Australian Government | Infrastructure Australia

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Infrastructure workforce and skills supply

A report from Infrastructure Australia's Market Capacity Program

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ACKNOWLEDGEMENT OF COUNTRY

Infrastructure Australia proudly acknowledges the Traditional Owners and Custodians of Australia, and their continuing connections to the land, waters and communities. We pay our respects to them and to their Elders past, present and emerging. In preparing for the future of our infrastructure, we acknowledge the importance of looking beyond the immediate past to learn from Aboriginal and Torres Strait Islander peoples' unique history of land management and settlement, art, culture and society that began over 65,000 years ago.

As part of Infrastructure Australia's commitment to reconciliation, we will continue to develop strong, mutually beneficial relationships with Aboriginal and Torres Strait Islander partners who can help us to innovate and deliver better outcomes for Aboriginal and Torres Strait Islander communities, recognising their expertise in improving quality of life in their communities.

Executive summary

Australia has ambitious plans when it comes to investing in public infrastructure. A skilled workforce that is available when required will be pivotal in realising these plans. The proposed rapid expansion of public infrastructure is testing the limits of existing capacity and capability. Signs of shortages are already prevalent across the workforce with demand anticipated to reach unprecedented levels, well beyond the sector's ability to service them. Projections show that at its projected peak in 2023 the infrastructure workforce will be 48% short of demand, a deficit of 93,000 people.

At a glance

- Public infrastructure draws from four infrastructure-based occupational groups: project management professionals; engineers, scientists and architects; structures and civil trades and labour; and finishing trades and labour.
- An estimated 182,000 individuals are currently engaged in the delivery of public infrastructure across Australia. This includes an estimated 25,000 project management professionals, 43,000 engineers, scientists and architects, 49,000 structures and civil trades and labourers and 65,000 finishing trades and labourers.
- 79% of the engaged workforce are in New South Wales, Victoria or Queensland, and 78% of the construction workforce are in major cities creating challenges for regional labour markets.
- Smaller jurisdictions or regional areas also face higher risks to workforce retention. A lack of diversity in construction work means that when government funding ceases, so do the jobs. Just under 30% of the relevant Northern Territory workforce is engaged in public infrastructure compared with under 15% in Queensland or Victoria.
- Detailed design work is increasingly being concentrated in New South Wales and Victoria where two-thirds of engaged engineers, scientists and architects reside, with Western Australia and Northern Territory having much higher proportions of finishing trades and labour.
- Of the 50 occupations identified as relevant to public infrastructure, some 34 are rated as either likely or potentially in shortage (16 occupations are rated as likely in shortage and 18 rated as potentially in shortage). Half of these are engineers, scientists and architects, although there are shortages in all occupation groups.
- Occupations do not capture the full extent of skills required to deliver public infrastructure. Consideration of roles within occupations is required to understand this. Analysis of Burning Glass Technologies job advertisements identified 81 roles (below occupation level) as likely or potentially in shortage, 22 of which are within occupations that are unlikely to be in shortage overall. These roles are mostly senior or specialist roles.
- Over the next three years demand for labour is anticipated to reach unprecedented levels. Labour shortages are anticipated to be three times greater than in 2017-2018, peaking at a likely shortfall of 93,000 workers in early 2023 or 48% higher than projected supply.
- Shortages are anticipated to peak at 19,000 project management professionals, 70,000 engineers, scientists and architects, 16,000 structural and civil trades and labour and 14,000 finishing trades and labour at different points across the next three years. The country is nearing peak demand for engineers, scientists and architects in 2021.
- Risks posed by an ageing workforce (40% to potentially retire in next 15 years) are compounded by regulatory and procurement practices that result in workforce inefficiencies the sector cannot afford as it copes with escalating demand.
- Efforts to grow the workforce are compromised by a range of cultural, geographical, diversity and education issues that constrain the sectors' ability to rapidly grow its workforce. Migration can not meet the gap alone, and border closures, limitations of visa programs and poor utilisation of existing migrants are additional constraints.
- Action is required. Continued investment in public infrastructure without significant expansion of workforce supply risks compounding shortages already evident in the workforce, increasing the risks to delivery of this once in a generation investment pipeline in the years to come.

Public infrastructure relies on a wide range of workers and skills for delivery

Public infrastructure is defined as any structure that is owned by the government or that is developed for the public good. Public infrastructure draws on a range of workers and skills to support delivery from four main infrastructure-based occupational groups: project management professionals; engineers, scientists and architects; structures and civil trades and labour and; finishing trades and labour.

Workers bring diverse and specialist skill sets, some of which are general (e.g. communication) or technical (e.g. project management) and found across many occupations, others are specialist and distinct to infrastructure with industry increasingly seeking workers with the right blend of general, technical and specialist skills as reflected in a 'T shaped' skills profile with both breadth and depth. Finding the right number of people with the right skills and experience, at the right time is, and will continue to be, a challenge for the sector.

The current workforce is small and geographically concentrated

The public infrastructure workforce is approximately 182,000 individuals. This is around 13% of a broader workforce of 1.37 million people that work in similar roles across construction and other industries. Figure 1 overleaf categorises this workforce by readiness to transition into public infrastructure and shows that most of these people are up to six months of training or equivalent experience away, although this varies for the different occupation groups.

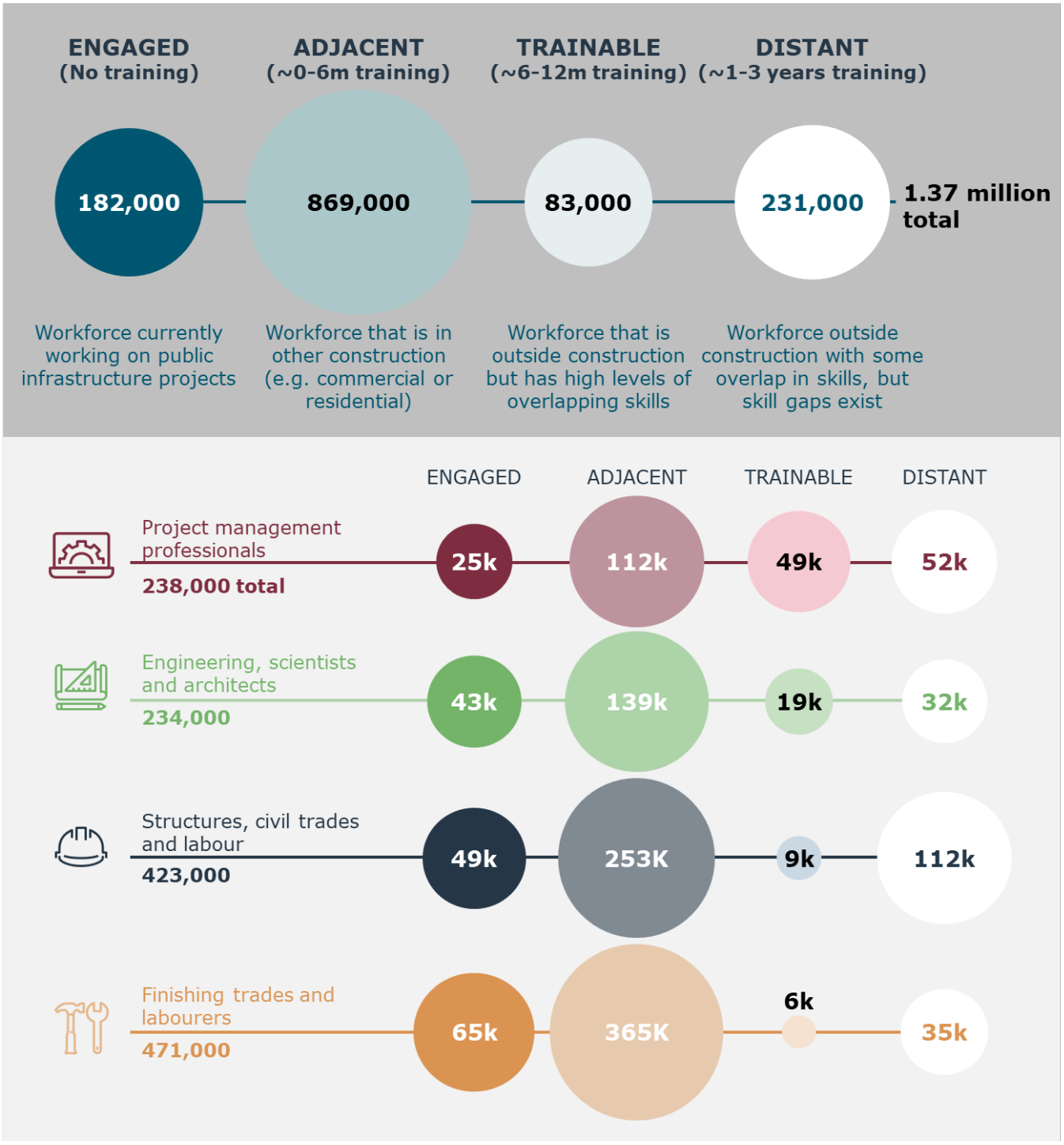
Mobility is limited between the engaged workforce that supports public infrastructure and the adjacent, trainable and distant workforces that share relevant skills. Skill and experience gaps, employment conditions, and salary differences all create barriers to mobility between these groups.

The engaged workforce is geographically concentrated, meaning capacity to deliver public infrastructure is variable across the country. Approximately four out of five workers are based in New South Wales, Victoria or Queensland. The vast majority live in major cities. In a buoyant market this creates difficulties for non-metropolitan areas to source labour.

A lack of diversity in construction work means that when government funding ceases, so do the jobs. For example, 28% of the relevant Northern Territory workforce is engaged in public infrastructure compared with less than 15% in Queensland or Victoria.

Capacity is constrained further when considering occupational groups. Two-thirds of engineers, scientists and architects engaged in public infrastructure work live in New South Wales or Victoria. Western Australia has greater access to finishing trades and labour. This is reflective of a broader trend where design may be conducted remotely but construction cannot.

Figure 1: Snapshot of workforce relevant to public infrastructure[1]



The workforce is already showing significant signs of shortage

Australia's currently planned infrastructure will extend the present infrastructure boom to 2025. The workforce is already exhibiting signs of strain as projects commence. Figure 2 shows that over two-thirds of key occupations are likely or potentially in shortage. Challenges are most acute amongst engineers, scientists and architects, which are expected to be 70,000 people short of demand in late 2021. All phases and all types of public infrastructure projects are reliant on this workforce, and so this shortage is likely to cause delays in projects. Shortages are also present across all other occupational groups, with peak unavailability in 2023.

Figure 2: Current state shortages across the infrastructure sector[2]

	Likely Shortages	Potential Shortages	Unlikely Shortages
Project Management Professionals	• Procurement management	• Construction management • Risk management	• Commercial management • Environmental and occupational health professionals • Project management
Engineers, Scientists and Architects	• Building surveyor • Civil engineer • Electrical engineer • Engineering manager • Environmental professionals • Geologists, geophysicists and hydrogeologists • Geotechnical engineer • Land surveyor • Materials engineer • Quantity surveyor • Other professional engineers, scientists, etc.	• Electronic engineer • IT professionals/engineers • Maintenance planner • Production engineer • Structural engineer • Telecommunications engineer • Mechanical engineer	• Architect • Landscape architect • Draftsperson
Structural and Civil Trades and Labour	• Driller (piling/foundation)	• Bricklayer • Carpenters and joiners • Concreter • Crane operator • Rail track worker • Road based civil plant Operator	• Plant operator • Rigger and dogman • Structural steel erector • Truck drivers
Finishing Trades and Labour	• Electrical line workers • Telecommunications cabler • Telecommunications field staff • Tiler	• Electricians • Glazier • Painting trades • General construction labourer	• Electrical or telecommunications trades assistant • Mechanical engineering trades workers • Plasterers • Plumbers • Safety officers

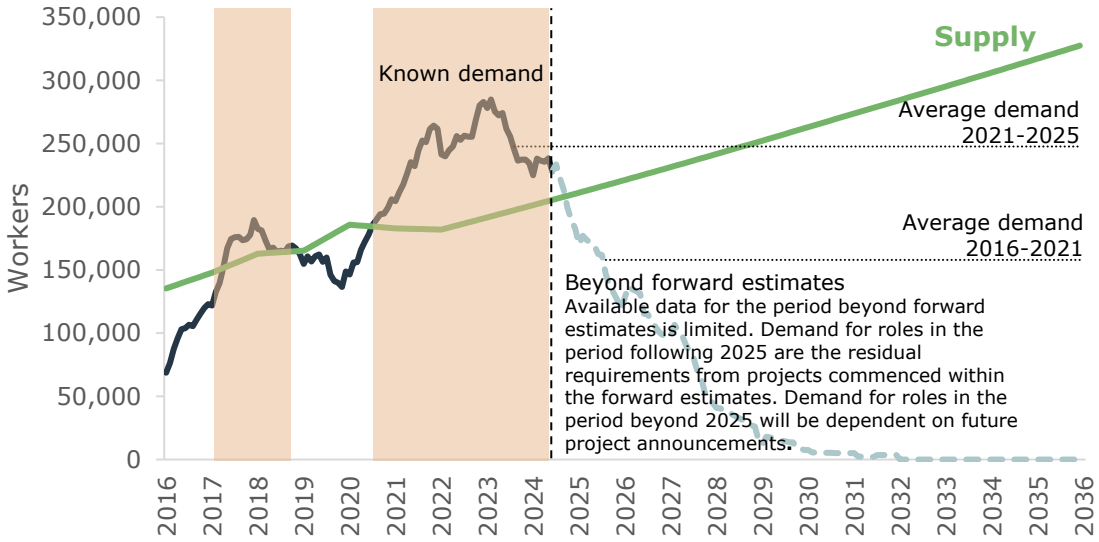
Shortages can also be found at more granular levels, for example specialist or senior roles within an occupation. The absence of one worker with a specific skill set can have significant implications for a project and a debilitating impact on the industry if not addressed. Eighty-one specific roles that exist within occupations have been identified as likely or potentially in shortage. Twenty-two of these are part of occupations that are not considered to be in shortage overall.

In some cases, shortages are also driven by changing skills needs, which mean the experience of the existing workforce is no longer relevant.

Planned demand is anticipated to dramatically exceed the workforce's capacity

Over the next three years demand for labour in public infrastructure is projected to reach unprecedented levels. The labour shortages are anticipated to be more than three times as severe as experienced in 2017-2018, peaking at 93,000 additional workers required in early 2023. At this point, approximately one in three jobs advertised in public infrastructure would remain unfilled. This is illustrated in Figure 3 below. Shortages are expected to last until at least 2024 based on currently confirmed projects that are primarily focused over the forward estimates. Even if the shortages do not cause delays on projects, the workforce challenges will likely extend further as new projects are confirmed. A conservative estimate shows this could extend out till 2028.

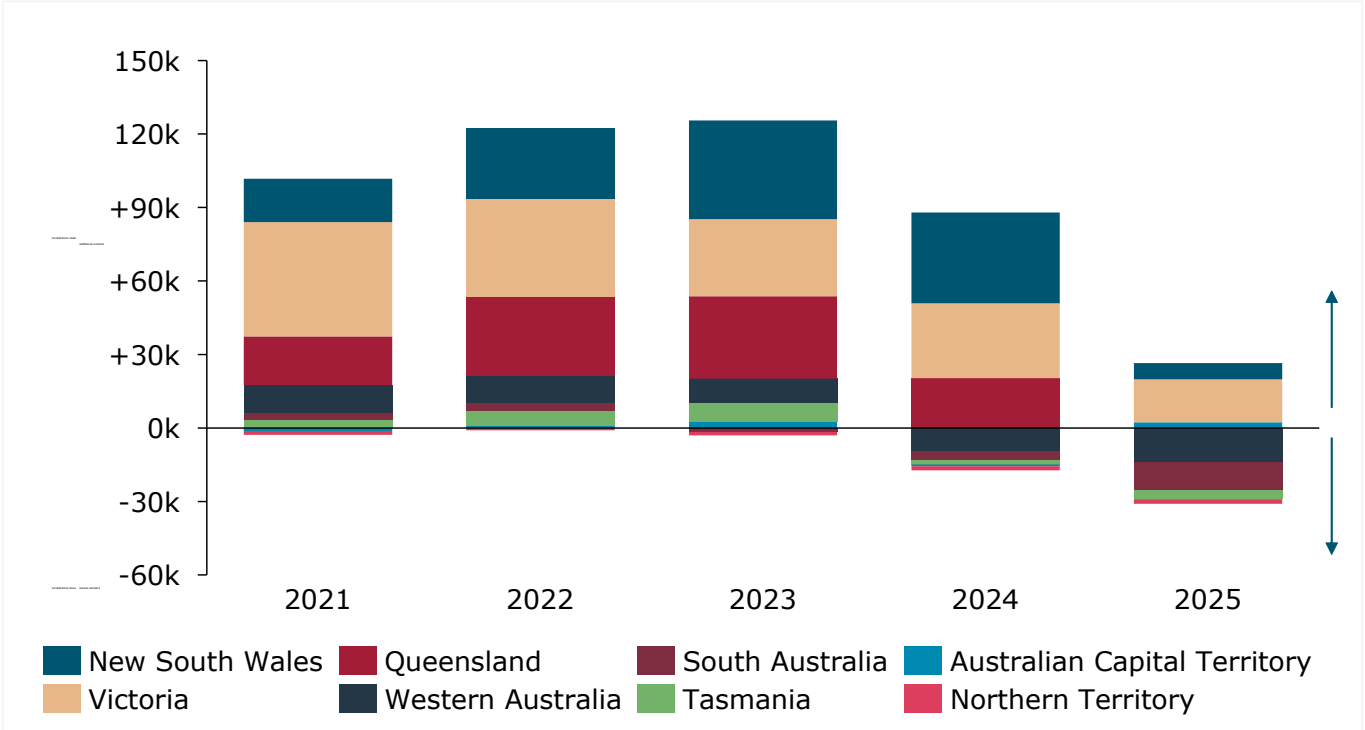
Figure 3: National supply and demand for workers in public infrastructure, historical (2016-2021) and projection (2021-2032)[3]



Note: the visibility of forward infrastructure spending is limited by available data. Only publicly known projects are included, and therefore generally occur within the forward estimates. As a result, future expenditure is likely to be larger than forecast beyond the forward estimates as new projects are announced. Increased clarity of the long-term pipeline is highly desired to support this understanding.

The national picture also masks significant variation across the country. Despite having the largest workforces, New South Wales, Victoria and Queensland face the greatest risk of shortage. Figure 4 shows that demand is anticipated to significantly outpace supply for these three states every year from 2021 to 2024.

Figure 4: Net required additional public infrastructure workers by jurisdiction, 2021–2025 (000s)[4]



All jurisdictions except the Northern Territory will have a shortage at least nearly half the size of their projected workforce, although not all at the same time. There will be some opportunity to

resolve specific local shortages through interstate migration, but this will not address the major national shortages across 2021-2024. In considering potential shortages across states and territories it is important to note also the potential impact from competing sectors of the economy, for example oil and gas construction, not captured through this analysis as it is focused on major public infrastructure.

As overall labour shortages persist, specific occupation shortages will become more acute. Between 2021 and 2024 shortages are anticipated in all four key occupational groupings but are likely greatest amongst engineers (multiple) and general construction labour. Procurement professionals, surveyors (various), geologists and similar occupations, road and civil based plant operators, drillers, safety officers, telecommunication field staff and electrical line workers are other occupations with strong likelihood of nationwide shortage.

Unless addressed, labour shortages are likely to spill over to other sectors and industries, as each worker who takes a job delivering public infrastructure more than likely leaves a vacancy elsewhere that must be filled. This drives a war for talent and may inflate costs. Historically, public infrastructure has utilised 12-14% of the overall workforce in relevant occupations. If demand estimates are realised this would require the share of the workforce supporting public infrastructure to increase to 20% by 2023. More than 50% of engineers, scientists and architects working in other construction sectors would need to retrain to work in public infrastructure this year, as well as 16% of project management professionals, 6% of structures and civil tradespeople and labourers, and 3% of finishing tradespeople and labourers by 2023. This compares to shifts of approximately 2.1-3.5% for each group over the past five years.

Constraints limit the productivity of existing workers and attraction of new ones

Anticipated demand can only be met though the mobilisation and productivity of existing workers and attraction of new ones. However, a range of constraints and barriers limit these opportunities.

The infrastructure workforce is ageing, with over 40% of current workers likely to retire over the next 15 years. While new entrants will join the sector, the loss of experience will be significant. This challenge is greatest for project management professionals and structures and civil trades and labour, both of which have more than 40% of workers over the age of 45. At the same time regulatory and procurement practices result in workforce inefficiencies that limit the productivity of the existing workforce, which the sector cannot afford as it copes with escalating demand.

At a time when the sector needs to grow its workforce, efforts are compromised by a range of cultural, geographical, diversity and education issues that constrain the sectors' ability to rapidly grow its workforce.

Migration, which is often perceived as a panacea to these shortages, can no longer be relied upon to fill a growing skills gap. Border closures, lead times and complexity of visa processes and poor utilisation of existing migrants constrain the sectors' ability to effectively respond to the supply challenge through skilled migration, whether through targeted critical skills, or more generally. Even if these issues were resolved, skilled migration is not a large enough pipeline to address the demand challenges. It is projected to provide just 6% of new entrants to the workforce.

The challenges for the capacity and capability of Australia's public infrastructure workforce are clear. As the gap between demand and supply grows, the importance of early action is perspicuous. Many proposed investments are in the early stages of planning, but continued investment without significant expansion of workforce supply risks compounding shortages already evident in the public infrastructure workforce, increasing the risks to delivery of this once in a generation investment pipeline in the years to come.

These issues are further explored across the following sections:

- **Section 1** provides an overview of the type of workforce needed to design, construct and maintain public infrastructure in Australia.
- **Section 2** outlines the current public infrastructure workforce including the geographic distribution for each occupation category.
- **Section 3** assesses pressures on the current public infrastructure workforce.
- **Section 4** assesses the capacity and capability of the future public infrastructure workforce to meet predicted future workforce demand.
- **Section 5** outlines the constraints to addressing Australia's looming infrastructure workforce shortage through mobilisation of existing workers and growth in new workers.

1. Key skills in the public infrastructure sector

At a glance

- This section provides an overview of the type of workforce needed to design, construct and maintain public infrastructure in Australia.
- Public infrastructure draws from four main infrastructure-based occupational groups: project management professionals; engineers, scientists and architects; structures and civil trades and labour; and finishing trades and labour.
- Workers bring diverse and specialist skill sets, some of which are *general (e.g. communication) or technical (e.g. project management)* that are found across many occupations; others are *specialist* and distinct to infrastructure.
- Industry is increasingly seeking workers with the right blend of general, technical and specialist skills as reflected in a 'T shaped' skills profile.

Public infrastructure includes the development of roads, bridges, airports, train stations, water, gas and electricity systems, as well as public assets such as community centres and hospitals.[5] It is a sub-sector of the broader construction industry which also includes residential construction (detached medium density dwellings that are constructed for the purpose of housing), civil construction and private industrial and commercial construction (medium to high rise dwellings which may have multiple occupants that are constructed solely through investment of a private individual or company, for a commercial purpose).

The focus of this section of the report is on the nature of the workforce required to meet Australia's growing public infrastructure demands.

