Name: Engineers Australia

Submission date: 6/06/2025

Improve school student outcomes with the best available tools and resources

What (if anything) needs to be done to improve the use of edtech tools (including GenAI) in schools?

confidence, and support to integrate these tools effectively.

Foundational knowledge, particularly in STEM subjects like mathematics, is critical. Yet 2024 research from the Australian Mathematical Sciences Institute (AMSI) shows that nearly 40 per cent of Australian maths teachers lack formal qualifications, undermining both teaching quality and student confidence.

This has downstream effects, limiting students' progression into higher-level mathematics and, ultimately, engineering pathways.

Engineers Australia's Impact of AI and Generative Technologies on the Engineering Profession report calls for the education sector to take an active role in teaching and managing GenAI use to mitigate risks and support learning. While the report is predominantly focussed on the tertiary education sector, similar principles apply to schools.

Educators face multiple barriers to adopting GenAI: limited time to learn the tools, a lack of ongoing support to keep pace with rapid technological changes, and the additional workload of adapting assignments and curricula. These are compounded by existing pressures on teacher time and resources.

Engineers Australia emphasises that teachers must have both subject-matter expertise and institutional support to foster student confidence and capability. This principle applies across all EdTech tools, not just GenAI, and is especially important in areas foundational to engineering education.

Engineers Australia's research identified two key concerns specific to GenAI in education:
• A competence gap—students may not know when and how to use GenAI effectively.
• An overreliance on the technology—which can create a "knowledge gap," stunting the development of core engineering competencies and critical thinking skills.

These trends raise important concerns about whether future engineers will graduate with the skills required to meet professional standards. To address this, educational institutions must support both educators and students to develop responsible and proficient engagement with GenAI and other EdTech tools. In the implementation of any tools, it is to ensure a safe balance, wherein students can utilise such technologies, whilst simultaneously continuing to develop their core competencies.

What more (if anything) needs to be done to improve awareness and access to high quality lesson planning and curriculum materials in schools?

As noted, teachers need more time, training and support to effectively integrate EdTech, especially GenAI, into lesson planning.

From an engineering perspective, this support must be underpinned by stronger foundational mathematics. Teacher subject expertise, particularly in STEM, is essential to delivering high-quality content and inspiring long-term interest in engineering careers.

This is especially urgent given the ongoing decline in Year 12 maths enrolments, an essential entry point to STEM pathways, as reported by the Australian Mathematical Sciences Institute (AMSI) where in 2022 only 26.7 per cent of students with a Year 12 qualification studied mathematics to at least intermediate level, compared with 34.9 per cent in 2008.

This is not just a skills pipeline issue, it is an economic imperative. As Jobs and Skills Australia estimated in October 2023 in its The Clean Energy Generation: workforce needs for a net zero economy report, nearly 2 million workers in building trade and engineering will be needed for the clean energy sector by 2050. In addition, the Australian Council of Engineering Deans projects a shortfall of 100,000 engineers by 2030.

We urge the Australian Government to work with us to set a national target for 60,000 additional engineering graduates over the next decade.

This would catalyse universities, industry and governments to collaborate on strengthening this essential professional pipeline, assure its future capacity amid increasing global competition for talent.

These roles are critical to lifting productivity across the economy, given engineers' central role in designing productivity-enhancing products and infrastructure. A failure to meet demand risks significant lost productivity gains.

Meeting this demand requires early exposure to engineering concepts and building teacher capacity to deliver technically relevant, high-quality curriculum.

Is there anything more you would like to say about edtech, GenAI or lesson planning and curriculum materials?

Engineering should have greater visibility in the national curriculum. It is rarely taught as a standalone subject in schools, limiting early exposure to the profession. It is one of, if not the, largest occupational professions in the nation, with more than 540,000 engineers in Australia in the last census.

However, without a strong domestic pipeline, Australia risks engineering shortages that constrain productivity growth and economic growth. Engineers are essential to designing the infrastructure and technologies that drive productivity.

Support for skills development must also extend beyond school and tertiary education into the workplace. For example, Engineers Australia's Impact of AI and Generative Technologies on the Engineering Profession report (January 2025) found that 66 per cent of engineers have received no formal training in GenAI.

Receiving no training at work reduces confidence in using GenAI and increases the risk of misuse. The same report found that engineers without GenAI training scored lower in confidence across all applications and usage metrics. Among key metrics were those related to safety, including data privacy and recognising when AI is being used. Also, low confidence can contribute to misuse or avoidance, both of which undermine the potential for the technology to support productivity growth.

When major technological shifts occur, engineers and other professionals at all career stages must be equipped to adapt and apply new tools effectively. This is especially important in sectors where misuse or lack of proficiency can lead to serious consequences for safety, productivity, or economic performance.

Which of the following best describes you?

Professional Association

Are you currently using any edtech tools (including learning games and GenAI) to support teaching and learning in the classroom?

No

If yes, what has been your experience with using these tools?

The participant did not respond to this question.

Are there things you would like to do with GenAI or edtech tools that you can't do currently? What's stopping you from doing these things?

The participant did not respond to this question.

If no, can you tell us why you are not using any edtech tools?

Professional Association

Do you access lesson planning and curriculum materials online?

No

If yes, what has been your experience with using these tools?

The participant did not respond to this question.

If no, can you tell us why you are not using online lesson planning and curriculum materials?

Professional Association

Support the workforce through a flexible post-secondary education and training sector

Credit transfer and recognition of prior learning

In your experience, how well does the credit transfer and recognition of prior learning system operate in Australia? Does it adequately support students to move between courses or have their work experience recognised as part of a qualification? Are there ways it could be improved?

The OECD has highlighted recognition for prior learning as a key building block of national skills policy which can empower upskilling strategies of a country (Meghnagi & Tuccio, 2022, The recognition of prior learning: Validating general competences, OECD Social, Employment and Migration Working Papers).

Engineers Australia believes robust RPL policy and practice that is consistently applied can significantly support skill transfer and upskilling to contribute to the overall productivity of Australia.

The policy framework for RPL provided by the Australian Qualification Framework (AQF) and the Higher Education Standards Framework (HESF) of the Tertiary Education Quality and Standards Agency (TEQSA) emphasises the need for recognising diverse learning experiences, but how the recognition avenues are created and applied varies between institutions and professional bodies which can result in inconsistency, lack of fairness, and sometimes can be complex and frustrating for individuals seeking RPL.

Engineers Australia believes an over-arching framework co-designed by government bodies, academic institutions, professional and assessing bodies can provide a fair, consistent, and robust approach to RPL to ensure recognition of skills at an appropriate level that provides confidence of repeatable, quality decisions.

A National Framework, aligned more explicitly with AQF levels and learning outcomes, but also applicable in an industry setting, which assesses against competencies, should support more transparent and consistent credit/RPL decisions. Strengthening collaboration between tertiary providers, TEQSA, ASQA, professional and industry bodies should also ensure that recognition processes remain both rigorous and responsive to the needs of industry, professionals and para-professionals.

Which of the following best describes you? Please select all that apply.

Professional Association - Input informed by the experiences of our membership and staff.

In the past 3 years, have you applied for credit recognition or recognition of prior learning (RPL)?

The participant did not respond to this question.

If yes, what was your experience in applying for credit recognition or RPL like?

The participant did not respond to this question.

If no, can you elaborate on why you didn't apply?

The participant did not respond to this question.

Work related training

What are the main reasons individuals and/or businesses do or do not participate in work-related training?

Low confidence in a program's usefulness or transferability can deter investment. Engineers Australia's 2024 Transferability of Skills for the Energy Transition report found that training perceived as overly bespoke or not clearly applicable to adjacent sectors may discourage participation by individuals or businesses. In particular, if credentials are not recognised nationally or across organisations, there may be little incentive for individuals or businesses to undertake training, particularly those working across states or sectors.

Engineers Australia's research highlights underutilised talent groups, particularly women, who face reduced opportunities. The Women in Engineering Report (June 2022) found that only 55 per cent of women surveyed reported receiving equal opportunities to men, and nearly one in five experienced gender-based bullying or exclusion. These factors contribute to higher attrition and lower participation in training.

Engineers Australia's Impact of AI and Generative Technologies on the Engineering Profession (January 2025) found that GenAI uptake is higher in larger organisations, likely due to greater resources for implementation and training. The same principle applies to training more broadly. Businesses operating on tighter margins are more likely to forgo training to protect revenue. This highlights the need to develop work-related training support, incentives, and approaches for small to medium enterprises which often do not have the financial resources to do so.

In some cases, individuals and businesses may simply be unaware of the availability or benefits of training. Limited awareness of how training supports workforce development can reduce participation.

What role, if any, should businesses be playing to address any barriers and better support the offer of work-related training to employees?

Engineers Australia's 2024 Transferability of Skills for the Energy Transition report identifies business as playing a key role in addressing supply challenges. By partnering with government on skill-mapping initiatives, businesses can help ensure that work-related training aligns with industry needs and delivers greater value.

This collaboration can support the development of industry-recognised skillsets and certifications, reducing reliance on over-specialised, firm-specific training that limits workforce mobility. By partnering with government on skill-mapping initiatives, businesses can help shape training that aligns with current and emerging industry demands, improving both uptake and return on investment.

In addition, employers can strengthen workforce development by promoting clear career pathways and improving access to upskilling and reskilling through micro-credentials. These actions can improve retention, boost workforce mobility, and reduce inequities in access to training.

Businesses should also actively support employees in obtaining professional credentials, which are essential to engineering practice. Credentialing not only strengthens confidence in the skills of individual engineers but also builds trust in the businesses that employ them.

What, if anything, could government do to address barriers and better support the offer of work-related training to employees?

Government plays a vital role in improving access to work-related training by addressing cost barriers and creating the right policy environment. Direct public investment can make training more affordable, accessible, and attractive, particularly for individuals and small businesses that often struggle to cover the costs.

Engineers Australia's 2024 Transferability of Skills for the Energy Transition report highlights two key opportunities for government to address barriers and strengthen support for work-related training.

Firstly, government should ensure alignment across workforce strategies and initiatives. Consistent policy settings provide stability and give businesses the confidence to invest in workforce development. Clear and sustained signalling of priority skills further supports this investment, reassuring employers that policy changes will not render those skills obsolete.

Secondly, the report identifies the opportunity for government to support skill accreditation processes and to incentivise and coordinate the development of industry-wide skill sets. A core element of this approach is the creation of a skills passport—a tool for streamlined skill identification and recognition that would encourage greater investment from both individuals and employers. Government could work with the private sector and education providers to define core skill sets and standardise training content across industries.

Also, governments can use procurement to encourage greater investment in work-related training. Through contracts, government can set clear requirements for employers to provide training or ensure workers hold specific qualifications to participate in projects.

Which of the following best describes you? Please select all that apply.

The participant did not respond to this question.

For business owners, managers and sole traders, how many employees do you have?

The participant did not respond to this question.

For employees/individuals, have you participated in any work-related training in the last 12 months that did not relate to general compliance (such as WHS)?

The participant did not respond to this question.

If yes, can you elaborate on the reasons for the training and any benefits you received from doing it?

The participant did not respond to this question.

If no, can you elaborate on any challenges or barriers you faced in attempting to undertake work-related training?

The participant did not respond to this question.

For business owners, managers or sole traders, have you provided or supported your employees to participate in work-related training in the past 12 months?

The participant did not respond to this question.

If yes, can you elaborate on the reasons for the training and any benefits you or your employees received from doing it?

The participant did not respond to this question.

Can you describe whether you accessed any government assistance, what type, and the amount received? If you didn't access any financial assistance, please tell us the reasons why.

The participant did not respond to this question.

If no, can you elaborate on any challenges or barriers you faced in attempting to provide or support your employees to undertake work-related training, such as the time or cost, availability of relevant or high-quality courses, and level of interest from your employees?

The participant did not respond to this question.

Balance service availability and quality through fit-for-purpose occupational entry regulations

What are the effects of occupational entry regulations? Please describe your experience and name the specific occupations you are referring to.

Occupational entry regulations are essential for ensuring consumer protection, reducing community risk, recognising professional competency, and supporting legislative efficiency.

In the engineering profession, entry is underpinned by international accords that define expected graduate attributes and competencies and enable global mobility.

Engineers Australia is a signatory to the Washington Accord (professional engineers), Dublin Accord (engineering technologists), and Sydney Accord (engineering associates). Engineers Australia is the only approved body to provide professional accreditation under these accords at the AQF 8/9,7 and 6 levels.

Statutory registration for engineers in Australia is managed at the state and territory level, leading to inconsistent regulatory frameworks across jurisdictions. While quality is assured through national professional accreditation of engineering courses and education by Engineers Australia, the absence of a nationally consistent statutory registration scheme limits the full effectiveness of occupational entry regulation and can have adverse effects on sector productivity and service availability.

Engineering work frequently spans multiple jurisdictions. Under the current fragmented system, individual engineers must maintain separate registrations in each jurisdiction, comply with varying continuing professional development (CPD) and legal obligations, and manage duplicative record-keeping. This imposes significant administrative burdens, which can reduce mobility, discourage cross-border work, and limit productivity.

Engineering firms face similar challenges. They must pay multiple fees, manage varying regulatory obligations for staff, and often incur higher administrative costs. In some cases, these burdens discourage firms from operating in certain jurisdictions, reducing service availability and potentially compromising safety and quality.

Figures from Consult Australia demonstrate that having nationally consistent registration schemes can provide over $54 million in savings for businesses with registered professional engineers that are working across various state jurisdictions.

Do you believe current occupational entry regulations are proportionate to the level of risk associated with different professions? Why or why not? If not, do you have any suggested improvements to regulations to better reflect risks? Please name the specific occupations you are referring to.

Engineering is a high-risk profession in which failures can have profound economic, environmental, health and safety consequences for communities. Public trust in the work of engineers depends on strong professional standards and robust regulatory oversight. Engineers Australia believes that statutory registration should apply to anyone providing professional engineering services, in recognition of the significant risks and responsibilities involved. Engineering and related occupations—including engineering technologists and associates—should be incorporated into a national licensing scheme that reflects these risks.

Importantly, regulatory settings must preserve clear distinctions between the roles, qualifications and competencies of different occupational categories. For example, engineering technicians should not be permitted to present themselves as professional engineers, as this risks undermining both public safety and community trust.

Additionally, Engineers Australia calls for engineers who are already chartered and/or on the National Engineering Register to automatically be recognised by mutual recognition, given they have already been certified as demonstrating required standards and expectations.

Engineers Australia has consistently emphasised the need for a nationally consistent regulatory scheme—most recently through its Engineering Tomorrow report, its submission on the ACT's registration framework, and its guide The Case for Nationally Consistent Registration.

At present, occupational entry regulations for engineers are not proportionate to the level of risk involved, nor are they applied consistently. Registration laws are managed by individual States and Territories, resulting in a fragmented and misaligned system. While some states have comprehensive registration schemes in place, other jurisdictions vary significantly in the scope and application of their requirements.

A nationally consistent approach, underpinned by automatic mutual recognition and aligned with international benchmarks such as the Washington Accord, is essential. Such a system would ensure that only suitably qualified and competent individuals are permitted to deliver professional engineering services, regardless of where in Australia they practice.

Which of the following best describes your connection to occupational entry regulations? Please select all that apply.

Industry association or professional-body representative

Which state or territory are you predominantly based in?

National Organisation

Cover sheet: Supporting document #1

ENGINEERS
AUSTRALIA

Engineering Tomorrow

Strengthening the engineering workforce for Australia's future prosperity

April 2025

Engineering Tomorrow:
Strengthening the engineering workforce for Australia's future prosperity

ISBN 978-0-646-71488-2

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Foreword

At Engineers Australia, we back today's problem-solvers so they can shape a better tomorrow. Engineering is critical to Australia's ability to maintain a high quality of life and to advance society. Engineers in Australia are delivering more resilient infrastructure, developing smart systems, clean energy and critical mineral technologies, implementing building reforms and advancing domestic manufacturing. In short, Australia's engineering capability is a national asset.

Across Australia and throughout the world, Engineers Australia members are tackling some of the most significant industrial and social challenges of our time: the large-scale transformation of how we generate and use energy; a massive build-out of housing; revitalising our manufacturing industry and strengthening supply chains; pursuing innovative medical devices and diagnostic tools for healthier communities; and helping deliver on unprecedented investment in infrastructure. Engineers are crucial to all these initiatives.

A skilled workforce fuelling a strong engineering capability is critical for Australia's prosperity.

We are calling on our nation's leaders to jumpstart Australia's engineering capability by taking critical and urgent steps to secure our national engineering workforce pipeline:

1. **Secure Australia's future through a boost to our national engineering capability.** A national engineering surge could be informed by engaging Engineers Australia to deliver a rapid-response report with five key actions to dismantle existing obstacles and strengthen the engineering pipeline from school through to skilled migration.
2. **Set a target for 60,000 additional engineering graduates over the next decade.** This would catalyse universities, industry and governments to collaborate on strengthening this essential professional pipeline.
3. **Establish additional senior engineering roles in the Australian Public Service, including a National Chief Engineer.** This would ensure access for public decision-makers to critical technical and systems advice to inform procurement, programs and policy. This would help minimise risks, including cost and time overruns, and increase resilience, achieving optimal project outcomes for all Australians.
4. **Respond in full to the 2024 Pathways to Diversity in STEM report,** implementing its recommendations for stable and sustainable action to increase diversity and inclusion in STEM.

The Australian engineering profession is skilled, talented, and capable and it continues a tradition of engineering that dates back tens of thousands of years to indigenous innovation in hunting and fishing. Aboriginal and Torres Strait Islander peoples designed fish traps, used thermoplastic resins to set spear tips, and carved aerodynamics into boomerangs to make them return. Engineers Australia and all levels of government must continue working together to create better outcomes for engineers and the engineering profession, for the benefit of all Australians.

Dr Raj Aseervatham
BE(Hons, Civil) MBA PhD(Eng) GAICD FIEAust CPEng EngExec
National President and Board Chair

Romilly Madew AO
FTSE HonFIEAust EngExec
Chief Executive Officer

Executive Summary

The engineering profession is essential to the nation's economic performance, both as a core contributor to GDP and critical industries, and as the largest STEM employer.

Engineers help to drive technological advancement and foster productivity.

Engineering is at the heart of the innovation process which translates new scientific knowledge into practical solutions, products and technologies.

Engineering is a socio-technical profession that impacts on an ever-increasing complex of interrelated systems and challenges. Key areas of impact include advanced manufacturing, building and construction, climate change, critical minerals, defence and space, energy, health and medicine, infrastructure, IoT, R&D, cyber systems, transport and mobility, water and waste management.

The changes that will impact our economy in the next decade and beyond will rely extensively on engineering expertise to lead us to a sustainable, innovative and productive future for Australia, including to:

- → Deliver the energy transition
- → Apply circular economy principles and practice
- → Transform transport and infrastructure
- → Build workforce capability for Australia's growing decommissioning industry
- → Improve climate-related disaster resilience
- → Engineer water security
- → Revitalise manfuacturing
- → Grow sovereign capability and new industries, and
- → Develop and apply nascent technology and AI.

Many national challenges require engineered solutions, which means that bolstering Australia's engineering skills capability is critical. A skilled future for Australia will:

- → Meet engineering skills needs in the economy, matching labour supply and demand
- → Ensure skilled engineers, including migrant engineers, do not face barriers to employment in engineering roles
- → Utilise all talent available to enter the engineering profession, ensuring that the workforce reflects the diverse communities it serves
- → Remove impediments to workforce mobility across jurisdictions, including through nationally consistent registration for professional engineers

Australia must address critical challenges with its engineering workforce, including that a significant portion of Australian engineers are set to retire in the coming years, amidst increasing global competition for STEM talent.

Despite being a sought-after and valued profession, engineering faces significant challenges in retaining talent at every stage of the pipeline, from education through to professional practice.

The declining representation of engineering in government is undermining public sector project delivery. Decisions made for the community must be informed by robust technical analysis. Chief Engineers strengthen technical leadership in governments to address critical priorities.

Engineering is the essential link between thinking and doing, between ideas and implementation. At Engineers Australia, we back today's problem-solvers so they can shape a better tomorrow.

The engineering profession has come together to back the solutions in this report, building on Engineers Australia's latest research and analysis along with our established, evidence-based positions to strengthen Australia's engineering capability.

Engineers Australia is indebted to the new and experienced engineers right across the country who shared their thoughtful insights and lived experience in service of this report. Typical of the engineering team, our consultations elicited both enthusiasm and practical, pragmatic solutions designed to deliver the best outcomes to the community.

A skilled workforce fuelling a strong engineering capability is critical for Australia's prosperity. Engineers Australia calls on the Australian Government to adopt four solutions to strengthen the national engineering workforce.

1. National engineering surge

2. Engineering graduate target

3. Strengthening engineering advice in government

4. Diversity in STEM

1.0 Introduction

As Australia's national body for the engineering profession, we are the voice and champion of 130,000 plus individual members. As a mission-based, not-for-profit professional association, Engineers Australia is constituted by a Royal Charter to advance the science and practice of engineering for the benefit of the community.

Adept with complex systems and grounded in ethical decision-making, the engineering profession is synonymous with collaborative problem solving and renowned for providing trusted and reliable advice to governments, industry and the broader community

Engineers Australia draws on the collective experience of our members. Our professional engineers, engineering technologists and engineering associates represent every discipline of engineering and work across every sector of the economy. Established in 1919, our membership spans five generations of Australians, and we are the internationally recognised custodian of the engineering profession in Australia.

Our members:

- share technical insights with other professionals and the broader community
- guide practical design and delivery – from the largest buildings to the smallest sensors, and
- provide pragmatic, workable policy advice to the highest levels of government.

Engineers Australia and its members work closely with our industry partners and allied professions.

This report provides the context and rationale for our recommendations to government, including:

- engineering workforce insights and challenges
- the profession's contribution to the economy
- the importance of engineering skills and representation in government
- the need for engineering skills in addressing societal challenges and opportunities
- research and policy recommendations for a more sustainable, skilled and innovative Australia

The report provides an update and builds on policy advice in Engineers Australia's 2022 report, 'Strengthening the Engineering Workforce'. Much of the analysis and recommendations in that report remain highly relevant, including the actions for government, industry, and the tertiary sector to address Australia's engineering skills challenges. The foundational insights into the factors influencing the engineering workforce—such as education pathways, skilled migration, workforce retention, and industry demand—continue to shape policy discussions.

This report provides a comprehensive view of Australia's engineering workforce needs and the ongoing strategies required to support a resilient and sustainable profession.

ENGINEERS AUSTRALIA

2.0 Engineering and the economy

The engineering profession is essential to the nation's economic performance, both as a core contributor to GDP and critical industries, and as the largest STEM employer.

2.1 Contributing to national GDP

The engineering profession has long been a core contributor to Australia's gross domestic product (GDP) and key industries, adapting over time to meet evolving needs. Engineers play a crucial role in technological development - a key driver of productivity and economic growth. Over half of industry value added in the economy is generated through just six engineering-heavy segments of the private sector.[1] The largest value adding sector in Australia, mining,[2] accounted for 13.6 per cent of GDP in 2023,[3] and has been particularly dependent on engineering innovation to deliver economic benefits.

Infrastructure is also reliant on engineering expertise and a key performer in Australia's economy. Estimates suggest that for every $1 million invested in infrastructure, $3 million is returned to the economy.[4] According to the 2024 Infrastructure Market Capacity Report, Australia's five-year major public infrastructure pipeline stands at $213 billion, signalling a potentially substantive return for the broader economy.[5]

Historically, nations that were early creators, developers, and adopters of technology generally were those that gained the more significant economic and strategic advantages. The global impact of engineering on economic development was analysed by the Royal Academy of Engineering (UK), who found strong correlations between engineering capacity and economic success.[6] Similarly, a study co-authored by the World Bank's Chief Economist for Latin America and the Caribbean showed a "robust correlation" between a country's number of engineers during the Second Industrial Revolution, and that country's present-day income levels.[7] It found that countries with similar income levels in 1900 experienced markedly different economic trajectories in the following century, largely based on their varying engineering capacities.

When reflecting on historical divergences, the parallels with today's context—shaped by the dual revolutions of energy transition and smart technology—are striking. For example, commentators have argued that China's significant increase in engineers since 2000 "heralds a fresh growth model" that opens opportunities to lead the world in AI applications and biotech.[8] The risk of Australia not investing in engineering capacity, in an era defined by rapid technological change, threatens our ability to meet national goals and maximise societal benefits, both in the short and longer term.

1 Organisation for Economic Co-operation and Development (OECD), Gross Domestic Product (GDP), OECD, https://data.oecd.org/gdp/gross-domestic-product-gdp.htm.

2 Organisation for Economic Co-operation and Development (OECD), Gross Domestic Product (GDP), OECD, https://data.oecd.org/gdp/gross-domestic-product-gdp.htm.

3 U.S. Department of Commerce, International Trade Administration. "Australia - Mining." Trade.gov, https://www.trade.gov/country-commercial-guides/australia-mining.

4 National Builders Guide. "Engineering Construction Keeps the Economy Moving." National Builders Guide, www.nationalbuildersguide.au/industry/engineering-construction-keeps-the-economy-moving/.

5 Infrastructure Australia. 2024 Infrastructure Market Capacity Report. 23 Dec. 2024. www.infrastructureaustralia.gov.au/reports/2024-infrastructure-market-capacity-report.

6 Centre for Economics and Business Research (Cebr). "Engineering and Economic Growth: A Global View." Royal Academy of Engineering, September 2016. https://raeng.org.uk/publications/reports/engineering-and-economic-growth-a-global-view.

7 Maloney, William F., and Felipe Valencia Caicedo. "Engineering Growth: Innovative Capacity and Development in the Americas." CESIFO Working Paper No. 6339, Category 5: Economics of Education, February 2017. Accessed February 23, 2025. https://www.ssrn.com/sol3/papers.cfm?abstract_id=2932756.

8 Henderson, Greg. "China's Engineer Dividend Is Paying off Big Time." The Australian Financial Review, 25 Mar. 2025, http://www.afr.com/world/asia/china-s-engineer-dividend-is-paying-off-big-time-20250325-p5lme4

2.2 Improving productivity

Productivity growth is a crucial driver of economic expansion and improved living standards.[9] However, following a strong period in the 1990s and 2000s, it has declined globally among advanced economies. Between 2010 and 2020, productivity growth was the slowest in 60 years. [10]

This decline is attributed in part to stagnating technological advancements and innovation, global economic impact on global trade and ageing populations. The Global Financial Crisis and the COVID-19 pandemic have also played a part in persistent declines in productivity, mainly due to a reduction in investment[11]. If productivity growth had remained consistent with the average over the past 60 years (1.7 per cent instead of 1.1 per cent), gross national income would have been about 6 per cent higher in 2020[11]. Australia must seek to invest in an enhanced productive capacity to ensure we can attain our economic goals and maintain or increase our standard of living.

The engineering profession helps to drive technological advancement and foster productivity. Their expertise is directly involved in the creation of productivity enhancing systems, products and services that provide benefit to workers across almost all occupations[13]. Engineers drive productivity growth in two key ways:

→ **Productivity-enhancing product development:** Engineers are adept at translating scientific knowledge into practical applications. By creating new and more efficient tools or methods, engineers help increase efficiency across multiple sectors, boosting overall productivity. Examples may include modern methods of construction, the development of digital twins, or innovation of manufacturing process design.

→ **Development of productivity-enhancing infrastructure:** Engineers have long been instrumental in designing infrastructure that drives productivity and development, including rail, roads and air travel systems. They also design and maintain digital infrastructure that ensures connectivity and access to productivity-enhancing services, such as generative AI. By developing such infrastructure, the engineering profession acts as an enabler of broader productivity.

2.3 Engineering and innovation

Innovation is central to driving economic complexity, which is vital for increasing national income and fostering long-term prosperity[14]. At the heart of this process is engineering, which translates new scientific knowledge into practical solutions, products, and technologies. The expertise of engineering professionals directly contributes to advancing innovation, enabling economies to develop new capabilities and enhance their global competitiveness.

Australia has a strong foundation for innovation, with world-class engineering research and development (R&D) output. For

[9] Parliament of Australia. Productivity Commission Inquiry Report: Chapter 2. House of Representatives, 2022, www.aph.gov.au/parliamentary_business/committees/house_of_representatives_committees?url=economics/productivity/report/chapter%202.pdf.

[10] Australian Government Treasury. Intergenerational Report 2023: Australia's Demographic and Economic Outlook. Australian Government, 2023, https://treasury.gov.au/sites/default/files/2023-09/p2023-447996-06-ch4.pdf.

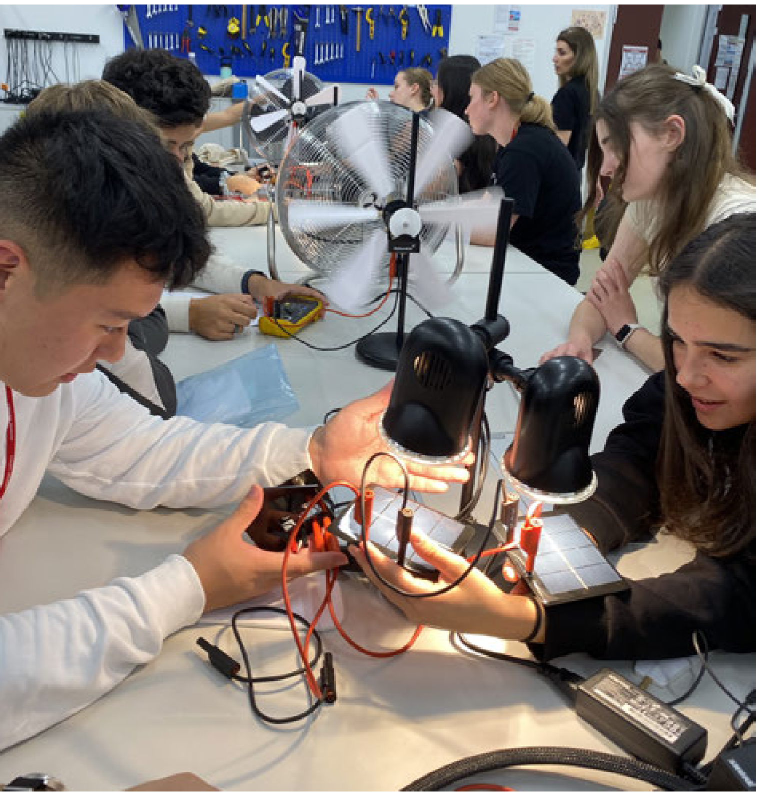
[11] 5-year Productivity Inquiry: The key to prosperity The Australian Government Productivity Commission, July 2022. https://www.pc.gov.au/inquiries/completed/productivity/interim1-key-to-prosperity/productivity-interim1-key-to-prosperity.pdf

[12] Recent trends in Australian Productivity Reserve Bank of Australia, September 2023. https://www.rba.gov.au/publications/bulletin/2023/sep/recent-trends-in-australian-productivity.html

[13] Engineers Australia. Submission to the Productivity Inquiry. Engineers Australia, 7 Oct. 2022. www.engineersaustralia.org.au/sites/default/files/2022-10/Engineers-Australia-Submission-Productivity-Inquiry-20221007-Final.pdf.

