sight. You can't plan for a long-term industry if you don't have a long-term policy and plan" (Briggs et al., 2020b).

Thirdly, attracting and retaining skilled workers in other industries can be difficult when continuity of work is not assured. Fourthly, volatility also creates uncertainty and barriers to increasing local manufacturing and supply chain employment, either from external investment or investment by local suppliers to scale up operations – especially for small and medium enterprises in regional areas.

4.2. Training capacity needs to be increased for rapid workforce upskilling for renewable energy

In the survey of NSW regional businesses for the *Baseline and Opportunities* study, skill shortages were identified as the major barrier to increasing participation in renewable energy supply chains (Fig. 4).

In qualitative research for the *baseline and opportunities study*, there were frequent references to skill shortages in regional workshops and stakeholder interviews [13]. Australian renewable energy industry surveys have identified 'recruitment difficulties' for key professionals and managers (electrical, civil and mechanical engineers, construction managers and site supervisors), trades and technicians (electricians, electrical and mechanical technicians for wind farm maintenance) and specialised trades and labourers (transmission lineworkers and riggers, and crane operators) ([15]: 21).

Skills shortages are driven by a range of factors both external and internal to the renewable energy sector. The supply of skilled labour is influenced by the performance of the training system. A series of formal reviews at National and NSW level have identified structural issues with the Vocational Education and Training (VET) sector [24,25,26,27]. At a systemic level, factors identified in reviews include under-resourcing for staff and equipment and lower entry rates as trades and VET have

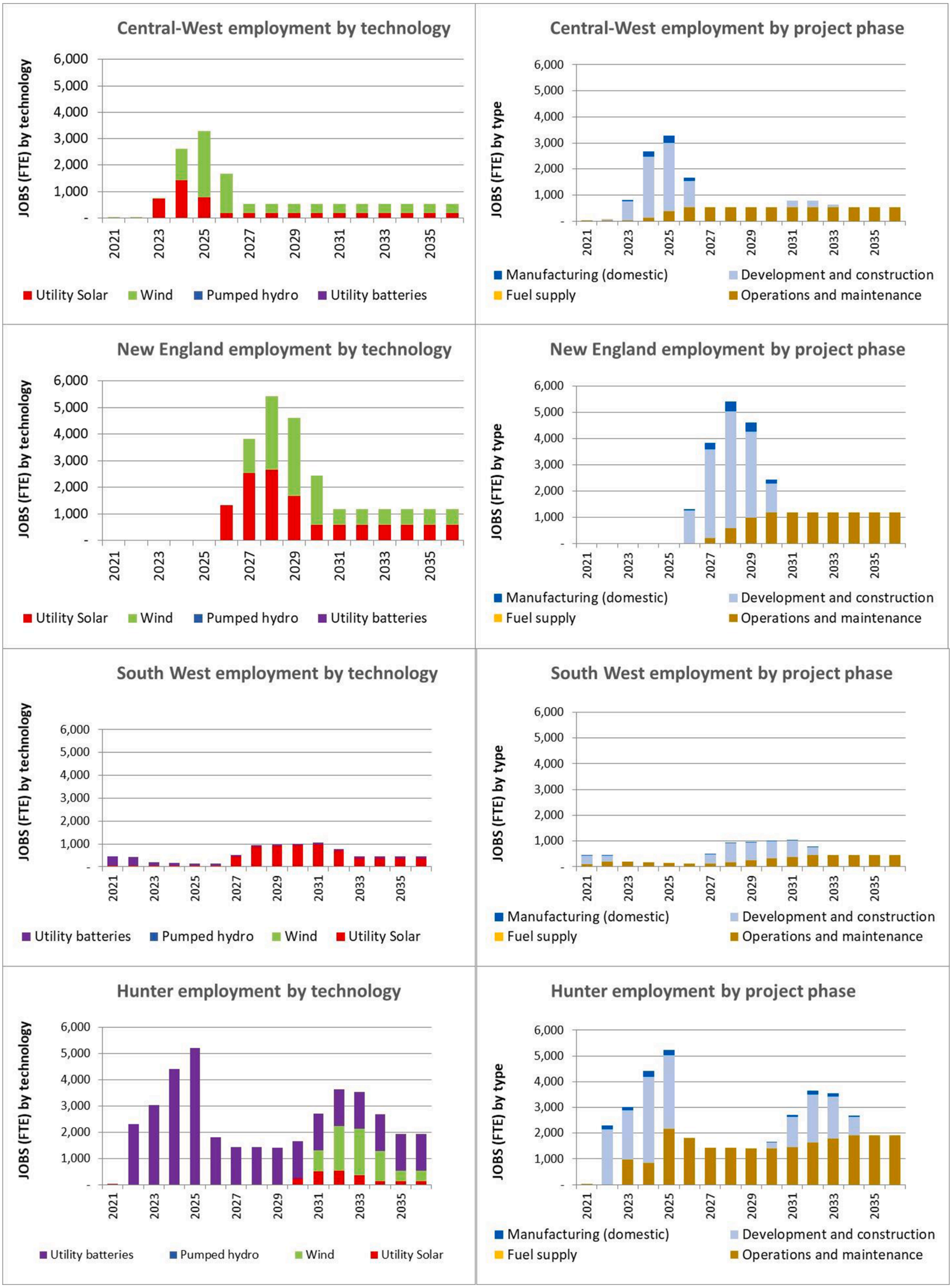

Fig. 3. Projected regional renewable energy employment by technology and project phase.

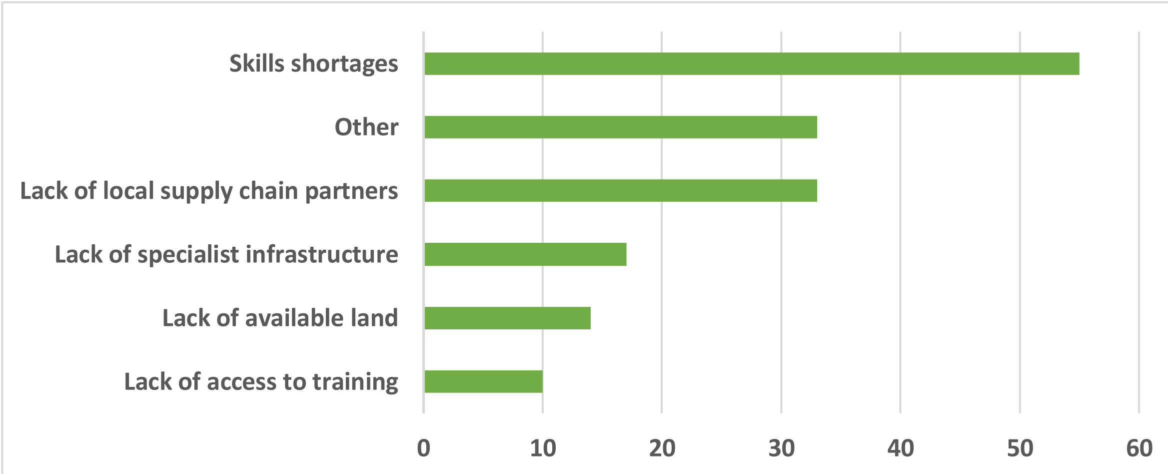

Fig. 4. Primary constraint to realise opportunities from renewable energy and transmission projects, business respondents. Note: survey respondents that answered ‘other’ were provided with a text-box to explain. A significant number of the ‘other’ responses also referred to skill and labour shortages.

