Making a clean transition

Transferability of engineering skills for the clean energy transition

Engineers Australia

Mott MacDonald

Making a Clean Transition - Transferability of engineering skills for the clean energy transition

Authors: Megan O'Connell and Nikki Deighton, Mott MacDonald Australia in partnership with Grant Watt and Jenny Mitchell and the team at Engineers Australia

The report can be downloaded at engineersaustralia.org.au

Engineers Australia
11 National Circuit, Barton ACT 2600
Tel: +61 2 6270 6555
Email: policy@engineersaustralia.org.au

Mott MacDonald Australia
Level 17, Tower One, Collins Square
727 Collins St Melbourne VIC 3008

Contents

TABLE OF FIGURES

TABLES

Key terms

Abbreviation	Meaning
AEMO	Australian Electricity Market Operator
ANZSCO	Australian and New Zealand Standard Classification of Occupations
BESS	Battery Energy Storage System
CAD	Computer-aided design
CEC	Clean Energy Council
DEWR	Australian Government Department of Employment and Workplace Relations
GWO	Global Wind Organisation
HV	High voltage
JSA	Jobs and Skills Australia
JSC	Jobs and Skills Councils
NEM	National Electricity Market
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaic
REZ	Renewable Energy Zones
TAFE	Technical and Further Education
VET	Vocational Education and Training

1. Executive Summary

This report examines the transferability of engineering skills for the clean energy transition, in the context of the crucial role engineers will play in ensuring Australia can respond with agility and innovation as it heads towards Net Zero.

The report is the result of integrated research undertaken over 2024 by Mott MacDonald Australia for Engineers Australia, comprising a desktop literature review, interviews, case studies, innovative skills mapping and gap analysis drawing on job advertisements data, and an examination of existing policy instruments.

There are **five key areas of findings**:

1. **Engineers possess transferable knowledge, skills, mindsets and capabilities**
   Employers are seeking a combination of knowledge, skills and experience, capabilities and mindsets. There are a range of internal factors impacting engineers' readiness to change roles, occupations or employers including willingness to learn and adapt, to have a growth mindset, and to take risks. The task of engineering itself in the clean energy sector relies on many of the same engineering skills employed in the thermal energy production, but it relies on a greater breadth of capabilities including professional skills such as stakeholder management, community engagement and negotiation.

2. **Building the engineering workforce labour force remains a key challenge**
   The current skill shortage for engineers is a key barrier to ensuring a sufficient engineering workforce to support the energy transition. Many engineers in clean energy are trained overseas, but there is large and growing global demand for engineers. Australia has a large, latent cohort of engineers that could be re-engaged to support the transition to clean energy. Over 40 percent of engineers are not working in engineering.

3. **Location will continue to play a role in the capacity to attract workers**
   Communities that are experiencing the transition to clean energy are facing dislocation without sufficient government intervention to support the co-location of renewable energy projects; whilst engineers who can stay working in a more proximal location are more inclined to stay in the profession. Employment models, such as contracting and fly-in, and fly-out, can pose additional challenges to workforce attraction and retention. Innovative and flexible employment models are needed.

4. **Policy drivers are supporting innovation but need coordination**
   There are a multitude of investments and initiatives across the clean energy space in Australia. Without sufficient coordination, there will be a likelihood of ongoing workforce shortages in vital industries, including renewable energy and industries supplying and processing vital minerals and metals.

5. **Training pathways are still needed**
   Whilst many engineers move roles regularly and are likely to transition smoothly, some will require extra support. There are a range of initiatives that would support engineers to gain experience and skills to transition to the clean energy sector.

The report reveals how engineers, with their problem-solving mindsets, are vital to create innovative solutions to spearhead the transformation to Net Zero. Many engineers will make the transition to the renewable energy sector easily, but some will require additional support. New measures are needed to make pathways clearer, and to ensure a sufficient stock of engineers in the face of competing industries.

As the breadth of findings shows, transformation will require a holistic, resourced and coordinated approach across government, communities, training providers and industry.

Detailed research findings and recommendations (see discussion in Chapter 8) highlight what can be done by governments, employers, training providers and engineers themselves, to support the engineering workforce to transition to the clean energy sector en masse.

Summary of Findings and Recommendations

Key Area of Findings 1: Engineers possess transferable knowledge, skills, mindsets and capabilities

- Finding 1.1: Employers hire based more on engineers' mindsets and capabilities than discipline expertise. The task of engineering itself in the renewables sector relies on many of the same engineering skills employed in thermal energy production, but it relies on a greater breadth of capabilities including professional skills such as stakeholder management, community engagement and complex capabilities like systems thinking. The most likely transitions are from and to broad or adjacent engineering roles.
- *Recommendation 1a: Employers can encourage employee flexibility and growth, for example by highlighting the benefits of flexible mindsets when responding to new and emerging opportunities and supporting access to a diversity of continual professional learning including sharing of divergent ideas.*
- Finding 1.2: Engineers transition to the renewable energy sector in a variety of ways. Those in broad qualifications are likely to make a direct transition, whilst others move upwards to managerial roles rather than sidewards to technical roles in the renewable energy sector. For some, transition to an interim role with their existing employer will support them to gain new skills, before undertaking a similar role in the renewable sector.
- *Recommendation 1b: Employers can identify possible transition pathways to support employees to transition to emerging roles, including through interim roles.*
- Finding 1.3: Key roles in the electricity industry such as grid engineer, require many years of experience, meaning transferability between roles is low and shortages are higher. Some initiatives, such as the grid engineer graduate program, showcase how employees can be fast-tracked to gain a breadth of experience.
- *Recommendation 1c: Governments can incentivise and share learnings from innovative models.*

Key Area of Findings 2: Building the engineering workforce labour force remains a key challenge

- Finding 2.1: The current skill shortage for engineers is a key barrier to ensuring a sufficient engineering workforce to support the transition to renewables. There is global demand for engineers to support the energy transition meaning Australia's capacity to attract foreign trained workers is constrained.
- *Recommendation 2a: Governments can commission Jobs and Skills Australia to further analyse demographic data on the latent engineering workforce and to advise on further strategies to address the looming skills shortage.*
- Finding 2.2: Key groups that leave the profession include women, engineers qualified overseas and older workers.
- *Recommendation 2b: Employers can support pilot initiatives to re-attract women back to engineering, and more flexible workplace conditions to attract and retain a diversity of employees.*
- *Recommendation 2c: Employers can explore strategies for engaging overseas qualified engineers and re-engaging older workers to alleviate workforce shortages.*

- *Recommendation 2d: Governments can ensure that new initiatives, such as those designed to attract women to the Clean Economy, focus equally on workforce retention, operate across vocational and higher education, and share findings broadly to encourage adoption of good practice.*
- Finding 2.3: New employees in the renewable sector are often driven by a moral commitment to improving the environment – but the environment aspect of roles is not always promoted.
- *Recommendation 2e: Employers can actively promote the purpose-driven opportunity to work in renewable energy and support Net Zero through communications, position descriptions and job advertisements.*
- Finding 2.4: Salary differences and working conditions between the thermal and renewable sectors, as well as international labour market conditions, may pose a challenge to transitions. The transition to renewables is an opportunity for employers to review and improve the working conditions and salary packages of their workforce in order to attract and retain staff.
- *Recommendation 2f: Employers can prioritise work life balance as a way of attracting workforce through the creation of competitive working conditions and salary packages.*
- *Recommendation 2g: Government authorities, such as the Net Zero Economy Authority and Future Made in Australia, can incentivise employers to restructure their workforce to provide greater flexibility, and share findings of successful initiatives.*

Key Area of Findings 3: Location will continue to play a role in the capacity to attract workers

- Finding 3.1: Ensuring roles in energy remain in existing communities where possible is important. This can be supported through co-locating new developments in existing thermal energy communities, and incentivising employment of local staff.
- *Recommendation 3a: Governments can consider location and context when supporting communities transitioning, including making decisions around local workforce employment requirements when investing in clean energy initiatives. This needs to continue as a key responsibility of the Net Zero Economy Authority.*
- Finding 3.2: Awareness and understanding of opportunities afforded by the renewable energy sector is a key area for focus and improvement. The shift to clean energy will be more daunting for workers who have been in one role or industry for a significant period of time, and may not recognise that similar roles are likely to exist in the renewable energy sector.
- *Recommendation 3b: Employers and government can work together to showcase the similarities in roles between the thermal and renewable energy sectors to demystify and build understanding, engagement and buy-in through approaches that include sharing stories of successful transitions.*
- *Recommendation 3c: Employers can focus on supporting employees to gain exposure to new roles to support flexibility and internal transitions*
- Finding 3.3: Like in the thermal energy sector, some roles in the renewable energy sector will be remote, or require travel between a range of sites. Whilst some engineers are able or want to travel for work, many leave this mode of employment when they have a family. There is potential to reorganise the work. This is occurring in pockets, with some key roles being offered remotely and automation providing greater opportunities to locate work where families live.
- *Recommendation 3d: Employers can seek to review and reorganise the work to attract a breadth of engineers, and explore options such as automation and remote connection.*
- *Recommendation 3e: Governments can support the reorganisation of work and workplaces through incentives, and by sharing and promoting effective strategies, tools and processes to drive effective workplace transformation, and ensuring supportive structures exist such as housing, childcare and broadband.*

Key Area of Findings 4: Policy drivers are supporting innovation but need coordination

- Finding 4.1: Consistent policy settings support employers to invest in innovation, with emissions targets motivating large employers to innovate and seek to decarbonise. Engineers in thermal energy production will play a key role in supporting this transformation.

- *Recommendation 4a Governments can ensure stability, including on timelines, to create confidence in investment and support a managed transition process for employees.*
- Finding 4.2: There is significant new government investment and a raft of initiatives to support the transition to renewable energy. However, some policy levers, like caps on migration and higher education, including for international engineering students, may reduce the accessible engineering labour pool in the short-term.
- *Recommendation 4b: Governments can ensure strategies and initiatives align and complement each other, and that systemic action occurs at every level.*
- Finding 4.3: Recent government investment, including in the Net Zero Economy Authority, is aimed at supporting communities to transition. The mapping process found there were many new roles for engineers in the renewable sector, with many different titles (sometimes for very similar roles), responsibilities and skills and capabilities that could make finding a clear path to transition difficult.
- *Recommendation 4c: Governments can support people to understand the myriad of new roles emerging in the renewable sector.*
- *Recommendation 4d: Governments, through Jobs and Skills Australia, can validate the skill profiles in this report and develop additional occupational profiles for emergent roles. Combined with revised occupational codes, this would provide greater clarity and support transitions.*
- *Recommendation 4e: Governments can work with employers to engage in ongoing skills mapping to identify and plan for emerging roles and to engage and prepare existing workers to transition, including developing and validating occupational profiles, revising occupational codes and supporting the emergence of common language to assist transitions.*
- *Recommendation 4f: Governments can invest in innovation hubs to capture, showcase and coordinate innovation to support the energy transition.*

Key Area of Findings 5: Training pathways are still needed

- Finding 5.1: Many employers and employees are investing in workforce training to provide bespoke skills in the renewable sector, but this could result in skills wastage if they are not transferable between employers.
- *Recommendation 5a: Governments can support a process to accredit these skills and incentivise employers to develop skills on an industry basis. The proposed skills passport could be explored as a vehicle to support skills recognition and transferability in the engineering sectors.*
- *Recommendation 5b: Engineers Australia can broker discussions with engineers and work with government to meet the renewable workforce challenge including by supporting transferability of skills training, for example through badging.*
- Finding 5.2: Roles in the renewable sector cross vocational and higher education divides, but pathways for vocationally trained engineering occupations are not sufficiently agile at present.
- *Recommendation 5c: Governments and training providers can bridge the vocational and higher education divides through new initiatives. New models can be created to provide targeted skill development to support engineering technicians to upskill to engineering qualifications whilst remaining in the workforce.*
- *Recommendation 5d: Governments can support the Net Zero Economy Authority to explore transition pathways for the thermal workforce including for engineering technicians.*
- Finding 5.3: Familiarisation training is needed to support workers to understand and gain experience in the renewable energy sector.
- *Recommendation 5e: Governments can fund the development and rollout of familiarisation training including short micro-credentials that elevate consistency and transferability of skills across the industry and demystify the differences between sectors and include information on key aspects of renewables, including jargon and standards.*

- Finding 5.4: Building the engineering workforce labour force (including ensuring sufficient staff for the thermal industry during the transition) remains a key challenge. The existing skills shortage needs to be addressed in a comprehensive way, from career education for the future generation to ensuring all engineers are trained in sustainability.
- *Recommendation 5f: Schools and industry can work together to build the future workforce, through programs to excite and inspire school students, cascading to industry exposure, work experience and pathway programs.*
- *Recommendation 5g: Training providers and employers can promote the benefits of working in the renewables sector through work experience, outreach and training pathways.*
- *Recommendation 5h: Training providers can ensure all engineering courses and degrees include sustainability alongside foundational engineering skills.*

2. Introduction

2.1 Engineering skills for clean energy

Engineers Australia engaged the Education, Training and Capability Uplift team of Mott MacDonald Australia to undertake this research in order to inform and support Engineers Australia's policy and advocacy agenda for a sustainable, skilled and innovative future (Engineers Australia (a), 2024). By providing evidence and insight into current and future skills requirements for the clean energy sector, both organisations can support the mechanisms required to enable Australia to transition from thermal energy production to renewables, decarbonisation, and a cleaner, greener future.

Examining issues in the broadest sense, the research considered a full spectrum of engineers, from technicians trained through vocational education to university trained engineers, across a broad range of disciplines given the multidisciplinary approach needed to create and implement solutions efficiently in the clean energy economy.

The research took a broad view of the clean energy transition, including skills to support the transition within the thermal sector with the phasing down of fossil fuels. It considers supporting the capacity of the mining sector to transform and become as clean as possible as it produces products that underpin the renewable energy economy, and the transition of workforces from thermal sectors to other sources of energy, including wind and solar.

The report embraces the notion of a just transition to clean energy, that supports organisations and existing communities to transition and ensures inclusion of workers who are currently underrepresented in the energy workforce.

2.2 Approach

The project was conducted over five stages. It commenced with a desktop review of relevant resources, federal government policy initiatives and reports pertaining to the engineering workforce and the clean energy transition. This was supplemented by 12 interviews with key organisations and individuals to provide detailed and timely insights, particularly related to the engineering workforce.

Data from the interviews, job advertisements and the Australian Skills Classification was used to create skills profiles that articulate knowledge, skills, capabilities and mindsets and dispositions.

Given the early insight from the research that employers' preference is to hire new staff based on capabilities and mindsets – prioritising these over technical experience, we analysed the intersection between mindsets and capabilities in specific roles in the thermal and renewables sectors to identify possible transitions. Mapping of transition pathways identified commonalities and gaps between selected occupations and identified existing pathways or the need to create new pathways.

De-identified case studies were included to highlight examples of employees and employers transitioning.

Policy instruments and incentives were examined to determine their capacity to support the transitions of engineers to the clean energy economy.

Whilst the research found that many engineers will transition well, more needs to be done to ensure engineers transition in sufficient numbers to support Australia in achieving Net Zero and so that organisations leading the transition have access to the skills and capabilities that they need.

3. Desktop review and stakeholder reflections

3.1 Methodology

This chapter provides a desktop review to describe the context for the transition to Net Zero, including its impact on the engineering workforce. Key reports and data repositories were drawn upon to provide a succinct profile of the current and potential future workforce, and to articulate challenges and enablers.

The desktop review is supplemented by interviews with twelve organisations, from small consultancies to government agencies and multinationals. Interviews were held with senior representatives from:

- Sustainenergy Consulting Pty Ltd
- Ampcontrol
- LMS Energy
- RJE Global
- Perenti Ltd
- Ausgrid
- ExxonMobil
- Mott MacDonald Australia
- Stanwell
- AEMO
- Net Zero Economy Authority
- Jobs and Skills Australia.

Insights shared helped to reinforce, delve deeper or contest findings from the literature, including elucidating opportunities to support workforce attraction and retention and expansion in order for Australia to achieve Net Zero. Throughout the report, quotes are provided that confirm, add to or contest concepts raised in the literature. Quotes are de-identified and not attributed individually as this enabled interviewees to speak freely.

Case studies are integrated to provide illustrative examples and have been compiled from published literature supplemented with interviews. They are not exhaustive, merely illustrative of the types of transitions engineers are making and could make in future, initiatives that are assisting, and enablers and barriers.

3.2 Government context

The project is conducted within the context of Australia supporting global emissions reductions including a commitment to achieving Net Zero under the Paris Agreement by 2050. The context has been longstanding, with a Renewable Energy Target set in 2001 sparking a series of new policies and reforms (Ai Group Centre for Education and Training, 2024) backed up by the 2050 commitment in 2015.

As will be articulated in more detail in Chapter 7, there have been a raft of successive government policies focused on the transition to Net Zero, and most recently a more intensive focus in establishing supporting mechanisms. This includes supporting a just transition through legislation to establish the Net Zero Economy Authority, and investment through the Future Made in Australia framework.

Interviewees confirmed that government drivers are significant, with the need to report on carbon emissions compelling companies to invest in new solutions.

3.3 Timelines for transition

In the lead up to the 2050 Net Zero deadline, Australia will require an alignment between closure or transformation of existing thermal power sources, and emergence and integration of new, sustainable sources.

Australia's remaining coal-fired power stations are likely to gradually close over the coming 30 years, whilst Australia's energy export industry is likely to change as markets decarbonise. The full extent of these changes is difficult to model, as it is dependent to a degree on emergence of viable replacements. Given this, the resources examined utilise a variety of scenarios to map the potential shift to renewable energy by 2030 (Jobs and Skills Australia, 2023).

By 2030, Australian Government policy is to reduce 2005 levels of emissions by 43%, with 83% of electricity in the National Electricity Market being supplied by renewable sources (Australian Energy Market Operator, 2024).

The timing of transition to Net Zero will be influenced by a range of factors, including global and domestic demand, shareholder expectations and government policies and incentives, in addition to the availability of resources including labour. A later chapter of this report examines policy initiatives and incentives.

3.4 Defining the clean energy workforce

The clean energy workforce is broad and difficult to define, and thus quantify. It extends beyond roles in solar, wind and hydroelectricity across the workforce, including in transitioning and emission intensive sectors. The below diagram from Jobs and Skills Australia articulates key segments of the workforce:

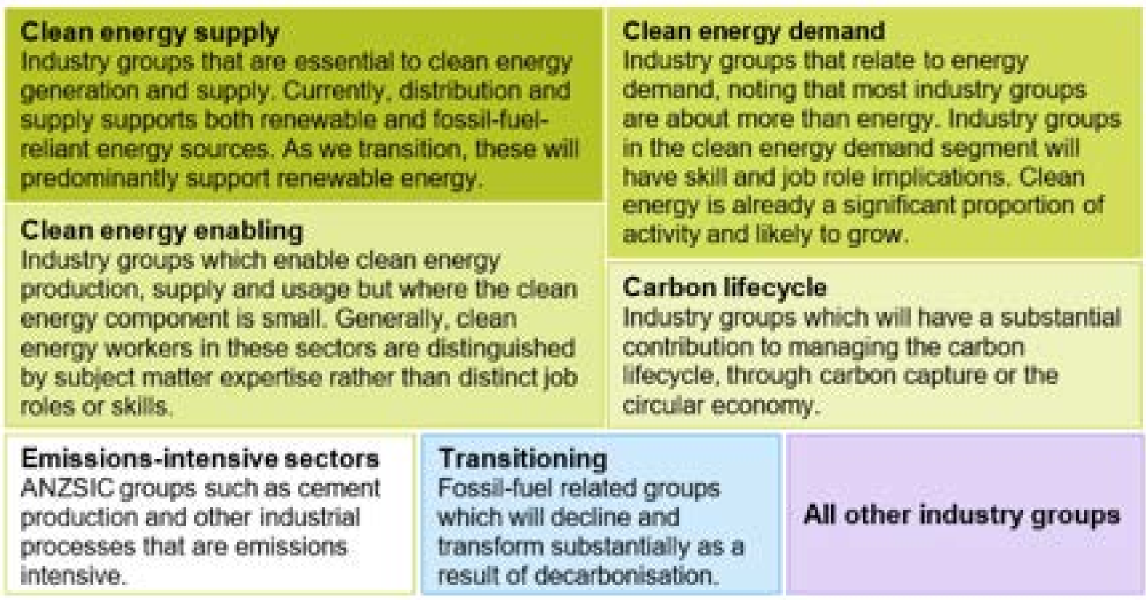


FIGURE 1: CLEAN ENERGY WORKFORCE SEGMENTS

Source: (Jobs and Skills Australia, 2023, p. 9)

Jobs and Skills Australia estimates that around 30% of the workforce has direct exposure to the transition to renewable energy, with the bulk of these in renewable energy demand (Jobs and Skills Australia, 2023, p. 45).

3.4.1 Quantifying workforce future demand

Jobs and Skills Australia conducted a workforce capacity study that found the clean energy workforce is at the brink of major transformation, both regarding how we generate, use and export energy and how we deliver skills. Three objectives are set for the transition to Net Zero:

1. That skill shortages do not hinder the transition
2. That workforce opportunities are sustainably shared
3. That communities in transitioning sectors can access workforce opportunities (Jobs and Skills Australia, 2023).

Preliminary modelling suggests that close to two million workers in building and engineering trades will be needed by 2050, an increase of around 40%, and the clean energy supply workforce will likely need to grow from approximately 53,000 workers today to 84,000 by 2050 (Jobs and Skills Australia, 2023, pp. 13-14). Alternative reports suggest the renewable energy sector could increase by 130,000 to 200,000 jobs by 2030 (Rutovitz J. V., 2021, p. 6).

Given modelling predicting renewable energy jobs will outnumber the decline in traditional jobs, it is imperative that a transition process supports the retention and transition of as many employees in the workforce as possible (CEDA, 2030). This is especially important as there will be heightened workforce competition, for example in construction between renewables and other sectors, with a risk of skill shortages and boom-bust cycles if adequate labour cannot be sourced and projects coordinated (CEDA, 2030).

This was confirmed in the stakeholder interviews, with employers citing intense competition between industries and states for engineers.

An additional challenge is global competition for the workforce, and in particular energy workers, as power systems are transformed, which has elevated the need for power systems and grid engineers who possess particular technical skills (Australian Energy Market Operator, 2024).

3.4.2 Key workforce characteristics

The current clean energy workforce is more likely to be male, more qualified and more likely to be in shorter term employment particularly during the build phase of the transition to alternative energy sources (Jobs and Skills Australia, 2023). The graph below highlights how much of the workforce is male dominated, with the exception of enabling areas such as legal and education.