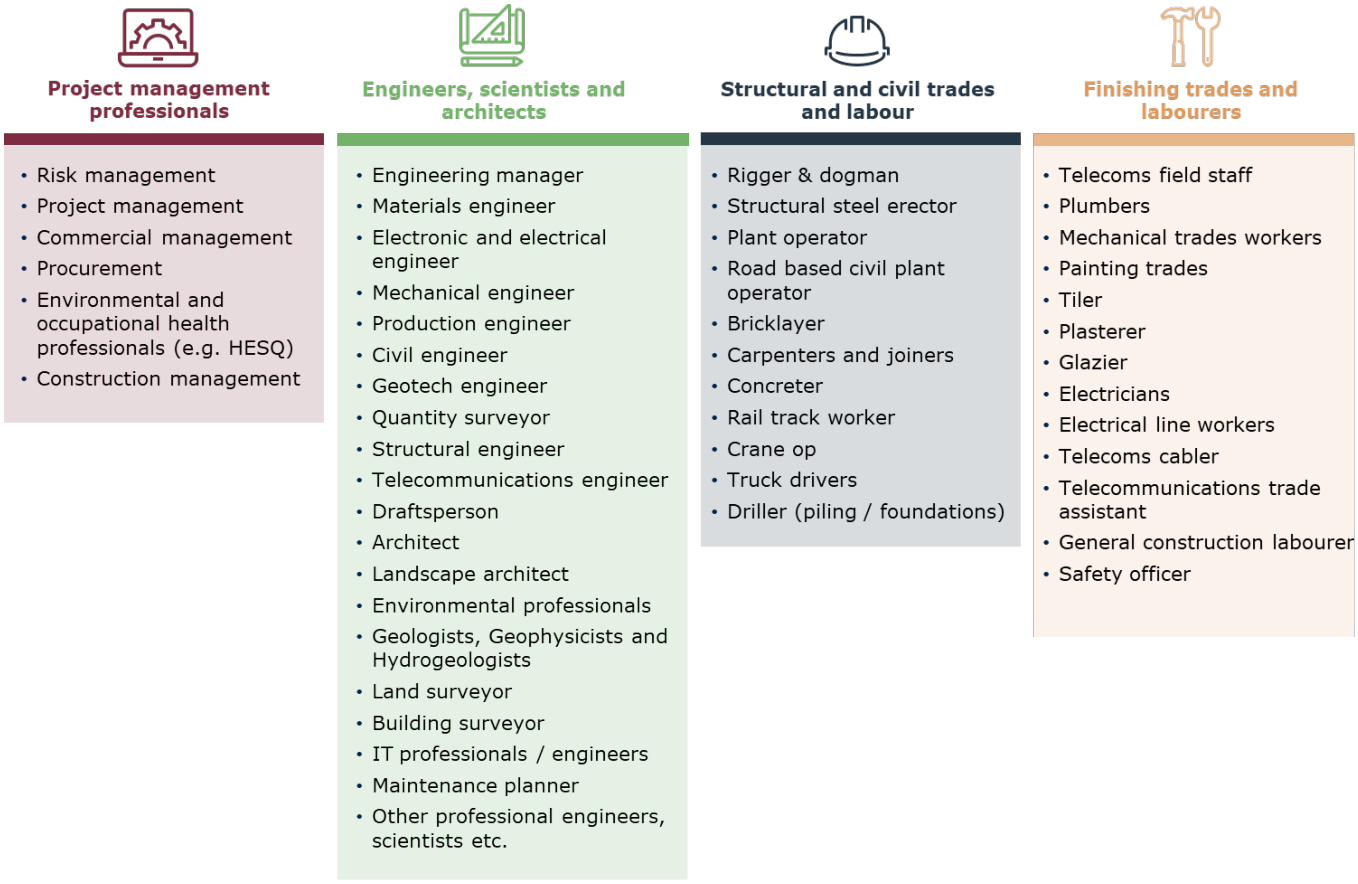
The design, construction and maintenance of public infrastructure draws on four main groups of workers

The infrastructure workforce consists of four main occupational groups:

- **Project management professionals** are involved in the planning, organisation, direction, control and coordination of the construction process. These occupations are typically responsible for the physical and human resources engaged across the construction lifecycle, including planning, procurement, risk and compliance.
- **Engineers, scientists and architects** are engaged on infrastructure projects to design, plan, organise and manage the detailed specifications of the construction and maintenance. These occupations are typically engaged early in the construction process, for the duration of the build, and include many subspecialists that have unique knowledge.
- **Structures and civil trades and labour** includes individuals experienced in the pre-construction preparation and construction works. It includes excavation, steelwork, concreting, carpentry, and drilling. It also includes activities that underpin these tasks, such as cranes and trucks.
- **Finishing trades and labourers** includes individuals who move infrastructure projects from construction to completion. They develop the fit out for construction projects and ensure infrastructure is operational and can be used for their intended purpose.

Each group contains discrete occupations, as set out in Figure 5. These occupations were informed by Australian and New Zealand Standard Classification of Occupations (ANZSCO) and through consultation with industry experts and additional key stakeholders.

Figure 5: Public infrastructure occupational taxonomy[6]



This classification was developed to account for the limitations of the existing ANZSCO taxonomy. Further, each occupation includes a range of roles which reflect the different specialisations or experiences that distinguish positions within a given occupation. These roles were identified using job advertisement data from Burning Glass, along with consultation with industry. This provides a greater level of specificity on the workforce needed to support the current and future infrastructure pipeline that would otherwise be masked by purely focussing on ANZSCO. The full classification is outlined in Appendix A – Occupation and role mapping to ANZSCO, including the ANZSCO alignments and the specific roles.

Burning Glass Technologies aggregates job advertisements to create insight into the supply and demand for talent. The data set includes around nine million job advertisements covering every occupation and industry in Australia. Through their proprietary algorithms they have defined and referenced over 1,500 general and technical skills identified by employers as important for new hires. This can be used to understand trends in skill demand, including skill needs for specific occupations.

Outside of the four main occupational groups there are other occupations that make public infrastructure possible. This fifth group of individuals includes individuals that support general business operations in any organisation – for example human resources, administration and accounting as well as specialists in other industries like bankers, lawyers and economists. This group of individuals has been excluded from this analysis, but are no less important to the functioning of the infrastructure industry.

Public infrastructure requires diverse and specialist skill sets

Public infrastructure relies on a large workforce with a broad range of skills. These range from long-practiced and common skillsets to those that are niche and at the cutting-edge of technology.

At the most granular level, every occupation and role represent a portfolio of skills. Skills are combined in different ways to perform specific jobs or tasks. For the purposes of this analysis three categories of skills have been identified:

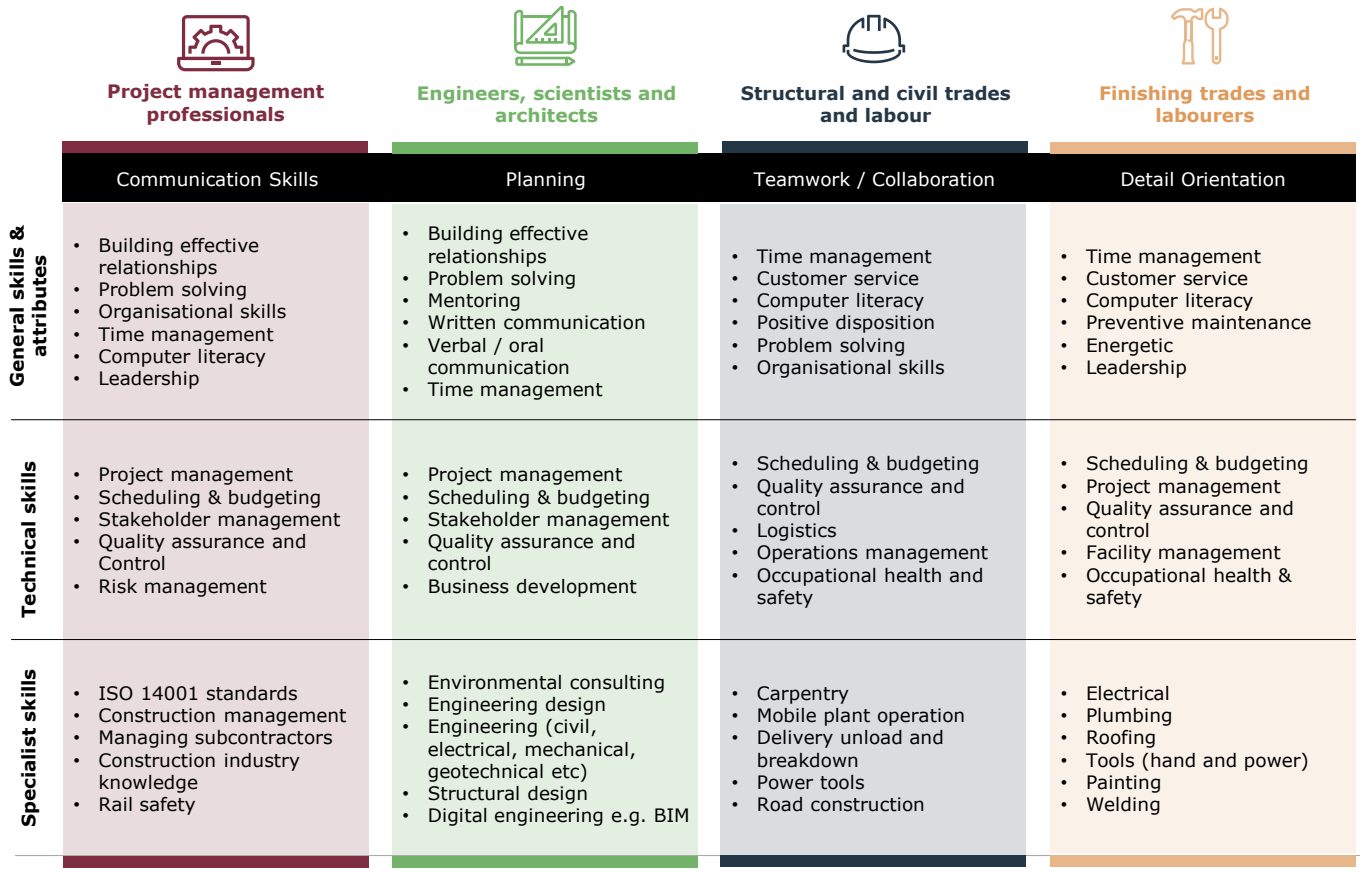
- **Generalist skills** are often referred to as enterprise or soft skills and include skills or attributes that are common to most occupations such as communication, problem solving and time management.
- **Technical skills** are required to perform specific, practical tasks that are necessary for many occupations, but are not confined to construction. These may include skills such as project management, stakeholder management or quality assurance and control.
- **Specialist skills** are required by a specific profession and often require a certain qualification and/or accreditation. Construction related specialist skills are often distinct to the industry. These include types of engineering, construction management and construction labour skills.

Analysis of the skills employers' request in job ads shows that most roles require a combination of these skills as reflected by a "T shaped" skills profile, with generalist and technical skills to provide breadth, and specialist skills the depth. This is illustrated in Figure 6.

What is a T-shaped skills profile?

A T-shaped skills profile is one of deep specialist knowledge and skills in a particular area, the vertical stroke of the 'T', along with generalist and technical skills, a collaboration mindset and people skills, the horizontal stroke.[7]

Figure 6: Example skills profiles by occupational group[8]



To assist with a greater focus on skills, the National Skills Commission (NSC) has recently released a BETA version of an Australian Skills Classification. Over time, this will provide a common language for skills, and the range of skills linked to specific occupations.[9]

The BETA introduces a set of core competencies and specialist tasks designed to describe day-to-day work within an occupation. While presenting a common language, further work is required to connect them to job advertisements to understand how demand for skills is changing. For this reason, this report makes use of the Burning Glass Technologies skills taxonomy.

2. The current public infrastructure workforce

At a glance

- This section outlines the current public infrastructure workforce including the geographic distribution for each occupation category.
- An estimated 182,000 individuals are currently engaged in the delivery of public infrastructure across Australia. This represents about 13% of the total 1.37 million people working in the occupations outlined in Section 1.
- The workforce engaged with public infrastructure includes an estimated 25,000 project management professionals, 43,000 engineers, scientists and architects, 49,000 structures and civil trades and labourers and 65,000 finishing trades and labourers.
- The remaining 1.18 million individuals support a range of other sectors and industries.
    - Approximately 869,000 people (63% of the total workforce) work in other construction sectors and could potentially retrain to work in public infrastructure within six months.
    - Approximately 83,000 people (6% of the total workforce) could support delivery of public infrastructure in six to 12 months with skill development and transition programs in place.
    - A final 231,000 (17% of the total workforce) would take one to three years to transition, subject to considerable investment in skills development.
- Beyond skills and experience gaps, employment conditions and lack of interest will make it difficult to attract enough individuals from other industries. If successful in attracting individuals, competition for labour will likely result in a rapid escalation in labour costs.
- The country's workforce distribution also presents challenges. 79% of the engaged workforce are in New South Wales, Victoria or Queensland, and 78% of the construction workforce are in major cities. In a buoyant market this creates difficulties for non-metropolitan areas to source labour.
- When individuals are attracted to smaller jurisdictions or regional areas the risks to retention are higher. A lack of diversity in construction work means that when government funding ceases so do the jobs. 28% of the relevant Northern Territory workforce is engaged in public infrastructure compared with just 12-13% in Queensland or Victoria.
- Not all work needs to be decentralised. There are indicators that detailed design is being concentrated in New South Wales and Victoria where two-thirds of engaged engineers, scientists and architects reside, with Western Australia and Northern Territory having much higher proportions of finishing trades and labour. While design may be undertaken remotely, construction cannot.

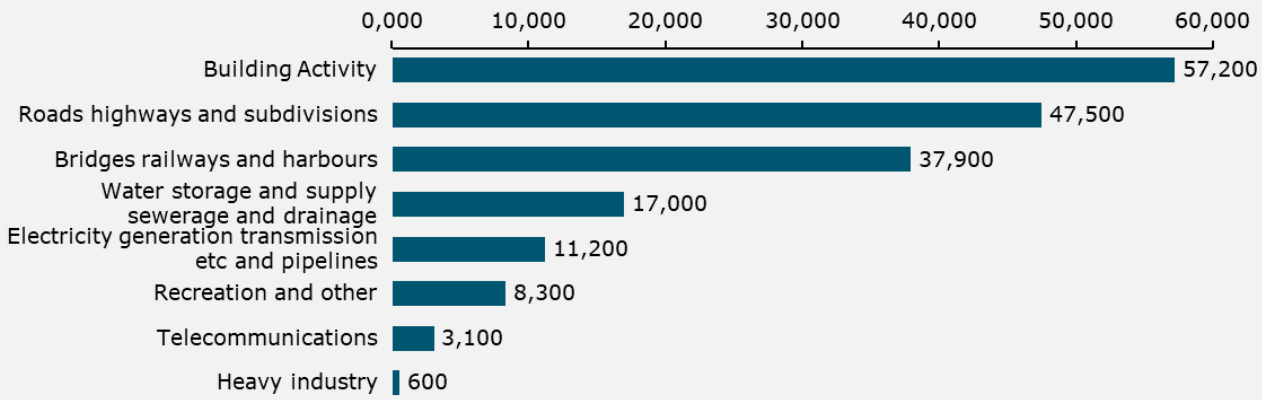
An estimated 182,000 Australians work in public infrastructure, out of a total 1.37 million working in occupations outlined in Section 1. A wide range of industries compete for similar individuals while an uneven distribution of people presents geographical challenges for the sector that must be overcome.

This section outlines the current public infrastructure workforce including the geographic distribution for each occupation category.

An estimated 182,000 individuals are currently engaged in the delivery of public infrastructure across Australia

There are approximately 182,000 people currently working on public infrastructure projects across Australia. This can be broken down into sectors within infrastructure. Figure 7 highlights that most individuals are engaged on building activity (residential and commercial construction), roads highways and subdivisions, and bridges, railways and harbours.

Figure 7: Estimated number of individuals by public infrastructure sector[10]



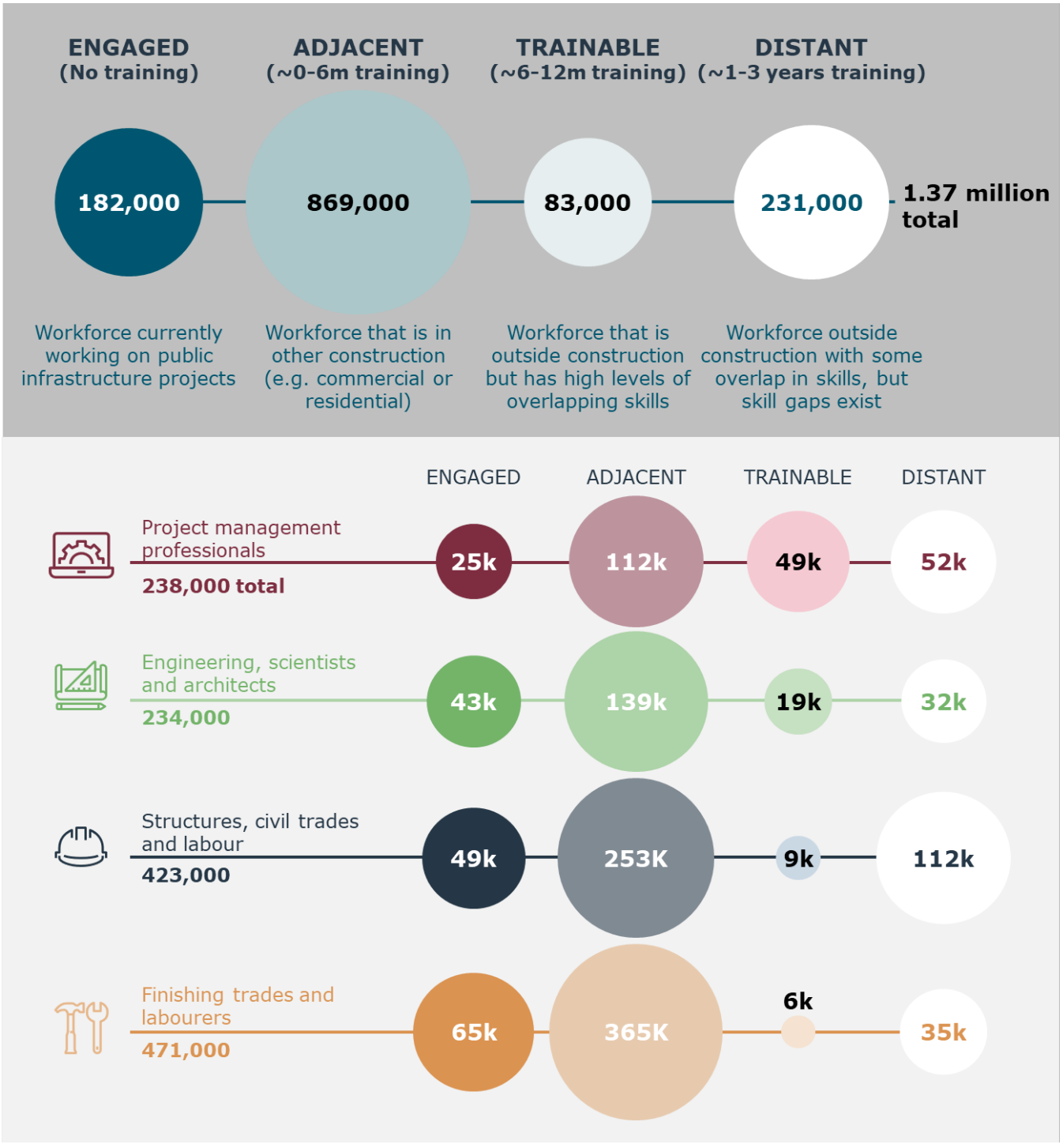
Beyond the engaged workforce, there are another 1.18m individuals working in the occupations outlined in Section 1. They can be classified into three further categories differentiated by their readiness to transition to work in public infrastructure: adjacent, trainable and distant.

The adjacent category includes people working in other construction sectors, while the trainable and distant groups have been defined based on the similarity of the skills requested by employers. The closer a worker is to engaged, the less additional training would be required to be ready to work on a public infrastructure project. Estimates range from 0-6 months for adjacent through to 1-3 years if distant.

Figure 8 provides definitions of the readiness categories and a snapshot of the total workforce. It shows that while there is a large adjacent workforce in the other construction sectors, only project management professionals have significant numbers in the trainable category. While there is a large distant category, these individuals would need significant retraining before they could usefully contribute to public infrastructure projects.

More detail is available in Appendix B – Occupational group snapshots, which includes the numbers for specific occupations and jurisdictional distributions.

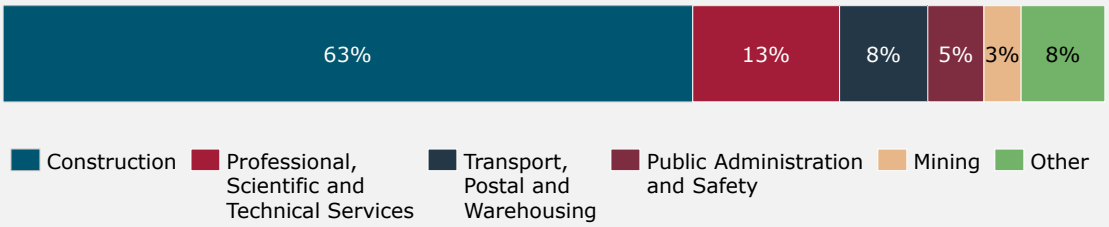
Figure 8: Snapshot of workforce relevant to public infrastructure[11]



There are a further 1.18 million workers in relevant occupations, but many are in fundamentally different roles

Figure 8 shows there are a total 1.37 million people working in the relevant occupations outlined in Section 1. 63% of this workforce are in the construction industry, according to Australia and New Zealand Standard Industrial Classifications (ANZSIC) definitions, which includes public infrastructure, along with residential construction, civil construction and private industrial and commercial construction. The remaining 37% work in other industries such as professional, scientific and technical services, transport, postal and warehousing, public administration and safety and mining. Figure 9 below shows how these individuals are distributed by industry.

Figure 9: Distribution of relevant occupations by industry[12]

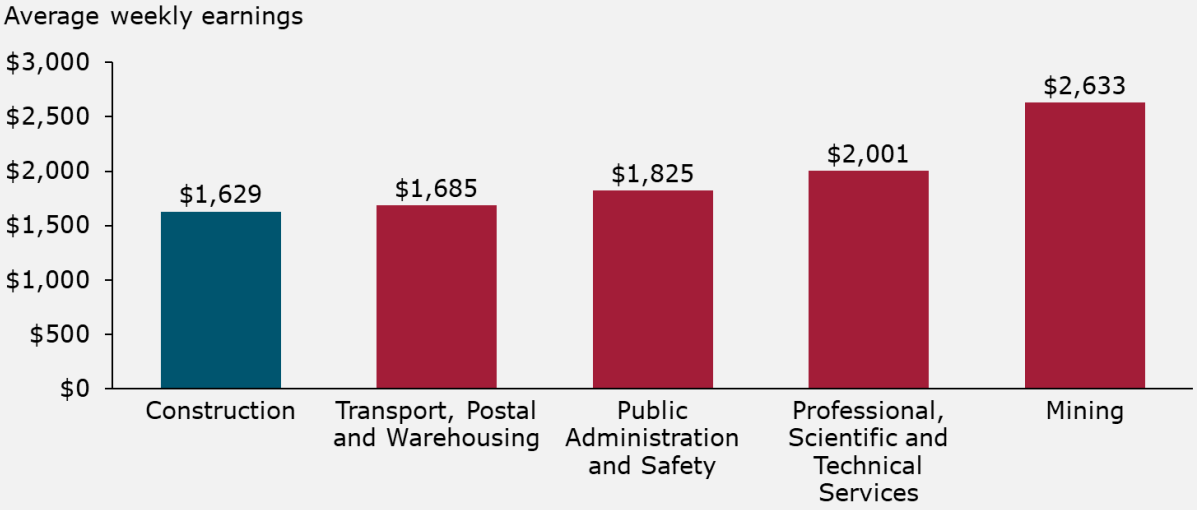


This shows that large portions of the 1.18 million workforce in the adjacent, trainable and distant categories are in fundamentally different roles and may not actually have the skills needed to work in public infrastructure, although they could be retrained with sufficient time and resources. While this presents as an opportunity to address changing workforce requirements of public infrastructure it will not be a realistic solution in many cases.