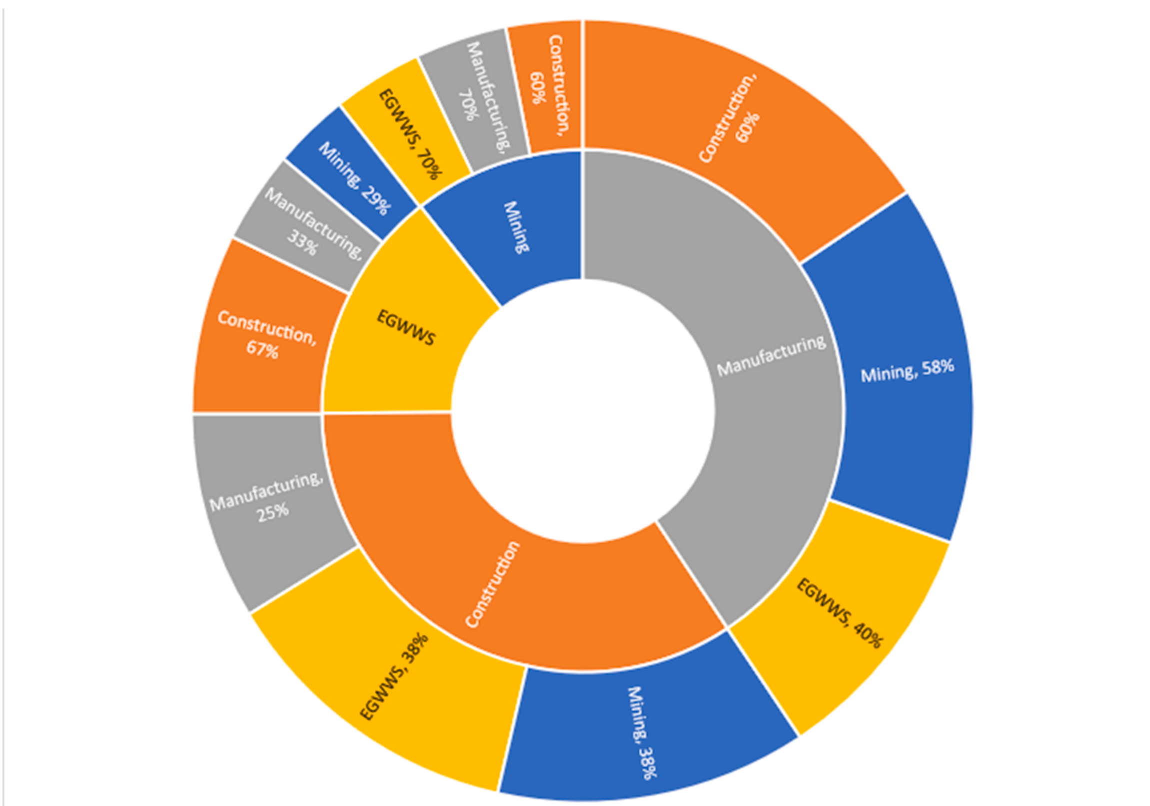

Fig. 5. Interconnections between renewable energy businesses and adjacent sectors. Source: ISF & SGS 2021: 31–32.

become less attractive relative to university education for school-leavers and young people. Low enrolments have resulted in rationalisation of training packages that could otherwise provide the core foundational skills required for renewable energy construction. Relative pay differentials between industry and training jobs create barriers to attracting new trainers to the VET sector contributing to an ageing trainer workforce. Consequently, formal reviews have concluded there are ‘chronic skill shortages, particularly in the trades’ ([26]: 87) and key professions such as engineers ([28]: 9).

However, there are factors specific to renewable energy which amplify systemic issues in the training system. In particular, renewable energy faces the challenge of building training capacity in the context of ‘thin markets’, as demand for specialised renewable energy training is volatile and spread across the regions. Industry experts interviewed for the *baseline and opportunities* study noted capital expenditure on new equipment is high and specialist training can be expensive to set up. The low demand in regional areas combined with high set-up costs of specialist training makes it commercially unattractive for private training organisations and public training organisations in the context of reduced funding. Consequently, there is an under-supply of the specialised training needed to scale up local workforces in the NSW REZs [13].

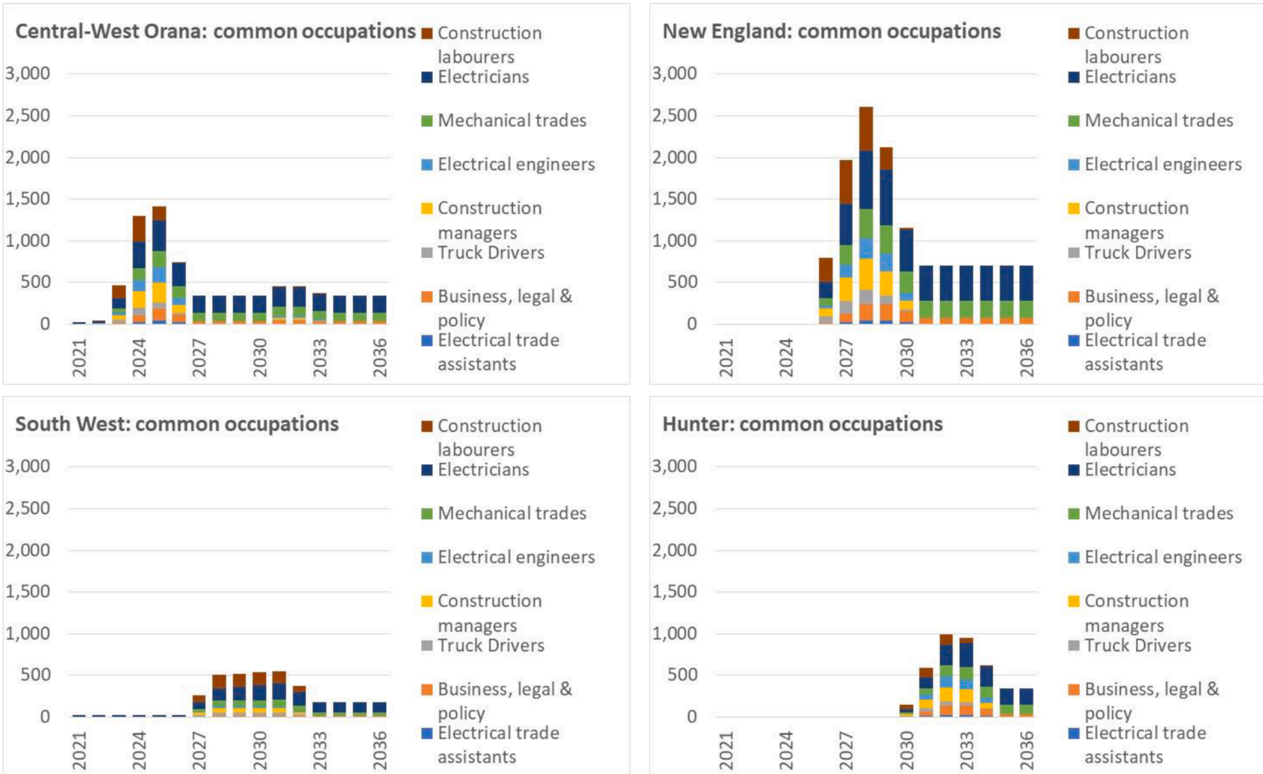

Fig. 6. Employment Demand, Common Occupations by REZ, 2021–2036.