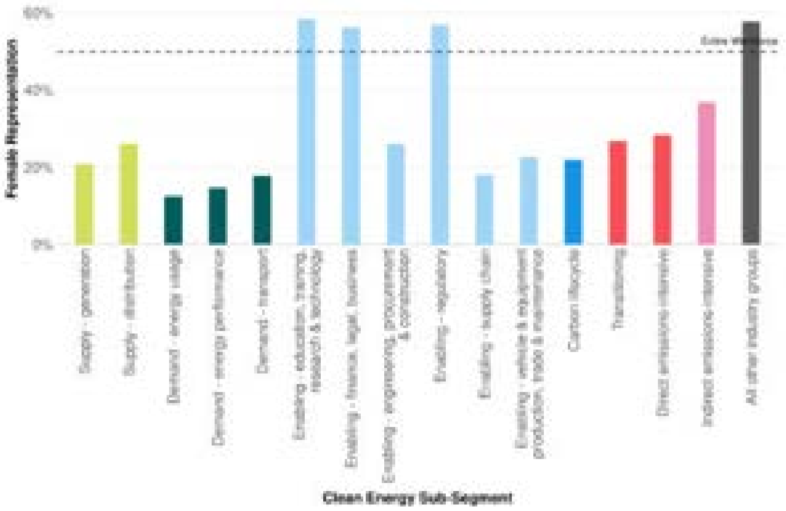


FIGURE 2: FEMALE REPRESENTATION IN CLEAN ENERGY SEGMENTS

Source: **(JOBS AND SKILLS AUSTRALIA, 2023, P. 66)**

Although the clean energy workforce as a whole is less likely to be born overseas, engineers are more likely to be overseas born. Engineers are likely to have a similar age profile to the broader transitioning workforce. Predominant models of employment for engineers include fly-in, fly-out, given the regional and remote locations of new energy sources such as offshore wind.

Wages in the clean energy workforce are reported to be lower than in traditional, fossil fuel workforces. Part of the reason for this is the wage premium commanded in the mining industry, and accompanying conditions such as fly-in, fly-out. The graph below shows a subset of data on wages and highlights the discrepancy in wages for engineers ranging from a difference of $10,000 to over $20,000.

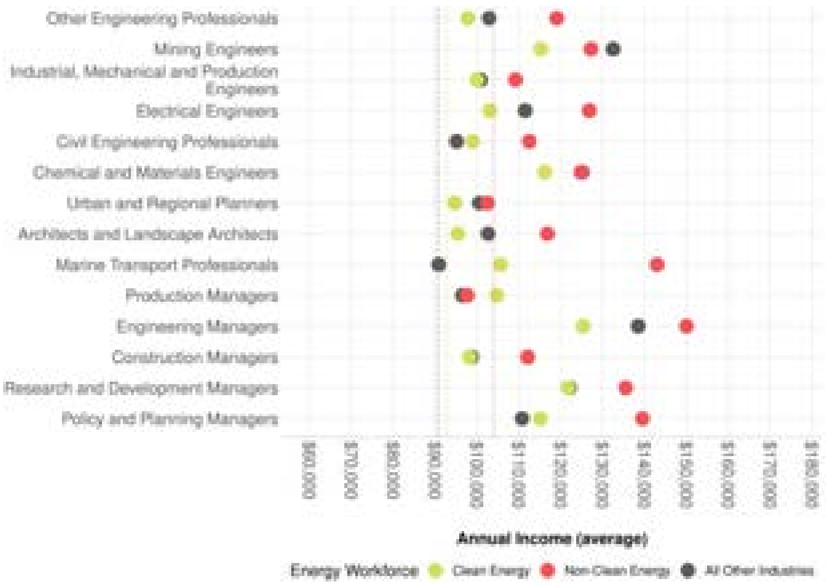


FIGURE 3: WAGE DIFFERENTIALS BETWEEN CLEAN AND NON-CLEAN ENERGY INDUSTRIES

Source: (Jobs and Skills Australia, 2023, p. 80)

Key skills identified in clean energy fall within four categories: engineering and technical, operation management, monitoring and science (CEDA, 2030). It is estimated that 80 percent of the skills required in the short to medium term transition to Net Zero are present today (CEDA, 2030, p. 30).

3.4.3 The role of engineering within the clean energy workforce

Engineering is a commonly occurring occupation both within the emerging renewable energy segments and underpinning current fossil fuel production, in addition to playing a key role in enabling sectors vital for new technologies. Many employers in coal and gas fired power generation have commenced diversifying into renewable power generation, whilst the inclusion of mandatory reporting of emissions and standards has motivated large carbon emitters to invest in new solutions.

Engineering skills are needed to research, design and construct ways to improve practices, to deliver energy and develop circular practices. This will impact across a range of engineers, including electrical, civil, chemical, environmental and mechanical (Victorian Skills Authority, 2023).

It is difficult to identify the full range of engineering roles in the clean energy sector as not all are included in the Australia and New Zealand Standard Classification of Occupations (ANZSCO). However, there are changes proposed to include specialisations such as grid connection, power systems and renewable energy engineers within electrical engineering, and new occupations including mechatronics engineers (Australian Bureau of Statistics, 2024).

In addition, there are new and emerging occupations like energy efficiency engineers, solar energy engineers and blade engineers. Further modelling often excludes occupational breakdowns for new and emerging technologies, and for mineral processing to produce renewable energy technologies. What is clear is there will be continual demand for highly skilled workers to engage in innovation, research and development (CEDA, 2030).

Existing reports provided analysis of the engineering workforce – for example a breakdown of the electrical engineering workforce by different energy sources (Rutovitz J. L., January 2023, p. 33). The graph below shows requirements for electrical engineers under the step change scenario seeing a peak in demand in 2025 before dropping back to current levels towards 2040. This trend aligns with construction cycles.

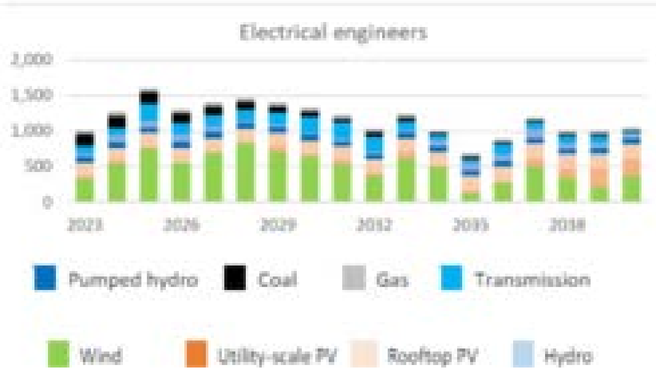


FIGURE 4: ELECTRICAL ENGINEERS BY ENERGY SOURCE

Source: (Rutovitz J. L., January 2023)

Engineers featured among the clean energy occupations with the highest growth rates for 2023 – 2030, under a variety of scenarios. Growth levels across all industries moderated closer to 2050 due the completion of builds (Jobs and Skills Australia, 2023, p. 160).

Occupation	Low	Central	High
Telecommunications Trades Workers	7.9	8.0	8.4
Electronics Trades Workers	6.0	6.1	6.5
Electronic Engineering Draftspersons and Technicians	5.2	5.1	5.4
Structural Steel Construction Workers	3.0	3.2	3.9
Construction Managers	2.6	2.9	3.7
Plumbers	2.3	2.6	3.4
Electricians	2.1	2.5	3.3
Airconditioning and Refrigeration Mechanics	2.4	2.6	3.2
Agricultural and Forestry Scientists	2.7	2.9	3.2
Urban and Regional Planners	2.3	2.4	2.7
Other Engineering Professionals	2.2	2.3	2.6
Industrial, Mechanical and Production Engineers	2.0	2.1	2.4
Civil Engineering Professionals	1.5	1.5	1.9
Engineering Managers	1.7	1.7	2.0
Electrical Engineers	1.5	1.6	1.9

Source: Deloitte Access Economics 2023.

FIGURE 5: PROJECTED GROWTH RATES UNDER DIFFERENT TRANSITION SCENARIOS

Source: (Jobs and Skills Australia, 2023, p. 160).

A wide range of engineering degrees are additionally sought after, such as mechatronics, environmental engineering and project management qualifications (Clean Energy Council, 2024).

Beyond renewable energy, engineers are sought after in other growing sectors and in particular construction.

4. The current engineering workforce

4.1 The latent engineering workforce

The number of qualified engineers increased by over 4% per annum since 2011, rising to over 540,000 qualified engineers in 2021. Most engineers are employed as civil engineers (16%), industrial, mechanical and production engineers (10%), software and application programmers (8%) and electrical engineers (6%).

Around 25% of qualified engineers are not in current employment (and most of these are not in the labour force). Of the 420,000 who are working, only 58% are working in engineering occupations. This is referenced in the graph below.

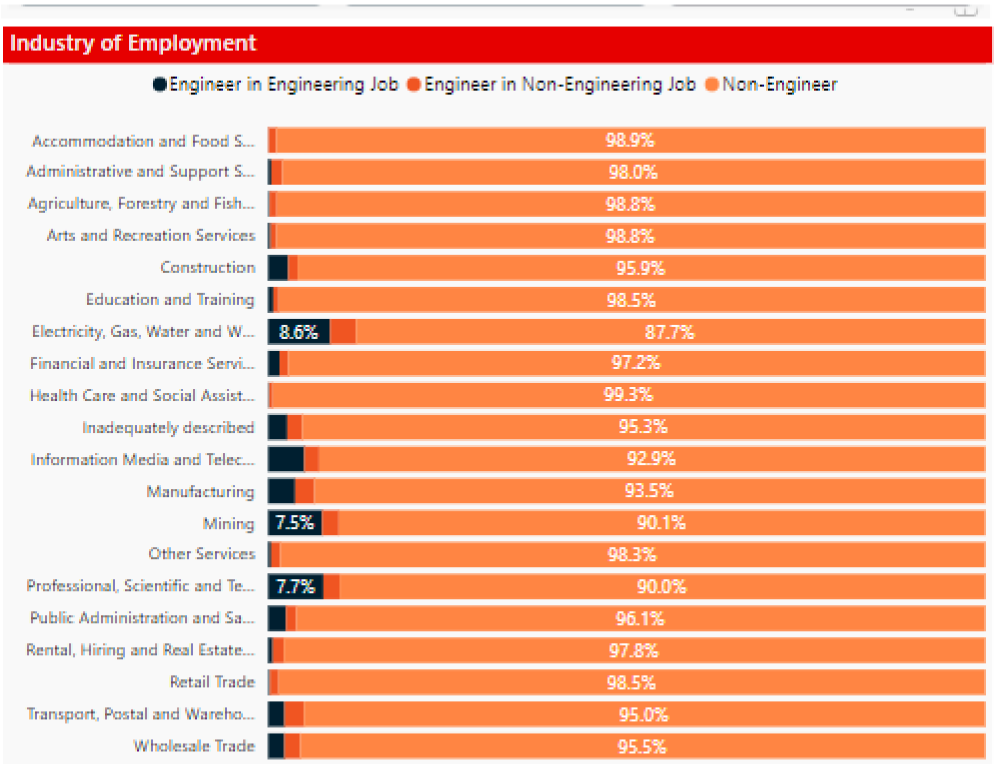


FIGURE 6: ENGINEERING WORKFORCE BY INDUSTRY

Source: (Engineers Australia (b), 2024).

There is a large, latent engineering workforce. Whilst some engineers move on to other related roles, like project management, evidence suggests other engineers, in particular foreign trained engineers, struggle to acquire their first role in Australia and represent an untapped workforce (Romanis, Barriers to Employment for Migrant Engineers; Research Report, 2021).

Around sixty percent of qualified engineers in Australia who were born overseas are not working in engineering (Engineers Australia (b), 2024). Whilst some would be retired and not in the labour force, it is likely many are working out of field. As identified in earlier research reports, there is potential to grow the engineering workforce by engaging trained engineers who may be retired, not engaged full time, or out of field including skilled migrants and women (Romanis, Women in Engineering: Identifying avenues for increasing female participation in engineering, by understanding the motivators and barriers around entry and progression, 2022; Romanis, Barriers to Employment for Migrant Engineers; Research Report, 2021).

Further insights are needed to understand the pathways of the 40% engineers who are no longer in engineering roles, in order to assess whether it is possible to create pathways back in. There is limited data publicly on who is entering and exiting the engineering workforce, when, why and where they are going to support workforce planning initiatives.

> "More data on stocks and flows would be good. Anecdotally I've got mates that have gone to consulting or teaching for work life balance."

The current engineering workforce is predominantly male – (458,000 compared to 88,000 females). Women who are qualified as engineers and are in employment are less likely to work in engineering (52%) than men (58%). The workforce is mainly full-time – less than 10 percent of engineers (9% males, 15% females) are working in engineering roles part-time. By contrast, 17% of engineers who work in any occupation are part-time (17% males, and 38% females are part time) (Engineers Australia (b), 2024).

Evidence suggests females move out of engineering to other, unrelated professions to combine work and family, whilst males are more likely to move into higher-level management roles.

Some sectors, such as mining and electricity, gas, water and waste disposal are more heavily dependent on full-time workers, although engineering as a whole has far fewer part-time workers than on average. This lack of flexibility is likely acting as a barrier to retention of workers seeking to combine work and life balance obligations.

The median age of engineers varies across occupations and generally aligns with the labour market average of 41 years (Jobs and Skills Australia, February 2024). Electrical engineers, with a median age of 37, are younger than many engineers (Jobs and Skills Australia, 2024).

5. Enablers and barriers to transition

5.1 Types of transitions

There is a wide breadth of transitions employees in the thermal industries may make, from internal transitions to supporting the shift to renewables, to new industries and locations as the table below illustrates:

Type of transition	Extent of change	Example	Type of supports
Changing work type	Same employer and occupation, but the focus shifts.	Petroleum refining moving towards biofuels.	In-house people management. Minor upskilling and familiarisation.
Changing worksite	Worksite closes but similar opportunities exist with same employer. Requires relocation.	Individual coal mine or power station closures.	In-house people management. Relocation support.
Changing employer	Employer retrenches staff due to changing needs. Requires job searching for same role.	Individual coal mine and power station closures but others exist.	Retrenchment supports to find new job.
Changing industry	Limited opportunities within same industry, or wanting to learn about new markets and trends. Can apply majority of skills to new industry.	Electrician moving from coal power station to renewables.	Retrenchment supports to find job in new industry. Upskilling likely.
Changing occupation	Limited opportunities within same occupation. Requires major reskilling or upskilling.	Power plant operator.	Retrenchment supports and major reskilling.
Exiting the labour force	Leaving employment.	Unemployment, unplanned early retirement, full-time study or short-term breaks from employment.	Specialist financial advice for workers. Employment services for partners.

FIGURE 7: TYPOLOGY OF TRANSITIONS

Source: (Jobs and Skills Australia, 2023, p. 137)

Interviewees provided nuanced insights into these transitions, suggesting that disciplinary knowledge and skills can be drawn upon to support carbon-intensive firms to transition. In particular, they talked about the internal transformation taking place in industry, which requires the repurposing of infrastructure and staff:

> "When you think about particularly carbon capture storage, and how to build that into already existing oil and gas depletion network, you're essentially using all the same skills…we've got mechanical engineers, who look after our large compressors and a large rotating machinery, pumps and whatnot. They're still going to be required because you're still going to need to compress. Once you create a hydrogen source, you're going to need to be able to pump it and liquefy it and put it onto tankers or convert it into ammonia and ship it. And the CO2

> that's emitted - you're going to need to compress that into a liquid form dehydrator, remove any liquids and start pumping it down pipeline."

Analysis showed that higher-skilled workers such as engineers are more likely to be able to retrain, especially given the similar skills needed between fossil fuels and renewables (CEDA, 2030). Further, employees with strong foundational skills are more readily deployed in new roles. Thus, engineers are likely to have or be able to learn the skills needed for new roles and have strong foundational skills including literacy and numeracy. However, as will be discussed shortly, aligned capabilities and mindsets are needed, and a capacity to locate and acquire knowledge through clear, accessible training pathways.

Skills shortages could delay the transition to the clean energy economy, so care and targeted interventions are needed to support traditional energy employees that can and wish to transition to find aligned roles.

Previous structural adjustments, such as car manufacturing, revealed that a core segment of the workforce failed to transition to new roles. New analysis suggests adoption of a worker-centred approach to transition is needed, with case management, workplace delivery of training and well-being and financial supports crucial. Some workers, including mature aged, CALD, female and First Nations can face greater challenges to transition (Jobs and Skills Australia, 2023, pp. 250-253).

5.2 Technical knowledge and skills transferability

The competency standards for engineers identify the underpinning, transferable knowledge, skills and personal attributes shared by the engineering profession. This includes deep discipline knowledge underpinned by scientific and mathematical understanding.

Engineers apply engineering methods to solve complex problems by asking questions and drawing on evidence to create solutions. They are committed to operating ethically, being creative and innovative, and effectively participating in and leading teams. Whilst these skills and attributes may look different from one discipline to the next, the practice and standard is the same (Engineers Australia (e), 2024).

Interviews confirmed the transferability of engineering skills between different roles and industries on the whole, with engineering providing a good technical base regardless of discipline studied. Many engineers already switch between different projects and industries, relying on their initial discipline training and supported by further education and breadth acquired during their career.

Analysis showed that people in fossil fuel occupations had similarly high-level skills to those in renewables, particularly managerial and technical skills and competencies, with more than 90 percent of the oil and gas workforce having medium to high skills transferability (Rutovitz J. V., 2021).

Some employers, particularly in emerging industries, adopt an approach of training people in their technologies rather than recruiting for particular skill sets:

> "Tritium is an advanced manufacturing company based in Brisbane that designs, builds and sells EV chargers around the world. The company has created around 600 jobs in Australia with and describes its staffing profile as a mix of "...communications engineers, electronics engineers, electrical, mechatronics, mechanical, software. So a very diverse workforce, and also a workforce that staff can walk in off the street, and we can train them up in two to three weeks into manufacturing jobs" (Jobs and Skills Australia, 2023, p. 133).

This approach is mirrored by many of the interviewees who hire regardless of engineering discipline:

> "We look for good people, we don't worry about what discipline they are engaged in, at grad recruitment there's an expectation of an aptitude and appetite for acquiring and applying technical knowledge."

Many interviewees discussed how graduates are placed in their engineering discipline when they are hired, but then are deliberately provided with broader experiences within two to three years. Alternatively, they employ matrix models where employees work across projects whilst being functionally aligned to their discipline. Those wanting to stay deeply technical develop additional technical expertise including managing technical teams.

Further, interviewees contended there is a high level of transferability between thermal and renewable energy in many cases due to comparable technologies:

> “Gas is gas, a fan for a boiler is a fan. If you've controlled something in a power station, you can control a turbine on top of a pole - there's a wind turbine. The physics doesn’t change even if the motors are different. So, it's those skill sets [that] are pretty much the same, but it's understanding jargon.”

Some skillsets transfer neatly, like welders and electrical engineers, from onshore energy to offshore wind given the technical nature of the work. Given challenges reported in recruiting electrical engineers, in 2021 an equal number of candidates were recruited as electrical project engineers from mechanical and civil engineering qualifications (Clean Energy Council, 2024). Other skillsets, like grid connection engineers and hydropower engineers are more specialist and highly unlikely to recruit from outside their specialisation. These are treated as a separate subset, although current shortages mean a new approach to support workforce growth is needed.

The transferability of skills is confirmed by the OECD (OECD, 2024), which notes the small retraining gap for high skilled occupations, and greater gap for low skilled occupations.

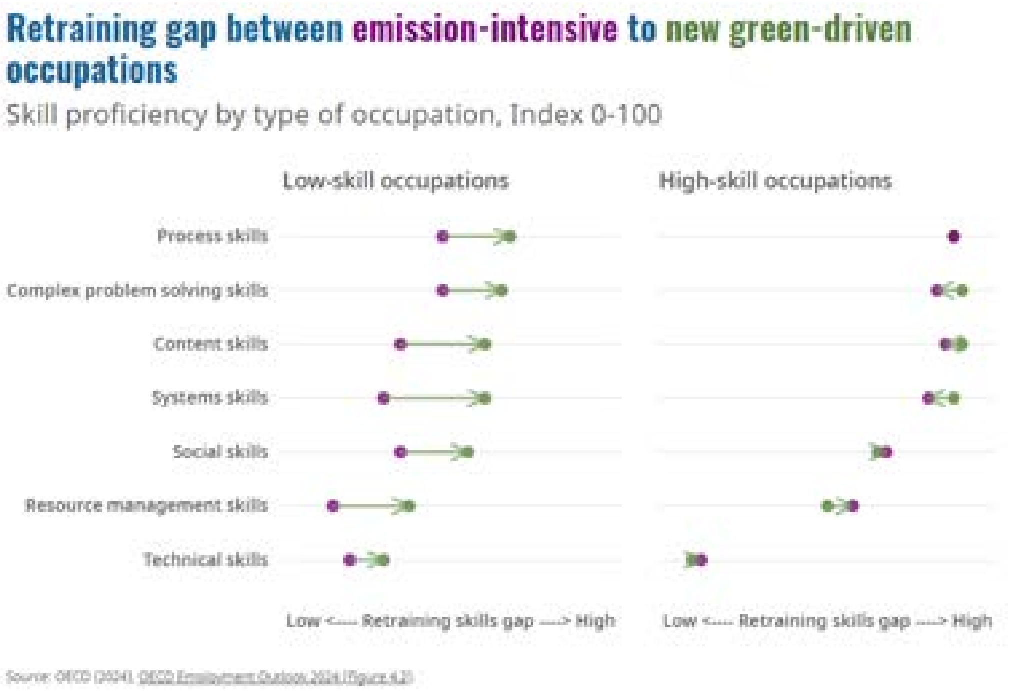


FIGURE 8: RETRAINING GAP BETWEEN EMISSION-INTENSIVE AND GREEN OCCUPATIONS

The Victorian Clean Economy Workforce Development Strategy identifies a range of new roles for engineers including biomass engineers and fuel cell technicians. They identify roles that need support to transition, including engineering production workers, and new occupations including for battery storage, circular design, and energy auditing (Victorian Skills Authority, 2023). As will be discussed later, recruiting into these roles may be difficult if extensive experience is demanded, and agile training pathways will be needed to meet emerging occupation skill needs.

5.3 Engineering and general capabilities

Many interviewees commented on the skills needed across the workforce, which include both engineering and broader workforce capabilities. There is overlap and crossover between what could be considered a technical skill, and a capability, and what is an engineering-specific compared to a more general capability. Regardless of categorisation, the necessary capabilities include:

- Systems thinking
- Risk management
- Project management
- Asset management
- Hazard identification
- Understanding of physics and chemistry
- Safety
- Horizon thinking
- Communication
- Working in and leading a team.