Most of the adjacent, trainable and distant workforce is already gainfully employed, and so the individual must want to leave to attract them to public infrastructure. Overcoming this hurdle is not insignificant, as industry consultations have repeatedly referenced the difficulty of managing workforces through boom and bust periods, which are hard to predict and make the industry unappealing to new entrants.

Many other industries that rely on similar skillsets often pay more and are more likely to keep or attract individuals. Figure 10 shows that construction has relatively low average earnings compared to other relevant industries, suggesting that attracting individuals from other industries is not a reliable approach, and would likely result in a significant escalation in costs.

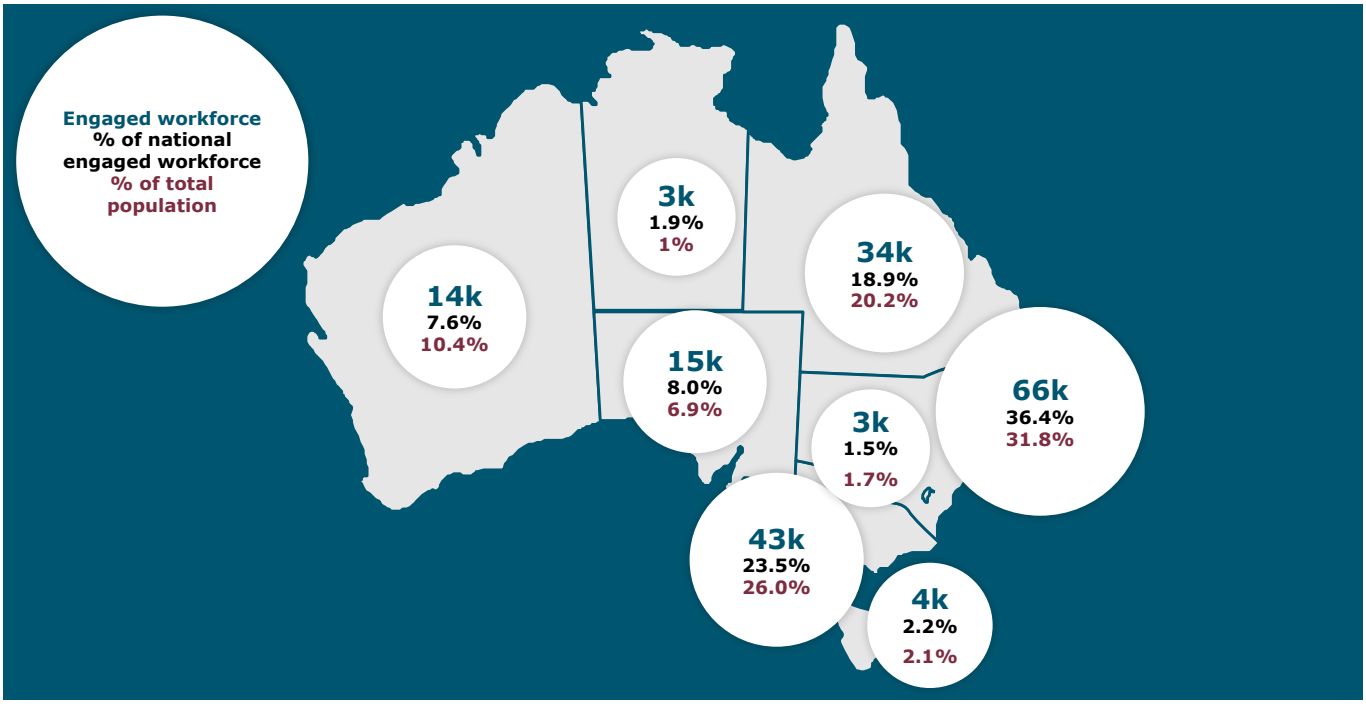
Figure 10: Average weekly earnings for most common industries among relevant occupations[13]



The engaged workforce resides in cities and larger states

The engaged workforce is geographically concentrated, reflecting the location dependent nature of public infrastructure projects. Figure 11 below shows that three states dominate, with 79% of individuals based in New South Wales, Victoria and Queensland.

Figure 11: Geographic distribution of engaged workforce and total population by jurisdiction[14]



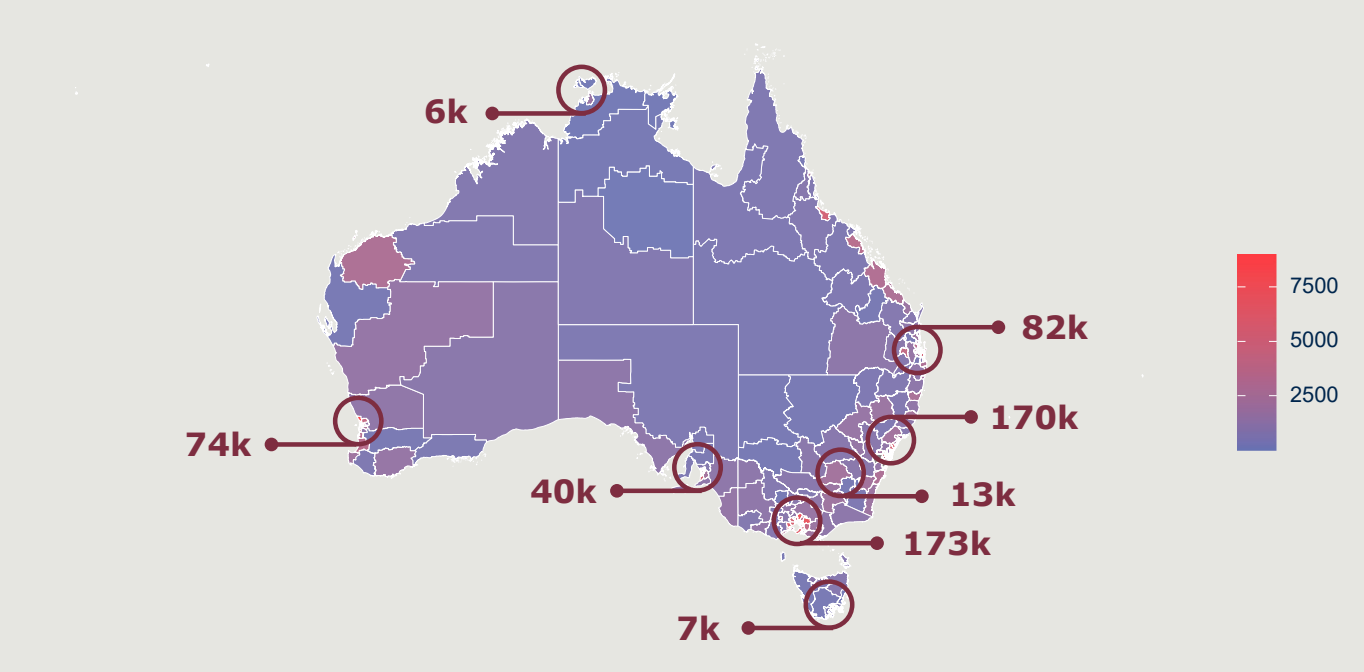
Total population data based on Australian Bureau of Statistics national, state and territory population September 2020.

The engaged supply of individuals is not distributed evenly across states and territories, based on the detailed supply analysis outlined in Appendix F – Modelling methodology. For example, nearly two-thirds of engaged engineers, scientists and architects live in New South Wales and Victoria, while Western Australia has a much higher proportion of finishing trades and labour than other occupational groups. The Northern Territory is the largest outlier, with a very strong skew towards both structural and finishing trades, and very few professional roles relative to their workforce. This is likely reflective of the fact that detailed design is something that can be done remotely but physical construction can not.

The Northern Territory is also the jurisdiction most concentrated on public infrastructure in 2021, with 28% of individuals in relevant occupations classified as engaged. No other state has more than 20% of the relevant workforce engaged in public infrastructure, and some of the largest workforces in Victoria and Queensland have among the lowest focus on infrastructure, with just 12-13% of each state's workforce classified as engaged. This indicates that smaller jurisdictions do not have the diversity in construction work to accommodate significant shifts in demand for public infrastructure. This may exacerbate the already precarious imbalance between the public infrastructure workforce concentration in larger states and the population spread across the country as individuals migrate to where opportunities are greater when projects conclude.

Figure 12 below shows that the construction workforce is also concentrated in urban areas, even more so than the Australian workforce overall. This includes both the engaged and the adjacent workforces as they cannot accurately be separated at this granular level. 78% of the construction workforce live in major cities (as defined by the Australian Bureau of Statistics (ABS) Remoteness Area classifications), 3% higher than the share of Australia's total population that live in these areas. From a market perspective the 3% overrepresentation in major cities can have a significant impact on the ability to deliver public infrastructure outside of metropolitan areas due to the challenges incentivising individuals to move to regional areas. This becomes even harder in a buoyant market.

Figure 12: Geographic distribution of construction (engaged and adjacent) workforce by region (SA3)[15]



The constraints of providing a workforce for projects in regional areas, smaller states and states that compete with other industries such as mining that have the potential to draw individuals from the public infrastructure workforce, can be difficult to overcome. The availability and nature of work, lifestyle and training opportunities will always dictate where occupations cluster but understanding and implementing methods to enable mobility will help to overcome geographical impediments.

3. Emerging workforce pressures

At a glance

- This section assesses pressures on the current public infrastructure workforce.
- Of the 50 occupations identified as relevant to public infrastructure, 16 occupations are rated as likely in shortage and 18 rated as potentially in shortage. Half of these are engineers, scientists and architects, although there are shortages in all occupation groups.
- Occupations do not capture the full extent of skills required to deliver public infrastructure. To understand this consideration of roles within occupations is required.
- Analysis of Burning Glass Technologies job advertisements identified 81 roles as likely or potentially in shortage, 22 of which are within occupations that are unlikely to be in shortage overall. These roles are mostly senior or specialist.
- The absence of one worker with a specific skill set can have significant implications for a project and a debilitating impact on the industry if not addressed.
- Shortages are likely being compounded by changing skills needs that lead to the existing workforce no longer having the right skills. Occupations identified with a high degree of skill change also indicate a strong likelihood of being in shortage.
- Increased demand for generalist and technical skills is contributing to a large share of change as employers seek more 'T shaped' skill profiles, as described in Section 1.
- The challenge is greatest with engineers who historically have preferenced specialist skills. Just 24% of skills required for engineers, scientists and architects are generalist, compared to 32% in other infrastructure occupations.

Australia's public infrastructure workforce fluctuates in response to demand. Significant capacity shortages during 2017-18 were followed by a period of weaker demand. This ebb and flow leads to a loss of skills as the reduced number of available jobs forces people to find employment elsewhere, after which they may not return. Australia is now at the verge of its next infrastructure boom and the workforce is showing signs of strain. Shortages already present across occupations and roles are being compounded by changing skill needs.

This section outlines assessments of current pressures on the public infrastructure workforce.

Australia's public infrastructure workforce is under strain

The pressure placed by new infrastructure investment on Australia's public infrastructure workforce is beginning to show. Some occupations are experiencing short-term acute shortages, whereas other shortages are reflective of systemic issues in the industry. This raises concerns that as our projected infrastructure pipeline increases, existing shortages will worsen and new ones will emerge.

Of the 50 occupations identified as relevant to public infrastructure in this context, 16 are likely already in shortage, 18 are potentially in shortage and only 16 are estimated to have sufficient capacity to meet existing demand. These are illustrated in Figure 13.

Each occupation has been assessed for signs of current shortages. Four distinct and independent methods have been used:

- are they on a relevant migration shortlist;

- are they recognised by industry through literature or stakeholder consultation;
- is there a shortfall of between the currently modelled supply and demand, and;
- do a set of labour market indicators show shortage.

Each occupation was classified as likely to be in shortage if three or more of these assessments showed a shortage, potentially in shortage in two assessments suggested a shortage but the other two did not or were unclear, and unlikely to be in shortage if only one or none of the assessments identified a shortage. For detail on each of these approaches and assessments by occupation see Appendix C – Current occupational shortages detail.

Figure 13: Current state shortages across the infrastructure sector[16]

	Likely Shortages	Potential Shortages	Unlikely Shortages
Project Management Professionals	• Procurement management	• Construction management • Risk management	• Commercial management • Environmental and occupational health professionals • Project management
Engineers, Scientists and Architects	• Building surveyor • Civil engineer • Electrical engineer • Engineering manager • Environmental professionals • Geologists, geophysicists and hydrogeologists • Geotechnical engineer • Land surveyor • Materials engineer • Quantity surveyor • Other professional engineers, scientists, etc.	• Electronic engineer • IT professionals/engineers • Maintenance planner • Production engineer • Structural engineer • Telecommunications engineer • Mechanical engineer	• Architect • Landscape architect • Draftsperson
Structural and Civil Trades and Labour	• Driller (piling/foundation)	• Bricklayer • Carpenters and joiners • Concreter • Crane operator • Rail track worker • Road based civil plant Operator	• Plant operator • Rigger and dogman • Structural steel erector • Truck drivers
Finishing Trades and Labour	• Electrical line workers • Telecommunications cabler • Telecommunications field staff • Tiler	• Electricians • Glazier • Painting trades • General construction labourer	• Electrical or telecommunications trades assistant • Mechanical engineering trades workers • Plasterers • Plumbers • Safety officers

Engineering occupations are currently most at risk of shortage. This is consistent with the feedback from industry stakeholders such as Engineers Australia and Consult Australia. Geophysicists, geotechnical engineers, structural engineers and civil engineers are identified as shortages in most assessment methods. Some of the main drivers of shortages are flagged as lack of applicants with technical skills and experience, and lack of applicants altogether. Master Builders Australia raise similar concerns noting that capital cities as well as regional New South Wales and Queensland are experiencing difficulties recruiting sufficiently skilled civil engineers.[17] These shortages are typically difficult to address through short-term measures because they require technical expertise and long training periods.

Some shortages appear to be ongoing and systemic, for example building surveyors. The recent Building Confidence Report indicated an extreme workforce supply issue in the building surveying profession due to an ageing workforce and ill-defined career pathway.[18] Similar concerns were raised by Consulting Surveyors National which noted a workforce shortfall of over 600 surveyors and spatial scientists nationally. This shortfall is expected to continue to increase due to retirements as the average age of surveyors is around 52 years.[19]

Project management professionals show mixed signs of shortage. Construction managers and procurement managers are on skilled migration lists, while analysis of supply and demand shows

shortfalls in most occupations, but only procurement management is consistently identified as an area of shortage.[20] Industry associations have recognised current challenges with capacity to support the delivery of projects in Australia. The specific shortages identified are generally for senior roles, which is discussed more in the next section.

Indicators of shortages for occupations in structural and civil trades and finishing trades and labour are much more varied. Labour market analysis of skilled occupations indicates a shortage of bricklayers in all states except for Western Australia and Northern Territory. This is also supported by a 2020 job report by Hays.[21] However, most of the potential shortages indicated under structural and civil trades and labour were recognised by industry or by demand supply analysis and are not reflected in the migration lists or labour market indicators. This may mean that shortages are felt more acutely in specific regions or specific specialisations. This may also reflect only recent acute experiences of workforce shortage. In contrast to engineering occupations, concreters and rail track workers present low bars to entry and therefore there are fewer barriers to filling acute shortages.

On the other hand, many of the potential shortages flagged in finishing trades and labour are recognised by various migration lists and stakeholder feedback and do not appear in labour market indicators or supply and demand data. This includes electricians, glaziers, and electrical line workers. This may be due to heightened demand in other sectors.

Occupational assessments mask pressing workforce challenges

Just as assessment of the overall market can mask shortages for specific occupations, assessment at an occupational level masks challenges at the more granular level of specific roles. Shortages can be found amongst specialist roles within an occupation, or at more senior levels, even if overall there appears to be enough people in the occupation. Just because demand for a role is small does not mean it is any less critical to the delivery of public infrastructure. The absence of one worker with a specific skill set can have significant implications for a project and a debilitating impact on the industry if not addressed.

Analysis of shortages at role level has to date been limited to qualitative insights from industry with limited data available. However, non-traditional data sources such as Burning Glass Technologies job advertisement data can shed light on sub occupational trends. Some roles that are likely to be in shortage are outlined in Figure 14. A more comprehensive assessment against each occupation can be found in Appendix D – Role shortages detail. Role titles reflect those used most by employers in job advertisements.

Figure 14: Roles likely in shortage based on labour market indicators[22]

	Role shortages likely driving occupation shortages		Role shortages within occupations that are overall unlikely or potential shortages
Project management professionals	• Procurement specialist • Purchasing officer • Construction supervisor	• Procurement officer • Senior procurement officer	• Risk and compliance manager • Health, Safety and Environment (HSE) advisor • Safety advisor • Senior strategic planner
Engineers, scientists and architects*	• Senior software engineer • Senior estimator • Environmental advisor • Senior environmental advisor • Ecologist • Application support analyst • Head of engineering • Geologist	• Hydrogeologist • Principal geotechnical engineer • Electronic engineer • Senior signalling engineer • Telecommunications engineer • Building inspector • Building certifier	• Mechanical engineering technician • Automation tester
Structural and civil trades and labour	• Joiner • Apprentice carpenter • Concreter • Crane operator	• Driller • Blast hole driller	• Multi combination driver • Grader operator • Dozer operator • Reach forklift driver • Excavator operator • Backhoe operator • Final trim grader operator
Finishing trades and labour	• Electrician • Industrial electrician • Electrical supervisor • Industrial painter • Apprentice painter	• Powder coater • Linesperson • Tiler • Wall and floor tiler	• Diesel fitter • Fitter • Mechanical fitter • Drainer • Electrical trade assistant • Maintenance plumber • Pipefitter • Solid plasterer

*Engineers, scientists and architects includes roles likely to be in shortage. Roles that are in potential shortage are: Systems Engineer Operations Engineer, Production Engineer, Software Engineer, Civil Designer, Senior Civil Designer, Mechanical Designer, Site Engineer, Civil Supervisor, Senior Landscape Architect, Stormwater Engineer, Environmental Engineer, Sr Environmental Officer, Engineering Surveyor, Maintenance Manager, Maintenance Officer IT Support, Test Manager, Mechanical Design Engineer, Engineering Manager, Geotechnical Engineer, Senior Geotechnical Engineer, Building Surveyor, Engineer, Senior Engineer.

This analysis shows a range of examples of shortages being concentrated on specific roles within an occupations workforce. Many of the role shortages identified through analysis and stakeholder consultation exist in senior, experienced positions. For example, principal geotechnical engineers, senior signalling engineers, and heads of engineering have been identified as roles that are likely to be in shortage.

Senior roles generally have different skill requirements to junior roles, with senior roles consistently placing a lower emphasis on generalist skills and attributes, but the skills that replace them varies by occupation. [23] Trades and labour show significant shifts with experience away from specialist skills (which are primarily useful within their occupation) towards technical skills (which are more transferable across occupations) as they become more experienced. Engineers, scientists and architects show a similar trend to a lesser extent, while project management professionals increase the focus on both specialist and technical skills. The time it takes to develop these skills means that

junior individuals are not always able to step into senior roles, and so when a shortage appears at a more senior level it is likely to persist.

Similar trends appear for roles that require greater technical specialisation. For example, while few indicators suggest an overall shortage of plumbers, there are potential shortages in specialist roles including drainer, maintenance plumber and pipefitters. This is also seen in plant operator roles, including grader operator, excavator operator and backhoe operator. [24] By their nature these more senior or specialist roles are likely to be filled by older workers. Shortages could be exacerbated as those with highly specialised occupational knowledge retire.

Systems engineers are flagged by industry stakeholders as an area of extreme current shortage, despite quantitative indicators showing an adequate supply of the broader occupation production engineers. Systems engineers are a niche and highly experienced role that is small enough to be outweighed by other roles, but can be a key dependency risk for projects.

On the other side of the spectrum potential shortages exist in some apprentice and junior roles. This includes potential shortages in apprentice carpenters and painters and electrical trade assistants. For carpenters and painters that are categorised as potentially in shortage, this may indicate that existing shortages are driven by a weak pipeline for entry level workers.

In addition, industry stakeholders working in rail suggest a worsening shortage of roles integral to rail infrastructure, in particular rail signallers and systems engineers. Consultation with industry bodies suggested that these shortages are worse in Western Australia where similar roles are utilised by the mining sector. Specialist rail worker positions, including rail surveying or rail construction management, require large amounts of technical knowledge. Therefore, a shortage of only a few individuals can have a significant impact on a jurisdiction's ability to meet rail project milestones. Rail track workers were also flagged as an area of potential shortage due to unprecedented demand and competition for entry level workers. Shortages in rail are expected to increase in light of international travel restrictions due to COVID-19 as the sector heavily relies on overseas skilled workers.[25]

Industry perspective: Australasian Railway Association

"There are significant skills shortages in most rail roles, particularly in specialised areas. Often the numbers do not appear large enough to be significant, but due to the importance of some roles and the length of training time, the gaps can be substantially detrimental. The under-investment in skills and training, due to decentralisation of rail training and privatisation of rail, as well as lack of trainers and assessors, are key contributors to the current challenges the rail industry faces. This task is further exaggerated with the significant investment in rail and the current restrictions impacting skilled migration, in turn leading to wage inflation.

There is currently no specific rail training available to those that are not employed in rail. Qualifications are often not completed, with employees only completing units that are required, given training is often paid for by the employer. There are currently no undergraduate rail units in relevant degree programs, and very limited post graduate rail specific courses.

Differing rail network systems stemming back to Federation have seen a lack of standardisation and harmonisation in standards, requirements, and competencies. This has a negative effect on the economies of scale in training, but also the portability of workers across jurisdictions or networks. Often years of experience is a requirement to work on some networks, and therefore the ability to attract additional experienced workers with domain and product knowledge is limited. A co-regulatory environment means that Rail Transport Operators have the responsibility for managing their obligations under the National Rail Safety Law, however, this has limited the ability of industry and government to improve harmonisation and interoperability.

The Australasian Railway Association (ARA) is pleased to see the cooperation by Rail Network Operators/Maintainers in developing national competency matrices to provide alignment and harmonisation of competencies, and the take up of the Rail Industry Worker Program to support the portability of rail contractors. It is expected that the work under the National Rail Action Plan will also further address the current skills challenges via a more collaborative approach by state governments and industry.

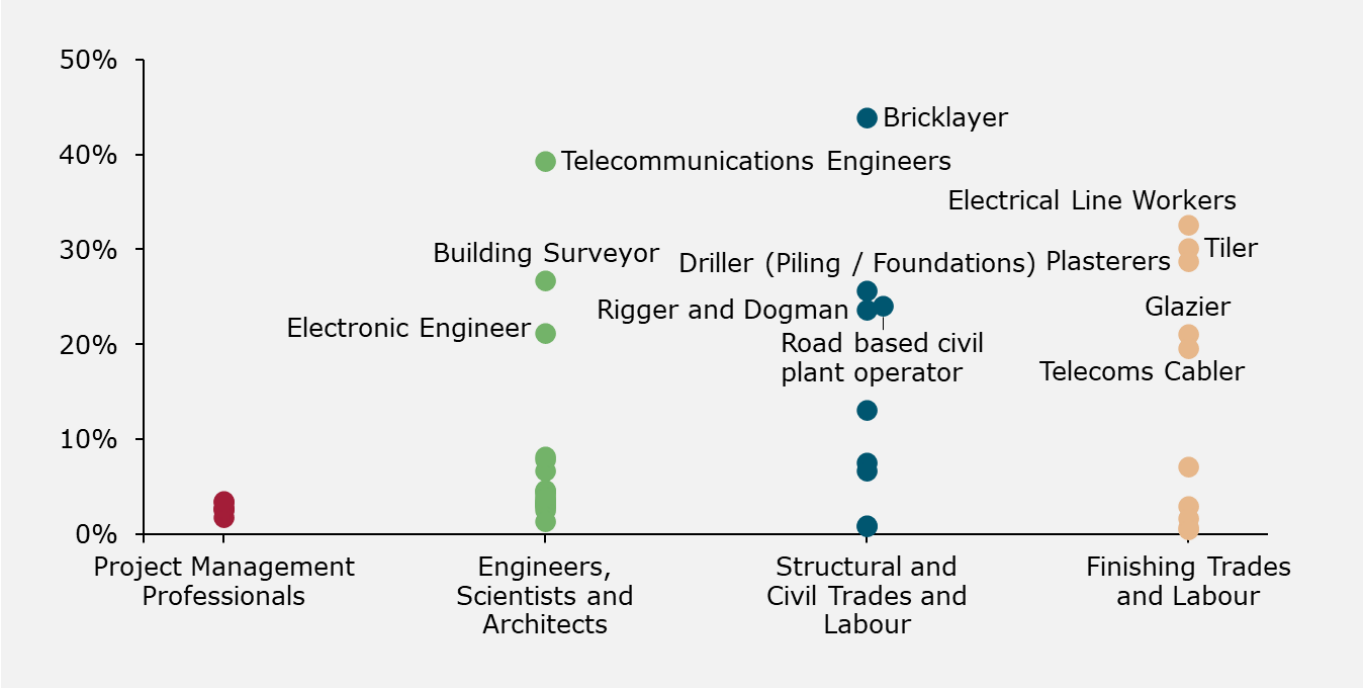
The ARA is focused on raising awareness about the benefits of a career in rail, providing increased clarity on pathways into rail, improving access to training and education, and expanding the diversity of the rail workforce to ensure the rail industry can deliver the outcomes needed to support the growth of our communities and economy."