4.3. Renewable energy supply chains and workforce are interconnected with adjacent sectors creating competition for labour

Within regional economies, the energy transition can be more complex and nuanced than a simple shift 'from coal to renewable energy'. The survey undertaken for the *Baseline and Opportunities Study* found a high level of interconnection between regional businesses operating in renewable energy, infrastructure, manufacturing and resources supply chains (Fig. 5). The inner circle shows the primary sector of business respondents, with most businesses operating in renewable energy identifying construction, followed by manufacturing, electricity, gas, water and waste services (EGWS), and mining as their primary sector. The outer circle is the secondary sector, and shows, for example, that nearly 40% of construction businesses within renewable energy also operate in EGWS. Just under 85% of the respondents have operations in one or more secondary sectors illustrating high inter-connections (outer circle in Fig. 5).

Renewable energy industry surveys have also found interconnections between labour markets. In a survey of Australian renewable energy businesses in 2019, around 20 per cent of respondents nominated competition for labour as the key reason for 'recruitment difficulties' and observed retaining employees could be challenging when activity increased in the mining and infrastructure sectors ([14]: 57).

The structural inter-connections and competition for labour between sectors is likely to intensify as Australia enters what Infrastructure Australia [28] has described as an 'unprecedented infrastructure boom'. Based on committed projects, there is $52 billion of infrastructure projects scheduled to occur in the next five years. Infrastructure Australia [28] projects employment would need to increase 48% to meet committed public infrastructure investments, more than eight times the projected workforce growth of 3.3.%, and identifies as many as 34 out of 50 occupations where there could be shortages. The renewable energy sector will be attempting to attract and retain labour in regional areas as it scales up in the context of very high inter-sectoral competition for workers.

4.4. Regional labour market characteristics can create barriers to local employment

Broadly, there are three primary options for expanding the renewable energy workforce within a region:

- transferring workers from adjacent sectors in occupations with relevant skills through recruitment and retraining;
- recruiting new workforce entrants from school, university and VET;
- increasing labour utilisation from the unemployed, under-employed or persons not currently in the labour force.

However, the capacity to increase the workforce through these channels is mediated by regional economic and labour market characteristics. In particular, our analysis of the NSW REZ highlighted the influence of four key labour market dimensions:

- the size of the labour market and depth in key occupations;
- labour utilisation;
- the composition of surplus labour and concentration of social disadvantage; and
- demographic changes, especially the size of new workforce cohorts and population ageing.

4.4.1. Labour market size and occupational depth

In relation to labour market and occupational size, renewable energy employment demand in major occupational groups is large relative to the existing local workforce in key or common occupations for the NSW REZs. Based on a list of key occupations identified through industry survey (Briggs et al. 2019), employment demand for key occupations were generated for each REZ (Fig. 6).

Employment demand for key occupations exceeds current labour supply for two REZs in peak periods (New England, South-West) and peaks at around two-thirds of current supply for the Central-West. Only

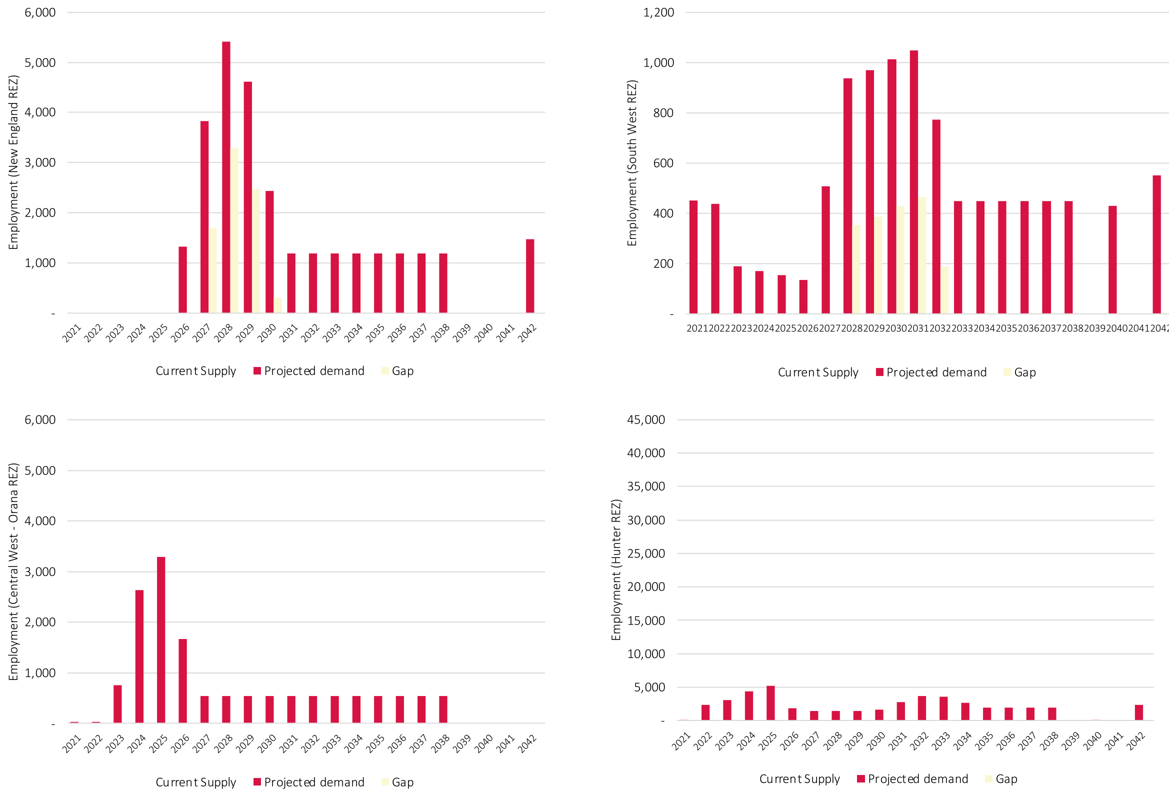

Fig. 7. Labour Supply and Demand, Common Occupations. Note: New England (top left), South-West (top right), Central West (bottom left), Hunter Valley (bottom right). Source: Employment projections were generated based on AEMO scenarios and employment survey data as outlined in the context and methodology section. The source for total employment for key occupations is ABS [29].

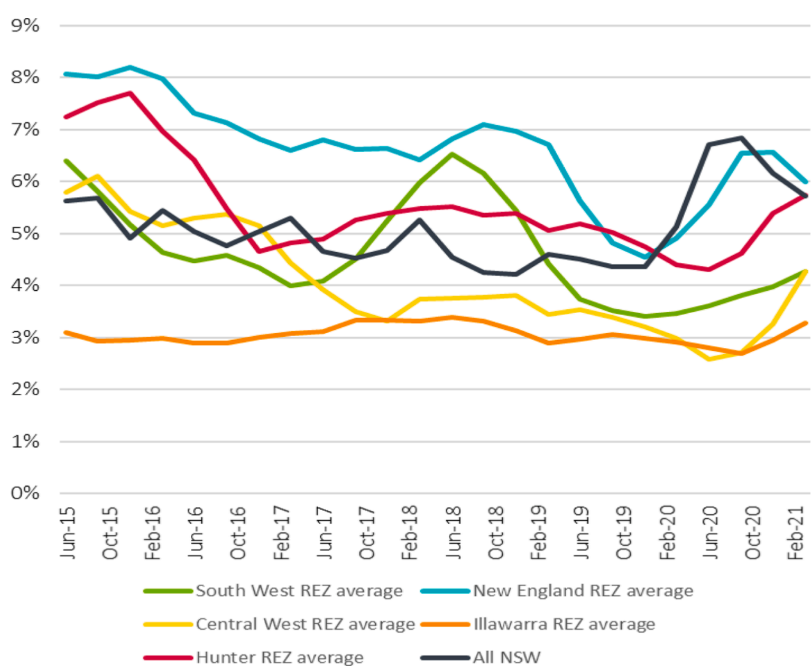

Fig. 8. *Unemployment, All REZs* versus *NSW, 2015 to 2021 (%)*. Source: Department of Education, Skills and Employment, 2021.

in the Hunter REZ, which has a large industrial base and lower employment demand, does the supply of key occupations clearly exceed projected demand (Fig. 7).