Interviewees affirmed that there are general engineering capabilities that apply regardless of industry, and that draw upon both technical knowledge and capacity to apply a variety of lenses:

> "If you're looking at a piece of pipe, whether it's, you know, a foot long or, you know, a 100kms long, you ask the same questions and they apply the same. So what happens when the temperature goes high? What happens when the temperature goes low? What happens when the pressure goes high when it goes low, slide, reverse flow, and the other sorts of questions that you ask, which standard has some questions. So, when you're looking at a bigger system, yeah, it's the same questions."

Interviewees highlighted that there are a variety of pathways to provide engineers with a breadth of capabilities, from studying degrees like industrial engineering to engaging in multiple placements within worksites. They also cited the value of continuing professional development to enable engineers to get out of their comfort zone, learn things from left field and bring this knowledge back to the workforce.

Some interviewees highlighted how working across fossil fuel industries builds a range of practical skills and experience that can then be applied at a more strategic level in the renewable energy economy:

> "…the experience with how to create plans, how to look at the economics of large-scale projects, how to engage with communities, how to build relationships with regulators. You need to project manage these large endeavours of building wind farms and building large-scale solar farms and you've got people who have experience with that at a practical level."

5.3.1 Extending the gaze to integrate a broader range of thinking

Interviewees cited the need for engineers to integrate commercial thinking into their decision-making, and to have a sense of the political, economic, environmental and social landscape in which they operate. They reiterated this should be part of an engineer's DNA:

> "Well, any engineer should be looking to put their community first because that's what our charter and ethics say that we should be doing. Community first that means that you've got to think outside of what you may be asked to be currently doing. It's got two advantages, you're doing the right thing for the community, but you're also thinking about what happens when you connect

> your project, into this other project or into the bigger system, and what the implications might be. So you anticipate the problems…working out all how things come together."

This need for interconnectedness has driven a variety of interviewees to seek further education, with many embarking upon MBAs.

As will be examined further below, interviewees cited the need for holistic, systems thinking and connecting between siloes to ensure action in one part of the sector does not have a negative impact on others:

> "We need people to understand that even though they can generate power they shouldn't jam the power network."

Interviewees noted the tension, particularly for contractors, between coming up with a fast, incremental solution and engaging in transformative change:

> "If you look at electrification, you think of it as a change out of equipment only. Which will save you on power bills and fuel bills, which is kind of how they tend to think they're very incremental…Optimising, converging on a solution fast. It's really hard to make them change their mindset to something more transformative. It is very hard and that's got to be driven by something that that's bigger than them like the client dictating it."

The growth of the contracting role was raised by several interviewees, as contractors work in more agile, and potentially financially unstable, conditions. This switch between being permanent employees with one company, and working from job to job particularly as part of the renewable energy build process, may be a difficult transition for some engineers.

Interviewees further noted that commercial imperatives mean that each organisation is trying to solve issues individually. However, a collective approach would see Australia optimise our capacity to deliver renewable energy as a country:

> "If we all solved it, it would be like Silicon Valley, but it won't happen with current mindsets with everyone optimising for individual profit, we're not seeing the bigger, huge pie."

The result of a company-based approach is that innovations are not being shared and built upon to lift Australia's competitiveness as a whole:

> "We need to learn from earlier work in Europe [about] what works, especially regarding asset management. At the moment, we're reactive and will repeat mistakes - need some sort of uniformity to do this. What are the common shared learnings rather than all making [the] same mistakes?"

These insights indicated that by better coordinating skilling and innovation, and facilitating collaboration including sharing project learnings across industry, we can transform and lift Australia's collective capacity to drive the transition to the renewable energy economy. One way to do this would be for government and industry to support 'innovation hubs' which showcase and share innovative approaches, including those applied overseas, adapted for the Australian context.

5.4 Mindsets, dispositions and behaviours

Engineers, by their nature, are creative problem solvers.

> "What did they know? They knew that human qualities, such as intellectual skills, could be cultivated through effort. And that's what they were doing—getting smarter. Not only weren't they discouraged by failure, they didn't even think they were failing. They thought they were learning." (Dweck, Mindset: The New Psychology of Success, 2007)

A range of analysis, as well as insights from interviews, has drawn out the importance of mindsets in supporting the increasing adaptability of the engineering workforce, with engineers changing role on average every 5.1 years.

Adaptable and flexible mindsets, behaviours and dispositions can work to support engineers to adapt to new technologies and industries. This includes a curiosity to acquire new knowledge, to work with and learn from others, a capacity to take risks and to manage one's emotions (Brunhaver, 2021).

Dweck (Dweck, Mindset, 2008) found that one of the most basic beliefs we carry about ourselves is how we view and inhabit what we consider to be our personality. A "fixed mindset" assumes that our:

> "…character, intelligence, and creative ability are static givens which we can't change in any meaningful way. Success is then the affirmation of that inherent intelligence. It is an assessment of how those givens measure up against an equally fixed standard; striving for success and avoiding failure at all costs become a way of maintaining the sense of being smart or skilled.
>
> A "growth mindset," on the other hand, thrives on challenge and sees failure not as evidence of un-intelligence but as a heartening springboard for growth and for stretching our existing abilities."

Out of these two mindsets, which we manifest from a very early age, springs a great deal of our behaviour, our relationship with success and failure in both professional and personal contexts, and ultimately our capacity for happiness.

A growth mindset is about being optimistic, flexible, committed to ongoing improvement and it also influences:

- how we interact with others
- how we seek and respond to feedback
- how we respond to change
- how we conduct conversations with our peers and other adults in our personal and professional lives.

Interviewees confirmed that these mindsets combined with core engineering knowledge support engineers to grapple with new problems:

> "Innovation and creativity are part of that process of engineering. You should be able to come up with unique and disparate solutions to problems. Just based off what you understand, you know, from your chemistry and physics and of the system. You can be creative… it's the art of engineering."

Innovation was seen as crucial in the clean energy economy as solutions are still being created and engineers need to be able to take risks and adapt. Engineers who are open to change and who understand that innovation is a process, not a destination, who think and act fast and welcome new ideas and ways of doing are more likely to make a smoother transition to renewable energy roles. The willingness to move from employment-based roles to consulting projects depends on mindset, as does the capacity to upskill in anticipation for jobs that do not exist yet.

The advent of reporting on emissions has motivated further investment in innovation, as companies seek to further reduce their footprint beyond the low hanging fruit of known solutions like solar panels and buying offsets from an energy provider:

> "The solutions are not all there, so it requires pilots and trials. A lot of initiatives to try out new products. Yep. And it's actually put a little bit of a rocket up the bum for, innovation in some ways."

Interviewees pointed to the need for fresh thinking that can connect knowledge across disciplines.

5.4.1 Transitioning to multi-disciplinary engineering for many, but not all

Many engineers commence their career in one discipline and build knowledge and transcend industries over time.

The notion of a t-shaped engineer can be helpful. Technical expertise and engineering habits of mind are combined with attributes like resilience and adaptability and utilised to engage in a variety of tasks including systems thinking and problem solving (Crosthwaite, 2021).

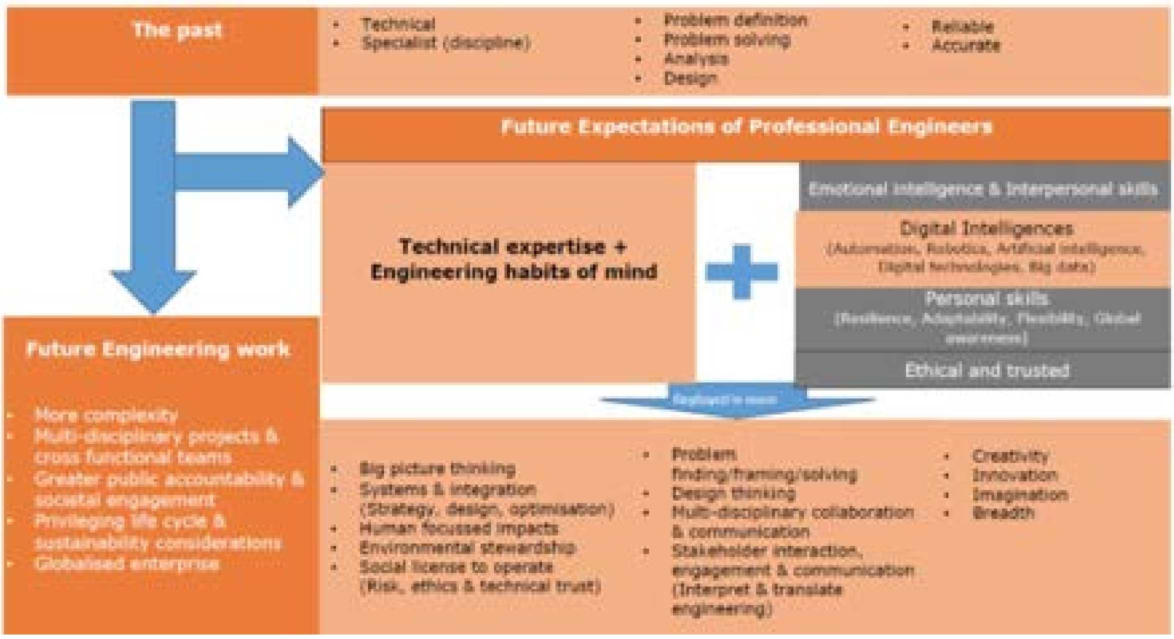


FIGURE 9: DIAGRAMMATIC REPRESENTATION OF TRADITIONAL AND T-SHAPED ENGINEER

Source: (Crosthwaite, 2021).

Some interviewees agreed with the growth of a t-shaped engineer based on the premise:

> "…there is access to enormous amounts of information that we did not have a couple of generations ago, all engineers need to know how to access and understand knowledge…"

Others contested this, arguing that multi-disciplinary knowledge is needed. They argued that rather than t-shaped, engineers need knowledge across a variety of disciplines: from a t to a bridge shape with multiple pillars. The image below is reflective of this paradigm shift to multi-disciplinary engineering, built on practice knowledge and underpinned and supported by capabilities and mindsets. Engineers interviewed who had transitioned to the clean energy economy shared this common profile.

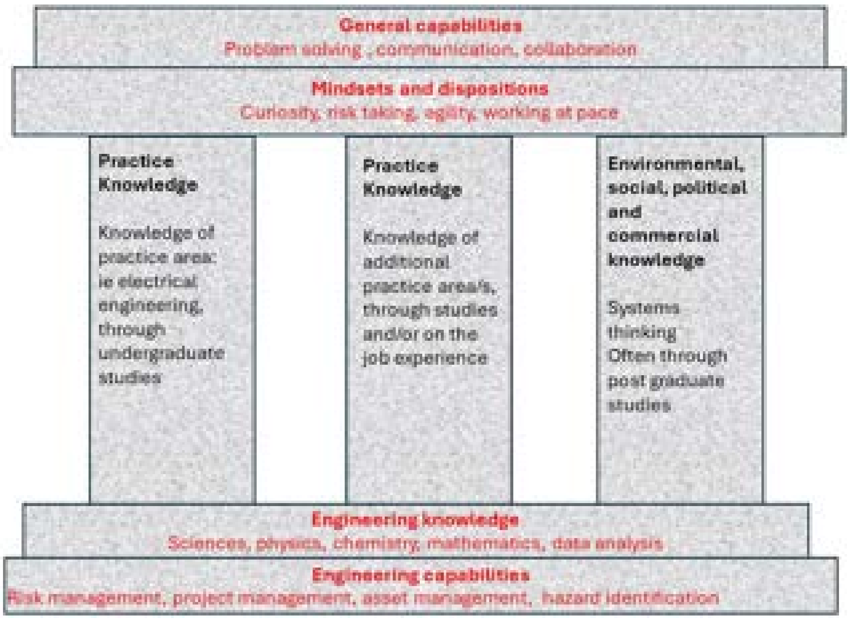


FIGURE 10: DIAGRAMMATIC REPRESENTATION OF TRANSITIONING ENGINEERS

Whilst there was general agreement from interviewees that most engineers have a range of transferable technical skills, only some choose to move on from highly technical roles:

> "When people start out, they do the engineering and at some stage most transition to getting the engineering done. And there are some people who just keep doing engineering. We've got a handful of those people who still do engineering. They have no interest in managing other people [or] working with anybody else and they are the absolute foundations of the business. We need them."

> "…some engineers are deeply technical, and don't have communication skills, and we need them, but many will reach a stage of wanting more."

For an example of an employee transition, see **6.2 A case study profiling individual engineer transitions**.

However, interviewees raised concern about a small group of engineers who aligned more to their function than the engineering profession:

> "…not everyone is motivated to change, some align more with the industry than their occupation and don't do CPD, they don't see value in being registered or chartered, they won't change…"

Whilst knowledge of renewable energy is high across engineering, there is a perceived need to de-risk the transition for engineers who have been performing similar routine tasks for a long while and show how their skills can be utilised in the clean energy sector. This is a challenge when new roles are still in formation, so the exact roles and tasks required are still emerging.

For example, an *'Introduction to the renewable energy sector'* micro-credential could be developed, including guidance on the different standards that apply across different energy types:

> "…a technical course, that covers each of these elements to give those individuals the confidence to move across under that. Nothing too long as people are at a stage in career where [they're] not investing too much. Current programs are too narrow. We need to show we're not requiring them to start again."

This includes providing quick guidance - like a ready reckoner - on the different standards, and a guide to understanding different industry jargon to demystify the different sectors.

5.5 Industry pace and innovation

Several interviewees highlighted that the oil and gas industry provides a good grounding for transferring between roles and industries.

> "The oil and gas game teaches you a lot. You see a lot of really clever people and you continually learn and if you don't, you don't survive in that industry. So I think moving into any other industry [it is] pretty much the same…and you just rely [on] and leverage your education."

The commercial imperative in this industry means a constant requirement to innovate to increase output and reduce cost, whilst adhering to strict regulatory frameworks.

Interviewees noted the often faster timeframes for jobs in the renewable energy economy, and requirements to make decisions on limited information:

> "It's still delivering projects on a timeframe faster than the usual. It's more dynamic and you've got to be responsive, you know, to different types of tenders and different obligations. You've just got to make judgment calls on occasion which terrifies young people."

Agility was seen as important, as well as foresight and the capacity to predict longer term problems and to feel comfortable making quick decisions on limited information.

5.6 Company culture is a key to mindset change

Interviewees reflected on enablers of mindset change, and in particular willingness to take a risk, and to adopt a less incremental approach:

> "Change needs to be led from the top. If managers are institutionalised, then so are workers."

Company culture was seen as a key enabler, with investors needing to incentivise rather than penalise risk-taking. Increasingly, companies are being incentivised through customer expectations, shareholder activism and the monetisation of emissions. Research confirmed this, citing the safeguarding mechanism as a key turning point to incentivise heavy emitters to focus on emissions reductions (Ai Group Centre for Education and Training, 2024).

This culture translates to a backing of staff to genuinely engage with new ideas:

> "CPD done well makes a difference. Some people just treat that superficially and just go and study different boiler tubes. We encourage our engineers to get out there and go to conferences and places that I'd never thought about going. And they come back, like "gee I didn't know that existed". Yeah, well, there you go. So, you know, it's about popping your head up and having a look around. I've

> seen quite a few engineering managers who don't allow their staff to do that. So your job is to look after boiler tubes and that's all."

This desire to learn more is valued and rewarded by companies who rely on innovation:

> "Some staff come in really ambitious and want to learn and move; come to the attention of the CEO. So if you're looking for a career progression, it's a good way to be seen by the CEO. You can deliver on these newer projects or win the work or whatever it might be…there are opportunities for people to look differently and work differently."

5.7 Labour force availability

Many of the occupations needed to support the transition to clean energy are in current shortage, with competing construction projects drawing on civil engineers, for example. Other occupations in shortage include electrical engineers, whilst mining engineers are likely to be in medium-term shortage.

Jobs and Skills Australia modelling shows engineering occupations are likely to have sufficient supply in the transition to clean energy but notes this does not take into account current shortages for some occupations, including civil and electrical engineering, or the volatility in labour supply including the reliance on skilled migrants (Jobs and Skills Australia, 2024). It relies upon sufficient engineers moving to roles in renewable industries from other industries, rather than assessing whether there will be sufficient stock of engineers in the labour market overall.

Interviewees cited challenges with recruiting engineers, and in particular high demand for experienced electrical engineers. The need for electrical skills is also exacerbated by a shortage of electricians, and the movement of electrical engineers into senior roles including engineering managers and project managers. This shortage is likely to continue as data shows completion from engineering and related technology courses declined between 2018 to 2022, and concerningly enrolments have declined 8.7% from 2018 to 2022, although domestic bachelor enrolments increased marginally in 2021 and 2022 (Department of Education, 2024). Data shows there are under 9000 new bachelor-level domestic engineering and related graduates each year, well below projected levels of workforce growth over the last five years (Department of Education, 2024).

Australia is heavily reliant upon overseas-trained engineers, but there is global demand for these skills. As well as attracting, retaining and developing workers, maximising labour force utilisation is essential. Adoption of local planning can support the avoidance of boom and bust cycles by managing workforce transition as construction projects draw to a close and supporting ongoing and planned workforce transition.

5.7.1 Retaining and growing the female workforce

The engineering workforce is skewed towards full-time, male-dominated employment. One reason engineers leave the profession is due to a difficulty combining work and family. Women face significant issues with workplace culture, including bullying and discrimination, and lack of career progression which contribute to attrition (Romanis, Women in Engineering: Identifying avenues for increasing female participation in engineering, by understanding the motivators and barriers around entry and progression, 2022).

Many interviewees themselves, both women and men, had moved from engineering roles to management, consultancy and directorships, often to combine work and family, having gained a solid foundation in an intensive and varied early career.

Few women enter engineering, although female engineers are growing at a faster rate than male. Despite this growth, many females disappear from the workforce. This was highlighted by one interviewee:

> "Women disappear at the age of 35. And I think there's a huge cohort of women who are over 35, who actually probably left. Usually they leave because of families. Yep, my industry is not, um, conducive to mixing career and family. Because it's too inflexible. Yeah, hours and culturally it can be, it can grind you down and I think around the age of 35, we're pretty ground down and seek change. I think there's a whole cohort of women that are invisible and off the radar. To find a way to pull them back. How do we attract them back? How can we help them? Refresh those old skill sets and then apply them in any way and when you've been out of the industry, it's easier to unlearn and relearn. So I just think that women are a massive resource that we're still not really tapping into."

As will be discussed later, the 2024-25 Budget announced new policy initiatives aimed at attracting women to careers in clean energy.

Pilot initiatives could be explored that re-attract women to engineering, including supporting employers to create flexible work environments with a view to creating a more diverse workforce and supporting retention.

The transition to clean energy provides the opportunity to rethink how work is organised, as is envisaged in **6.3 A case study envisioning a brighter disrupted future for mining**.

A range of further factors, including skilled migration, trust in overseas qualifications, and re-attracting engineers who have left the workforce, will impact labour force availability.

5.7.2 Ensuring skilled migrants can access opportunities

Of the 340,000 overseas born engineers in Australia, less than 140,000 are working in engineering (Engineers Australia (b), 2024). Although some of the engineers would be retired, and other working in aligned industries, interviewees confirm there are barriers to fully utilising skilled migrants.

One barrier raised was the transferability of qualifications between countries and either perceived differences in education standards "we know there's a difference and need greater confidence in their capacity to hire them" or difference in experience and understanding, for example different power systems overseas:

> "That's a lot of engineers coming from international who are in power systems are trying to get a strong experience. Now we've a lot of our engineers saying, yeah, they've got power systems but it's not related to what we do."

Several interviewees raised the challenge of overseas trained workers gaining their first job in Australia, and the need for employers to 'be brave' and take them on. One concept raised was of an internship program for engineers with no local experience to support transitions:

> "An internship program where they would come to businesses with vetted employment rights and qualifications. Employers could be supported to employ and train these engineers for the local context. At the end of that program, you know you've got an engineer you can keep on. If he doesn't stay with your business at least when he goes into the workforce, he knows is able to say I've worked with an Australian company and has referees. You could draw talent to regional centres this way."

An aligned, alternative initiative is an orientation program for skilled migrants where they could be hosted by a series of workplaces over six to twelve months, with employers supported to co-operatively host employees. Engineers Australia's Global Engineering Talent (GET) Program and the Professional

Year in Engineering aim to address this issue by providing familiarisation with the Australian context, followed by a paid work placement (Engineers Australia (c), 2024; Engineers Australia (d), 2024). A similar model is in operation through the Clean Energy Council and AEMO for grid engineers, which involves a two-year, four rotation program for graduates including technical courses (Clean Energy Council, 2024).

5.7.3 Ensuring a future pipeline

Interviewees cited new entrants are often attracted to engineering as a profession to enable them to help the world; the profession is chosen as a means to achieve their goal. This poses an opportunity for workforce attraction if links between engineering roles and the goal of Net Zero can be made clear throughout the education system:

> “We're building the future, we're making the energy transition. So as children go through school, we can create awareness like we have for jobs in the army for example. So you build that awareness at a really young age. There's a whole range of career options, a million of them in renewable energy that we can inspire them with…get them to see really cool things. The inspiration piece is missing at the moment.”

Whilst many engineers believe the occupation has high visibility, there is potential to ensure all children and young people develop an understanding of the breadth and impact of engineering, including its contribution to the clean energy economy.

5.8 Locations of ‘old’ versus ‘new’ roles

Jobs and Skills Australia mapping of clean energy workforces shows a strong alignment between clean energy and transitioning segments. This mapping does not include battery storage or alternative uses of thermal industry sites, which may result in transitioning locations pivoting to different energy sources and/or roles. Nonetheless, there are locations like Illawarra and Upper Hunter and Central Highlands where transitioning workers represent more than 10% of local employment at present (Jobs and Skills Australia, 2023). It is possible this landscape could change, if existing infrastructure at these sites can be repurposed and utilised.

For insights into how one company is supporting the workforce transition, see **6.1 A case study of a large energy provider in a period of transition**.

