Australian Composites Manufacturing CRC

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Education and Training Scoping Study

WHITE PAPER

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This White Paper was initiated by ACM CRC to gather industry intelligence on skills gaps and training needs in the Australian composites manufacturing sector, including practitioners, suppliers, R&D agencies and educational institutions.

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Figure 1 The Newcastle Memorial Walk, a 450m coastal walkway, was built by Wagners Constructions to commemorate the 100th anniversary of the ANZAC landing at Gallipoli. Designed by EJE Architects and built by Wagners Composite Fibre Technologies (CFT), the walk includes a 160m cliff-top bridge with steel silhouettes of soldiers and inscribed names of Hunter Valley men and women who served in World War I. It also forms part of the Bathers Way, a six-kilometer coastal walk. Courtesy of Wagners CFT ANZ

1 Executive Summary

The Australian composite manufacturing industry has unique origins, having evolved through pioneering entrepreneurial endeavours, engineering innovations and advancements in material science. In parallel, strategic investments by government into research agencies and universities have enabled substantial scientific and engineering achievements. As a result, new markets have emerged and sovereign technical challenges have been conquered, often replacing traditional metal casting methods and fostering a unique sector of specialised SMEs. Many companies operate across multiple industries, leveraging manufacturing technologies that they have invested in, while others focus on proprietary products. The dominant sectors—including pools and spas, marine craft, transport and industrial products—remain the largest consumers of material inputs, sustaining the industry.

This scoping study was launched to examine education and training challenges within this dynamic and rapidly evolving sector. It aims to leverage the industry's extraordinary talent across the workforce and training institutions while seizing opportunities in robotics and automation to meet existing efficiencies and emerging market demands.

Composites Australia conducted industry interviews, an online survey and an analysis of state and federal industry policy to gain contextual insights.

Encouragingly, the findings indicate strong industry confidence, with most survey respondents planning workforce expansion over the next one to five years and an intention to continue producing in Australia. Though cautious, investments in automation are enhancing productivity and competitiveness.

Workers with experience in composite production processes, particularly in niche applications such as composite fabrication and materials chemistry, are highly valued. Equally, women are making their mark in production roles. Companies are also keen to engage interns with higher education qualifications, providing them with practical workforce experience to support their transition into roles of greater responsibility.

Industry clusters, particularly those near universities in regional areas, have leveraged strategic locations and targeted investments to drive growth in advanced manufacturing and employment. Sectors such as defence, prefabricated housing, haulage, renewable energy, wind energy, recycling and composite repair and sustainment have been identified as key areas for future growth, driven by government policy and investment in research centres.

Recent government initiatives and private investment have also led to increased apprentice enrolments, which are expected to expand the pool of qualified workers in the coming years. To fully realise Australia's investment in composite innovation, however, ongoing investment in both training and assessment resources and the recruitment of vocational education and training (VET) instructors will be essential.

Employers remain committed to continuous learning for workers at all levels, recognising the ever-evolving nature of technology and the importance of foundational knowledge. Training covers key areas such as 'Composites 101,' 'tool/mould design and manufacture,' 'resins and catalysts,' 'adhesives and bonding technologies' and 'composite repair'. For practical reasons, in-house training remains the preferred approach to skills development, complemented by online learning and externally accredited qualifications.

This commitment to skills and knowledge development extends to strengthening pathways from VET to higher education, particularly into engineering degrees. The Australian Universities Accord, released by the Department of Education in early 2024, reinforces this approach, recognising VET and higher education (HE) as integral parts of the same system and ensuring a seamless transition between vocational training and advanced qualifications.

An investment in learning and assessment resources that integrate robotics and newly established industry standards (AS/NZ, ISO, ASTM1[1]) is recommended to ensure students are equipped with the skills needed to meet evolving industry demands.

The study proposes a series of strategic initiatives under four key themes:

- **Bridging training and industry needs:**
  Enhancing alignment between educational programs and industry skill requirements.
- **Bridging academia and industry through dissemination:**
  Encouraging knowledge exchange between universities, researchers and industry stakeholders.
- **Building the next-generation composites workforce:**
  Expanding training and career pathways to attract new talent.
- **Championing industry talent:**
  Recognising and supporting workforce diversity and leadership development.

Together, these documents offer a comprehensive evidence base to inform policy, guide program development and support collaboration between industry and academia.

A sincere thank-you to all who generously contributed their insights and perspectives on future workforce trends, helping to shape a positive and forward-looking outlook for the industry.

2 Key Findings and Possible Initiatives

2.1 Possible Initiatives

The study outlines recommended initiatives for ACM CRC to consider and implement, providing a strategic roadmap for developing a workforce that can sustain and advance the composites industry. Throughout this scoping study, various suggestions and strategies emerged to address workforce development, focusing on up-skilling the current workforce while equipping Higher

Degree by Research (HDR) students and early career researchers (ECRs) with the expertise needed to thrive in this dynamic and rapidly evolving sector. The following strategies are presented without a specific priority order.

Using the validated Agent-based model as a testbed, we performed a series of batch runs of with different initial conditions. From this, a robust optimisation of the overall system performance at

[1] **AS/NZS** – Australian/New Zealand Standard: Joint standards developed by Standards Australia and Standards New Zealand. These standards apply to products, services and systems to ensure safety, quality and consistency across both countries.
ISO – International Organization for Standardization: A global body based in Switzerland that develops and publishes international standards covering everything from manufacturing and technology to health, safety and the environment.
ASTM – American Society for Testing and Materials (now known simply as ASTM International), A US-based organisation that develops voluntary consensus standards for materials, products, systems and services, widely used around the world, particularly in engineering and manufacturing

each set of demand requirements can be established and visualised. The optimisation software deployed was a plug-in suite of Python code from the scikit code bundle. This allowed a range of optimisation, clustering and regression-based techniques to achieve a good optimisation result.

2.1.1 Bridging training and industry needs

A. Develop learning materials for short courses and micro-credentials targeting:

- Identified gaps in analysis and design processes as well as composite repair.
- Integration of lean manufacturing principles to minimise waste and improve efficiency.

B. Establish a formal partnership with Fraunhofer IFAM to facilitate training and certification in European Adhesive Engineer (EAE) programs, tailored for applications in defence, aerospace and advanced manufacturing.

C. Analyse the Industry Skills Accelerator (ISA) micro- credential catalogue to determine courses that are suitable for broader application within the composites industry.

D. Review ISA learning materials to determine compliance with apprenticeship standards relevant to the composites manufacturing sector and evaluate the potential for credit alignment.

E. Collaborate with Advanced Manufacturing Readiness Facility (AMRF) and ISA to develop future education programs (Learning Lab), with a particular focus on skills required for automation and digitisation of the composites manufacturing industry (e.g., filament winding, machine learning and digital twinning).

2.1.2 Bridging academia and industry through dissemination

F. Fund and create a seminar (or social media) series focused on case studies highlighting the return on investment from implementing automation in composite manufacturing.

G. Leverage the expertise of established composite manufacturers in collaboration with universities to organise and deliver specialised workshops on composites.

H. Fund and initiate composite themed webinars (Lunch and Learn) targeted at engineers to count towards Professional Development registration requirements.

I. Fund the development of a comprehensive directory of research expertise and associated equipment at universities with active portfolios in composite technologies.

J. Revise breadth and possibilities of digital twinning for manufacturing environments.

K. Encourage and provide financial support for academic staff and students to attend key industry events and for industry representatives to attend academic conferences.

2.1.3 Building the next-generation composites workforce

L. Lobby Manufacturing Industry Skills Alliance (MISA) for the inclusion of units determined to be relevant to the composites manufacturing industry but are currently not featured, such as MEM25013 Produce 3D printed plugs and moulds into MEM31119 and MEM30719 (KC).

M. Review relevant apprenticeships to assess whether learning resources and strategies include units that address requirements for contemporary composites manufacturing, such as CNC machining and 3D printing standards.

N. Fund and develop learning and assessment resources for:

- MEM25013 - 'Produce 3D plugs and moulds.'
- MEM26015 - 'Select and apply repair techniques' to meet standards relevant to the specific part.

O. Promote increased participation of women and under- represented groups in teaching roles within the technical field of composites.

P. Explore collaborative projects with TAFE/VET, MISA and dual-sector universities to develop pathway programs that allow students to progress from short courses and vocational training to a bachelor’s degree, with the option to pursue a higher degree by research if desired.

2.1.4 Championing industry talent

Q. Establish and fund a mentorship program through the ACM CRC, pairing participants with Senior Female Executives to run concurrently with the RISE program.

R. ACM CRC to develop a policy aimed at supporting under-represented groups in the composites industry.

S. Launch a composite design competition, led by the example of the World Solar Challenge, encouraging university students to design and develop innovative solutions for Australia’s housing challenges using composite technologies, with a focus on joining techniques, design, engineering and sustainability.

2.2 Potential Research Themes

Figure 2 Ship's Company of HMAS Anzac form the number 20 on the flight deck to mark its 20th Birthday at sea during its South East Asia Deployment 2016.

Industry participants highlighted several priority areas where further research could directly support workforce development and technological advancements. Advanced manufacturing techniques and productivity- driven innovations, coupled with automation, lean manufacturing and material performance, are top of the list. Practical, application-driven research on composite repair techniques is also a priority. Collectively, these priorities align with the industry's overarching goal of enhancing productivity and competitiveness in the sector.

Research

T. Establish a formal partnership with the Clean Energy Council to explore research into in-situ end-of-life technologies for wind turbines to avoid landfill disposal.

U. Review opportunities to research into enhancing efficiencies in turbine blade repair processes tailored to Australian conditions including UV curing.

V. Investigate research opportunities to advance joining techniques for composites and dissimilar materials in the context of transport, aerospace, marine and civil engineering (e.g., prefabricated housing).

W. Research techniques and advancements in repairing composite materials across industrial assets and clean energy, in particular '3D Preforms', for streamlining the repair process and enhancing the durability of composite products.

X. Initiate and fund a Life Cycle Analysis updating UNSW's School of Mechanical and Manufacturing Engineering, 'Composites: Calculating their embodied energy,' study.[2]

3 Introduction

3.1 Background to the scoping study

The Australian composites manufacturing sector is undergoing significant transformation, driven by advancements in materials and technologies and strategic national policies to strengthen sovereign capabilities. Operational modernisation is now a prerequisite, particularly as businesses navigate a tight labour market and rising operational and materials input costs.

Companies are adopting advanced equipment and automated technologies to remain competitive, driving demand for technical skills in robotics and automation. Workforce expansion is also a key focus, contingent upon the availability of skilled professionals and up-skilling or re-skilling pathways via VET and higher education.

Composites Australia, in collaboration with the Australian Composites Manufacturing Cooperative Research Centre (ACM CRC) and RMIT (Royal Melbourne Institute of Technology) University, is undertaking a comprehensive skills development initiative to address these challenges in the composites industry. This effort targets the current workforce's up-skilling while equipping Higher Degree Research (HDR) students and early career researchers (ECRs) with the expertise needed to contribute to this dynamic and rapidly evolving sector constructively.

Through our analysis of evidence-based industry feedback, this project will develop targeted strategies and programs to build a skilled, adaptable and future-ready workforce and bridge gaps between academia, manufacturing and supply chains.