Changing skill needs compound worker shortages

The skill needs of industry constantly change. There is a natural use by date on many skills as they are replaced by new and emerging processes, standards, equipment, or technology. People must upskill to keep up with this change, or else their skill set may become out of date, and they may no longer be able to perform the job that employers are seeking.

When the skills needed for an occupation change rapidly, large proportions of the workforce may find their skills are out of date. This can result in employers struggling to find appropriately skilled staff, not because there aren't enough people in the occupation but because those people no longer have the relevant skills. This situation is a result of a skills mismatch as opposed to shortage. Figure 15 highlights the occupations that have experienced the largest shift in required skills in recent years, and so are at the greatest risk of a skills shortage. Almost all the highlighted occupations have been identified as potentially or likely in shortage by either industry, government shortage lists, or analysis in this report, suggesting that they are experiencing skills shortages or that this is driving labour shortages.

Figure 15: Change in skills required by occupation between 2017 and 2020[26]



Some of these changes are reflective of changes in the industry. Many occupations with the greatest changes are shifting the profile of skills to become more 'T shaped', as described in Section 1. Bricklayers, drillers (piling/foundations) and electrical line workers have had some of the largest increases in requirements for technical skills among all occupations. On the other hand, building surveyors, road based civil plant operators, drillers (piling/foundations) riggers and dogmen, telecoms cablers, plasterers, and tilers have increased their focus on specialist skills. Drillers appear on both these lists because of a substantial move away from generalist skills and attributes.[27]

The desire for 'T shaped' individuals is strongest in occupations such as engineers and project managers. In this case the breadth is being provided not just by generalist skills but by a set of technical skills that are transferable across occupations. 25% of skills required by project management professionals are technical compared to 11% for engineers, scientists and architects and just 7% for trades and labour roles.[28] This may be a result of digitisation and automation across the construction sector that has introduced a new set of skills along with increasingly complex project arrangements that place a premium on effective communication and multidisciplinary understanding.[29] The 'T' brings together the expertise in a single field with the knowledge base and general skills to collaborate with experts across a range of disciplines. This is not restricted to specialist skills. A similar trend is occurring with trades and labour where multiskilled individuals are highly valued.[30]

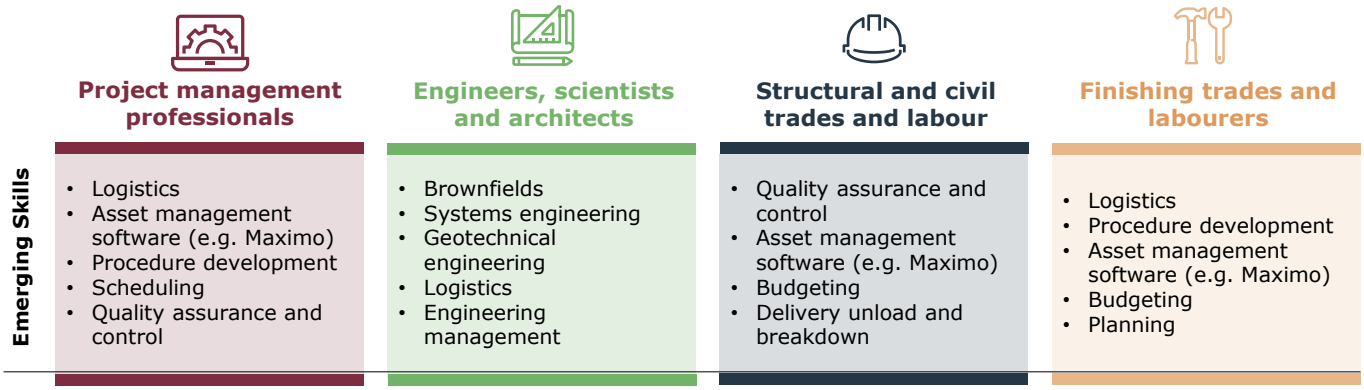
The difference between occupation groups is more pronounced when focussing on the most important skills for each occupation, rather than the complete skills profile. Based on changes in the relative importance of the top ten technical, generalist and specialist skills, the four occupation groups all show different trends:

- Project management professionals have seen only a minor shift in emphasis, which is reflected in those occupations not showing significant skill change in Figure 15.
- Engineers, scientists and architects roles require a broader 'T' with a shift in focus from specialist skills to technical skills such as scheduling, budgeting and project management.
- Structures and civil trades and labour roles also show a reduced focus on specialist skills, but instead are broadening the 'T' through more generalist skills and attributes.
- Finishing trades and labour show the reverse trend, with increasing focus on depth in specialist skills at the expense of the technical skills.

Change across the industry is also seen in the emerging skills that make use of new technologies and processes, and eventually replace obsolete skills. Figure 16 identifies the top emerging skills

across the industry. These emerging skills show increasing industry trends such as a greater focus on experience with brownfield sites, or greater priority on effective planning seen in skills such as logistics and procedure development, and technologies like asset management software. Emerging skills also often relate to roles in skills shortage due to the lag between demand and workers developing the new skills. This lag comes firstly from the delay in demand becoming widespread enough that the workforce has to respond, and then in the time taken to train and develop the relevant skills.

Figure 16: Emerging skills over the last five years by occupation group[31]



4. The future workforce supply challenge

At a glance

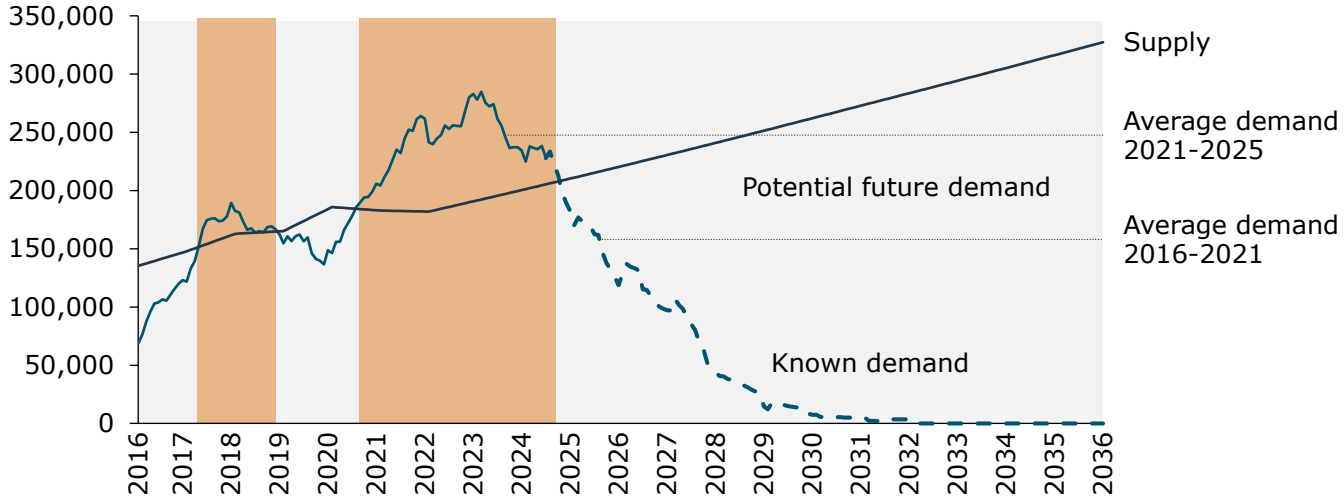
- This section assesses the capacity and capability of the future public infrastructure workforce to meet predicted future workforce demand.
- Over the next three years demand for labour is anticipated to reach unprecedented levels. The consequences are significant with labour shortages anticipated to be three times greater than in 2017-2018, peaking at a likely shortfall of 93,000 workers in early 2023.
- At this peak, demand is 48% higher than supply. Meeting this demand would require growth of 25% per year over the next two years, which is more than eight times higher than the projected growth rate of 3.3% p.a. over the same period.
- Victoria, Queensland and Tasmania will experience the greatest risk of shortage. At points between 2021 and 2025, all three jurisdictions will require a workforce that is approximately twice the size of the projected supply available.
- As labour shortages persist, occupational shortages will become more acute. Between 2021 and 2024 shortages are anticipated in all four key occupational groupings but are likely greatest amongst engineers (multiple) and general construction labour.
- Shortages are anticipated to peak at 19,000 project management professionals, 70,000 engineers, scientists and architects, 15,000, structural and civil trades and labour and 14,000 finishing trades and labour at different points across the next three years.
- Procurement professionals, surveyors (various), geologists, geophysicists and hydrogeologists, road and civil based plant operators, drillers, rail track workers, general construction labourers and electrical line workers are other occupations with a strong likelihood of nationwide shortage.
- Labour shortages are likely to spill over to other sectors and industries, driving competition for talent and escalating costs, as each worker who takes a job delivering public infrastructure more than likely leaves a vacancy elsewhere that must be filled.
- To meet demand for public infrastructure, 50% of engineers, scientists, and architects, 16% of project management professionals, 6% of structures and civil trades labour and 3% of finishing trades and labour working outside the sector would be required to change jobs (leaving a subsequent gap elsewhere) to support delivery of the Major Public Infrastructure Pipeline.
- This compares to total movement in the past five years of around 3.5% of adjacent workers (those most easily retrained) to engaged or about a third of what would be required to meet the projected peak.

Australia is facing a public infrastructure workforce crisis

Australia's demand for public infrastructure is forecast to reach unprecedented levels over the next three years. The workforce consequences are significant with labour shortages anticipated to be almost three times more than that in 2017-2018. Figure 17 shows historical and projected supply and demand with projected labour shortages lasting from late 2020 to late 2024, peaking at a gap of almost 93,000 additional workers being required in early 2023.[32] At this peak, demand is 48% higher than supply. Meeting this demand would require growth of 25% per year over the next two years, which is more than eight times higher than the projected growth rate of 3.3% p.a. over the

same period. This growth would also be required after a slight decrease in supply over 2020-2021, caused by a decline in public construction work which likely caused a corresponding shift of individuals from the engaged workforce to the adjacent workforce.[33]

Figure 17: National supply and demand for engaged workers in public infrastructure, historical (2016-2021) and projection (2021-2032)[34]



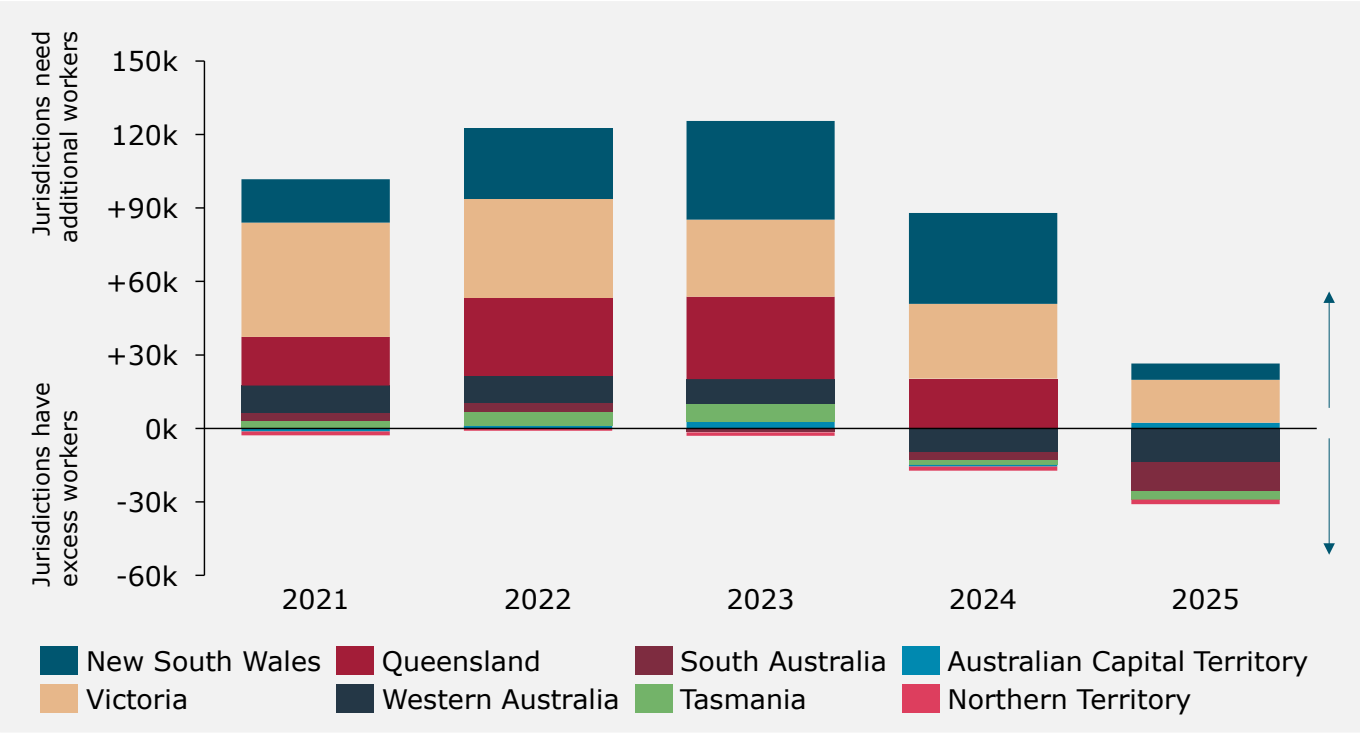
While Figure 17 illustrates an equilibrium of sorts being reached by 2024, projections only account for projects confirmed as of 30 April 2021. Recent announcements and new infrastructure projects over coming years will likely push this out further. The decline in known demand shown after 2025 will also be reversed and brought up by new projects. The potential range for future demand is based on recent averages.

The national picture also masks significant variation across the country. Figure 18 is based on the same analysis as Figure 17 and shows that New South Wales, Victoria and Queensland face the greatest risk of shortage. In every year from 2021 to 2024 demand is anticipated to outpace supply for these three states. In 2024, New South Wales and Victoria show signs of continued shortage as other jurisdictions wrap up their currently confirmed projects.

The variation between states and territories is due to the different profile of demand projections. All jurisdictions except the Northern Territory are projected to need to increase their workforce by 47% or more beyond projected supply to meet peak demand. Victoria, Queensland and Tasmania all have points where they will need workforces to approximately double (or more in Tasmania's case) what is projected to be available within the jurisdiction. The timing of shortages is also varied – Victoria is already in a shortage that will continue until 2026, while South Australia's most significant shortage is not until 2027.

The variation between states means there will be some opportunity to resolve specific local shortages by reallocating individuals across the country. However, this will not address the major national shortages across 2021-2024. This is discussed further in Section 5.

Figure 18: Net required additional public infrastructure workers by jurisdiction, 2021–2025 (000s)[35]



Occupation shortages are projected to become more acute

As labour shortages persist, occupational shortages emerge. Between 2021 and 2024 shortages are anticipated in all four occupational groups: project management professionals; engineers, scientists and architects; structures, civil trades and labour; and finishing trades and labour.

The scale of anticipated shortages is outlined in Figure 19, which compares the gaps between projected supply and demand currently and at the peak shortage in 2023, based on projections outlined in Appendix F – Modelling methodology. This shows that engineers, scientists and architects are already close to the peak projected shortage, while structures and civil trades and labour and finishing trades and labour will flip from current excesses of supply to significant shortages in the next few years.

Figure 19: Projected increase in shortages by occupational group[36]

Occupation groups	Current shortfall	Peak projected shortfall (2021-2025)	Occupation groups	Current shortfall	Peak projected shortfall (2021-2025)
Project management professionals	13,700	19,100	Structures, civil trades and labour	-6,200	Up to 15,700
Engineers, scientists and architects	63,900	70,200	Finishing trades and labourers	-20,700	Up to 13,600

The projections underlying this figure show that pressure on the supply of all occupations will increase over the next few years. For the occupations identified in Section 4 as already experiencing shortages this will exacerbate the difficulties face by an already strained sector.

Occupations in engineering, scientists and architects that are currently experiencing shortages are generally experiencing or soon to experience the most extreme peak of their potential shortage. For example, while existing shortages in geotechnical engineers, geologists, geophysicists and hydrogeologists and quantity surveyors will grow, the growth will not be exponential. Shortages in land surveyors and civil engineers on the other hand are likely to continue to increase incrementally over the next few years. To meet demand across Australia, over 41,000 further individuals are estimated to be required to fill engineering occupations including positions in civil, geotechnical, structural and materials engineers. Of all the occupations, materials engineers have the largest projected workforce shortage and will require the profession to increase fivefold to meet demand.

Surveyors are another existing shortage that is projected to grow. The current building surveyor and land surveyor professions will be required to double over the next few years to meet demand. To fill demand almost all building surveyors who are currently working in other industries (such as residential construction) would be required to transition to public infrastructure. Much of this demand is driven by infrastructure work in New South Wales and Victoria. Shortages in quantity surveyors are anticipated to be concentrated in Queensland and Victoria.

While most project management occupations are not currently experiencing shortages, there will be an increased pressure on supply in the next few years. In particular, shortages in commercial management and project management are expected to significantly grow. Targeted measures to increase current supply of these professions will be required soon to avoid significant future constraints. Likewise, occupations in finishing trades and labour will experience more severe shortages in the coming years then are currently experienced. This includes in occupations such as general construction labourers, plumbers, painting trades and tilers.

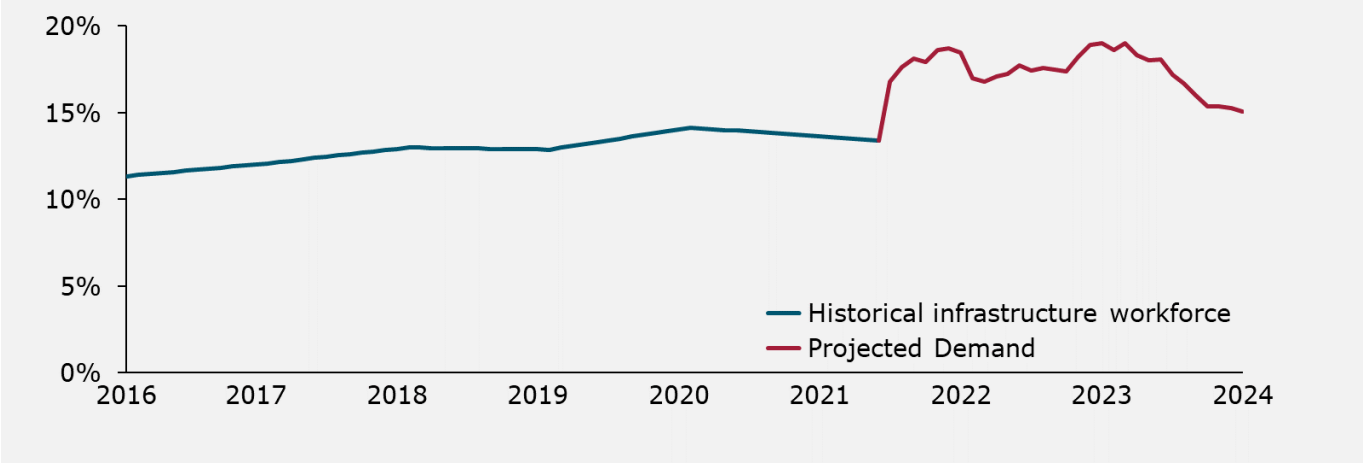
Projected shortages in structures, civil trades and labour are more evenly spread across most of the sub-occupations. There are projected shortages in concreters, crane operators, drillers, rail track workers and structural steel erectors. There is however significant diversity at the jurisdiction level for these occupations. For example, there are no projected shortages for concreters in Western Australia, South Australia and Northern Territory. Shortages in concreters, drillers would only need to draw on approximately 10% of individuals working in other industries to fill potential shortages. Shortages in drillers and rail track workers on the other hand cannot be filled by transitioning workers in similar occupations in adjacent professions. These may be drawn on by the larger states who will potentially experience future shortages. Plant operators and road based civil plant operators will experience the largest growth in shortages over the next five years.

As discussed in Section 3, some of the change in shortages are likely to be due to changes in the skills profile that employers require, for example shifts in the 'T profile' as roles shift their focus between generalist, technical and specialist skills. This cannot be easily projected due to the difficulty in assessing which emerging skills will fade and which will become more significant. This is further complicated by the fact that as skills become more prevalent, they can reach a point of being assumed capability and no longer referenced within job ads.

Consequences are likely to be felt across multiple industries

Public infrastructure shares a workforce with other sectors of the construction industry and beyond. Significant increases in workforce demand for public infrastructure has potential widespread consequences to the general availability of labour. Historically, public infrastructure has utilised around 12-14% of the overall workforce in relevant occupations, and currently sits at 13%.[37] If demand estimates are realised this would require the percentage of the workforce supporting public infrastructure to increase to 19%, a point to be reached in 2023 as illustrated in Figure 20.

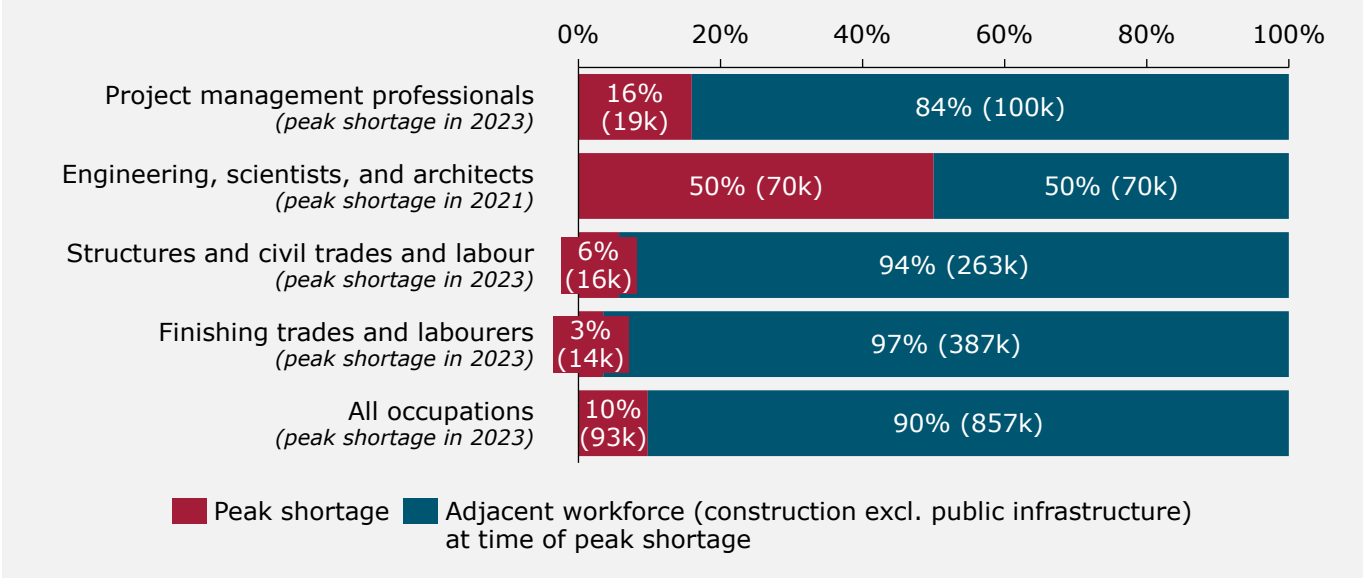
Figure 20: Proportion of relevant workforce engaged on public infrastructure 2016–2025[38]



While the share of individuals engaged on public infrastructure has steadily increased since 2016, a 5.7% jump in share of workers would be unprecedented. Each worker that takes a job delivering public infrastructure is likely to leave a vacancy elsewhere that must be filled with cascading impacts across sectors and escalating costs.