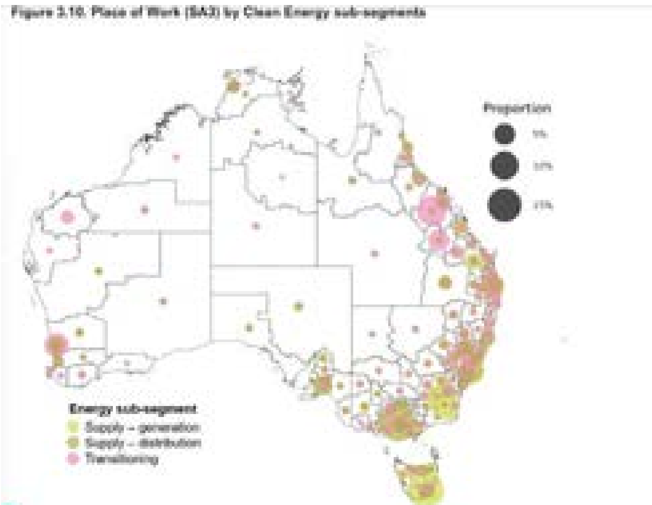


FIGURE 11: MAP OF ENERGY SUB SEGMENTS

Source: (Jobs and Skills Australia, 2023)

Interviewees cited key barriers to staffing roles in remote areas, including the FIFO nature of work, and the lack of childcare and housing in nearby communities making it difficult to attract workers with families. They posited that, driven by economic imperatives of renewable energy, it may be possible to re-imagine a new future for mining that is more just and inclusive, arguing that through electrification and automation of mining:

> "…operations centres could be based in regional or major cities, rather than FIFO. Workers can be engaging in more critical and creative thinking, doing better and more interesting work and combining work and family."

This could support the retention of workers who might otherwise shift out of profession, and the engagement of women who, according to interviewees, often leave the profession when seeking to combine work and family.

5.9 Training pathways

Training pathways are essential to supporting workers' transitions (Clean Energy Council, 2022). The Clean Energy Council notes the need for strategic industry wide programs in key occupations, such as grid connection engineers, and for under-represented demographics. They highlight the need for government to incentivise industry and higher education collaboration, including to support harmonisation of skills in key roles to ensure workers can transition between employers.

There is a risk in specialised, firm specific training limiting workers' ability to transition between different employers (Jobs and Skills Australia, 2023). This points to the need for industry recognised skill sets and certifications.

The requirement to attend training in person can make it inaccessible for employees, with a need for in situ training to ensure access to industry facilities in regional areas.

One key challenge raised is the potential growth in operational and maintenance roles which, post build, will be ongoing. These roles aren't visible, and it is difficult to predict what skills will be needed depending on the energy source (Clean Energy Council, 2022). Ongoing skills mapping will be essential to identify and plan for these emerging, ongoing roles and to engage and prepare existing workers to transition.

Jobs and Skills Australia notes that the renewable energy workforce will build on the existing qualifications (including 15,000 bachelor of engineering commencements per annum) within the workforce, but be supplemented to fill skills gaps, and to support emerging workforces.

There is increasing interest in renewable energy training, with a 500% growth in VET unit enrolments (Jobs and Skills Australia, 2023).

There is a challenge to creating new pathways to meet skill gaps as it requires a critical mass of students, which is not always possible in some regions. A host of new micro-credentials and engineering specialisations have been created, although it is difficult to ascertain if these are designed to attract students and or meet the renewable energy industry needs as feedback in this project suggests specialisations can make it more confusing for employers.

An alternative exists at Federation University, with their globally recognised post-trade turbine technician training course developed by the German industry network BZEE. The six-month intensive course for electricians, mechanical fitters, and automotive technicians includes an internship with wind turbine manufacturers and service organisations, covering electrical, mechanical, and hydraulic systems training (Jobs and Skills Australia, 2023). Similar post-graduate programs could be created for engineers.

5.9.1 The role of focused degrees

Some universities have responded to student interest in sustainability by creating bespoke engineering degrees, but these may not support employability or transition. Interviewees noted the plethora of emerging university degrees focused on the renewable energy sector, arguing the variability in offerings made it difficult for employers to understand what skills graduates possessed. Employers confirmed that an understanding of sustainability is needed across all engineering degrees, as well as a base level understanding of data and analytics. However, interviewees contended these degrees are confusing the market:

> "Most engineering managers understand what electrical engineers have studied, or mechanical or chemical. We know what they are suitable for when they graduate. We know what they know and what they don't know. But if someone turns up with a degree in renewables, for example, you go, what have you done?"
>
> "We still need the core engineering ingredients."

Whilst there may be a need for specialised degrees on parts of the renewable industry – like power engineers - a generalised engineering sustainability degree is generally not viewed as helpful. Existing degrees will need to transform to respond to shifts in settings, for example mining systems engineers will need to increasingly understand automation and electrification as well as retain foundational engineering skills and a fundamental understanding of how mines work.

5.10 Policy settings

Transitioning to new roles takes time, and investing in new technology and product streams requires a level of certainty and a focus on concrete supports. Interviewees raised the need for clear and consistent policy settings to enable the transition to alternative energy sources. For workers, this includes clarity and long lead times to ensure that workers can retrain prior to plant closures.

Policy settings can also support retention of employment in regional communities, for example by requiring companies tendering for energy contracts to hire a percentage of the local workforce. The case study of a large energy provider highlights how this supports retention of skilled staff in communities.

Additional government intervention may be required to enable the offering of wages sufficient to attract highly skilled workers to the clean energy sector.

6. Case Studies

6.1 A case study of a large energy provider in a period of transition

The scenario

A major energy provider owns coal-fired power stations. Their future is in renewables, and they are diversifying into hydrogen, wind and solar.

Lessons Learned - what is working well

The company draws on the skills and strengths of their workforce to evolve their generation portfolio into solar, wind and hydrogen. Many of their new ventures are located in the vicinity of their existing power stations, supporting the transition.

A key strength is the local understanding that existing staff bring to projects. "Engineers might have worked in their community for 30 years. They know their neighbours, and can talk to farmers. They have a social license."

Further, there is a strong sense of culture that can spread across an expanding workforce:

"The guys I work with have such great pride, I don't want to lose a single one of them, I trust these guys, they have our culture drilled into their heads. I want them to develop the culture of the new engineers".

Many of the skills engineers need for roles in renewables are the same as in coal-fired power stations. "What the role is called might be different, and the project, but the skills are transferable".

Not all roles can be located locally, but there is optimism, particularly from younger engineers who want to live in a city or at the coast and are happy to travel to sites.

Challenges and opportunities

There is a desire and need to provide a sense of certainty to the workforce. "We're working through the whole transition program, with job security guarantees and individual transition plans."

All workers have the skills to transition, but not all may want to: "Some people are excited by renewables and will transition quickly, others are more conservative and will want more certainty or more information. Some will be really cautious and swayed by others".

Although some workers will be of retirement age, there is a desire to keep staff, "We need more workers, not less and should be asking what do we need to do to keep you?"

The pace of change means experienced workers are needed to meet project deadlines, but existing staff need opportunities to gain experience across renewables. The company is trialling ways of doing this that are as cost-effective as possible:

"People aren't coming from a zero starting point, they've managed capital projects…we're trying to mirror people on projects to fast track them to get that experience". This is occurring at present with an engineer shadowing a project manager on a large battery storage project.

Despite efforts to date, there isn't a consistent understanding across the workforce that there are many similarities in jobs in the renewable industry, and people need support to identify their transferable skills: "I had a conversation with one of our procurement managers recently at one of their sites. And he said I don't have transferable skills. What are the jobs for me?"

Up next

Managers are working to articulate the skills that will be needed in the future, to reduce ambiguity, enable transitioning workers to think about where they might wish to move to, and provide time for consideration. “We’re going to hold a road show to indicate to the workforce the indicative roles and skills and get people to express interest. We can then map skills and find ways of filling gaps – through micro credentials and top-up courses. There will be a need to cross-skill rather than necessarily up skill.”

Transitioning workers will relate to information in different forms, including videos. Stories of successful transitions have a particular resonance and will be shared.

“For example, we had an operations manager who had a PhD in gasifying coal, and she went on to run the wind farm.”

The company is also looking to the future generation, including establishing a renewable work experience program.

With a structured approach in place, and willingness to explore flexible options, the company hopes to retain and transition the majority of their workforce and draw on their skills for years to come.

6.2 A case study profiling individual engineer transitions

The scenario

Engineers regularly transition between roles and employers. In this case study we combine learnings from several engineers who have transitioned to the renewable energy sector. Flexible mindsets and being open to learning and change are key to successful transitions.

Lessons Learned - why did they decide to transition to renewable energy

Many of the engineers who transitioned had prior experience in oil and gas which exposed them to high pace, high pressure environments with the need to solve problems quickly. Others worked across electricity generation.

Many travelled overseas for work and engaged in multiple roles throughout their early careers before returning to Australia.

Over time, several of the engineers profiled sought to move away from roles requiring long hours and travel, and to combine work and family. They were more comfortable engaging in project-based roles, including through consulting.

Each engineer had a thirst for new knowledge and challenges. As their career progressed, many engaged in postgraduate studies in management.

They spoke of curiosity about new technologies – “I was looking around at future markets…I always try to push myself.”

A growing belief in the potential for renewable energy sparked the transition, in one case in spite of detractors “I interviewed a c-suite executive and showed him my analysis and research on wind and solar and they said it will never take off” and in another case interest was sparked by a colleague who was working in sustainability and a masters in sustainable energy followed.

Challenges and opportunities

The path to working in renewables was enabled through continuous learning, study, reading, short courses and self-navigation. Each engineer looked at where they wanted to be, spoke to others and navigated into new roles.

The transition to renewable energy was driven by self-belief and a willingness to take risks. They didn’t have all, or sometimes many, of the skills and experience that were sought but were confident to take risks and willing to learn.

Transitioning engineers spoke of the ability to innovate at pace in the renewable sector. This included a willingness to take risks and fail in order to solve new problems, and to work with a project mindset. This was seen as a key differentiator to working in thermal based roles.

Up next

A key learning shared by each engineer is the need to apply a broader lens, being flexible and open, to think about economic, social and environmental considerations in the work you do and think about the implications beyond your immediate role.

6.3 A case study envisioning a brighter disrupted future for mining

The scenario

Mining will continue to play a role in our clean energy future, with increased requirements for minerals such as graphite, lithium and cobalt.

At the same time, mining operations themselves need to transform to reduce their thermal footprint.

There is the possibility of thinking broader, beyond electrification of mine vehicles, to examine how we could transform mining to meet the challenge of Net Zero, scale up operations and recruit and retain engineers in a tighter labour market through re-inventing mines.

We can dream big, rather than just embrace incremental change in the shift to renewables.

This scenario is about envisioning the future, and how we could shift from diesel powered mine vehicles to electrified and autonomous mining and in the process lead workforce transformation.

Lesson Learned - what might be possible

With the growth of electrification, and possibilities for accompanying use of autonomous vehicles, one interviewee painted a picture of a compelling new future in mining.

Electrified autonomous vehicles could be dispatched into mines to perform mineral extraction. This could be planned as part of new mining operations that will be essential to deliver the critical minerals needed for the renewable sector.

Lives could be saved through technology replacing manual labour, as well as the carbon footprint being reduced as mining achieves Net Zero.

The quality of the workplace would be enhanced as machines could be controlled remotely, from communities where families live.

The mining workforce would be accommodating of life circumstances, retaining women of childbearing age and older workers.

Challenges and opportunities

What would it entail?

New mines could be designed that can accommodate electrified, autonomous vehicles and minimise environmental degradation. Associated infrastructure, including localised power supplies would be needed. Workers would still need to visit sites at times including during the technical build, but the reliance on staff at site on an ongoing basis would reduce and with it a reduction in risk and a broadening where the work in mining occurs and who is involved.

Mines could be monitored from afar, in remote or virtual control rooms in communities where families reside.

Mining engineering courses would need to adapt to this change to support engineers to design and monitor new mines.

What would the benefits be?

Under this scenario, mining undergoes a technological transformation, with the nature of the sector changing from a workforce reliant on manual labour to a highly technical workforce with world leading practices and infrastructure.

Beyond the initial likely higher build cost for electrified, autonomous mines the ongoing cost is lower.

Staff do not need to travel to site, reducing the carbon footprint which is already lower due to the electrification and reliance on renewable power sources.

The capacity to supervise mines remotely means mineral extraction mining can be scaled up to meet the needs of the renewables sector.

A diverse workforce would be attracted to mining engineering, with staff able to work in a variety of environments, and with flexible conditions enabling them to manage work and family.

There is the opportunity to position mining at the forefront, to reduce carbon emissions, secure vital minerals and achieve workforce transformation through adoption of new technologies and practices.

7. Skills mapping

This research project seeks to develop skills profiles to identify which roles can easily transition between energy sectors, and which will require additional knowledge and experience. The following skills mapping is illustrative rather than comprehensive, providing mapping of key engineering occupations against common clean energy occupations.

An initial scan of skill maps has been conducted to inform the approach.

Jobs and Skills Australia identified transition pathways by looking at industries that employ the same occupations, then examining occupation transitions that have occurred.

They mapped several engineering-related workforces and some key transitions:

Mechanical Engineer	Engineering Design and Engineering Consulting Services Other Heavy and Civil Engineering Construction Manufacturing, nfd Motor Vehicle Manufacturing Iron Ore Mining	Engineering Manager Mechanical Engineering Technician* Construction Project Manager Motor Mechanic (General) Civil Engineer	Production or Plant Engineer (HIGH) Industrial Engineer (HIGH) Engineering Technologist (HIGH) Materials Engineer (HIGH) Structural Engineer (HIGH) Mechanical Engineering Technician* (HIGH) Electrical Engineers (HIGH) Chemical Engineer (HIGH) Geotechnical Engineer (HIGH) Aeronautical Engineer (HIGH)
Electrical Engineer	Engineering Design and Engineering Consulting Services Electricity Distribution Electrical Services Other Heavy and Civil Engineering Construction Electricity Transmission	Electrician Electronics Engineer Electrical Engineering Technician* Mechanical Engineer* Computer Network and Systems Engineer	Production or Plant Engineer (HIGH) Engineering Technologist (HIGH) Mechanical Engineer* (HIGH) Industrial Engineer (HIGH) Electrical Distribution Trades Workers (HIGH) Electrical Engineering Technician* (HIGH) Electrical Engineering Draftsperson (HIGH) Telecommunications Engineering Professional. (HIGH) Materials Engineer (HIGH)
Electrical Engineering Technician	Electrical Services Electricity Distribution Scientific Testing and Analysis Services Other Heavy and Civil Engineering Construction Oil and Gas Extraction	Electrician (General) * Electrical Engineer* Electronic Engineering Technician*	Electrical Engineering Draftsperson (HIGH) Mechanical Engineering Technician (HIGH) Electronic Engineering Draftspersons & Technicians* Civil Engineering Technician (HIGH) Electrician (General) * (HIGH) Electrical Engineers* (HIGH) Mechanical Engineering Draftsperson (HIGH) Electronic Instrument Trades Worker (General) (HIGH) Electrician (Special Class) (HIGH) Engineering Technologist (HIGH)

* occupations that appear in common real-world transitions and skills similarity (columns 3 and 4)

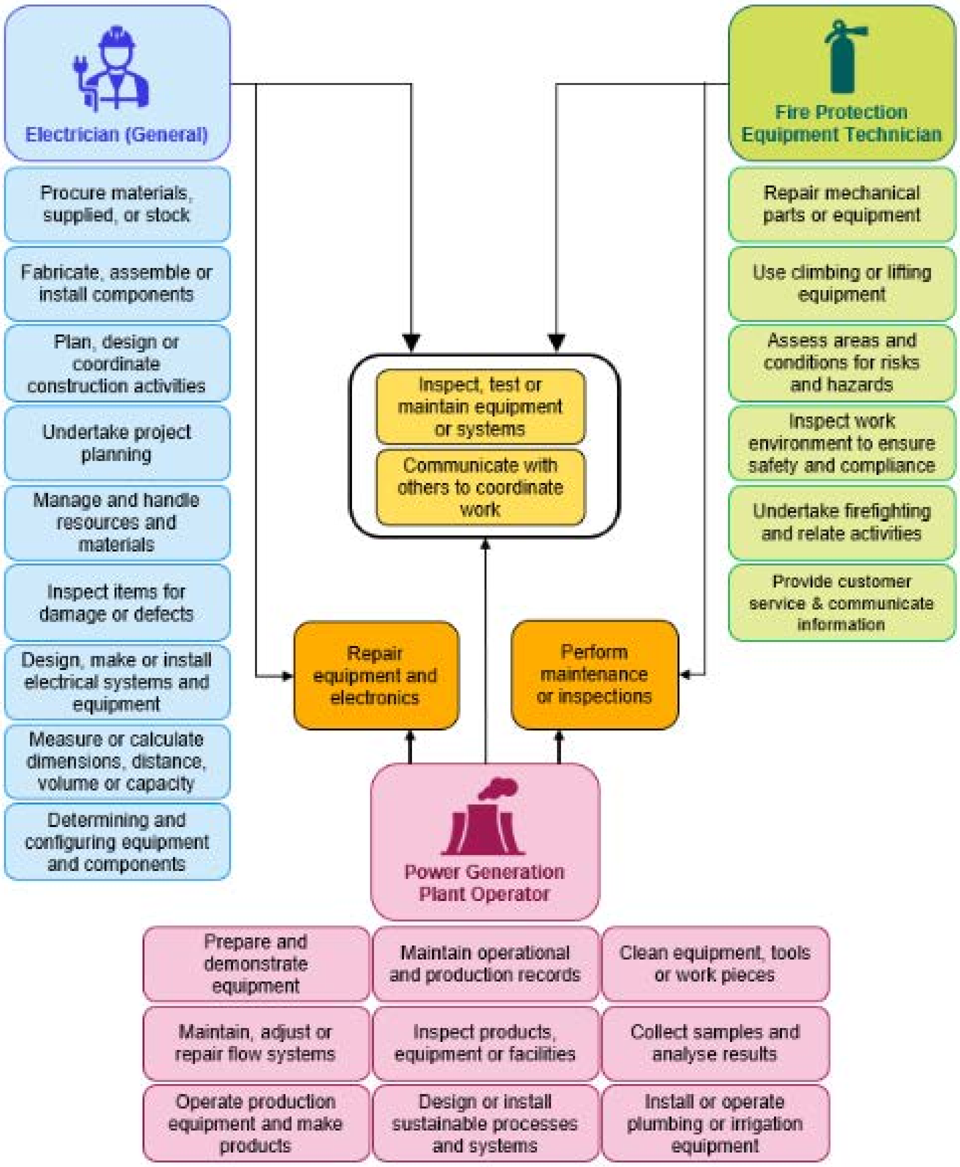
FIGURE 12: COMMON ENGINEERING TRANSITIONS

Source: (Jobs and Skills Australia, 2023, pp. 144-147)

This mapping is based on actual transitions made over time, drawing on government data.

These maps are useful in illustrating common pathways, although further research is needed to understand what supported or enabled the transitions. Further, this approach maps to roles categorised by ANZSCO codes, whilst clean and renewable energy roles are continuing to emerge, with many of the occupations in the Clean Energy Council list not explicitly identified in ANZSCO.

Another approach used by Jobs and Skills Australia is to map key skills to see which transitions are likely to have less friction, as follows.



Source: JSA, Australian Skills Classification November 2022. Yellow skills are in common across all three occupations, while the orange skills are in common across two occupations.

FIGURE 13: SKILLS MAPPING EXAMPLE

Source: (Jobs and Skills Australia, 2023)

This approach notes there are other factors that may limit transferability, including training, licensing and organisation of work.

7.1 Approach to profiles development

The tailored approach to mapping in this report is aimed at showcasing pathways into clean energy roles that are in shortage, noting there are many other roles which engineers are readily transitioning into. It is reliant upon existing, published information supplemented with information garnered through interviews, case studies, and job advertisements.

It draws from the approach used by Jobs and Skills Australia in mapping skills from the Australian Skills Classification (ASC) where possible, but seeks to include broader information, including mindsets, experience levels and capabilities, to identify barriers and enablers to transitions.

The approach to developing profiles is as follows:

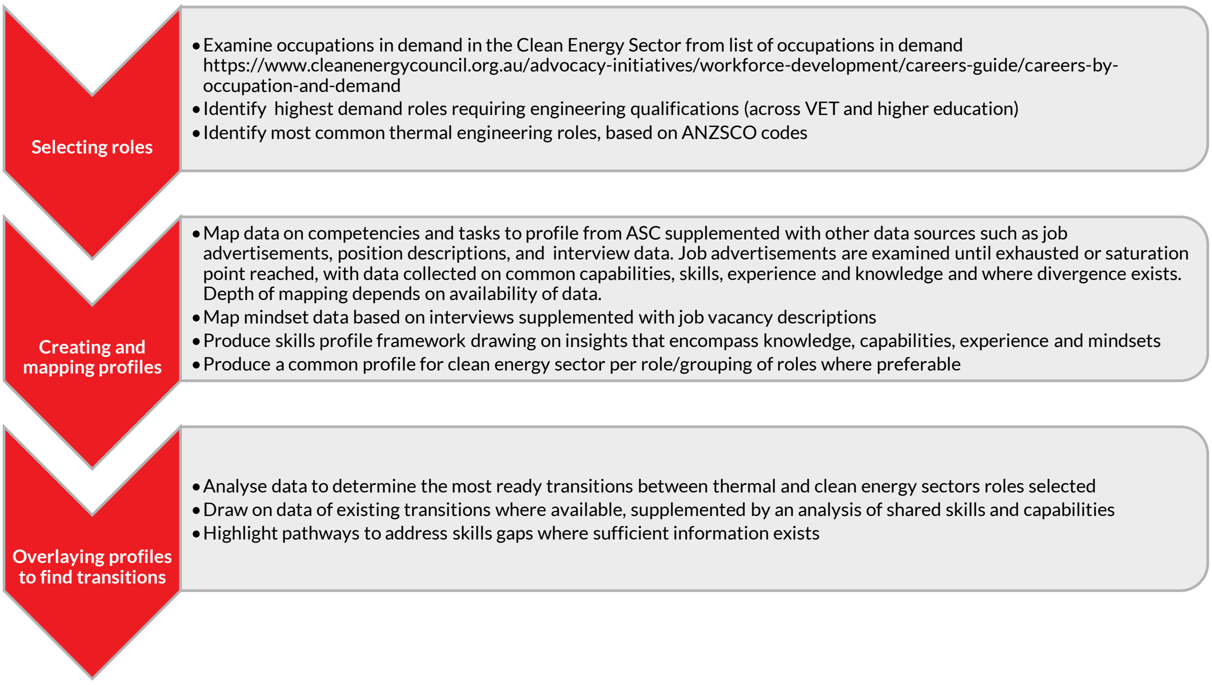


FIGURE 14: APPROACH TO PROFILE DEVELOPMENT

7.2 Selecting roles to map

The Clean Energy Council provides a comprehensive list of occupations making up the renewable energy industry. These are categorised by energy source, and degree of shortage. It should be noted that these roles are related to new energy sources, and not the transition of existing sources to Net Zero, but they represent the most comprehensive list available of roles and shortages. This list of roles does not align neatly to ANZSCO codes given many of the roles are emergent.