The study presents a set of recommended initiatives for ACM CRC consideration and implementation, offering a strategic roadmap to cultivate a workforce capable of sustaining and advancing the composites industry.

3.2 Federal government policy framework

The COVID-19 pandemic exposed significant vulnerabilities in global supply chains and highlighted Australia's dependence on imported goods, raising concerns about national security and economic stability. In response, the Federal Government, has progressively introduced policies and associated fiscal programs to strengthen domestic manufacturing capabilities, reinforce local supply chains and enhance national self-reliance – adding to legacy manufacturing policies and programs. Details of these initiatives are outlined in section 9.1.

Additional initiatives, including the substantial National Reconstruction Fund, are continuing to be rolled out and refined. The resulting programs will influence the manufacturing landscape throughout ACM CRC's lifespan, potentially nudging and supporting industries to capitalise on emerging opportunities in areas yet to be understood or anticipated.

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[2] https://www.compositesaustralia.com.au/wp-content/uploads/2024/06/Final-Report-Composites-Embodied-Energy-Study.pdf

3.2.1 The Universities Accord

The Australian Universities Accord[3], released by the Department of Education on 25 February 2024, recognised the need for a more integrated tertiary education system. It makes several recommendations to improve pathways from vocational education and training (VET) to university through a framework of 'Seamless Navigation'. We support the report's view that higher education and VET are essential parts of the same system, each contributing unique strengths. To that end, we explored pathways to a more flexible system that could facilitate smoother transitions between VET and higher education to meet the evolving needs of students and the workforce, confidently and adequately equipped to better serve Australian manufacturing.

3.3 Key stakeholders

3.3.1 Australian Composite Manufacturing CRC (ACM CRC)[4]

The ACM CRC (acmcrc.com) was founded in 2022 to advance Australia's composite materials, technologies and manufacturing capabilities. The decade-long collaboration program, co- funded and constituted under the Australian Government's Cooperative Research Centres (CRC) program, brings together industry, researchers and the government. It aims to advance the nation's composites engineering and manufacturing. It aims to advance the nation's composites engineering and manufacturing capabilities and to capitalise on emerging sectors and technologies. Structured around programs in materials, manufacturing processes, computer modelling and simulation and performance and design integration, the CRC includes an Education and Training program, the development and delivery of which will be informed by this scoping study.

3.3.2 RMIT University

Founded in 1887 with roots in industrial sectors, RMIT offers programs spanning vocational education, undergraduate, postgraduate and research levels. With campuses in Melbourne, Vietnam and Spain and a strong online presence, RMIT combines academic rigour with industry-focused education. The university specialises in advanced manufacturing, engineering, architecture and creative industries, preparing graduates for dynamic capabilities and to capitalise on emerging sectors and technologies. Structured around programs in materials, manufacturing processes, computer modelling and simulation and performance and design integration, the CRC includes an Education and Training program, the development and delivery of which will be informed by this scoping study.

[3] https://www.education.gov.au/australian-universities-accord/resources/final-report
[4] ACM CRC.com

3.3.3 Composites Australia Inc.[5]

Composites Australia Inc. (CA) is the peak industry body representing Australia's composites sector. Founded over 50 years ago, CA is a not-for-profit, industry-led organisation that serves as a voice for composite manufacturers, practitioners, suppliers, R&D agencies and educational institutions.

CA actively participates in government and industry committees and forums to contribute to policy development at both state and federal levels. It also implements government initiatives designed to build capability and strengthen industry sectors. The association plays a pivotal role in fostering industry development through events such as conferences, international trade delegations, seminars and workshops. Additionally, CA maintains a comprehensive communication program to disseminate information on advanced technologies and end-use applications in composites manufacturing.

- CA is the nominating organisation for Standards Australia and a founding member of the Global Coalition for Sustainability in Composites.
- Composites Australia is also an ordinary member of the Manufacturing Industry Skills Alliance (MISA), a not-for-profit, industry-led Jobs and Skills Council that oversees several training packages for specialised manufacturing skills, develops contemporary vocational education training (VET) training products and fosters collaboration between industry and training providers to improve training and assessment practices.

CA's Executive Director, Kerryn Caulfield, is a recognised leader in advanced manufacturing and serves as the principal consultant, researcher and author for this study.

[5] compositesaustralia.com.au

3.4 Methodology

Figure 3 This massive bulk liquid storage tank was made by Envirotanks at its Coolaroo site in Victoria.

This scoping study draws on both primary and secondary sources to gather quantitative and qualitative data on industry perspectives. The collected evidence informs the findings and proposed initiatives outlined in this report.

Primary Sources: Stakeholder engagement was a key component of this study, with personnel from 61 organisations providing evidence-based insights. The data collection process included:

One-on-one Interviews (qualitative- focused on exploring participants' experiences, perceptions and insights in depth):

- **41** in-person interviews conducted across Victoria, New South Wales, Queensland and Western Australia.
- **20** additional interviews conducted remotely via Zoom or telephone.

Online Survey (a mix of closed (quantitative) and open-ended (qualitative) questions):

- A **27**-question survey distributed to industry stakeholders received 32 responses.
- **69** per cent of respondents opted to remain anonymous.

Stakeholder interviews and surveys involved representatives from:

- Composites manufacturing companies
- Suppliers of material inputs, equipment and engineering services
- University personnel
- TAFE training providers and MISA

The study prioritised ACM CRC partner companies (Tier 1) while also engaging with non- partner organisations to capture perspectives from the broader composites sector (Tier 2).

A list of companies interviewed is provided in Section 9.2. Interviewees were highly engaged, openly sharing their expertise, professional experiences and perspectives on future industry directions.

Secondary Sources: A desktop literature review was conducted, analysing key reports and research relevant to the industry. These secondary sources complement the primary data by providing context, benchmarking and broader insights.

A full list of referenced materials is included in section 9.3.

4 Overview of Composite Materials and Structures

4.1 What are composites?

Composites, commonly called Fibre-Reinforced Polymer (FRP) materials, consist of a polymer matrix reinforced with engineered fibres, which can be synthetic or natural. The matrix protects the fibres from environmental and external damage and facilitates load transfer between fibres, while the fibres provide strength and stiffness. In addition to the matrix and fibres, composites may include fillers, additives, core materials (in sandwich configurations) or surface finishes to enhance functionality, manufacturing efficiency, appearance or performance.

The most common composite material is glass fibre-reinforced polymer (GFRP), which combines glass fibre reinforcements with polymer resins such as polyesters. Other widely used composites include carbon fibre-reinforced polymer (CFRP), which is valued for its high strength and lightweight characteristics. Alternative fibre reinforcement choices include aramid/Kevlar™ and basalt fibres. The selection of fibres and resins depends on the final product's manufacturing processes, equipment and intended application.

The engineering performance of composites exceeds that of individual components. Fibre-reinforced composites produce lighter, stronger and more durable materials than conventional engineering materials, such as monolithic metals. These advanced materials are favoured for their exceptional strength-to-weight ratio and corrosion resistance and durability, offering enhanced protection for people and assets. As non-metallic materials, composites allow radio waves to pass through efficiently. They can be embedded with technical functionalities, such as structural health monitoring systems, making them versatile choices for a wide range of industries.

4.2 Composite manufacturing process

Raw material inputs are processed through various stages to transform into composite components. The specific stages depend on the chosen manufacturing technology, which is selected based on the intended application, engineering specifications or required standards.

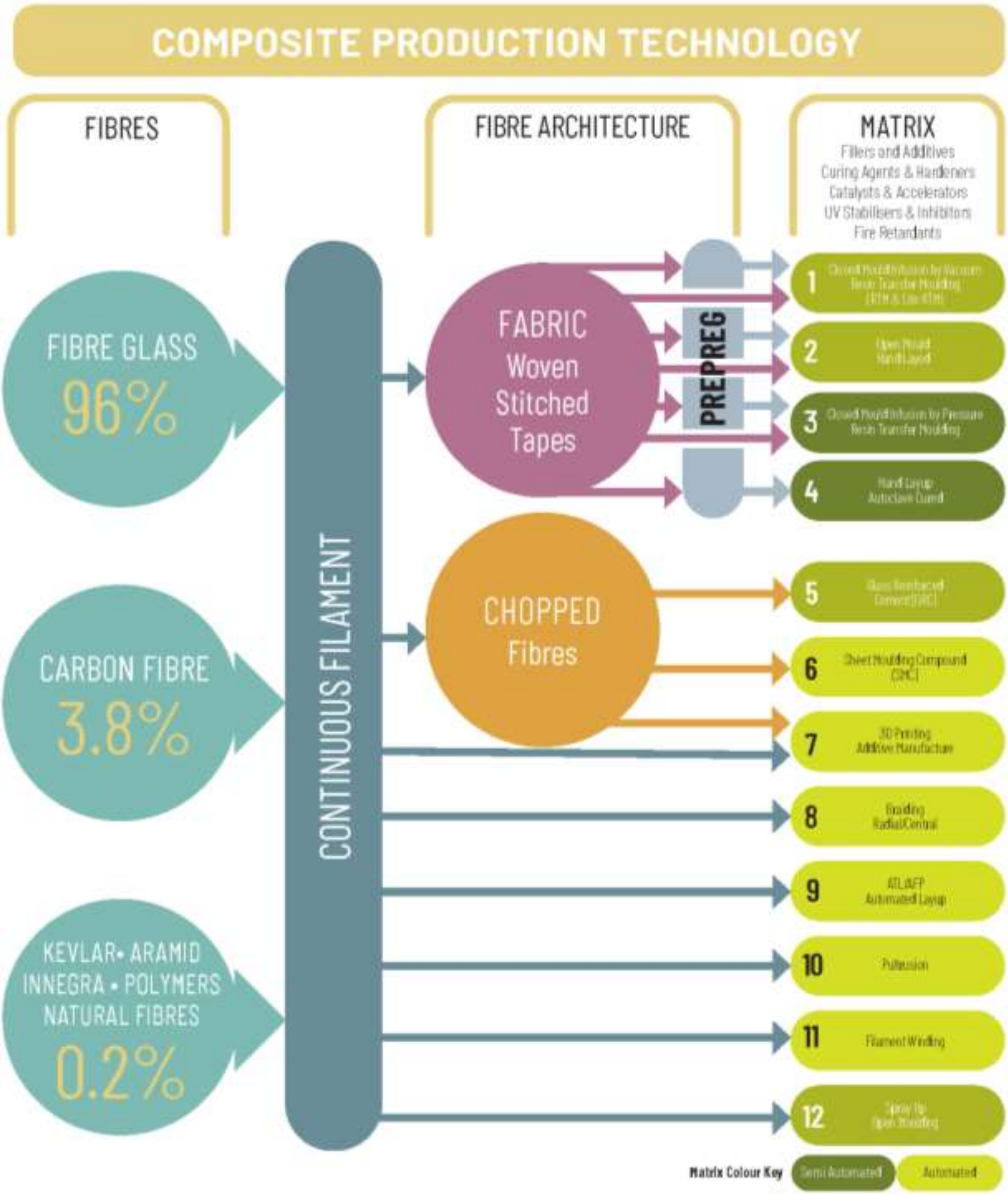
Resin-coated fibreglass rovings and carbon fibre tow can be directly converted into finished composites using filament winding, pultrusion, braiding and automated layup technologies. In intermediate processing, fibres or filaments are transformed into semi-finished products, like textiles and prepregs then combined with a resin matrix to create final composites. Standard methods for this stage include wet hand layup, vacuum bagging, resin transfer moulding, compression moulding and autoclave or out-of-autoclave curing.