[14] Hausmann, Ricardo, et al. The Atlas of Economic Complexity: Mapping Paths to Prosperity. MIT Press, 2011. https://direct.mit.edu/books/oa-monograph/3014/The-Atlas-of-Economic-ComplexityMapping-Paths-to.

all R&D, Australia has the 6th highest share of world citations and publications (3.5 per cent), and is cited 42.2 per cent higher than the world average[15]. Our universities rank highly in global engineering education, and the quality of Australia's R&D output across sectors is reflected in various national and international assessments: 18 Australian institutions in the top 200 for citations per staff in QS's R&D rankings, and 15 institutions in the top 200 overall.[16]



In the 2024 Global Innovation Index, Australia ranks 23rd.[17] However, despite having one of the world's most educated and wealthy populations, and a notably productive tertiary research sector, Australia underperforms in commercialising local engineering innovation, ranking 61st out of 67 countries in the 2024 IMD World Competitiveness Yearbook rankings for 'entrepreneurship'.

One of the key issues is Australia's capacity to translate R&D into viable products and services; we continue to face commercialisation challenges that impede our innovation capacity. The 2024 Global Innovation Australia report highlights a 14.3 per cent decline in international patent filings from 2022 to 2023,[18] signalling weaknesses in turning innovation into economic output. Further;

- → Australia ranks 84th globally when it comes to the percentage of graduates in science and engineering[19], and
- → Australia ranks 91st globally in terms of production and export complexity.

To reverse this trend, and to maintain our ability to innovate and commercialise new solutions and products, Australia must retain and build its engineering workforce. A critical lack of engineers coupled with increased inefficiencies in innovation, may see low degrees of economic complexity persist, and impair economic growth into the future. Australia must invest further in its innovative capacity to ensure future economic wellbeing.

Product development is a key driver of economic complexity, through enhancing productive capabilities, and the range of goods and services that can be produced and exported. Innovation, particularly in engineering and technology, plays a substantive role in product development by transforming new ideas and research into tangible products.

[15] Independent Expert Panel. Strategic Examination of R&D Discussion Paper.12 February, 2025. Commonwealth of Australia. Retrieved from https://storage.googleapis.com/converlens-au-industry/industry/p/prj31a02fa37c9ece8370e29/page/SERD_Discussion_Paper.pdf.

[16] QS Quacquarelli Symonds. 2025 QS World University Rankings. 2024. www.topuniversities.com/university-rankings/world-university-rankings/2025.

[17] World Intellectual Property Organization (WIPO). Global Innovation Index 2024. https://www.wipo.int/gii-ranking/en/australia

[18] Ibid.

[19] Ibid.

Global case study: Republic of Korea (South Korea)

The Republic of Korea (South Korea) is cited as one of the most high performing innovation countries and most capable of translating research inputs to outputs. It invests heavily in research and development, has a strong focus on high quality education emphasising STEM, and it has an innovation-friendly ecosystem that has fostered the growth of tech giants such as Samsung and LG.

South Korea ranked 18th in the proportion of graduates in science and engineering (in contrast to Australia which ranked 84th). This correlation is observed across a number of the highest performing countries on the index, and demonstrates the importance of engineers in facilitating innovation and economic growth.

2.4 Employment and jobs

Engineering stands as the largest employer within the STEM field in Australia. According to the 2020 Australia's STEM Workforce Report[20], individuals with engineering qualifications represented 80 per cent of the VET STEM-qualified labour force and 38 per cent of the university STEM-qualified labour force. The report highlighted the strong earning potential enjoyed by engineering graduates, including that 40 per cent of employed engineering bachelor graduates were earning in the highest income brackets, and engineering graduates had the highest employment rate among all STEM qualifications for university and doctoral graduates.As such, the engineering profession not only plays a vital role in addressing key societal challenges but also contributes to economic resilience by providing a stable and well-compensated career pathway for many.

The engineering profession also offers extrinsic benefits and has the potential to create a multiplier effect in employment. As engineering projects often require support from other industries, the increased employment of engineers can lead to both direct and indirect job opportunities within the field, and in engineering-adjacent professions across various industries.

Case study: Engineering's contribution to the US economy

The engineering and architectural sector plays a significant role in job creation. For example, aside from accounting for 2.8 per cent of jobs in the United States, each new job in the sector leads to two more being created in supporting industries.[21] This pattern of job creation is similarly observed across various engineering-related fields, including technical consulting and the manufacturing of electrical equipment, medical devices, semiconductors, and other essential components. [22]

Conversely, the loss of engineering jobs can have a significant negative impact on employment across sectors. For example, the American durable manufacturing sector—an industry closely tied to engineering expertise—has the second-highest employment multiplier of any of the major industry groups analysed in the survey. For every 100 direct jobs lost in this sector, 744 indirect jobs are also lost. [23]

[20] Leigh, Katherine, et al. Australia's STEM Workforce: Science, Technology, Engineering, and Mathematics. Office of the Chief Scientist, July 2020, www.chiefscientist.gov.au/sites/default/files/2020-07/australias_stem_workforce_-_final.pdf.

[21] American Council of Engineering Companies. "Engineering Industry Impact Report." American Council of Engineering Companies, 2020, www.programs.acec.org/impact-report/.

[22] Bivens, Josh. Updated Employment Multipliers for the U.S. Economy. Economic Policy Institute, 2023, www.epi.org/publication/updated-employment-multipliers-for-the-u-s-economy.

[23] Ibid.

Key areas of impact

Engineering is a socio-technical profession that impacts on an ever-increasing complex of interrelated systems and challenges. The engineering profession is able to analyse and consider these interconnected and interdependent systems, meaning that engineering skills and engineering solutions are applied and valued across broad and diverse sectors, industries and societal challenges.

Advanced manufacturing

Advanced manufacturing plays a pivotal role in modern production, with engineering essential to every stage – from product development to system design. The potential of Industry 4.0 and automation have unlocked opportunities for highly sophisticated and cost-effective manufacturing processes that can significantly benefit Australia's economy. A range of industrial, mechanical and production engineers, including automation, process and systems engineering specialists, are at the forefront of driving this evolution.

Building and construction

Engineers in civil, structural, mechanical, fire safety and electrical fields are crucial to boosting housing supply and affordability. The steady flow of these engineering projects has a strong influence on economic growth and urban development.

Climate change

Environmental and sustainability engineering professionals assess and mitigate the impact of human activities on the environment, managing natural resources and addressing issues like contamination from past activities. Heritage engineers support sustainability initiatives and conserve natural resources through maintenance, repurposing and adaptive reuse. Engineers from a wide range of disciplines will also be pivotal in achieving more sustainable and resilient project outcomes through engineering design, innovative construction methods, development and use of recycled materials and decommissioning.

Critical minerals

Australia possesses large mineral reserves, many of which are central to global supply and value chains. Critical minerals serve as enablers of many crucial technologies, such as batteries, computer chips, and renewable energy technologies. Mining and chemical engineers are essential to this sector, playing a key role in ensuring extraction and refinement processes are safe, efficient, and sustainable.

Cyber systems security

Cyber security and resilience engineering are vital to national security and the protection of sensitive data and information. Engineers design, implement and improve information security measures to protect the confidentiality, integrity, availability and safety of systems.

Defence and space

Engineers in Australia's Defence Force and defence industry including in disciplines such as mechanical, electrical, aeronautical and cybersecurity, support national security and defence operations in Australia and overseas. Australia's growing space industry relies on engineering expertise from all disciplines, including aerospace and systems engineers, to deliver activities such as ground operations, satellite communication, robotics, astronomy and Earth observation.

Energy

The engineering profession plays a critical role in the development of economic business cases, planning design, construction, roll out, maintenance and decommissioning of projects across many sectors. A key aspect of their work will be to ensure the efficient adaptation of our energy systems to greener technologies, as well as protecting energy delivery during the transition. As well as civil and electrical engineers, specialists such as power systems engineers and grid engineers are essential to a smooth transition to net zero.

Health and medicine

With an ageing, growing population and a trend towards precision medicine, biomedical engineering is an important area of practice that is applying and improving medical technologies to optimise healthcare diagnostics and delivery. Rehabilitation engineering is providing technological solutions to overcome challenges of people with disabilities.

Infrastructure

Australia is currently delivering on a record level of infrastructure investment, including more mega projects than ever before. Planning, designing and constructing major infrastructure such as roads, bridges, pipelines, harbours, airports and railways is only possible with the engineering team.

Internet of Things (IoT)

Engineers, including software and systems engineers, design applications, creating a network of internet-connected devices that communicate and share data with each other over the internet. These technologies can collect and exchange data, enabling them to monitor and control various aspects of the physical world. These technologies have immense potential in analytics, predictive maintenance and the operation of 'smart cities'.

Research and development

Engineering scholars in our universities and research-focussed engineers in the broader research sector are essential to developing new technologies, materials, processes and engineering solutions. Commercially, engineers possess a unique product development mindset that enables the creation of technologies in high demand by both businesses and households.

Transport and mobility

Transport and mobility infrastructure are vital for livable cities and facilitating the flow of commerce. This infrastructure is also central to individual wellbeing, by ensuring accessibility, safety and community access. Inclusive and efficient transport systems rely on engineers with specialist skills in transport, rail, maritime, aviation and logistics to design and deliver systems that operate safely and effectively and remain fit for purpose amidst a changing urban environment and across regional and international transport routes.

Water and waste

Chemical engineers are vital in processing water, food, fuel, metals, pharmaceuticals and waste. They are an integral part of developing and implementing renewable, sustainable technologies and embedding the circular economy.

3.0 Today's engineering workforce

Australia must address critical challenges with its engineering workforce, including over-reliance on international migration and a significant portion of engineers set to retire in the coming years.

Engineers Australia periodically gathers data about the engineering workforce to help understand whether there are enough engineers coming into the profession to maintain our present and future engineering capabilities. We source data from various trusted sources, including census data which is available every five years.

3.1 Snapshot of Australia's engineers

Below are some key highlights from 'The Engineering Profession: A statistical overview, 15th edition' [24] and 'The Engineering Labour Market Overview'. [25]

- At the time of the last census in 2021, there were 546,905 qualified engineers in Australia, with 433,353 participating in the labour force, and 243,157 working in engineering occupations.
- In 2021, nearly 44 per cent of the engineering workforce were Millennials, representing the largest proportion of working engineers.
- Over 60 per cent of Australia's qualified engineers were born overseas.
- Only 16 per cent of engineers working in engineering occupations are women (around 87,000), and only 4.1 per cent of the engineering qualified labour force are women born in Australia.
- Up to almost 70,000 engineers are predicted to retire over the next 15 years, and at current rates more than 60 per cent of domestic engineering graduations would need to enter the workforce to replace these departing engineers.
- Aboriginal and Torres Strait Islander people working in engineering occupations have increased by 51.9 per cent compared with the 2016 census. Although Indigenous people make up 3.8 per cent of the overall Australian population, they represent just 0.3 per cent of the engineering workforce—about 12 times smaller than their proportion of the population.
- Like most of the Australian population, a vast majority of engineers live in urban, metropolitan areas, in and around capital cities.
- The average Australian engineer's salary during the 2021 census was $118,232.
- 60.3 per cent of engineers work full-time, 12.7 per cent work part-time, 20.6 per cent are not in the labour force, and 2.9 per cent are unemployed and looking for work.

[24] Briggs, P. 'The Engineering Profession: A Statistical Overview Fifteenth Edition' Engineers Australia. 2023, https://www.engineersaustralia.org.au/publications/engineering-profession-statistical-overview-15th-edition

[25] The Engineering Labour Market Overview – August 2024. Engineers Australia, 2024, https://www.engineersaustralia.org.au/sites/default/files/2024-09/The-Engineering-Labour-Market-Overview-August-24.pdf.

Labour force statistics

	Qualified Engineers		Working in Engineering Occupations	
Component of Labour Force	Number	% of LF	Number	% of EO
Male, Aboriginal and Torres Strait Islander	1,086	0.3%	638	0.3%
Male, born in Australia	146,779	33.9%	95,775	39.4%
Male, born overseas	217,375	50.2%	112,730	46.4%
Male total	364,154	84.0%	209,143	86.0%
Female, Aboriginal and Torres Strait Islander	82	0.0%	63	0.0%
Female, born in Australia	17,979	4.1%	10,985	4.5%
Female, born overseas	51,220	11.8%	23,029	9.5%
Female, total	69,199	16.0%	34,014	14.0%
Aboriginal and Torres Strait Islander total	1,168	0.3%	701	0.3%
Australian total	164,758	38.0%	106,760	43.9%
Overseas born total	268,595	62.0%	135,759	55.8%
Total	433,353	100.0%	243,157	100.0%

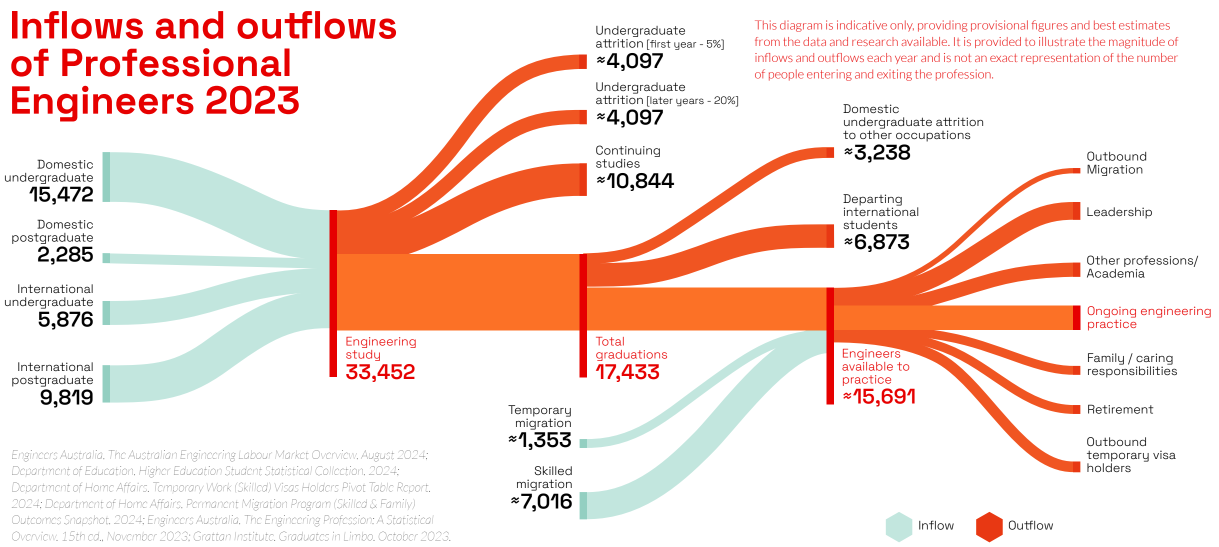
Top 20 occupations

Occupation	Number
Civil Engineering Professionals	38,347
Industrial, Mechanical and Production Engineers	24,342
Software and Applications Programmers	19,993
Electrical Engineers	14,782
Engineering Managers	12,377
Construction Managers	11,440
Contract, Program and Project Administrators	8,974
ICT Managers	7,882
Mining Engineers	6,586
Production Managers	6,560
Other Engineering Professionals	6,349
Other Specialist Managers	5,021
Air Transport Professionals	4,934
Chief Executives and Managing Directors	4,867
Management and Organisation Analysts	4,750
Architectural, Building and Surveying Technicians	4,194
ICT Business and Systems Analysts	3,861
Electronics Engineers	3,776
Telecommunications Engineering Professionals	3,677
General Managers	3,639
University Lecturers and Tutors	3,588
Total	199,939

3.2 Attraction and retention

Despite being a sought-after and valued profession, engineering faces significant challenges in retaining talent at every stage of the pipeline, from education through to professional practice.

Only 70 per cent of students who commence an engineering degree in Australia complete their studies, based on 9-year outcomes.[26] Some are lost to attrition, with others either continuing their education, moving overseas, or transitioning to other fields. At the four-year point, only 22.3 per cent of engineers have graduated with their bachelors qualification; this number has fallen 15 per cent since 2011.[27] There is a need to better understand this as we know many factors influence this outcome. For example, a strength of Australian engineering programs is that they are often completed as double degrees. Earn while you learn program models also need to be considered.



Engineering is a key part of Australia's STEM talent pipeline and holds strong appeal among students due to positive perceptions of engineering as a career.[28] Factors such as personal interest, job security, creativity, and societal impact drive students' interest in engineering. However, a student's level of interest is also strongly influenced by their family's career perceptions.

Despite favourable perceptions of the profession, Engineers Australia research found both traditional and technology-driven engineering fields face challenges with limited teacher encouragement,[29] potentially deterring students from pursuing engineering careers. This issue could stem from educators' limited exposure to engineering concepts, career pathways, and real-world applications.

These findings support earlier research into the motivators and barriers for entry into engineering specifically for women and girls. The research found that greater familiarity with engineering among several groups – from teachers and career advisors to parents and guardians – will lead to greater external encouragement of girls to study engineering. In some cases girls are actively **dis**couraged from pursuing engineering – they may be pushed to instead study science or health degrees.[30]

[26] Engineers Australia. Australian Higher Education Statistics 2012-22. Engineers Australia, 2024, www.engineersaustralia.org.au/sites/default/files/2024-11/Australian-Higher-Education-Statistics-2012-22-Nov24.pdf

[27] Ibid

[28] Engineers Australia & Student Edge. Decoding the Career Path of Today's Young People. June 2024.

[29] Ibid

[30] Romanis, J. Women in Engineering. Engineers Australia. June 2022, https://www.engineersaustralia.org.au/publications/women-engineering

Even when students choose to study engineering, retaining them in the profession remains a challenge. The attrition rate of engineering students is noted to be five per cent in the first year, with a further 20 per cent attrition over later years.[31] Research by Engineers Australia has shown that engineering students often feel unsupported throughout their studies, a potential factor in this trend.[32] In addition, many graduating engineers from international backgrounds may return to their home countries, where they can contribute to their local communities or practice in familiar environments. However, failing to retain these international graduates in Australia represents a missed opportunity to tap into a talent pool with professionally accredited qualifications and valuable knowledge of engineering practice in the Australian context.

Attrition continues to occur in the professional stage due to retirements, family and caring responsibilities, leadership opportunities, transitions into other non-engineering roles and outbound migration. This loss is particularly impactful on long-term supply, as engineering professionals who have been away from the field for extended periods face challenges re-entering the workforce. This issue is especially pronounced for young graduates who have never had the opportunity to work in a professional engineering role.

3.3 Vacancies and demand

Many engineers and engineering employers are reporting skills challenges of varying degrees in their organisations. A survey of audience members at Engineers Australia's Climate Smart Engineering Conference in 2023 found 36 per cent of the audience were experiencing acute skills shortages in their work, and 60 per cent had faced skills shortages at certain times or for more particular skills. [33]

Consult Australia's 2024 survey of its members found this trend had changed, but 57 per cent of businesses needed to redeploy staff to alternative projects, and 51 per cent of businesses identified staff recruitment as their biggest challenge. [34] Evidently, there are still ongoing challenges related to skills and their efficient allocation to where they are most needed.

According to a labour market analysis in August 2024, vacancies remain elevated (16.8 per cent above the indexed level recorded in January 2006). [35] The largest share of vacancies is for Civil Engineering Professionals, with Chemical and Materials Engineers showing the lowest proportion of vacancies. Vacancies are highest in ACT, Tasmania and WA.

In the face of current skills challenges, Australia has the additional task of preparing itself for anticipated rises in demand for engineering professionals. Ongoing increased investment in public infrastructure is driving demand for engineers, as is a re-emergence of demand for minerals, a global transition to clean energy and climate change adaptation. Employment across all STEM disciplines is projected to grow by 14.2 per cent by 2026, nearly double the growth rate for non-STEM jobs. [36]

[31] Engineers Australia. The Engineering Profession: Statistical Overview, 15th Edition. Engineers Australia, 2023, https://www.engineersaustralia.org.au/sites/default/files/2023-11/engineering-profession-statistical-overview-fifteenth-edition.pdf. & King, R., 'Australian Engineering Higher Education Statistics 2010–20', Australian Council of Engineering Deans, (April 2022) https://www.aced.edu.au/downloads/ACED%20Engineering%20Statistics%20April%202022.pdf

[32] Engineers Australia. The Engineering Profession: Statistical Overview, 15th Edition. Engineers Australia, 2023, https://www.engineersaustralia.org.au/sites/default/files/2023-11/engineering-profession-statistical-overview-fifteenth-edition.pdf.

[33] Engineers Australia. The Engineering Labour Market Overview: August 2024. Engineers Australia, August 2024, www.engineersaustralia.org.au/sites/default/files/2024-09/The-Engineering-Labour-Market-Overview-August-24.pdf.

[34] Consult Australia. 2024 Confidence & Continuity Report. Consult Australia, 2024, www.consultaustralia.com.au/docs/default-source/advocacy/2024-confidence-continuity-report.pdf?sfvrsn=2dfca33_3.

[35] Engineers Australia. The Engineering Labour Market Overview: August 2024. Engineers Australia, August 2024, www.engineersaustralia.org.au/sites/default/files/2024-09/The-Engineering-Labour-Market-Overview-August-24.pdf.

[36] Jobs and Skills Australia. NSC22-0041 Employability Projections. 2022, jobsandskills.gov.au.

Preliminary modelling by Jobs and Skills Australia indicates Australia will need nearly two million workers in engineering and building trades in the clean energy sector by 2050.[37] An Australian Council of Education Deans (ACED) working paper shared projections that Australia will need one hundred thousand more engineers alone by 2030, representing a 50 per cent increase to deliver on government initiatives.[38]

The Australian Government's Jobs and Skills Councils (JSCs) have also highlighted the skills challenges in engineering across the diverse portfolio of workforce plans. The JSCs bring together employers, unions and governments in a tripartite arrangement to find solutions to skills and workforce challenges. For example, the Manufacturing Industry Skills Alliance highlight the demand growth for skills in core manufacturing occupations electrical engineering, systems engineering and mechanical engineering[38] . Likewise, the Industry Skills Australia Maritime[39], Rail and Aviation[40] industries' workforce plans all include engineering among the occupations required to deliver on major projects and cite shortages across many engineering disciplines required for these workforces.

Notwithstanding, Infrastructure Australia has found businesses continue to report pipeline uncertainty as one of the biggest risks to project delivery. Despite workforce shortages at the national aggregate level, Infrastructure Australia suggest delays or uncertainty at the project level may disincentivise businesses from investing in workforce capacity building.[41] This trend is seen in Consult Australia's 2024 survey of design, advisory and engineering businesses which found that in the last 12 months, almost half (46 per cent) of respondents have made resource cuts and more (57 per cent) have redeployed staff to alternative projects due to changes to the government infrastructure pipeline. [42]

However, the scale of activity required to undertake the clean energy transition and decarbonise the economy by 2050, as well as the infrastructure and construction demand from an increasing population, and the new investment from the Australian Government's Future Made in Australia agenda is likely to see strong demand for engineers in the longer-term.

[35] Jobs and Skills Australia. The Clean Energy Generation: Workforce Needs for a Net Zero Economy, 2023, https://www.jobsandskills.gov.au/publications/the-clean-energy-generation.

[36] King, Robin. Engineer Shortages and Projections. Australian Centre for Engineering Education, Dec. 2021, www.aced.edu.au/downloads/Engineer%20Shortages%20and%20Projections%20Dec%202021.pdf.

[37] 2023 Initial Workforce Plan' Manufacturing Industry Skills Alliance (Accessed 8 May 2024) https://manufacturingalliance.org.au/wp-content/uploads/2024/02/Initial_Workforce_Plan_2023_excerpt.pdf

[38] Manufacturing Industry Skills Alliance '2023 Initial Workforce Plan' Manufacturing Industry Skills Alliance (Accessed 8 May 2024) https://manufacturingalliance.org.au/wp-content/uploads/2024/02/Initial_Workforce_Plan_2023_excerpt.pdf

[39] Industry Skills Australia Limited, Maritime Industry 'Maritime Industry 2023 Initial Workforce Plan' Industry Skills Australia (Accessed 8 May 2024) https://www.industryskillsaustralia.org.au/initial-workforce-plans

[40] Industry Skills Australia Limited, Aviation Industry 'Aviation Industry 2023 Initial Workforce Plan' Industry Skills Australia (Accessed 8 May 2024) https://www.industryskillsaustralia.org.au/initial-workforce-plans

[41] Infrastructure Australia. 2024 Infrastructure Market Capacity Report. Infrastructure Australia, 2024, www.infrastructureaustralia.gov.au/2024-infrastructure-market-capacity-report.

[42] Consult Australia. (2024). 2024 Confidence and Continuity Report. Retrieved from https://www.consultaustralia.com.au/docs/default-source/advocacy/2024-confidence-continuity-report.pdf

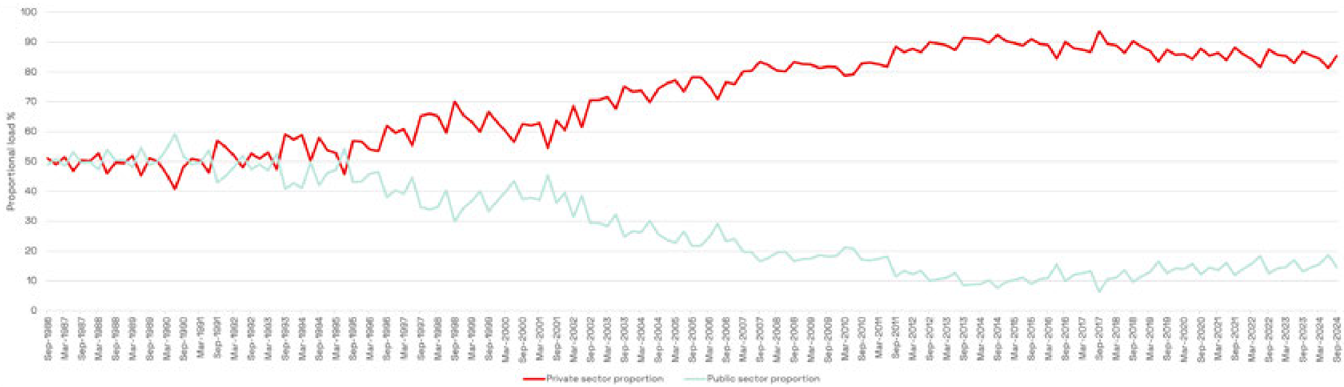
4.0 The declining representation of engineering in government

Senior engineering roles in government ensure decisions made for the community are informed by robust analysis and innovative thinking to enhance outcomes. Chief Engineers strengthen technical leadership in governments to address critical priorities.

The demand for public sector work is rapidly growing, driven by the federal government's goals and Australia's expanding population. The nation's major public infrastructure pipeline, valued at $213 billion through to 2027-28,[43] underscores the increasing need for government-funded projects across urban infrastructure, public transport, and energy systems. As the country faces the imperatives of the energy transition and a future built on sustainable development, the government will continue to bear substantial responsibility for critical engineering projects. This growing demand for public infrastructure stands in stark contrast to the decreasing proportion of engineers employed within the public sector.

Currently, around 45 per cent of all engineering work is completed for the public sector, yet only 15 per cent of engineering work is executed by the public sector itself.[44] This shift reflects an alarming reality—despite the increasing pressure on the government to deliver projects with greater scale and frequency, the share of engineers directly employed by the public sector continues to proportionally decline. As of 2021, 85.7 per cent of qualified engineers work in the private sector,[45] highlighting the shift toward private procurement and consultancy. In 2021, there were 59,292 engineers employed across the three levels of Government,[46] a 40 per cent reduction to the estimated size of the engineering workforce in the public sector in the 1980s.[47] At the same time, the inflation adjusted value of engineering construction work conducted for the public sector has increased by an astounding 211.8 per cent from 1986 to 2024. [48]

Chart 1: Proportion of Australian Engineering work completed by Public v Private Sector



Data extracted from: Australian Bureau of Statistics. Engineering Construction Activity, Australia, latest release, Australian Bureau of Statistics, www.abs.gov.au/statistics/industry/building-and-construction/engineering-construction-activity-australia/latest-release. Accessed 5 Mar. 2025

[43] Infrastructure Australia. 2024 Infrastructure Market Capacity Report. Infrastructure Australia, 2024, www.infrastructureaustralia.gov.au/2024-infrastructure-market-capacity-report.