From this list, the following twelve roles were identified as being in shortage in most regions and requiring engineering skills (Clean Energy Council, 2024):

Role	Industry/s
Battery deployment manager	Battery storage
Battery design specialist - utility scale	Battery storage
Blade engineer	Wind
Blade technician	Wind
Control room operator	Wind, Solar, Hydro, Battery
Electrical engineer	Wind, Solar, Hydro
Grid connection manager	Wind, Solar, Battery
HV engineer	Wind, Solar, Hydro, Battery
Power Systems engineer	Wind, Solar, Battery

Quality Manager engineer	Wind, Solar
Solar farm technician - mechanical	Solar
Wind farm technician - mechanical	Wind
Structural engineer	Wind, Solar, Hydro

TABLE 1: CLEAN ENERGY ROLES

Selecting engineering roles to map from the thermal sector is more difficult, as there is no one definitive list of roles that constitute the thermal sector. As a proxy, engineering occupations across the mining and electricity, gas, water and waste were examined as a priority to narrow down on industries. This is broadly consistent with the approach taken by Jobs and Skills Australia.

Roles at the ANZSCO three and four digit level are examined firstly under:

Professionals > Design, Engineering Science and Transport Professionals, Engineering Professionals.

This showed a prevalence of engineers in mining and electricity, gas, water and waste across civil, electrical, industrial and mining engineering occupations.

These were then broken down into six digit level occupations.

The most prevalent occupations appearing across electricity, gas, water and waste and mining were examined.

These were then narrowed to occupations having at least 1000 employees across the above occupations.

Two vocationally trained occupations were included as they have over 2500 staff across mining and electrical.

The following occupations were selected:

Role	Industry/s
Civil engineer	Thermal (mining, electricity, gas, water and waste as proxy industries)
Electrical engineer	Thermal (mining, electricity, gas, water and waste as proxy industries)
Mechanical engineer	Thermal (mining, electricity, gas, water and waste as proxy industries)
Mining engineering – ex petroleum	Thermal (mining, electricity, gas, water and waste as proxy industries)
Petroleum mining engineer	Thermal (mining, electricity, gas, water and waste as proxy industries)
Electrical engineering draftsperson	Thermal (mining, electricity, gas, water and waste as proxy industries)
Electrical engineering technician	Thermal (mining, electricity, gas, water and waste as proxy industries)

TABLE 2: THERMAL ENERGY ROLES

7.3 Findings from skills profiles

Through the process of examining the Australian Skills Classifications and job advertisements, we garnered more detailed insights into occupations in the renewable energy and thermal energy sectors, confirming some of the insights in the literature and providing new insights. Below are key takeaways and implications:

- Advertised roles tend to be for higher-level, more experienced staff, especially in the renewable energy sector. This may be due to difficulty filling roles, hence vacancies remaining advertised for longer, and use of other recruitment streams such as graduate recruitment processes for entry level roles.
  Given this project is aimed at looking at pathways for engineers in employment in thermal roles, this does not pose a barrier as existing workers will be unlikely to seek entry level roles.

- Many advertised roles for engineers in the renewable energy economy are in consulting. Further, roles in consulting or with large mining and some electricity companies offer flexible conditions including part-time work.
  Consulting work can be less stable, require greater levels of agility, and travel to different project locations. This will impact the desirability of these roles, especially for workers who are not in FIFO or remote based work, but this may be tempered by the availability of flexible work.

- Whilst many roles across renewable energy and thermal energy are in regional areas and/or conducted on a FIFO basis, there is an emergence of roles that can be conducted remotely, such as control room and drafting roles.
  The capacity to work remotely in some roles may provide for greater transferability of the workforce. For example, control room roles that are conducted in regional or city centres may attract engineers seeking to reduce travel, and/or to work more flexible hours to accommodate family or other responsibilities.

- Salaries in renewable energy appear lower than thermal roles, consistent with the literature.
  Roles in the thermal economy were frequently advertised with high salary ranges, bonuses and other incentives such as RDOs in contrast to renewable energy which rarely stated salary, and included few other benefits. Some renewable roles required very long hours at remote sites, for example at wind farms, without commensurately high salaries. Surprisingly, roles in renewable energy often did not highlight the opportunity to work in the renewable energy sector as an incentive.

- Consistent with the literature and interviews, there are a range of general capabilities shared across engineering. Many of the renewable energy roles advertised required a wider range of capabilities, including professional capabilities such as client liaison, than similar advertisements in the thermal economy. Similar capabilities were shared across renewable energy roles, with differences in knowledge and experience depending on energy source.
  Roles in the renewable energy sector often require engineers with a wider range of capabilities than in the thermal sector. This may be due to organisational size or structure, for example, the newness of roles meaning there is no established hierarchy for entry-level staff, or the growth of more challenging roles requiring employees to have high-level technical and professional skills.

- Many roles examined had specific requirements, especially around knowledge and years of experience of HV power.
  Many roles required experience in HV, and nearly a thousand advertisements appeared for HV as a search term. HV power knowledge and experience featured in a wide range of roles, within and outside of direct engineering roles including quality managers, construction managers and project managers. Technician roles were often also open to engineers, likely due to the shortage of technicians. This may indicate a significant demand for engineering skills and experience outside of core engineering occupations.

- Consistent with the literature, as engineers progress in their careers they move to roles requiring technical and professional skills, requiring broader capabilities and in particular project management experience and at times experience across different energy sources.
  High level communication, project management and negotiation skills features consistently across senior level roles. Some higher level roles require additional skills, such as preparing costings and tender documents and community consultation.

- Some roles, especially senior roles, required membership or professional recognition / registration, most often as chartered engineers or in Queensland registration as a professional engineer.
  This could pose a barrier to some staff who, whilst working in engineering occupations, moved into these roles from vocational education and are unlikely to gain recognition without extensive further study, as will be highlighted later in the skills mapping.

- Mapping to the selected occupations was difficult as there were a myriad of role titles that, especially in the renewable energy sector, did not align with the original search term. These roles were across a variety of levels from entry to senior level, and often combined skills and experience across roles and skill levels. For example, a search of battery deployment managers did not result in any job advertisements, but a search of Battery Energy Storage System (BESS) found over a hundred vacancies for engineers to deploy batteries, with role titles including BESS engineers, project engineers, sales engineers and project development managers. There was less clear hierarchy between roles in the renewable energy sector than in the thermal economy, where often roles were cascaded from technician to engineer, lead engineer and project manager.
  Given this, the skills profiles will be based around a group of like roles rather than a singular role title where necessary, with delineation of skills levels where possible.

  This multiplicity of role titles may make the transition from one role to another more challenging for employees, as it is more difficult to find a clear path. As noted in the review of ANZSCO, there needs to be a mechanism to capture and understand the wide variety of roles appearing in the Renewable energy sector. Further mapping of skill pathways and occupations could support employees to navigate the range of roles emerging.

Skill profiles were developed based on aligned occupations in a single profile, categorisation as technical or professional based on whether the skills specified are more technical or professional, the skill level where specified, and to reflect the nature of the work, for example FIFO, where known and prevalent across advertisements.

Below is a skills profile for a battery design specialist role. In this example there are a variety of different role titles that align with a common description, knowledge and skill requirement. As highlighted above, the role is one that requires a large breadth of capabilities in addition to technical skill. The full suite of skills profiles are in the Appendix.

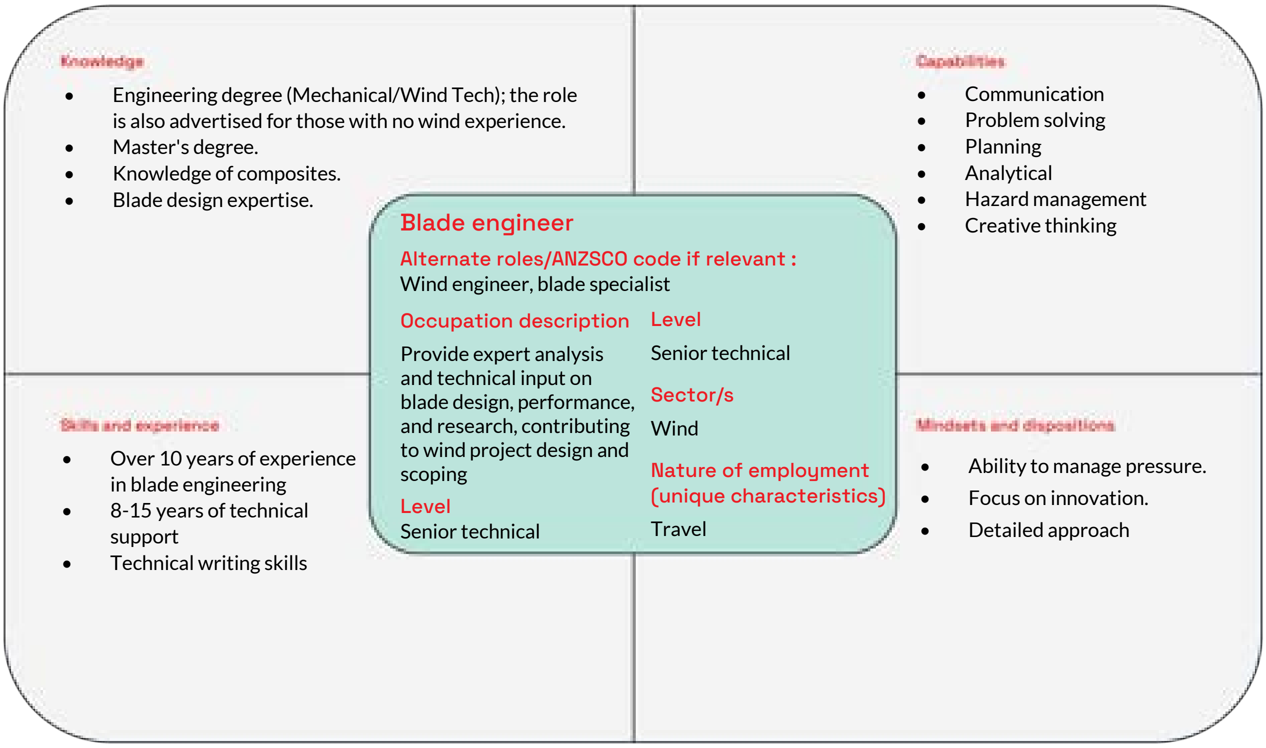


FIGURE 15: SAMPLE SKILLS PROFILE

Twenty skills profiles were developed based on the data collected, with profiles for the renewable energy sector generally providing more detail, especially regarding capabilities whilst thermal roles often covered a suite of experience from entry-level to senior.

The profiles provide a sense of current industry requirements based on job advertisements at the time of analysis. They also reveal the variety of terms utilised across industries, with similar capabilities described in nuanced ways. Some profiles are less detailed than others, especially for new and emerging roles in the renewable sector where less data was available and/or less commonalities in occupations or descriptions to draw upon. The profiles include commonly referenced knowledge, skills, capabilities and mindsets and dispositions.

Interestingly, unlike in interviews, skills and qualifications feature heavily in profiles for the renewable energy sector. This may be because, as referenced in one interview, human resources professionals are responsible for advertisements and continue to advertise based on traditional understandings of roles, and/or they reflect an aspirational candidate rather than the likely candidate.

The skills profiles, while based on a small sample of job advertisements, enhance an understanding of roles in the renewable energy sector given there are various titles for roles with similar requirements. See **Appendix 10.1** for the compendium of profile maps.

7.4 Skills profile gap analysis

The skills profile data was examined to determine the thermal roles most likely to be able to transition to the renewable energy workforce, with the aim of providing transition pathways for up to ten roles. This was based on profile matching. Given there are reported shortages across the roles profiled, it is possible that there is not sufficient workforce capacity at present to support these transitions, but over time this capacity may emerge as thermal roles transform or diminish.

7.4.1 Process of Matching Roles

A matrix of qualifications, knowledge, skills, capabilities and mindsets was created, with items recoded to remove duplication across categories and to aggregate items where possible. A visual inspection revealed a greater level of crossover in capabilities and mindsets between thermal and renewable energy roles than in knowledge or skills, potentially because the knowledge and skills are more fine-grained and unique to industries. The initial mapping process had 101 criteria, with the most common areas of overlap being in knowledge of software, and planning, communication and project management. The map is available in the Appendix.

This data was then further refined, with the combining of like terms and removal of criteria that are not shared between thermal and renewable energy roles to identify crossover. This resulted in a reduction down to 45 criteria. This mapping is below, with thermal roles below the line.

	Level and qualificaton																Knowledge				Capabilities												Mindsets and dispositions									Skills			
ROLES (T indicates thermal)	Entry	Mid	Senior	Technical	Professional	Engineering degree (broad)	Bachelor of Structural Engineering/Civil, ideally chartered engineer	Bachelor of Civil Engineering	Bachelor of Electrical Engineering	Certificate/diploma in electrical engineering or bachelor	Certificate in engineering, diploma in power systems, bachelor engineeri	Bachelor of Mechanical Engineering or electrical	Bachelor of Mining Engineering	A Certificate III highly regarded.	VET/degree in electrical or renewable	quality systems/control/assurance	safety	software/CAD	standards and codes	resource allocation	systems thinking	planning/organising	modelling	calculation/evaluation/numeracy	leadership/team management	data analysis	project management	design/schematics/graphical representations	communication	reading/analysis	report writing/documentation	problem solving	balancing competing tasks/demands/prioritisation	comfort with new technology	innovation	judgement/decisive/solutions focused	attention to detail	manage pressure/fast paced	initiative	team player/collaborative	compliance	designing systems	designing structures	test,calibrate, install equipment	surveying
Battery deployment manager		x	x	x	x	x										x									x																				
Battery design specialist - utility scale		x	x	x	x													x			x						x		x						x	x									
Blade engineer			x	x																		x					x		x	x		x								x		x			
Blade technician	x	x		x										x		x													x	x		x													
Control room operator		x		x					x*or VET						x											x			x			x	x				x								
Electrical engineer	x	x	x	x					x												x		x				x		x	x		x		x					x						
Grid connection manager			x	x	x				x* or masters									x								x					x					x					x				
HV engineer			x	x	x		X* VET for testing									x		x	x			x					x	x	x	x												x			
Power Systems engineer			x	x			x									x		x		x		x					x	x	x	x										x		x			
Quality Manager/Engineer		x	x	x		x										x						x			x				x		x				x	x	x	x						x	
Solar farm technician - mechanical	x			x										x			x	x				x						x	x								x								
Wind farm technician - mechanical	x			x										x			x	x																											
Structural engineer	x	x	x	x	x		x										x	x	x	x		x		x	x		x	x	x	x							x		x				x		x
Civil engineer (T)	x	x	x	x	x			x									x	x		x		x		x	x			x	x	x						x			x				x		x
Electrical engineer (T)	x	x	x	x	x				x* or VE+10 years exp									x		x	x	x	x				x		x					x	x				x						
Mechanical engineer (T)				x								x				x		x	x			x		x	x		x	x	x	x			x		x			x	x			x			
Mining engineering – ex petroleum (T)				x									x				x	x				x	x				x			x		x					x		x		x				
Petroleum engineer (T)				x* highl		x																x			x		x		x	x		x							x	x					
Electrical engineering draftsperson (T)				x						x							x	x				x		x		x	x	x		x	x	x					x		x			x			
Electrical engineering technician (T)				x							x					x	x	x				x				x		x		x	x	x							x	x		x		x	

FIGURE 16: REFINED SKILL PROFILE GAP ANALYSIS

See **11.2 Skill Profile gap analysis** for landscape versions of this mapping for closer analysis.

Given interviewee feedback on the importance of capabilities and mindsets and dispositions, these were used as the key criteria to match roles between thermal and renewable sectors.

Two roles, battery deployment manager and wind farm technician that share one or less mindset and disposition with a thermal role, were removed. These are roles with precise technical requirements that will require training. An analysis of alignment between thermal and renewable energy roles revealed seven unique roles in the thermal sector are aligned on four or more mindsets and capabilities with seven unique roles in the renewable sector, with twenty five possible transitions identified. Most roles mapped to electrical engineering in the renewable sector, whilst roles that mapped to structural engineering mapped across the highest number of criteria. Battery design specialist had the least overlap of all matched roles, with a focus on bespoke knowledge of battery systems and energy markets, and transferable skills such as systems thinking and consulting.

Ten of these roles were selected for pathways mapping, with selections based on ensuring a cross section of roles are mapped, with each role mapped at least once, and not more than two times.

The matrix below shows the mapping, with thermal roles running vertically and renewable horizontally. For example, reading across from civil engineer, there are 4 mindsets and capabilities shared with HV engineers, power engineers and quality managers and 7 with structural engineers. For ease of reading, only matches on 4 or more criteria are shown.

Roles	Battery design specialist	Blade/wind engineer	Electrical engineer	HV engineer	Power systems engineer	Quality manager	Structural engineer
Civil engineer				4	4	4	7
Mechanical engineer		4	4	5	5	5	8
Mining engineering – ex petroleum		4	5				
Petroleum engineer		6	5		5		5
Electrical engineer	4		6				
Electrical engineering draftsperson		4	4	4	4		6
Electrical engineering technician		4					4
KEY	Roles in white - clean energy sector Role in black - thermal sector Numbers - number of shared capabilities and mindsets role pairs Dark shading - transitions selected for creation of pathway maps						

FIGURE 17: ROLE OVERLAP AND SELECTION FOR MAPPING BASED ON MATCHING CRITERIA

7.5 Pathway mapping

Maps were created that articulate the shared factors across matched industries, and skill gaps for thermal workers seeking to transition and possible pathways. These maps drew on the recoded data to ensure common term were utilised for similar items, and enable differences to be more readily identified.

The process undertaken to create pathways maps included:

- Mapping experience (qualification, seniority and professional and technical split), knowledge, skills, capabilities and mindsets and dispositions to identify items in common between thermal and renewable energy role, and additional requirements in renewable energy
- Identifying possible pathways including drawing on vocational education qualifications and skillsets, micro-credentials, university qualifications and short courses through a scan of industry providers
- Assessing the ease of transition based on the length of training, number of transitions needed and requirements for experience in the role.

As the pathway maps were based on job advertisements, they do not take into account that many engineers may, as interviews found, be working across disciplines and have experience, especially in electrical engineering which is a requirement of many of the roles examined. This would ease the transition process by reducing experience as a barrier.

They maps do not account for differences in location, although the thermal roles included often included extensive travel or FIFO. Following is an example of a pathway map, with the ten maps included in the appendix.

Transition from Civil Engineer, Thermal Sector, to Structural Engineer, Renewable Energy

Category	Items in common	Gaps	Possible pathways and gaps	Ease of transition
Experience	Entry to Senior level Technical and Professional focus Bachelor in civil or structural engineering		Straight transition	Simple Given the commonalities between civil and structural engineering, including the interchangeable nature of engineering disciplines this is a very likely transition path. Time lags for transition would be minimal, as training can be completed quickly or be part of ongoing professional learning. Transition may be context dependent for workers in existing FIFO roles, and salary requirements given lower average salary in for civil engineers in clean energy.
Knowledge	Software Resource allocation Safety	Simulation models Standards and codes	On the job learning Gap A micro-credential providing insight to Clean Energy sector including relevant codes and standards Existing courses, are lengthy, not tailored to standards	
Skills	Designing structures Surveying	Inspection	On the job learning, skillset – for example Off-grid renewable inspector skill set https://training.gov.au/Training/Details/UEERE0074 EA short course in in site inspection https://eea.org.au/courses/site-inspections-engineers	
Capabilities	Planning Calculating Leadership Design Communications Reading/Analysis	Project management Negotiation	Professional Short course – EA courses in project planning, scheduling and control https://eea.org.au/courses/project-management-essentials Contract negotiation short course Formal training – management diploma or postgraduate degree	
Mindsets and Dispositions	Initiative	Attention to detail		

FIGURE 18: SAMPLE PATHWAY MAP

7.6 Pathway mapping outcomes

Individual transition maps were created for the 10 transition pathways explored. These maps, which require further validation across a broad range of stakeholders and employers, provide a starting point on how transitions can be mapped, including indicating the ease of transition based on retraining experience and alignment of capabilities. Below is a summary of the transition mapping outcomes.

Transition	Pathway, gaps and skilling options	Further Information	Difficulty of transition
Civil engineer thermal to structural engineer renewable	• Gap – micro-credential in standards for renewables • Possible inspection and project planning short courses	• Interchangeable qualifications and shared capabilities	Simple
Civil engineer thermal to quality manager renewable	• Possible micro-credentials in instrumentation and quality. • Possible course in renewables	• Civil engineer thermal to structural engineer renewable transition pathway through quality manager role in thermal energy industry	Simple
Mechanical engineer thermal to HV engineer renewable	• Master/ grad cert of electrical engineering, • Short course re substations and HV • Gap – micro-credential in standards for renewables	• Many advertised roles, most require experience but possible transition if working in like role. • Matching capabilities • Significant lead time to retrain	Moderate
Mechanical engineer thermal to power systems engineer renewable	• Master of Power Systems • AEMO courses • Micro-credentials on PV or BESS	• Most roles require 5+ years of experience	Difficult
Mining engineer thermal to electrical engineer renewable	• Graduate certificate electrical engineering • AEMO course • BESS short courses	• Additional training of 12 months or more may be necessary. • Movement within employers may be possible or alternatively MBA to gain a managerial role	Moderate
Petroleum engineer thermal to power systems engineer renewable	• Master of Power Systems • AEMO course • Micro-credentials on PV or BESS	• Most roles require 5+ years of experience	Difficult
Electrical engineer thermal to battery design specialist/BESS engineer renewable	• Range of short courses, such as BESS • Project management short course • Gap – micro-credential in standards for renewables	• Most roles require experience in renewables • Movement within employers may be possible to gain this experience. • Capabilities gaps re agility, judgement and consulting skills	Moderate
Electrical engineer thermal to electrical engineer renewable	• Graduate certificate renewable energy technologies • AEMO Course • Short courses as per energy source	• Likely transition although some roles require HV or BESS experience • Capabilities misalignment may inhibit transitions although some roles will be more routine	Simple
Electrical engineering draftsperson to thermal to structural engineer renewable	• Advanced standing into Bachelor of Engineering, or Master of Engineering - minimum 2 years full time study. • Professional certificate structural design • Gap – micro-credential in standards for renewables	• Professional recognition as an engineer and role progression is unlikely without lengthy training. • Possible pathway into roles like control room operator • Management stream via MBA an easier transition	Difficult
Electrical engineering technician thermal to blade engineer/specialist renewable	• Possible pathway via interim role, blade service technician. • Gap in training in composites. • May require GWO basic training • Project management course.	• Pathway may emerge for blade specialist via technical stream. • Lack of alignment in dispositions may impact transition. • Niche role - heights and travel.	Moderate

TABLE 3: SUMMARY OF TRANSITION PATHWAYS

7.7 Discussion and analysis of pathway mapping

The mapping revealed that some transitions from roles in the thermal sector to the renewable sector are likely to be simpler than others, based on matches in capabilities and mindsets combined with skilling and experience requirements.