Figure 3 shows an infographic revealing the relationship between fibre and fabric inputs and composite manufacturing processes. The illustration omits some production methods that are not widely adopted in Australia but are instead used in other regions.

The range of processes highlights Australia's diverse manufacturing methods and technologies. Manufacturers typically seek workers with experience in their specialised production processes, particularly in niche applications in which they have invested expertise. This includes specialised knowledge in composite design and the chemistry of composite raw material inputs.

4.2.1 Composite production technology

Composites production technologies. Descriptions of each technology are found in Section 9.4 Page 62.



5 Composites manufacturing supply chain

The composites supply chain is an extensive national and global network that enables manufacturers to transform raw materials into commercial components and products. It includes suppliers of essential materials such as chemicals, fibres, resins and fabrics, along with providers of critical equipment, engineering, R&D, testing and software services - all built on collaborative relationships requiring technical expertise at every stage.

The supply chain begins with raw materials, including fibreglass and advanced fibres like carbon fibre, as well as resins, pigments, catalysts and additives. Most of these materials are sourced globally, either directly by manufacturers or through specialised domestic agencies involved in formulation. Additional specialised inputs—such as mould release agents, adhesives, toughening agents, coatings and core materials for sandwich composite configurations— provide specific functional benefits essential to manufacturing efficiency and end product performance.

Intermediate manufacturers also process raw materials into fabrics and sandwich materials. Equipment essential for manufacturing composite products is sourced from specialised equipment suppliers, adding further depth to the supply chain.

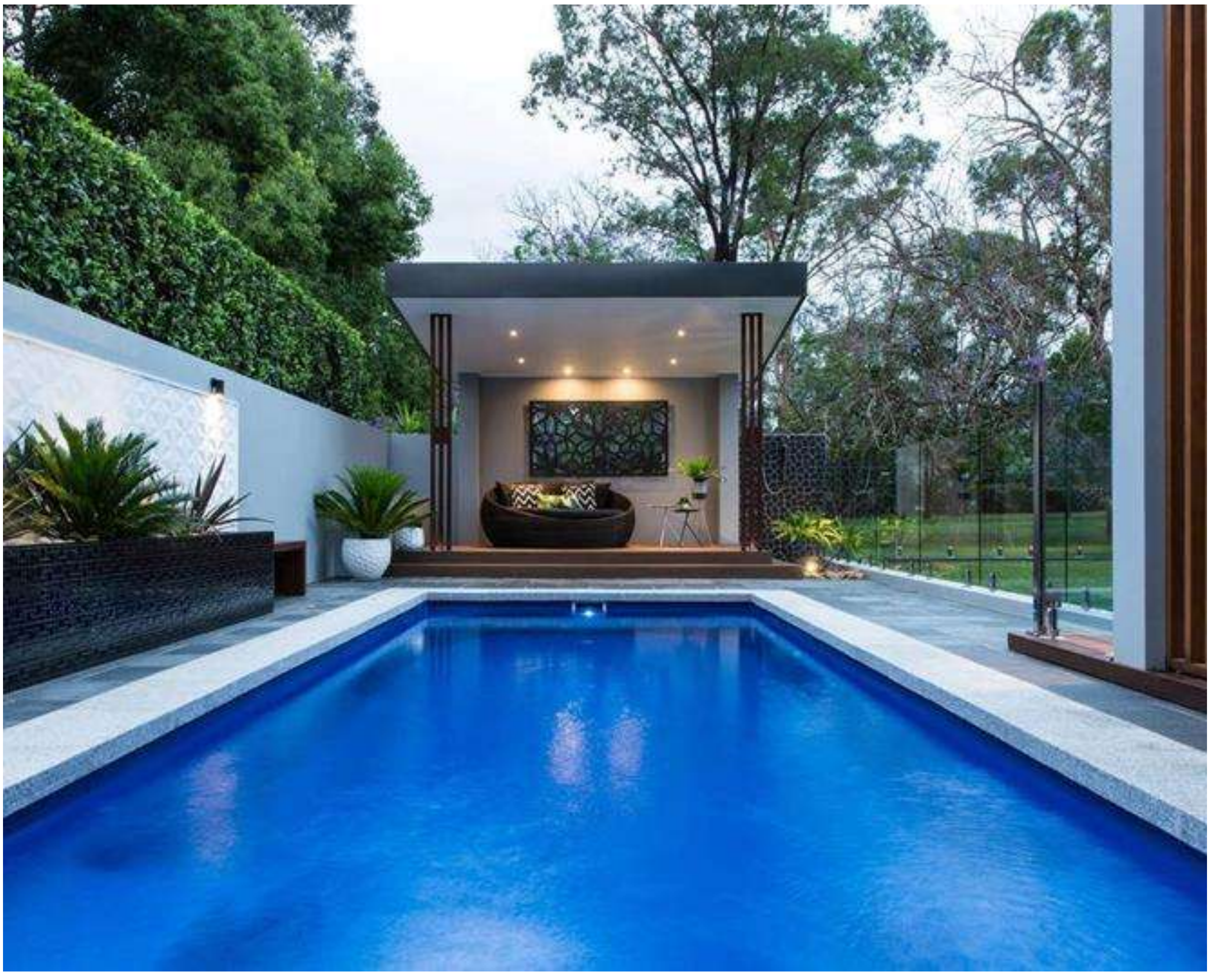


Figure 4Fibreglass pool (Caprice) by Aquatic Leisure Technologies, Jandakot WA. ALT is Australia's largest pool manufacturer, producing under five brands with over 70,000 pools installed since 1976. Around 60% of output is exported interstate and overseas. Courtesy of ALT.

Allnex is the sole manufacturer of high-performance resins and gelcoats in the Oceania region, supplying Australia's composites supply chain. The output from its Brisbane-based plant is a critical component in coatings, adhesives and composite materials, supporting a wide range of industries across Australia.

Equally **Colan Australia** recently celebrated 70 years in business. Colan was the first mill to innovate with high-performance and sustainable fibres, maintaining its status as Australia's sole manufacturer of advanced technical fabrics, including carbon fibre, Kevlar™ (Aramid™), and Innegra™. These materials are essential for high-performance applications such as ballistic fabrics, flame-retardant materials and specialised composites across various industries.

5.1 Industry origins and culture

In the 1960s, the world embraced plastics, captivated by a seemingly infinite potential to shape products in ways previously unimaginable. Fibreglass inspired the emergence of numerous start- up's producing a wide range of items and often replacing traditional metal casting methods that had been used for centuries.

In Australia, the entrepreneurial ecosystem is characterised by innovation, adaptability and problem-solving, which has led to a unique sovereign sector of SMEs as distinct from the corporate-dominated industrial sectors of Europe and the US. Many companies have thrived as generalists, manufacturing components for various industries under contract, while others specialise in proprietary products such as boats, pools or caravans.

Several of the composite manufacturing industry's founding companies remain operational today, marking significant milestones. Colan Australia, for example, celebrated its 70th anniversary this past August, while their forebears–companies like Freedom Pools and Bowell Corporation–have continued to sustain their legacies. These pioneering entrepreneurs achieved numerous global firsts, though much of their contribution remains unrecognised.

The vast distances between Australian states and small and volatile markets significantly shaped the sector's development. Companies learned to diversify and stay agile, allowing them to adapt to shifting demands and navigate economic cycles effectively. These factors fostered resilience and innovation within the industry.

Despite constant change, foundational elements such as geographic location, diverse business models and entrepreneurial roots across multiple market segments remain relevant. They continue to influence market profiling and understanding of industry attitudes, dynamics and segmentation.

Vocational and higher education training developed in parallel to support the evolving sector, equipping a workforce with skills and knowledge to meet the industrial demands of composite manufacturing. These educational pathways remain essential in developing and upholding industry standards and fostering continuous learning.

The growth of the Australian composites sector has also been profoundly shaped by the evolution of engineering, manufacturing strategies and software designed to tackle unique sovereign technical challenges. Storage and fuel tanks, piping systems, mining machinery, infrastructure, carbon fibre wheels and aeroplane components are among the engineering achievements attributed to Australian engineering. Many of these accomplishments are published in the Composites Australia Connection5 magazine, reflecting the sector's engineering capability.

A recent article on sustainability engineering of composites for safeguarding Australia's unique environment was featured in a four-page article in the European JEC Composites Magazine[6] – Special Issue on Composites Sustainability[7].

5.2 Market sectors

Figure 5 The state-of-the-art Malibu facility, housed in two massive factories within two kilometres of the Murray River, plays a significant role in local employment, supporting around 50 skilled workers and contributing to the regional economy. The Malibu range includes 12 models across five series, offers varying lengths crew capacities, ballast options and colour choices.

Australian composite manufacturing companies are conventionally categorised into broad market sectors based on their products. A non-exhaustive list of these sectors is:

- Recreational marine craft, vehicles including caravans and campers and aquatic products such
- as swimming pools.
- Transport, including trucks, trailers, rail and buses and related components.
- Civil infrastructure, including utility poles, profiles for bridges, walkways, pit lids and other structural elements.
- Defence and aerospace, including aircraft components, industrial vessels and drones.

[6] https://www.compositesaustralia.com.au/connection-magazine/
[7] https://www.compositesaustralia.com.au/news/composite-technologies-safeguarding-australias-unique-environment/

- Industrial, including pipes, tanks and other corrosion-resistant equipment for industrial use.
- Architectural, including building facades and urban art.
- Composite Repair and Sustainment.

Many companies operate across multiple sectors, resulting in some overlap. The dominant sectors include pools and spas, marine craft and transport and industrial products, which are the largest consumers of material inputs sustaining the industry[8]. Renewable energy is an emerging market with ongoing demand for Composite Repair and Sustainment, discussed further in Section 6.1.6.

The state-of-the-art Malibu facility, housed in two massive factories within two kilometres of the Murray River, plays a significant role in local employment, supporting around 50 skilled workers and contributing to the regional economy. The Malibu range includes 12 models across five series, offers varying lengths crew capacities, ballast options and colour choices.

5.3 Geographical distribution

Most composite companies in Australia are located in industrial zones within outer metropolitan areas in each state. These urban locations provide businesses access to essential infrastructure, established supply chains and a skilled workforce, all critical for operating in a competitive manufacturing environment. Beyond metropolitan areas, however, regional clusters also contribute to the national industrial landscape, highlighting the geographic diversity of the sector.

Thirty-seven per cent of composite manufacturing companies are located in Victoria, followed by 20 per cent in Queensland, 19 per cent in New South Wales, 11 per cent in Western Australia, 10 per cent in South Australia and three per cent in the ACT and Tasmania combined. It is noted that this distribution reflects the number of companies, though it does not account for their size, employment levels or production output.