Natural realignment of the labour force to meet the market can address some of the projected shortages, but likely not all. Figure 21 shows that the peak projected shortages represent around 10% of the overall adjacent workforce. This compares to total movement in the past five years of only 3.5% of adjacent workers (those most easily retrained) to engaged or about a third of what would be required to meet the projected peak. This problem is significantly worse for engineers, scientists and architects, where the peak shortage is over 50% of the adjacent workforce, which is projected to occur towards the end of 2021.

Figure 21: Share of adjacent workforce needed to meet additional demand by occupational group[39]



Note that the adjacent workforce is projected to grow faster than the engaged workforce for all occupation groups except engineering, scientists and architects.

Many occupations in demand to support public infrastructure have limited capacity to draw on an adjacent workforce. Over 41% of rail track workers are already classified as engaged, and this is as high as 58% in Tasmania, suggesting minimal opportunity to increase the engaged supply by retraining people from the adjacent workforce. Amongst occupations already classified as being in shortage, 27% of drillers (piling/foundations) and 25% of building surveyors are already classified as engaged. At the other end of the scale, only 5% of project managers and 2% of IT professionals are engaged.

Migration will have a role in addressing workforce demand but there are challenges in the extent to which this can be used relative to the scale of the shortage, which are explored in Section 5. While migration may be the difference between capacity or shortage for some occupations like electrical engineers or specific highly skilled individuals at senior levels, it is unlikely to be sufficient to grapple with the demand for civil engineers, particularly in the face of global demand for these skills as countries around the world leverage infrastructure as part of post-COVID stimulus strategies.

Industry perspective: Consult Australia

"Consult Australia sees skill shortages as a key workforce challenge, and many shortages that we observe have been a systemic issue for more than a decade. There have been limited successful efforts to date to address the underlying causes for skill shortages, which include challenges with science, technology, engineering and mathematics (STEM) education and immigration policy. This challenge is exacerbated by rapidly growing pipelines of projects across the country, with a limited focus on managing these pipelines through a skills supply lens.

Consult Australia undertakes an annual member survey on skill shortages and key reasons behind recruitment difficulties, with the most recent in December 2020.[40] In this report, there were 39 professions identified by members as experiencing a skill shortage, with the most acute being civil engineers, structural engineers, civil engineering drafters, and transport engineers.

Our findings regarding civil engineers show recruitment challenges in all major cities. Shortages were prevalent for mid-level and senior roles, with a lack of applicants with appropriate experience. This is leading to wage increases, of more than 10% for many businesses.

For structural engineers, Sydney and Melbourne are the hotspots, with shortages across all experience levels. However, mid-level roles are the most in demand because of their technical skills and their practical experience. Like civil engineers, wages are increasing with some businesses reporting a need to relax experience requirements.

Investments that have historically followed a peaks and troughs approach such as the rail and mining sectors have created a workforce development legacy for our industry. It has impacted our industry's ability to retain talent and develop experience and skills over the long-term.

Furthermore, a lack of involvement by small and medium-sized enterprises in projects suggests government procurement processes are not effectively utilising the full breath of the market's current capacity.

Our industry also has an inability to attract a sufficient supply of talent, which has increased the need to rely on the skilled migration system. At the same time, costly, complex and slow skilled migration processes creates a barrier for many businesses and individuals, and current border restrictions have drastically reduced access to global talent.

In regard to STEM education, Australia not only needs to consider why it lags compared to its peers in participation and performance, but also how we are promoting STEM-related careers in our industry to the next generation."

5. Constraints to addressing the supply challenge

At a glance

- This section outlines the constraints to addressing Australia's looming infrastructure workforce shortage through mobilisation of existing workers and growth in additional workers.
- The public infrastructure sector is facing an ageing workforce with over 40% of the total workforce with potential to retire in the next 15 years. At the same time regulatory and procurement practices result in workforce inefficiencies that the sector cannot afford as it copes with escalating demand.
- The sector needs to grow its workforce. However, a range of cultural, geographical, diversity and education issues constrain the sectors' ability to rapidly grow its workforce.
- Migration, often seen as a solution for specific skills gaps, can no longer be relied upon to meet a growing gap. Border closures, limitations of the existing migration visa program and poor utilisation of existing migrants constrain the sectors' ability to respond to the skills supply challenge.

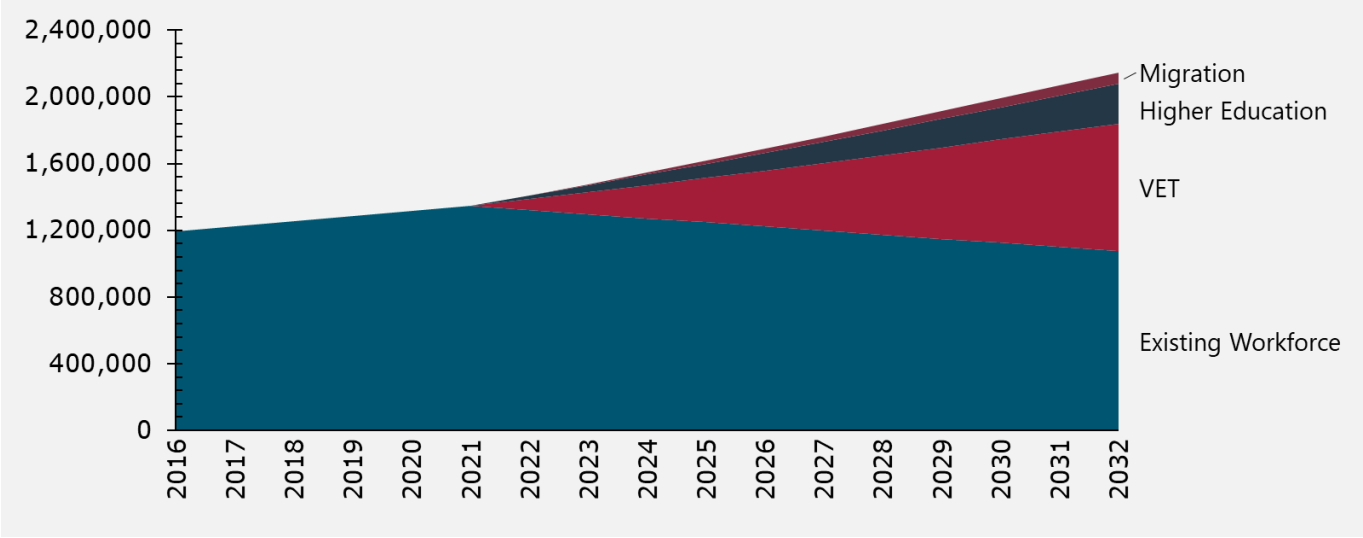
The Australian public infrastructure sector has historically relied on a predominantly Australian, male workforce, looking to migrants to fill specific vacancies as they emerge. To meet anticipated demand the sector can no longer maintain current practices and must address the constraints that have resulted in shortages and challenges in maintaining labour supply.

This section outlines the key constraints that must be addressed if Australia is to secure the workforce needed to deliver on its ambitious plans for investment in public infrastructure.

The future labour supply will come from different sources

The total workforce, across all closeness categories is forecast to grow in the future, with an inflow coming from vocational education and training (VET), higher education and migration. Without these additional workers the total workforce would shrink as current employees retired or moved to other areas of the economy. Figure 22 shows the estimated labour supply for the workforce by source. These forecast changes are based on education inflows of individuals that will graduate as workforce-ready in the case of VET and higher education, using a field of education to ANZSCO mapping to estimate the supply of infrastructure workers. Migration figures use Department of Home Affairs data, at an ANZSCO unit group level, focusing on permanent visa classes and assumes consistent migration from 2023 onwards. These growth figures would have some variance in occupation over time.

Figure 22: Estimated future labour supply by source[41]



Note: Estimates of supply are based on census data that is inclusive of individuals on temporary and permanent visas. AIHW population projections including a combination of assumptions on future levels of fertility, mortality and migration are used to drive forecasts of future potential education and training activity and subsequently workforce. Overall figures are then adjusted for the likely number of permanent migrants that will be added to the labour force over this period. Estimates are based on data supplied by the Department of Home Affairs on four visas that relate to permanent labour increases: 186 Employer Nomination Scheme; 187 Regional Sponsored Migration Scheme; 189 Skilled – Independent; and 190 Skilled – Nominated. Migration estimates include individuals who migrate to Australia without declaring skills relevant for public infrastructure on entry. Migrants who subsequently gain the skills to work in public infrastructure after arriving in Australia are included in higher education, VET and existing workforce estimates. Temporary visas were excluded from analysis to avoid double counting of the workforce due to their time bound nature.

Figure 22 shows the total workforce relevant to public-infrastructure, including the engaged, adjacent, trainable and distant workforces. As discussed above in Section 4, shortages in infrastructure cannot be completely solved by redirecting workers from these other sectors due to the significant impacts that would be passed on to those sectors, even if individuals could be persuaded to prioritise public infrastructure.

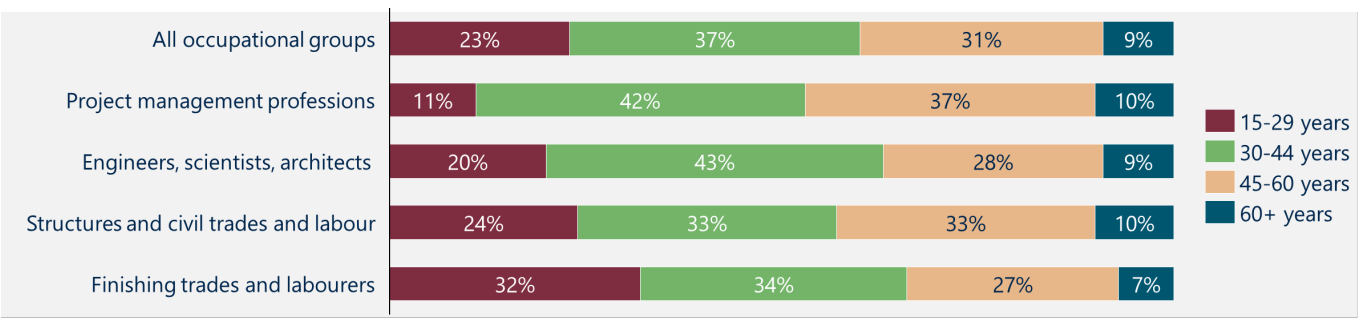
The future availability of infrastructure workers is at risk

Australia has a limited supply of public infrastructure workers and those that are working are not being effectively utilised. Age, regulation and procurement practices all present barriers to making full use of the existing workforce in the future.

The public infrastructure workforce retires young

Over the next 15 years the sector could lose over 40% of its potential workforce due to early retirement. The average age of retirement for a construction worker is 60 years, and labourers even younger at 58.[42] When compared to the Australia-wide recent retiree average age of 63 years, the construction industry has a significantly greater risk to the availability of skilled and experienced public infrastructure workers, above the broader workforce.[43] In considering this, Figure 23 shows the risk to the potential infrastructure workforce given the substantial portion of the population over 45 years of age.

Figure 23: Distribution of age by occupation group for potential infrastructure workforce[44]



The risk is greatest in project management professionals, who have nearly half of their workforce over 45, and in structures, civil trades and labour with 43%. It is noted that those in non-labouring roles are likely to retire slightly later. In contrast the workforce for finishing trades and labour and engineering, scientist and architects are younger, with nearly one third of the finishing trades and labour workforce in the 15 to 29 age group. Beneath the high-level occupational groups, the greatest risk from an ageing workforce can be found in building surveyors, crane operators, drivers, safety officers and rail track workers.

Public infrastructure work can be physically demanding. Older, blue-collar workers in the construction industry are more likely to suffer from physical impediments to ongoing work than white-collar professions.[45] While project management professionals, engineers, scientists and architects are less likely to retire for physical reasons, losing the depth of experience in these occupational groups can be devastating to the industry. How roles are crafted for older team members as they near retirement will be a key determinant in whether the sector will be able to continue to leverage their substantial expertise to extended their workforce engagement.

Public infrastructure requires a workforce that is highly mobile, but regulation can restrict movement

The construction workforce is approximately 15% more likely to have moved in the past five years than the average Australian. Tradespeople (e.g. construction trades workers, bricklayers, carpenters, glaziers and plasters) are up to 20% more likely than engineers or telecommunications trades workers to move location.[46]

Public infrastructure delivery by nature can be varied in demand. There are, for example, ongoing spikes in infrastructure investment and demand, and geographic-specific initiatives that require specialist skills that make it difficult for jurisdictions to sustain a supply of workforce that aligns with existing work. This is particularly true, for highly technical specialist skills, where the demand fluctuates with the nature of the project. Mobility is essential to meet fluctuations in the infrastructure pipeline, and to enable individuals to pursue and maintain careers in highly technical or specialist areas.

States and territories have responsibility for deciding which occupations require registration or licencing, and on what basis. Consequently, differences can emerge between jurisdictions. Jurisdictions currently maintain a range of regulatory requirements for individuals to practice within their borders. This is established for architects, building surveyors, land surveyors, plumbers and electricians with moves by a number of jurisdictions to extend to other occupations such as civil, mechanical, electrical and fire safety engineers.

Occupations which are registered or licensed in one jurisdiction are not automatically recognised elsewhere. Interstate licensing and registration schemes are only accepted under mutual recognition laws, sometimes with conditions on registration equivalents. In practice this means that individuals looking to move may be required to undertake a registration process in one jurisdiction despite already being registered in another. For example, an out of state electrician wanting to work in Western Australia must apply to have their qualifications recognised. This creates logistical barrier for those wishing to move on short notice to meet public infrastructure demand.

New South Wales, Victoria, Queensland and the Australian Capital Territory have recently established an automatic mutual recognition scheme for most electrician roles to reduce the regulatory burden for those wishing to move interstate.[47] A national automatic mutual recognition scheme has also been passed by the Australian Parliament 2021, which will enable licensed workers to operate across two jurisdictions (home and one other) using automatic notification. This is intended to "make it easier and faster for skilled workers to take up jobs across borders".[48]

Importantly, improved labour mobility is only a solution to localised shortages. If one state is experiencing shortages and others are not, then mobility leads to improved national productivity within existing resources. In the case of a nationwide shortage, labour mobility can result in competition between jurisdictions for skilled labour. Resulting anticipated wage inflation may drive overall increases the costs of public infrastructure.

Cultural challenges

Despite unprecedented demand, reports continue to emerge of employers having difficulty attracting and retaining suitable entry level workers to the sector due to perceptions around jobs or careers, long and irregular hours, travel and inconsistent work. Calls are often loudest in traditional trades outside of electrical and plumbing such as apprentice painters identified in Section 3.

Working in public infrastructure can be demanding and involve shifts of 12 to 14 hours, more than double contracted hours.[49] The pipeline of work can fluctuate, and to minimise disruption to the public, work is often done in off-peak times, such as nights, weekends and holidays. In addition, there can be a need to travel long distances to the location of required work.

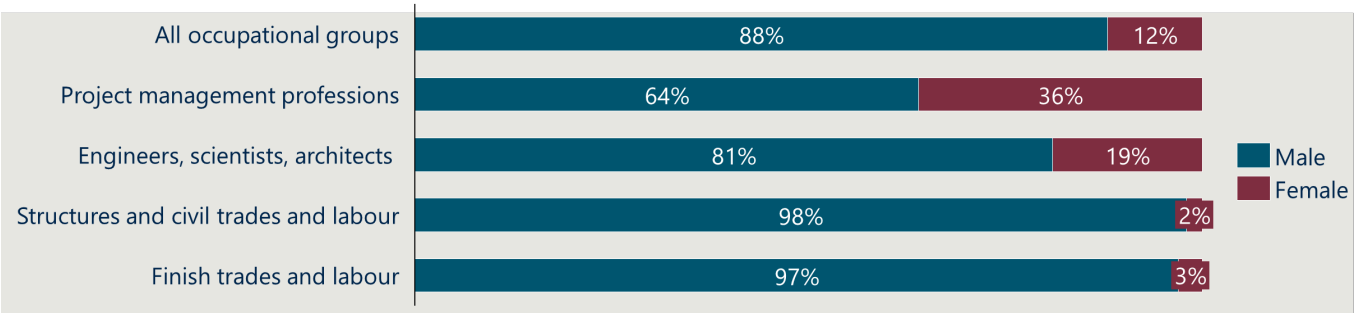
The perception of excessive workloads, "dog-eat-dog environments", and an unhealthy work culture all weigh into the limited ability to fill the future workforce pipeline.[50] [51] Combatting these perceptions will be critical to attracting a new generation of public infrastructure workers.

Female underrepresentation limits the sectors' ability to grow its workforce

Women currently make up less than 12.7% of the workforce in construction occupations and less than 2% of related trade jobs.[52] This is a result of historic gender imbalance, insufficient pathways for women into the industry and a lack of strategies to attract and retain women. Further, females are likely to be paid less (between 20 and 26% based on average weekly earnings) and less likely to be in senior positions (three times less likely than other industries).[53]

The extent of this imbalance is represented in Figure 24 which illustrates the male dominated nature of the occupation groups that are relevant to public infrastructure. For detailed information by individual occupation see Appendix E – Gender diversity by occupation.

Figure 24: Public infrastructure occupation groups are dominated by males[54]

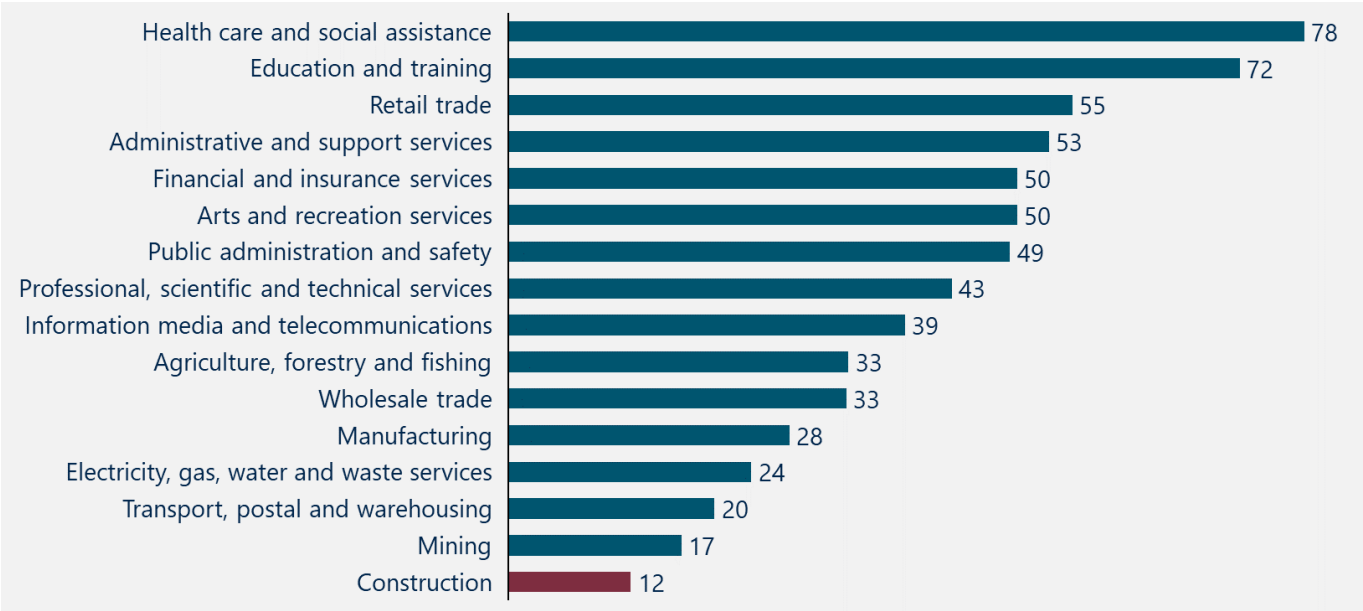


The gender disparity in the public infrastructure and construction workforce is improving, though very slowly. The overall number of women in construction roles increased by 34% between 2015 and 2020[55], but is still a small portion of the workforce.

Most countries do poorly in encouraging and enabling female participation in construction occupations. In comparing Australia (12%) to other large, developed economies Australia ranks 12th of 15, well behind France (17% female workforce), the UK (16%) and Germany (15%) and only ahead of Turkey, the USA and Japan.[56]

When compared to other Australian industries, construction is stark in its lack of gender diversity. Construction has the lowest proportion of female workforce of any industry included in ABS industry benchmarks, as shown in Figure 25.

Figure 25: Female proportion of workforce by industry[57]



These challenges are not confined to a single occupational group or jurisdiction. Project management professionals appear to have a larger proportion of women than other infrastructure-relevant professions. However, this is likely driven by a large percentage of workforce in those occupations working outside of construction (44%). In contrast construction management as a sub-occupation has a female workforce of 8% which aligns with industry commentary on female participation.[58]

The engineers, scientists and architects group also has greater participation of women. The female workforce in this occupation group is skewed by three specific occupations – architects, landscape architects and environmental professions, three occupations not experiencing shortages – all which have approximately equal participation by women and men.

Governments are acting with several programs aimed at increasing female participation in trades and infrastructure, but a concerted effort will be required given the limited progress achieved over the last 6 years.[59] Investment in trade training is a gateway to increased female participation in the workforce. The New South Wales Government's 'Built for Women' fee-free training program, which will provide 3,000 training places for women in trades, is an example of how policies are being used to drive a long-term shift in the industry.[60] Similar programs exist in other jurisdictions. These programs are beginning to have an impact with increased numbers of women in apprenticeships, for example Queensland nearly doubled the number of women construction apprentices between 2010 and 2020[61].

The constraints for women are multifaceted from stereotypes and attitudinal bias through to remuneration and work conditions. Addressing the current imbalance to harness all of the population could assist infrastructure in meeting supply challenges and allow the workforce and industry to benefit fully from the advantages of diverse workforces, such as improved communications, better teamwork and problem solving.[62]

Industry perspective: Australian Constructors Association

"With governments around the world investing heavily in infrastructure, even when international borders open, skilled migration is not a viable solution to addressing Australia's capability and capacity constraints. Instead, Australia needs to find ways to become more productive with our available resources.

As a starting point, the construction industry is missing out on employing almost half the working population. Women make up only 12% of the construction industry's overall workforce and that number reduces to just 2% for the blue-collar workforce. The adversarial culture of the construction industry is a contributing factor toward the low participation of women, and this cultural problem extends to the industry's ability to attract and retain workers with the right skills.

Another major challenge is productivity. Productivity growth in the construction industry over the last thirty years lags other industries by 25%. To achieve productivity improvements, the focus must be on increasing the efficiency of procurement and delivery processes. Valuable resources must focus on undertaking high value activities like optimising designs and de-risking projects rather than undertaking repetitive tasks associated with procurement processes.

To improve productivity, the Federal Government needs to take a more active role in defining and incentivising the use of best practice procurement and delivery processes. Adopting more collaborative procurement and delivery processes will help to improve industry culture by addressing some of the key issues, such as inflexible work hours, that are preventing the industry from becoming an employer of choice. Further, these processes have the ability to influence the sharing of information which will promote the uptake of digital engineering and in turn bring the cost of construction down."