For the three REZs where most of the renewable energy infrastructure will be constructed, the size of local labour supply limits capacity to meet employment demand, especially where there are sharp demand peaks.

4.4.2. *Labour utilisation in regional labour markets*

The level of labour utilisation and spare capacity is another key factor. While current data is limited, the level of spare labour market capacity in NSW regions is often relatively low (Fig. 8). Unemployment

Table 1
First nations persons, employment status, central-West Orana, New England and South-West REZs.

	Full-time	Part-time	Unemployed	Not in labour force	Total
Central-West Orana	26.9%	15.2%	10.2%	47.7%	100%
New England	19.4%	15.7%	9.9%	55.0%	100%
South-West	31.1%	15.6%	8.0%	45.3%	100%

Source: ABS Census 2016.

rates for the REZs in recent years have ranged from 3% (Illawarra), 4 – 6% (Central-West, South-West) and 5 – 8% (New England, Hunter). Data for under-employment is not available at regional level, but at an Australian and NSW level under-employment closely tracks and doubles the unemployment rate (ABS 2021). Overall, the level of spare labour capacity is generally low to moderate.

Labour utilisation data also highlights the likelihood of significant competition for labour with other sectors.

4.4.3. Composition of surplus labour capacity

In addition to the size of the pool of surplus labour, the composition of the unemployed, under-employed and persons outside the workforce influences the capacity to increase the size of the regional workforce. Of particular note is the higher proportion of First Nations persons in the unemployed and outside the labour force the inland REZs reflecting wider social and economic disadvantage (Table 1).

The relatively high concentration of socially disadvantaged First Nations persons in the surplus labour capacity represents both a challenge and opportunity. There are examples of solar farms and transmission line construction projects in Australia engaging significant numbers of First Nations persons from outside the workforce. Out of a peak workforce of 300 persons, the Karadoc solar farm (Victoria) engaged 90 long-term unemployed persons, 38 First Nations persons and 12 persons on community-based orders. 70 per cent of the workforce had not previously worked on a solar farm. At the Bomen solar farm in Wagga (NSW), 75 per cent of the workforce were local persons including 15 per cent First Nations persons (Hicks et al. 2020: 32, 38).

However, active labour market, training and social programs by businesses and government are required to enable employment of First Nations persons who are unemployed or not in the labour force. Strategies used by projects that have employed First Nations persons include collaborations with recruitment businesses with established relationships within First Nations communities, pre-employment training to bridge skills gaps and for employability, mentoring for new employees and cultural training for the existing workforce to support integration of First Nations persons [30]. In short, there is surplus labour that can be utilised to both expand labour supply and reduce social disadvantage within the NSW REZs but active labour market, training and human resource strategies are required.

4.4.4. Demographic changes

The inland REZs have disproportionately lower levels of the population in key working age cohorts with older workforces than the NSW or Australian average.[3] The South-West REZ is typical of the Inland REZs (Fig. 9) with lower proportions of the population in prime working-ages and higher proportions of young people and older people over 50-years of age.

Consequently, population is projected to grow modestly over the next 25-years in the inland REZs - respectively, Central-West Orana (7.5%), South-West (3.7%), New England (2.4%) – and population ageing represents a challenge to maintain workforce size. However, each of the REZs do have a higher proportion of 10–19 year-olds. Young people have left the regions for economic and lifestyle opportunities in higher numbers in recent decades [31]. There is an opportunity for the renewable sector to grow the regional workforce if it is able to attract and recruit school leavers and university students.

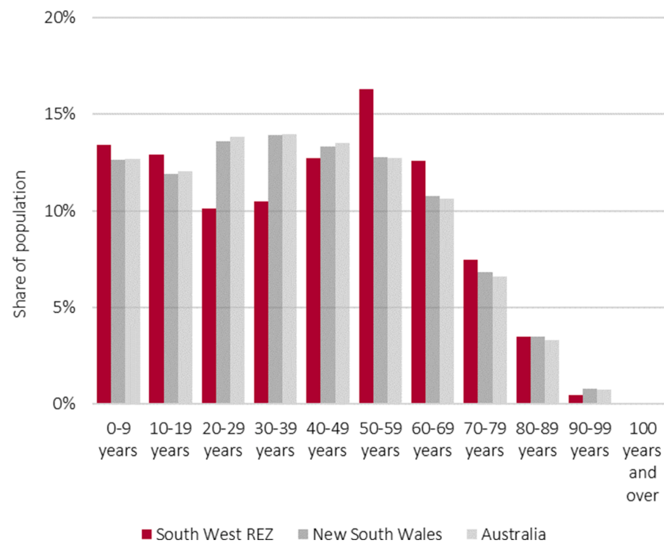

Fig. 9. Population Age, South-West REZ versus NSW and Australia (%). Source: ABS 2016.

4.5. Regional infrastructure and services capacity constraints create barriers to workforce growth and attraction

Regional government staff interviewed for the *baseline and opportunities* study viewed the REZs as an opportunity to permanently increase the workforce as workers enter the region for a project and settle in the area. However, the quality of economic and social infrastructure is considered by industry and regional stakeholders to be a barrier to attracting investment and workers into regions – especially in the short-term as the workforce swells during construction and exceeds the capacity of local social and economic infrastructure such as childcare, health services, schools, accommodation and housing. One battery manufacturer said they were reluctant to relocate because of concerns with retaining staff ([13]: 75). While the evidence is anecdotal, it highlights the potential for economic and social infrastructure to be a barrier to permanent regional workforce growth and that investment across other economic and social domains could be required.

Together, these factors represent significant barriers to local renewable energy workforce development and growth. Some of these factors may be specific to the circumstances of NSW and Australia, but a range of these factors are likely to apply in other regions, including volatile employment profiles with high demand relative to labour market size, thin training markets and the characteristics of regional labour markets. With tight delivery timeframes for large-scale projects, these barriers increase the likelihood of project developers relying heavily on a fly-in, fly-out workforce recruited from cities, other regions and abroad.

5. Policy implications for other jurisdictions

The challenge of building a regional workforce for renewable energy will be common to many jurisdictions. In many cases, there will be limits to the capacity of regional labour markets to supply workers which are assumed to be available in modelling scenarios. The focus of electricity sector modelling is usually to find the least cost supply scenario to meet energy demand. While the employment demand is sometimes modelled,

[3] The two REZs in industrial regions are projected to experience rapid population growth – Hunter (24%) and Illawarra (24.7%)

Table 2
Evaluation of development pathways for the NSW REZs.