[44] Foley, B. & Briggs, P. 'The engineering workforce in Australia – supply and demand dynamics'. Engineers Australia, July 2024. (internal briefing)

[45] Engineers Australia. About Engineering: Statistics. Engineers Australia. https://www.engineersaustralia.org.au/about-engineering/statistics

[46] Engineers Australia. Engineering Profession: A Statistical Overview, Fifteenth Edition. Engineers Australia, 2023, https://www.engineersaustralia.org.au/sites/default/files/2023-11/engineering-profession-statistical-overview-fifteenth-edition.pdf.

[47] Engineers Australia. "Why Government Needs More Engineering Expertise." Engineers Australia, 2018, https://www.engineersaustralia.org.au/news-and-media/2018/07/why-government-needs-more-engineering-expertise.

[48] Australian Bureau of Statistics. Engineering Construction Activity, Australia, Latest Release. Australian Bureau of Statistics, https://www.abs.gov.au/statistics/industry/building-and-construction/engineering-construction-activity-australia/latest-release. Statistics were retrieved from this source, with the 1986 figure CPI adjusted. The percentage increase represents the proportional percentage difference.

The impacts of increased reliance on procurement and contracting

While private sector delivery of public projects can provide significant benefits, the shift towards private procurement does not remove the need for technical skills and advice – rather it necessitates deploying these skills in different ways. Market-based approaches can drive efficiency, but government leadership is necessary at a system-level.

Engineering expertise is needed in procurement for project scoping, ideation of solutions, knowledge about technical limitations and compliance issues, and an understanding of systems integration. This ensures tender documentation is prepared in a way that efficiently supports the best and most competitive responses from the private sector (including those that support innovation and sustainability), and funding agreements support governments as informed buyers – with expert technical assessment of feasibility, cost, risk and safety. In-house, ongoing engineering expertise can further support private sector innovation, by advising governments on where they can have a higher risk appetite to 'do things differently' and adopt innovative private sector solutions, rather than undertake procurement for an already-determined – and potentially less ideal – outcome.

Engineering expertise is crucial in many central public sectors like defence, energy, transport, infrastructure, and climate, where decisions, investments and projects have particularly long-lasting impacts. While outsourcing engineering advice or hiring fixed-term contactors may fill short-term gaps, it cannot replace institutional knowledge and the long-term commitment needed for nation-building projects, which limits the capacity to drive continuity and a broader, systems-level view of infrastructure development.

However, it is apparent that where the use of procurement mechanisms has led to the assumption that external firms can deliver the needed expertise, then in-house technical expertise has been reduced. This reliance on private sector procurement reduces the incentives for government departments to identify and scope senior engineering roles, which, over time, diminishes the government's internal technical capability.

As fewer engineers remain in the public sector, its capacity to design and evaluate projects effectively, scrutinise costs and risks, and ensure the most efficient utilisation of taxpayer funds is eroded. This raises the risks of project failures, delays and cost overruns. The 2024 Strategic Review of the Infrastructure Investment Program identified $32.8 billion in cost pressures, including $14.2 billion arising from projects still in the planning phase. [49] The review noted many projects received government funding before sufficient planning, robust design, or accurate costing had been completed. This premature funding could potentially stem from a knowledge or expertise gap, as well as a reduction of in-house oversight. The lack of adequate internal technical expertise may contribute to inefficiencies, delays, and increased risks of failure, highlighting the importance of strengthening public sector engineering capacity to ensure more effective project management. In acknowledging the value of procurement services, the public sector must match their engagement with proportional hiring of engineers, to ensure such services can be leveraged in the most effective manner.

Impacts on technically sound policy and regulation

Much of contemporary policy-making is increasingly shaped by engineering-related issues, yet the reduced proportion of engineering professionals in government limits the development of informed policies and regulations. In a global context marked by complex technological implementation and interrelated systems challenges, governments need to have access to adequate technical expertise.

[49] Department of Infrastructure, Transport, Regional Development, Communications and the Arts. Independent Strategic Review of the Infrastructure Investment Program – Executive Summary. Australian Government, 2024, www.infrastructure.gov.au/sites/default/files/documents/independent-strategic-review-iip%E2%80%93executive-summary.pdf.

The expertise gap can undermine governance and planning at the systems level, particularly when addressing critical challenges such as the energy transition, supply chains, and national risk and resilience. With less in-house technical expertise, governments have diminished access to the necessary knowledge to inform policy, planning and regulation.

Benefits of Engineering Advice in Government

- By training, engineers apply a systems approach
- Engineers assess risks and safety, and have a practical eye for implementation
- Engineering expertise directly aligns with government responsibilities such as planning and project management
- Engineers work to improve quality and reliability
- Engineers are integral to testing, inspecting and detecting defects
- Technical understanding and subject matter expertise supports innovative policy solutions

The role of Chief Engineers

Governments worldwide recognise the importance of professional expertise by appointing Chief Officers in various fields, such as Chief Medical Officers, Chief Economists and Chief Scientists. Chief Engineer roles follow this model, ensuring engineering expertise informs government decisions.

Chief Engineers in governments can be responsible for providing system-level, strategic and technical advice to support sustainable, practical and informed policy, projects and decision making. An example includes the New South Wales Chief Scientist and Engineer, who provides independent advice on research support and industry development, to drive research commercialisation, and science and engineering outreach. [50]

[50] Office of the Chief Scientist and Engineer, New South Wales. Chief Scientist and Engineer, NSW. https://www.chiefscientist.nsw.gov.au/

"Governments own and operate a wide range of assets for the community, including schools, hospitals, roads, parks and urban spaces and rail to name a few. The Chief Engineer role, and the engineers delivering the projects, ensure that decisions made for the community are informed by sound engineering principles, delivering robust and fit for purpose infrastructure.

Engineers are a key profession when it comes to strategic planning for our cities. I think it is important, and valuable for governments, to have senior leaders in their executive team who have a technical/engineering background, who can influence and support good government decision making.

I would also say that engineers are trained problem solvers (irrespective of the issue) so they can be valuable contributors to any process. Engineers, with their STEM background, also provide diversity of thought and experience that complements other decision makers such as public policy experts."

ACT's former Chief Engineer Adrian Piani FIEAust CPEng EngExec NER on why it is important to have Chief Engineers working in the states and territories. [51]

[51] Engineers Australia. "The Role of Engineering in Government." Engineers Australia, 2023, www.engineersaustralia.org.au/news-and-media/2023/09/role-engineering-government.

5.0 Strengthening the engineering workforce

Many national challenges require engineered solutions, which means that bolstering Australia's engineering skills capability is critical. At Engineers Australia, we back today's problem-solvers so they can shape a better tomorrow.

By leveraging our member expertise and convening power, we partner with governments and industry to solve critical societal challenges for the benefit of the community. Engineers Australia advocates on important matters for engineers, the engineering profession and for all Australians.

The changes that will impact our economy in the next decade and beyond will rely extensively on engineering expertise to lead us to a **sustainable, innovative** and **skilled** future for Australia.

A sustainable future

with a decarbonised economy that has adopted the principles of a circular economy to reduce waste and maximise reuse of resources, mitigating the impacts of climate change and delivering sustainability and resilience across sectors including energy, transport and infrastructure.

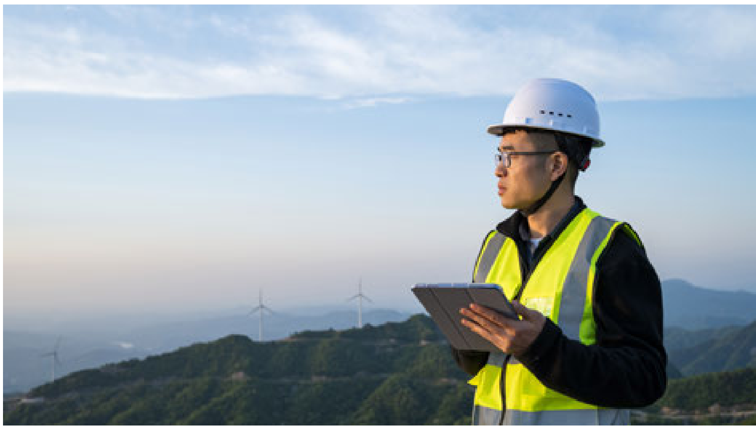
An innovative future

centred on:

- advanced manufacturing that is critical for industry growth and sovereign capability as well as enhancing national productivity;
- effective development and deployment of emerging technologies including the rapid adoption of AI, other digital innovation and biomedical technologies; and
- a thriving research and development ecosystem that supports the translation and commercialisation of new knowledge and discovery into innovative products and processes.

A skilled future

where a robust, highly skilled and competent, ethical, diverse and highly mobile engineering workforce pipeline fuels the strong engineering capability critical for national prosperity. Quality education, training and skills development is at the centre of improved productivity and increased innovation in industry and the public sector.



A Sustainable Future

Achieving a sustainable future will rely extensively on engineering expertise. A sustainable future envisions a decarbonised nation, where Australia's complex and interconnected energy systems and industries align with global efforts towards achieving net-zero emissions by 2050. To achieve ambitious net-zero targets, and to fully decarbonise our economy, significant changes are required across several key sectors, such as energy, transport and infrastructure. The growing challenges of climate change, alongside the increasing intensity of extreme weather events, will necessitate the strengthening of disaster resilience as well as considered resource use and sustainable management of water, biodiversity and other natural resources.

Delivering the energy transition

Engineers are essential to the development and deployment of clean energy technology and the optimisation of energy grids. However, persistent skills challenges and structural barriers to entry pose significant obstacles to our capacity to transition to clean energy, in addition to decarbonising our emissions-intensive sectors. Wage disparities and limited awareness of career opportunities may prevent the seamless transfer of skills to new industries and hinder a timely decarbonisation process.

Australia must also ensure that its energy market and regulatory bodies have effective engineering capabilities for technical power system design, operation and regulation to complement the existing capabilities in economic design. Engineering insights must be integrated into government decision-making frameworks to support sound analysis on the future of Australia's energy mix.

Energy is more than a component of the economy; it is fundamental to the prosperity and well-being of all Australians. The future of energy generation must be safe, reliable, affordable and clean. The energy market must be able to draw on a mix of proven available generation and distribution technologies, noting Australia's abundance of resources and strategic and geographical advantages.

The decarbonisation of our emissions-intensive energy sector stands as one of the most significant and complex engineering challenges of our time. According to the Australian Energy Market Operator's (AEMO) 2024 Integrated System Plan (ISP), addressing this challenge will require tripling grid-scale variable renewable energy by 2030 and increasing it six-fold by 2050, almost quadrupling firming capacity from non-coal sources, and supporting a four-fold increase in rooftop solar to 72 GW by 2050. [52]

At present, the Australian Government is attempting to deliver the energy transition in line with its 82 per cent renewable electricity by 2030 target.[53] Delivering this exponential increase in renewable energy generation—and fundamentally transforming the energy system within times set out—will require a significant expansion of the engineering workforce skilled in renewable technologies.

Preliminary modelling by Jobs and Skills Australia (JSA) suggests the clean energy workforce will need to grow by 58.49 per cent by 2050. [54]

Beyond scaling up renewable energy supply, managing a smarter, net-zero energy grid requires new skills to manage, maintain, and continuously develop infrastructure. Alongside technical expertise, engineers will need to develop specific capabilities in teamwork, digital literacy, and interpersonal skills to meet the demands of this evolving sector. [55]

[52] Australian Energy Market Operator, 2024 Integrated System Plan, June 2024, https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp

[53] Department of Climate Change, Energy, the Environment and Water. Capacity Investment Scheme. Australian Government, last updated 25 February 2025, www.dcceew.gov.au/energy/renewable/capacity-investment-scheme

[54] Department of Employment, Skills, Small and Family Business, The Clean Energy Generation, 2023, https://www.jobsandskills.gov.au/publications/the-clean-energy-generation

[55] Engineers Australia, Discussion Paper: Integrating DER into the Grid, March 2022, https://www.engineersaustralia.org.au/publications/discussion-paper-integrating-der-grid

Transferability of Engineering Skills for the Clean Energy Transition

Engineers are well-positioned to transition into the renewable energy sector due to their adaptability and transferable skill sets. Research by Engineers Australia, in partnership with Mott McDonald, examined the skills required for the energy transition and the barriers preventing engineers in the thermal sector (as the fossil fuel industry is phased out) from moving into clean energy opportunities. Through extensive interviews, workforce data, and consultations with employers, the study identified several key challenges: [56]

- A wage gap between clean energy roles and fossil fuel industries, with the latter offering higher wages due to remote locations of work and industry premiums.
- A lack of awareness regarding renewable energy careers as viable and impactful options, creating a significant barrier to entry.
- A growing skills shortage in the clean energy sector threatens to delay rollouts across the sustainable energy economy.
- Training pathways and coordination of policy drivers are needed.

Failing to address these challenges could create significant workforce issues in the energy transition. Retaining engineers in the sector and encouraging new talent to enter the clean energy workforce is crucial to achieving broader national objectives. The phase out of fossil fuels poses an imperative to ensure engineers and other such professions from the sector are supported to remain in work, and to ensure the existing skills base is not lost or underutilised.

Applying circular economy principles in engineering practice

A circular economy is an innovative process model that prioritises sustainable and efficient use of resources, making it highly relevant to the engineering profession. Unlike the traditional linear model of "take, make, dispose", the circular economy seeks to maintain the value of resources within the system for as long as possible.

According to modelling by the CSIRO, doubling Australia's circularity in line with Australia's Circular Economy Framework could add $26 billion in GDP each year by 2035.[57] The Framework outlines three ambitious targets to help achieve this goal:

1. Reducing the material footprint (i.e. the use of raw materials) by 10 per cent
2. Lifting materials productivity (i.e. how efficiently materials are used) by 30 per cent
3. Safely recovering 80 per cent of our resources from landfill

The engineering profession plays a critical role in designing out waste and pollution, preserving and enhancing material value and conserving natural resources and regenerating nature – the three guiding principles of a circular economy. Rethinking product design and optimising materials usage will

[56] Engineers Australia, Transferability of Engineering Skills for the Clean Energy Transition, September 2024, https://www.engineersaustralia.org.au/publications/transferability-engineering-skills-clean-energy-transition.

[57] Department of Climate Change, Energy, the Environment and Water. Australia's Circular Economy Framework. Australian Government, 2022, www.dcceew.gov.au/sites/default/files/documents/australias-circular-economy-framework.pdf. report.pdf

require upskilling and the development of updated training methods for engineers, to ensure the broader adoption of circular principles.

The established circular economy sector in Europe has proven to be a significant source of employment, with the number of people employed in the sector increasing by around 28.1 per cent from 2005 to 2021.[58] A survey conducted by the Australian Industry Group revealed that only 39 per cent of businesses felt their workforce possessed circular economy skills. Among the businesses that anticipated an increase in skills requirements, 48 per cent believed this would be in areas related to the circular economy.[59]

To meet the growing demand for these specialised skills, the Circular Economy Ministerial Advisory Group recommended in their final report that the government address skills gaps within the circular economy and invest in the development of a workforce with skills relevant to a circular economy.[60] The report stresses the need for comprehensive workforce planning, with a particular focus on upskilling and reskilling existing workers. Micro-credentials are cited as a flexible, scalable solution to help meet the sector's needs.

As the transition to a more circular economy accelerates, the demand for engineering professionals—particularly those equipped with relevant circular economy skills—will increase significantly.

Transforming transport and infrastructure

Australia's net-zero transition extends beyond transforming national energy infrastructure—it requires fundamental changes across industries, all of which will demand new skills and an expanded workforce to meet rising demands.

Transport is Australia's third-largest source of emissions (after electricity and stationary energy production), accounting for 20 per cent of national emissions, with over two-thirds coming from light vehicles.[61] This highlights the need for inclusive, efficient, and low-emissions transport solutions.

Decarbonising transport infrastructure presents unique challenges, given Australia's vast geography and reliance on emissions-intensive systems.

Challenges exist in broader infrastructure development, where expertise in carbon cost accounting, lifecycle assessment, material provenance, and material composition will be essential. Training professionals—such as project directors, engineers, development managers, and cost controllers—in these areas will be critical to ensuring infrastructure projects align with net-zero goals.[62]

[58] European Environment Agency. Employment in the Circular Economy. European Environment Agency, June 2024, https://www.eea.europa.eu/en/circularity/thematic-metrics/business/employment-in-the-circular-economy.

[59] Australian Industry Group. Skills for a Cleaner Future: Report January 2024. Australian Industry Group, Jan. 2024, https://www.aigroup.com.au/globalassets/news/reports/2024/skills_for_a_cleaner_future_report_jan_2024.pdf.

[60] Department of Climate Change, Energy, the Environment and Water. Circular Advantage: Final Report. 2024, https://www.dcceew.gov.au/sites/default/files/documents/circular-advantage-final-report-cemag.pdf.

[61] Engineers Australia, Submission to the Transport and Infrastructure Net-Zero Consultation Roadmap, July 2024, https://www.engineersaustralia.org.au/sites/default/files/2024-08/EA_Submission_Transport-and-Infrastructure-Net-Zero-Consultation-Roadmap.pdf.

[62] Engineers Australia, Reducing Infrastructure Embodied Emissions, November 2023, https://www.engineersaustralia.org.au/publications/reducing-infrastructure-embodied-emissions.

Building workforce capability for Australia's growing decommissioning industry

Decommissioning is a growing industry in Australia. Much of the offshore oil and gas infrastructure is approaching the end of its productive life and decommissioning is expected to take decades. Engineering expertise is essential in the decommissioning of emissions-intensive infrastructure, a $60 billion industry over the next 30-50 years.[63] The Centre of Decommissioning Australia (CODA) estimates there is around 5,695 kilotons of offshore infrastructure that will need to be removed, mainly steel and concrete but also other materials that have more complicated disposal and recycling pathways.[64] As much as possible, Australia should look to conduct these activities locally.

The task of decommissioning is another demand on workforce capability, particularly given the limited local experience to date. CODA and the Department of Industry, Science and Resources are working to identify the skills required and analysing the gaps in capability. CSIRO estimates show the decommissioning value chain could create more than 3,500 jobs.[65] Many of these workers could transition from the oil and gas industry and be needed by the offshore wind industry in the decades ahead. The scale of this opportunity not only underscores the financial potential of decarbonisation and decommissioning but also highlights the pressing need for workforce readiness. Currently, only two universities in Australia offer undergraduate petroleum engineering programs, and only one course specifically covers decommissioning.[66]

Improving climate-related disaster resilience

As the frequency and intensity of climate-related disasters escalate, it is vital Australia's engineering workforce is equipped to strengthen community resilience. Engineering expertise is integral to planning, preparedness, disaster management, and long-term recovery.[67] Engineering skills and workforce supply must extend to working collaboratively on endeavours to insulate communities from risk and to recover from disaster and extreme-weather events. This requires investment in specialist skills such as flood modelling, resilient infrastructure design, emergency response planning, and climate risk assessment to ensure engineers can effectively address these challenges.

For example, Engineers Australia members have played a key role in strengthening disaster resilience through its leadership in updating the Australian Rainfall and Runoff (ARR) guidelines.[68] First published in 1958, these guidelines are critical for flood estimation and infrastructure design across the country. Recognising the growing challenges posed by climate change, Engineers Australia, in partnership with the Australian Government Department of Climate Change, Energy, the Environment and Water, led a comprehensive update of the ARR guidelines. This revision incorporates the latest climate science, equipping engineers and decision-makers with improved tools to design infrastructure that is more resilient to increasing flood risks.

By integrating contemporary data and predictive models, the updated guidelines enable more accurate assessments of flood behaviour, enhancing communities' ability to prepare for and respond to extreme weather events.[69] However, the effective application of these guidelines relies on ensuring that engineers across sectors, particularly in local government, consulting, and construction, have access to the necessary training and expertise.

63 Yielded from Engineers Australia's Decommissioning consultations, statistic comes from Dr Francis Norman (CODA)

64 Department of Industry, Science and Resources. Understanding Australia's Decommissioning Value Chain. Australian Government, 2024, www.industry.gov.au/publications/australias-offshore-resources-decommissioning-roadmap/understanding-australias-decommissioning-value-chain

65 Australia's Offshore Resources Decommissioning Roadmap. Department of Industry, Science and Resources, Dec. 2024, www.industry.gov.au/sites/default/files/2024-12/australias-offshore-resources-decommissioning-roadmap.pdf.

66 Engineers Australia. Decommissioning Roadmap Submission, Oct. 2023, www.engineersaustralia.org.au/sites/default/files/2023-10/EA_Decom%20Roadmap_Submission_Oct2023.pdf. In time since the Submission, UNSW has started offering a decommissioning course.

67 Engineers Australia, Submission to the Inquiry into Australia's Disaster Resilience, December 2023, https://www.engineersaustralia.org.au/publications/submission-inquiry-australias-disaster-resilience.

68 Ball, J., et al. "Climate Change Chapter Update (2022), Chapter 6, Book 1." Australian Rainfall and Runoff: A Guide to Flood Estimation, edited by J. Ball, M. Babister, R. Nathan, W. Weeks, E. Weinmann, M. Retallick, and I. Testoni, Version 4.2, Geoscience Australia, 2019.

69 Foster, L. "New Rainfall Guidelines Go Step Further in Tackling a Changing Climate." Create Digital, 8 Aug. 2023, www.createdigital.org.au/rainfall-guidelines-tackling-changing-climate/.

Engineering water security

Engineering expertise plays a pivotal role in advancing sustainable water outcomes across Australia through the implementation of integrated water management strategies. By adopting a holistic 'OneWater' approach, engineering professionals consider all water sources—surface water, groundwater, stormwater, and recycled water—as a unified resource. This methodology ensures the sustainable use of water resources to meet diverse needs, including potable supply, agriculture, industry, environmental preservation, recreation, tourism, and cultural practices.[70] Such comprehensive management enhances water security, supports public health, and bolsters environmental and urban amenities. To achieve these outcomes, Australia must secure and develop engineering expertise in water-sensitive urban design, large-scale water infrastructure planning, hydrological modelling, and climate adaptation strategies.

Furthermore, the engineering profession is instrumental in developing water infrastructure that is resilient to climate change, thereby safeguarding communities against future challenges.[71] However, the increasing frequency of extreme weather events, coupled with population growth and rising demand for water resources, underscores the need to strengthen engineering capability in areas such as desalination, wastewater treatment, and circular water management.

In the context of Australia's transition to green hydrogen, engineers are addressing the significant water demands of hydrogen production. By integrating water source considerations into hydrogen strategies, they ensure that the burgeoning hydrogen industry develops sustainably without compromising water resources.[72] This requires expertise in water allocation planning, technological innovation in water efficiency, and collaboration between engineers, policymakers, and industry to balance competing water needs.

Through these multifaceted efforts, the engineering profession is essential in steering Australia toward a future where water resources are managed sustainably, supporting both societal needs and environmental integrity.

[70] Engineers Australia, submission to the National Water Agreement: Principles Consultation, September 2024, https://www.engineersaustralia.org.au/sites/default/files/2024-09/national-water-agreement-submission-principles-consultation-sep-2024.pdf

[71] Engineers Australia, submission to the National Water Reform Inquiry, February 2024, https://www.engineersaustralia.org.au/sites/default/files/2024-02/National-Water-Reform-EA-20240202.pdf.

[72] Costello S. & Simpson, M. Exploring the Water-Energy Nexus through Hydrogen: An Early Careers Perspective, October 2024 https://www.engineersaustralia.org.au/sites/default/files/2025-01/Water-Energy-Nexus-through-Hydrogen.pdf.

An Innovative Future

The engineering team are the architects of progress, driving innovation and shaping the systems, products, and services that propel industries forward. Through fostering efficiency, embracing new technologies, and solving complex challenges, the engineering profession is central to advancing sectors and enhancing national productivity. As Australia looks to develop sovereign capabilities—particularly through initiatives like the Future Made in Australia agenda—the nation finds itself at a pivotal moment.

Manufacturing

Globally, nations are recalibrating their manufacturing strategies in response to supply chain disruptions from the COVID-19 pandemic and ongoing geopolitical shifts. For Australia, adopting advanced manufacturing technologies presents a significant opportunity to rebuild a competitive sector while focusing on high-value and niche products.

Transitioning to advanced manufacturing processes will require overcoming substantial structural challenges, including the aftermath of decades of offshoring and the stagnation of multifactor productivity in the manufacturing industry up to 2023.[73] Moreover, existing infrastructure is often ill-equipped to accommodate the technologies required to meet the ambitions of the Future Made in Australia agenda.

The revitalisation of domestic manufacturing will need significant investment in technology, infrastructure, and workforce development. A critical component of this transition is the reskilling of the existing workforce to bridge the gap between current capabilities and the requirements of Industry 4.0 technologies. The 2024–25 Federal Budget's allocation of $22.7 billion over the next decade to stimulate private sector manufacturing investment marks a crucial step in this process.[74]

However, these investments must be paired with comprehensive efforts to reskill workers and address shortages in essential professions, particularly engineering. At present, the Future Made in Australia agenda lacks detailed initiatives and dedicated funding to establish a strong skills foundation in advanced manufacturing, which is vital to its long-term success.

Manufacturing workforce

Projections for manufacturing employment suggest only a modest recovery, from 909,100 workers in 2024 to 959,300 by 2034, with the industry's share of total employment declining from 6.3 per cent to 5.9 per cent.[75] These figures highlight a growing disconnect between Australia's ambitions to revitalise manufacturing and the current trajectory of the sector. Recruitment challenges are further exacerbating this concern, with 92 to 95 per cent of manufacturing employers reporting difficulties in finding workers with the necessary skills to support current activity levels, let alone the growth required to meet government targets.[76]

[73] Engineers Australia, The Engineering Labour Market Overview, June 2024, (https://www.engineersaustralia.org.au/sites/default/files/2024-09/The-Engineering-Labour-Market-Overview-August-24.pdf.

[74] Department of Employment, Skills, Small and Family Business, Towards a National Jobs and Skills Roadmap, October 2024, https://www.jobsandskills.gov.au/publications/towards-national-jobs-and-skills-roadmap.

[75] Department of Employment, Skills, Small and Family Business, Employment Projections (https://www.jobsandskills.gov.au/data/employment-projections), accessed January 11, 2025.

[76] Engineers Australia, Engineering Profession Statistical Overview, 15th Edition, November 2023, https://www.engineersaustralia.org.au/publications/engineering-profession-statistical-overview-15th-edition.

Growing sovereign capability

The Future Made in Australia legislation presents significant opportunities to advance Australia's national interests, particularly through its 'Economic Security and Resilience Stream.' This stream focuses on strengthening supply chain resilience, which is vital for Australia as a middle power in the Asia-Pacific, where resilience is shaped by regional shifts and global dynamics.

Improving responsiveness to these shifts and dynamics requires an economy capable of producing crucial resources independently of exogenous shocks and global disruptions. Engineers play a key role in ensuring this sovereign capability by designing and developing the infrastructure, technologies, and systems that enable Australia to operate independently in critical sectors. By fostering sovereign industries and developing the necessary skills, Australia can better progress national economic and strategic priorities, ensuring preparedness for both foreseeable and unforeseen challenges in an increasingly contested world. Any investment into economic security and resilience will require parallel consideration of the skills required to develop and maintain these sectors, which in some cases will need to be built from the ground up.

Growing industries

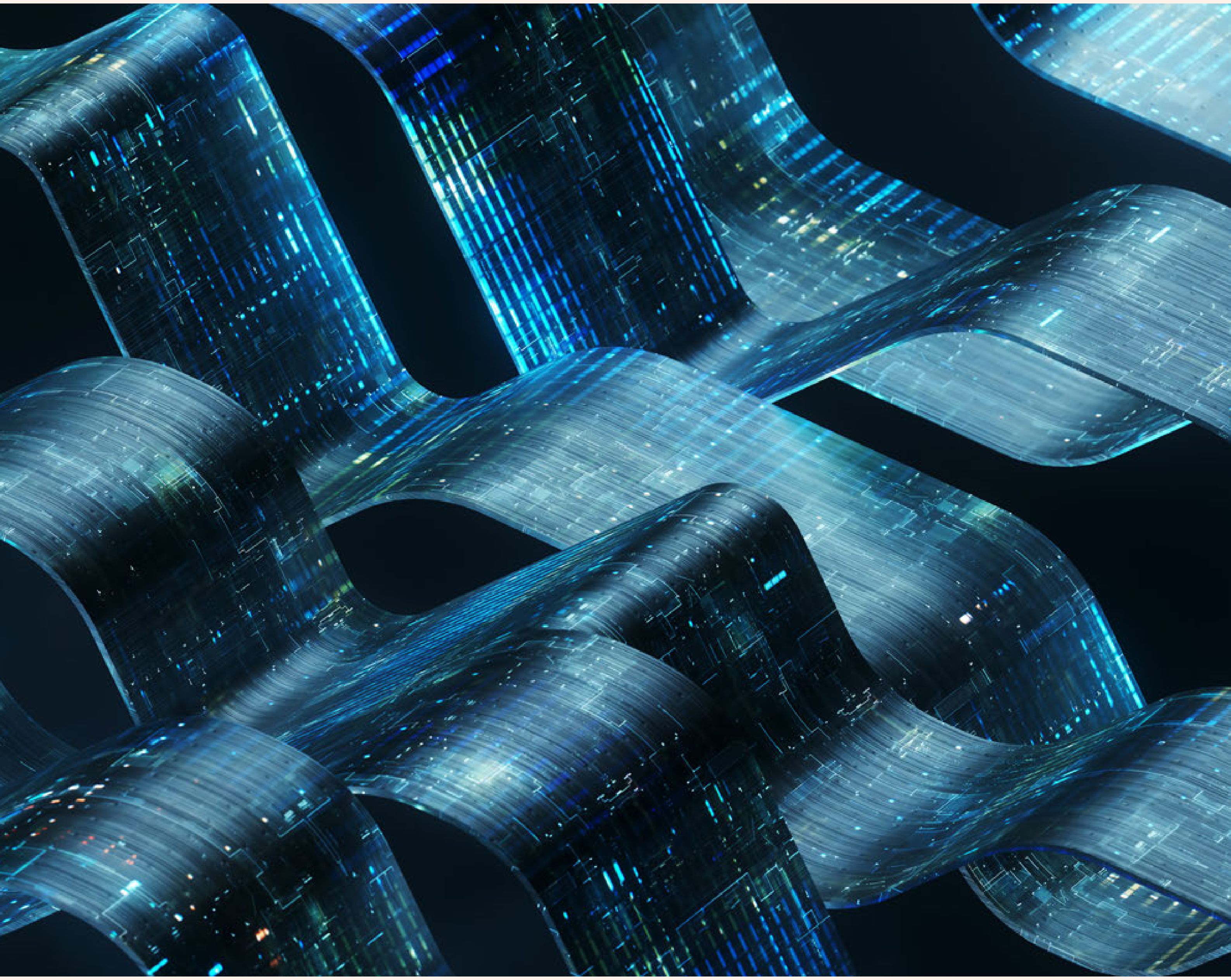
The engineering profession is central to the development of sovereign capability in several defence-adjacent sectors, where engineering expertise is pivotal to advancing national interests. Engineering expertise assists in the creation and maintenance of essential technologies and infrastructure required to support Australia's strategic interests and deliver on critical Defence strategies such as the National Defence Strategy, Defence Industry Development Strategy, and Digital Engineering Strategy.