5.4 The emergence of industrial clusters

Industrial clusters leverage geographic proximity to create networks of interdependent companies that drive innovation and efficiency. Global studies of clusters in Europe and the United States demonstrate that co-location fosters collaboration, facilitates resource sharing and provides industrial advantages, driving growth and competitiveness within the sector.

Australian examples highlight how specific conditions have driven the formation of composite manufacturing clusters:

Coomera Marine Cluster (QLD): Evolved from its proximity to waterways, anchorages and a long-standing marine culture, supporting global boatbuilders like Riviera Australia and Maritimo. Additional information on this important cluster is found in section 9.5.

Henderson Cluster (WA): Established due to the strategic role of the Port in supporting defence, shipbuilding, resource extraction and offshore oil and gas industries.

Toowoomba Cluster (QLD): The entrepreneurial endeavours of government investment in research regional areas in collaboration with the University of Southern Queensland.

[8] Kerryn Caulfield, State of the Composites Industry Report 23, November 2021

• **Geelong Future Economy Precinct (VIC):** Created through government funding to transform traditional industrial hubs into advanced manufacturing centres, focusing on technical fibres and composite materials.

These clusters demonstrate how locational advantages and targeted investment can catalyse economic development through attracting jobs in advanced manufacturing in what are often regional locations.

Smaller marine clusters are found in coastal towns, where micro-companies often specialise in the manufacture and repair of composite boats and surf craft. These businesses are a feature of regional employment and economic development, supporting local fishing, tourism and recreation industries.

Coomera Marine Precinct, Queensland – Home to over 100 businesses and approx. 2,500 workers. With major employers like Riviera and Maritimo, and a dedicated TAFE marine campus onsite, the precinct plays a vital role in marine manufacturing, servicing, and training.

Figure 6 Coomera Marine Precinct, Queensland – Home to over 100 businesses and approx. 2,500 workers. With major employers like Riviera and Maritimo, and a dedicated TAFE marine campus onsite, the precinct plays a vital role in marine manufacturing, servicing, and training.

5.4.1 Challenges in metropolitan and regional areas

The intersection of housing costs, education access and employment opportunities shape the dynamics of both metropolitan and regional industrial clusters.

A manufacturer in metropolitan industrial zones face challenges from gentrification, which raises housing prices and subsequently limits the availability of local skilled workers. Regional manufacturers can attract workers due to more affordable housing, contributing to workforce availability and retention.

Maps of Australia's composite clusters highlight notable activity in Newcastle, South Perth, Southeast Melbourne, Geelong, the Gold Coast and an emerging cluster on the Sunshine Coast. These urban and regional areas contribute to the composites sector through a balance of locational advantages, lifestyle considerations and industry drivers.

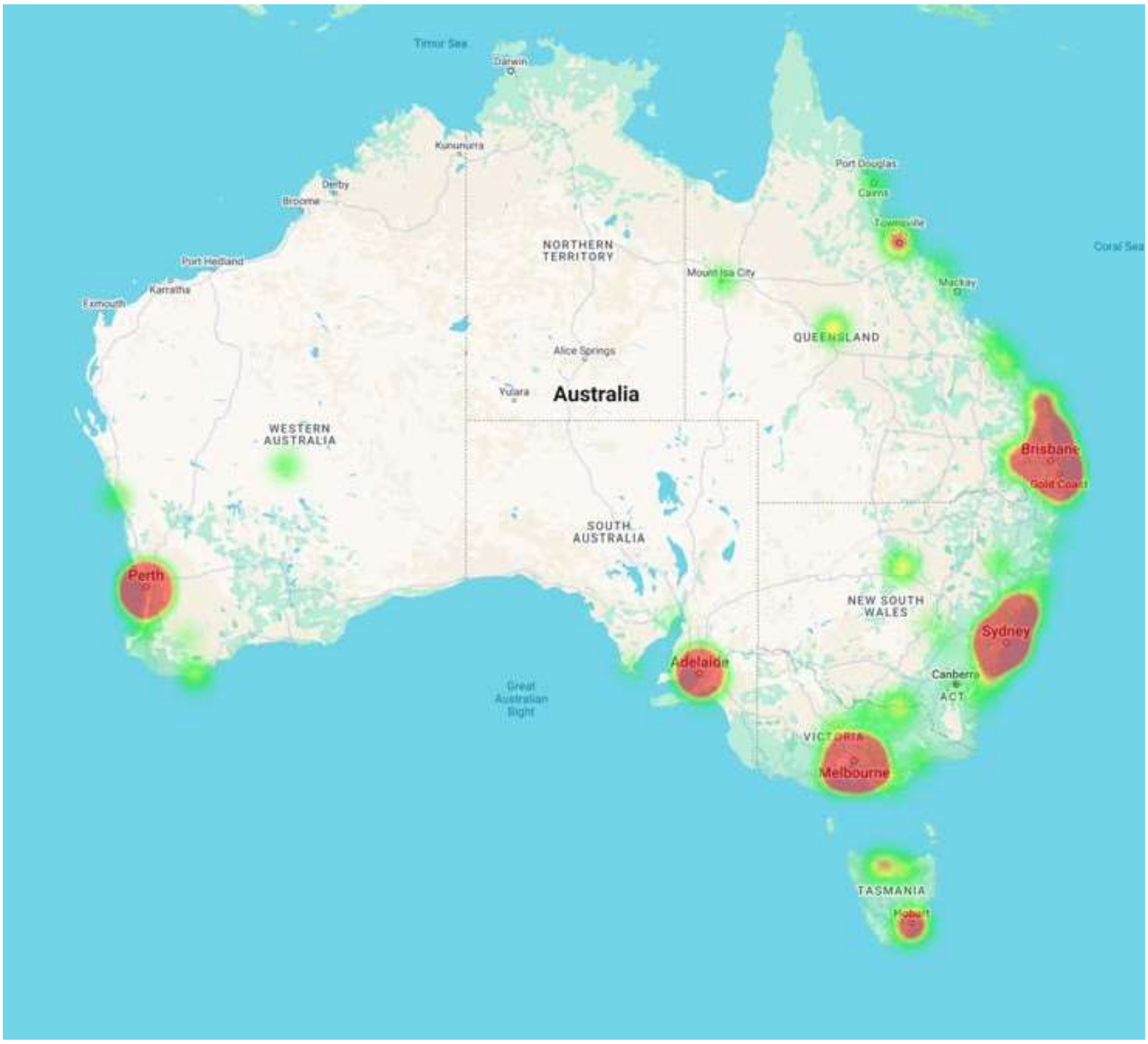


Figure 7 Cluster Location Heat Map: Distribution of Composites Manufacturers and Fabricators, Education Providers, R&D Agencies (including Universities), Engineering Services, and Key Industry Suppliers across Australia.

5.5 Workforce tenure

One of the composite manufacturing industry's defining features is its low employee turnover rate. Industry feedback highlights workforce stability and employee loyalty, with many composite manufacturing companies reporting employees with over 25 years of service.

Survey respondents reported an average tenure of 9.4 years – higher than average for manufacturing[9], dispelling the myth that 'Australians prefer non-manufacturing roles'. Seasoned employees ensure the transfer of critical skills, craftsmanship and efficiencies and play an invaluable role in demonstrating a work ethic that fosters accountability.

[9] https://www.acclaimedworkforce.com.au/blog/insights-manufacturing-in-australia

A notable example is that of ACM CRC partner Steber International. Managing Director Alan Steber reported several long-serving employees, including one with 42 years of service (and only five days off during that time) and others with 38 and 30 years of service.

When long-serving employees leave, however, they take a wealth of accumulated knowledge, skills and experience, which can significantly disrupt operational continuity, creating a gap in expertise that may take years to rebuild, affecting productivity, efficiency and the overall quality of output. Employers also experience a profound sense of loss, as the unique value of a long- term employee's institutional knowledge, client relationships and problem-solving capabilities is difficult to replace.

5.6 Women in composites manufacturing

The composites manufacturing sector, much like broader manufacturing industries, is grappling with the challenge of attracting more women into its workforce. Over 70 per cent of respondents to the survey confirm that the number of women in their workforce has increased over the last five years. Feedback from both the survey and interviews indicate that women are valued for their skills in layup processes, where aptitude and attention to detail are required for producing high-performance and complex parts.

Employers expressed an aspiration to hire more women but cite a limited number of applicants with the requisite skills as a key obstacle. Bridging this gap requires not only targeted recruitment strategies but also industry-wide efforts to inspire, train and support women considering a career in composites manufacturing.

Data from the government-run Workplace Gender Equality Agency reveals that just 27 per cent of Australia's 300,000-strong manufacturing workforce is female[10]

Across the manufacturing sector, a plethora of state and federal government initiatives actively aim to attract more women into the industry. These efforts are supported by marketing campaigns and slogans designed to challenge stereotypes and inspire participation.[11,12,13]

In Queensland, the documentary series 'She Made It', released through the Women in Manufacturing[14] initiative, highlights stories of women excelling in manufacturing roles, while the Australian Manufacturing Workers' Union promotes programs such as 'Getting Women into Trades'.[15]

Parallel to these campaigns are high-profile conferences and events like the 'Women in Industry Awards'[16] that celebrate the achievements of women in manufacturing, albeit often profit-driven.

Feedback from both the survey and interviews strongly support the 'Social Learning Theory'[17], which asserts that individuals are influenced by observing the successes and behaviours of others - i.e. 'one woman attracts another'.

The Boeing Aerostructures Australia Female Apprenticeship Program is a leading example of an industry initiative proactively encouraging women to pursue careers in manufacturing.

CASE STUDY

Boeing Aerostructures Australia Female Apprenticeship Program[18]

In 2022, Boeing Aerostructures Australia launched a first-in-kind Female Apprenticeship Program that encourages more women into aviation trade roles and seeks to remove barriers faced by women wanting to start a career in traditionally male-dominated trades. Upon completion of the four-year program, apprentices graduate with their Certificate IV Aeroskills (Structures) MEA41318 from Aviation Australia.

[10] https://www.wgea.gov.au/sites/default/files/documents/BCEC_WGEA_Gender_Equity_Insights_Report_
[11] 10 https://www.premier.sa.gov.au/media-releases/news-archive/blueprint-laying-out-path-to-gender- equality.
[12] https://skills.education.nsw.gov.au/skills-initiatives/built-for-women
[13] https://www.vic.gov.au/women-in-manufacturing
[14] https://www.rdmw.qld.gov.au/manufacturing/manufacturing-assistance-programs/women-in- manufacturing
[15] https://www.amwu.org.au/women_in_trades
[16] https://womeninindustry.com.au/
[17] Social Learning Theory (1977) by Albert Bandura
[18] https://www.boeing.com.au/about-boeing-in-australia/subsidiaries/boeing-aerostructures- australia#anchor6

STEM-focused events designed to spark early interest in manufacturing and engineering careers for young women are being delivered across the country[19],[20].

Despite ongoing efforts, a notable imbalance persists in both VET and higher education. Men continue to significantly outnumber and outrank women as teachers, researchers and leaders in technical fields such as composites – reinforcing the myth that only men can be subject matter experts.[21]

5.7 Attitudes to training (conventional)

Conventional approaches to education and training across the Australian manufacturing sector have been shaped by factors such as workforce demographics, perceptions of job and career opportunities, accessibility of training facilities program relevance and cost and effectiveness.