Scarce resources are increasingly consumed by complex procurement processes

Public infrastructure procurement approaches in Australia have become increasingly sophisticated, driven by buyer desires to manage cost and risk, and increased transparency required to deliver to policy objectives.

The consequence is a process that requires extensive resources to respond to and manage these obligations. This requires costly resources to be diverted away from other areas. Consultation with industry identified multiple incidences of individuals leaving the sector because of the long hours required to respond to requirements in designated timeframes. Industry consultation also identified excessive information and documentation requirements (Australian bid costs are 25-45% higher than Canadian equivalents, largely driven by increased design focus and purchaser requests), and an emphasis on architectural design and design innovation increasing the required workforce for large projects.[63]

These procurement costs have a direct effect, both from a financial and effort perspective, that have the potential to drive businesses and individuals away from public infrastructure construction to industries that have less arduous procurement processes.

Systemic issues create barriers for individuals seeking employment

Additional workers will be required to meet planned public infrastructure investment with new entrants critical for workforce growth. The sector may be required to incentivise workers and draw on sectors of Australia's workforce that have typically not engaged in public infrastructure. In addition, the current education system can fall short in providing access to high quality qualifications that are needed to rapidly grow its workforce.

Leakage from educational pathways is common and quality is mixed

Around 94% of new workers are forecast to come through either the higher education (22%) or VET sector (72%). While critical to the supply of future workers, these sectors can also act as constraints on future supply and reinforce other issues. For example 2% of VET apprenticeships and trainees in 2020 were female, highlighting and exacerbating workforce diversity issues.[64] The ability to access the right course, receive high quality training and graduate into a job in the sector all present key challenges. In the current environment any lost potential worker has an immediate cost to the sector and potential downstream consequences for more experienced roles for years to come.

Effective educational pathways start with access. In the case of public infrastructure, access to relevant courses is inconsistent. People in regional and remote areas often do not have a local option for tertiary education, which reduces participation.[65] Delivery costs can be two to five times higher in thin markets, where there training numbers are low, so even if there is an accessible training provider, they are unlikely to have a full suite of courses unless subsidised to do so.[66] The impacts of thin markets are also seen in specialist areas; for example there are very limited rail specific courses in Australia. This lack of access creates a form of leakage at the start of the training pipeline, with potential students prevented from pursuing qualifications that could lead them to the public infrastructure workforce.

Once engaged in training the next challenge is retention. Many students in infrastructure-relevant qualifications do not complete their training or go on to work in other industries – for example 38% of qualified engineers work in other industries.[67] While there will always be people in both these groups due to different interests and capabilities, they can be minimised through better quality training and better development and articulation of pathways into the public infrastructure workforce.

The final challenge is alignment of what is learnt and what is valued by the sector. Employers regularly report that graduates are not work-ready and that additional on the job training is required. This contributes to the direct leakage from the training pipeline by making it harder to get work, but also limits productivity of the workforce at junior levels. It can also affect the pace of career progression, further increasing leakage while reducing the rate of new people in senior and experienced roles.

Migration alone cannot address labour shortages

Migration is projected to provide 6% of new workers in the public infrastructure industry over the next 15 years (see Figure 22). This is based on Department of Home Affairs migration data of permanent visa classes, based on ANSZCO unit group level, and assumed the same migration numbers from 2023 onwards. This is a critical contribution, particularly as a source of workers ready for more senior roles.

Australia has historically relied on skilled migrants to fill workforce shortages across public and private infrastructure projects. However, borders closures because of COVID-19 have placed a strain on businesses' ability to meet the current increase in demand for services. As borders begin to open there will be a greater focus from the public infrastructure sector on obtaining skilled migrants.[68]

Engineering is particularly dependent on skilled migration and will be significantly affected by border closures.[69] However, migration can not resolve all shortages – policy responses will be required across migration, education and training, and facilitating transition of existing workers into public infrastructure delivery.[70]

Between 2017-2018 and 2020-2021 Australia increased its intake of migrants in infrastructure relevant occupations by approximately 40% or 4,409 individuals. The increase was primarily driven by an additional 5,669 individuals on temporary visas which more than offset a decrease of 1,260 individuals being granted permanent visas.

Historically, public infrastructure has utilised around 12-14% of the overall workforce in relevant occupations. In this case additional migration would represent a minimum increase of 530 workers for public infrastructure projects, although may be higher.

Most temporary visas were granted to engineers, scientists and architects who received approximately two thirds of new temporary visas with the remainder split across the other occupational groups. Despite growth across most occupations, fewer visas were granted to civil, electrical and material engineers, due to a reduction in permanent visas. Overall, there were 1,124 fewer permanent visas granted to engineers, scientists and architects in 2020-2021 compared to 2017-2018.

Migration is an inherently time consuming and risky proposition for businesses

As Australia continues to take on larger more complex public infrastructure projects, the recruitment of global talent to fill senior expert roles will be an important contribution. Australia's Skilled Migration Program sets out the key occupations and skills required to fill short- and medium-term shortages. Construction project manager, mechanical engineer and maintenance planner are all currently listed on Australia's Priority Migration Skilled Occupation List.[71]

However, for some businesses the program can be too complex and inflexible to be fully effective. Restrictions such as age limitations and number of migrant workers per business prevents businesses from flexibly utilising the program to meet their needs. Stakeholders note the program's current age limitation of 45 limits the ability for businesses to fill gaps where substantial technical skill and seniority is required. The process is also costly for small and medium businesses. In particular, the cost involved in sponsorship of skilled workers and the level of Temporary Skilled Migration Income Threshold can be prohibitive.[72] This leads many employers, particularly smaller and more regional organisations, to decide that it is not worth pursuing and is particularly true for sponsorship of construction workers and tradespeople.[73]

Furthermore, the occupations list is drawn from ANZCO classifications and does not adequately reflect growing workforces and emerging skills such as rail systems or digital engineering.[74] Section 3 identifies 22 roles likely in shortage within occupations not identified as in shortage through existing skills shortage lists.

Existing migrants are poorly utilised by the current market

Not all migrants are equally effective in addressing workforce shortages. While businesses often sponsor highly skilled migrants, those that arrive through other visas do not always have the same impact. Our migration estimates exclude individuals who migrate to Australia without declaring skills relevant for public infrastructure on entry.

Migrants are more likely to work in areas that are outside and below their qualifications and skill set. In the case of migrants with engineering qualifications, they are more likely to work in industries such as retail trade, accommodation and food services. The Committee for Economic Development of Australia (CEDA) similarly found that despite indicators civil engineers are in shortage, 28% of migrant qualified civil engineers were unable to find work in the occupation.[75] The reasons for this are lack of recognition of overseas skills and qualifications, employer reluctance to employ individuals without local experience, lack of understanding of Australian standards and English language barriers. Migrants who subsequently gain the skills to work in public infrastructure after arriving in Australia are included in this report under higher education, VET and existing workforce estimates.

Border closures for international students will have long-term workforce impacts

Ongoing border closures have substantially limited the inflow of international students, who are major contributors to the public infrastructure workforce. In 2019, international students made up 34% of undergraduate enrolments in engineering, and 23% in architecture and building.[76] Between study and post-study visas, they are eligible to spend up to twelve years in the country before applying for permanent visas, which means they can contribute substantially to workforce supply. They are also better placed to overcome the barriers to migrant employment identified above, as they are more likely than other skilled migrants to have strong English-language skills, understanding of Australian standards and experience in Australian contexts.

Priority Migration Skilled Occupation List

Travel restrictions have protected the health of Australians and ensured that Australia's borders remain strong and protected from the transmission of COVID-19.
The Government has worked closely with Australian businesses to support the entry of critical workers to help Australia's economic recovery, including by introducing a Priority Migration Skilled Occupation List (PMSOL).

The PMSOL identifies 44 occupations that fill critical skills needs to support Australia's economic recovery from COVID-19[77]. The list is based on advice from the National Skills Commission and consultation across the Australian Government. This list currently includes a number of those occupations identified as relevant to the public infrastructure workforce, including construction project managers, surveyors, and engineering occupations.

The Australian Government has announced that employer sponsored nomination and visa applications with an occupation on the PMSOL will be given priority processing. All other skilled occupation lists will remain active, but the PMSOL occupations will take priority.

The list is temporary and priority occupations may change as Australia recovers from the pandemic. The Australian Government and the National Skills Commission will continue to monitor the impact of COVID-19 on the Australian labour market and assess Australia's skills needs as they evolve and new sources of data emerge.

National Skills Commission

The National Skills Commission provides expert advice and national leadership on Australia's labour market and current, emerging and future workforce skills needs. Understanding where the jobs in demand are, and what skills are needed to do those jobs, will help more Australians get back to work and build a strong economy for the future.

The Commission monitors, researches and analyses employment dynamics across different demographic groups, industries, occupations and regions.

The Skills Priority List (SPL) is key deliverable for the NSC that provides a detailed view of shortages as well as the future demand for occupations across Australia.

The SPL uses a range of inputs to deliver labour market assessments for occupations based on labour market data analysis, employer surveys, industry consultation and federal and state/territory government input. This list provides the backbone piece of labour market analysis on occupations that will be a key input to a range of Australian Government policy initiatives, including targeting of skilled migration, apprenticeship incentives and training funding. Noting that each of these measures will also need to consider other inputs relevant to their specific policy needs. The SPL is reviewed and updated annually and is published on the NSC website at https://www.nationalskillscommission.gov.au/2021-skills-priority-list

Infrastructure Australia acknowledges the support of, and looks forward to continuing to work with, the National Skills Commission to support this work through the ongoing analysis provided through the Market Capacity Program.

Table of figures

Appendix A – Occupation and role mapping to ANZSCO

Table 1 below details the ANZSCO mapping to the four key infrastructure categories.

Table 1: Occupation and role taxonomy mapping

	Sub-Classification	Roles	ANZSCO
Project Management Professionals	Risk Management	Risk Manager	139914
	Project Management	Project Manager Project Director Project Sponsor Project Controls Project Officer Project Administrator/Coordinator Project Engineer	511112
	Commercial Management	Commercial Director	111211
	Procurement	Purchasing Leads Procurement Manager Purchasing Officer Procurement Officer	591113
	Environmental and Occupational Health Professionals	HSE Managers Safety Manager Quality Managers HSE Advisors	2513
	Construction Management	Construction Manager Construction Director Construction Foreman Superintendents	133111 312112
Engineers, Scientists and Architects	Engineering Manager	Engineering Manager Head of Engineering Coordinators	133211
	Materials Engineer	Materials Engineer Materials Lead Welding Engineer Materials Scientist	233112
	Electronic Engineer	Electronic Engineer Electronic Lead Signalling Engineer	233411
	Electrical Engineer	Electrical Engineer Electrical Lead	233311

		Control Engineer Engineering and Design Managers	
	Mechanical Engineer	Mechanical Engineer Mechanical Lead	233512
	Production Engineer	Production Engineer Production Lead Operations Engineer Flow Assurance Engineer Production Engineering Managers	233513
	Civil Engineer	Civil Engineer Site Engineer Civil Managers and Supervisors Civil Lead and Principal Engineer Hydraulic Engineers	233211 233215
	Geotech Engineer	Geotech Engineer Geotechnical Lead or Principal Engineer	233212
	Quantity Surveyor	Quantity Surveyor Construction Estimator Lead or Quantity Survey Manager	233213 312114
	Structural Engineer	Structural Engineer Structural Lead Building or Façade Engineers Fire Engineers Structural Designers	233214
	Telecommunications Engineers	Telecommunications Engineer Wideband Designer	2633
	Draftsperson	Architectural Draftsperson Revit Documenter/Technician Mechanical Draftsperson Mechanical Engineering Technician Civil Draftsperson CAD Related Occupations Civil Engineering Technician Electrical Engineering Draftsperson Electrical and Electronic Draftspersons Electrical Engineering Technician Electronic Technician Civil Designer	312111 3125 3122 3123 3124

	Architect	Architect Designer Design Manager Managing or Lead Architect	 232111 232511
	Landscape Architect	Landscape Architect Landscape Designer Principal Landscape Architect	 232112
	Environmental Professionals	Environmental Engineer Environmental Scientist Environmental Consultant Conservation Officer	 2343 233915
	Geologists, Geophysicists and Hydrogeologists	Geologist Geophysicist Hydrogeologist	 2344
	Land Surveyor	Land Surveyor Building Surveyor Lead or Surveyor Manager	 232212
	Building Surveyor	Building Survey Building Inspector Building Certifier Planning Enforcement Officer Civil Inspector	 312113
	IT Professionals/Engineers	ICT Support Engineer ICT Systems Test Engineer ICT Support and Test Engineer ICT Quality Assurance Engineer	 2632
	Maintenance Planner	Maintenance Manager, Supervisor, Superintendent Maintenance Officer Maintenance Planner Maintenance Technician Maintenance Coordinator	 312911
	Other Professional Engineers, Scientists, Etc.	Various Specialist Engineers Project Engineer Lead or Managing Engineers and Professionals Engineer	 233999
Structures and Civil Trades and Labour	Rigger and Dogman	Rigger Dogman Rigging Supervisor	821711 821911
	Structural Steel Erectors	Steel Erectors and Structural Steel Erectors	821714
	Plant Operators	Earthmoving Plant Operator Backhoe Operator Bulldozer Operator	7212 721311 721912

		Excavator Operator Grader Operator Loader Operator Forklift Driver Linemarker Paving Plant Operator Road Roller Operator	721913 721915
	Road Based Civil Plant Operators	Road Based Civil Plant Operator	721999
	Bricklayers	Brick or Block Layer/Labourer	331111
	Carpenters and Joiners	Carpenter Carpenter and Joiner Joiner	3312
	Concreters	Concrete or Cement Worker/Labourer Pre-Cast Worker/Labourer Concrete/Cementing Supervisor	821211 712914 821713
	Rail Track Workers	Railway Track Worker	821611
	Crane Operations	Crane or Lift Operator/Driver Hoist or Piling Rig Operator Crane or Piling Rig Supervisor	712111
	Truck Drivers	Truck Drivers	733111
	Driller (Piling/Foundations)	Pilings and Foundations Driller Drilling Plant Operator Driller	712211
Finishing Trades and Labourers	Telecoms Field Staff	Telecommunications Field Engineer Telecommunications Technical Officer/Technologist Radiocommunications Technician	3132
	Plumbers	Airconditioning and Mechanical Services Plumber Drainer Plumber (General) Gasfitter Roof Plumber	3341
	Mechanical Trades Workers	Metal Fitters and Machinists Precision Metal Trades Workers	3232 323314
	Painting Trades	Painter Power Coater	332211

		Painting Contractor or Supervisor	
	Wall and Floor Workers	Fibrous Plasterer Solid Plasterer Floor Finisher Wall and Floor Tiler	3332 3334 332111
	Glazing	Glazier Window or Glass Installer/Worker	333111
	Electricians	Electrician Lift Mechanic	3411
	Electrical Line Workers	Electrical Linesworker Field Service Engineer Surveyor	3422
	Telecommunications Trade Assistant	Telecommunications Trainee	899914
	Telecoms Cabler	Data and Telco Cabler Telecommunications Cable Jointer Telecommunications Technician Telecommunications Linesworker/Mechanic	3424
	General Construction Labourer	Builders Labourer Earthmoving Labourer Plumbers Assistant Construction Labourer	8211 821511 821712 821913 821915
	Safety Worker	Safety Inspector Safety Officer	312611 899923

Appendix B – Occupational group snapshots

The visuals in Figure 26 provide greater detail on the estimated workforce for each occupational group and their individual occupations.

Figure 26: Project management professionals occupational detail[78]

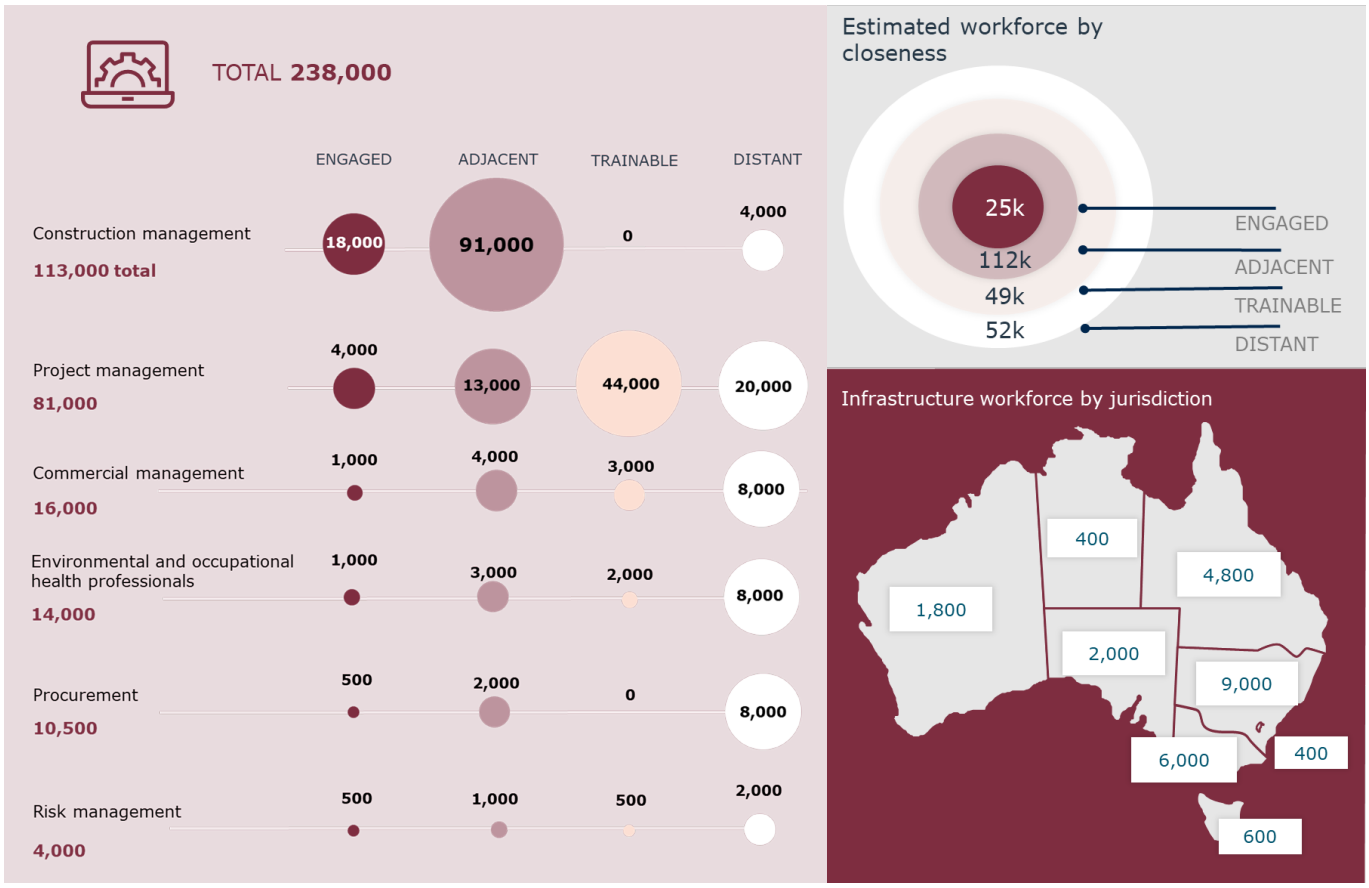


Figure 27: Engineers, scientists and architects occupational detail[79]

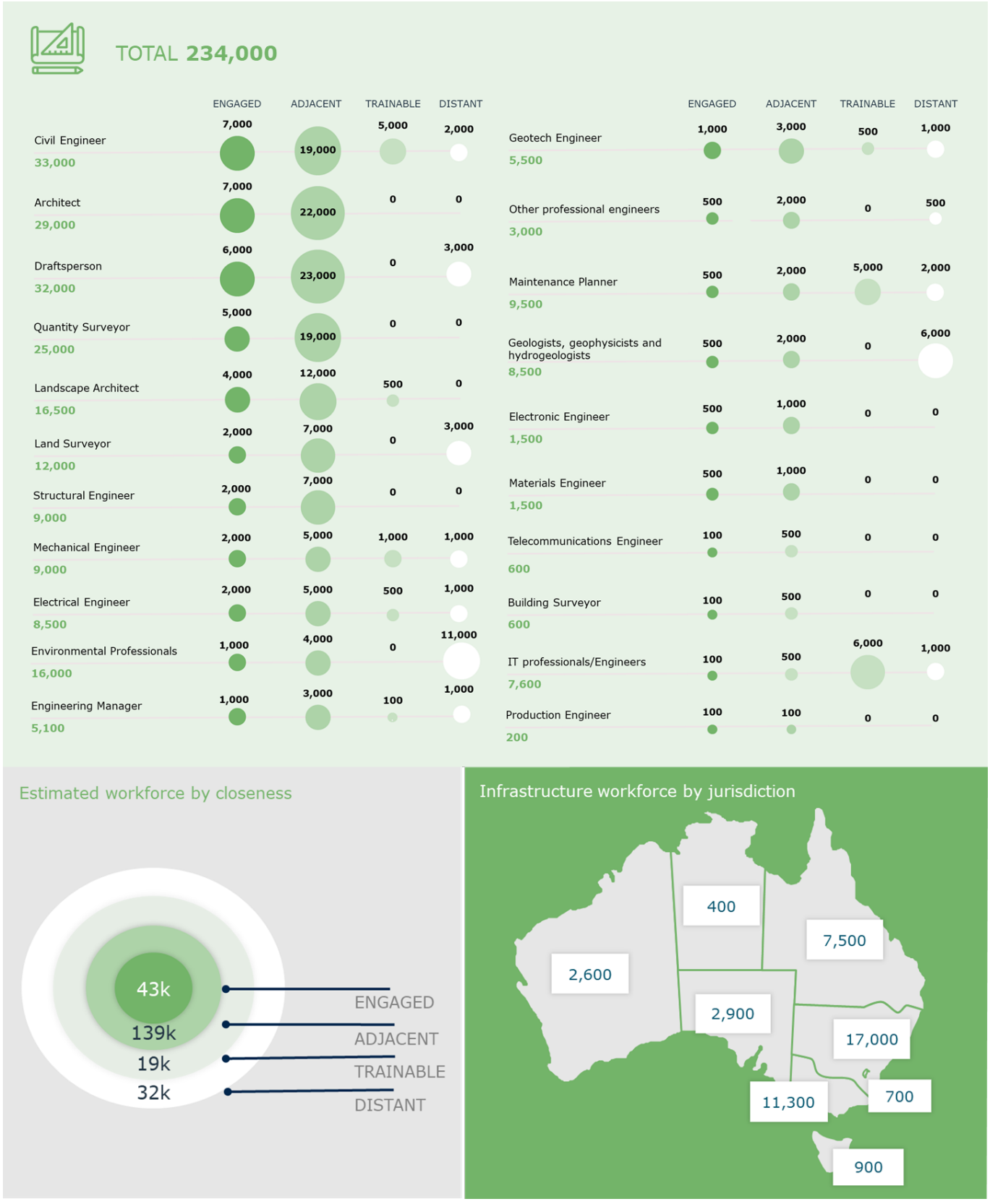


Figure 28: Structures and civil trades and labour occupational group detail[80]