	Late	REZ-aligned	Early	Supply chain adjusted
Financial Costs (Net Present Value, $bn)	35.78	36.91	36.57	36.06
Cumulative greenhouse emission relative to Late	–	−22.8 Mt C02e (−7%)	−44.23 Mt CO2e (−14%)	−25.7 Mt CO2-e (−8%)
Resilience	Delayed schedule provides least flexibility and is the most vulnerable to uncertainties	Coordinated build aligns with other REZ developments and allows for advance or delay against plan in response to uncertainty	Advanced schedule is vulnerable to misalignment with other developments including transmission augmentation	Adjusted schedule offers the most resilience as it provides the greatest opportunity to respond to uncertainties
Competition	Late peak provides minimal learning opportunities	Peaks in build reduce opportunity for participants to refine bids over time	Peaks in build reduce opportunity for participants to refine bids over time	Frequent low volume tenders leads to better value bids over time
Minimises supply chain constraints	Supply chain risks compounded if network augmentation delayed	Supply chain risks exist based on generation build peaks	Supply chain risks exist based on generation build peaks	Lowest risk of supply chain constraints

Source: table adapted from AEMO Services [[32]: 53].

this very rarely includes consideration of the match with labour supply or the ability to make these scenarios a reality within regional labour markets. Building regional labour supply in renewable energy is important to realise energy transition scenarios and maintain social licence for a rapid transition.

Our analysis highlights four key implications for policy-makers in other jurisdictions to better match labour supply with labour demand and increase local employment in renewable energy:

- Firstly, employment and supply chain considerations need to be bettter integrated into electricity sector planning for greater certainty on industry, employment and training demand, preferably including smoothing of the development profile to reduce boom-bust cycles;
- Secondly, there should be a coordinated approach between government and industry to increase training investment, develop training system capacity and increase local workforce supply;
- Thirdly, developing a regional workforce to meet the employment demand for renewable energy is likely to require building training and employment pathways for diverse labour market segments;
- Fourthly, labour development in renewable energy in regional economies should be managed as a 'skills ecosystem' that also includes adjacent sectors

Employment demand is highest in the construction phase but it is also important for policy-makers to focus on industry development and employment throughout the project lifecycle. For example, regional employment in professional jobs in the project development phase is typically low (but could be increased through, for example, auction criteria). workers with mechancial skills in adjacent sectors and agriculture can be engaged as operation and maintenance staff, coal mining workers could be transitioned into mining and mineral processing for renewable energy technologies and there are other opportunities such as regional recycling hubs for end-of-life technology management which

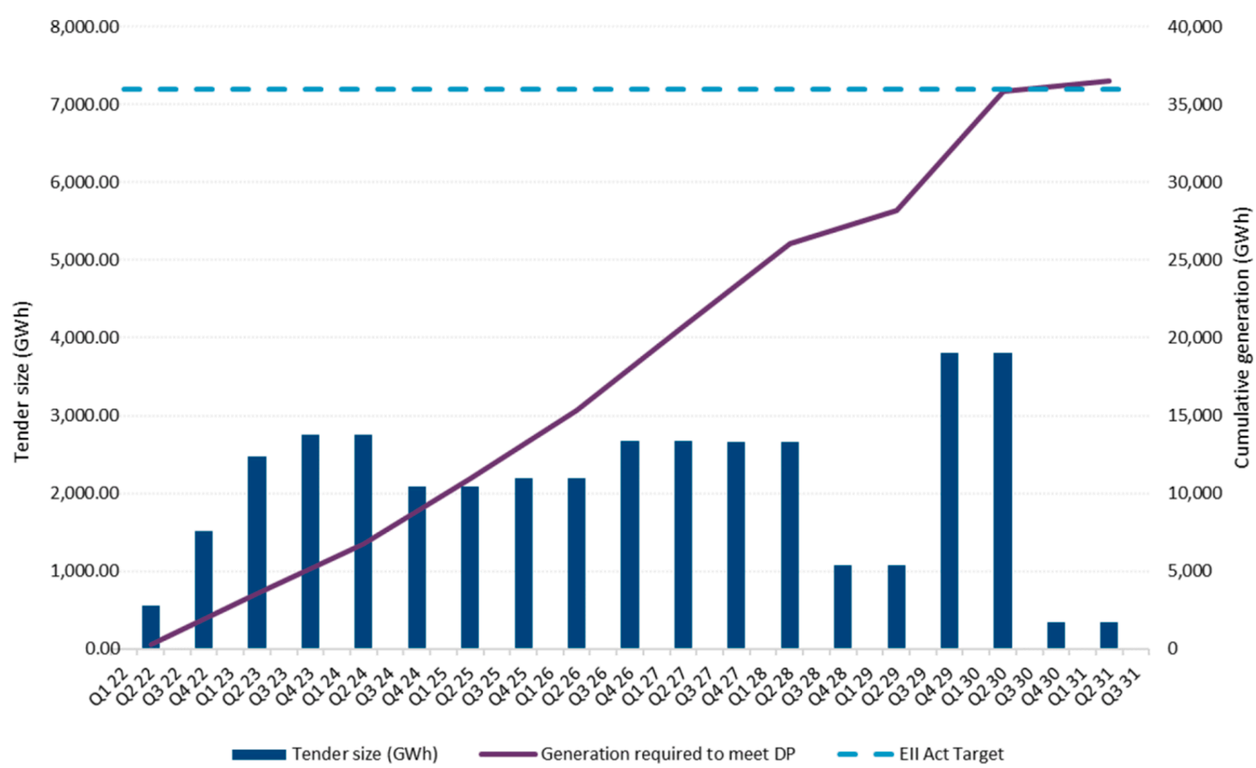

Fig. 10. *Generation Development Pathway, NSW REZs.* Source: AEMO Services [[32]: 7]. Note DP = Development Pathway.

are not yet well analysed.

5.1. Integrating employment and energy planning: 'Smoothing' the deployment profile of renewable energy

There is a strong case to integrate employment considerations into electricity sector planning and smooth development profiles to reduce the severity of boom-bust cycles. There is a higher level of fluctuation inherent to construction-based sectors such as renewable energy, which can be significantly exacerbated when projects are cluster due to policy actions, These large upward and downward swings increase the risk of exceeding regional labour market capacity, creating project delays and costs to secure labour. Less uncertainty and better signalling of forward demand is important to enable planning and investment in training and industry development.

Table 3
Policy levers to increase regional labour supply.

Labour supply source	Description	Policy implication examples
School leavers and new entrants	Increasing the supply of young workers with professional, trade and technician skills.	As a new sector, industry and regional stakeholders widely observed that school leavers in NSW often don't understand the training pathways and employment opportunities in the renewable energy sector. Policy options to increase the participation of young people (and stop the drift away from the regions) include industry engagement with school students, career counselling, internships and pre-apprenticeship courses in schools.
Increased supply from outside the labour market	Increased labour supply from unemployed and persons out of the workforce	Labour market programs and pre-employment training to increase employability of disadvantaged labour market groups. can increase labour supply and reduce social disadvantage. In NSW, First Nations communities represent a higher proportion of unemployment, but programs could be delivered through specialist employment services firms located within and run by indigenous communities.
Mature-aged trades	Recruiting mature-aged workers into trades	The experience of mining booms in Australia has illustrated programs can accelerate trade completions amongst mature-aged groups within eighteen months. These groups include people with incomplete apprenticeships. defence personnel with engineering skills, related trades and trade assistants with skills but not formal qualifications ([34]: 3).
Increasing female participation	Increasing the employment of women which is estimated at just 13 per cent of the construction workforce ([28]: 91).	Industry-led programs to increase female employment by, for example, engaging specialised project officers, changing workplace culture and improving access to childcare
Attracting skilled workers into regions on a long-term basis	Attracting skilled workers to settle in the region	Attracting and retaining labour into regions – instead of a fly-in, fly-out model - through marketing programs, relocation incentives and investment in social and economic infrastructure to sustain larger populations.