Historically, higher education was often limited to professional roles, such as accounting and training and education programs and budgets were less frequently allocated to women, reflecting societal values of the time. These dynamics were further shaped by the interplay between business conditions, worker motivations, educational systems and industry requirements.

Progression through a company often began with apprenticeships or cadetships, which provided employees with hands-on experience across various systems and processes within a workplace. Starting at entry-level roles allowed employees to develop a comprehensive understanding of manufacturing operations—from production to quality control and beyond— while fostering connections across processes and departments.

Advancement to senior roles was typically available to those who demonstrated ambition, a willingness to pursue personal development and a visible commitment to the organisation. Employers often supported further education, such as attending ‘night school’, to foster knowledge, skills growth and employee loyalty. These values and practices continue influencing workforce development and career progression in the composites manufacturing sector.

[19] https://www.rmit.edu.au/students/student-life/events/2024/aug/women-in-stem-conference
[20] https://www.unsw.edu.au/science/engage-with-us/women-stem-ambassador-program
[21] https://www.engineersaustralia.org.au/sites/default/files/2023-03/WIE%20Data%20Report%20-%20Workplace%20Gender%20Equality%20Agency.pdf.

5.8 Government investment in the sector

Figure 8Carbon Revolution Mega-line demoulding station: the mould tools, preserve precise part geometries upon demould.

State and federal investment in research and development (R&D) through universities and direct grants to companies has been instrumental in driving the evolution of the composites sector in Australia. These transformative initiatives have stimulated the development of industrial facilities and strengthened industry partnerships enabling technological innovation. The following are examples of some of legacy initiatives.

The Advanced Composites Structures Cooperative Research Centre (ACS-CRC): constituted in 1991 as a collaborative initiative between the CRC, industry and universities, delivered practical technologies and advanced capabilities in composites, significantly boosting the competitiveness of Australia's composites industry. Today, the legacy of this initiative lives on through ACS Australia, a for-profit enterprise based in Port Melbourne, Victoria, housing state-of- the-art manufacturing facilities and world-class engineering expertise. A notable achievement of the ACS-CRC was its foundational research that underpinned Boeing Australia's proprietary dry carbon fabric resin infusion manufacturing process for the B787 wing structure component. This breakthrough enabled the establishment of a globally competitive composites engineering and manufacturing facility in Victoria, which remains a key player in the aerospace industry.

The Centre for Future Materials (CFM): An initial investment by the Queensland Government in 2003 intoregional research capability at the University of Southern Queensland (USQ), the CFM played a pivotal role in advancing winding composite technologies for Australia's infrastructure projects. This regional research capability at USQ has since evolved, broadening its focus to encompass diverse applications across industries such as aerospace, defence, mining and civil engineering.

Carbon Nexus (Deakin University): Located within the Geelong Future Economy Precinct, Carbon Nexus commenced operations in early 2014, co-funded by Deakin University, the Victorian Government and the Federal Government. This open-access carbon fibre and composites research facility features an 80-tonne carbon fibre production line and an R&D-scale single tow line. The investment served as a catalyst for a manufacturing cluster in the region, spawning successful startups such as Carbon Revolution Ltd, a globally-oriented manufacturer of carbon fibre wheels.

Figure 9 Automated Fibre Placement (AFP) robot at AMAC, UNSW Sydney. Courtesy of the ARC Training Centre for Automated Manufacture of Advanced Composites.

ARC Training Centre for Automated Manufacture of Advanced Composites (AMAC): Established in 2017 at the University of New South Wales (UNSW Sydney), the centre focuses on material enhancement, process optimisation and simulation and design integration to improve composite production efficiency and performance. AMAC's Automated Fibre Placement (AFP) facility, unique in the southern hemisphere, enables the manufacturing of complex composite structures and metal-composite hybrid components. Through collaborations with nine industry partners, AMAC bridges the gap between research and industry application, aligning with Australia's National Manufacturing

Priorities and contributing to sectors such as defence through the development of advanced composite technologies.

Swinburne-CSIRO National Industry 4.0 Testlab for Composite Additive Manufacturing: Located in Clayton, this facility features the world's first industrial-scale 3D printing of multilayer fibre-reinforced composite parts. This innovation reduces waste, enhances production quality and minimises preform trimming, achieving cost-effective manufacturing solutions. In addition, Swinburne's Space Technology and Industry Institute is leveraging state and federal investments to advance Australia's space manufacturing capabilities, contributing to the nation's growing presence in the global space industry.

Additional initiatives expected to drive advancements in Australian manufacturing capabilities include the Advanced Manufacturing Research Facility in Western Sydney, as well as efforts by institutions such as the University of Queensland, the Australian Nuclear Science and Technology Organisation (ANSTO), RMIT University, the University of Sydney, the University of

Figure 10 Swinburne's Aerostructures Innovation Research (AIR) Hub. Courtesy of Swinburne University of Technology

5.9 Government investment in research

In addition to the legacy initiatives mentioned above and the investment in the ACM CRC in 2022[22] – which has commissioned this Scoping Study - the Federal Government, through the Australian Research Council (ARC), has invested in composites-related research across nine program categories since 2019. This investment includes:

- 61 grants awarded[23]
- $51.5 million in funding
- 148 nominated researchers involved
- 17 universities participating

State governments have also invested in composites research across the country with the equal intent of priming Australia's advanced composite manufacturing capabilities.

The stark contrast between research investment and the availability of qualified vocational education and training (VET) teachers highlights a critical gap in Australia's composites workforce pipeline. Currently, the number of VET teachers specialising in composites is alarmingly low—few enough to be counted on two hands—exposing a significant imbalance between research funding and the capability to train the next generation of skilled technicians and tradespeople[24].

[22] https://www.unsw.edu.au/newsroom/news/2022/05/unsw-secures--70-million-to-advance-next-gen-materials
[23] ARC Future Fellowships; ARC Training Centre; CRC-P; Discovery Early Career Researcher Award 2020/21/22; Discovery Projects 2020/21/22; Industrial Transformation Research Hubs 2021; Industrial Transformation Training Centres 2021; Linkage Infrastructure, Equipment and Facilities 2022; Linkage Project; Mid-Career Industry Fellowships - https://dataportal.arc.gov.au/NCGP/Web/Grant/Grants#/20/9//composites/(year- from%3D%222019%22)
[24] Composites Australia assessment PARTEC/AIE/Academy of Excellence/SMTAFE/Gold Coast TAFE & Sydney TAFE 2024

6 Education and Training

Figure 11 Aaron Stephens, Composites Technician inspecting bus component 2021, FDP Composites. Image courtesy of FDP. Copyright Mark Crocker Photography.

The conventional pathway for production workers to become a Fibre Composite Technician (alternative titles can include Laminator, Composite Fabricator, Fibreglass Technician/Tradesperson and Shipwright) is through formal VET qualifications, typically a four-year Certificate III apprenticeship at TAFE (Technical and Further Education) Institutions or via on-the-job training.

An engineering degree in the automotive, aerospace or civil discipline can also serve as a pathway into composites manufacturing or a teaching or research career within the sector. Additionally, chemistry and polymer science qualifications are highly valued in the sector.

6.1 Vocational education and training

TAFE qualifications and their associated units are organised into training packages, which are developed and maintained within a structured framework involving collaboration between federal and state authorities, Jobs and Skills Councils and industry, ensuring graduates are well-prepared for the workforce.

ORGANISATION	ROLE	FUNDING
Jobs and Skills Australia (JSA) www.jobsandskills.gov.au	Provides independent advice to government on current and future workforce skills needs and supports strategic workforce planning and policy development.	Funded by the Federal Government.
Jobs and Skills Councils (JSCs) www.dewr.gov.au/skills-reform/jobs-and- skills-councils	Ensure graduates are well-prepared for the workforce by aligning VET qualifications with industry needs and future skills demands.	Funded by the Department of Employment and Workplace Relations (DEWR).

The Australian Skills Quality Authority (ASQA) www.asqa.gov.au	The national regulator for VET, ensuring that TAFE and other registered training organisations (RTOs) meet quality standards and comply with the AQF.	Funded by the Federal Government, partly through cost recovery from providers.
Australian Qualifications Framework (AQF) www.aqf.edu.au	Distinguishes each VET qualification level based on specific learning outcomes, evaluated in terms of knowledge, skills and application.	Developed and maintained by the Federal Government.
State Training Authorities (STAs) www.myskills.gov.au/more/state-territory- governments	Manage the VET system within their jurisdictions, including TAFE delivery, funding and alignment with state-specific economic and employment goals.	Funded by state/territory governments, sometimes with federal support.

This integrated system ensures TAFE education is consistent, industry-relevant and recognised nationally.

The following trade qualifications are most relevant for composite technicians:

- Certificate III in Engineering – Composites Trade (MEM31119)
- Certificate III in Marine Craft Construction (MEM30719)
- Certificate III & IV in Polymer Technology (PMB50121)
- Certificate IV in Aeroskills (Structures) (MEA41318)
- Certificate III – IV in Recreational Vehicle Manufacturing (MSM31122)

The following is a list of leading vocational and education training providers:

6.1.1 Partec – Composites Training Centre[25]

The Plastic and Rubber Technical Education Centre (PARTEC) and Composites Training Centre is a 500-square-metre composites training centre in Brisbane, designed to operate as a functioning manufacturing enterprise. It is equipped for hand layup, resin infusion, gel-coat spray-up, a 3-axis CNC router, a pre-preg storage freezer and a temperature- and humidity- controlled clean room for aerospace composites work.

As a Registered Training Organisation (RTO), PARTEC delivers the Certificate III – IV Composites Technician apprenticeship, along with direct entry short courses that incorporate units of competency from training packages in tooling design , toolmaking and CNC operation and FRP applications. Customised training programs are also available to meet the specific needs of individual companies. Apprentices currently travel from as far as Tasmania to attend training at PARTEC.

[25] https://partec.qld.edu.au/

Figure 12 The PARTEC, located on the TAFE QLD Mt Gravatt campus, is a training hub for composites, plastics,and polymer processing, delivering nationally recognised qualifications and apprenticeships in composites fabrication, toolmaking, injection moulding and CNC machining. Image courtesy of PARTEC.

6.1.2 South Metropolitan TAFE – Naval Base Campus[26]

Located approximately 30 km south of Perth, SM TAFE's Naval Base campus offers a comprehensive trade program designed to equip students with the practical skills and knowledge required to excel in various trades. The program covers multiple disciplines, including electrical, plumbing, carpentry, transport and more.

Students benefit from factory simulated facilities, industry-experienced instructors and hands-on training. The program includes qualifications such as MEM30719 Certificate III in Marine Craft Construction and MEM31119 Certificate III in Engineering - Composites Trade, both of which focus on theory and practical application.

6.1.3 The Australian Institute of Engineering[27]

The AIE is a private training institution that delivers a range of trade qualifications, preparing industry-ready practitioners for global careers. A national organisation, the Institute collaborates closely with the manufacturing industry to align training with employer needs, ensuring graduates are job- ready.