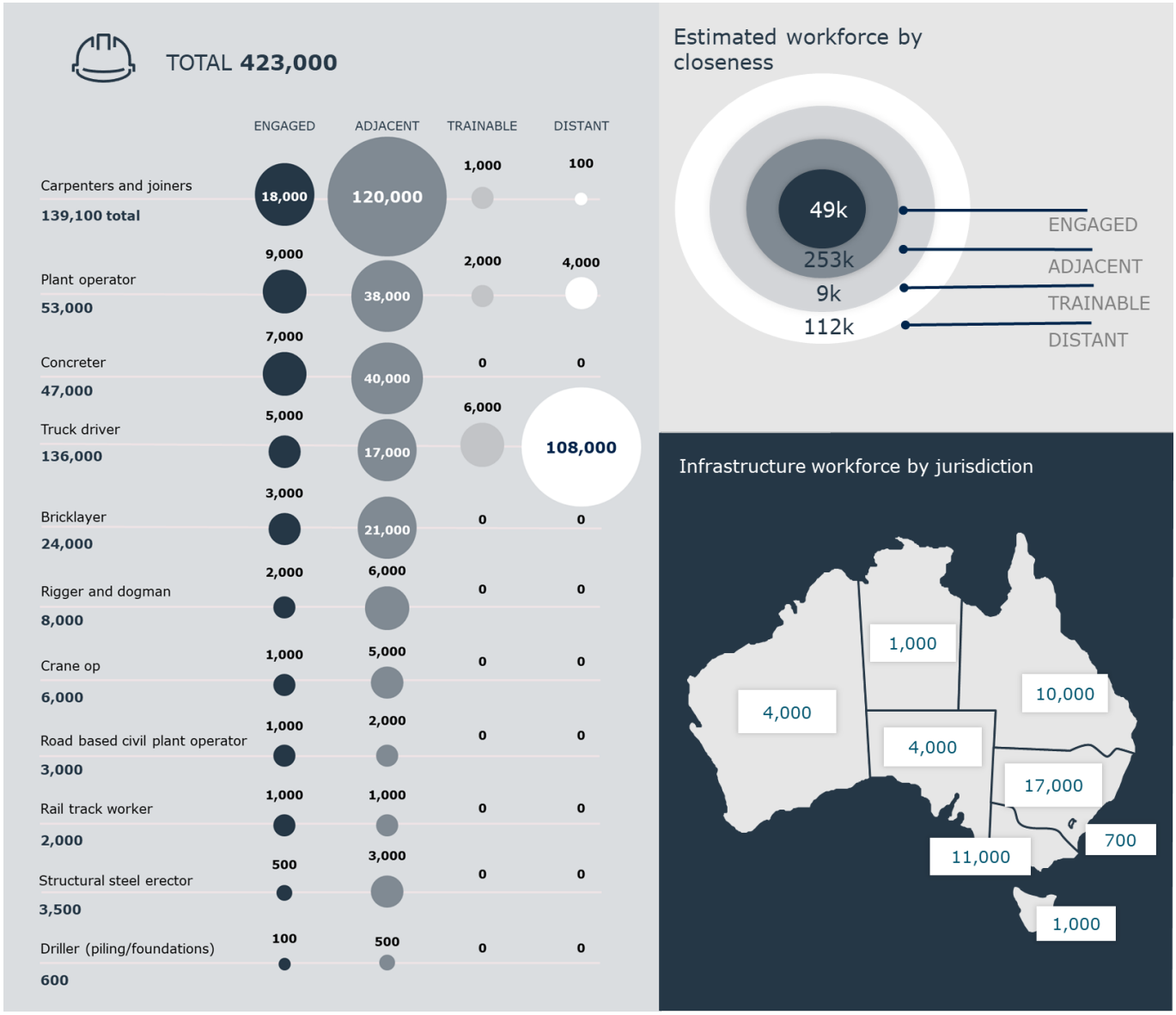
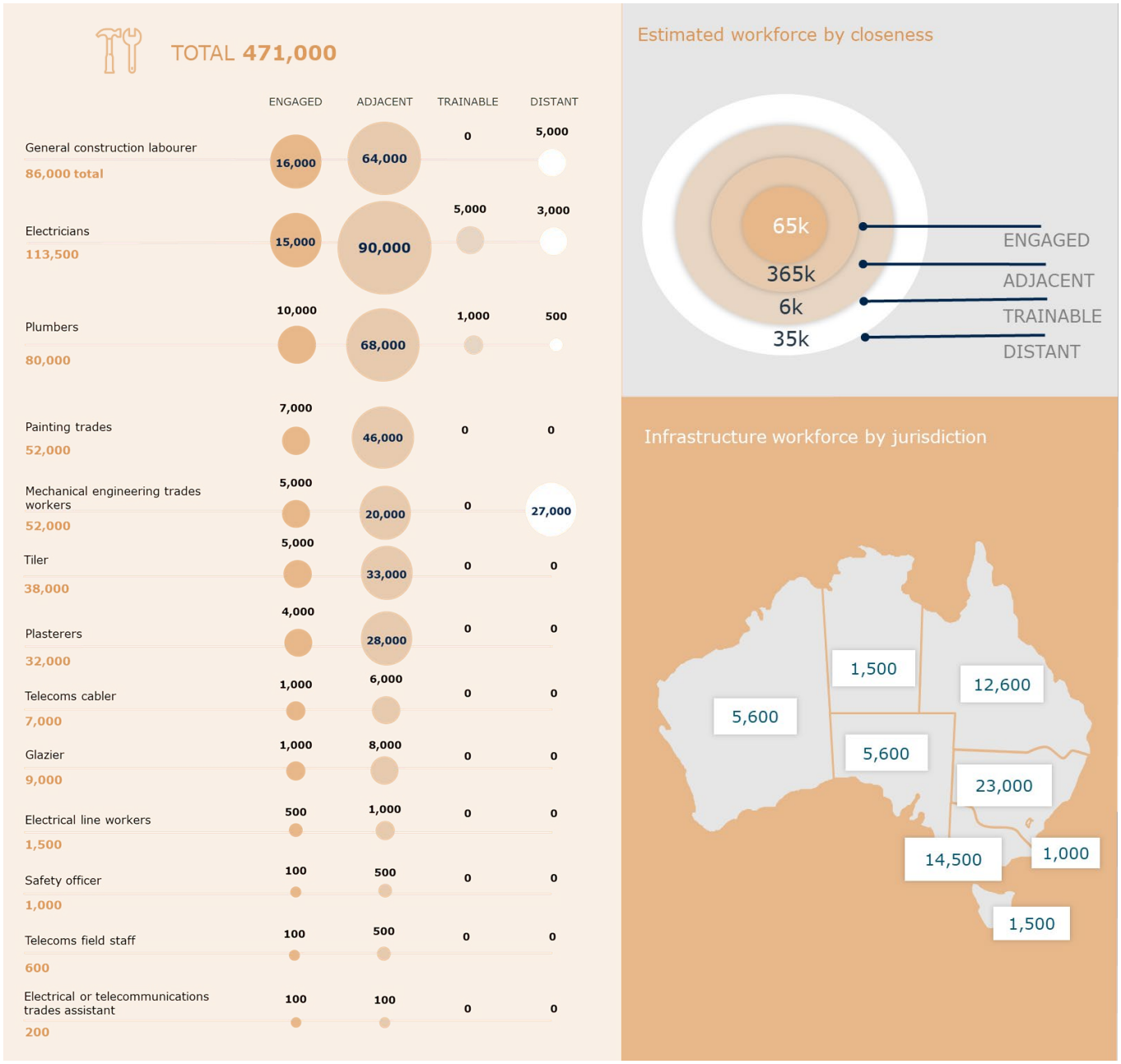


Figure 29: Finishing trades and labourers occupational group detail[81]



Appendix C – Current occupational shortages detail

The visuals below provide an assessment of the likely existing occupational shortages as determined by an analysis of the following criteria:

- **Migration shortage list** – where an occupation was included on an existing migration priority list. This included the Medium and Long-term Strategic Skills List (MLTSSL), the Short-term Skilled Occupation List (STSOL), the Regional Occupation List (ROL) and the Regional Sponsored Migration Scheme (RSMS) ROL List.
- **Recognised by industry** – where an occupation was suggested to be in shortage in relevant literature or by industry stakeholders in consultation.
- **Existing worker shortage in public infrastructure** – when historical and forecast supply was combined with public infrastructure demand and the occupations current supply was assessed as not meeting current demand (as at May 2021).
- **Labour Market Indicators** – where an occupation was assessed as being in shortage against the following criteria: change in advertised salary, change in share of job advertisements and share of advertisements posted for greater than 30 days.

Occupations were assessed as likely in shortage (fulfilled three or more criteria), potentially in shortage (two criteria) or unlikely in shortage (under two criteria). Occupations were categorised as unlikely to be shortage where they met two criteria and the second was indicated as varying views in literature and consultation as to whether shortage exists.

Figure 30 to Figure 34 illustrates the existence of shortages against the criteria:

⊗ Considered a shortage against the specific indicator

⊖ Varying views in literature and consultation as to whether shortages exist

Figure 30: Project management professionals – indicators of shortage[82]

OCCUPATIONS	IA indicators	INDICATORS OF SHORTAGE			
		Migration shortage list	Recognised by industry	Existing worker shortage	Labour Market Indicators
Construction management	Potential	⊗	⊗		
Project management	Unlikely		⊖	⊗	
Commercial management	Unlikely			⊗	
Procurement managers	Likely	⊗		⊗	⊗
Environmental and occupational health professionals	Unlikely			⊗	
Risk management	Potential		⊗	⊗	

Figure 31: Engineers, scientists and architects (1/2) – indicators of shortage[83]

OCCUPATIONS	IA indicators	INDICATORS OF SHORTAGE			
		Migration shortage list	Recognised by industry	Existing worker shortage	Labour Market Indicators
Production engineer	Potential		⊗		
Draftsperson	Unlikely	—	—		
Architect	Unlikely		—		
Civil engineer	Likely	⊗	⊗	⊗	
Quantity surveyor	Likely	⊗	⊗	⊗	
Landscape architect	Unlikely				
Environmental professionals	Likely	⊗	⊗		⊗
Land surveyor	Likely	⊗	⊗	⊗	
Maintenance planner	Potential	⊗		⊗	
Structural engineer	Likely	⊗	—	⊗	

Figure 32: Engineers, scientists and architects (2/2) – indicators of shortage[84]

OCCUPATIONS	IA indicators	INDICATORS OF SHORTAGE			
		Migration shortage list	Recognised by industry	Existing worker shortage	Labour Market Indicators
IT Professionals / engineers	Potential		⊗	⊗	
Mechanical engineer	Potential	⊗	⊗		
Electrical engineer	Likely	⊗	⊗	⊗	
Engineering manager	Likely	⊗	⊗		⊗
Geologists, geophysicists and hydrogeologists	Likely	⊗	⊗	⊗	⊗
Geotechnical engineer	Likely	⊗		⊗	⊗
Electronic engineer	Potential	⊗			⊗
Materials engineer	Likely	⊗	⊗	⊗	
Telecommunications engineers	Potential	⊗		⊗	
Building surveyor	Likely	⊗	⊗	⊗	⊗
Other professional engineers, scientists, etc.	Likely	⊗	⊗	⊗	

Figure 33: Structures and civil trades and labour – indicators of shortage[85]

OCCUPATIONS	IA indicators	INDICATORS OF SHORTAGE			
		Migration shortage list	Recognised by industry	Existing worker shortage	Labour Market Indicators
Carpenters and joiners	Potential	⊗	⊗		
Truck drivers	Unlikely		⊖		
Plant operator	Unlikely				
Concreter	Potential		⊗		⊗
Bricklayer	Potential	⊗	⊗		
Rigger and dogman	Unlikely				
Crane operator	Potential		⊗	⊗	
Driller (piling / foundations)	Likely		⊗	⊗	⊗
Structural steel erector	Unlikely			⊗	
Rail track worker	Potential		⊖	⊗	
Road based civil plant operator	Potential			⊗	⊗

Figure 34: Finishing trades and labourers – indicators of shortage[86]

OCCUPATIONS	INDICATORS OF SHORTAGE				
	IA indicators	Migration shortage list	Recognised by industry	Existing worker shortage	Labour Market Indicators
Electricians	Potential	⊗	⊗		
Plumbers	Unlikely	⊗	—		
General Construction Labourer	Potential		⊗	⊗	
Mechanical Engineering Trades Workers	Unlikely	⊗			
Painting Trades	Potential	⊗	⊗		
Tiler	Likely	⊗	⊗		⊗
Plasterers	Unlikely	⊗			
Glazier	Potential	⊗	⊗		
Telecommunications Cabler	Likely	⊗	⊗		⊗
Electrical Line Workers	Likely	⊗	⊗	⊗	
Safety Officers	Unlikely			⊗	
Telecommunications Field Staff	Likely		⊗	⊗	⊗
Electrical or Telecommunications Trades Assistant	Unlikely		⊗		

Appendix D – Role shortages detail

Figure 35 to Figure 39 set out the potential shortages at the role level as determined by Labour Market Indicator Analysis (see Appendix F – Modelling methodology for a description of methodology). The figures used below to indicate where a shortage is *likely to exist* or *potentially exists* only reflects an assessment against the Labour Market Indicator analysis.

Figure 35: Project management professionals – potential role shortages[87]

OCCUPATIONS		INDIVIDUAL ROLES		
		Likely shortages	Potential shortages	Shortages unlikely
Construction management	✓		• Construction supervisor	• Construction manager • Foreman • Site manager / Supervisor • Site administrator
Project management	✓		• Project administrator • Project officer	• Project manager • Senior project manager • Senior project officer • Project coordinator
Commercial management	✓		• Chief operating officer • Senior strategic planner	• Commercial manager • Business manager • General manager • Operations manager
Procurement managers	—	• Purchasing officer	• Procurement officer • Senior procurement officer • Procurement specialist	• Buyer • Procurement analyst
Environmental and occupational health professionals	✓	• HSE advisor • Safety advisor		• HSE manager • Safety manager • Environmental health and safety officer
Risk management	✓	• Risk and compliance manager		• Quality assurance manager • Quality assurance coordinator

Figure 36: Engineers, scientists and architects (1/2) – potential role shortages[88]

OCCUPATIONS		INDIVIDUAL ROLES		
		Likely shortages	Potential shortages	Shortages unlikely
Production engineer	✓	• Senior software engineer	• Systems Engineer • Operations Engineer • Production Engineer • Software Engineer	• Senior Systems Engineer • Solutions Architect
Draftsperson	✓	• Mechanical Engineering Technician • Automation Tester	• Civil Designer • Senior Civil Designer • Mechanical Designer	• Draftsperson • Revit Drafter • Electrical Technician
Architect	✓			• Architect • Senior Architect • Interior Designer • Design Manager
Civil engineer	✓		• Site Engineer • Civil Supervisor	• Civil Engineer • Hydraulic Engineer • Senior Civil Engineer
Quantity surveyor	✓	• Senior Estimator		• Quantity Surveyor • Senior Quantity Surveyor • Estimator
Landscape architect	✓		• Senior Landscape Architect	• Landscape Architect
Environmental professionals	✓	• Environmental Advisor • Sr Environmental Advisor • Ecologist	• Stormwater Engineer • Environmental Engineer • Sr Environmental Officer	• Environmental Officer • Senior Ecologist
Land surveyor	✓	• Mine Surveyor	• Engineering Surveyor	• Surveyor • Senior Surveyor
Maintenance planner	✓		• Maintenance Manager • Maintenance Officer	• Maintenance Technician • Maintenance Planner
Structural engineer	✓			• Sr Structural Engineer • Structural Engineer

Figure 37: Engineers, scientists and architects (2/2) – potential role shortages[89]

OCCUPATIONS		INDIVIDUAL ROLES		
		Likely shortages	Potential shortages	Shortages unlikely
IT professionals / engineers	✓	• Application Support Analyst	• IT Support • Test Manager	• Automation Test Analyst • Senior Test Analyst
Mechanical engineer	✓		• Mechanical Design Engineer	• Senior Mechanical Engineer • Mechanical Engineer
Electrical engineer	✓			• Electrical Engineer • Sr Electrical Engineer
Engineering manager	—	• Head of Engineering	• Engineering Manager	
Geologists, geophysicists and hydrogeologists	✗	• Geologist • Mine Geologist • Hydrogeologist		
Geotechnical engineer	—	• Principal Geotechnical Engineer	• Geotechnical Engineer • Senior Geotechnical Engineer	
Electronic engineer	—	• Electronic Engineer • Sr Signalling Engineer		
Materials engineer	✓			• Materials Engineer
Telecommunications engineers	✓	• Telecommunications Engineer		• Communications Engineer* • Wideband Designer*
Building surveyor	—	• Building Inspector • Building Certifier	• Building Surveyor	• Senior Building Surveyor
Other professional engineers, scientists, etc.	✓		• Engineer • Senior Engineer	• Design Engineer • Maintenance Engineer

Figure 38: Structures and civil trades and labour – potential role shortages[90]

OCCUPATIONS		INDIVIDUAL ROLES		
		Likely shortages	Potential shortages	Shortages unlikely
Carpenters and joiners	✓		• Joiner • Apprentice Carpenter	• Carpenter • Shopfitter • Leading Hand
Truck drivers	✓	• Multi Combination Driver		• Truck Driver • Heavy Combination Driver
Plant operator	✓	• Grader Operator • Dozer Operator	• Reach Forklift Driver • Excavator Operator • Backhoe Operator • Final Trim Grader Operator	• Forklift Driver • Loader Operator • Scraper Operator
Concreter	—	• Concreter		• Concrete Finisher
Bricklayer	✓			• Bricklayer • Apprentice Bricklayer
Rigger and dogman	✓			• Rigger • Dogman
Crane operator	✓		• Crane Operator	
Driller (Piling / Foundations)	✗	• Driller • Blast Hole Driller		
Structural steel erector	✓			• Structural Steel Erector
Rail track worker	✓			• Rail Track Worker
Road based civil plant operator	—			• Roller Operator

Figure 39: Finishing trades and labourers – potential role shortages[91]

OCCUPATIONS		INDIVIDUAL ROLES		
		Likely shortages	Potential shortages	Shortages unlikely
Electricians	✓		• Electrician • Industrial Electrician • Electrical Supervisor	• Maintenance Electrician
Plumbers	✓		• Drainer • Maintenance Plumber • Pipefitter	• Plumber • Roof Plumber • Apprentice Plumber
General construction labourer	✓			• Construction Labourer
Mechanical engineering trades workers	✓		• Diesel Fitter • Fitter • Mechanical Fitter	• Field Service Technician • Electrical Fitter • Maintenance Fitter
Painting trades	✓		• Industrial Painter • Apprentice Painter • Powder Coater	• Painter
Tiler	—		• Tiler • Wall and Floor Tiler	
Plasterers	✓		• Solid Plasterer	• Plasterer
Glazier	✓			• Glazier
Telecommunications cabler	✓			• Telecommunications Technician
Electrical line workers	✗	• Linesperson		
Safety officers	✓			• Safety Inspector*
Telecommunications field staff	✓			• Radio Communications Technician*
Electrical or telecommunications trades assistant	—		• Electrical Trade Assistant	

Appendix E – Gender diversity by occupation

This appendix includes information, for each occupation, on the male / female figures of the current workforce.

Figure 40: Project management professional gender breakdown by occupation[92]

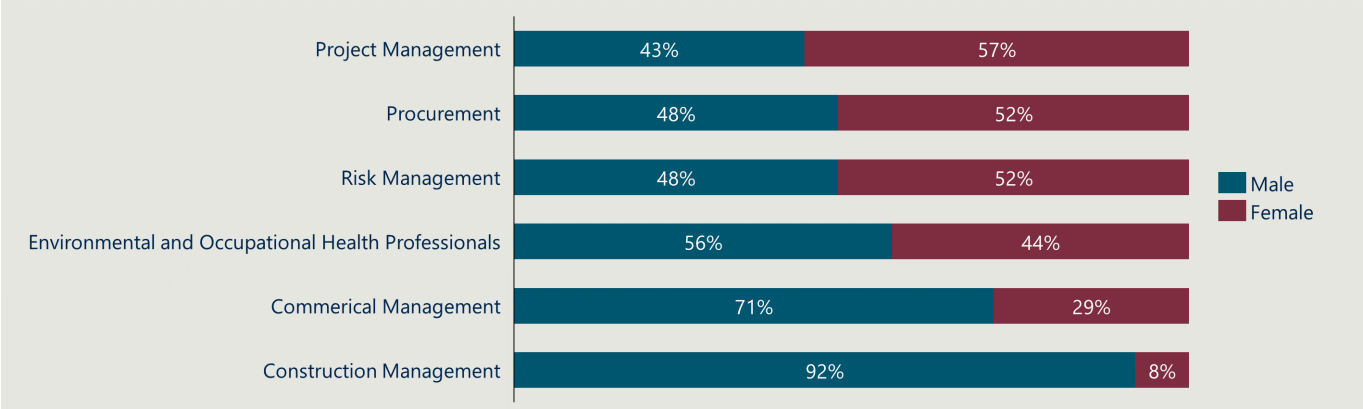


Figure 41: Engineers, scientists and architects gender breakdown by occupation[93]

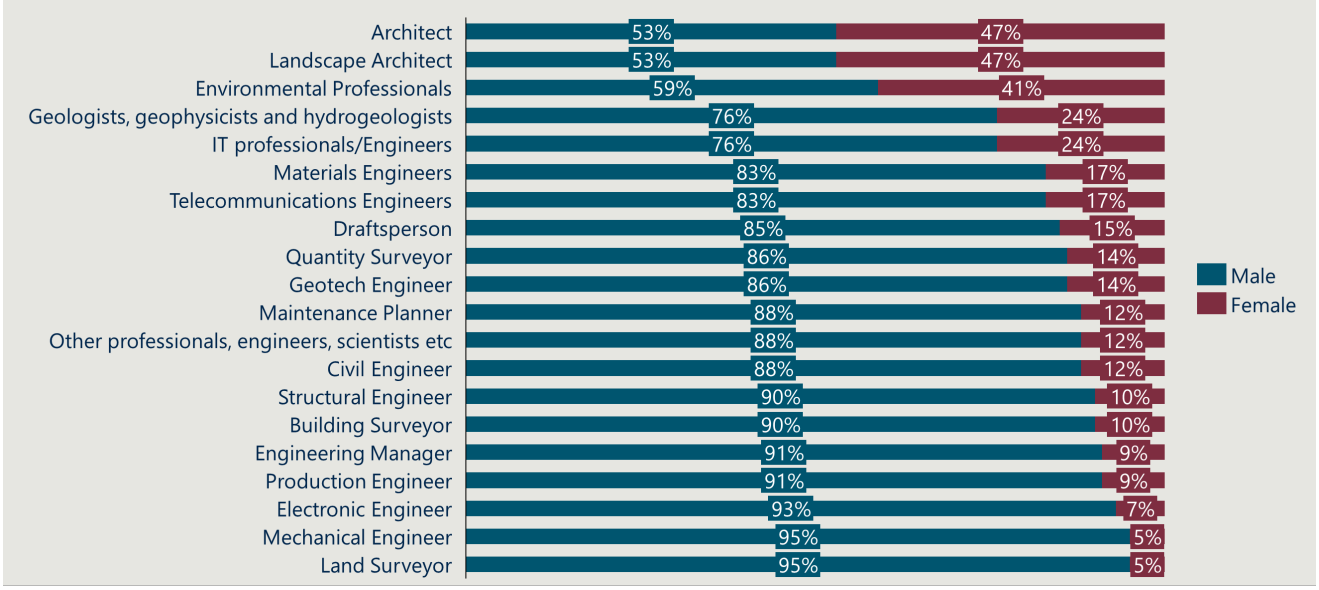


Figure 42: Structural and civil trades and labour gender breakdown by occupation[94]