In practice, there are questions that would need to be answered on smoothing the development profile. How much should the development profile be 'smoothed'? If renewable projects are pushed back, can emissions reductions targets still be achieved, and conversely, what are the cost implications if projects are brought forward? Is there a trade-off or tension between smoothing development profiles and rapid energy transition aligned with Paris Climate Agreement commitments? How in practice can smoothing be achieved?

The NSW approach provides some lessons for other jurisdictions. The NSW REZ targets would lead to a projected increase of the share of renewable energy from just over 25 per cent to over 80 per cent by 2030, broadly consistent with a 1.5° emissions reduction trajectory. AEMO Services [32] has published a draft 20-year development pathway for capacity auctions to achieve the NSW generation and storage targets. The end-targets in 2030 were fixed but AEMO Services considered a range of development trajectories:

- 'early build': bringing forward construction schedules as early as possible;
- 'late build': back-ending construction schedules as late as possible; and
- REZ-aligned' build: construction of new generation and transmission infrastructure aligned until 2030;
- a 'supply-chain adjusted' build: aligned generation and transmission build but with maximum and minimum annual capacity limits (i.e. smoothed).

Using a multi-criterion analysis, the supply-chain adjusted build (Table 2) was found to deliver the best results.

The late build pathway was modelled to deliver slightly lower costs and the early build pathway would have the least cumulative emissions, but the supply-chain adjusted build (reproduced in Fig. 10) was found to create lower delivery risk, more resilience to shocks and better scope for learning and competition between suppliers ([32]: 10–11). AEMO Services concluded there was a modest cost and emissions penalty in exchange for a lower risk development pathway.

Fluctuations would not be eliminated under the smoothed development pathway (Fig. 10) but are much less pronounced across most of the construction period and there is a signal for the industry that encourages investment in local training and industry development. Further analysis should be undertaken to analyse the potential for smoothing development profiles in other contexts, but the case of NSW demonstrates capacity auctions can establish a platform for smoothing aligned with ambitious targets that could be deployed by other jurisdictions.

5.2. A coordinated approach between government and industry is required to rapidly scale up training investment

A major scaling-up of training is required to develop a skilled workforce for the renewable energy and transmission sectors. The general approach to skill development for renewable energy to date in Australia can be characterised as a fragmented, market-based approach (see [33]: 14–17). Public investment in training programs or resources for renewable energy has been intermittent and industry-level training initiatives have been rare. At the firm level, disincentives identified such as policy and labour demand uncertainty have led to insufficient training investment and reliance on importing labour. One of the consistent themes to emerge from interviews with renewable energy, transmission and training stakeholders over a 2-year period was a need for greater industry coordination and collaboration between industry, government and training authorities to improve local skill formation and employment [14,15,13].

'We want to have that partnership at regional level to be able to attract staff … there is incredible scope for the long-term opportunity to develop workforce – but it needs a holistic view. A collaborative approach to industry and training workforce. We have a highly fragmented workforce in Australia … people try to stitch together careers or otherwise we seek the international workforce' (Transmission construction survey respondent, [15]: 11).

Public investment is required to create a training system with the capacity to build a regional workforce for renewable energy. In the context of thin regional markets and uneven demand, private training providers are unlikely to create training capacity on their own. Public funding is therefore needed to create training capacity – by for example expanding training courses, increasing the volume of trainers, investing in training centres and infrastructure to extend the reach of training in regional area (e.g. mobile training units) and platforms for workforce redeployment (e.g. 'micro-credentials' systems for retraining workers from other sectors). Private sector training organisations can play an important role in delivering training but 'the market' will not deliver on its own for renewable energy workforce development in regional areas - public investment and infrastructure will be needed to enable the market.

Mechanisms are needed to increase industry involvement and investment in training, especially to resolve 'collective action' or 'free-rider' barriers. To build the pool of skilled labour in a region, firms need to invest in apprenticeships, trainees, and other forms of site-specific training. In the context of project-based construction, there are opportunities and incentives for free-riding. There are a range of mechanisms which could be used including voluntary coordination via an industry association, industry training levy and incentives and minimum training requirements through government auctions.

5.3. Building a regional workforce for renewable energy

Due to the depth of regional labour markets and other constraints, building a regional workforce for renewable energy will require a multi-dimensional strategy to increase labour supply from a range of pathways. These labour market segments include school leavers and new entrants, disadvantaged groups outside the labour market, workers in adjacent sectors and other regions. The key labour market segments in the NSW context and illustrations of policy levers are outlined in Table 3 drawing upon industry, regional and training stakeholder workshops and interviews for the Baseline and Opportunities study [13].

5.4. Renewable energy employment needs to be managed as part of a 'skill ecosystem' encompassing adjacent sectors within regional economies

One of the findings from the business survey for the *Baseline and Opportunities Study* is that renewable energy is part of a 'skill ecosystem' [35] with inter-connections across other sectors such as resources and infrastructure construction. Managing workforce and skill development across sectors can help address barriers to training investment such as thin markets and project-based employment. A 'skill ecosystem' approach could deliver both a more sustainable labour supply and better employment continuity and career paths for workers. Typically, a 'skill ecosystem' approach involves collaboration to align training provision with industry needs and an approach to skill development that includes not just increasing training supply but also workforce development for the acquisition, use and renewal of skills on-site. Interventions are designed across an industry and/or region – not just at an individual firm level [36]. Overall, a skill ecosystem approach aims for a more holistic approach across a place, sector or supply chain that addresses labour market and workplace factors that impact on labour supply and skill development as well as training supply.

Using NSW REZ as an illustration, the original driver was to coordinate transmission and generation investment but there is a platform for a skill ecosystem approach. Working groups could be established with representation from a range of stakeholders (government, key industries, regional development agencies, unions and training organisations) as a mechanism for collaboration between sectors to manage labour demand. Collaboration could range from simple information sharing (e.g. project pipeline and labour demand) through to mapping skills, auditing local training capacity and identifying local workforce training to deeper coordination of workforce requirements such as developing and implementing mechanisms for workforce redeployment. Industry stakeholders observed that this kind of coordination occurs in coal power station maintenance where workers move between scheduled projects to avoid labour constraints ([15]: 39).

Closely associated with a skill ecosystem approach is the development of mechanisms to facilitate workforce mobility and redeployment. One element of the solution is training to create portable skills to enable redeployment:

Training targeted on the renewable energy sector should invest in skills that are portable. Even with efforts taken to adopt a smooth transition approach, employment in development, construction and installation may be volatile. In occupations linked to operations and maintenance, there may also be periods when scope to employ newly trained workers will be limited. Education and training courses should therefore be built around a core qualification that will be useful in a broader range of sectors ([23]:9).

Beyond training for core skills, there are other options to increase workforce redeployment such as:

- a 'digital passport' for recognition of workforce skills and qualifications;
- a common on-line platform for jobs and apprenticeship listings to reduce transaction costs;
- a micro-credentialling framework and training that target identified skills shortages by extending the skills of workers in adjacent sectors;
- portable employment entitlements linked to continuity of service (e.g. long service leave) within the renewable energy sector;
- Development of the Group Training Organisations sector to share apprenticeships between employers and projects.

6. Conclusions

Employment and labour markets - and the associated skill shortage and social licence risks – are under-considered within energy transition studies, electricity sector modelling, and strategies. Within techno-economic models, labour is assumed to be available just-in-time, even as cost-optimisation modelling generates development profiles with sharp peaks and troughs which would make labour supply and management very challenging and impacts on social license by reducing local and regional employment. The combination of rapid growth and uneven development in regions which mostly do not have energy infrastructure creates a significant risk of skill shortages, delays and cost impacts and social licence issues which could impact on the speed of the energy transition. This article is based on detailed empirical research of the barriers, opportunities and policy-options for developing local employment at a regional level within a coal-dominated jurisdiction (New South Wales) to contribute to understanding of the employment dimensions of clean energy transition.