The Institute specialises in a flexible training model that delivers on-the-job programs, particularly MEM30719 Certificate III in Marine Craft Construction and MEM31119 Certificate III in Engineering -

[26] https://www.southmetrotafe.wa.edu.au/campuses/naval-base
[27] https://www.auie.edu.au/

Composites Trade. By collaborating with employers and apprentices, the Institute develops customised training to meet industrial requirements. Its Broadmeadows campus provides a hands-on learning environment for students on block release.

6.1.4 Defence Aviation Safety Authority (DASA)

The Air Force Training Group located at the RAAF base at Amberley, Queensland offers a six-week Composite Specialist Course to equip participants with the knowledge, skills and technical expertise required to assess and repair damage to ADF composite aircraft structures. The training focuses on the critical technical aspects of composite maintenance and repair, ensuring compliance with ADF safety and performance standards for all ADF fixed-wing and rotary-wing aircraft. This course is designed for:

- Air Force, Army and Navy Aircraft Technicians
- Aircraft Structural Technicians
- Civilian contractors involved in ADF aircraft maintenance

Figure 13 Royal Australian Air Force maintainer, Corporal Cory Cochrane, inspects an Australian F-35A on the flight line at Luke Air Force Base, Arizona, USA. ACM CRC partner Quickstep produces over 50 composite components and assemblies for the F-35, including parts for the centre fuselage and vertical tail. Photographer: SGT Christopher Dickson

6.2 Shortfalls in VET training for composites

Enrolments and completions in composites-related VET qualifications declined after the 2008 global financial crisis (GFC). Employers, facing economic uncertainty, hesitated to invest in training due to unpredictable demand. The downturn also affected manufacturing and construction, reducing the need for specialised VET qualifications. Additionally, government funding cuts since 2011–12 affected training availability and quality, while competition from private providers further pressured traditional VET institutions.

Government-backed workforce recovery initiatives post-COVID-19, however, have increased apprentice enrolments. Programs like the Australian Apprenticeships Incentives Program prioritised employer support, encouraging businesses to take on apprentices. The JobTrainer program also provided significant skills training funding, driving interest in VET qualifications. While challenges remain, government interventions have revitalised interest in VET.

Like many industries, Australia's VET sector is also grappling with workforce challenges in attracting and retaining skilled professionals. Recognising these issues, the government is developing a comprehensive strategy to nurture a robust VET network.[28]

While the increase in enrolments is positive, there remains a critical shortage of TAFE teachers in Australia, highlighted previously in section 4.1. A recent example is GOTAFE's[29] decision to cease apprentice training for Victorian manufacturers. As of December 2024, GOTAFE discontinued MEM31119 Certificate III in Engineering - Composites Trade without explanation, transferring students to the Australian Institute of Engineering. This shift has disrupted government funding and raised concerns among manufacturers and apprentices about the stability of training programs.

Another example is the Gordon TAFE, which developed a short composite course funded by the Victorian government that is not part of an AQF qualification. 22312VIC Course in the Use of Carbon Fibre in Composite Manufacturing comprised four units and was delivered twice weekly over seven weeks. Held at the Advanced Manufacturing and Composite Centre (AMACC), a purpose-built facility that opened in 2018 at the East Geelong Campus, the fee-paying course was abandoned due to low enrolment and staff shortages. It was quietly deregistered by the Victorian Government in 2022.

The VET system - and the qualifications it oversees - are linked to the Australian and New Zealand Standard Classification of Occupations. ANZSCO is a skill-based classification system used to categorise all occupations and jobs in the Australian and New Zealand labour markets. It provides a framework for analysing and defining job requirements, including descriptions, tasks, required skills and qualifications. It is also used in labour market analysis to understand employment trends and unemployment patterns. While ANZSCO is not directly linked to award wages, its classification system provides a framework for understanding the skill requirements of occupations, which can indirectly influence wage structures and industry awards. In the context of immigration, ANZSCO is used to determine wage thresholds for visa applicants.

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[28] https://www.dewr.gov.au/newsroom/articles/blueprint-building-stronger-and-more-sustainable-vet-workforce?utm_source=chatgpt.com

[29] Golburn Ovens TAFE

6.3 TAFE as a pathway to higher education

A Certificate III typically does not directly provide a pathway to an engineering degree program at the HE level. Depending on the field and available pathways, however, the qualification can be a foundational step towards pursuing higher qualifications. The Manufacturing and Engineering

(MEM) training package is a likely pathway to higher qualifications in engineering. Composites Trade (MEM31119) and Marine Craft Construction (MEM30719) are relevant qualifications that cover composite layup skills, material selection, handling, storage, component use, repairs, modifications, resin and chemical formulations and appropriate joining techniques.

RMIT University offers pathways into engineering degrees through vocational education programs such as the Certificate IV in Tertiary Preparation. This certificate includes an engineering stream and provides a guaranteed pathway into many RMIT courses, including engineering degrees if specific criteria are met. It is designed for individuals who need additional preparation before starting higher-level qualifications.

Additionally, students with a Certificate IV with an engineering-related focus within the MEM training package may progress to an Advanced Diploma or Associate Degree in Engineering at RMIT, which can then lead to entry into undergraduate engineering degrees. These pathways often include credit transfer for completed units, reducing the duration of the Bachelor’s program.

An example is the Advanced Diploma of Engineering (MEM60122) for which RMIT offers an 'articulation agreement' with the student’s vocational training provider into the Bachelor of

Engineering (Aerospace Engineering) (Honours) to recognise and grant credit for prior learning equal to 1.5 years, effectively reducing the degree to 2.5 years.

This scoping study also explored pathways from VET to higher education, focusing on engineering degrees with specialisations in shipbuilding and maritime engineering. Using the UNSW VET-HE transition pathways as an example, the study examined how a Certificate III can serve as a stepping stone towards the Bachelor of Naval Architecture Engineering (Honours).

Figure 14 Open mould, hand lay-up process: Resin is applied manually to each layer using a brush or roller, followed by consolidation to eliminate air pockets and achieve uniform resin distribution. The part is then left to cure at ambient temperature or under controlled heat.

6.4 Engineering Qualifications

The occupational categories for professions in engineering in Australia include:

OCCUPATION	MINIMUM QUALIFICATION	BACHELOR'S DURATION (FULL-TIME STUDY)	INTERNATIONAL ACCORD	AUSTRALIAN CONTEXT
Professional Engineer	Batchelor's Degree (Honours) in Engineering	Four years	Washington Accord	Accredited by Engineers Australia
Engineering Technologist	Bachelor's Degree in Engineering	Three years	Sydney Accord	Accredited by Engineers Australia
Engineering Associate	Associate Degree or Advanced Diploma in Engineering	Two years	Dublin Accord	Accredited by Engineers Australia

Notes:

- **Washington Accord:** Sets the international benchmark for professional engineering degrees.
- **Sydney Accord:** Pertains to Engineering Technologists.
- **Dublin Accord:** Applies to Engineering Associates and their vocational qualifications.
- **Engineers Australia:** A founding signatory to all three accords and sets the national accreditation standards.

University units are primarily developed by individual institutions, giving them the flexibility to design industry-curated programs and courses that align with the specific needs of the industries and communities they serve. The courses or units undergo internal review and approval processes involving various academic committees, including Academic Boards, to ensure their relevance and compliance with national quality standards set by the TEQSA (Tertiary Education Quality and Standards Agency) and other relevant professional bodies such as Engineers Australia.

A persistent perception expressed during the interviews was that higher education does not adequately equip workers with knowledge of composite production. While it is true that university degrees may not teach students how to manufacture a specific composite component, it is important to note that these programs equip students with a broader skill set. University degrees provide a foundation in the fundamental theories of composite structural design, often supported by hands-on experience. This exposure typically occurs under the supervision of practising engineers during capstone (final year) research projects, ensuring students develop theoretical knowledge and essential practical skills. This combination prepares graduates to approach composite manufacturing with a comprehensive understanding of its fundamental principles. A worthy undertaking would be to develop an information profile on the qualifications and role of a composites engineer.

The following list was compiled by RMIT, for this report to illustrate composites-related courses/ units/subjects offered through higher education programs within engineering degrees at ACM CRC partner universities and select non-member universities across Australia.

Monash University

- **MTE4102** - *Advanced Materials Processing and Manufacturing*
  This unit covers advanced processing and manufacturing technologies of ceramics, polymers and composites.
- **MAE3406** - *Aerospace Materials*
  This course includes topics on the manufacture, processing and fabrication of aerospace materials, with a focus on structure-property relationships and the joining of composites.

RMIT University

- **AERO2289** - *Composite Materials and Structures*
  This course (delivered until 2023) covered fundamental aspects of composite materials, including their properties, manufacturing processes and applications in aerospace structures.
  University of Melbourne
- **MCEN90052** - *Advanced Materials*
  This subject explores the mechanical behaviour and structure of materials, from continuum modelling of properties to microscopic analysis.

University of Sydney

- **MECH3362** - *Engineering Materials for Advanced Manufacturing*
  This unit provides a practical and theoretical introduction to the recent development of advanced manufacturing and the role of engineering materials in it.

Western Sydney University

- **CIVL7002** - *Advanced Composite Structures*
  This subject enables students to gain an in-depth knowledge of composite structures based on Australian and International Standards.

University of New South Wales (UNSW)

- **MATS4005** - *Composites and Functional Materials*
  This course aims to enhance knowledge and understanding of two important categories of advanced materials, namely functional materials and composite materials.
- **MECH9420** - *Composite Materials and Mechanics*
  This course covers the analysis and design of composite structures and failure analysis of laminated panels.
- **CVEN9826** - *Advanced Mechanics of Structures and Materials*
  The course includes lectures on scalar, vector and tensor calculus as it relates to the analysis of structures and materials elasticity and other advanced topics.
- **CVEN9822** - *Steel and Composite Structures*
  This course focuses on the design and analysis of steel and composite structures.

University of Tasmania

- **ENG713** - *Composite Steel Concrete Structures*
  This unit introduces students to composite structures and their design for strength and serviceability in accordance with Australian Standards and Eurocode.

University of Adelaide

- **MECH ENG 7067** - *Advanced Mechanics of Materials*
- This course covers topics including the application of metals, polymers and ceramics and composite materials.

University of Queensland

- **AERO4300** - *Aerospace Composites*
  This course introduces composite materials, manufacturing and design, primarily focusing on applications in the aerospace industry.

6.4.1 Continuing professional development (CPD)

Professional development requirements for engineers in Australia vary across states and territories to uphold engineering standards and competencies. Engineers Australia, the national professional body, facilitates this through its Continuing Professional Development (CPD) program, which includes industry seminars, workshops and accreditation pathways. Interviews revealed that engineers value CPD to stay informed about advancements in composite technologies and changes in regulations, standards and practices. Several interviewees, however, noted a lack of informal opportunities, apart from the annual Composites Australia conference and tech events, for engineers working with composite technologies to keep up to date with the latest developments.

6.5 Private composites training providers

Outside the university and TAFE systems, fee-for-service training is primarily provided by equipment and software suppliers. For example, ACM CRC partner Pacific Engineering Systems International—the Australian and New Zealand distributor for ESI Group's advanced virtual prototyping software—offers a comprehensive training suite as part of its service portfolio. The company leverages its expertise to deliver customised training programs that support the effective use of its software products.