The nascent domestic space industry is heavily reliant on engineering skills. Engineers Australia's National Committee for Space Engineering has highlighted the growing uptake of space-related activities in Australia, signalling the urgent need for investment in skills development and local industry growth.[78] However, Australia must address the absence of a robust "pyramid of supply" that exists in more established space sectors such as the US and the UK. These countries benefit from well-established supply chains that underpin the space sector, providing critical infrastructure and human capital that Australia needs to build from the ground up. Investment in both local industry growth and workforce development is therefore essential to establish a competitive and sustainable space sector in Australia.

Commitments under the AUKUS agreement requires Australia to develop a highly skilled workforce for constructing, operating, and maintaining conventionally-armed, nuclear-powered submarines. This is a monumental task and, with Australia's limited experience in this highly specialised field, it is clear an influx of skilled engineers will be essential.

[78] Engineers Australia. Space Policy Advice Paper. Engineers Australia, Feb. 2024, http://www.engineersaustralia.org.au/sites/default/files/2024-02/Space-Policy-Advice-Paper.pdf

Digital and data sovereignty are crucial to Australia's prosperity. Positioned strategically in the Asia-Pacific region, Australia is an attractive destination for foreign investment, boasting world-class digital infrastructure that ranks highly on the global stage.[79] As digital technology evolves, the demand for physical infrastructure—particularly data centres—will increase to support the growing digital economy and technologies such as e-commerce, AI (Industry 4.0), and cloud computing. Australians also require reliable access to internet and mobile services for personal use. Government initiatives like the Universal Service Obligation will further drive the need for expanded infrastructure. As demand for advanced digital technologies rises, developing and maintaining this infrastructure will require specialised engineering skills. In addition to traditional engineering expertise, professionals will need to stay ahead of emerging technologies and develop innovative solutions to meet the growing infrastructure demands.



[79] Australian Trade and Investment Commission (Austrade). Why Australia – Digital Technology. Commonwealth of Australia, 2023, www.international.austrade.gov.au/content/dam/austrade-assets/international/documents/reports/why_australia_digital_technology_2023.pdf.

Nascent technology and AI

An integral part of progressing Australia's vision for an innovative future is being adequately prepared for the effective deployment of emerging technologies. The rapid adoption of AI, generative AI (GenAI), and other digital innovation technologies is transforming industries and workplaces, demanding a workforce capable of leveraging these tools while managing their risk. Engineers Australia affirms that, as key developers and deployers of such technologies, engineers must be equipped with the skills and knowledge to be able to navigate this evolving landscape. [80]

The Impact of AI and Generative Technologies on the Engineering Profession [81]

The potential of AI to drive productivity is undeniable. In 2024 Engineers Australia commissioned Ergo Strategy to engage in research investigating the impact of Generative AI on the Engineering Profession. The proliferation of accessible GenAI programs presents a significant opportunity to enhance productivity, much like in other sectors. Through this research, Engineers Australia aimed to understand how engineers' work has already been altered by GenAI, their trust in the technology, their ability to fully utilise it, demographic factors influencing comfort with the tools, and access to training.

The findings revealed that 72 per cent of members agreed that GenAI would significantly boost productivity in the engineering sector, with 77 per cent viewing it as a professional tool, similar to the calculator. However, 90 per cent of engineers acknowledged the inherent risks of GenAI, and 82 per cent believed it would always require oversight. Alarmingly, 78 per cent of engineers reported that their learning was mostly self-driven, rather than formal education, and 66 per cent indicated they had received no workplace training on GenAI.

The research highlighted the critical role of businesses and employers in fostering a culture of openness and in ensuring engineers are empowered to use productivity-enhancing technologies effectively and appropriately.

Ethics training should be integrated into engineering education and professional development. Engineers need to possess technical expertise and have the ability to anticipate and address potential societal harms associated with emerging technologies. The global conversation about AI ethics, as seen in the European Union's AI Act and OECD AI principles,[82] highlights the need for Australia to align with international standards and contribute to global AI governance.

The lack of structured upskilling as identified through the Engineers Australia report exposes engineers to risks such as cybersecurity threats, inaccurate outputs, and data leaks—risks already demonstrated in real-world cases like biased AI in hiring and cybersecurity breaches. Without proper training, engineers may struggle to fully leverage AI's potential while mitigating these risks.

[80] Bell, M. (2025). The impact of AI and generative technologies on the engineering profession. Engineers Australia. Retrieved from https://www.engineersaustralia.org.au/sites/default/files/2025-01/impact-ai-generative-technologies-engineering-profession_0.pdf

[81] Ibid

[82] OECD. OECD Principles on Artificial Intelligence, Organisation for Economic Co-operation and Development, 2019, oecd.ai/en/ai-principles. & European Commission. Regulatory Framework for AI, Digital Strategy, European Commission, 2024, digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai#

Australia must urgently invest in upskilling and reskilling initiatives that go beyond basic AI literacy. Engineers need the skills to safely deploy AI and GenAI technologies, as well as the ethical foundation to make responsible decisions. Engineers Australia's call for mandatory AI guardrails highlights the importance of developing strong regulatory frameworks to ensure AI is used safely, prioritising public safety and societal benefit.

This investment in skills extends to other emerging technologies like IoT, blockchain, and quantum computing. Engineers must be prepared to design secure systems, with education addressing these areas. As digital technologies advance, the risks grow, requiring proactive workforce preparation and regulatory agility. Quantum computing, for example, will revolutionise industries but will also present new cybersecurity challenges.

A Skilled Future

The shape and face of the engineering profession are constantly evolving. Key drivers involve access to novel and big data, automation, the race to decarbonise the global economy, circular economy uptake, the Internet of Things, and increasing globalisation.

To remain globally competitive, Australia must address the existing skills challenges and build a sustainable pipeline of engineering skills. Our engineering workforce needs to be inclusive, accessible, and future-ready. An engineering workforce fit for the future requires an increase in the number of students choosing to study and practice engineering in Australia as well as equipping existing engineers to be able to meet rapidly evolving workforce and community needs.

The Engineering Labour Market Overview by Engineers Australia highlights the increased demand for engineering skills to solve these challenges:

"The scale of activity required to undertake the clean energy transition and decarbonise the economy by 2050, as well as the infrastructure and construction demand from an increasing population, and the new investment under the Australian Government's Future Made in Australia agenda, is likely to see strong demand for engineers in the longer term." [82]

Long-term demand for engineering expertise is unlikely to be met in a system already struggling to meet existing skills needs. Several demand-side and supply-side factors that currently impact Australia's engineering workforce must be addressed if we are to meet our future workforce needs.

Labour demand factors

Several demand-side trends are impacting the engineering workforce – some of which impact the labour market as a whole, and others that are unique to the engineering profession.

The COVID-19 pandemic retains a residual impact on current engineering skills challenges, due to the surge in infrastructure demand in its aftermath, and the decline in employment faced throughout it. Border closures during the pandemic further limited skilled migration exacerbating these challenges.[83]

The rising cost of living has similarly impacted the engineering workforce. Engineering students, pressured by high living costs and the demands of their qualification, often cannot commit to full-time study, resulting in lower graduate completion rates.[84]

The challenge of regional development and access to engineering expertise is another trend affecting the sector. With the majority of engineering roles in metropolitan areas, particularly Sydney and Melbourne, there is reduced opportunity for infrastructure development essential to productivity growth to be developed across regional communities.[85] Engineers are essential to regional Australia for building and maintaining roads, rail, and energy networks, driving renewable energy projects, and supporting industries transitioning from traditional sectors to advanced manufacturing and clean energy. They play a key role in designing resilient infrastructure to withstand extreme weather events, improving water security for agriculture,

[82] Engineers Australia, The Engineering Labour Market Overview, June 2024, https://www.engineersaustralia.org.au/sites/default/files/2024-09/The-Engineering-Labour-Market-Overview-August-24.pdf

[83] Engineers Australia. Submission to the Australian Universities Accord. Engineers Australia, 2023, www.engineersaustralia.org.au/publications/submission-australian-universities-accord.

[84] Ibid.

[85] Engineers Australia. Enhancing Australia's Migration Program. Engineers Australia, Dec. 2022, www.engineersaustralia.org.au/sites/default/files/2022-12/enhancing-australias-migration-program.pdf. & Engineers Australia. Regional Development: Global Sydney Submission June 2017. Engineers Australia, June 2017, www.engineersaustralia.org.au/sites/default/files/2022-06/regional-development-global-sydney-submission-june-2017.pdf.

and ensuring sustainable regional development. Without sufficient engineering capacity, regional areas risk falling behind in infrastructure investment, economic diversification, and sustainability efforts, limiting their ability to attract businesses, workers, and long-term residents.

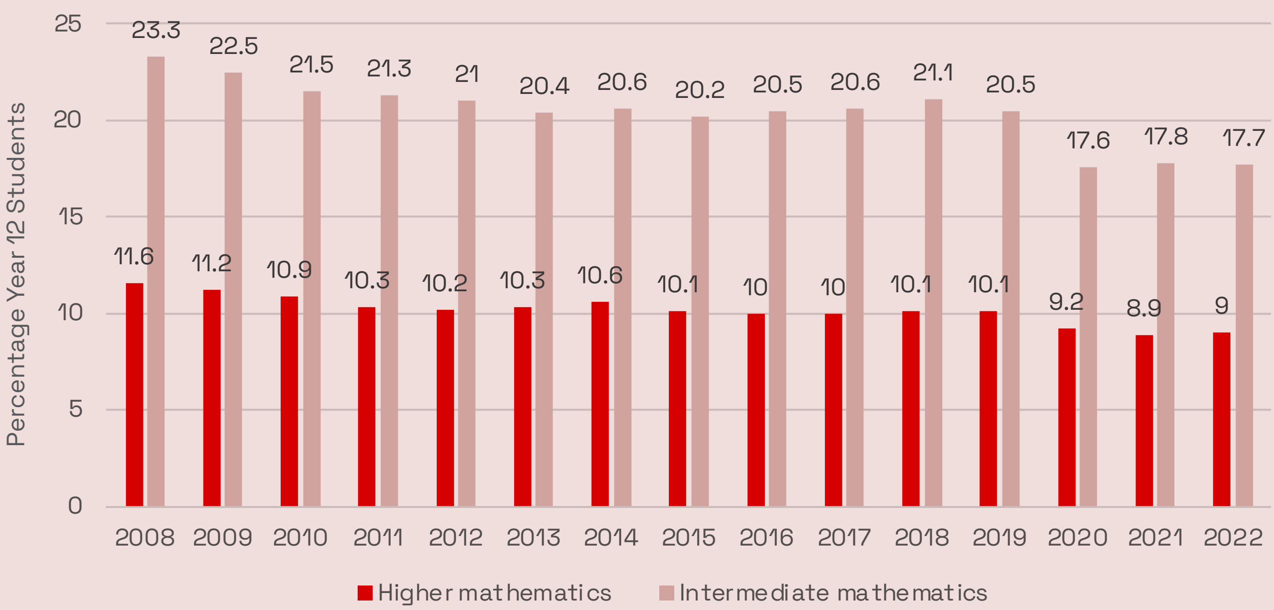
Labour supply challenges

Insufficient supply of new engineers: the domestic engineering talent pipeline is at risk

Challenges arise early in the STEM talent pipeline, as students often develop narrow perceptions of engineering, viewing it as overly focused on mathematics or less interesting compared to other career paths. Research suggests improving understanding of engineering as a viable career option is essential to better support students' entry into the pipeline.[86]

Research from the Australian Mathematical Sciences Institute (AMSI) reveals nearly 40 per cent of Australian maths teachers lack formal maths qualifications, undermining student confidence and leading to poorer outcomes.[87] The Program for International Student Assessment (PISA) shows a decline in mathematical literacy since 2003, with performance dropping further between 2012 and 2022.[88] This decline results in a growing number of students leaving primary school without foundational maths skills, limiting their ability to pursue secondary-level maths and eventually engineering careers. AMSI data also highlights Year 12 participation in higher-level maths is at an all-time low.

Chart 2: Proportion of high school students studying mathematics in Australia (Source: AMSI, 2022)[89]



[86] Engineers Australia & Student Edge. Decoding the Career Path of Young People – Key Outcomes. July 2024

[87] Marchant, Tim, and Sophie Kennedy. The State of Mathematical Sciences 2024: 8th Discipline Profile of Mathematics and Statistics in Australia. Australian Mathematical Sciences Institute, 2024, amsi.org.au/?publications=the-state-of-mathematical-sciences-2024-8th-discipline-profile-of-mathematics-and-statistics-in-australia.

[88] OECD, PISA 2022 Results (Volume I and II): Country Notes – Australia, Dec. 2023, https://www.oecd.org/en/publications/pisa-2022-results-volume-i-and-ii-country-notes_ed6fbcc5-en/australia_e9346d47-en.html.

[89] AMSI. Year 12 Mathematics Participation Report Card: Mathematics Enrolments Remain at All-Time Lows April 2024. https://amsi.org.au/?publications=year-12-mathematics-participation-report-card-mathematics-enrolments-remain-at-all-time-lows#:~:text=Since%202020%20the%20numbers%20and,in%20intermediate%20mathematics%2C17.7%25.

This trend in maths education is linked to the reduced supply of domestic engineering graduates. Domestic engineering commencements have declined since 2014, increasing reliance on imported skills. In 2018, the total number of graduations of international students overtook those of domestic students.[90] Retention and completions also have room for improvement. Only 25 per cent of engineering students complete their degree in the minimum four-year time frame and just 50-65 per cent of students who start engineering degrees graduate.[91]

The decline is similar in graduate and post-graduate studies, with ACED statistics showing a 22 per cent drop in domestic students completing doctorates and a 35 per cent decrease in those completing research or master's degrees.[92] The COVID-19 pandemic exacerbated this trend, with commencements for both degree types remaining 40 per cent below the 2015 peak.

Inefficient allocation of existing engineers: migrant engineers are not employed in engineering roles

A report by Settlement Services International Limited claimed Australia can unlock $9 billion annually, economy wide, by fully utilising the skills potential of already settled permanent migrants.[93] Research by Engineers Australia found some 47 per cent of migrant engineers actively seeking a job in the sector were currently unemployed.[94] Many engineers born overseas continue to be employed in industries where their skills are not being utilised, and the over indexation of qualified engineers in non-engineering professions suggests sub-optimal employment outcomes for this cohort.[95]

Consultations as part of the research found this cohort was susceptible to structural barriers that prevented them from obtaining gainful employment in the engineering sector, with many respondents indicating their lack of local experience was a significant barrier to obtaining any experience, and a large amount feeling their international experience was not valued. On the employer side, Engineers Australia found a lack of awareness regarding the availability of migrant engineers as a talent pool capable of resolving immediate skills supply issues, due to misperceptions of employer accessibility.[96]

The underutilisation of migrant engineers is noted across the sector, with the 2024 Infrastructure Market Capacity Report acknowledging the challenge, and some attempted resolutions to address this problem through government funded programs.[97] This includes a revised approach that prioritises the skills and experience needed in Australia, rather than relying solely on the Occupation Standard Classification for Australia (OSCA, formerly ANZSCO) occupation list. Furthermore, it is noted Australia should maintain a migration program that is adaptable to the evolving needs of the Australian context. Currently, the skills listed on the migration assessment are too rigidly tied to the OSCA occupations list, limiting the ability to respond to emerging skill demands.[98]

[90] ACED, Engineering Statistics April 2022, http://www.aced.edu.au/downloads/ACED%20Engineering%20Statistics%20April%202022.pdf

[91] Engineers Australia, Engineering Profession Statistical Overview, 15th Edition, November 2023, https://www.engineersaustralia.org.au/publications/engineering-profession-statistical-overview-15th-edition.

[92] ACED, Engineering Statistics April 2022, http://www.aced.edu.au/downloads/ACED%20Engineering%20Statistics%20April%202022.pdf.

[93] Settlement Services International Limited, Skills Mismatch Report, June 19, 2024, https://www.ssi.org.au/wp-content/uploads/2024/06/DAE_SSI_Skills_Mismatch_Report_19062024_WEB.pdf.

[94] Barriers to Migrant Employment. Engineers Australia, 2021, https://www.engineersaustralia.org.au/Barriers-to-Migrant-Employment.

[95] Engineers Australia, Engineering Profession Statistical Overview, 15th Edition, November 2023, https://www.engineersaustralia.org.au/publications/engineering-profession-statistical-overview-15th-edition.

[96] Barriers to Migrant Employment. Engineers Australia, October 2021, https://www.engineersaustralia.org.au/Barriers-to-Migrant-Employment.

[97] Infrastructure Australia 2024 Infrastructure Market Capacity Report, December 2024, https://www.infrastructureaustralia.gov.au/reports/2024-infrastructure-market-capacity-report.

[98] Engineers Australia. Review of the Points Test Submission, May 2024, https://www.engineersaustralia.org.au/sites/default/files/2024-05/Engineers-Australia-submission-Migration-Review-of-the-points-test-%28Cth-May-2024%29.pdf.

Underutilised talent: The current workforce does not reflect the diverse communities it serves

As of 2021, women accounted for just 16 per cent of Australia's engineering workforce, with Australian-born women making up only 4.1 per cent. Engineering has the lowest female representation across all STEM professions, with structural barriers preventing greater participation.

Research by Engineers Australia highlights key factors constraining female participation, spanning the entire engineering pipeline. According to AMSI, in 2020 37.8 per cent of students undertaking higher mathematics were female, the gender balance is more even at the intermediate level.[99] Many women and young girls avoid engineering due to a lack of awareness and familiarity with the profession, coupled with negative perceptions, such as its male-dominated image and the belief that it is not fulfilling or impactful.[100] These issues are compounded by poor STEM engagement in schools, with many young women reporting insufficient support during their STEM education. Although university experiences are generally positive, many female engineering students feel less supported compared to peers in other disciplines.

The challenges continue into the workplace, where only 55 per cent of women in engineering report equal opportunities to men, and nearly one in five women report gender-related bullying or exclusion. These factors contribute significantly to the high attrition rates of women in the engineering workforce.

Similarly, Aboriginal and Torres Strait Islander peoples are underrepresented in Australia's STEM workforce. While they make up 3.8 per cent of the population, they represent only 0.3 per cent of the engineering workforce.[101] This disparity underscores the need to promote greater First Nations participation in engineering to ensure the profession reflects the diversity of the communities it serves.

Impediments to workforce mobility across jurisdictions: a lack of nationally consistent registration for professional engineers

Comprehensive statutory registration for engineers in all Australian states and territories has long been touted as a method of raising professional standards amongst engineers. In the absence of regulation for engineering, anyone could purport to be an engineer and provide engineering services without appropriate qualifications, experience, or competencies and with disregard to professional standards and ethical conduct. Until recently, Queensland was the only state with such laws.

Australia is a federation where the states and territories have responsibility for certain areas of government, including the registration of professions. This means that the registration of engineers in Australia is unlikely to ever be governed by a single piece of legislation, enacted by the Commonwealth Government. However, a "federal" system, whereby registration is managed on a state-by-state basis, but with close alignment of standards and application of the Mutual Recognition Act 1992, is achievable.

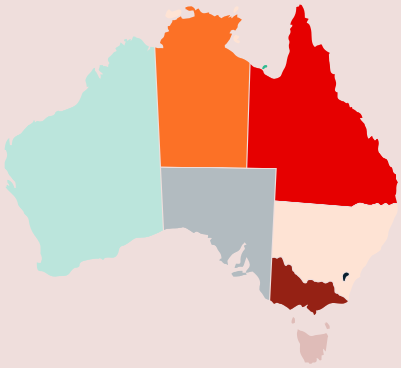
[98] Engineers Australia, Engineering Profession Statistical Overview, 15th Edition, November 2023, https://www.engineersaustralia.org.au/publications/engineering-profession-statistical-overview-15th-edition.

[99] Australian Mathematical Sciences Institute, Year 12 Participation in Higher-Level Mathematics: 2022 Report, April 2022, https://amsi.org.au/wp-content/uploads/2022/04/year-12-participation-2022.pdf.

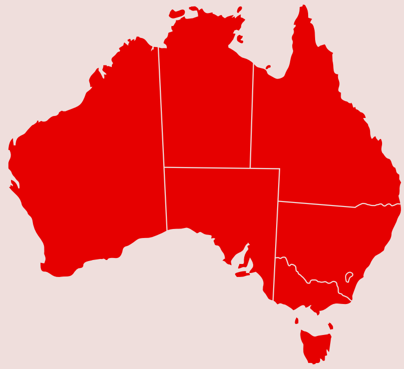
[100] Romanis, J. Women in Engineering. Engineers Australia. June 2022, https://www.engineersaustralia.org.au/publications/women-engineering

[101] Engineers Australia, Engineering Profession Statistical Overview, 15th Edition, November 2023, https://www.engineersaustralia.org.au/publications/engineering-profession-statistical-overview-15th-edition.

National Registration



State registration



Nationally consistent registration

Nationally consistent registration enables effective mutual recognition and reduces regulatory burden for engineers and industry that work across state (and international) borders.

Engineers Australia advocates for nationally consistent engineering registration schemes, meaning that each jurisdiction's engineers registration scheme is consistent with the other schemes across the country. Having nationally consistent schemes should allow for a model (facilitated by Mutual Recognition) of 'register once, practice anywhere', similar to the operation of driver licences. Having consistent schemes stands to deliver over $54 million in savings for businesses with registered professional engineers that work across state borders[102]. By comparison, without nationally consistent registration schemes:

- Individual engineers, particularly those that provide services in more than one jurisdiction, need to maintain records and keep track of their registration in the various jurisdictions. These can vary in cost, area of engineering they will be registered under, period of registration, CPD requirements and legal obligations. This increases administrative burden and hampers productivity.
- Engineering firms and other businesses delivering or receiving engineering services, see increases in administrative costs. Many companies cover the cost of registering their employees to do their work. For companies which work across jurisdictions, this would mean paying fees for their employees in each jurisdiction. Variations in legal obligations also increase administrative burdens on businesses possibly forcing them to pull out of jurisdictions.
- Regulators, would struggle to trust the assessment of engineers from other jurisdictions, this hampers mobility and force engineers to get registered in every state they wish to practice in.

[102] Consult Australia, Federal Pre-Budget Submission 2025-26, January 2025, https://www.consultaustralia.com.au/docs/default-source/submissions/consult-australia's-federal-pre-budget-submission-2025-26.pdf?sfvrsn=ecd06ecd_0

6.0 Solutions

Engineering is the essential link between thinking and doing, between ideas and implementation. Engineers Australia calls on the Australian Government to adopt the following four solutions to strengthen the national engineering workforce. A skilled workforce fuelling a strong engineering capability is critical for Australia's prosperity.

Solution 1 Engineering Surge

The Australian Government should secure Australia's future through a boost to our national engineering capability. A national engineering surge could be informed by engaging Engineers Australia to deliver a rapid-response report with five key actions to dismantle existing obstacles and strengthen the engineering pipeline from school through to skilled migration.

An urgent, concentrated effort to grow, strengthen and secure our national engineering capability is essential for Australia's future. Engineering is crucial for driving economic growth, infrastructure development, and advancing sectors like renewable energy and advanced manufacturing.

The Australian Government should commission Engineers Australia to develop a rapid-response report to zero in on critical, targeted action to dismantle barriers and strengthen the engineering pipeline from schooling through to skilled migration. Rapid-response reports are effective because they provide timely, evidence-based insights that allow for swift decision-making and immediate action. Engineers Australia, with its extensive expertise, national reach and industry convening power, is uniquely positioned to provide this advice, having a deep understanding of sector needs and challenges.

The report would focus on the top five practical actions for efficient, low-cost and high-impact change – avoiding a long 'to-do' list. Based on existing research and validated by industry and other engineering advocates, the actions would focus on disrupting enduring engineering workforce challenges such as skill shortages, underutilisation of skills, impediments to mobility across jurisdictions, and declining STEM access and capability in the future pipeline that risk hindering progress.

Engineers Australia's ability to collaborate with industry partners ensures the recommendations are practical, aligned with real-world needs, and can be swiftly implemented. By engaging stakeholders across the sector, including businesses, educational institutions, and government agencies, we can work together to address immediate workforce gaps and ensure the long-term sustainability of Australia's engineering talent pool.

This initiative will enhance the engineering workforce, tap into talent, support emerging industries, and secure the skilled professionals needed to drive Australia's long-term prosperity.

Solution 2 Graduate Target

The Australian Government should set a target for 60,000 additional engineering graduates over the next decade. Setting a target would catalyse universities, industry and governments to collaborate on strengthening this essential professional pipeline.

The demands of a sustainable and innovative future necessitate the development of new skills within the engineering workforce, along with new approaches to tackling contemporary challenges. To facilitate this shift and ensure the future supply of talent, Engineers Australia urges the Australian Government to set a national target of 60,000 additional engineering graduates by 2035 - over and above the number we can reasonably anticipate graduating based on current trends.

In the same way that the current government has set targets for tertiary attainment[103], and for the tech sector workforce[104], setting an engineering graduate target will signal the national priority to strengthen Australia's engineering skills pipeline and ensure we have the domestic workforce necessary to achieve our long-term objectives. This communicates and promotes to students, their parents, careers advisors, career-changers, industry and education providers the value of engineers and engineering, encouraging pathways into engineering careers.

The engineering talent pipeline in Australia is affected by attrition at key stages and heavily relies on international students to maintain tertiary participation, and skilled migration to meet industry workforce demand. Migrant engineers make a strong, positive contribution to Australia's engineering workforce and bring with them global expertise and experience. However, Australia faces growing competition from other advanced economies for engineering talent, as global demand for engineering skills rises with the approaching peak population and all countries seek to retain their own homegrown STEM talent. Growing the future pipeline of domestic graduates is therefore essential to build longer-term self-sufficiency and to reduce dependence on external sources in an increasingly competitive contest for global talent.

While increasing commencements of undergraduate engineering students to meet this target will be important, so too will be increasing the retention and completion rates of students already in the pipeline – as well as supporting more timely completions to facilitate ready graduates into industry and professional practice. Enabling more supportive pathways to completion of Masters-level engineering qualifications, and innovative VET/higher education pathways, will also support additional graduates into the pipeline.

Thus, the target is not about finding an additional 60,000 school leavers to take up engineering; it aims to address critical barriers in the STEM talent pipeline, which can only be achieved through fostering collaboration between universities, industry, and governments to drive efforts to enhance engineering education and align it with workforce needs. For example, extending financial support like the Commonwealth Practical Payments to engineering students to help them to undertake industry work placements during their studies will help to retain students who suffer from financial hardship while attempting to complete their degree.

Why 60,000 over the next decade? On average, Australia sees just over 11,000 domestic higher education completions in engineering and related technologies each year.[105] Engineers Australia has analysed and triangulated relevant data to estimate the additional needed capacity, taking into account expected population and economic growth, and trends in qualified engineers who do not work in engineering. For example, we know that with an ageing workforce, up to 70,000 engineers are predicted

[103] Australian Government, Department of Education. Australian Universities Accord 2024-25 Budget Summary. 2024, http://www.education.gov.au/download/18195/australian-universities-accord-2024-25-budget-summary/37352/document/pdf#:~:text=The%20Government%20is%20setting%20the,working%20aged%20people%20by%202050

[104] Husic, Ed. "Mapping Out Australia's Path to Tech Jobs of the Future." Minister for Industry and Science, 26 Mar. 2025, http://www.minister.industry.gov.au/ministers/husic/media-releases/mapping-out-australias-path-tech-jobs-future

[105] ACED Engineering Statistics April 2022. Australian Council of Engineering Deans, Apr. 2022, http://www.aced.edu.au/downloads/ACED%20Engineering%20Statistics%20April%202022.pdf

to retire over the next 15 years; at current rates more than 60 per cent of domestic graduations would need to enter the workforce just to replace these departing engineers. However, as cited earlier in this report, various predictions anticipate growth in demand for engineers and other STEM professionals right across the economy, including in clean energy and infrastructure. Research by the Australian Council of Engineering Deans in 2021 showed that a 10 per cent per annum (compounding) increase of domestic graduates was needed at a minimum.[106]

This solution also aligns with reform underway through the Universities Accord. Targeted pathways into engineering education, fostering university-industry collaborations, and increasing access to engineering education in regional areas through flexible learning options would all mutually support an engineering capability uplift as well as Australia's vision for a revitalised higher education sector.

[106] Engineer Shortages and Projections December 2021. Australian Council of Engineering Deans, Dec. 2021, http://www.aced.edu.au/downloads/Engineer%20Shortages%20and%20Projections%20Dec%202021.pdf

Solution 3 Strengthening the Voice of Engineering in Government

The Australian Government should establish additional senior engineering roles in the Australian Public Service, including a National Chief Engineer. This would ensure access for public decision-makers to critical technical and systems advice to inform procurement, programs and policy – addressing cost overruns, risk and resilience, and ensuring the best, integrated, sustainable outcomes for Australians.