Three pairs of roles were identified as likely transitions, four as possible transitions with greater skilling requirements or requirements for experience and three as unlikely with extensive skilling and/or experience requirements.

Pathways between roles involved either straight transitions, top-ups in renewable energy, skill sets related to practice areas, or more extensive upskilling qualifications.

The most likely transition was from and to broad or adjacent engineering roles. As these occupations are likely to employ more engineers overall, this ease of transition will mean more engineers can readily transition to the renewable sector, and in essence slot into similar occupations.

Transitions to more discrete roles are more difficult as they require skills training and often experience. Often the pathway to these roles is not clear. Employers are attempting to recruit staff that may not exist in the numbers desired, as is the case in many power roles, but pathways to grow the workforce at pace appear to be lacking.

Transitioning to new roles with a current employer may support engineers to gain experience, for example as a quality manager in thermal energy as a midpoint to moving to the same role in a renewable role.

The mapping confirmed and enhanced the findings from the interviews and literature examined, with key insights detailed below.

7.7.1 Capabilities and mindsets can be supported

The mapping showed a range of capabilities are usually required in the renewable energy sector, including problem solving, agility, analysis and adaptability. In some cases, engineers possessed many of the same capabilities and mindsets across renewable and thermal sectors. One exception is electrical engineering, as a difference in capabilities and mindsets (as indicated by job advertisements, which may reflect roles rather than the people fulfilling them) may pose a barrier to transition for some engineers despite possessing electrical engineering qualifications.

A lack of transferable capabilities could prevent some engineers from transitioning to renewable energy, noting that interviewees cite that many engineers have a range of transferable skills. Capabilities can be cultivated, supported and promoted through the curriculum, both in school and tertiary studies, and their importance for careers emphasized. Employers can encourage employee flexibility and growth, for example by encouraging a diversity of continual professional learning including sharing of divergent ideas.

7.7.2 New models needed to support engineers in gaining experience in renewables

Most roles advertised require experience in a variety of technical aspects related to renewable energy. This poses challenges for engineers in thermal industries, as well as any engineers not presently in employment. The requirements may cause greater friction if there aren't enough experienced employees to fill roles. As recognised by Jobs and Skills Australia (Jobs and Skills Australia, 2023) and confirmed by this research, familiarisation training is needed to support workers to gain experience in the renewable energy sector.

The requirement for significant experience is especially noticeable in power-related roles, posing obstacles for engineers to transition to these roles or enter these occupations from overseas. Employers could consider how to structure roles to enable staff to gain experience either by creating greater controls and hierarchies, or alternatively if innovations similar to existing programs such as the those for skilled migrants and for Grid Engineers examined in Section 5.7.2 needed for more experienced staff moving sidewards to enable a breadth of experience.

7.7.3 Pathways to new roles are unclear for employees and employers

Across many roles there is a need for familiarisation with renewables including knowledge of standards. This could support existing employees seeking to transition to understand the similarities, and differences, between energy sources and roles. This appears to be a gap in current courses and offerings which are lengthy and/or based on one renewable source.

The process for identifying pathways is complex because pathways from one role to another are not visible, and often require identifying a range of different courses that can be potentially married together. This makes it difficult for employers and employees alike.

Whilst it is usually easy to locate information, for example on becoming a structural engineer, there is no clear information on how to move from one type of engineering to another, or to the myriad of new and emerging roles. Case study examples and interviews highlighted how proactive individuals locate training and opportunities to bridge between practice areas, and employers may invest in enterprise specific training to facilitate transitions. There may be benefits in articulating what new and emerging roles are, and possible pathways into these, to smooth transitions for employees.

7.7.4 New paths needed for vocationally trained engineering employees

Significant barriers exist for vocationally trained engineering employees to move to roles requiring a bachelor degree, even if they have the skills and capabilities. Despite potentially working as part of these engineering teams for many years, vocationally trained engineering employees need to complete upwards of two years of a bachelor's degree to be accredited as a professional engineer to meet international standards. This training is often only delivered on campus, during work hours, making the pathway both lengthy and inaccessible. New and emerging roles are increasingly demanding professional and technical expertise that is a hybrid of vocational and university qualifications, which are extremely limited at present. There is a gap in training to bridge vocational and academic divides, with limited models for dual qualifications or transition pathways for existing workers.

7.7.5 Credentialling to multiple practice areas

Although interviews found engineers work across practice areas, advertisements often seek engineers from a specific or multiple practice areas. Engineers can be recognised in multiple practice areas, for example as chartered engineers, in order to demonstrate their capability across a breadth of engineering areas.

7.7.6 Relative ease of moving to managerial roles

The transition to general professional roles such as project or construction managers requires shorter additional training, training is conducted in a flexible manner, and likely has a higher return for many engineers than moving sidewards to a similar role in the renewable energy sector. This is due to the experience and technical skill requirements for some roles. The move to management level roles has a clearer pathway with training targeted at existing workers, and less requirement for experience with different energy sources.

8. Policy drivers

This chapter examines relevant policy drivers in brief. It is not an exhaustive overview of all the policy drivers that may impact upon workforce transition, which would include regional development, housing, employment and education policy. Key barriers to worker mobility raised during consultation often lay outside of education, and include a lack of suitable or affordable housing, and a lack of early childhood education and care to support families to move to an area. These policy issues are crucial but fall beyond the scope of this report. It also addresses federal policy drivers only.

In this section we touch in brief upon push factors for the energy transition including climate change policies, and enabling factors including migration and education policy, with a concluding reflection on possible opportunities and gaps.

8.1 Climate change policies

Australia has a longstanding commitment to renewable energy, with the setting of a Renewable Energy Target in 2001. More recent changes are aimed at accelerating and supporting progress to Net Zero.

The Government's *Climate Change Act (2022)* outlines Australia's greenhouse gas emissions reduction targets of a 43% reduction from 2005 baseline levels by 2030 and net zero by 2050. The commitment forms part of Australia's contribution to the United Nations Framework Convention on Climate Change (UNFCCC).

A series of successive budgets have invested in climate related spending, from $24.9 billion (over ten years) in the October 2022-2023 Budget and an additional $4.6 billion in 2023-2024 budget.

Key initiatives include the:

- Powering Australia Plan, and Rewiring the Nation to grow and modernise Australia's electricity grid, boosting energy performance and supporting electrification.
- The Clean Energy Regulator to manage programs aimed at carbon abatement including investment in household PV and solar water heaters.
- The Clean Energy Finance Corporation (CEFC), a National Reconstruction Fund and the Australian Renewable Energy Agency (ARENA) to mobilise funding for renewable energy projects.
- The New Energy Apprenticeships Program to encourage more Australians to consider careers in the clean energy sector.
- The Safeguard Mechanism (SM) which requires Australia's largest greenhouse gas emitters to keep their net emissions below an emissions baseline. This mechanism was raised throughout interviews as a key driver of investment in innovation and alternative technologies to reduce emissions.

The 2023-24 budget provided an additional $4 billion investment including to support:

- The creation of the Net Zero Economy Authority to support the transition of workers and communities impacted by the shift to renewable energy. This includes investment facilitation, worker transition support, coordination of policy and communications and engagement.
- $2 billion investment in large scale renewable hydrogen through Hydrogen Headstart.

The 2024-25 budget included $22.7 billion investment in the Future Made in Australia policy in initiatives focused on:

- Incentivising investment in batteries, solar panels and hydrogen,
- Investment in mineral processing and refinement
- Supporting workforce planning and structural adjustment
- Supporting training and skilling.

The table below highlights the key initiatives in the Future Made in Australia policy.

Investing in a Future Made in Australia

Attracting investment in key industries and making Australia a renewable energy superpower

- A new 'front door' for priority projects, and streamlined and strengthened approvals
- $6.7 billion production tax incentive for the production of renewable hydrogen
- $1.7 billion to promote net zero innovation, including for green metals and low-carbon fuels
- $1.5 billion to strengthen battery and solar panel supply chains through production incentives

Value adding to our resources and strengthening economic security

- $7 billion production tax incentive for the processing and refining of critical minerals
- $566.1 million to map Australia's geological potential to support net zero transition
- $14 million to build better markets through trade, promoting competitive and fair global markets
- $268 million to support the development of defence industries and skills

Investing in skills for priority industries and higher education

- $1.1 billion to reform higher education and deliver our skilled workforce
- $88.8 million for 20,000 new training places relevant to construction
- $55.6 million to support women's careers in clean energy

Strengthening our digital, science and innovation capabilities

- $466.4 million to advance Australia's quantum computing capabilities
- $288.1 million to expand Digital ID into a whole-of-economy service
- $448.7 million for advanced satellite data on climate, agriculture, and natural disasters

Supporting small business and our regions

- $290 million to extend the $20,000 instant asset write-off for small businesses
- $10.8 million to support the mental and financial wellbeing of small business owners
- $519.1 million from the Future Drought Fund for farmers and rural communities

FIGURE 19: FUTURE MADE IN AUSTRALIA INITIATIVES

Source: (Australian Government, 2024, p. 29)

The raft of initiatives and investments will require careful coordination to ensure investments align and do not exacerbate workforce shortages.

The regional focus of workforce adjustment is essential, given some workers will not wish to change locations for work. However, some employees need support to transition to different locations, including to understand and fill new and emerging roles. The process of developing skill profiles revealed a range of roles emerging for which there is no perfect skills match or training pathway.

It is important that transitions are planned to ensure thermal sectors can continue to attract and retain workers during the transition process. This is necessary to ensure energy supply as well as to maintain supply of core materials needed for construction underpinning the energy transition. There is a risk that incentives to move to renewable sectors could result in shortages in existing industries.

The Building Women's Career program is aimed at supporting women to access vocational education and training and work opportunities, to enable women to gain high paying careers in male dominated industries (Department of Employment and Workplace Relations, 2024). Pilot projects would ideally focus on showcasing best practice for retention of women in male dominated industries, rather than a primary focus on attraction. This program could be extended to higher education to support a wider array of pathways.

Similar initiatives could be supported for other underutilised labour forces, such as overseas trained engineers. The Net Zero Economy Authority is well placed to explore how workforces can be supported to engage in the transformation to renewable energy.

8.2 Education and employment policies

The Australian Government is directly investing in skilling for Net Zero by establishing p to six TAFE centres of excellence in clean energy. Dual-sector tertiary providers and TAFE centres of excellence that can work with industry and create new courses and qualifications to meet the pace of transformation were highlighted as key initiatives in the employment white paper (The Treasury, 2024).

The skills mapping highlighted a raft of new roles, and often a need for professional and technical skills ideally provided across vocational and university education. There needs to be greater connection between vocational and higher education, which could be encouraged in these centres of excellence and is referenced in the employment white paper.

The Universities Accord final paper recognises the need to increase tertiary attainment to 80% of the working age population by 2050. It references the need for more flexible, efficient ways to attain skills including through micro-credentials (Australian Government, 2024).

The Accord includes a long-range target to more than double Commonwealth Supported Places by 2050. It also references the need for work integrated learning, including through degree apprenticeships (Australian Government, 2024). However, in the short-term, higher education places may not increase as universities already over-enrol students. This model does not represent a return to demand-driven funding and places are capped.

International student places are also capped in line with restricted migration settings (and are purported to be reduced even further), and fees for student visas have also increased. Around 40,000 international students study engineering presently, with many of these likely to complete internships with industry and some to remain in Australia post study (Department of Education, 2024). A reduction in international engineering students would likely reduce the potential engineering labour pool to support the transition to renewable energy.

The National Skills Agreement includes fee free places in areas of priority including the clean economy and construction (Australian Government, 2024). This is supported by funding in the 2024-25 budget to upgrade training capacity, funding for a National Hydrogen Technology Skills Training Centre and bonuses for apprentices in priority areas amongst other initiatives.

Consultation on a skills passport is also underway which may support skills recognition and transferability.

Whilst this report does not examine policy levers across different jurisdictions, we note that there are aligned actions in other jurisdictions, with investments in training centres of excellence, workforce and infrastructure development across Australia.

9. Discussion, findings and recommendations

This report synthesises a large array of information, from academic and grey literature to stakeholder consultations and job advertisement data to analyse what is needed to support engineers in their key roles as part of the renewable energy sector.

The report identifies that engineers will play a key role in the energy transition, in thermal energy sectors as they transform, in clean energy providers and to ensure the provision of minerals and resources vital to the clean economy.

Given the breadth of roles requiring engineering expertise, the report notes the imperative of retaining engineers in the workforce and supporting their transition.

A holistic approach is needed to ensure a sufficient supply of engineers to deliver on net zero, as is articulated in the findings.

The findings map to the infographic below and were tested in consultation and through the release of interim findings by Engineers Australia in July.

The findings inform recommendations to support the engineering workforce to transition to the renewable sector, and are key opportunities for intervention for government, employers, training and pathway providers and Engineers Australia.

FIGURE 20: INFOGRAPHIC SUMMARISING REPORT FINDINGS BY BROAD AREA

9.1 Engineers possess transferable knowledge, skills, mindsets and capabilities

Finding 1.1

The research found that employers hire based more on engineers' mindsets and capabilities than discipline expertise. The task of engineering itself in the renewables sector relies on many of the same engineering skills employed in thermal energy production, but it relies on a greater breadth of capabilities including professional skills such as stakeholder management, community engagement and complex capabilities like systems thinking. The most likely transitions are from and to broad or adjacent engineering roles.

Recommendation 1a: Employers can encourage employee flexibility and growth, for example by highlighting the benefits of flexible mindsets when responding to new and emerging opportunities and supporting access to a diversity of continual professional learning including sharing of divergent ideas.

Finding 1.2

Engineers transition to the renewable energy sector in a variety of ways. Those in broad qualifications are likely to make a direct transition, whilst others move upwards to managerial roles rather than sidewards to technical roles in the renewable energy sector. For some, transition to an interim role with their existing employer will support them to gain new skills, before undertaking a similar role in the renewable sector.

Recommendation 1b: Employers can identify possible transition pathways to support employees to transition to emerging roles, including through interim roles.

Finding 1.3

Key roles in the electricity industry such as grid engineer, require many years of experience, meaning transferability between roles is low and shortages are higher. Some initiatives, such as the grid engineer graduate program and professional year program, showcase how employees can be fast-tracked to gain a breadth of experience.

Recommendation 1c: Governments can incentivise and share learnings from innovative models.

9.2 Building the engineering workforce labour force remains a key challenge

Finding 2.1

The current skill shortage for engineers is a key barrier to ensuring a sufficient engineering workforce to support the transition to renewables. There is global demand for engineers to support the energy transition meaning Australia's capacity to attract foreign trained workers is constrained.

Recommendation 2a: Governments can commission Jobs and Skills Australia to further analyse demographic data on the latent engineering workforce and to advise on further strategies to address the looming skills shortage.

Finding 2.2

Key groups that leave the profession include women, engineers qualified overseas and older workers.

Recommendation 2b: Employers can support pilot initiatives to re-attract women back to engineering, and more flexible workplace conditions to attract and retain a diversity of employees.

Recommendation 2c: Employers can explore strategies for engaging overseas qualified engineers and re-engaging older workers to alleviate workforce shortages.

Recommendation 2d: Governments can ensure that new initiatives, such as those designed to attract women to the Clean Economy, focus equally on workforce retention, operate across vocational and higher education, and share findings broadly to encourage adoption of good practice.

Finding 2.3

New employees in the renewable sector are often driven by a moral commitment to improving the environment – but the environment aspect of roles is not always promoted.

Recommendation 2e: Employers can actively promote the purpose-driven opportunity to work in renewable energy and support Net Zero through communications, position descriptions and job advertisements.

Finding 2.4

Salary differences and working conditions between the thermal and renewable sectors, as well as international labour market conditions, may pose a challenge to transitions. The transition to renewables is an opportunity for employers to review and improve the working conditions and salary packages of their workforce in order to attract and retain staff.

Recommendation 2f: Employers can prioritise work life balance as a way of attracting workforce through the creation of competitive working conditions and salary packages.

Recommendation 2g: Government authorities, such as the Net Zero Economy Authority and Future Made in Australia, can incentivise employers to restructure their workforce to provide greater flexibility, and share findings of successful initiatives.

9.3 Location will continue to play a role in the capacity to attract workers

Finding 3.1

Ensuring roles in energy remain in existing communities where possible is important. This can be supported through co-locating new developments in existing thermal energy communities, and incentivising employment of local staff.

Recommendation 3a: Governments can consider location and context when supporting communities transitioning, including making decisions around local workforce employment requirements when investing in clean energy initiatives. This needs to continue as a key responsibility of the Net Zero Economy Authority.

Finding 3.2

Awareness and understanding of opportunities afforded by the renewable energy sector is a key area for focus and improvement. The shift to clean energy will be more daunting for workers who have been in one role or industry for a significant period of time, and may not recognise that similar roles are likely to exist in the renewable energy sector.

Recommendation 3b: Employers and government can work together to showcase the similarities in roles between the thermal and renewable energy sectors to demystify and build understanding, engagement and buy-in through approaches that include sharing stories of successful transitions.

Recommendation 3c: Employers can focus on supporting employees to gain exposure to new roles to support flexibility and internal transitions

Finding 3.3

Like in the thermal energy sector, some roles in the renewable energy sector will be remote, or require travel between a range of sites. Whilst some engineers are able or want to travel for work, many leave this mode of employment when they have a family. There is potential to reorganise the work. This is occurring in pockets, with some key roles being offered remotely and automation providing greater opportunities to locate work where families live.

Recommendation 3d: Employers can seek to review and reorganise the work to attract a breadth of engineers, and explore options such as automation and remote connection.

Recommendation 3e: Governments can support the reorganisation of work and workplaces through incentives, subsidies and by sharing and promoting effective strategies, tools and processes to drive effective workplace transformation, and ensuring supportive structures exist such as housing, childcare and broadband.

9.4 Policy drivers are supporting innovation but need coordination

Finding 4.1

Consistent policy settings support employers to invest in innovation, with emissions targets motivating large employers to innovate and seek to decarbonise. Engineers in thermal energy production will play a key role in supporting this transformation.

Recommendation 4a Governments can ensure stability, including on timelines, to create confidence in investment and support a managed transition process for employees.

Finding 4.2

There is significant new government investment and a raft of initiatives to support the transition to renewable energy. However, some policy levers, like caps on migration and higher education, including for international engineering students, may reduce the accessible engineering labour pool in the short-term.

Recommendation 4b: Governments can ensure strategies and initiatives align and complement each other, and that systemic action occurs at every level.

Finding 4.3

Recent government investment, including in the Net Zero Economy Authority, is aimed at supporting communities to transition. The mapping process found there were many new roles for engineers in the renewable sector, with many different titles (sometimes for very similar roles), responsibilities and skills and capabilities that could make finding a clear path to transition difficult.

Recommendation 4c: Governments can support people to understand the myriad of new roles emerging in the renewable sector.

Recommendation 4d: Governments, through Jobs and Skills Australia, can validate the skill profiles in this report and develop additional occupational profiles for emergent roles. Combined with revised occupational codes, this would provide greater clarity and support transitions.

Recommendation 4e: Governments can work with employers to engage in ongoing skills mapping to identify and plan for emerging roles and to engage and prepare existing workers to transition, including developing and validating occupational profiles, revising occupational codes and supporting the emergence of common language to assist transitions.

Recommendation 4f: Governments can invest in innovation hubs to capture, showcase and coordinate innovation to support the energy transition.

9.5 Training pathways are still needed

Finding 5.1

Many employers and employees are investing in workforce training to provide bespoke skills in the renewable sector, but this could result in skills wastage if they are not transferable between employers.

Recommendation 5a: Governments can support a process to accredit these skills and incentivise employers to develop skills on an industry basis. The proposed skills passport could be explored as a vehicle to support skills recognition and transferability in the engineering sectors.

Recommendation 5b: Engineers Australia can broker discussions with engineers and work with government to meet the renewable workforce challenge including by supporting transferability of skills training, for example through badging.

Finding 5.2

Roles in the renewable sector cross vocational and higher education divides, but pathways for vocationally trained engineering occupations are not sufficiently agile at present.

Recommendation 5c: Governments and training providers can bridge the vocational and higher education divides through new initiatives. New models can be created to provide targeted skill development to support engineering technicians to upskill to engineering qualifications whilst remaining in the workforce.

Recommendation 5d: Governments can support the Net Zero Economy Authority to explore transition pathways for the thermal workforce including for engineering technicians.

Finding 5.3

Familiarisation training is needed to support workers to understand and gain experience in the renewable energy sector.

Recommendation 5e: Governments can fund the development and rollout of familiarisation training including short micro-credentials that elevate consistency and transferability of skills across the industry and demystify the differences between sectors and include information on key aspects of renewables, including jargon and standards.

Finding 5.4

Building the engineering workforce labour force (including ensuring sufficient staff for the thermal industry during the transition) remains a key challenge. The existing skills shortage needs to be addressed in a comprehensive way, from career education for the future generation to ensuring all engineers are trained in sustainability.

Recommendation 5f: Schools and industry can work together to build the future workforce, through programs to excite and inspire school students, cascading to industry exposure, work experience and pathway programs.

Recommendation 5g: Training providers and employers can promote the benefits of working in the renewables sector through work experience, outreach and training pathways.

Recommendation 5h: Training providers can ensure all engineering courses and degrees include sustainability alongside foundational engineering skills.

The report reveals how engineers, with their problem-solving mindsets, are vital in creating innovative solutions to spearhead the transformation to Net Zero. Many engineers will make the transition to the renewable energy sector easily, but some will require additional support. New measures are needed to make pathways clearer, and to ensure a sufficient stock of engineers in the face of competing industries and strong international demand for engineers.

As the breadth of findings shows, transformation will require a holistic, resourced and coordinated approach across government, communities, training providers and industry.

10. References

Ai Group Centre for Education and Training. (2024). *Skills for a cleaner workforce - building the workforce for a clean economy*. Melbourne: Ai Group.