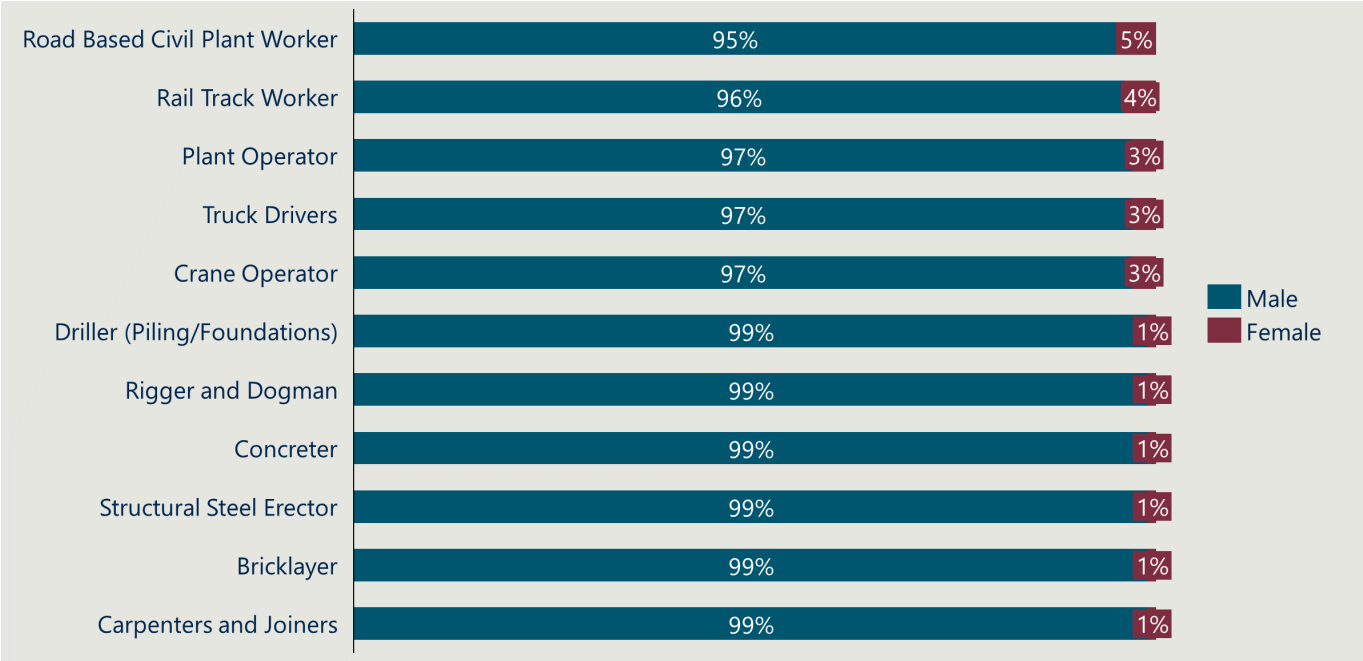
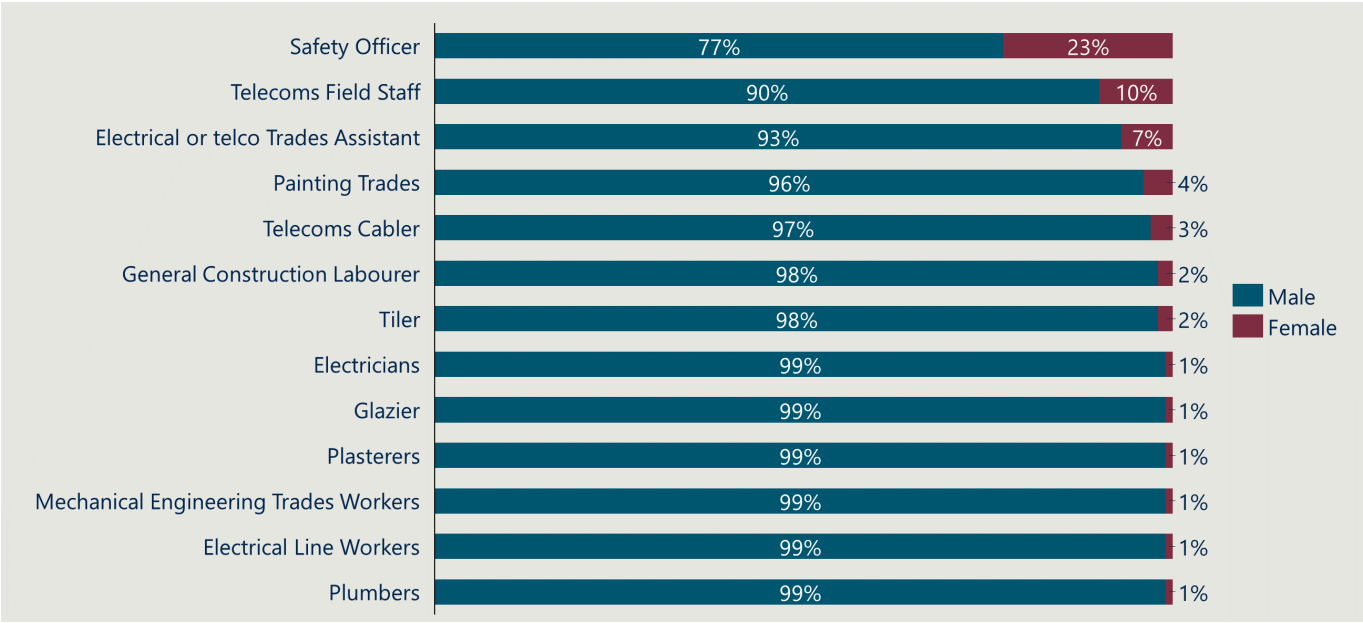


Figure 43: Finishing trades and labourers gender breakdown by occupation[95]



Appendix F – Modelling methodology

Introduction

The fundamental question addressed by this report is to what extent the current and projected supply of labour can support Australia's proposed investment in public infrastructure. To understand this, it was necessary to clearly define the occupations and skills that underpin this workforce and estimate the numbers of people available at different points in time, including projections for the future. The broad approach was to estimate numbers of people in or near the workforce as determined by official statistics and our own forecasts or modelling based on those statistics; and confront these estimates with additional data (such as job advertisements) that provides extra information on variables (such as skills) not covered by the official statistics; and extra granularity (such as estimates down to the level of "roles", below existing ANZSCO unit groups) on variables which required further detail than official statistics provided.

The analytical work can be understood as two distinct types: development of classifications, and development of estimates. The two types overlap – we used data-based estimates to define our classifications – but it is useful to understand the steps separately.

There were two key classifications developed for this work and are used through the report. These build on the standard classifications used for occupation and industry – ANZSCO and the ANZSIC. Using data to categorise, combine (and in some cases add) our final occupational classifications added additional granularity to the standard measures. The two classifications define:

1. The occupations and roles that are relevant to public infrastructure
2. The parts of the workforce in relevant occupations are engaged, adjacent trainable or distant from public infrastructure

These classifications were developed to capture the full range of occupations that contribute to public infrastructure in single streamlined taxonomy. They also support a more nuanced view of the labour force recognising the portability of skills across and between sectors. Finally, the addition of roles provides a level of granularity not present in ANZSCO, yet critical to understand skill needs.

There were six key pieces of data analysis that built on those classifications, seeking to estimate:

1. historical and current labour supply
2. anticipated workforce attrition
3. future labour supply
4. workforce shortages
5. skill profiles
6. demographics

The methods used for these two classifications and six pieces of analysis are outlined in more detail below.

The most important data sources across the project were the 2016 Census and the ongoing Labour Force Survey to quantify where supply matched demand until 2036; and job advertisement data from Burning Glass as an indicator of demand. Each of these data sources has its own strengths and weaknesses leading to limitations in the conclusions that can be drawn. The Census is comprehensive but infrequent; it is self-completed and depends on respondents identifying their own occupation and industry. The Labour Force Survey is carefully calibrated to definitive population totals, has higher quality consistent use of classifications but is based on a sample. The job advertisements are also a sample but of a varying and unknown proportion of the full quantum of demand – varying not just over time but also by occupation and industry. The classification of job advertisements to industry and occupation is done by a statistical/machine learning algorithm based on analysis of the original text, introducing its own statistical noise.

Key limitations of the analysis can be understood in several categories:

- measurement noise – such as Census respondents misclassifying their industry or occupation, in a way different to any misclassification that takes place in the Labour Force survey
- processing noise – such as the Burning Glass machine learning algorithm misclassifying the occupation of a job advert
- analytical assumptions – such as assuming that the proportions of detailed job titles within an ANZSCO unit Group in the workforce reflect the proportion of those titles appearing in job adverts for that ANZSCO unit group; or that the proportion of people in each industry working in each occupation at the time of the Census (the best source at that level of granularity) has not changed materially since

Every effort has been made to control for these problems, as outlined in the detail below, but significant uncertainty and limitations are inevitable.

Defining public infrastructure relevant occupations and roles

Methodology

An occupational and role taxonomy was developed in partnership with Infrastructure Australia and their other consulting partners. Prior to the commencement of this project Infrastructure Australia identified a three-tier taxonomy including occupation group, classification and sub classification.

An initial mapping of sub classifications was provided to Nous Group for review. Nous mapped unit level ANZSCOs to classifications to enable alignment with the Infrastructure Australia and ANZSCO taxonomies. The full mapping is available in Appendix A – Occupation and role mapping to ANZSCO.

With classifications defined, job advertisement data provided by Burning Glass was used to identify key roles by occupational classification. Roles are a level below ANZSCO unit group.

Many project management roles on public infrastructure projects were undertaken by individuals captured under other occupations. Nous Group analysed job advertisements data to identify roles that required a similar skill set using cosine similarity. A weighting was then developed to apportion a share of sub classifications to the project manager sub classification. Any ANZSCOs that contained less than 1% of project management professional roles in its job advertisements, were excluded from further analysis.w

Assumptions

The following assumptions were adopted in defining infrastructure relevant occupations:

1. Job advertisements are matched appropriately to ANZSCO unit groups in the Burning Glass Technologies data set.
2. All individuals covered by a mapped ANZCO unit group have skills relevant to public infrastructure.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. The workforce engaged in public infrastructure is diverse. Several occupations involved in pre-planning stages have been omitted from the analysis such as construction lawyers, transport economists and policy analysts.
2. Infrastructure relevant occupations are limited to those identified as working in the sector. Individuals outside of defined occupations may share a sufficient base of skills to be relevant for public infrastructure. This is most likely true for labouring occupations such as general construction labour, riggers or operators of basic plant.

Defining engaged, adjacent, trainable and distance share of workforce

Methodology

Individuals were allocated to ANZSIC Group segments by ANZSCO based on census data. ANZSIC groups were then classified based on those directly linked to the construction of public infrastructure

and those that were not. ANZSIC groups identified as directly linked included ANZSIC E, 692, 942 and 529. These formed the basis of estimates for the engaged and adjacent workforces, while estimates of the trainable and distant workforces are drawn from the remaining ANZSICs.

Weightings were developed to apportion workers in the selected ANZSICs between the engaged and adjacent categories. Workforce-to-spend ratios provided were used to calculate public-private split estimates based on labour, rather than for the total value of projects by state and type of project. Occupational profiles by ANZSIC Groups, were then used to estimate which occupations were most likely to be working on public and private projects, allowing us to map the monetary public-private split data to the actual supply of labour for engaged and adjacent individuals.

Skills profiles were developed for each ANZSIC group that was not directly linked to construction of public infrastructure, using Burning Glass Technologies job advertisement data. This was compared to the profile for the same occupation in directly linked ANZSICs using cosine similarity analysis. Based on similarity score, the ANZSCO-ANZSIC segment was allocated to either trainable (higher similarity) or distant (lower similarity) categories.

Assumptions

The following assumptions were adopted in defining the engaged, adjacent, trainable and distant share of workforce:

1. ABS data collections capture the full extent of government investment in public infrastructure.
2. ANZSIC E, 692, 94 and 529 account for most of the building and engineering construction activity.
3. Ratios to translate value to employment are consistent with industry practice.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. Our definition includes work funded by all tiers of government (federal, state and territory and local councils). We are unable to differentiate based on funder.

Estimating historical and current labour supply for public infrastructure

Methodology

Bespoke estimates of workforce supply by ANZSCO unit and ANZSIC group for relevant occupations were developed by Nous Group. Estimates were developed for 2016 based on census data at ANZSCO 4 and Burning Glass Technologies job advertisement data. This approach was used due to ABS perturbation of data where there is a risk of identifying individuals due to small numbers. Iterative proportional fitting was used to ensure that figures at the ANZSCO 6-digit level were consistent with higher level census results. A tailored ABS request was used to validate estimates based on the ANZSCO unit by ANZSCO group level data provided.

Supply estimates were projected forward to 2021 based on results of ABS labour force survey using iterative proportional fitting. The result was estimates for total workforce in infrastructure relevant roles. This workforce was than apportioned based on weightings developed in previous step to determine the number of engaged, adjacent, trainable or distant individuals from 2016 to 2021.

Assumptions

The following assumptions were adopted to estimate the historical and current labour supply for public infrastructure:

1. The distribution of job advertisements by ANZSCO unit group is a reasonable approximation of the workforce under each ANZSCO minor group.
2. Individuals are classified in the same way under census, labour force survey and Burning Glass Technologies data.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. Small variations in estimates may occur at sub jurisdictional level from official statistics due to the approach adopted to overcome limitations in census microdata.

Estimating anticipated future workforce attrition

Methodology

Estimates of workforce attrition are based on changes to the age profile of the current infrastructure workforce between two consecutive Census surveys.

Age profiles of individuals in the current workforce were approximated using 2016 ABS Census demographic data of individuals working in construction related industries, split by five-year age groups. Attrition rate was calculated based on movement between the 2011 Census and 2016 Census of consecutive five-year age groups for individuals older than 45 years old under the construction ANZSIC. The change between the two Census surveys and consecutive age groups captures mortality, retirement, and career changes.

Nous Group then iteratively shifted the age distribution of the current workforce every five years, and applied attrition estimates to the respective five-year age groups. This produced attrition estimates by occupation and age to 2036.

Assumptions

The following assumptions were adopted in projecting workforce attrition:

1. The age distribution of the current infrastructure workforce is well-approximated by the age profile of individuals working in construction related industries.
2. The change in workforce between the two Census surveys mostly captures mortality and retirement.
3. The change in workforce at an ANZSCO 6-digit level is well-approximate by changes at the ANZSCO 4-digit level.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. Estimated attrition ranges may vary within the ANZSCO 6-digit level compared to the ANZSCO 4-digit level.
2. We are unable to differentiate attrition by mortality, retirement, or career changes.

Estimating future labour supply for public infrastructure.

Workforce supply forecasts from 2021 to 2036 were developed by integrating current supply with education and migration inflows starting from 2022 and 2023 respectively. Once the two components were integrated, Nous Group overlayed attrition projections, prorated relevant ANZSCO groups, and applied an engaged ratio developed in calculated in determining the share of engaged, adjacent, trainable and distant workforce to determine the overall engaged workforce supply.

Education inflow

New entrants via education were estimated based on the number of workforce-ready graduates across higher education and VET (including apprenticeships and traineeships, qualifications and individual units of competency) in each year and mapped to infrastructure related ANZSCOs. This was done in three steps:

Forecast population to 2036 by five-year age groups

Population projections derived by the Australian Institute of Health and Welfare (AIHW) were used to model population in five-year age groups at the Statistical Area Level 2 granularity up until 2032.

Population projections between 2032 to 2036 were interpolated using the compound annual growth rate from 2027 to 2032.

Projecting the number of workforce-ready graduates (all pathways)

Domestic bachelor (higher education) commencements were calculated each year, by age group and translated to a ratio of commencements in each region, per age group, by its population. The commencement ratio was then combined with population forecasts to 2036 to obtain commencements into 2036. Commencements were then overlayed with estimated completion rates from the Department of Education, Skills and Employment to project graduations. Estimates were then adjusted to account for students who may delay workforce entry to pursue further study.

Vocational education and training graduates were calculated in three parts – apprenticeships and traineeships, qualification completer and part completers (people that may only undertake a few units of competency for occupational or high-risk licencing purposes). Apprentice and trainee completions were calculated with a similar approach used for domestic bachelor graduates, with completion rates based on Nous Group estimates. Our approach for non-apprenticeships or traineeship was adjusted to accommodate individuals who did not complete their full training but had completed all intended training to obtain the job they needed. The completion rates for non-apprenticeships and non-completers who had completed all intended training draw on NCVER data. Both apprenticeships and non-apprenticeship graduates were filtered to only include individuals studying to get a job or transition careers to avoid double counting of individuals already in the labour market.

The workforce ready graduates were mapped to occupation groups and subclasses using Nous Group's proprietary concordance system that links education to occupation.

Migration inflow

Migration inflows were projected using data supplied by the Department of Home Affairs. Data was broken down by visa subclass at an ANZSCO unit group level. Four visa subclasses were modelled that relate to permanent labour increases: 186 Employer Nomination Scheme; 187 Regional Sponsored Migration Scheme; 189 Skilled – Independent; and 190 Skilled – Nominated. Temporary visas were excluded to avoid double counting of the workforce. Migration figures were apportioned to regions based on existing distributions.

Assumptions

The following assumptions were adopted to estimate future labour supply for public infrastructure:

1. New supply is estimated on an annual basis and distributed evenly across the calendar year.
2. Population forecasts from 2032 to 2036 follow the compound annual growth rate of the AIHW's 2027-2032 population forecast.
3. The current rates of people commencing study is maintained to 2036.
4. The relationship between field of education and ANZSCO career outcomes are maintained.
5. 40% of commencing higher education students join the workforce after 4 years of commencing study. An additional 40% join the workforce over the next 4 years (years 5-8).
6. 0.2% of bachelor completions move to postgraduate study each year and enter the workforce two years later.
7. 57% of apprentices and civil trainees join the workforce after 4 years of commencing study. An additional 8% join the workforce over the next 4 years (years 5-8).
8. 20% of non-apprenticeship students join the workforce after one year of commencing study. An additional 20% join the workforce in the following year.
9. 15% of all non-apprenticeship commencements are non-completers who have acquired the skills required to transition to the workforce. They join the workforce the following year.
10. VET students have been segmented into different categories based on reason of study. "Skillers" and "starters" (as identified through the student outcomes survey) are students who represent a

net addition to the workforce. The ongoing proportion of "skillers" and "starters" maintain the same ratio as per student survey outcomes.

11. The visa classes of interest are: 186 employer nomination scheme; 187 regional sponsored migration scheme; 189 skilled independent; and 190 skilled nominated. These permanent visa classes represent a net workforce migration to Australia.
12. The visa classes of interest are: 186 employer nomination scheme; 187 regional sponsored migration scheme; 189 skilled independent; and 190 skilled nominated. These permanent visa classes represent a net workforce migration to Australia.
13. The 2018-2019 migration value for the above subclasses is assumed to be maintained from 2023-2036.
14. Perturbed data instances in the migration data which have a value of "<5" has been assumed to take on a value of three.
15. The distribution of migration to different states is assumed to follow the current distribution of infrastructure workers.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. Education completion rates could vary due to factors including age, region and field of study. This has not been individually estimated in this study.
2. Distribution of migrants to states could vary depending on external market factors. This has not been individually estimated in this study.

Identifying shortages based on modelled supply and demand

Methodology

Our demand estimates were matched to Nous Group supply forecasts by sub classification to estimate potential shortage or surplus at group, classification and sub classification.

Assumptions

The following assumptions were adopted to estimate future labour supply for public infrastructure:

1. Occupational definitions are consistent for demand and supply side estimates.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. Demand estimates are based on known infrastructure investment as of 30 April 2021.
2. Demand estimates do not incorporate demand from individual councils for public infrastructure.

Identifying shortages based on labour market indicators

Methodology

Burning Glass Technologies job advertisements were used to calculate three indictors of potential shortage, namely change in advertised salary, change in share of job advertisements, and share of advertisements posted for greater than 30 days. Values were calculated for all ANZSCO unit groups and compared with Infrastructure Australia's sub classifications and roles. Occupations and roles were ranked on relative performance to identify those that were more likely to be experiencing shortages. Results were tested with industry stakeholders.

Assumptions

The following assumptions were adopted to identify shortages based on labour market indicators:

1. Movement in indicators is reflective of difficulties by employers in sourcing labour.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. A range of factors may contribute to movement in identified indicators. Consequently, indicators should be viewed in conjunction with other assessments of shortage to provide a fuller picture.

Developing skills profiles for identified occupations

Methodology

Burning Glass Technologies job advertisements were used to develop skills profiles by occupation and roles based on their skills taxonomy and text analytics algorithm.

Nous Group assessed each skill identified by whether they were general or specialist as defined by Burning Glass Technologies and the distinctiveness of the skill – how concentrated the demand for a skill is in specific occupations. These combined to create the three categories general, technical and specialist outlined in section one of the report.

Nous also assessed the degree of change in mentions of a particular skill. Two periods 2015-2017 and 2018-2020 were compared to identify skills with increasing, declining or stable demand.

Assumptions

The following assumptions were adopted to develop skills profiles for relevant occupations:

1. Mentions of skills in job advertisements are representative of an employer's skills needs for a given occupation.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. Sample sizes can be small for some occupations. To ensure sufficient samples all job advertisements were used for a given occupation, rather than restricting to those industries directly linked to public infrastructure.

Demographic analysis

Methodology

Detailed data tables were provided by the ABS on Census 2016 employment figures. The tables provided employment data by gender, age, SA3 of residence, and ANZSCO 6-digit level occupation.

The figures were used to summarise age and gender distribution across occupations in scope for this report. The geographic indicators were used to explore concentrations of the infrastructure labour force across Australia.

The data used for these analyses required no modelling or estimation, just a summary of custom tables, that are not publicly available.

Assumptions

1. Gender, age and geographic distributions within infrastructure-specific occupations are consistent with broader industry trends and population estimates from 2016 to 2021.
2. Gender and age distributions for common job titles within the infrastructure industry do not differ significantly from distributions in other industries.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. Demographic information could not be explored by ANZSIC industry classifications because of (1) table size restrictions imposed by the ABS data warehouse and (2) individual categories with small numbers, which the ABS is unable to provide to protect individual privacy.
2. A key implication for analysis was the inability to accurately explore different segments of the infrastructure workforce (such as engaged, adjacent, trainable and distant) by demographic breakdown. Only broader aggregations were possible.
3. Gender and age distributions could not be explored per geographic unit because the data was supplied by the ABS in separate tables.

Data sources and usage

A range of data sources have been used to support analysis for this report. These are outlined in Table 2.

Table 2: Data sources used and purpose

Data source	Definition of occupations	Definition of public infrastructure	Estimation of current and historical supply	Estimation of future workforce attrition	Estimation of future workforce supply	Modelled supply and demand shortages	Labour market indicators of shortage	Development of skills profiles	Demographic analysis
Burning Glass Technologies labour market data	x	X	x		x	x	x	x	
ABS Census 2011-2016[96]		X	x	x	x	x			x
ABS Engineering Construction Activity[97]			x		x				
ABS Building Construction Activity[98]			x		x				
ABS Detailed Employment[99]			X						
ABS Payroll Jobs and Wages[100]			X						
Australian Institute of Health and Welfare[101]					x	x			
Department of Home Affairs migration data[102]					x	x			
Higher education completion rates[103]					x	x			
Higher education graduates[104]					x	x			
VET completion rates[105]					x	x			

Data source	Definition of occupations	Definition of public infrastructure	Estimation of current and historical supply	Estimation of future workforce attrition	Estimation of future workforce supply	Modelled supply and demand shortages	Labour market indicators of shortage	Development of skills profiles	Demographic analysis
VET student outcomes survey data[106]					x	x			
HEIMS enrolment data[107]					x	x			
NCVER Total VET Activity data[108]					x	x			
Infrastructure demand data[109]						x			

Appendix G – Acronyms

Acronyms used in this report:

Australasian Railway Association	ARA
Australia and New Zealand Standard Industrial Classifications	ANZSIC
Australian and New Zealand Standard Classification of Occupations	ANZSCO
Australian Bureau of Statistics	ABS
Australian Capital Territory	ACT
Australian Institute of Health and Welfare	AIHW
Committee for Economic Development of Australia	CEDA
Health, Safety and Environment	HSE
Health, Safety and Environment	HSE
Medium and Long-term Strategic Skills List	MLTSSL
National Skills Commission	NSC
New South Wales	NSW
Northern Territory	NT
Regional Occupation List	ROL
Regional Sponsored Migration Scheme	RSMS
Science, technology, engineering and mathematics	STEM
Short-term Skilled Occupation List	STSOL
Vocational education and training	VET
Western Australia	WA

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