Strengthening access to in-house engineering advice in government is essential to ensuring national challenges are met with informed, technical responses that consider the range of risks and solutions to provide the best outcomes for the community. The creation of additional senior engineering roles within the federal public service, including the appointment of a National Chief Engineer, would provide access for decision-makers to essential technical oversight, guidance, and advisory resources for national systems and key technical projects, ensuring engineering expertise informs policy, procurements, implementation and regulation.

Additional engineering capability would be of benefit to a range of departments and agencies which maintain stewardship of important national systems or are overseeing critical national reform, for example:

- With respect to the energy transition and energy system governance, the Department of Climate Change, Energy, Environment and Water (DCCEEW), the Australian Energy Market Operator, Australian Energy Market Commission, Australian Renewable Energy Agency, Clean Energy Regulator, Clean Energy Finance Corporation, Climate Change Authority, Australian Radiation Protection and Nuclear Safety Agency, and the Net Zero Economy Authority
- With respect to national risk, resilience and emergency response, the Department of Home Affairs, the National Emergency Management Agency, and the Bureau of Meteorology
- With respect to critical infrastructure, the Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA), Infrastructure Australia, and other infrastructure and transport safety authorities
- With respect to emerging and future technologies and digital capability, the Department of Industry, Science and Resources (DISR), the Digital Transformation Agency, Geoscience Australia, and the Australian Space Agency

The 2019 Thodey Review of the Australian Public Service (APS) recommended establishing an APS 'professions model' to deepen capability and expertise in various disciplines and to build service-wide capability in procurement, contracting and commissioning. The model aims to define generalist and specialist careers paths, valuing technical expertise and leadership and management capability.[107] An engineering profession stream would align with this approach, ensuring technical expertise is recognised and embedded within government decision-making processes.

Australia also needs a National Chief Engineer to provide the highest level, strategic advice on the investment, implementation and operation of major government-backed projects and interdependent national systems. Complementing the role of Australia's Chief Scientist, the National Chief Engineer would consider whole-of-government implementation, procurement and regulatory challenges for technical projects and systems, facilitate cross-sector collaboration, and provide authoritative engineering expertise.

While Australia's Chief Scientist focuses on advancing research, innovation, and technology policy, a National Chief Engineer would apply engineering principles to infrastructure, technology investment, urban planning, transport, and energy systems. A National Chief Engineer would ensure:

- → Engineering rigor in decision-making, focusing on constructability, lifecycle performance, cost efficiency, and risk mitigation.
- → Technical scrutiny in major government investments, reducing investment or project risks and inefficiencies.
- → Practical implementation of new technologies, ensuring feasibility, safety, and economic viability.

A relatively low-cost investment, the National Chief Engineer would improve efficiency across the public service and reduce reliance on external expertise. The Chief Engineer would draw on engineering expertise across the APS to address cost blowouts, infrastructure quality, and shape innovative procurement and solutions, leading to strengthened public confidence and industry engagement. Even a 10 per cent reduction in project overruns could save billions annually – funds that could be reinvested in essential services and infrastructure.

The National Chief Engineer would be ministerially appointed and hosted within a key department such as the Treasury, Home Affairs, or Infrastructure. All Ministers would have access to technical insights, policy guidance, and coordination to deploy Australia's engineering capability to meet national needs.

[107] Department of the Prime Minister and Cabinet. Independent Review of the Australian Public Service (2019), 2019, www.pmc.gov.au/resources/independent-review-australian-public-service.

Solution 4 Diversity in STEM

The Australian Government should respond in full to the 2024 Pathways to Diversity in STEM report, implementing its recommendations for stable and sustainable action to increase diversity and inclusion in STEM.

Systemic, sustainable and evidence-backed change to enhance diversity and inclusion in STEM education and workplaces is needed to meet the growing skills demands of Australia's future. To fully harness the potential engineering talent available, it is essential to tap into underrepresented groups.

In 2023, the Independent Diversity in STEM Review Panel, chaired by Sally-Ann Williams, undertook considerable public consultation and research, including hearing from around 385 individuals and 94 organisations through conversations, interviews and workshops, and receiving 300 written submissions, and a new commissioned research report, STEM Career Pathways.[108] The Review Panel's final report, Pathways to Diversity in STEM, was released by the Australian Government in February 2024 and made 11 recommendations, including for:

- Government coordination and leadership
- Creating safe and inclusive workplaces
- Lifelong learning
- Changing perceptions and valuing diverse knowledge.[109]

In delivering its final report, the Panel said:

> "The recommendations in this report reflect the urgency of supporting and retaining diverse people in our existing STEM workforce. We cannot afford to lose anyone. We must harness the potential of all people with a curious mind, a spark for problem-solving and a keenness to build up and change our world." [110]

Twelve months on, the Australian Government had not responded to the Panel's report, nor implemented its recommendations. Then, on 5 March 2025, media reported comments made at an Adelaide conference by the Hon Ed Husic MP, Minister for Industry, Science and Resources, that the Government would accept all 11 of the recommendations and "make them a reality"[111]. However, this commitment did not translate to investment through the 2025-26 Federal Budget announced on 25 March 2025.

The engineering workforce must reflect the community it serves. Having more perspectives in the profession will lead to more productivity, innovation and better outcomes for everyone in our communities. We must ensure that all engineers, regardless of their background, are valued and supported to contribute meaningfully. Implementing the recommendations from the Pathways to Diversity in STEM report is imperative and should not be delayed any longer. These evidence-based, actionable measures can help increase the future-readiness of Australia's engineering sector by ensuring a more inclusive and diverse workforce.

[108] Husic, Ed. Pathway to Diversity in STEM: Report Released. Minister for Industry and Science, Feb. 2024, www.minister.industry.gov.au/ministers/husic/media-releases/pathway-diversity-stem-report-released. Pathway to Diversity in STEM Review Final Recommendations Report. Department of Industry, Science and Resources, 13 Feb. 2024, www.industry.gov.au/publications/pathway-diversity-stem-review-final-recommendations-report.

[109] Ibid.

[110] Hendry, Justin. "Govt Accepts All Diversity in STEM Review Recommendations." InnovationAus, 13 Feb. 2024, www.innovationaus.com/govt-accepts-all-diversity-in-stem-review-recommendations/ .

7.0 Next Steps

This report demonstrates a skilled workforce fuelling a strong engineering capability is critical for the nation's prosperity.

Australia needs to jumpstart its engineering capability by taking critical and urgent steps to secure our national engineering workforce pipeline.

We must attract and retain enough talent, with the right skills, to meet our current and future needs – this includes upskilling and reskilling within the workforce.

Advancing the science and practice of engineering for the benefit of society is Engineers Australia's purpose. It's what Engineers Australia was set up over 100 years ago to do.

We have ideas. We have solutions. Our advocacy focuses on realising them.

Now, we need your help to amplify these messages. We encourage you to share this report with your colleagues, industry partners, and professional associations, and engage MPs on the urgent need to strengthen Australia's engineering workforce. Together, we can drive action and deliver solutions that secure Australia's future.

To discuss the ideas outlined in this paper, please contact policy@engineersaustralia.org.au.

www.engineersaustralia.org.au

ENGINEERS
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Cover sheet: Supporting document #2

ENGINEERS
AUSTRALIA

The case for nationally consistent registration of professional engineers

Professional engineers plan, design, construct, test, commission, maintain, operate, and decommission safety critical systems whose performance can have significant consequences for public health and safety and economic implications for businesses and the community. Most engineers provide their services competently, ethically and with diligence. However, in the absence of regulation for engineering, anyone could purport to be an engineer and provide engineering services without appropriate qualifications, experience, or competencies and with disregard to professional standards and ethical conduct.

Engineering services are vital to national economic prosperity and social well-being, yet there is no uniform regulatory regime covering engineering practitioners in Australia.

Registration of engineers enhances public confidence the engineering services have been delivered by qualified, experienced, and competent professionals who practice ethically, develop safe and sustainable solutions, apply local engineering knowledge, and manage risks effectively.

The benefits of registration

Compulsory registration for anyone providing professional engineering services enables significant enhancement of public safety and consumer protection. More broadly, there are six key benefits of a registration system for engineers:

1. Reducing risks to public health, safety, and welfare through strengthening confidence in the competency of the people who deliver professional engineering services.
2. Economic benefits from reduced cost of re-work and improved system performance.
3. Improved industry and consumer information about who is competent to deliver professional engineering services.
4. Professional recognition for registered engineers.
5. Enhanced national and international mobility and trade in engineering services.
6. Legislative efficiency enabling regulators to more effectively develop, implement and improve consistent regulatory frameworks for the delivery of engineering services consistently in a timely manner.

Essential elements of statutory registration scheme

All registration systems should have the same characteristics in that standards must be set, qualification requirements specified, applicants assessed against specified competencies, and a register maintained. Performance must be monitored, and failures investigated and disciplined where appropriate. A register has greater effect if supported by legislated regulatory powers of government.

Engineers Australia supports the co-regulatory model of registration implemented in Queensland and Victoria through Professional Engineer Registration acts, which enables statutory bodies and professional associations to undertake roles that align with their expertise. The co-regulatory model provides greater assurance of the competency of registered engineering practitioners and reduces the risk of physical and financial harm to consumers. This approach allows industry and assessment entities, like Engineers Australia, to assess the qualifications and competency of individuals to the agreed national standards required. This then allows government to implement and maintain a formal register, including prosecution for unregistered work.

Statutory registration of professional engineers should apply to anyone who provides professional engineering services, and in any area of engineering in any industry. The exceptions are those performing professional engineering services under the supervision of an appropriately registered engineer, and those that only apply prescriptive standards/processes.

Some jurisdictions limit registration schemes to the building sector. The benefits of registration extend beyond the building sector as engineers provide critical services and products across all sectors including public infrastructure, power generation, manufacturing, health, and mining. Engineers Australia supports the expansion and alignment of schemes beyond the building sector to realise the benefits of nationally consistent registration of professional engineers.

How to regulate engineering

Engineers Australia supports the co-regulatory model of registration, initially introduced in the *Queensland Professional Engineers Act 2002*, which includes a statutory regulatory body and professional associations each undertaking the various roles they are best suited to perform.

Under a co-regulatory approach, Engineers Australia believes that legislation governing the delivery of engineering services in states and territories should:

- Include restrictions on who may deliver engineering services
- Restrict the 'registered' title to those who are on an engineering register
- Register engineers in the broadest possible areas of engineering practice aligned with the areas of practice and not limited to a specific industry sector, with the onus on each registered engineering practitioner to only undertake work that they are competent to undertake. Statutory registration should apply to professional engineers who provide engineering services in any industry
- Base registration on a set of minimum requirements which are benchmarked against recognised national and international standards. Refer to Engineers Australia's Minimum Requirements for Registration.

Mutual recognition

Australian governments have agreed to a nationally uniform approach to mutual recognition based on the *Commonwealth Mutual Recognition Act 1992*. In 2020 this Act was amended to provide for automatic mutual recognition (AMR).

Engineers Australia supports AMR as a key component of nationally consistent registration, with the effect that an individual professional engineer need only be registered in the engineer's home state to do professional engineering work while present in, or for a project located in, any other Australian jurisdiction without further application, assessment, or fees. Engineers Australia recognises that the provision of engineering services is not bounded by jurisdictional boundaries and there are productivity and administrative efficiencies through effective mutual recognition.

Support for comprehensive registration of engineers

Broad-based registration of engineers has very high levels of public support across all demographics. In a 2019 Engineers Australia commissioned poll[1] , 88 per cent of respondents answered 'Yes, engineers should have to be registered'.

About Engineers Australia

Engineers Australia was established in 1919 and is Australia's peak body for the engineering profession.

We are a not-for-profit organisation, constituted by Royal Charter, to advance the science and practice of engineering for the benefit of the community.

Our 115,000 individual members represent all disciplines and branches of engineering and all three of the profession's occupational categories (Professional Engineer, Engineering Technologist, Engineering Associate).

[1] The poll was conducted for Engineers Australia by OmniPoll. The poll was conducted nationally among 1222 people aged 18 years and over. Respondents were drawn from the online consumer panel managed by Lightspeed Research, OmniPoll's online partner. Sample quotas were set for each state, city and regional area, along with sex and age. To help reflect the overall population distribution, results were post-weighted to Australian Bureau of Statistics data on age, sex, area and highest schooling.

Cover sheet: Supporting document #3

The impact of AI and generative technologies on the engineering profession

January 2025

The impact of AI and generative technologies on the engineering profession

ISBN 978-1-925627-92-3

Author: Michael Bell AffilIEAust

Acknowledgements: Engineers Australia acknowledges Ergo Strategy and the research team Alicia Mintzes, Laura Coultas and Michael To.

We acknowledge the Information, Telecommunications and Electronics Engineering (ITEE) College for their continued support on our work on AI.

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Foreword

Artificial intelligence (AI) has been developing since the mid-1900s. Advanced algorithms, machine learning, and data analytics have helped engineers solve complex problems faster and more effectively as it has evolved.

In engineering, AI excels in design optimisation. AI-driven tools, such as generative design software, can analyse constraints and objectives to generate optimal designs for structures, components, or systems. These tools not only reduce design cycles but also offer solutions that were previously too onerous for traditional methods to assess and improve. For the traditional engineer who previously found juggling a dozen competing constraints and objectives challenging, AI multiplies the number of constraints and objectives that can be navigated.

Its application within complex types of engineering, such as materials engineering, is breaking new ground routinely. AI is also revolutionising mechanical tasks through its integration with robotics and automation. Autonomous machines, powered by AI, can perform tasks without exposing people to traditional hazards, such as those found in mining, manufacturing and construction. The optimisation abilities of AI increase productivity. Generative AI processes create new ways of approaching problem solving; be it productivity, safety, cost, impact or any other combination of parameters.

As with any new technology that shows promise of transformation for good, AI also comes with risks. Engineering advances are sometimes attached to shadows of unintended consequences; we need look only to the industrial revolution enabled by fossil fuel technology to recognise this.

The growth of AI in engineering allows some of the traditionally labour- and cognition-intensive tasks to be delegated to these new technologies effectively. At the same time, it elevates engineers' responsibility to do so with wisdom, and to apply engineering skills to higher-order tasks.

As the national body for engineers, Engineers Australia is deeply invested in comprehensively understanding the implications of AI for engineering. Our goal is to effectively communicate these insights, contribute to thought leadership on managing associated risks, and create the enablers that will allow AI to benefit engineers and engineering appropriately.

To harness AI effectively, we need the right education settings, ensuring the next generation of engineers are trained in the ethical and responsible use of these systems. We must also encourage company cultures that are open to exploring the technology and sharing benefits and lessons learned, and implementing policies and training that safeguard against risks, while realising the productivity, safety and positive impact benefits.

Engineers Australia is well-positioned to support the profession in navigating the evolving technology, including our ongoing work with the tertiary education sector, sharing case-studies through CPD events and promoting ethical and competent use of AI systems. We encourage all stakeholders to review this report and leverage the insights to contribute to our collective success.

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Chief Executive Officer
Engineers Australia

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January 2025

Executive summary

Over the past year, AI (and specifically GenAI) capabilities has become a topic which is hard to miss. Many of these discussions revolve around the future and how AI will impact the workforce. This report explores how AI and GenAI technologies have transformed engineering businesses and the workforce, and, importantly, how they will evolve.

Generative artificial intelligence (GenAI) will be an essential driver of change within the profession. The key question is how best to build the necessary confidence and support for GenAI to be used most effectively and safely.

Although traditional AI or older AI tools and methods have been used by engineers for 20 or more years, the recent advent of GenAI is already reshaping the engineering profession. More than 70 per cent of respondents agree GenAI will increase productivity in engineering work. This means the ability to use GenAI will be an essential skill for engineers in the future.

This report highlights that developing an engineer's ability to use and adapt to AI and GenAI technologies is a shared responsibility. Industry, professional and peak bodies, the tertiary sector and an individual engineer's own professional development must all play a part.

An important takeaway is that businesses need to foster a culture of openness to AI and GenAI so that engineers feel safe to collaborate, share and explore how the technology can best be used. In workplaces where engineers don't feel safe talking openly about using GenAI, they feel less confident and are less competent with the technology.

The reports also finds a limited understanding of how AI technologies can be applied – hence the need for openness. For instance, the value that toolboxes of advanced AI technologies, including GenAI and large language models (like Open GenAI, Domain-specific GenAI and Secure/custom GenAI) can deliver to the engineering profession is not widely and consistently understood. However, engineers' fundamental capabilities and skills, and their ability to think critically and solve complex problems, will stand them in good stead to embrace these tools – if they have the right support.

As to be expected, younger engineers do adopt GenAI faster than more experienced engineers, with young engineers finding the capabilities of explaining concepts beneficial as they learn and enter the workforce. Senior engineers tend to leave it to the next generation to see how GenAI could be incorporated into their work.

The findings outline the difference between multinationals and domestic firms, as well as larger and smaller organisations. Larger companies are more likely to have policies, training and support covering AI. Training helps to mitigate the risks associated with poor AI deployment. A key insight is that good AI support fosters a culture of learning and innovation, competitiveness and sustainability. As GenAI becomes more prevalent across all fields, including biomedical, electrical, chemical, industrial and systems engineering, it will create new jobs and opportunities for the growth of the nation.

To harness GenAI's benefits this report identifies four key focus areas for businesses to focus. These include:

1. Focus on deploying AI in areas which can enhance productivity by reducing labour-intensive tasks, such as assisting with initial drafts and developing skills.
2. Establish clear guidelines on data usage, risk management and security to prevent breaches and mitigate against biases, ensuring human oversight.
3. Build knowledge by sharing best practices and use cases, prompting skills and support resources.
4. Foster a culture that encourages experimentation with AI within the frameworks of company policies.

Seizing the benefits and opportunities presented by GenAI must also be balanced by appropriate safeguards, particularly where the technology is deployed in high-risk settings or where it impacts vulnerable members of the community. Engineers Australia therefore also advocates for a comprehensive standards framework for AI in Education and a balance of both regulatory and non-regulatory measures, to safeguard professionals, educators, students, and the community.

To further support the findings of this report, in addition to the funding provided to the adopt centres, Governments across Australia should continue to allocate funding for training and other upskilling programs to support workers developing proficiency in using digital tools and AI technologies across. A good example of this already happening is the *Introduction to AI* course powered by the NSW Government's Institute of Applied Technology and the Australian Government Department of Industry, Science and Resources.

Additionally, investing in public campaigns to increase awareness and understanding of AI technology is crucial. Such campaigns will help build trust and encourage the responsible use of AI systems, fostering a more informed and confident public.

Engineers Australia will continue to provide the engineering voice to government and the community on these issues and provide the resources, connections, and growth our engineers need to do ethical, competent and high-value work in our communities.

Introduction

Engineers play a crucial role in our society and economy and are vital to overcoming many of the challenges we face today and in the future. Engineers around the world are grappling with the rapid advancement of emerging technologies such as generative artificial intelligence (GenAI) (and its subsets) as well as the integration of artificial intelligence (AI) technologies with other technologies such as the Internet of Things and advanced robotics.

Engineers are essential to the development, implementation, integration, utilisation and maintenance of artificial intelligent systems and products. The swift adoption and ever-changing landscape of artificial intelligence have made the advancement and integration of these technologies a major priority across many industries. The focus of this study is the use of AI systems to undertake engineering processes and tasks.

Although AI has been around for decades, the evolution and advancements in GenAI systems have highlighted its powerful capabilities and potential negative impacts. It is critical for the engineering profession to understand these opportunities and impacts to adapt effectively. A clearer understanding will enable engineers to use these technologies to increase productivity and expand their skill sets to meet modern demands. This change also necessitates a corresponding shift in engineering education to meet industry needs while ensuring students retain essential tacit learning.

Background

Engineers Australia, through the Information, Telecommunications and Electronics Engineering (ITEE) College, has been examining AI for some time. This work became more of a focus in 2023 when the Australian Government released the consultation on *Responsible AI in Australia*. While some engineering disciplines, such as software engineering, are well known for their central role in building and deploying AI systems, it is essential to recognise that engineers from all fields of engineering are increasingly using AI tools and models and developing expertise in their use to undertake engineering processes and tasks.

At the outset of this work, it became apparent there was no clear and uniform understanding of the use of AI in engineering. Some considered AI and GenAI systems a gimmick, while others thought of AI only in the traditional sense of how it was already being used, rather than how GenAI might play a role in the future. A common thread that came to light was that the increased use of AI would be like the advent of the calculator, meaning that while it is anticipated AI will be a transformative tool for the profession, the skills of engineers themselves will remain in demand.

This report aims to support the adoption of AI within the profession by outlining the impact AI is having on how engineers work. The findings are drawn from exploratory research commissioned by Engineers Australia aimed at further understanding the current views and uses of AI within the profession.

Objectives

In 2024, Engineers Australia commissioned *Ergo Strategy*, a boutique consumer insights consultancy, to explore the impact of AI and emerging technologies on the engineering profession.

The primary objective was to understand how AI and emerging technologies have transformed engineering businesses and the workforce, and how they will evolve. With AI and other digital innovations reshaping the engineering profession, the task for the profession is to keep pace with the changes. Engineers and engineering businesses must be equipped to effectively leverage these technological advancements, while safeguarding the profession and the community from associated risks.

The study was designed to provide a common understanding of AI, how it is being used, and what engineers needed to know. This was done through three lenses:

1. Implications for the profession

2. Implications for the workforce and education
3. How Engineers Australia can support our members and the profession

Approach and methodology

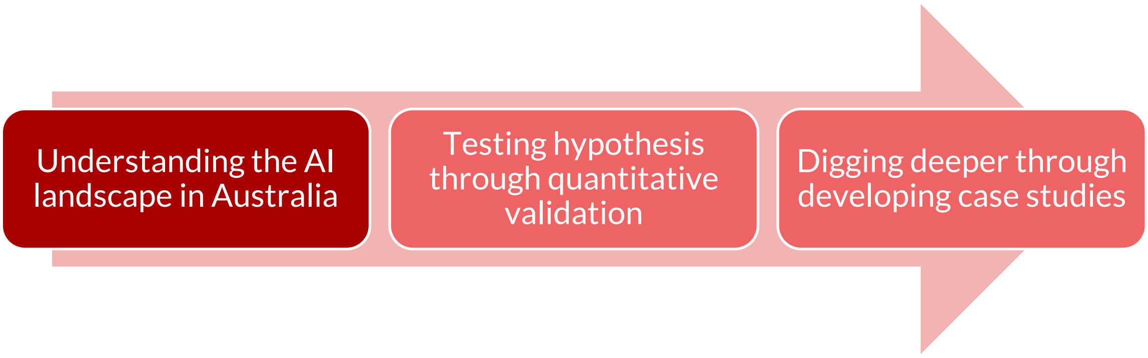
Engineers Australia undertook consultation with members and industry experts to develop the scope. As part of this, Engineers Australia adopted the definition of AI to be:

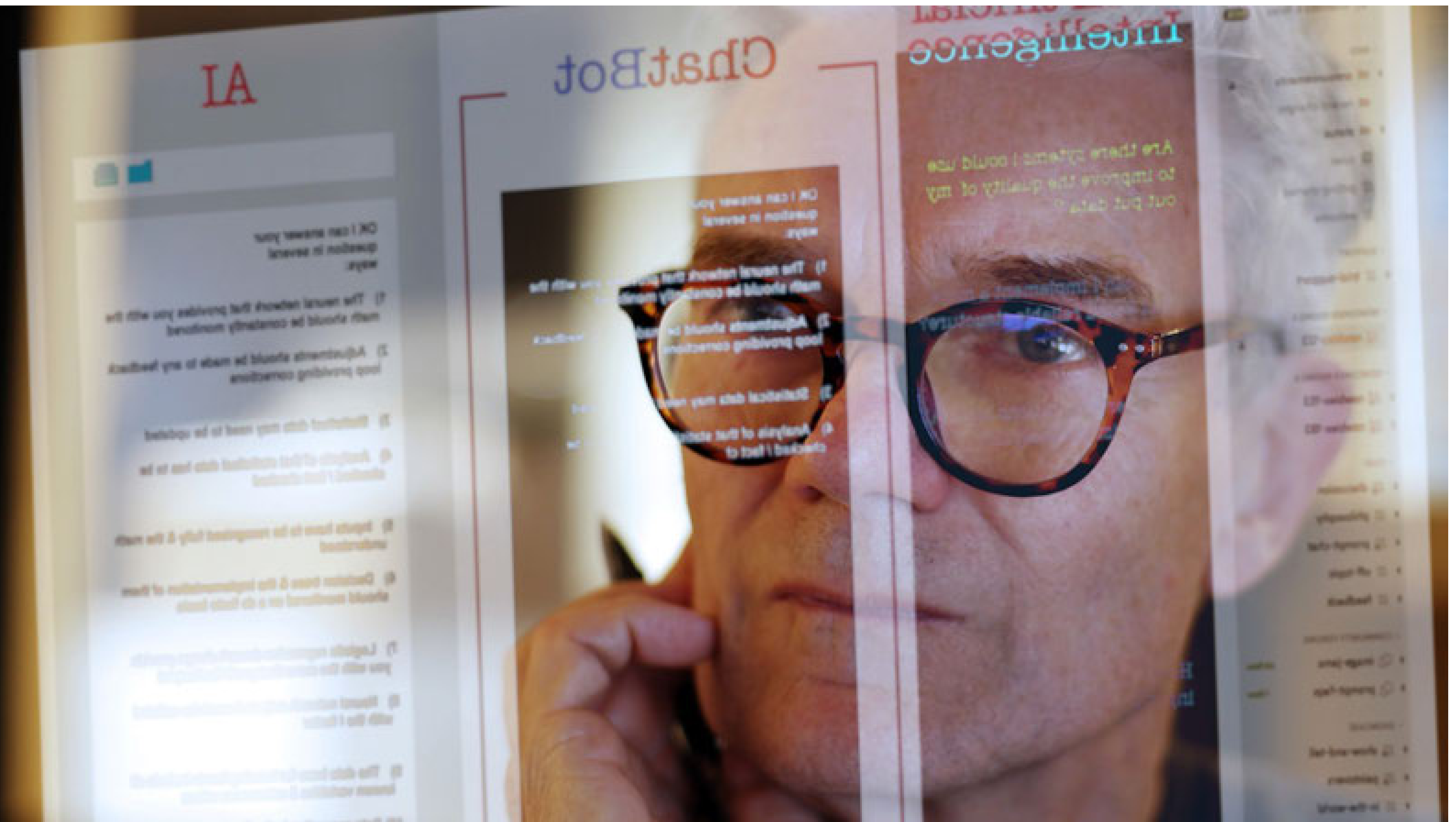
The theory and development of computer systems able to perform tasks normally requiring human intelligence.

Subsets of AI included machine learning, deep learning, expert systems, natural language processing, fuzzy logic, and machine perception. GenAI was defined as:

Generative AI refers to systems that use data models to generate new examples of content such as text, images, audio, code and other data modalities. Generative AI applications are typically trained on large amounts of real-world data and can approximate human generated content from prompts, even prompts that are limited or non-specific.

A three-stage approach was undertaken in gaining insights to achieve the objectives of the study. This included:





Methodology

To fit with the approach, the methodology consisted of three stages as outlined below.

Note: Weighting applied to career sample on age and size of company to be representative of the Australian engineering workforce and companies

Stakeholder engagement

Expert interviews to understand perspectives on the impact of AI on the engineering profession.

- Uses and impacts of AI
- Opportunities, challenges and risks with increased use of AI
- Regulation, skill gaps and educational needs

Qualitative exploration

34 interviews with engineers at different career stages, students and educators.

- 10 decision makers
- 9 early career engineers
- 5 engineering students
- 10 education experts

Quantitative validation

Online survey wtih N=2,197 Engineers Australia members and educators.

- N=1465 engineering professionals (career)
- N=448 engineering students
- N=53 educators
- N=231 other (retired etc.)

About Engineers Australia

As Australia's national body for engineering, Engineers Australia is the voice and champion of our 130,000-plus members. We provide them with the resources, connections, and growth they need to do ethical, competent and high-value work in our communities. A mission-based, not-for-profit professional association, Engineers Australia is constituted by Royal Charter to advance the science and practice of engineering for the benefit of the community.

Engineers Australia maintains national professional standards, benchmarked against international norms. As Australia's signatory to the International Engineering Alliance (IEA), this includes accreditation of undergraduate university engineering programs.

Contact

Engineers Australia welcomes the opportunity to discuss this report further. Enquiries can be sent to policy@engineersaustralia.org.au

The evolution of AI

Artificial intelligence (AI) is not a new concept and has been used in many industries and by many professions, including engineering, for years. Applications of more 'traditional' AI include smart assistance (devices such as Amazon's Alexa and Apple's Siri use AI to understand and respond to voice commands), chatbots, machine learning applications for predictive maintenance in manufacturing or quality control and control of systems. Retailers have used AI for years to support inventory management and to make online shopping experiences more 'personalised'. Many entertainment streaming services use AI to help suggest content for users based on their preferences as does Meta and TikTok.

Within the engineering profession, AI has been used for decades to optimise designs and analyse vast amounts of data, providing insights that inform decision-making, control systems and lead to more effective engineering solutions.

In 2022, OpenAI released ChatGPT, based on the generative pre-trained transfer (GPT) 3.5 architecture. This changed the way AI was considered by the public and brought it back to the forefront of public discourse. The discussion around AI has become pervasive, with governments around the world grappling with how to regulate the new and developing technologies. This includes Australia, where the safe, responsible and ethical use of AI has become a focus.

Engineers perceive recent advancements in AI and emerging technology as progress in Generative AI and large language models.