There are three key conclusions. Firstly, employment growth from renewable energy outstrips the decline in fossil fuel employment – in line with a large body of other studies (Ferroukhi et al., 2020; Cai et al., 2014; Rutovitz et al., 2009, 2010, 2012; Teske et al., 2012, 2015) – but the growth is volatile. Secondly, there can be significant barriers to building a regional workforce for renewable energy to deliver on a rapid energy transition, including the size of the labour market and depth in key occupations, high levels of labour utilisation, the composition of surplus labour and concentration of social disadvantage in regional areas. Thirdly, notwithstanding these challenges, there are a range of

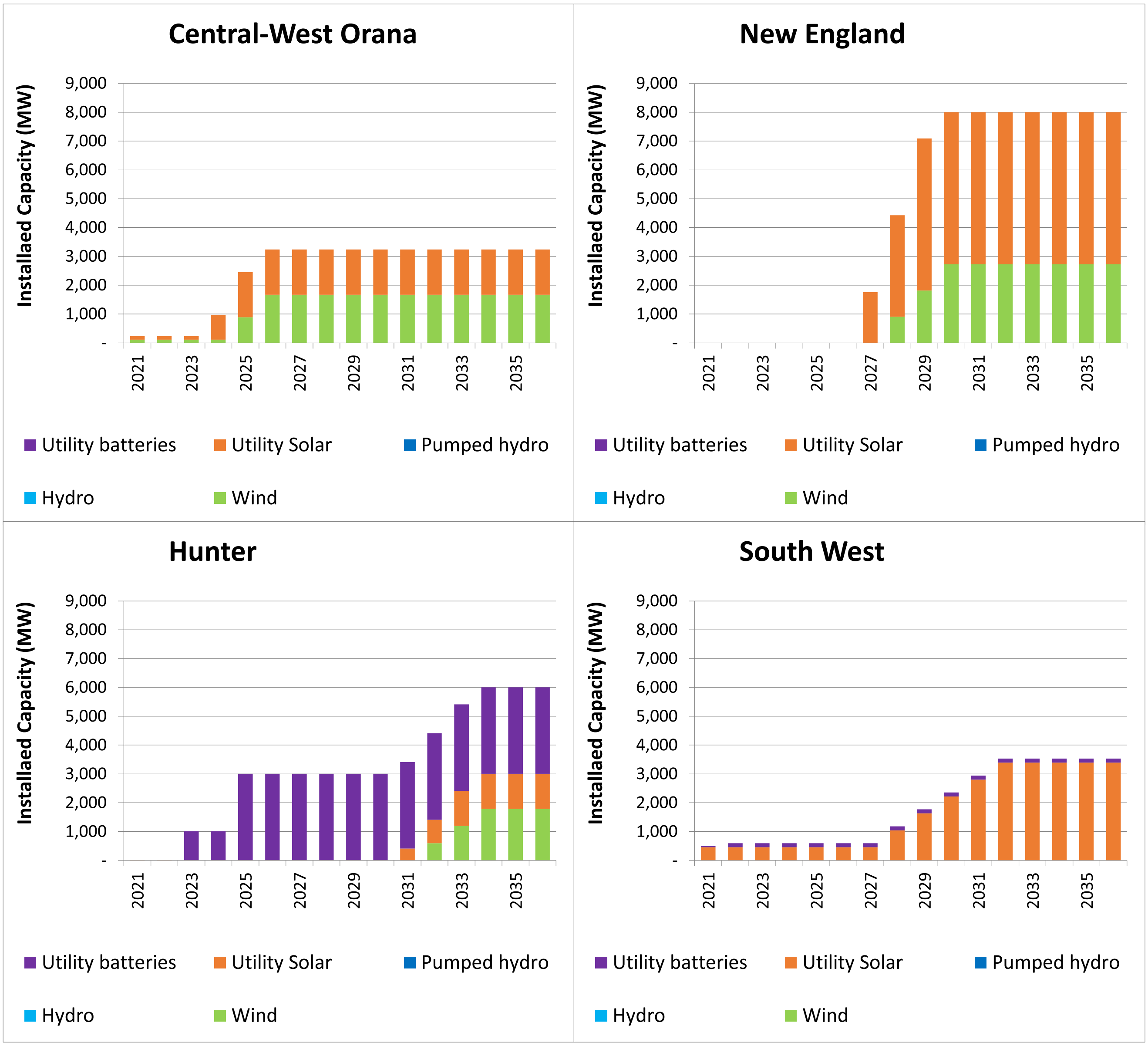

Fig. 11. Installed capacity by NSW Renewable Energy Zone, 2021 - 2036.

policy options available to increase regional employment.

The NSW case study illustrates smoothing the renewable energy development profile tcan be aligned with ambitious climate targets to facilitate local investment in workforce and industry development. Government and industry collaboration is required to scale up training investment but an effective strategy needs to go beyond increased training. In the context of regional labour markets, strategies to increase labour supply from a diverse range of labour market segments which will be necessary to build a regional workforce. Regional labour markets should be managed as 'skill ecosystems' to develop regional workforces that can move between renewable energy and adjacent sectors to create career paths and a more sustainable labour supply. Better integration of energy policy with labour and skills policy can reduce the risks of scaling up the workforce and enable regional workforce development which improves social licence for rapid energy transition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

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Clean Energy Council: funding was provided in 2019–20 to undertake a survey of employment in utility-scale solar and wind, distributed solar PV, pumped hydro and battery storage in Australia

Infrastructure Australia: funding was provided in 2020 to undertake a survey of employment in transmission construction and develop employment projections for the power sector in Australia.

New South Wales Department of Planning, Industry and Environment: funding was provided in 2021 to undertake research to map

renewable energy supply chains, identify employment opportunities and develop an action plan in the state of New South Wales for the New South Wales Renewable Energy Sector Board.

Appendix A Employment factors - electricity generation and transmission construction

	Construction/ installation Job-years/MW	Total manufacturing	Australian manufacturing	Operations & maintenance Jobs/MW	Fuel Jobs/GWh
Black coal [1]	11.2	5.4	n/a	0.2	0.04
Brown coal [1]	11.2	5.4	n/a	0.2	0.01
CCGT	1.3	0.9	n/a	0.1	0.07
Peaking Gas+Liquids	1.3	0.9	n/a	0.1	0.11
Hydro	7.4	3.5	n/a	0.1	
Wind	2.8	1.7	0.4	0.2	
Utility Solar	2.3	4.4	0.1	0.1	
Rooftop PV	5.8	4.4	0.2	0.2	
Utility batteries	4.7	6.6	0.3	1.2	
Distributed batteries	5.6	6.6	0.3	0.3	
Pumped hydro	7.2	3.5	0.7	0.1	
Transmission line [1]	Construction/installation (Job-years/km)				
]ingle circuit	0.7				
Double circuit	3.7				
	Construction/installation (Job-years/$m)				
Transmission (other) [1]	1.9				

Source: Table reproduced from Briggs et al. [15]

Note 1: Transmission employment factors derived in Briggs et al. [15]; coal and gas employment factors updated from Rutovitz et al. (2015), derivation of all other employment factors described in [16].

Note 2: job-years are used for construction because project lengths and annual employment vary. An employment factor of 2 means for example under a 100MW project that took 2 years to build, there was an average of 100 employees each year. Annual full-time equivalent employment is used for operations and maintenance.