ACM CRC partner FUZE Solutions has utilised Abaris Training[30] in the United States to meet some of its training requirements. Abaris Training29 offers 23 courses on advanced composite structures engineering, manufacturing and repair, with training covering multiple industries.[31]

It is also conventional practice for equipment suppliers to provide training, ensuring proper use, maintenance and safety. This training typically includes hands-on instruction for field and factory workers handling machines and equipment, formal orientation sessions to familiarise employees with operational procedures, on-the-job training to develop practical skills in real- world settings and buddy systems where experienced workers mentor new employees.

[30] https://www.abaris.com/
[31] https://www.abaris.com/

Figure 15 Riviera's Academy of Excellence is a state-of-the-art, 680-square-metre facility designed to foster the next

6.5.1 Riviera's Academy of Excellence

The opening of Riviera's Academy of Excellence[32] in early 2024 is a proactive investment in workforce development. Using its own training instructors, the Academy teaches apprenticeships across ten trades, including composite technology. Training at the 16.8 hectare

Gold Coast facility combines structured education with hands-on experience, offering participants a comprehensive understanding of manufacturing operations and roles within the company.

Notably, the 2024 apprenticeship program intake of 52 included 12 women.

Advancement opportunities within the company (Riviera) are accessible to individuals who demonstrate ambition, a commitment to personal development and a proactive approach to their career growth.

[32] https://www.rivieraaustralia.com/riviera-opens-new-apprentice-academy-of-excellence/

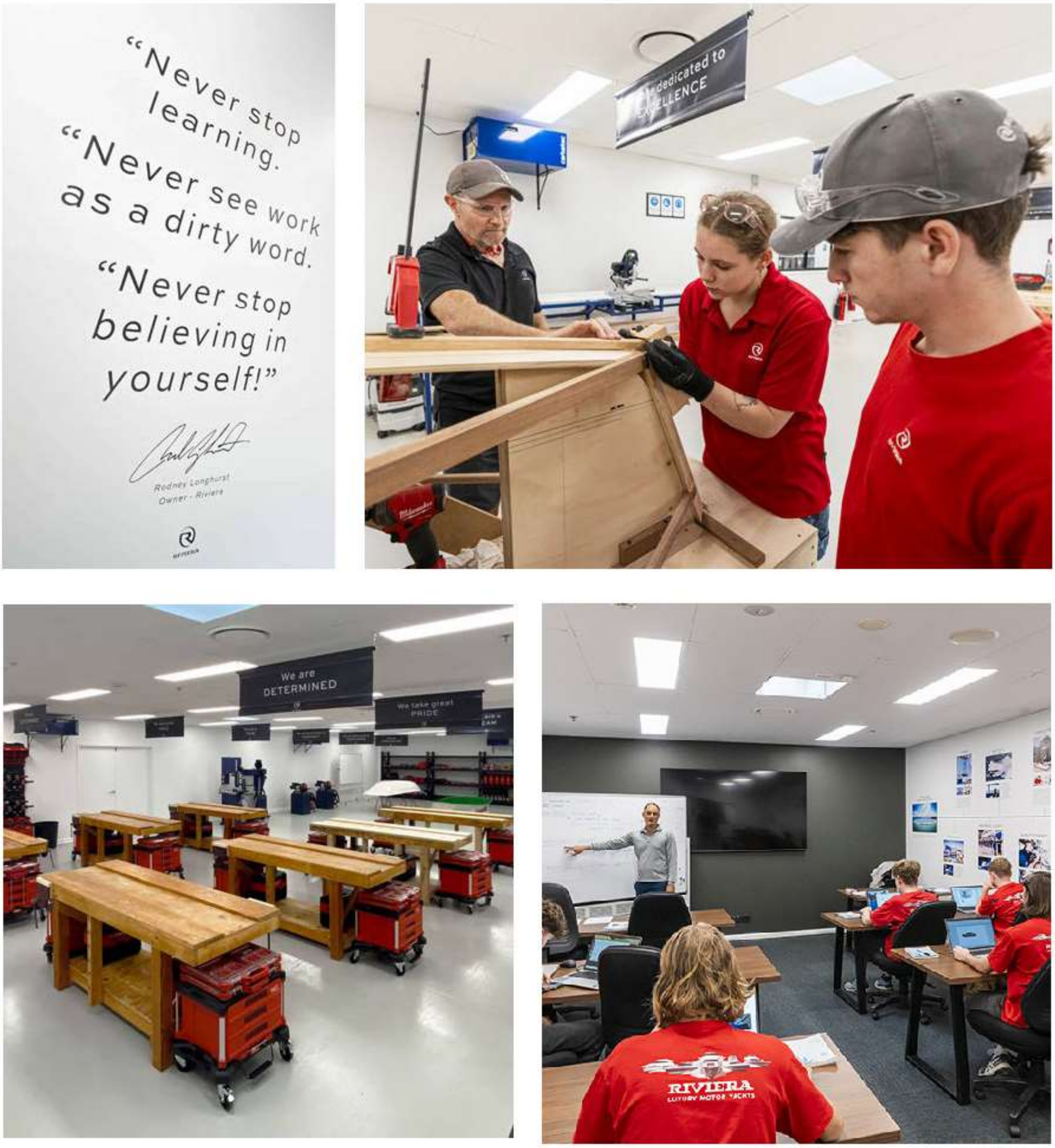


Figure 16 Students are taught to respect tools, the difference between high and low- quality equipment, the importance of tool management and how proper maintenance, organisation and handling ensure precision and safety.

7 Skills and Workforce Dynamics

Figure 17 Josie Eastman, General Manager of Edencraft inside the CNC machining centre which stands ready to shape the world's best trailer boat experience and far beyond. Image courtesy of Tom Cameron, Wicks Estate Media.

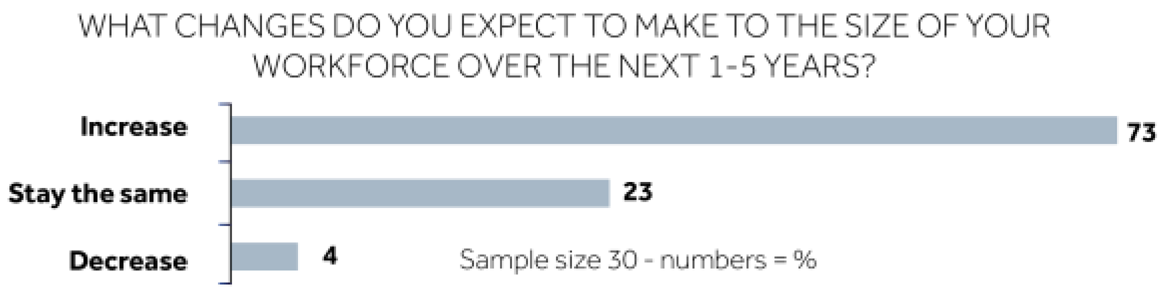
7.1 Future employment trends

Future employment trends in the composites industry point to growing workforce demand, with 73 per cent of survey respondents planning to expand their teams within the next 1–5 years.

The majority of those interviewed had growth ambitions and expressed the need for skilled and unskilled labour to support anticipated expansion. Meanwhile, 23 per cent of respondents expect to maintain their current workforce size and only four per cent foresee a reduction. These findings feature a stable and optimistic outlook for the industry and an anticipation of overall growth.

The 2024 Manufacturing Workforce Plan[33] projects employment growth of approximately 120,000 additional workers by 2033, representing a 17 per cent increase from current levels. The plan identifies four primary challenges currently facing the industry: attracting and expanding the pipeline of apprentices, addressing an ageing workforce, improving diversity and developing skills for emerging industries, such as clean energy, medical technology, defence and space sectors heavily relying on composite technologies. Clean energy, along with defence and space technologies, were highlighted by survey respondents and interview participants as key areas of growth and opportunity. In recent years, the Federal Government has significantly increased its commitment to defence.

[33] https://misa.manufacturingalliance.org.au/books/webi/#p=1



7.1.1 Defence composite technologies and training initiatives

The 2024–25 Budget[34] allocates $764.6 billion over the next decade to enhance a more capable and self-reliant Defence Force. This investment spans all domains— maritime, land, air, space and cyber sectors – in which composites manufacturers have a long-standing legacy of supply, providing critical components for aircraft, ground vehicles, naval vessels, missiles, weapons and body armour.

Key investments include international military support, strengthening the Australian Defence Force's preparedness, advancing the AUKUS nuclear-powered submarine program, expanding long-range strike capabilities and upgrading northern base infrastructure.

To address the need for specialised skills in the defence industry, several training initiatives have been introduced. One example is the Certificate III in Defence Industry Pathways (national code 52904WA)[35], first implemented in 2021 and updated in late 2022. This program provides a pathway to university through credit transfer arrangements.

Defence training and workforce development

Manufacturing Industry Skills Alliance has launched the following two programs as part of the previously mentioned plan:

- **The Building a Defence Manufacturing Workforce project[36]**
- **The Aviation Maintenance Skills Pathways project[37]**

The growing commitment to defence production will also necessitate alignment with international standards to ensure interoperability, quality assurance and competitiveness on a global scale.

Training initiatives are required to incorporate these benchmarks to equip engineers and technicians with the skills required to meet worldwide defence industry expectations.

Demand for skilled labour in the manufacturing sector is expected to surge with estimates that the AUKUS nuclear powered submarine project alone requires 20,000 new skilled jobs[38].

[34] https://budget.gov.au/
[35] https://www.southmetrotafe.wa.edu.au/defence-industry-pathways-program
[36] https://manufacturingalliance.org.au/national-project-tackles-skills-demand-for-australias-defence-manufacturing-industry/
[37] https://manufacturingalliance.org.au/advancing-aviation-maintenance-skills-pathways/#:~:text=Thepercent20Aviationpercent20maintenanceper cent20skillsper cent20pathways,graduallypercent20buildpercent20qualificationsper cent20overper cent20time.
[38] https://manufacturingalliance.org.au/national-project-tackles-skills-demand-for-australias-defence-manufacturing-industry/

RHEINMETALL DEFENCE AUSTRALIA: TRAINING IN BONDING TECHNOLOGIES

CASE STUDY

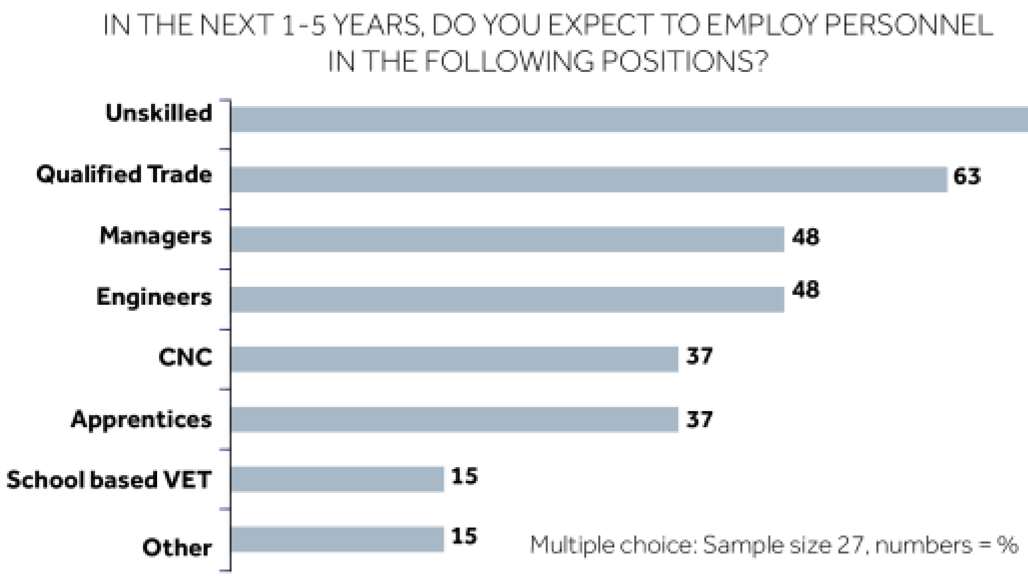
Rheinmetall Defence Australia produces the Boxer Combat Reconnaissance Vehicle (CRV) for the Australian Army under LAND 400 Phase 2, delivering 211 vehicles by 2026.