Regulating AI and AI policy

Respondents to the survey perceive Australia as lagging other nations in AI policy and investment. This is impacting the engineering profession's ability to implement these technologies and innovate. Australia needs to position itself as a leader at the forefront of AI and emerging technology development to enable the country to be globally competitive and get the most out of the technology. To do this, Australia needs to invest in AI technologies and work to develop the right policy and regulatory settings which safeguard AI usage while promoting greater investment in research and development, leading to innovation and commercialisation.

To support these policy settings, a comprehensive framework around the use of AI is needed to limit inconsistent and potentially unsafe AI applications. Businesses also need to be supported in implementing AI solutions to continue to compete on a global scale. Government initiatives such as the funding of AI Adopt Centres and the collaboration between the NSW Government and the Australian Government Department of Industry for free introduction to artificial intelligence courses will support businesses in this transformation.[1][2]

Australia needs to also ensure there is sufficient funding and support for AI and emerging technology research and development (R&D). Investment in quality research is crucial for the development, implementation, and control of emerging technologies that will enable Australia to stay current and reduce its reliance on other nations. The sentiment of engineers points to Australia lagging the US and China in research and patented technology. Focusing on this will allow for greater Australian innovation and quicker progress in developing AI use in crucial fields.

Addressing these areas is essential for Australia to harness AI's full potential and secure its position as a global leader in technology, spurring on economic growth and technological advancement.

[1] The Australian Government is funding up to five AI Adopt Centres to help small to medium enterprises grow their business through AI - [$17 million to boost AI adoption by SMEs | Department of Industry Science and Resources]

[2] 'Introduction to Artificial Intelligence' *NSW* Government https://store.training.tafensw.edu.au/product/introduction-to-artificial-intelligence/

Regulatory frameworks

The Australian Government's response to AI has largely been targeted towards the use of AI in high-risk settings, while ensuring the majority of low-risk AI use continues largely unimpeded. In 2023 the Australian Government published an interim response to the Safe and Responsible AI consultation. [3] Part of this work includes considering mandatory guardrails for AI development and deployment in high-risk settings, whether through changes to existing laws or the creation of new AI specific laws. To support this, the Government has set up a temporary AI expert group to provide guidance on implementing testing, transparency, and accountability measures for AI in legitimate, yet high-risk environments to ensure the safety of AI systems. The Australian Government has also released:

- **Voluntary AI Safety Standard** – a standard which provides practical guidance to enable more businesses to develop and deploy AI safely and responsibly.
- **AI Ethics Framework and Principles** – developed in conjunction with existing and emerging initiatives these guide businesses and government aimed at reducing risks and achieving high standards of ethics.
- Standards Australia has adopted the international standard ISO/IEC 42001, Information technology - Artificial Intelligence - Management System.[4]
- Australia has endorsed **OECD AI principles –** the first intergovernmental standard on AI[5]

Engineers Australia's position on AI

Engineers Australia advocates for a balanced approach, implementing both regulatory and non-regulatory measures—to harness AI's benefits while safeguarding professionals, educators, students and the community.

This must prioritise regulation for AI systems with high-risk implications, including a comprehensive standards framework for AI in education, to ensure public protection while maximising AI's benefits.

[3] 'The Australian Government's interim response to safe and responsible AI consultation' *Department of Industry, Science and Resources* (17 January 2024) https://www.industry.gov.au/news/australian-governments-interim-response-safe-and-responsible-ai-consultation
[4] 'Standards Australia adopts the international standard for AI Management System, AS ISO/IEC 42001:2023' *Standards Australia* (16 February 2024) https://www.standards.org.au/news/standards-australia-adopts-the-international-standard-for-ai-management-system-as-iso-iec-42001-2023#:~:text=In%20summary,%20AS%20ISO/IEC%2042001:2023%20provides%20organisations
[5] 'AI Principles' *OECD* (accessed 25 September 2024) https://www.oecd.org/en/topics/sub-issues/ai-principles.html#:~:text=The%20OECD%20AI%20Principles%20are%20the%20first%20intergovernmental

Perceptions of AI and emerging technologies

GenAI

One of the key insights when exploring this topic was the lack of a unified understanding of AI technologies. Broadly, engineers mainly recognise recent advancements in AI as progress in generative AI (GenAI) and large language models. Engineers are increasingly adopting advanced AI technologies, particularly GenAI and large language models, over traditional AI tools. Using these, it is easier for individuals to see the direct benefits to their job. GenAI tools include:

- **Open GenAI** – mainstream large language model AI tools, typified by mainstream models such as ChatGPT and LLaMA (an open-source AI LLM) which can manage tasks like administrative duties, summarising documents, research, etc.

- **Domain-specific GenAI** – GenAI embedded in software programs which can assist with specific tasks such as coding, image generation, rendering, etc. These help to streamline and automate tasks and assist with error detection.

- **Secure/custom GenAI** – systems and tools applied to secured internal data such as the enterprise version of Microsoft Copilot. This offers secure functions like proposal writing, data access and other task automation without businesses being concerned about the data being shared.

Traditional AI

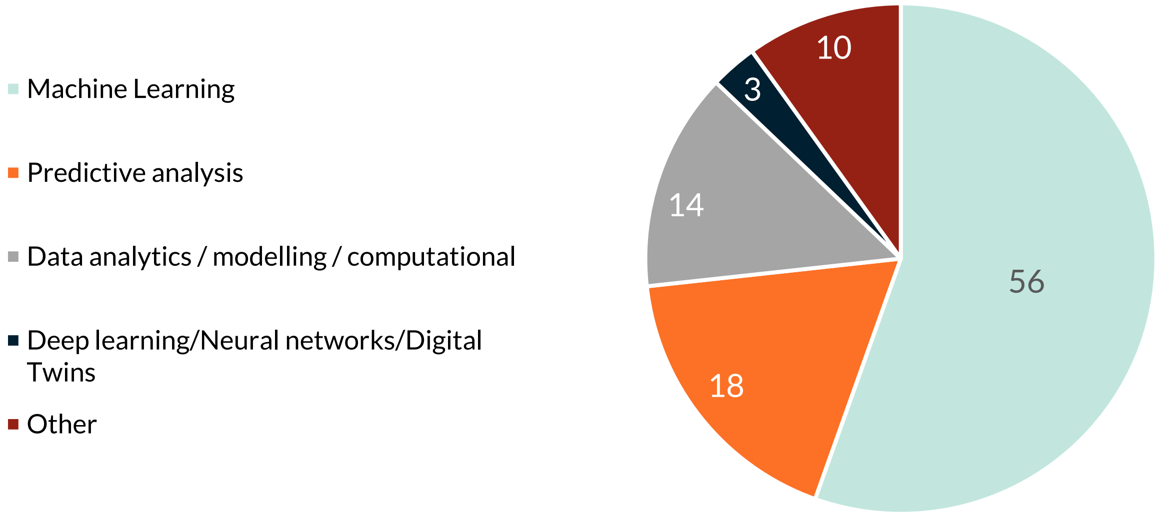
Traditional AI or older AI tools and methods, including fuzzy logic, machine learning, and neural networks, primarily focus on making decisions, predictions, or classifications based on pre-defined rules or learned patterns without generating novel outputs. These AI tools have been around for 20-plus years and are understood as an engineering specialty requiring trained experts. Traditional AI is often used in software or machinery with the user unaware AI is involved. An example of this is fuzzy logic in vehicle automatic transmission systems. Here fuzzy logic helps to determine best gear shift points considering inputs such as engine load, throttle position and speed. Operators of a vehicle are seldom aware this is occurring.

These tools are tailored to specific business needs and the process follows a typical product development and implementation cycle which includes:

- identifying business requirements
- assembling a team – often with external contractor/experts
- product development and testing
- pilot/trialling solutions
- implementation.

The most common of the traditional AI systems being used in workplaces is machine learning, with 56 per cent of engineers reporting machine learning is being used in the workplace.

FIGURE 1: OTHER TYPES OF AI USED (%)



What other artificial intelligence system(s) is your workplace using, besides generative ai? Base: career sample who use other types of AI other than GenAI n=295

Reshaping engineering practice

GenAI is identified as the major change reshaping the engineering profession compared to 'traditional' AI technologies. GenAI is free and accessible to everyone, producing easy to understand outputs and requires no technical expertise to operate, although technical competence is needed to discern whether the answers offered by GenAI are correct and credible. GenAI is rapidly evolving with improvements and advancements happening exponentially. Therefore, it is difficult to predict how GenAI will impact the profession in the future. Policies, frameworks, business case development, and education are all trying to catch up.

Advancements in GenAI are seen as helping to improve productivity with 72 per cent of respondents agreeing GenAI will increase productivity in engineering work. AI is automating administrative tasks and assisting with first drafts of documents like proposals, emails and reports. As more companies invest in AI tools, and create and pilot systems, further productivity gains will be realised.

The impacts on the profession will be even deeper as AI and GenAI continue to be integrated with existing technologies and as various types of AI are incorporated into other emerging technologies (such as advanced robotics, computer vision and the potential in quantum computing). An example of this is computer vision and machine learning merging to create powerful diagnostic medical machinery.

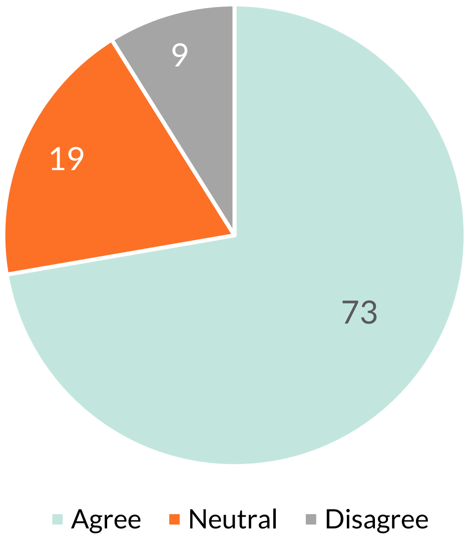
As the use of GenAI grows in the engineering profession, so will the need to have the capability to use it. Figure 2 shows more than 70 per cent of respondents believe the ability to use GenAI will be an essential skill for engineers in the future.

> "What the generative AI wave is doing is changing computing ...it's almost democratising knowledge in a way that's never happened before. Allowing us to do things like reason over unstructured information and that is going to change so much in professional services."
>
> - Engineer at large multinational

While GenAI will be an essential driver of change within the profession, frequent analogies were drawn between GenAI and other technologies. Examples such as when the profession moved from slide rulers to calculators to CAD were often shared. While there can be initial resistance to change, due to concerns of engineers losing valuable skills, the methods of achieving results change over time which is a natural part of a profession.

There is significant transformative potential of GenAI in the profession. However, the fundamental capabilities and skills of engineers along with their ability to think critically and solve complex problems will still be needed. Embracing these new technologies and adapting to the changing engineering landscape will be crucial, ensuring the modern engineer is using all the resources available to solve the world's most complex problems.

FIGURE 2: BEING ABLE TO USE GENAI WILL BECOME A CRITICAL SKILL? (%)



How much do you agree or disagree with the following statements? Base: Total sample N=2,197

CASE STUDY: "TRADITIONAL" AI IN ROAD MAINTENANCE

Challenge:
An engineering consultancy specialising in road maintenance faced significant challenges in assessing road conditions and developing renewal models and work programs.

A manual process of reviewing road data and identifying faults required for maintenance was time-consuming and labour-intensive. The primary employee handling this task was overburdened and despite efforts to train additional staff, the team was not large enough to keep up with the workload.

AI solution:
To address this, an AI-based solution involving a predictive analysis tool was developed and implemented. This tool automated the road condition analysis process by using AI to identify defects from images and recommend maintenance schedules.

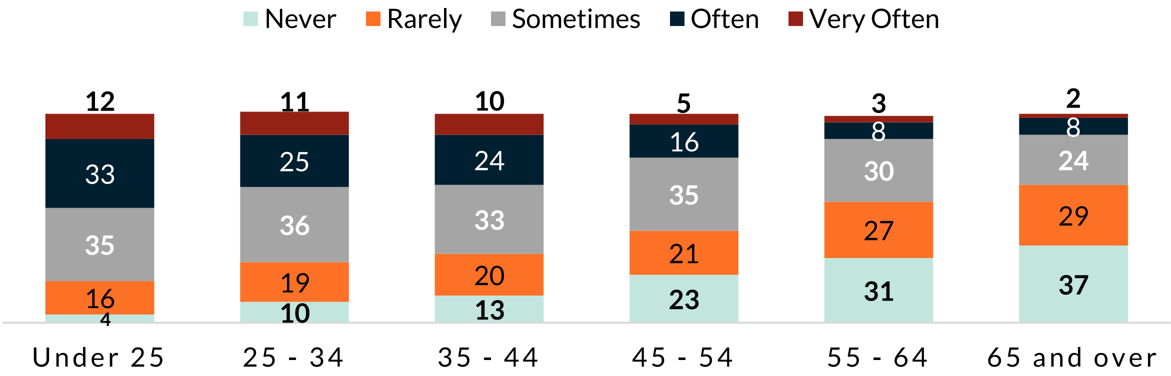
Development:
A dedicated team consisting of contractors, existing staff and a new hire was assembled to develop, train and test the AI model.

Outcome:
Currently, the team is in the trial phase, which is expected to last six months. By leveraging AI, the company was able to save considerable time and resources with the system currently able to do in 30 minutes what used to take a day. **This automation has not only boosted productivity, but also improved employee satisfaction** by reducing the amount of tedious manual work involved.

Engineers using GenAI

In the workforce, 43 per cent of engineers surveyed reported using GenAI, while the figure is much higher among engineering students with 74 per cent using the technology. Younger engineers are using generative AI more than senior or older engineers. Those aged between 18 to 24 years reported the highest use (more typically the age of an engineering student), followed by 25- to 34-year-olds (typically early to mid-career engineers).

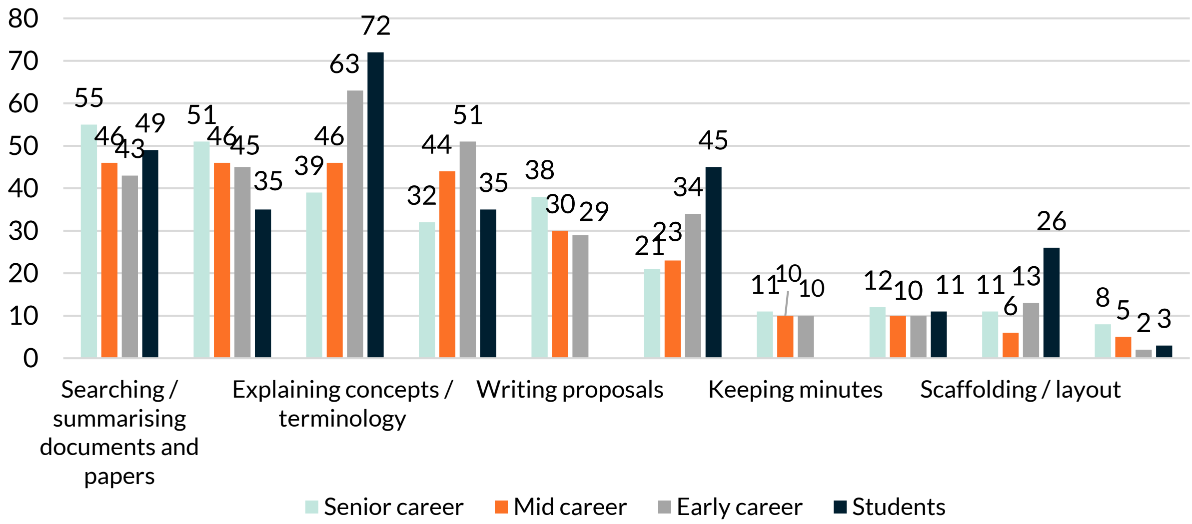
FIGURE 3: USE OF GENAI FOR ANY PURPOSE BY AGE GROUP (%)



How often do you use Generative AI for the following purposes? (Personal, Education, Work). Total sample: N=2,197

Depending on the stage of an engineer's career, their experience and knowledge impacts the use of GenAI. A common reason for the adoption of GenAI among younger engineers is because they have less established ways of working, making them more likely to adopt new technologies. Early career engineers and students are much more likely to use GenAI to explain concepts and terminology. This is due GenAI being good at answering questions on topics emerging engineers have a lower understanding and/or lack of confidence in. In contrast, senior level engineers tend to use it primarily to summarise documents and write proposals. This aligns with the specific tasks an engineer would be engaged on at different stages of career. Over 50 per cent of senior engineers use GenAI to search/summarise documents and papers and draft content, compared to 63 per cent of early career engineers who use it to explain concepts and terminology. No matter how the technology is used, low competence in GenAI decreases the chance GenAI is used effectively, and it also increases the risks to data safety.

FIGURE 4: GENAI USE BY LEVELS OF SENIORITY (%)

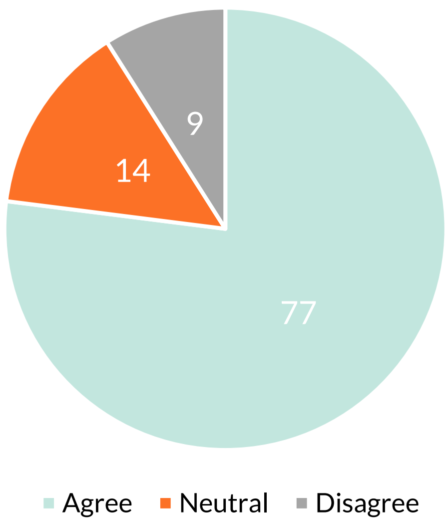


What do you use Generative AI to help you with in your work? by A11: What level are you at in this role?
Base – those who use GenAI: Senior Career N=276, Mid career N=574, Early career N=92, Students N=406, Educators N=47

Individual GenAI adoption is faster among engineers in younger age groups. Speed of adoption decreases with seniority among engineers. Many senior engineers reported leaving it to the next generation of engineers to see how it could be incorporated into the work. However, a universal understanding of how GenAI can be applied in engineering remains limited.

While there are many anecdotal examples of how AI is being used, understanding of how it works, its limitations and its potential in engineering is not universally known. This continues to impact attitudes and adoption of the technology. The speed at which GenAI is evolving and the hype around it is further affecting attitudes towards it. In many cases, there is confusion and scepticism about the actual capabilities of the technology and the unknown impacts, which is leading to uncertainty around when to invest in its adoption

FIGURE 5: GENAI WILL BCOME JUST ANOTHER TOOL, LIKE GOOGLE OR CALCULATORS? (%)



How much do you agree or disagree with the following statements?
Total sample: N=2,197

Contributing to this lack of understanding is the perception of 'AI washing', where AI is being marketed everywhere, as being involved in everything. The use of AI has become a buzzword, often applied to technology which may not qualify as AI. The impact of this is an increased desired to apply AI, even if it is costly and will have limited effectiveness. These perceptions are leading to a simplification in how it can be applied and used. Perceptions that AI can and should be used in all areas of engineering is creating high expectations. This leads to an unrealistic view of what it can deliver and the productivity savings it can offer, while underestimating the effort, training and the resources required. The use of certain terminologies further creates confusion. Referring to AI as 'magic' or describing its errors as 'hallucinations' is impacting the perception of GenAI. Developing a clearer understanding of AI can improve engineers' attitudes toward it.

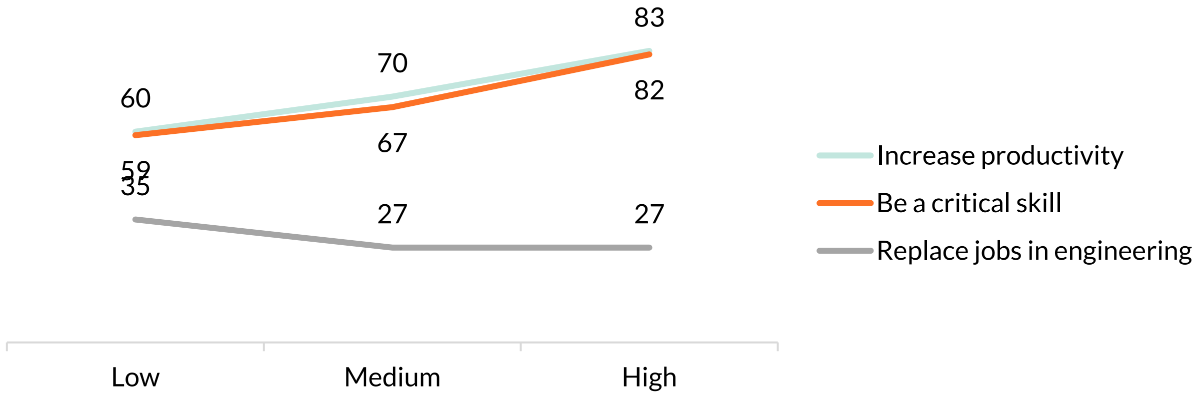
“It is a great marketing tool to say we are using AI because AI is modern, cool and innovative. But it is a problem with innovation where it is turns into a bit of a buzzword.”

1. Senior Engineer, Decision Maker

Attitudes and perceptions

Attitudes towards AI follow a similar trajectory across industries and engineers, based on their understanding and use of GenAI. As engineers gain a better understanding of AI, their attitudes shift from a position of fear and uncertainty, to viewing it as an augmentation tool. Perceptions of GenAI as a critical skill that supports engineers increases alongside their confidence in using it, while the view GenAI will replace jobs diminishes confidence. The better the understanding, the more that engineers focus on effective use and having the right support mechanisms. While an increased understanding of the use of GenAI leads to more positive views about it, 90 per cent of engineers recognise there will always be risks with using GenAI, regardless of confidence.

FIGURE 6: PERCEPTIONS ABOUT GenAI BY CONFIDENCE TO USE (%)

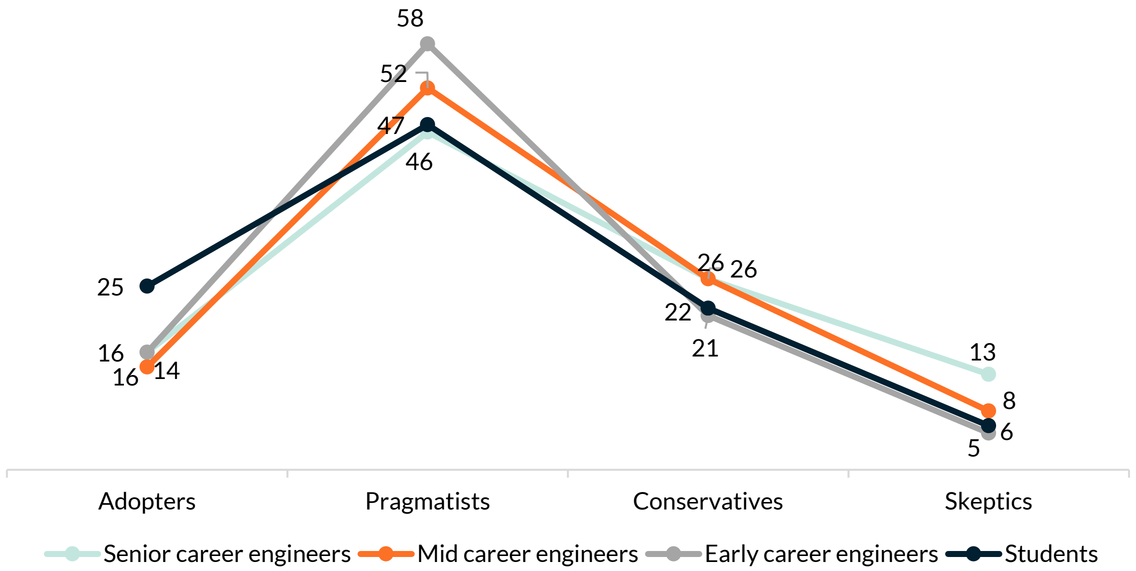


How confident are you in your ability to do the following? How much do you agree or disagree with the following statements? (Top-2-box agreement) Base: Career N=1,465

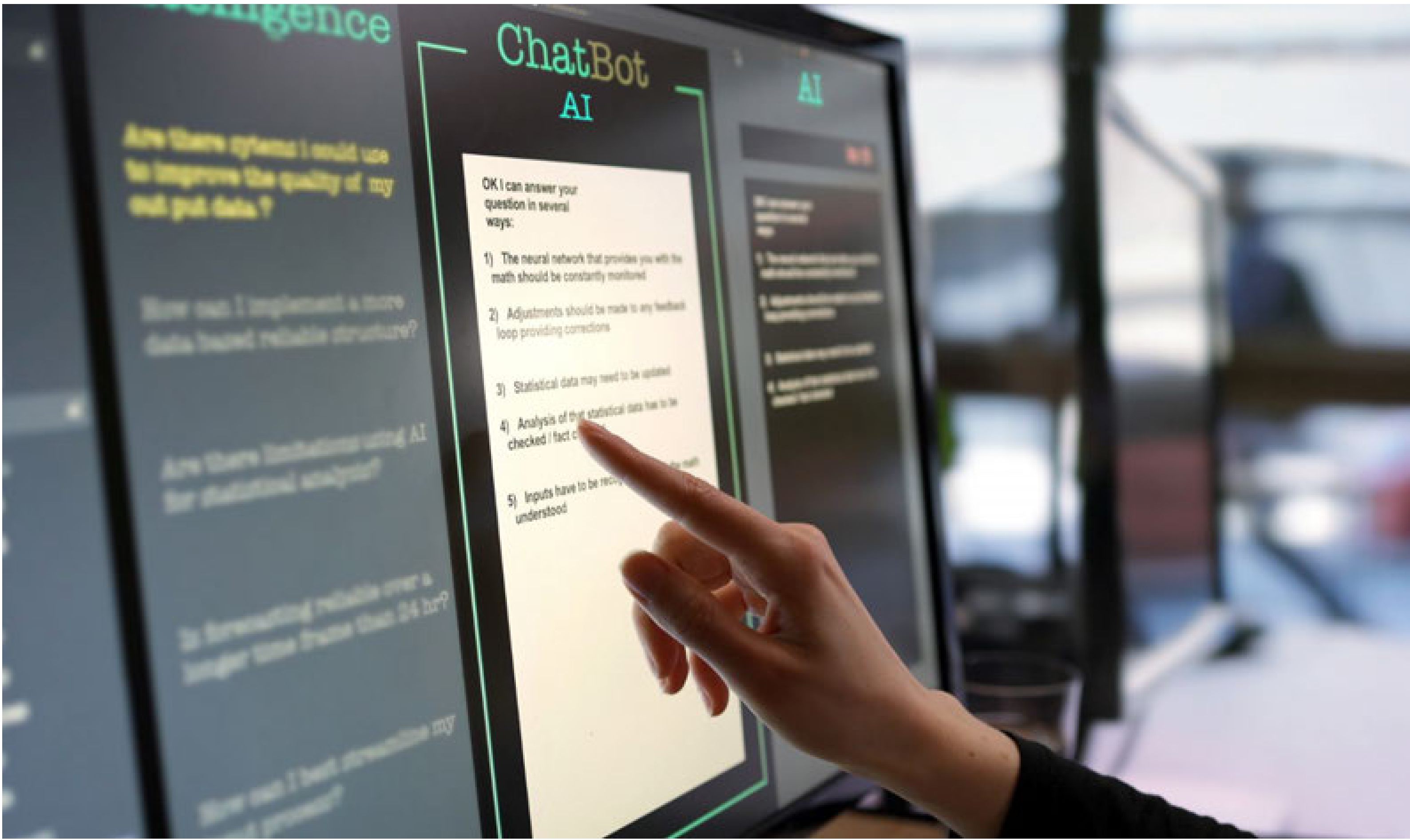
Confidence and competence in using GenAI

With younger engineers adopting GenAI more quickly, there is a need to ensure there is confidence in the outputs, and competence in safe and responsible use. Competency with GenAI is driven more by a personal desire to learn and upskill rather than formal education. Significantly, 78 per cent of engineers in the workplace and 81 per cent of students agree learning about GenAI is largely self-directed. The ability to effectively harness GenAI is due to self-motivation and personal research, often conducted on platforms like Stack Overflow and Reddit. Learning to use these technologies requires a strong willingness to learn independently, with young engineers more likely to be self-motivated compared to those who have been in the workforce longer. A contributing factor to this is the level of experience and confidence younger engineers possess in undertaking the work assigned to them, and the usefulness of GenAI to assist in understanding concepts and tasks.

FIGURE 7: ADOPTERS OF AI BY CAREER LEVEL (%)



Company Adoption & Individual Adoption (including sole trader). Base: Senior Career N=418, Mid-career N=881, Early career N=127, Students N=448



CASE STUDY: DEVELOPING AND CUSTOMISING CHATGPT
Small consultancy – self-driven problem-solving exercise by an early career engineer

Challenge:
An engineering consultancy providing flood and stormwater modelling for councils and individual clients for subdivisions and building developments needed to sift through many documents to map floods, flood extents, hazard and velocity, including council planning schemes, flood overlays and storm water codes. The process was labour intensive and time consuming.

GenAI solution:
Using a paid ChatGPT solution, the early career engineer trained the system with public data sources on flood overlays, storm water codes, suburb data, planning schemes and flood maps. An automated process was then developed whereby ChatGPT would provide stormwater codes and appropriate documentation based on a postcode search.

Development:
A challenge in the development was training ChatGPT to use the *most relevant* and appropriate data from councils and other government bodies. Development also requires working through errors, piloting results and checking for accuracy.

Outcome:
Development is ongoing.

The above case study demonstrates GenAI can be used by engineers to support their work. The system was trained on publicly available data with the intention of reducing a manual search process and therefore increasing efficiencies. This showcases how GenAI systems such as ChatGPT and Microsoft Copilot can be used with limited investment to produce benefits to businesses. It also shows the importance of validating the data used to train the AI model as well as the need to select the most appropriate AI model. This may require the participation of experienced engineers to validate the results.

Risks of limited competence

Lower competence and understanding by individuals of how GenAI works can lead to an increase in the associated risks. These risks include the likelihood of employees unintentionally leaking sensitive information through providing it to a GenAI platform; and trusting GenAI responses which are wrong or biased. Where businesses were getting the best value out of GenAI, the user knew how to prompt correctly. Those who didn't have knowledge about prompting were more likely to get suboptimal outputs.