Australian Bureau of Statistics. (2024). *consult abs.* Retrieved from ANZSCO [Preliminary] Proposed Changes - Consultation Round 2: https://consult.abs.gov.au/standards-and-classifications/anzsco-comprehensive-review-round-2/results/final_consultationround2_preliminaryproposedchanges.pdf

Australian Energy Market Operator. (2024). *Draft 2024 Intergrated System Plan for the National Energy Market.* AEMO.

Australian Government. (2024). *Australian Univeristies Accord Final Report.*

Australian Government. (2024). *Budget Overview.* Retrieved from https://budget.gov.au/content/overview/download/budget-overview-final.pdf

Australian Government. (2024, July 10). *National Skills Agreement*. Retrieved from https://www.dewr.gov.au/skills-reform/national-skills-agreement

Brunhaver, S. &. (2021). CAREER: Ready for Change: Fostering Adaptability along the engineering pathway. *2021 ASEE Virtual Annual Conference Content Access.* Retrieved from https://www.researchgate.net/publication/354043495_CAREER_Ready_for_Change_Fostering_Adaptability_along_the_Engineering_Pathway

CEDA. (2030). *Powering the transition: The net-zero workforce challenge.*

Clean Energy Council. (2022). *Skilling the Energy Transition*. Clean Energy Council.

Clean Energy Council. (2024, June 3). *Clean Energy Careers Guide*. Retrieved from https://www.cleanenergycouncil.org.au/advocacy-initiatives/workforce-development/careers-guide/engineering-careers#:~:text=In%20wind%20power%2C%20wind%20reliability,candidates%20with%20electrical%20engineering%20qualifications.

Clean Energy Council. (2024, June 7). *Cleanr energy careers by occupation and demand*. Retrieved from Clena energy council careers guide: https://www.cleanenergycouncil.org.au/advocacy-initiatives/workforce-development/careers-guide/careers-by-occupation-and-demand

Clean Energy Council. (2024, August 29). *Grid Connection Engineer Graduate Program*. Retrieved from https://cleanenergycouncil.org.au/working-in-clean-energy/grid-connection-engineer-graduate-program

Crosthwaite, C. (2021). *Engineering Futures 2035: Engineering Education Programs, Priorities and Pedagogies.* Australian Council of Engineering Deans.

Department of Education. (2024, June 6). *Higher Education Statistics.* Retrieved from Student Enrolment Pivot Table 2022: https://www.education.gov.au/higher-education-statistics/resources/student-enrolments-pivot-table-2022

Department of Employment and Workplace Relations. (2024, July 9). *Building Women's Careers Program.* Retrieved from https://www.dewr.gov.au/building-womens-careers-program

Dweck, C. (2007). *Mindset: The New Psychology of Success.* Random House.

Dweck, C. (2008). *Mindset.* Ballantine Books.

Engineers Australia (a). (2024, August 29). *Policy and Advocacy*. Retrieved from https://www.engineersaustralia.org.au/policy-and-advocacy

Engineers Australia (b). (2024, June 6). *The engineering professional in Australia: a statistical snapshot*. Retrieved from Engineers Australia Power BI: https://app.powerbi.com/view?r=eyJrIjoiMzcxMzcwNjUtZDY5Ny00MmJjLWI4OTEtYzhmNmQ0MTBiZmRhIiwidCI6ImI4ZTMzOGUzLWVjNDItNGQwNi05OWMyLWIzNDk0YmYyN2IwMyJ9&pageName=ReportSection72c0b4ae479efaedf0e2

Engineers Australia (c). (2024, August 29). *Global Engineering Talent Program*. Retrieved from https://eea.org.au/global-engineering-talent-program?utm_source=EngineersAustralia&utm_medium=website&utm_campaign=GETProgram

Engineers Australia (d). (2024, August 29). *Professional Year*. Retrieved from https://eea.org.au/professional-year-program?gad_source=1&gclid=Cj0KCQjwz7C2BhDkARIsAA_SZKZ6Cum3s_L4Mlz2IFPQe2hkhS5djGbUu-9f92zYIaEHmpruu5GV2zEaAiTAEALw_wcB

Engineers Australia (e). (2024, June 6). *Stage 1 Competency Standard for Professional Engineer.* Retrieved from Engineers Australia: https://www.engineersaustralia.org.au/sites/default/files/2022-07/stage-1-competency-standard-professional-engineer.pdf

Jobs and Skills Australia. (2023). *The Clean Energy Generation.* Canberra: Australian Government .

Jobs and Skills Australia. (2024, June 12). Retrieved from The Clean Energy Generation - Supplementary modelling report: https://www.jobsandskills.gov.au/download/19313/clean-energy-generation/2383/supplementary-report/docx

Jobs and Skills Australia. (2024, June 6). *Labour Market Insights - Occupations*. Retrieved from https://www.jobsandskills.gov.au/data/labour-market-insights/occupations/2333-electrical-engineers

Jobs and Skills Australia. (February 2024). *Labour Market Update* . Canberra: Australian Government.

OECD. (2024). *OECD Employment Outlook 2024.* Paris: OECD.

Romanis, J. (2021). *Barriers to Employment for Migrant Engineers; Research Report.* Barton ACT: Engineers Australia.

Romanis, J. (2022). *Women in Engineering: Identifying avenues for increasing female participation in engineering, by understanding the motivators and barriers around entry and progression.* Engineers Australia.

Rutovitz, J. L. (January 2023). *The Australian Electricity Workforce for the 2022 Integrated System Plan: Projections to 2050. Revision 1.* Prepared by the Institute for Sustainable Futures for RACE for 2030.

Rutovitz, J. V. (2021). *Developing the future energy workforce - Opportunity assessment for RACE 2030.*

The Treasury. (2024, July 9). *Working Future: The Australian Government's White Paper on Jobs and Opportunities.* Retrieved from Employment White Paper: https://treasury.gov.au/employment-whitepaper/final-report

Victorian Skills Authority. (2023). *Clean Economy Workforce Development Strategy 2023-33.* Melboure: VSA.

11. Appendix

11.1 Skill Profiles

Knowledge

- Engineering degree (electrical, renewable, civil or other)
- Legislation and software
- Energy, civil and electrical
- CEC/SAA PV

Capabilities

- Team management/leadership
- Stakeholder engagement
- Costing
- Scheduling
- Risk management
- Project delivery
- Design
- Negotiation
- Hazard management/safety
- Problem solving
- Quality control

Battery deployment manager

Alternate roles/ANZSCO code if relevant :

Senior project engineer battery storage

Occupation description

Install battery systems on solar, wind, industrial or domestic properties.

Level

Mid to senior, technical and professional

Sector/s

Battery storage

Nature of employment (unique characteristics)

Travel

Skills and experience

- 3+ years of installs to 10+ years
- Solar and BESS
- Project management
- Renewable engineering design
- Computer science

Mindsets and dispositions

- Agility
- Continuous improvement
- Proactive
- Fast paced

Battery design specialist - utility scale

Alternate roles/ANZSCO code if relevant :

Senior BESS engineer, senior design engineer, project engineer. BESS engineer

Occupation description

Design battery energy storage systems , layout and formal drawings

Level

Mid to senior, technical and professional

Sector/s

Battery storage

Nature of employment (unique characteristics)

Consulting

Travel

Knowledge

- Engineering degree (electrical or solar PV)
- Legislation and software
- Battery design
- CEC/SAA PV

Capabilities

- Risk management
- Systems thinking
- Judgement
- Consulting
- Team management
- Communication
- Project management
- Client management
- Costing

Skills and experience

- 10+ years/smaller scale roles 5+ in solar PV, 2+ for entry level
- REZ studies detailed design
- CAD
- Chartered engineer or working towards

Mindsets and dispositions

- Agility
- Innovation
- Consulting

Blade engineer

Alternate roles/ANZSCO code if relevant :

Wind engineer, blade specialist

Occupation description

Provide expert analysis and technical input on blade design, performance and research and contribute to a wind project design and scoping.

Level

Senior technical

Sector/s

Wind

Nature of employment (unique characteristics)

Travel

Knowledge

- Engineering degree(mechanical) wind tech also advertised with no wind experience needed
- Masters degree
- Knowledge of composites
- Blade design

Capabilities

- Communication
- Problem solving
- Planning
- Analytical
- Hazard management
- Creative thinking

Skills and experience

- 10+years blade,
  8-15 wind turbine technical support
- TechnicalTechnical writing

Mindsets and dispositions

- Manage pressure
- Innovation
- Detailled approach

Blade technician

Occupation description

Inspect quality and performance of wind turbine blades through install, operation and maintenance

Sector/s

Wind

Level

Entry-mid technical

Nature of employment (unique characteristics)

Travel
Seasonal

Knowledge

- NA - but Cert III advantageous, some are technicians, some electricians
- Industrial, electrical, commissioning
- Knowledge of composites

Capabilities

- Communication
- Problem solving
- Quality assurance

Skills and experience

- Manufacturing experience
- GWO blade repair
- GWO all traiining
- White Card

Mindsets and dispositions

- Comfort with heights
- Shift/summer work (some)
- Physicaly fit to climb

Control room operator

Occupation description

Engage in real-time monitoring, incident management, and market trading activities, contributing to the efficiency and stability of Australia's energy market. Heavy software usage

Level

Mid-technical

Sector/s

Wind, Solar, Hydro, Battery

Nature of employment (unique characteristics)

Remote operations possible

Knowledge

- VET/degree in electrical or renewable
- Wind, solar, batteries
- Plant operations
- Energy market

Capabilities

- Data
- Communication
- Problem solving
- Risk management
- Market trading

Skills and experience

- 2+ years control monitoring

Mindsets and dispositions

- Attention to detail
- Balancing competing tasks

Knowledge

- Bachelor of Electrical Engineering or renewable (or masters)
- NEM/AEMO familiarity
- Power system analysis/ experience (can be limited)
- Renewable energy systems/BESS

Capabilities

- Project management
- Communication
- Systems thinking
- Reporting
- Client management
- Presentations
- Resource planning
- Analysis
- Modelling

Electrical engineer

Alternate roles/ANZSCO code if relevant :

233311 hv engineer, commissioning engineer

Occupation description

Design and implementation of electrical systems across various renewable energy projects.

Sector/s

Wind, Solar, Hydro

Level

Entry-mid technical, Prinicpals, technical and supervisory

Nature of employment (unique characteristics)

Travel
Consulting

Skills and experience

- 1-10+ years of experience
- Bess and wind
- Modelling
- Renewable/Solar
  Powers systems/commissioning

Mindsets and dispositions

- Initiative
- Comfort with new technology
- Innovation
- Pro-active

Knowledge

- Bachelor of Electrical Engineering
- Often Masters Power Engineering, Wind Grid connection engineer, only bachelor qualified
- Knowledge of NEM and AEMO
- Software/PSCAD etc, wind, solar, BESS

Capabilities

- Simulation models
- Systems thinking
- Highly technical thinking
- Decision making
- Negotiation
- Communication
- Negotiation
- Stakeholder management

Grid connection manager

Alternate roles/ANZSCO code if relevant :

233312 (proposed specialisation) lead engineer grid

Occupation description

Ensure grid connection compliance with AEMO and power systems network service providers

Level

Senior technical + professional

Sector/s

Wind, solar, battery

Nature of employment (unique characteristics)

Regional (some roles)

Skills and experience

- 10 years experience/5 years or 3 projects, wind grid connect, 2-3 year BESS, solar and wind
- Connection experience
- 3+ years experience in power systems Power systems modelling

Mindsets and dispositions

- Judgement
- Comfort with regulated environments
- Adaptable
- Solutions focused

Knowledge

- Bachelor of Electrical Engineering/power system. 1 role for engineering officer/substation design at diploma level, 1 role hv testing requiring minimum VET qualification
- Standards and codes
- Quality assurance

Capabilities

- Planning and organising
- Communication
- Design
- Analysis
- Project management
- Operating computer systems

HV engineer

Alternate roles/ANZSCO code if relevant :

Substation design engineer, hv substation design engineer, hv testing engineer, secondary engineer

Occupation description

Conduct, lead, review, and verify detailed designs and technical reports for the client, including substation secondary systems

Level

Senior technical and professional - few mid level

Sector/s

Wind, Solar, Hydro, Battery

Nature of employment (unique characteristics)

Many roles advertised

Skills and experience

- Manager level 15+ years experience in power, or 10+chartered
- Designing energy efficient systems
- Install electrical systems
- Electrical schematics
  Relationship with power utilities

Mindsets and dispositions

- Continuous learning

Knowledge

- Bachelor of Electrical Engineering
- Software and systems - power systems modelling
- Resource allocation
- Regulatory frameworks

Capabilities

- Planning and organising
- Communication
- Design
- Analysis
- Project management
- Operating computer systems

Power Systems engineer

Alternate roles/ANZSCO code if relevant :

233312 (proposed specialisation) Also electrical design engineer

Occupation description

Analyse grid data to identify optimal connection locations for renewable energy projects.

Collaborate with stakeholders to navigate the grid connection process effectively.

Level

Senior (as lead) technical, highly technical

Sector/s

Wind, Solar, Battery

Skills and experience

- 2+ years experience in grid connection engineering,
  5+ HV power systems
- Designing energy efficient systems
- Install electrical systems
- Electrical schematics
  Connection to NEM through AEMO

Mindsets and dispositions

- Motivated
- Flexible
- Personable
- Team player
- Technical expert

Quality Manager/Engineer

Alternate roles/ANZSCO code if relevant :

139916

Occupation description

Plans, organises, directs, controls and coordinates the deployment of quality systems and certification processes within an organisation.

Level

Mid-senior technical

Sector/s

Wind, Solar

Nature of employment (unique characteristics)

Many roles advertised

Knowledge

- Bachelor of Engineering - civil or construction, electrical
- Quality systems
- Civil construction
- QA on large construction sites

Capabilities

- Planning
- Organising
- Leadership
- Communication
- Data analysis
- Attention to detail
- Prioritising

Skills and experience

- Compliance
- Documentation
- Budget management
  Testing and calibration

Mindsets and dispositions

- Initiative
- Innovatiion
- Fast paced
- Indepence
- Balance demands

Solar farm technician - mechanical

Occupation description

Install and maintain the physical moving and stationery non-electrical components on a solar farm

Level

Entry level - some routine tasks, technical

Sector/s

Solar

Nature of employment (unique characteristics)

Travel
Shift work

Knowledge

- A Certificate III in a mechanical field such as Engineering – Mechanical Trade (MEM30219), or Engineering – Fixed and mobile plant (MEM31419) is highly regarded.
- Solar farms
- Software
- Safety

Capabilities

- Schematics
- Communication
- Compliance
- Hazard management
- Standards

Skills and experience

- Solar farm experience 2 years
- Schematics

Mindsets and dispositions

- Autonomy
- Attention to detail

Wind farm technician - mechanical

Occupation description

Work on all aspects of above ground electrical work on a wind farm.

Level

Entry level - some routine tasks, technical

Sector/s

Wind

Nature of employment (unique characteristics)

Travel

Knowledge

- A Certificate III in a mechanical field such as Engineering – Mechanical Trade (MEM30219), or Engineering – Fixed and mobile plant (MEM31419) is highly regarded. / electrician
- Wind farms
- Software
- Safety

Capabilities

- Safe work

Skills and experience

- Rope access
- GWO courses preferred
- Welder

Mindsets and dispositions

- Comfort with heights

Structural engineer

Alternate roles/ANZSCO code if relevant :

233214

Occupation description

Analyses the statical properties of all types of structures, tests the behaviour and durability of materials used in their construction, and designs and supervises the construction of all types of structures. Registration or licensing may be required.

Level

Entry to senior, technical and professional

Sector/s

Wind, Solar, Hydro

Knowledge

- Bachelor of Structural Engineering/Civil, ideally chartered engineer
- Software and systems
- Standards and codes
- Safety

Capabilities

- Planning and organising
- Reading/analysis
- Calculation/evaluation
- Team management
- Resource allocation
- Project management
- Communication
- Negotiation

Skills and experience

- Creating graphical representations - 1 job 5+ years
- Designing structures
- Inspections
- Computer simulations Surveying

Mindsets and dispositions

- Initiative
- Attention to detail

Knowledge

- Bachelor of Civil Engineering
- Software and systems

Capabilities

- Planning and organising
- Reading/analysis
- Calculation/evaluation
- Team management
- Resource allocation
- Quality assurance

Civil engineer

Alternate roles/ANZSCO code if relevant :

233211

Occupation description

Plans, designs, organises and oversees the construction and operation of dams, bridges, pipelines, gas and water supply schemes, sewerage systems, airports and other civil engineering projects. Registration or licensing may be required.

Sector/s

Thermal (mining, electricity, gas, water and waste as proxy industries)

Nature of employment (unique characteristics)

Remote/FIFO

Level

Entry to senior, technical and professional

Skills and experience

- Creating graphical representations
- Inspecting buildings
- Designing structures
- Surveying

Mindsets and dispositions

- Initiative
- Influential
- Decisive
- Action oriented

Knowledge

- Bachelor of Electrical Engineering
  (or trade certificate with 10 years experience)
- Software and systems
- Environmental social, commerical

Capabilities

- Resource allocation
- Planning and organising
- Communication
- Design
- Analysis
- Project management
- Risk management
- Problem solving
- Organised

Electrical engineer

Alternate roles/ANZSCO code if relevant :

233311

Occupation description

Designs, develops and supervises the manufacture, installation, operation and maintenance of equipment, machines and systems for the generation, distribution, utilisation and control of electric power. Registration or licensing may be required.

Sector/s

Thermal (mining, electricity, gas, water and waste as proxy industries)

Nature of employment (unique characteristics)

Remote/FIFO
Well paid

Level

Entry to senior, technical and professional

Skills and experience

- 5-6 years+ experience
- Electrical schematics
- Designing energy efficient systems
- Install electrical systems
- Written and verbal

Mindsets and dispositions

- Adaptable
- Thrive in challenging environments
- Autonomous and team
- Innovation

Mechanical engineer

Alternate roles/ANZSCO code if relevant :

233512

Occupation description

Plans, designs, organises and oversees the assembly, erection, commissioning, operation and maintenance of mechanical and process plant and installations. Registration or licensing may be required.

Level

Technical

Sector/s

Thermal (mining, electricity, gas, water and waste as proxy industries)

Nature of employment (unique characteristics)

FIFO

Knowledge

- Bachelor of Mechanical Engineering or electrical
- Software and systems
- Standards

Capabilities

- Planning and organising
- Reading/analysis
- Numeracy
- Team management
- Project management
- Problem solving

Skills and experience

- Designing systems
- Review designs and documentation
- Process improvements
- Quality control
  Communications

Mindsets and dispositions

- Initiative
- Innovation
- Working at heights (not in all cases)
- Prioritisation
- Working in high pressure

Mining engineering – ex petroleum

Alternate roles/ANZSCO code if relevant :

233611

Occupation description

Plans and directs the engineering aspects of locating and extracting minerals from the earth. Registration or licensing may be required.

Level

Technical

Sector/s

Thermal (mining, electricity, gas, water and waste as proxy industries)

Nature of employment (unique characteristics)

FIFO
Strong demand

Knowledge

- Bachelor of Mining Engineering
- Software and systems
- Safety

Capabilities

- Planning and organising
- Reading/analysis
- Safety
- Compliance
- Problem solving
- Project management

Skills and experience

- 2+years
- Create engineering models
- Monitoring operations
  Industry experience

Mindsets and dispositions

- Initiative
- Detailed

Knowledge

- Bachelor of Engineering - mechanical, chemical, petroleum
- Well control certification

Capabilities

- Planning and organising
- Reading/analysis
- Team management
- Problem solving
- Project management
- Communication
- Interpersonal

Petroleum engineer

Alternate roles/ANZSCO code if relevant :

Well engineer, general field engineer,
coal seam gas engineers 233612

Occupation description

Plans and directs the engineering aspects of locating and extracting petroleum or natural gas from the earth. Registration or licensing may be required.

Level

Technical, very industry specific, welll pumping

Sector/s

Thermal (mining, electricity, gas, water and waste as proxy industries)

Skills and experience

- Record management
- Direct energy production

Mindsets and dispositions

- Initiative
- Collaborative

Electrical engineering draftsperson

Alternate roles/ANZSCO code if relevant :

312311

Occupation description

Prepares detailed drawings and plans of electrical installations and circuitry in support of Electrical Engineers and Engineering Technologists. Registration or licensing may be required.

Level

Technical

Sector/s

Thermal (mining, electricity, gas, water and waste as proxy industries)

Nature of employment (unique characteristics)

Some roles can be delivered offsite/remotely

Knowledge

- Certificate/diploma in electrical engineering or bachelor
- Software and systems
- Technical specification
- Problem solving

Capabilities

- Planning and organising
- Data
- Reading/analysis
- Evaluation
- Project management
- Analysis

Skills and experience

- Technical design
- Electrical schematics
- Design systems

Mindsets and dispositions

- Initiative
- Detailed
- Collaborative

Electrical engineering technician

Alternate roles/ANZSCO code if relevant :

field service engineer, hv technician 312312

Occupation description

Conducts tests of electrical systems, prepares charts and tabulations, and assists in estimating costs in support of Electrical Engineers and Engineering Technologists. Registration or licensing may be required.

Sector/s

Thermal (mining, electricity, gas, water and waste as proxy industries)

Nature of employment (unique characteristics)

FIFO/remote based

Level

Technical

Knowledge

- Certificate in engineering, diploma in power systems, bachelor engineering
- Software and systems
- Drafting
- Industry dependent, some HV, switching, fuel

Capabilities

- Planning and organising
- Data
- Reading/analysis
- Digital
- Quality assure
- Problem solving
- Report writing
- Safety

Skills and experience

- 0-10+ years experience
- Fabricate and assemble equipment
- Evaluate designs
- Test and install electrical equipment
- Estimation

Mindsets and dispositions

- Initiative
- Collaborative

11.2 Skill Profile gap analysis

The initial mapping process has 101 criteria, with the most common areas of overlap being in knowledge of software, and planning, communication and project management. The initial mapping is shown below with thermal roles shaded at the bottom.