Appendix B: Installed capacity projections for the renewable energy zones

A 'NSW REZ' scenario was developed as an input to the employment model (Fig. 11). The scenario modifies the AEMO's 'Step Change' scenario in its 2020 *Integrated System Plan* (ISP), based on modelling in the NSW Electricity Infrastructure Roadmap (Department of Planning, Industry and Environment 2020).

References

[1] IEA, Net Zero by 2050: a Roadmap for the Global Energy Sector, IEA, Paris, 2021.

[2] S. Teske, T. Pregger, S. Simon, T. Naegler, J. Pagenkopf, B. van den Adel, Methodology, in: S Teske (Ed.), Achieving the Paris Climate Agreement Goals: Global and Regional 100 Per Cent Renewable Energy Scenarios, Springer International Publishing, 2019, pp. 25–78.

[3] UNFCCC, The Paris Agreement, United Nations Framework Convention on Climate Change, 2016. Available from: http://unfccc.int/paris_agreement/items/9485.php .

[4] European Commission (2020) 'The just transition mechanism: making sure no one is left behind', https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en. Accessed December 15 2021,.

[5] J. Burton, T. Caetano, B McCall, Coal transition in South Africa - understanding the implications of a 2°C-compatible coal phase-out for South Africa, IDDRI Clim. Strateg. (2018). https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Iddri/Rapport/20180609_ReportCoal_SouthAfrica.pdf.

[6] K. Mallon, M. Hughes, Industrial Constraints and Dislocations to Significant Emissions Reductions by 2050, 2008. Report Commissioned by World Wildlife Fund Australia.

[7] Jotzo F., Mazouz S., Wiseman J. (2018). Coal transition in Australia. Preparing for the looming domestic coal phase-out and falling export demand. https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Iddri/Rapport/20180609_ReportCoal_Australia.pdf.

[8] O. Sartor, Implementing coal transitions: insights from case studies of major coal-consuming economies, IDDRI Clim. Strateg. (2018). https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Iddri/Rapport/201809-Synthesis%20Report%20Iddri-COALTRANSITIONS-def.pdf.

[9] S. Nasirov, A. Girard, C. Pena, F. Salazar, F Simon, Expansion of renewable energy in Chile: analysis of the effects on employment, Energy 226 (2021) 1–12.

[10] E. Dominish, C. Briggs, S. Teske, F. Mey, Just transition: employment Projections for the 2.0 and 1.5 degree scenarios, in: S. Teske (Ed.), Achieving the Paris Climate Agreement Goals: Global and Regional 100% Renewable Energy Scenarios with Non-Energy Greenhouse Gas Pathways For 1.5 and 2 Degrees, Springer, 2019.

[11] S. Jenniches, Assessing the regional economic impacts of renewable energy sources – a literature review, Renew. Sustain. Energy Rev. V93 (2018) 35–51.

[12] NSW Department of Planning, Industry and Environment (2020) NSW Electricity Infrastructure Roadmap: Building an Energy Superpower.

[13] ISF & SGS Economics (2021) Employment, skills and supply-chains: renewable energy in NSW, https://www.energy.nsw.gov.au/sites/default/files/2021-10/isfsgs-nsw-rez-research-summary-presentation.pdf.

[14] Briggs, C., Rutovitz, J., Dominish, E. & Nagrath, K. (2020) Renewable energy employment in Australia, https://www.uts.edu.au/sites/default/files/2020-06/Renewable-Jobs-Australia-ISF%20F.pdf.

[15] C. Briggs, J. Rutovitz, R. Langdon, K Nagrath, Market Capacity for Electricity Generation and Transmission Projects, 2021. Report for Infrastructure Australia, https://www.infrastructureaustralia.gov.au/sites/default/files/2021-10/Market%20Capacity%20for%20Electricity%20Infrastructure%20211013.pdf.

[16] J. Rutovitz, C. Briggs, E. Dominish, K Nagrath, Renewable Energy Employment in Australia: Methodology, Prepared for the Clean Energy Council by the Institute for Sustainable Futures, University of Technology Sydney, 2020.

[17] Rutovitz, J., Dominish, E. and Downes, J. (2015) Calculating global energy sector jobs 2015 methodology update.

[18] AEMO (2020) 2020 integrated system plan for the national electricity market. https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2020-integrated-system-plan-isp.

[19] Caldwell, J. (2021a) Electricity distribution in Australia, https://my-ibisworld-com.ezproxy.lib.uts.edu.au/au/en/industry/d2630/about, January.

[20] Caldwell, J. (2021c) Electricity transmission in Australia, https://my-ibisworld-com.ezproxy.lib.uts.edu.au/au/en/industry/d2630/about, April.

[21] Caldwell, J. (2021c) Electricity retailing in Australia, https://my-ibisworld-com.ezproxy.lib.uts.edu.au/au/en/industry/d2630/about, May.

[22] AEMO (2021) Draft 2022 integrated system plan for the national electricity market. https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp.

[23] ILO (2011) Investment in renewable energy generates Jobs. Supply of skilled workforce needs to catch up. wcmsp5/groups/public/—ed_emp/—ifp_skills/documents/publication/wcms_168354.pdf.

[24] Commonwealth of Australia (2019) Strengthening skills: expert review of Australia's vocational education and training system, https://www.pmc.gov.au/si

tes/default/files/publications/strengthening-skills-independent-review-australia-vets_1.pdf.
[25] Gonski, D.&. Shergold, P. (2021) In the same sentence: bringing higher and vocational education together, March.
[26] NSW Productivity Commission (2021) White Paper 2021: rebooting the Economy.
[27] Productivity Commission (2020) National Agreement for Skills and Workforce Development Review, Study Report, December.
[28] Infrastructure Australia (2021) Infrastructure market capacity, October. https://www.infrastructureaustralia.gov.au/sites/default/files/2021-11/Infrastructure%20Market%20Capacity%20report%20211123.pdf. Accessed December 17 2021,.
[29] Australian Bureau of Statistics (ABS) (2016) ABS census of population of population and housing.
[30] M. Frangos, T. Bassani, J. Hollingsworth, C. Briggs, First Nations Guidelines: Case Studies on First Nations Community Engagement For Renewable Energy Projects, NSW Department of Planning, Industry and Environment, Sydney, 2022.
[31] C. Boyd, It's almost like you have to leave": young people from regional areas face a big stigma if they don't move to the city, Conversation (2021). October 21, https://theconversation.com/its-almost-like-you-have-to-leave-young-people-from-regional-areas-face-a-big-stigma-if-they-dont-move-to-the-city-168655/.pdf.
[32] AEMO Services (2021) Infrastructure investment objectives report, https://aemo.com.au/-/media/files/about_aemo/aemo-services/iio-report-2021.pdf?la=en.
[33] Buchanan, J. (2020) Submission to the national agreement on skills and workforce development review,, https://www.pc.gov.au/_data/assets/pdf_file/0005/255182/subir151-skills-workforce-agreement.pdf. Accessed October 3 2021,.
[34] National Apprenticeship Program (2014) Pilot Project Final Report.
[35] J. Buchanan, P. Anderson, G. Power, Skill ecosystems, in: J. Buchanan, D. Finegold, K. Mayhew, C. Warhurst (Eds.), The Oxford Handbook of Skills and Training, Oxford University Press, 2017.
[36] K. Windsor, C Alcorso, Skills in Context: a Guide to the Skill Ecosystem Approach to Workforce Development, NSW Department of Education and Training and Australian Department of Education, Employment and Workplace Relations, 2008. https://www.voced.edu.au/content/ngv%3A12460.