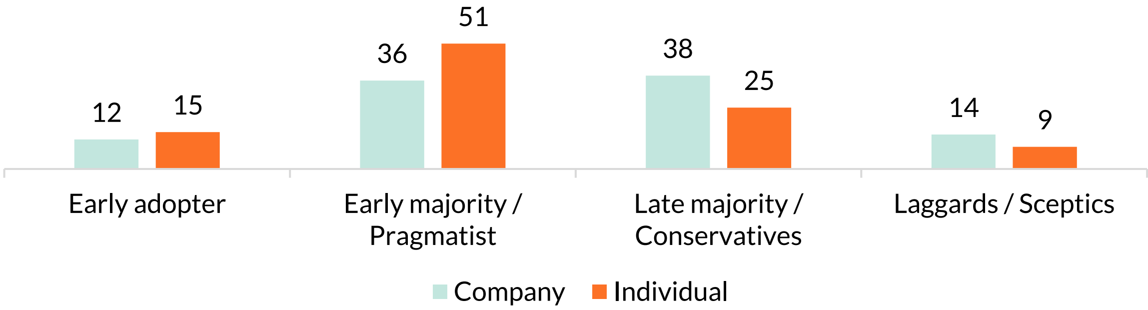
Engineers are more competent in using GenAI when there is more open discussion about the use of the technology and how it is being applied. Therefore, businesses should foster a culture of openness regarding the use of these technologies so that engineers feel comfortable to talk about and explore their use, in a safe way. The findings show the importance of building confidence and providing support for GenAI to be used most effectively including policies and processes for the use of AI.

> "No matter how tight your processes are, no matter how good your technology is, humans are your biggest vulnerability."
>
> - Engineer, Decision maker

GenAI in engineering workplaces

The rate of adoption[6] of GenAI in engineering workplaces is similar to the typical technology adoption lifecycle. Twelve per cent of companies reported being early adopters, investing in adopting GenAI tools early to leverage productivity gains. Those who gradually adopt GenAI tools after seeing proven value make up 36 per cent of companies, while the majority, 38 per cent, report adopting GenAI tools cautiously as they become widely accepted. Only 14 per cent reported not adopting GenAI tools until it's necessary or unavoidable.

FIGURE 8: ADOPTION OF GENAI (%)



Company Adoption & Individual Adoption (including sole trader), Career sample N=1,465

The companies which invested in adopting GenAI tools early, tended to be more multinational organisations or companies which operate internationally. Of the early adopters, 89 per cent use GenAI tools. Their attitudes toward GenAI were more open, with 95 per cent reporting they talk about and use GenAI across all levels of the organisation. There was also strong support (89 per cent) from superiors to use these technologies. These organisations were more likely to offer AI training, with 65 per cent having an expectation GenAI is going to be used at work.

The second cohort, early majority companies, are those which are gradually adopting GenAI tools after seeing proven value. They were more likely to be multinational or international companies as well as large private companies. These companies are open and progressive towards AI; however, they were less likely to provide training. GenAI was more likely used by those mid-low-level employees within the company, with only 66 per cent of respondents reporting support from superiors to use the technology. Within this segment, 82 per cent were using GenAI tools. The use cases leaned towards non-technical tasks for enhanced productivity.

Late majority adaptors, or those adopting GenAI tools cautiously as they become more widely accepted, skewed towards Australian organisations operating only in Australia (50 per cent), and SMEs in the private sector (52 per cent). These companies were less open to talk about using GenAI, with 40 per cent of them low in progressiveness to try new technologies broadly. Companies within this segment had more than 65 per cent of employees paying for their own GenAI licences. Overall, 59 per cent of late majority adopters were using GenAI tools. Similar to the early majority adopters, GenAI was mainly used for simple, non-technical tasks, with usage being less frequent.

[6] Company adoption segments developed based on the following dimensions about the workplace:

- Openness to talk about using GenAI
- Understanding GenAI is an expectation
- Encouragement in use of GenAI for simple, non-technical tasks
- Using GenAI in innovative ways
- Who uses GenAI
    - Everyone / senior
    - Junior / peers / other teams
    - No one / don't know / just me

The companies which are not adopting GenAI tools until it's necessary or unavoidable (those classified as laggards/ sceptics) were more likely to be Australian organisations with 52 per cent of them operating only in Australia. Just under half of them (49 per cent) were SMEs. This segment showed minimal openness to talk about using GenAI and very low appetite in trying new technologies broadly. These companies were more likely to see using GenAI as 'cheating' compared to others. Only 39 per cent of the laggards reported using GenAI tools, with use only being in simple, non-technical tasks. However, 69 per cent of employees reported paying for their own GenAI licences.

Individual adoption of GenAI is occurring faster than workplaces, with more than 50 per cent of engineers in the early majority/pragmatist phase and a further 15 per cent in the early adopter category. Bridging the gap between early adopters and the rest of the workforce requires careful planning and engagement.

Implementing AI in workplaces

Engineering companies are adopting AI technologies at different rates, influenced by their size and resources. The ability to use GenAI effectively in engineering requires appropriate application, clear oversight and data considerations to mitigate risks. For companies, setting parameters around GenAI use increases trust in its ability to provide useful outcomes.

Smaller companies are concerned GenAI will give larger organisations a competitive edge. Smaller companies are more likely to lack the financial means as well as the research and development capabilities needed to implement safe and secure AI systems. This is particularly the case for more advanced AI systems. However, smaller companies have an advantage as they can act more like a startup and implement new tools and systems faster. They are also finding the large language model (LLM) AI beneficial in assisting with basic tasks, as they don't have the level of staffing that larger companies have.

Medium-sized companies can find it harder to implement AI systems as they require more investment yet have less capital to risk. They also face difficulties in justifying investment in the technology, particularly for minor productivity gains. They tend to be more cautious and risk-averse, making it harder for them to embrace advanced AI technologies despite recognising the potential benefits.

For larger companies, the investment in new AI technologies is often higher, however, they are more likely to have the capital to invest in research and development to develop and implement the tools and systems. They are often better positioned to adopt AI technologies due to their superior data quality. They often already have or can invest in the necessary infrastructure and are better equipped to handle the complexities of AI implementation, viewing it as essential for maintaining their competitive edge and driving innovation. Often, larger companies see AI as a strategic advantage and are more likely to integrate the technology into their core operations.

Transitioning to an AI enabled business requires investment and support to drive AI discovery projects and monitor change. Among respondents, 22 per cent are involved in implementing GenAI in the workplace. Of these, 38 per cent hold leadership roles, with 20 per cent serving as lead decision-makers. Additionally, 26 per cent of middle managers were part of the implementation team, while only 13 per cent of engineers in team roles were likely to be involved in implementing GenAI.

> "Just giving someone a calculator does not mean it works, they need to be trained. GenAI and LLMs are the same."
>
> - Stakeholder

CASE STUDY: JOHN HOLLAND EMBRACES GENERATIVE AI

While the construction industry traditionally lags in digital adoption and innovation, John Holland has been bucking the trend over the past six years with its focus on technology and digital transformation.

Challenge:
Seeing the emergence and opportunity of GenAI and LLMs, but with concerns about data security, John Holland set out to develop a system which could realise the potential but limit the risks.

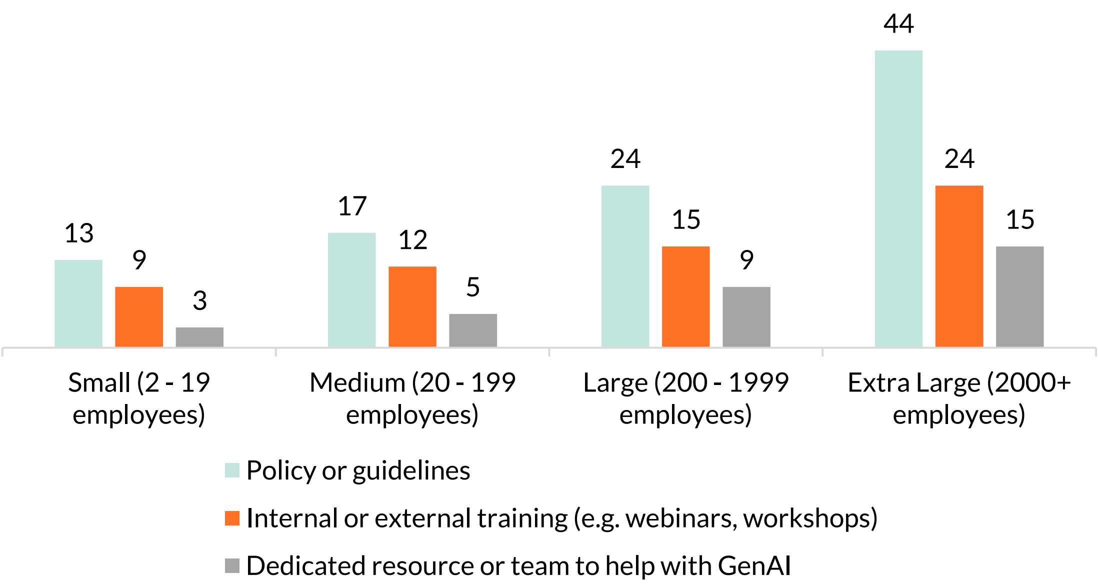
GenAI solution:
Partnering with Microsoft, they developed a secure, private version of OpenAI's ChatGPT. This collaboration allowed employees to utilise the capabilities of generative AI to find relevant information within the company while ensuring the protection of their data. The system can also be used by third parties, reducing risks through collaboration.

Outcome:
While still in pilot phase, the system is helping to increase productivity with developing/writing content and searching information. It is also improving the quality of communication from those with English as a second language.

Policies, training and support

Larger companies are more likely to have policies, training and support covering AI. Having these within the business is crucial to ensure the use of GenAI aligns with ethical standards and regulatory requirements. It also helps prevent misuse and sharing of sensitive data. Broadly speaking, policies, training and support will help organisations to manage the risks associated with AI deployment by enhancing employees' understanding of AI capabilities and limitations. This will enable them to integrate these technologies into their day-to-day work efficiently. Training fosters a culture of lifelong learning and innovation, ensuring a company's workforce stays up to date with the latest processes.

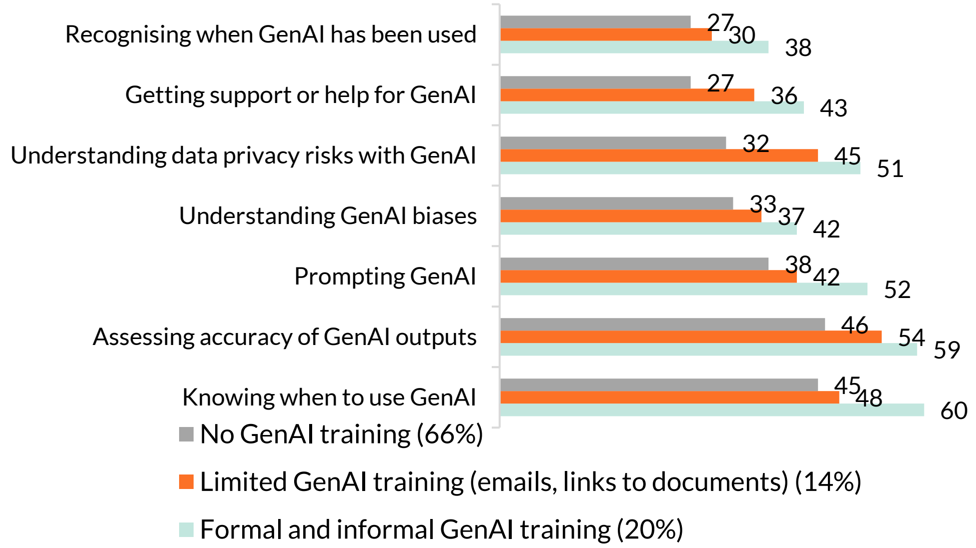
FIGURE 9: COMPANY SIZE BY AI POLICY, TRAINING AND SUPPORT (%)



What training or information about Generative AI have you received from your work? Does your workplace have a policy or guidelines about using Generative AI for work activities? Do you have a dedicated resource or team to help with Generative AI at your workplace? Approximately how many employees does your workplace currently have? Base: Small N=240, Medium N=346, Large N=375, Extra Large N=413

Clarity around data security and ways to use GenAI further increases confidence and abilities. There is a clear opportunity for engineering companies to educate their employees, with 66 per cent of engineers receiving no training at work, thus reducing their confidence in using GenAI and increasing risks.

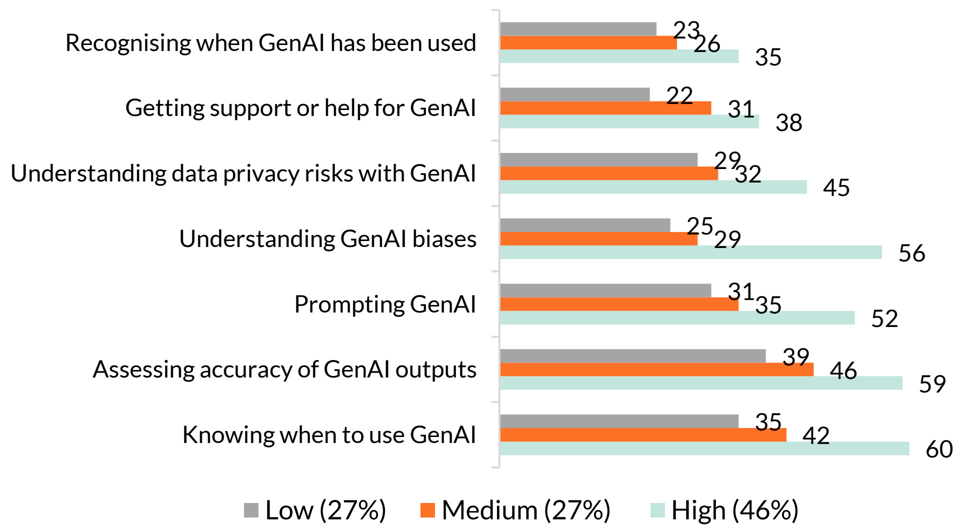
FIGURE 10: ENGINEERS' CONFIDENCE TO USE GENAI BY WORKPLACE TRAINING (%)



How confident are you in your ability to do the following? D4. What training or information about Generative AI have you received from your [pipe: Wording]? Base: Career formal & informal training N=293, Career limited training N=197, Career no training N=884

Just as important as having formal policies and training is building and maintaining a workplace culture that is open to discussion of AI and GenAI technologies. In workplaces where open discourse is encouraged, engineers are more confident in their abilities. Among the metrics used to measure workplace progressiveness on GenAI, openness has the highest correlation with individual confidence to use it.

FIGURE 11: ENGINEERS' CONFIDENCE TO USE GENAI BY WORKPLACE OPENESS (%)



How confident are you in your ability to do the following? How much do you agree or disagree with the following statements? - At work, we talk openly about using Generative AI Base: Career high workplace openness N=596, Career medium workplace openness N=381, Career low workplace openness N=397

Opportunities for businesses to limit risks and build employee confidence

While the use of this technology is increasing, embracing generative AI in engineering does not mean indiscriminate use and blind faith. Engineers are cautious and realistic about using GenAI in engineering with 82 per cent of engineers believing GenAI will always require oversight. There is an opportunity to better harness GenAI potential by addressing existing challenges and barriers.

Implementing AI technologies requires investment from businesses. To get the most out of GenAI and LLMs, Engineers Australia has identified four focus areas for business as follows:

1) Focus on implementing AI and GenAI technologies where they will have a positive benefit such as:
    a) Tasks which can increase productivity
    b) Labour intensive tasks which decrease job satisfaction
    c) Use for first drafts / initials inputs (like an "intern")
    d) Enhancing and developing skills and abilities
2) Develop and establish guidelines, procedures and internal policies on data usage, risk management and security to ensure use of GenAI does not create data breaches and limit negative impacts such as biased information:
    a) Clear guidelines around use and confidential data
    b) Ensure GenAI outcomes have human oversight and are reviewed for accuracy
    c) Knowledge of information sources
    d) Check outcomes for bias
3) Building knowledge around how GenAI works:
    a) Sharing effective use cases and platforms which can be used, and which adhere to company policies
    b) Teaching effective prompting and querying skills
    c) Guidance on where employees can go for assistance and support
4) Maintain a culture of openness to talk about and let employees try these technologies (within the bounds of company policies).

The future of AI and opportunities

It is predicted the use of AI and GenAI will continue to increase, particularly as later stage adopters start to understand the benefits this technology can provide. However, the "how" AI will increase is not yet known. As AI capabilities develop, it is expected the tools will evolve significantly, with enhanced capabilities in solving complex problems, especially in areas like mathematics, data analysis and coding. As GenAI becomes more embedded in the tools we already use, such as the Microsoft 365 suite and Apple Intelligence, it will become a ubiquitous presence in everyday life.

With AI advancing rapidly, governments need to ensure the right regulatory and legislative settings. Policies are needed to create the right paradigm ensuring responsible and ethical use of the technology, while enabling its benefits to support Australian industry and society.

Engineers Australia continues to provide the engineering voice to government on this issue as an essential component to the AI discussion. Certain engineering disciplines, such as software engineers, are well known as playing a central role in building, deploying and utilising AI systems. However, all fields, including biomedical engineering, electrical engineering, chemical engineering, industrial engineering, systems engineering, and sustainability engineering are increasingly using AI systems. As AI becomes more prevalent, the topic demands subject matter expertise to enable these systems to reach their potential while safeguarding against negative impacts. Engineering insights in how these systems are being used is therefore indispensable.

Positively, for the workforce, AI is expected to create new roles within the profession, focusing on the development and management of AI tools. These positions include areas such as prompt engineering[7] and software engineers and developers. It is further expected AI skills will become increasingly essential to an engineer, making it important to have a more structured understanding of the topic. While minimal jobs losses are expected, these are for more lower-level roles.

Opportunities to support the profession

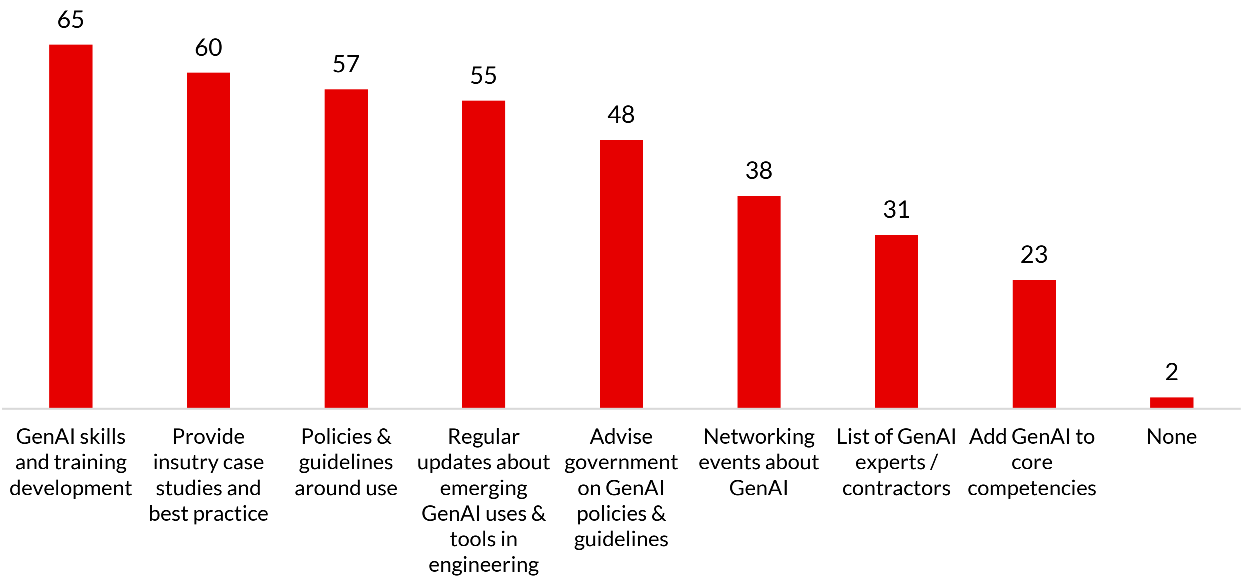
As the profession embarks on this journey, there is a need for greater support to be provided to help increase the understanding of AI and GenAI. Professional and industry bodies, such as Engineers Australia, are well positioned to support engineers. Almost all (98 per cent) of the respondents surveyed see Engineers Australia playing a role in the use of GenAI in engineering. Key areas of interest included GenAI training and skills, industry case studies and best practice, and policies and guidelines around use.

There was stronger interest among entry-level and more junior engineers for training and skills development, whereas more experienced engineers favoured the need for case studies and best-practice examples. Engineers in middle to senior management were more interested in policies and guidelines around use. Whereas educators placed high emphasis on training and skills development, industry case studies and networking events about GenAI.

> "Becoming over reliant on [GenAI] tools might lead to a knowledge gap. It is important to be able to use the tools, but it is also important to be able to do it yourself."
>
> \- Engineer, Decision Maker

[7] '*Prompt engineering is the practice of designing inputs for AI tools that will produce optimal outputs.*' McKinsey (22 May 2024) [What is prompt engineering? | McKinsey]

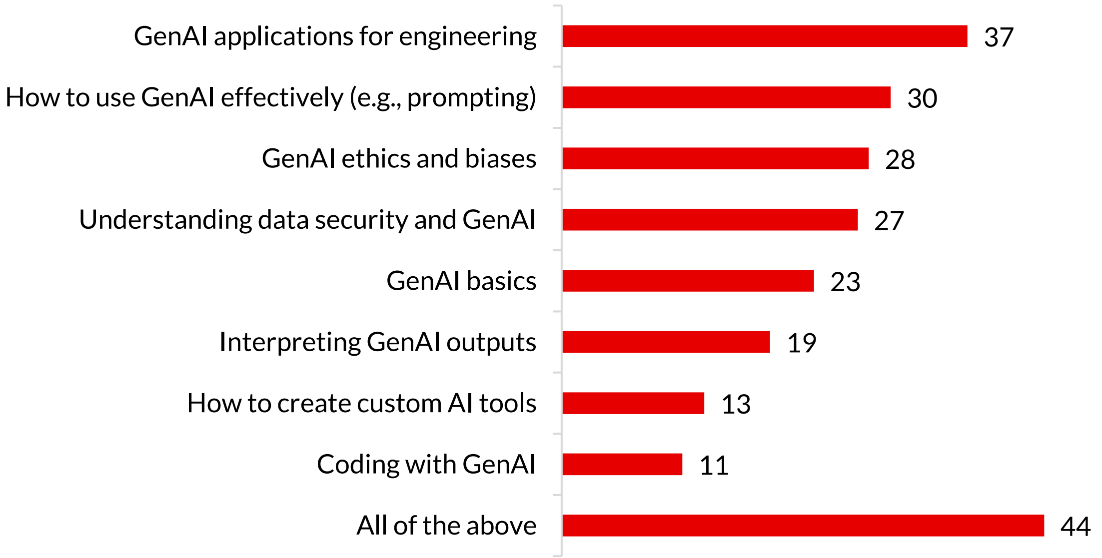
FIGURE 12: HOW ENGINEERS AUSTRALIA COULD BEST SUPPORT THE USE OF GENERATIVE AI IN ENGINEERING (%)



How could Engineers Australia best support the use of Generative AI in engineering? What is the most important thing Engineers Australia should do to support the use of Generative AI in engineering? Base: Career N=1,465, Student N=448, Educator N=53

For those wanting more skills development, having a range of training opportunities was key. This includes webinars, seminars and CPD events, conferences or symposiums, workshops, lunch-and-learns and having AI experts to consult with. The most sought-after training topic for engineers was the application of GenAI for engineering tasks, followed by how to use it most effectively.

FIGURE 13: GENAI TRAINING TOPICS OF INTEREST (%)



What Generative AI training should Engineers Australia provide?Base – those who are interested in training and skills development Career N=948, Student N=292, Educator N=42

Developing an engineer's ability to use and adapt to AI and GenAI technologies is a shared responsibility, with industry, professional and peak bodies, the tertiary sector and an individual engineer's own professional development journey all playing a part.

Impacts of GenAI in education

AI and GenAI in engineering education is still under development. The tertiary sector and program policies are still catching up with the evolution of AI, particularly GenAI. Engineers Australia has been engaging with government and the tertiary sector on these issues.[8] When GenAI first took off, the sector was mainly concerned with the use for cheating and plagiarism. Many institutions initially banned the use of the technology. As such, institutional policies on embracing GenAI to enhance learning have lagged.

The fast-paced change of this technology presents opportunities and challenges. The negative perceptions of GenAI, such as concerns around data privacy, accuracy of responses and the need for human oversight can hinder the willingness of some to embrace the tools in an educational setting.

To adopt GenAI effectively in the tertiary sector some critical issues need to be overcome. These include:

- The competency gap in engineering students on when and how to use GenAI effectively which can lead to misuse and exacerbate risks such as data breaches.
- An over-reliance on GenAI can impact the development of tacit knowledge needed to critically analyse the outputs of GenAI. This has raised concerns in industry as to whether future engineers will possess the necessary skills and competencies required.

There is a need for engineering education to manage and teach GenAI use to mitigate this risk and to help change attitudes. This involves:

- **Education and training:** Provide training to help students understand the potential and limitations of GenAI. This can be incorporated into the current curriculum.
- **Promote the opportunities of the technology:** Showcase the benefits and opportunities of GenAI when used responsibly, ethically and competently.
- **Ensure effective use:** By developing guidelines and best practices to ensure the technology is used in an appropriate manner.

The Tertiary Education Quality and Standards Agency provides guides and resources through the higher education good practice hub which aim to assist providers to meet the challenges and opportunities afforded by GenAI.[9] This includes resources on incorporating AI in classes and engaging students on the topic.

Educators

Educators in the tertiary sector are using AI similarly to both engineers and students, as shown in Figure 4. Like engineers, educators use it for writing emails and drafting content; they are also using it for coding and scaffolding activities. In addition, educators emphasised using GenAI for image generation. However, integrating it into day-to-day administrative tasks is simpler than integrating it into engineering education.

[8] 'Inquiry into the use of generative artificial intelligence in the Australian education system' *Engineers Australia* Submission to the inquiry into the use of generative artificial intelligence in the Australian education system (engineersaustralia.org.au)
[9] 'Artificial Intelligence' *Australian Government Tertiary Education Quality and Standards Agency* (accessed 7 October 2024 https://www.teqsa.gov.au/guides-resources/higher-education-good-practice-hub/artificial-intelligence#:~:text=TEQSA%20is%20closely%20monitoring%20the%20rapid%20enhancement%20of

Making changes to courses and assessments requires investment and training from already time-poor academics and educators. Challenges for educators include:

- Time needed to invest into learning and understanding GenAI for themselves
- Rapid evolution of GenAI makes it difficult to stay on top of the advancements
- Changing assignments and courses is time consuming and adds extra workload to staff
- In some cases, a reduction in support staff means there is an increased burden already on academics to change courses and grading systems.

Positively, the tertiary sector is seeing innovations to support the integration of these technologies into engineering education. Much like the other sectors, there is a need to demystify GenAI, both in industry and within academia to support how the technology can be taught to the next generation.

CASE STUDY: ASSESSMENTS USING ChatGPT

Challenge:
With the introduction of ChatGPT and seeing the use of it take off in student's work (sometimes very lazily), a university lecturer looked at how they could integrate ChatGPT into teaching first year engineers programming.

GenAI solution:
Incorporated the use of ChatGPT into an assignment and asked the students to provide a critical analysis of how ChatGPT performed. The purpose was to help educate students on use, quality of outcomes and how to critically assess outputs.

Outcome:
The activity partly took the fun and ease out of using ChatGPT as it was no longer an easy solution but required careful consideration and analysis of the outputs. The activity helped to teach the limitations of ChatGPT for solving more complex problems. Through this, it encourages sensible use of large language models and ensures fundamental skills are learnt and can be applied. It also reduces the trust on GenAI as it shows the outputs are not necessarily correct.

After the assignment, students reported ChatGPT was good for the basics, but when asked to do the implementation of a physics algorithm, it couldn't get it right.

"AI is a massive productivity booster...It turns a job that would be one day into a job that's one or two hours."

- Educator

Conclusion

The use of AI and particularly GenAI technologies in Australia continues to increase. While the advancements in these systems have powerful capabilities, there is the potential for negative impacts. To navigate this, it is necessary for the engineering profession to have a broader understanding of the technology, the use cases and its limitations. This understanding will enable engineers to adapt effectively, using AI to enhance productivity and expand their skills and capabilities. Engineering companies, industry and the tertiary sector all have a part to play, from creating a culture of openness around the use of these technologies, to more formative learning around correct prompting to get the best and most accurate responses.

Engineers Australia will continue to provide the engineering voice to the broader discourse on this topic, including on how to promote safe and responsible use while having the right mechanisms to safeguard against harm. As the peak body for the profession, Engineers Australia will also continue to support our members with demystifying GenAI and learning how most effectively to use it through continuous professional development and networking opportunities. To further support this work, Engineers Australia will continue to engage our members to explore other ways on how we can strengthen the engineering workforce by adopting and adapting to AI.