Level and qualificaton

ROLE (T indicates thermal)	Entry	Mid	Senior	Technical	Professional	Engineering degree (broad)	Bachelor of Structural Engineering/Civil, ideally chartered engineer	Bachelor of Civil Engineering	Bachelor of Electrical Engineering	Certificate/diploma in electrical engineering or bachelor	Certificate in engineering, diploma in power systems, bachelor engineering	Bachelor of Mechanical Engineering or electrical	Bachelor of Mining Engineering	A Certificate III highly regarded.	VET/degree in electrical or renewable
Battery deployment manager		x	x	x	x	x									
Battery design specialist - utility scale		x	x	x	x										
Blade engineer			x	x											
Blade technician	x	x		x										x	
Control room operator		x		x					x*or VET						x
Electrical engineer	x	x	x	x					x						
Grid connection manager			x	x	x				x* or masters						
HV engineer			x	x	x		x								
Power Systems engineer			x	x			x								
Quality Manager/Engineer		x	x	x		x									
Solar farm technician - mechanical	x			x										x	
Wind farm technician - mechanical	x			x										x	
Structural engineer	x	x	x	x	x		x								
Civil engineer (T)	x	x	x	x	x			x							
Electrical engineer (T)	x	x	x	x	x				x* or VE+10 years exp						
Mechanical engineer (T)				x								x			
Mining engineering – ex petroleum (T)				x									x		
Petroleum engineer (T)				x* highl		x									
Electrical engineering draftsperson (T)				x						x					
Electrical engineering technician (T)				x							x				

Knowledge

ROLE (T indicates thermal)	energy, civil and electrical	CEC/SAA PV	legislation and standards	quality systems/control/assurance	safety	civil construction	wind farms	software/CAD	standards and codes	environmental social, commerical	well control certification	technical specifications	solar farms	industrial, electrical, commissioning	Knowledge of composites	resource allocation	regulatory frameworks/NEM and AEMO	simulation models	drafting	renewable engineering
Battery deployment manager	x	x	x	x																x
Battery design specialist - utility scale	x	x	x					x												
Blade engineer	x	x	x																	
Blade technician				x										x	x					
Control room operator																				
Electrical engineer																	x			x
Grid connection manager								x										x		
HV engineer				x				x	x											
Power Systems engineer				x				x								x	x			
Quality Manager/Engineer				x		x														
Solar farm technician - mechanical					x			x					x							
Wind farm technician - mechanical					x		x	x												
Structural engineer					x			x	x							x		x		
Civil engineer (T)					x			x								x				
Electrical engineer (T)								x		x		x				x				
Mechanical engineer (T)				x				x	x											
Mining engineering – ex petroleum (T)					x			x												
Petroleum engineer (T)											x	x								
Electrical engineering draftsperson (T)					x			x				x								
Electrical engineering technician (T)				x	x			x											x	

Capabilities

ROLE (T indicates thermal)	scheduling	systems thinking	tenders/commercial negotiation	consulting	planning/organising	creative thinking	market trading	client management	modelling	calculation/evaluation/numeracy	Operating computer systems/computer science	leadership/team management	data analysis	project management	negotiation	risk management/hazard	design/schematics/graphical representations	communication	analysis	reading/analysis	report writing/documentation	digital	problem solving	continuous improvement
Battery deployment manager	x		x									x			x	x								
Battery design specialist - utility scale		x		x				x						x		x		x						
Blade engineer					x									x		x		x	x				x	
Blade technician																		x	x				x	
Control room operator							x						x			x		x					x	
Electrical engineer		x						x	x					x				x	x				x	
Grid connection manager													x								x			
HV engineer					x						x			x			x	x	x					
Power Systems engineer					x						x			x			x	x	x					
Quality Manager/Engineer					x							x						x			x			
Solar farm technician - mechanical					x											x	x	x						
Wind farm technician - mechanical																								
Structural engineer					x					x		x		x	x		x	x		x				
Civil engineer (T)					x					x		x					x	x		x				
Electrical engineer (T)		x			x				x					x				x						
Mechanical engineer (T)					x					x		x		x			x	x		x				x
Mining engineering – ex petroleum (T)					x				x					x						x			x	
Petroleum engineer (T)					x							x		x				x		x			x	
Electrical engineering draftsperson (T)					x					x			x	x			x		x	x	x		x	
Electrical engineering technician (T)					x								x				x			x	x	x	x	

Mindsets and dispositions

ROLE (T indicates thermal)	agile/flexible/adaptable	thrive in challenging environments	physicaly fit to climb/comfort with heights	balancing competing tasks/demands/prioritisation	comfort with new technology	innovatiion	independence/autonomous	continuous learning	motivated	technical expert	judgement/decisive/solutions focused	comfort with regulated environments	attention to detail	influential	action oriented	manage pressure/fast paced	initiative	team player/collaborative
Battery deployment manager	x																	
Battery design specialist - utility scale	x					x					x							
Blade engineer	x	x					x											x
Blade technician			x									x						
Control room operator				x									x					
Electrical engineer					x												x	
Grid connection manager	x	x									x	x						
HV engineer								x										
Power Systems engineer	x								x	x								x
Quality Manager/Engineer						x	x				x		x			x		
Solar farm technician - mechanical							x						x					
Wind farm technician - mechanical			x															
Structural engineer													x				x	
Civil engineer (T)											x			x	x		x	
Electrical engineer (T)					x	x											x	
Mechanical engineer (T)				x		x										x	x	
Mining engineering – ex petroleum (T)													x				x	
Petroleum engineer (T)																	x	x
Electrical engineering draftsperson (T)													x				x	
Electrical engineering technician (T)																	x	x

Skills

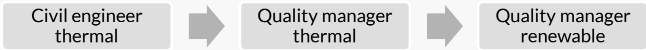
ROLE (T indicates thermal)	compliance	Manufacturing experience	record management	Rope access	REZ studies detailed design	fabricate and assemble equipment	Designing systems	Designing structures	GWO course/blade repair	direct energy production	connection experience	install electrical systems	Monitoring operations	costing/budget management	inspections	GWO all traiining	test,calibrate, install equipment	estimation	power systems modelling/commissioning	surveying	relationship with power utilities	White Card	BESS	Welding
Battery deployment manager					x									x									x	
Battery design specialist - utility scale														x										
Blade engineer							x		x															
Blade technician		x							x			x										x		
Control room operator																								
Electrical engineer																			x				x	
Grid connection manager	x										x								x					
HV engineer							x				x	x									x			
Power Systems engineer							x				x	x												
Quality Manager/Engineer															x		x							
Solar farm technician - mechanical																								
Wind farm technician - mechanical				x					x															x
Structural engineer								x							x					x				
Civil engineer (T)								x												x				
Electrical engineer (T)																								
Mechanical engineer (T)							x																	
Mining engineering – ex petroleum (T)	x												x											
Petroleum engineer (T)			x							x														
Electrical engineering draftsperson (T)							x																	
Electrical engineering technician (T)						x	x										x	x						

The table below shows the data further refined, with the combining of like terms and removal of criteria that are not shared between thermal and renewable energy roles to identify crossover. This results in a reduction down to 45 criteria. This mapping is shown below, with thermal roles below the line, and renewable energy roles above the line.

	Level and qualificaton																Knowledge				Capabilities												Mindsets and dispositions									Skills			
ROLES (T indicates thermal)	Entry	Mid	Senior	Technical	Professional	Engineering degree (broad)	Bachelor of Structural Engineering/Civil, ideally chartered engineer	Bachelor of Civil Engineering	Bachelor of Electrical Engineering	Certificate/diploma in electrical engineering or bachelor	Certificate in engineering, diploma in power systems, bachelor engineeri	Bachelor of Mechanical Engineering or electrical	Bachelor of Mining Engineering	A Certificate III highly regarded.	VET/degree in electrical or renewable	quality systems/control/assurance	safety	software/CAD	standards and codes	resource allocation	systems thinking	planning/organising	modelling	calculation/evaluation/numeracy	leadership/team management	data analysis	project management	design/schematics/graphical representations	communication	reading/analysis	report writing/documentation	problem solving	balancing competing tasks/demands/prioritisation	comfort with new technology	innovatiion	judgement/decisive/solutions focused	attention to detail	manage pressure/fast paced	initiative	team player/collaborative	compliance	designing systems	designing structures	test,calibrate, install equipment	surveying
Battery deployment manager		x	x	x	x	x										x									x																				
Battery design specialist - utility scale		x	x	x	x													x			x						x		x						x	x									
Blade engineer			x	x																		x					x		x	x		x								x		x			
Blade technician	x	x		x										x		x													x	x		x													
Control room operator		x		x					x*or VET						x											x			x			x	x				x								
Electrical engineer	x	x	x	x					x												x		x				x		x	x		x		x					x						
Grid connection manager			x	x	x				x* or masters									x								x					x					x					x				
HV engineer			x	x	x		X* VET for testing									x		x	x			x					x	x	x	x												x			
Power Systems engineer			x	x			x									x		x		x		x					x	x	x	x										x		x			
Quality Manager/Engineer		x	x	x		x										x						x			x				x		x				x	x	x	x						x	
Solar farm technician - mechanical	x			x										x			x	x				x						x	x								x								
Wind farm technician - mechanical	x			x										x			x	x																											
Structural engineer	x	x	x	x	x		x										x	x	x	x		x		x	x		x	x	x	x							x		x				x		x
Civil engineer (T)	x	x	x	x	x			x									x	x		x		x		x	x			x	x	x						x			x				x		x
Electrical engineer (T)	x	x	x	x	x				x* or VE+10 years exp									x		x	x	x	x				x		x					x	x				x						
Mechanical engineer (T)				x								x				x		x	x			x		x	x		x	x	x	x			x		x			x	x			x			
Mining engineering – ex petroleum (T)				x									x				x	x				x	x				x			x		x					x		x		x				
Petroleum engineer (T)				x* highl x																		x			x		x		x	x		x							x	x					
Electrical engineering draftsperson (T)				x						x							x	x				x		x		x	x	x		x	x	x					x		x			x			
Electrical engineering technician (T)				x							x					x	x	x				x				x		x		x	x	x							x	x		x		x	

11.3 Pathway maps

Transition from Civil Engineer, Thermal Sector, to Structural Engineer, Renewable Energy				
Category	**Items in common**	**Gaps**	**Possible pathways and gaps**	**Ease of transition**
Experience	Entry to Senior level Technical and Professional focus Bachelor in civil or structural engineering		Straight transition	Simple Given the commonalities between civil and structural engineering, including the interchangeable nature of engineering disciplines this is a very likely transition path. Time lags for transition would be minimal, as training can be completed quickly or be part of ongoing professional learning. Transition may be context dependent for workers in existing FIFO roles, and salary requirements given lower average salary in for civil engineers in clean energy.
Knowledge	Software Resource allocation Safety	Simulation models Standards and codes	On the job learning Gap A micro-credential providing insight to Clean Energy sector including relevant codes and standards Existing courses, are lengthy, not tailored to standards	
Skills	Designing structures Surveying	Inspection	On the job learning, skillset – for example Off-grid renewable inspector skill set https://training.gov.au/Training/Details/UEERE0074 EA short course in in site inspection https://eea.org.au/courses/site-inspections-engineers	
Capabilities	Planning Calculating Leadership Design Communications Reading/Analysis	Project management Negotiation	Professional Short course – EA courses in project planning, scheduling and control https://eea.org.au/courses/project-management-essentials Contract negotiation short course Formal training – management diploma or postgraduate degree	
Mindsets and Dispositions	Initiative	Attention to detail		

Transition from Civil Engineer, Thermal Sector, to Quality Manager, Renewable Energy				
Category	**Items in common**	**Gaps**	**Possible pathways and gaps**	**Ease of transition**
Experience	Mid to Senior Level Technical Bachelor in engineering	Need experience in quality assurance, can be acquired through thermal sector	Renewable knowledge through short course such as Graduate certificate renewable energy technologies - https://www.eit.edu.au/courses/graduate-certificate-in-renewable-energy-technologies/ 	Simple Time lags to gain experience in quality management unless it constitutes part of existing role. Possible transition via quality manager in thermal industry.
Knowledge		Quality systems Safety	On the job learning or https://eea.org.au/courses/project-management-essentials Or micro-credential https://www.microcredseeker.edu.au/explore/details/HEP-TCSI-1019-MO1006-quality-improvement/ or https://www.microcredseeker.edu.au/explore/details/HEP-TCSI-12049-500000027V01-quality-management-in-construction	
Skills		Inspections Test, calibrate, install equipment	Safety processes https://www.microcredseeker.edu.au/explore/details/HEP-TCSI-4469-CIP-professional-certificate-of-competency-in-instrumentation-automation-process-control https://www.microcredseeker.edu.au/explore/details/HEP-TCSI-4469-CSS-professional-certificate-of-competency-in-safety-instrumentation-systems-for-process-industries	
Capabilities	Planning and organising Leadership Communication	Evaluation Report writing	Acquired as part of quality improvement learning	
Mindsets and Dispositions	Attention to detail	Innovation Independence Judgement Attention to detail Manage pressure		

Transition from Mechanical Engineer, Thermal Sector, to HV Engineer, Renewable Energy				
Category	**Items in common**	**Gaps**	**Possible pathways and gaps**	**Ease of transition**
Experience	Technical Bachelor Level	Bachelor of Electrical Engineering HV experience, 2+ years	Master of Electrical Engineering (or grad dip/cert) https://cusp.sydney.edu.au/students/view-degree-page/stream/6077/dvid/2564 Graduate Diploma Electrical Engineering Gap – the opportunity to gain experience unless already in electrical role https://cusp.sydney.edu.au/students/view-degree-page/stream/6077/dvid/2564	Moderate Over 1000 roles for HV, and over 300 for HV engineer. Despite apparent shortage most roles require HV experience, and electrical engineering qualification. Long lead time to retrain in electrical/power systems (2 year full time). Limited opportunity for new entrants without experience.
Knowledge	Quality systems Software Standards and codes		Gap -A micro-credential providing insight to the Clean Energy sector including relevant codes and standards Existing courses, are lengthy, not tailored to standards Plus training in relevant codes and software	
Skills	Designing systems	Connection experience Install electrical systems Relationship with power utilities	Relevant short courses include https://eea.org.au/courses/as2067-substation-and-hv-installations#overview https://www.microcredseeker.edu.au/explore/details/HEP-TCSI-4469-CEY2-professional-certificate-of-competency-in-substation-design-control-protection-and-facility-planning- https://eea.org.au/courses/as2067-substation-and-hv-installations#overview	
Capabilities	Planning and organising Design Communication Project management	Operating computer systems Analysis		
Mindsets and Dispositions	Continuous Learning			

Transition from Mechanical Engineer, Thermal Sector, to Power Systems Engineer, Renewable Energy

Category	Items in common	Gaps	Possible pathways and gaps	Ease of transition
Experience	Technical Bachelor Level	Bachelor of Electrical Engineering 2+ years grid connection to 10+ years power system experience	Master of Power Systems Engineering/ Master of Engineering (power) Gap – opportunity to gain experience unless new graduate through grid engineer program	Difficult Requirement for extensive experience makes transition difficult Long training pathway
Knowledge	Quality systems Software	Resource allocation Regulatory Framework/NEM and AEMO	Courses through AEMO learning academy https://www.aemolearningacademy.aemo.com.au/	
Skills	Designing systems	Connection experience Install electrical systems Power systems modelling/commissioning	Variety of micro-credentials available such as https://www.tafensw.edu.au/course-areas/electrotechnology/courses/grid-connected-solar-pv-systems-design-accreditation--MHE20502A Range of short course, such as BESS https://cpdint.com.au/fundamentals-of-battery-energy-storage-for-large-scale-pv-plants/	
Capabilities	Planning and organising Design Communication Project management	Operating computer systems Analysis		
Mindsets and Dispositions		Motivated Technical expert Team player Agile and flexible	Highly technical and experienced role	

Transition from Mining Engineering Technician – ex petroleum, Thermal Sector, to Electrical Engineer, Renewable Energy				
Category	**Items in common**	**Gaps**	**Possible pathways and gaps**	**Ease of transition**
Experience	Technical	Bachelor degree in Electrical Engineering	Graduate certificate electrical engineering – various institutions Graduate certificate renewable energy technologies https://www.eit.edu.au/courses/graduate-certificate-in-renewable-energy-technologies/	Moderate Additional training of 12 months or more likely to be necessary. Movement at level may be possible with same employer to gain experience in electrical engineering. Postgraduate course, such as MBA, may enable utilisation of generic skills.
Knowledge		Regulatory framework NEM/AEMO Renewable engineering	Courses through AEMO learning academy https://www.aemolearningacademy.aemo.com.au/Short courses	
Skills		Power systems modelling/commissioning BESS	Range of short course, such as BESS https://cpdint.com.au/fundamentals-of-battery-energy-storage-for-large-scale-pv-plants/ Short courses	
Capabilities	Modelling Project management Problem solving	Analysis Communication Client management	On the job learning Management Short courses /MBA	
Mindsets and Dispositions	Initiative	Attention to detail Comfort with new technology		

Transition from Petroleum Engineer, Thermal Sector, to Power Systems Engineer, Renewable Energy				
Category	**Items in common**	**Gaps**	**Possible pathways and gaps**	**Ease of transition**
Experience	Technical Bachelor Level	Bachelor of Electrical Engineering 2+ years grid connection to 10+ years power system experience	Master of Power Systems Engineering/ Master of Engineering (power) Gap – opportunity to gain experience unless new graduate through grid engineer program	Difficult Requirement for extensive experience makes transition difficult
Knowledge	Quality systems Software	Resource allocation Regulatory Framework/NEM and AEMO	Courses through AEMO learning academy https://www.aemolearningacademy.aemo.com.au/	Long training pathway
Skills		Designing systems Connection experience Install electrical systems Power systems modelling/commissioning	Variety of micro-credentials available such as https://www.tafensw.edu.au/course-areas/electrotechnology/courses/grid-connected-solar-pv-systems-design-accreditation--MHE20502A Range of short course, such as BESS https://cpdint.com.au/fundamentals-of-battery-energy-storage-for-large-scale-pv-plants/	
Capabilities	Design Operating computer systems Analysis	Communication Project management Planning and organising	Management courses	
Mindsets and Dispositions	Team player	Motivated Technical expert Agile and flexible		

Transition from Electrical Engineer, Thermal Sector, to Battery Design Specialist/BESS engineer, Renewable Energy				
Category	**Items in common**	**Gaps**	**Possible pathways and gaps**	**Ease of transition**
Experience	Mid-Senior roles Professional and technical Bachelor degree	Battery Energy Storage System – 2-10 years' experience	Range of short course, such as BESS https://cpdint.com.au/fundamentals-of-battery-energy-storage-for-large-scale-pv-plants/ Gap gaining experience in first role in BESS	Moderate High number of roles advertised with differing levels of experience in renewables. Skills gap less apparent than experience gap. Movement with same employer more likely.
Knowledge	Software/CAD	Energy and, civil and electrical knowledge CEC/SAA/PV knowledge Legislation and standards	Gap A micro-credential providing insight to Clean Energy sector including relevant codes and standards Existing courses, are lengthy, not tailored to standards	
Skills		Costing/budget management	As per below or short course	
Capabilities	Systems thinking Project management Communication	Consulting Client management Risk management	Project management course or MBA https://eea.org.au/courses/project-management-essentials	
Mindsets and Dispositions	Innovation	Agile/flexible/adaptable Judgement		

Transition from Electrical Engineer, Thermal Sector, to Electrical Engineer, Renewable Energy				
Category	**Items in common**	**Gaps**	**Possible pathways and gaps**	**Ease of transition**
Experience	Entry to Senior roles Technical Bachelor of Engineering		Straight transition qualification wise Higher level qualifications for higher level power related roles	Simple Likely transition, although some roles require HV or BESS experience. Differences in capabilities, including the capacity to solve new problems could inhibit some transitions, although based on interviews many electrical engineers possess these traits and move between thermal and renewable roles. Further, some roles will remain routine.
Knowledge		Regulatory Framework/NEM and AEMO Renewable engineering	Graduate certificate renewable energy technologies https://www.eit.edu.au/courses/graduate-certificate-in-renewable-energy-technologies/ Courses through AEMO learning academy https://www.aemolearningacademy.aemo.com.au/	
Skills		Power systems modelling/commissioning BESS	Range of short courses, such as BESS https://cpdint.com.au/fundamentals-of-battery-energy-storage-for-large-scale-pv-plants/	
Capabilities	Modelling Project management Communication	Client management Analysis Problem solving	On the job, short courses and continuous professional learning	
Mindsets and Dispositions	Comfort with new technology Initiative		Inspire through continuous professional learning	

Transition from Electrical Engineering Draftsperson, Thermal Sector, to Structural Engineer, Renewable Energy				
Category	**Items in common**	**Gaps**	**Possible pathways and gaps**	**Ease of transition**
Experience	Technical	Bachelor level qualification	Advanced standing into Bachelor of Engineering – 2 years full time Alternatively, Master of Engineering or MBA *Note study options at masters level combine with work and study more effectively	Difficult Likely to adopt aspects of role, but recognition as an engineer unlikely not possible without lengthy training, limiting career progression. Dual qualification apprenticeships may be useful for new entrants, and other models of upskilling are needed for vocationally qualified staff. A smoother path is to move upwards into electrical engineering vacancies, or management level roles like control room. Alternatively obtain a generalist degree program, like MBA. or quality management.
Knowledge	Safety Software/CAD	Standards and codes Resource allocation Simulation models	Gap A micro-credential providing insight to Clean Energy sector including relevant codes and standards Existing courses, are lengthy, not tailored to standards	
Skills		Designing structures Surveying Inspections	Micro-credential – Professional certificate of competency in structural design for Non-Structural Engineers	
Capabilities	Planning/organising Calculation/evaluation/numeracy Project management Reading/analysis	Communication Negotiation Leadership/team management	MBA or short course–i.e. Cert IV in leadership and management	
Mindsets and Dispositions	Attention to detail Initiative			

Transition from Electrical Engineering Technician, Thermal Sector, to Blade Engineer/Blade specialist, Renewable Energy				
Category	**Items in common**	**Gaps**	**Possible pathways and gaps**	**Ease of transition**
Experience	Technical Vocational qualification	Bachelor for some roles Senior roles require 8 – 15 years of experience	Entry level aligned roles, such as maintenance planner, wind turbine service technician or commissioning technician Electrical engineering technician → Blade service technician → Blade specialist	Moderate Very few roles for blade engineers with high level vacancies for blade technicians.
Knowledge	Safety	Energy experience CEC/SAA/PV Legislation and standards Electrical Commissioning Knowledge of composites	Units from Certificate III in Engineering Composites Trades (unavailable to non-apprentices at present)	Emerging specialisations such as blade specialists and project managers for blade servicing.
Skills	Designing systems	GWO course/blade repair	May require GWO course such as basic technical training https://study.federation.edu.au/course/406063	Most likely pathway via wind turbine service technician experience. Most likely pathway via wind turbine/blade service technician experience.
Capabilities	Creative thinking Project management Communication	Planning/organising Reading/Analysis Problem solving Risk management	Project management course or MBA https://eea.org.au/courses/project-management-essentials	
Mindsets and Dispositions		Agile/Adaptable Thrive in challenging environments Innovation Attention to detail	Capabilities align with these mindsets	