Cover sheet: Supporting document #4

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

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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. More than 40 per cent 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; while 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 per cent, with 83 per cent 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:

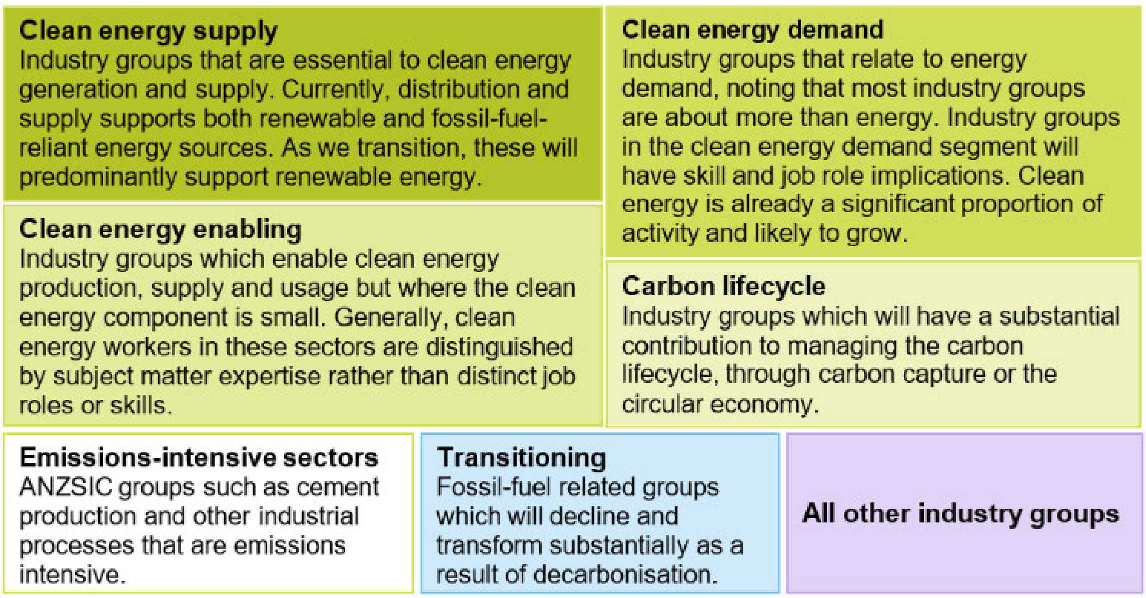


FIGURE 1: CLEAN ENERGY WORKFORCE SEGMENTS

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

Jobs and Skills Australia estimates that around 30 per cent 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 per cent, 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.

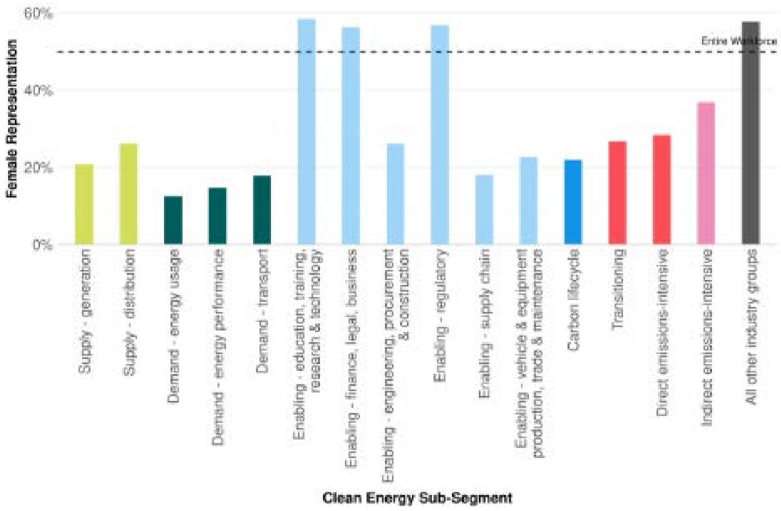


FIGURE 2: FEMALE REPRESENTATION IN CLEAN ENERGY SEGMENTS

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.

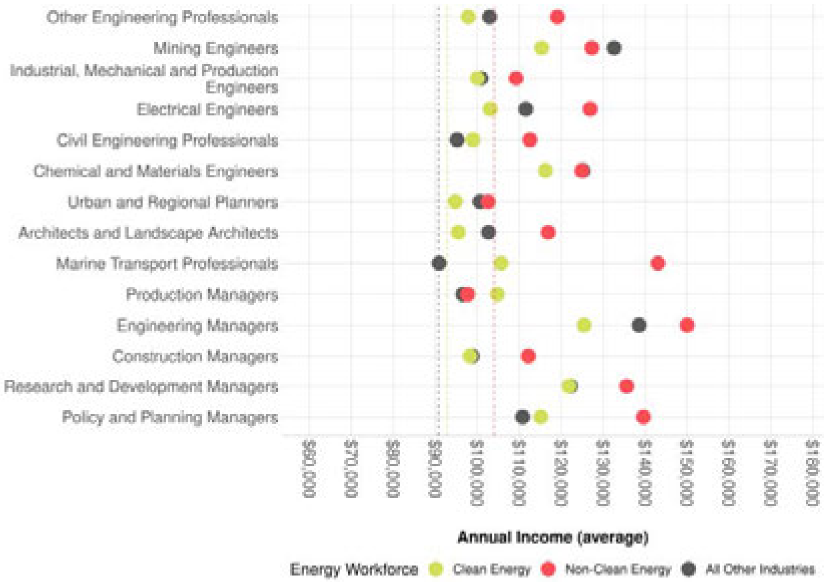


FIGURE 3: WAGE DIFFERENTIALS BETWEEN CLEAN AND NON-CLEAN ENERGY INDUSTRIES

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 per cent 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.

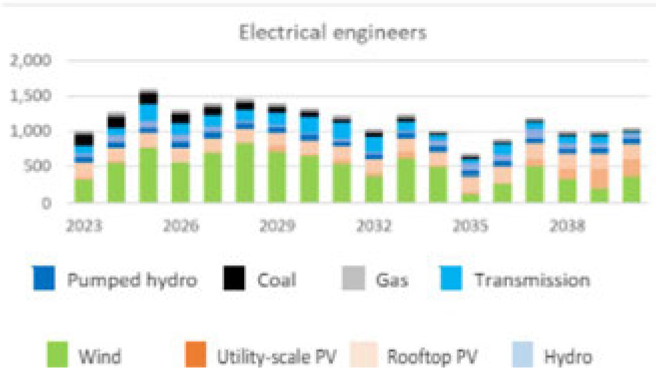


FIGURE 4: ELECTRICAL ENGINEERS BY ENERGY SOURCE

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 more than 4 per cent per annum since 2011, rising to over 540,000 qualified engineers in 2021. Most engineers are employed as civil engineers (16 per cent), industrial, mechanical and production engineers (10 per cent), software and application programmers (8 per cent) and electrical engineers (6 per cent).

Around 25 per cent 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 per cent are working in engineering occupations. This is referenced in the graph below.

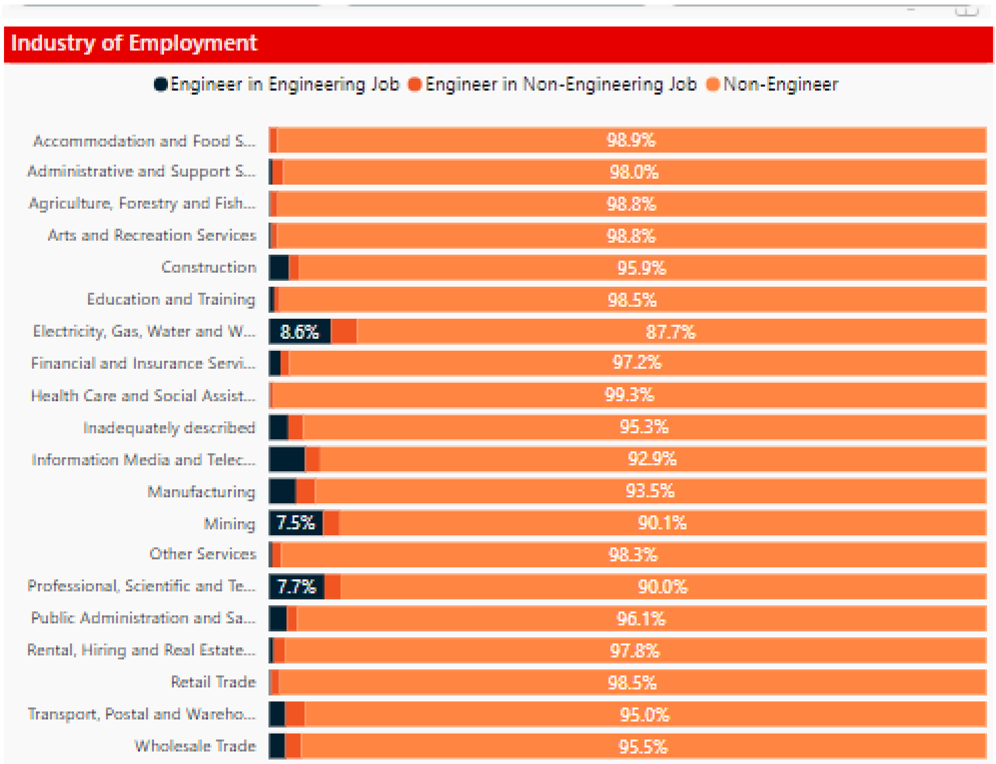


FIGURE 6: ENGINEERING WORKFORCE BY INDUSTRY

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

There is a large, latent engineering workforce. While 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 per cent 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 per cent 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 per cent) than men (58 per cent). The workforce is mainly full-time – less than 10 per cent of engineers (9 per cent males, 15 per cent females) are working in engineering roles part-time. By contrast, 17 per cent of engineers who work in any occupation are part-time (17 per cent males and 38 per cent females are part time) (Engineers Australia (b), 2024).

Evidence suggests females move out of engineering to other, unrelated professions to combine work and family, while 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. While 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 per cent 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 while 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.

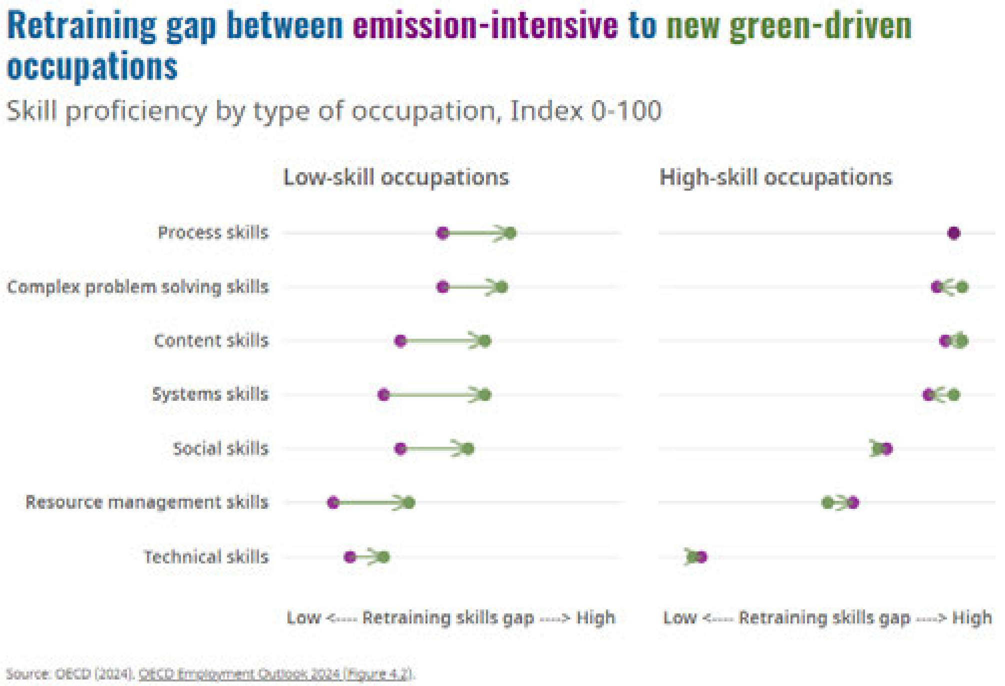


FIGURE 8: RETRAINING GAP BETWEEN EMISSION-INTENSIVE AND GREEN OCCUPATIONS

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).

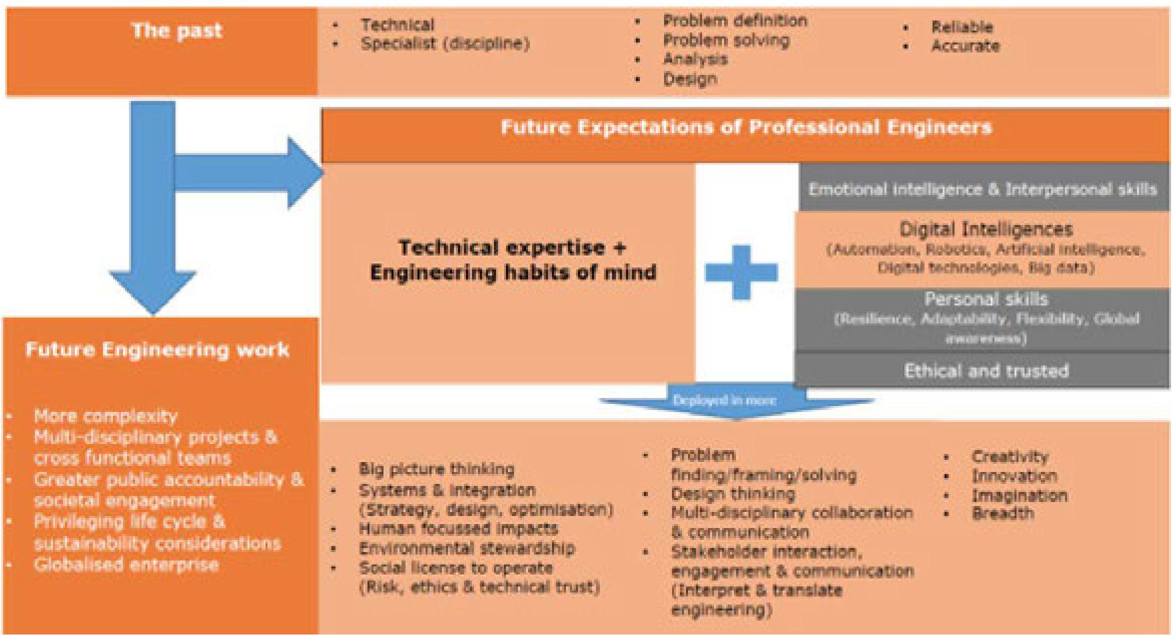


FIGURE 9: DIAGRAMMATIC REPRESENTATION OF TRADITIONAL AND T-SHAPED ENGINEER

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.

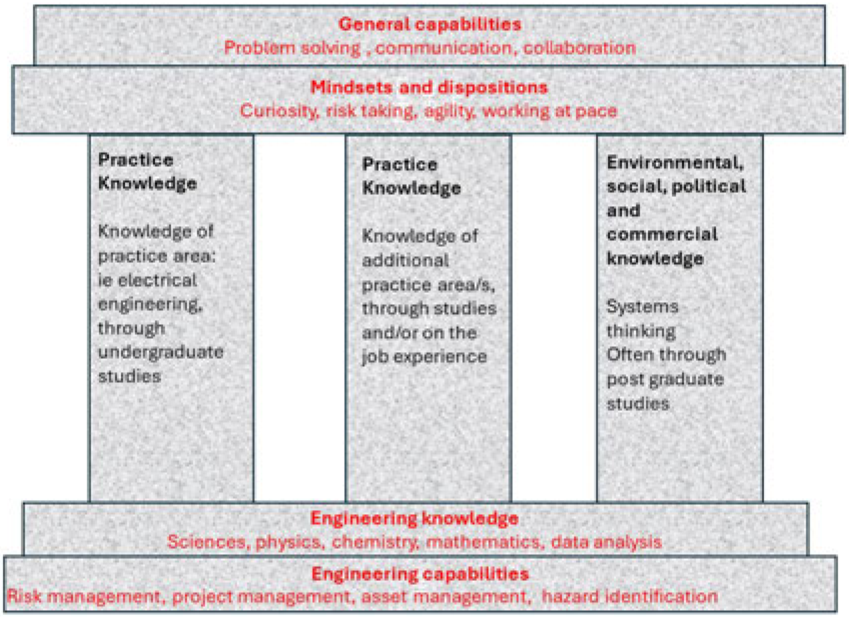


FIGURE 10: DIAGRAMMATIC REPRESENTATION OF TRANSITIONING ENGINEERS

While 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…"

While 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, while 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 per cent 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 12 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."

While 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 per cent 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**.

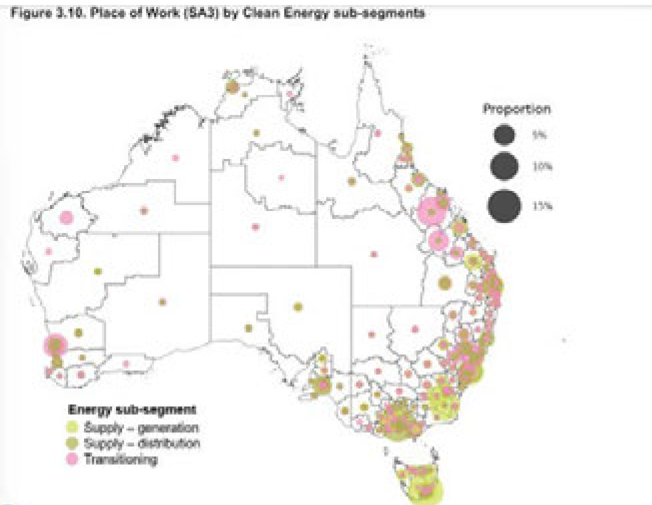


FIGURE 11: MAP OF ENERGY SUB SEGMENTS

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 per cent 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."

While 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)

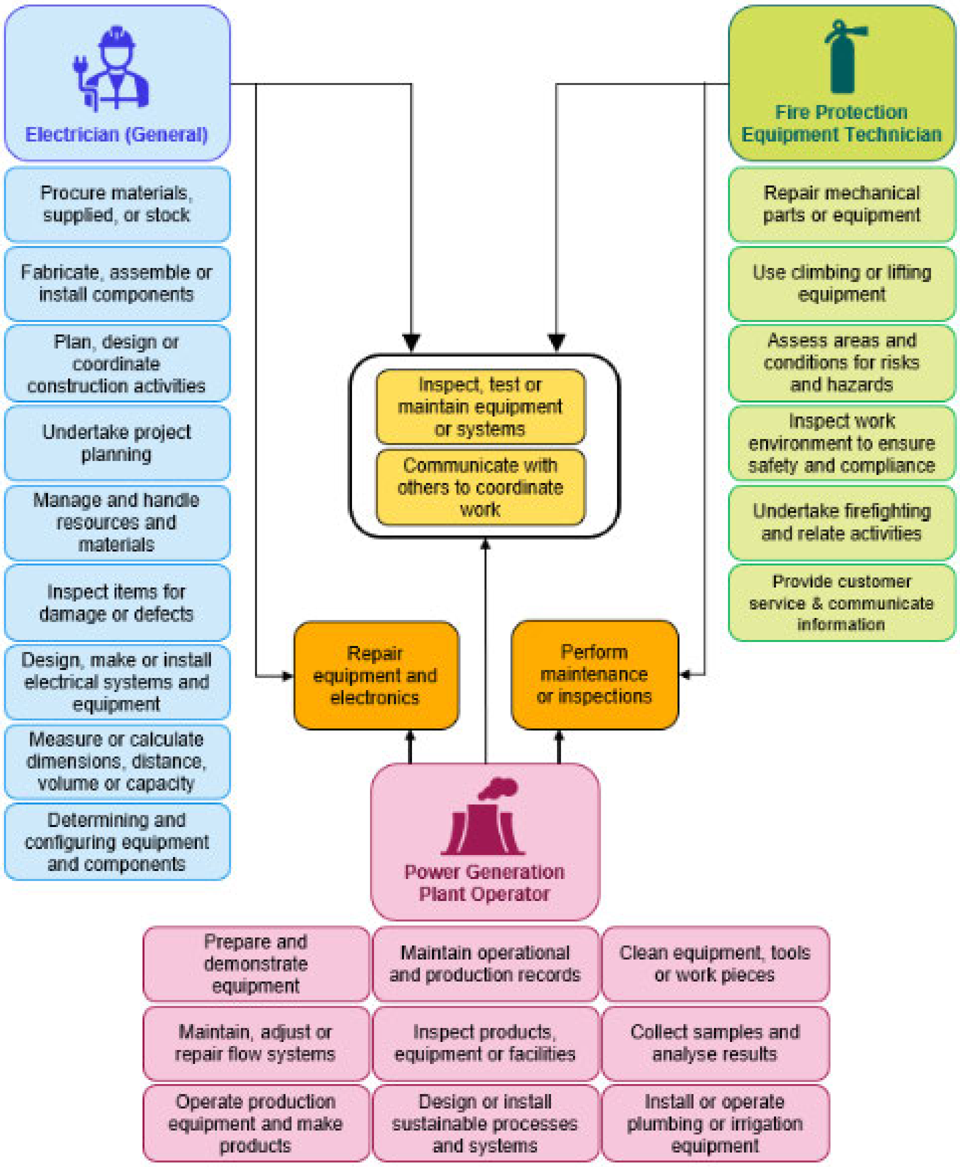
FIGURE 12: COMMON ENGINEERING TRANSITIONS

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, while 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:

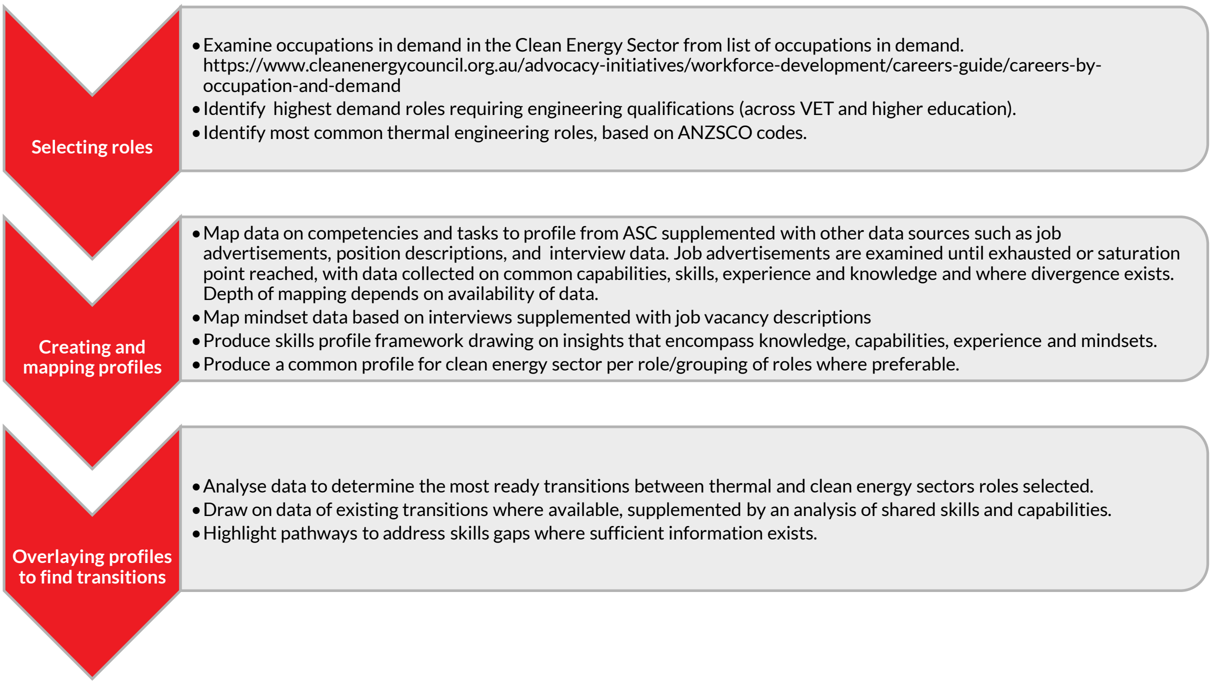


FIGURE 14: APPROACH TO PROFILE DEVELOPMENT

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 more than 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.

- While 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, while 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.

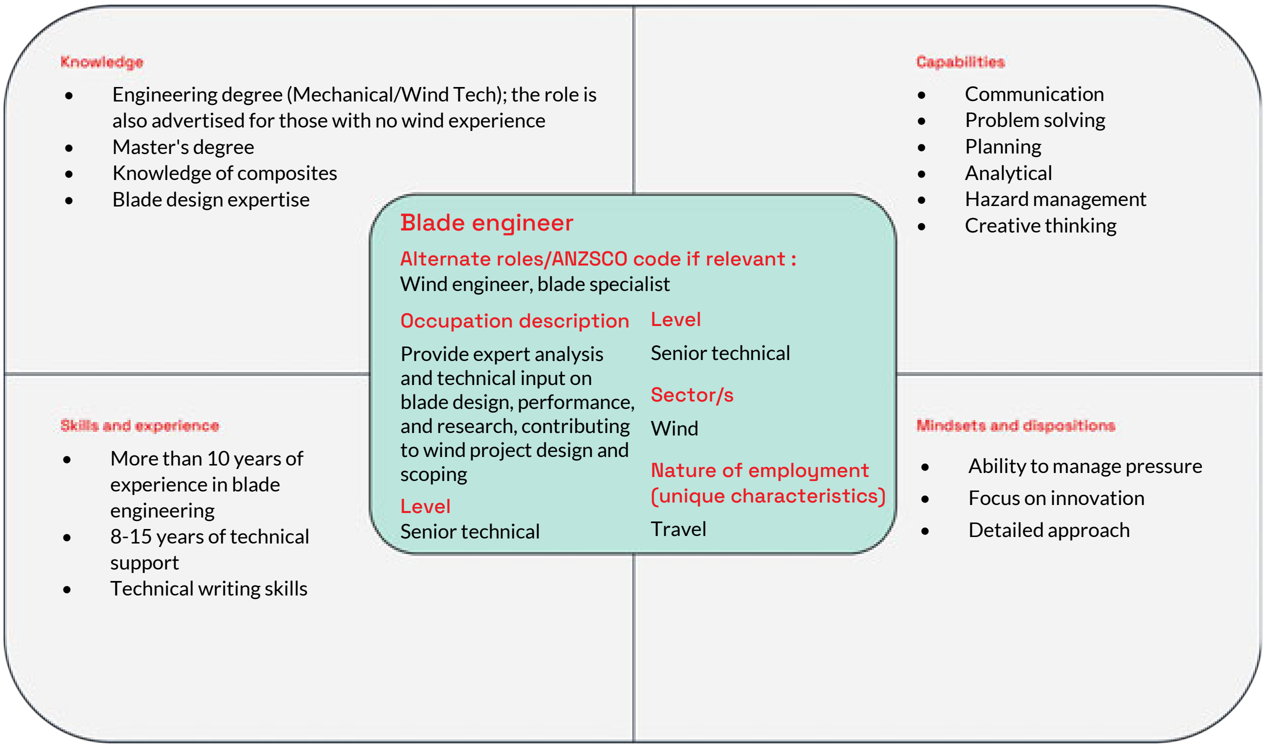


FIGURE 15: SAMPLE SKILLS PROFILE

Twenty skills profiles were developed based on the data collected, with profiles for the renewable energy sector generally providing more detail, especially regarding capabilities while 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 10 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 25 possible transitions identified. Most roles mapped to electrical engineering in the renewable sector, while 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 four mindsets and capabilities shared with HV engineers, power engineers and quality managers and seven with structural engineers. For ease of reading, only matches on four 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 10 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 Engineers Australia 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 – Engineers Australia 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/ Graduate Certificate of electrical engineering • Short course re substations and HV 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	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 two 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 emphasised. 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.

While 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 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 per cent 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 10 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 2023-2024 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 2024-2025 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 up 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 per cent 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 2024-2025 budget to upgrade training capacity, funding for a National Hydrogen Technology Skills Training Centre and bonuses for apprentices in priority areas among other initiatives.

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

While 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, while 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. While 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 while 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.

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11. Appendix

11.1 Skill profiles

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

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

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

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

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

Skills and experience

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

Mindsets and dispositions

- Manage pressure
- Innovation
- Detailed approach

Knowledge

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

Capabilities

- Communication
- Problem solving
- Quality assurance

Blade technician

Occupation description

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

Level

Entry-mid technical

Sector/s

Wind

Nature of employment (unique characteristics)

Travel

Seasonal

Skills and experience

- Manufacturing experience
- GWO blade repair
- GWO all training
- 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

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)

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

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

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

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

Skills and experience

- Compliance
- Documentation
- Budget management
  Testing and calibration

Mindsets and dispositions

- Initiative
- Innovation
- Fast paced
- Independence
- 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

- 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

- 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

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

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

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

Knowledge

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

Capabilities

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

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

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

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, well pumping

Sector/s

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

Knowledge

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

Capabilities

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

Skills and experience

- Record management
- Direct energy production

Mindsets and dispositions

- Initiative
- Collaborative

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

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

Skills and experience

- Technical design
- Electrical schematics
- Design systems

Mindsets and dispositions

- Initiative
- Detailed
- Collaborative

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

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

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, 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															
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
Battery deployment manager		x	x	x	x	x										x
Battery design specialist - utility scale		x	x	x	x											
Blade engineer			x	x												
Blade technician	x	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* VET for testing									x
Power Systems engineer			x	x			x									x
Quality Manager/Engineer		x	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				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					x

	Knowledge				Capabilities												Mindsets and dispositions									Skills			
ROLES (T indicates thermal)	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																				
Battery design specialist - utility scale		x			x						x		x						x	x									
Blade engineer						x					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					x						
Grid connection manager		x								x					x					x					x				
HV engineer		x	x			x					x	x	x	x												x			
Power Systems engineer		x		x		x					x	x	x	x										x		x			
Quality Manager/Engineer						x			x				x		x				x	x	x	x						x	
Solar farm technician - mechanical	x	x				x						x	x								x								
Wind farm technician - mechanical	x	x																											
Structural engineer	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
Electrical engineer (T)		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			
Mining engineering – ex petroleum (T)	x	x				x	x				x			x		x					x		x		x				
Petroleum engineer (T)						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			
Electrical engineering technician (T)	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 Engineers Australia 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 – Engineers Australia 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/ Civil engineer thermal → Quality manager thermal → Quality manager renewable	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 years 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	