Production is centred at MILVEHCOE in Redbank, Queensland, supporting domestic and international defence projects. Rheinmetall operates an armour shop and bonding room for ballistic panels, requiring advanced bonding expertise. The company integrates skill, development into its graduate program to meet European adhesive bonding standards. Engineers gain training aligned with European rail and German defence industry standards, moving toward VDI (Virtual Desktop Infrastructure) compliance. The company sponsored staff to undertake the European Adhesive Engineer (EAE) program at Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM) in Germany[39].

7.1.2 CNC machining and 3D printing

Investment in Computer Numerical Control (CNC) machining tools and Additive Manufacturing, also known as 3D printing, has been steady nationwide for several years. Companies operate these systems for in-house use as well as sub-contracting CNC services to external clients. The

relatively mature technology has well-defined processes and standards, making it suitable for high-volume production where consistency is critical. Indeed, 37 per cent of survey respondents plan to employ CNC Operator/Technician personnel in the next 1-5 years. Recognising the technology's potential for labour savings and product improvements, other respondents also plan to adopt CNC technology in the near future, training for which is usually done by the equipment suppliers as part of the commissioning process to ensure proper use, maintenance and safety.



[39] Presentation by Ben Bishop - Composites Australia conference 2024

Parallel with the growth of CNC machining and 3D printing has been the development of industry standards to ensure that parts and processes meet quality, safety and performance expectations, particularly as 3D printing becomes more prevalent in industries such as aerospace, medical and transport. For both VET and Higher Education, the challenge lies in incorporating recently developed standards for CNC machining and 3D printing into learning and assessment materials for established qualifications to ensure that students are educated with an awareness of these standards as they are developed and released. Section 9.8 provides more detail on these standards.

The Interviews revealed a narrow understanding of 'digital twinning' as merely a one-to-one copy of a physical asset. The breadth of technologies and productive applications of digital twinning remains widely overlooked, signalling a need for greater knowledge dissemination.

7.1.3 Prefabricated housing

Projections indicate a substantial number of new homes will be needed over the next decade to address the housing shortage across all states, particularly in regional areas. Australia needs practical housing solutions. Several interviewees highlighted modular and prefabricated housing as promising strategies to bridge the growing supply and demand gap. Prefabricated construction offers numerous advantages, including reduced build times and greater quality precision and consistency in a controlled factory environment. These methods also contribute to sustainability by minimising material waste and enabling the integration of energy-efficient designs.

'After all, caravans, houseboats and cruisers – made from fibreglass - are just towable or floating homes that industry mastered decades ago'[40]

Orienting the composites sector towards construction requires addressing specific challenges. According to the Prefabricated, Modular and Offsite Construction Handbook issued by the Australian Building Codes Board[41], one observation notes that 'the alignment of composite wall panels to other structures, such as concrete floors or roof structures may be problematic due to in-situ construction tolerances'.[42]

PrefabAUS estimates that 680 companies in the sector made a combined revenue of $11.4 billion in 2023, or seven per cent of the value of construction across residential and commercial building. This was likely to grow to 30 per cent over the next decade.[43]

7.1.4 Haulage

Interviews project that Australia's trucking industry will expand significantly to connect the country's food bowl via inland road routes, linking agricultural regions with major markets. Total road freight volumes are expected to surge alongside population growth, making fleet efficiency and

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[40] Interviewee to remain anonymous
[41] Along with the Building 4.0 CRC
[42] https://building4pointzero.org/wp-content/uploads/2024/11/Prefabricated-modular-and-offsite-construction-handbook-NCC-2022-Final.pdf
[43] https://www.afr.com/property/residential/cba-to-offer-loans-for-prefab-homes-a-sector- it-once-shunned-20250130-p5l8bw

sustainability essential to meet future demand and support the agricultural supply chain. Australia's ageing fleet will also require upgrading to comply with forthcoming regulations. Innovations in manufacturing composite parts, such as lightweight hoods, bumpers and dashboards, will support this transition by reducing vehicle weight, decreasing fuel consumption and emissions and increasing payload capacities.

Australia is a vast country that depends heavily on a comprehensive transportation network to provide access to essential services and economic activities across its entire continent. Our road system of 877,651 km and an additional 51,984 km of major roads, enables the trucking sector to serve the country's infrastructure. For the mining industry, the use of road freight is the primary method for moving urban, inter-urban and regional freight, playing a role in the import and export supply chain for food, mineral resources, machinery, capital equipment and other essential items to their sites.

According to the Bureau of Infrastructure and Transport Research Economics (BITRE), road freight volume has seen an eightfold increase, from approximately 26 billion tonne kms in the 1970-71 period to about 223 billion tonne km by 2019-20. The Bureau forecasting model for national road freight connects future road use with anticipated growth in population, income per capita and freight costs.

Figure 18 Felco's truck and semi-trailer mounted bulk liquid haulage tankers - ranging between 2000 to 20,500 litres capacity - are fully engineered and tested, and then handcrafted by the Felco team of advanced composite technicians in Toowoomba. Photo by Rod Monti.

Projections suggest that Australia's population will increase from about 26.6 million in 2024 to approximately 35.3 million by 2050, based on central forecast scenarios according to the ABS 2024 Population Statement. With income per capita expected to rise by about 0.9% annually from 2020 to 2050, the total road freight volume is estimated to surge by roughly 77% during the same period, reaching about

393.7 billion tonne km by 2050. Although this growth rate is slower than in the past, it implies a significant increase in the need for trucks, drivers and road mileage throughout Australia's road network.

In response to environmental concerns, the Federal Government is implementing stricter emissions standards, known as Euro 6, for new trucks and buses. These will be gradually introduced over a 12-month period starting from 1 November 2024. The Truck Industry Council report titled 'Modernising the Australian Truck Fleet'[44] provides an overview of the Australian truck industry, highlighting the involvement of nine truck manufacturers and distributors, which represent 16 different brands. The report estimates the value of the Australian new truck market at around $4.5 billion. Additionally, it notes the average age of vehicles weighing above 4.5 tonnes GVM (Gross Vehicle Mass) at 14.9 years, as per the ABS Motor Vehicle Census of January 2018.

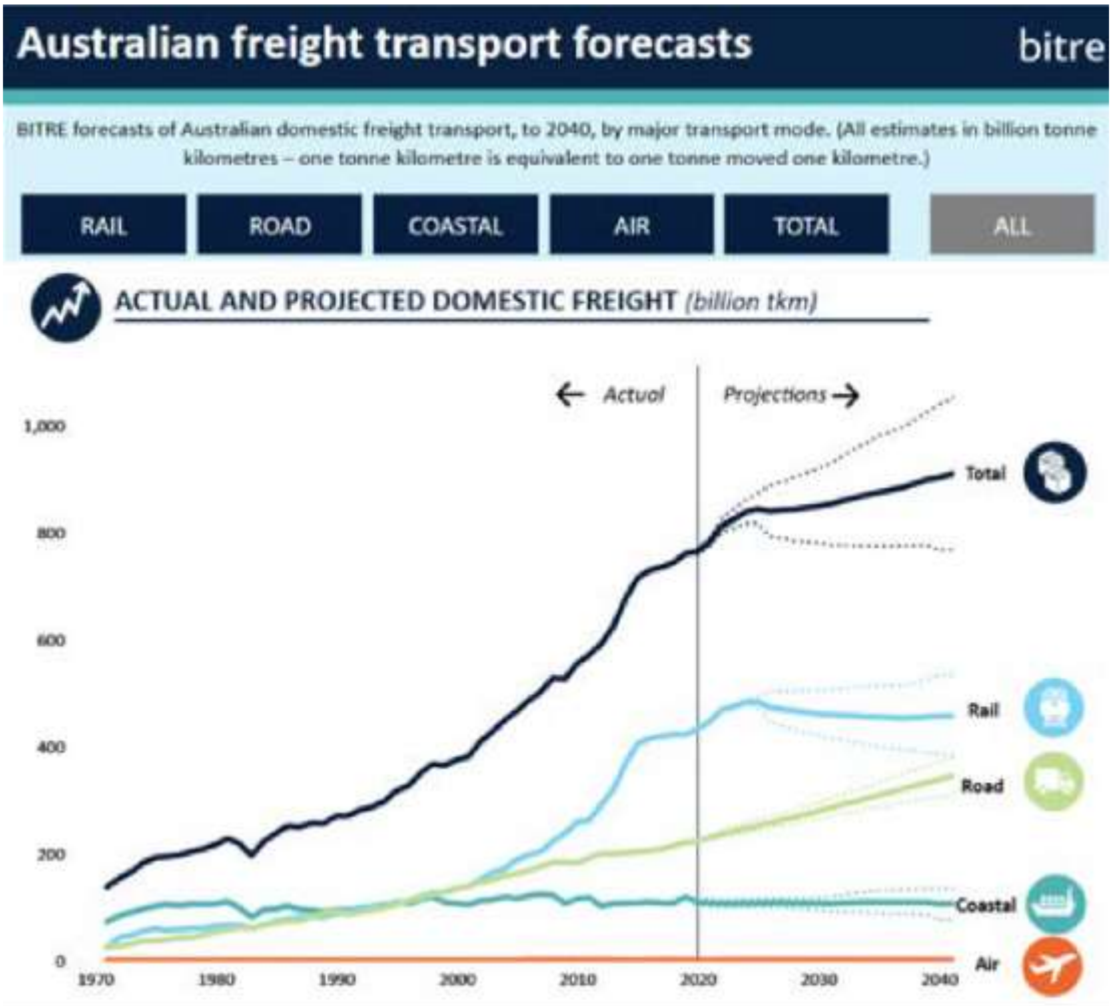


Figure 19 BITRE forecasts of Australian domestic freight transport, to 2040, by major transport mode. (All estimates in billion tonne kms – one tonne km is equivalent to one tonne moved one km.)

[44] https://treasury.gov.au/sites/default/files/2019-03/360985-Truck-Industry-Council.pdf

7.1.5 Renewable energy – Western Sydney

Western Sydney's significant investments in advanced manufacturing for renewable energy, including hydrogen capability, were initiated to support aviation and haulage while advancing the state's broader energy and environmental goals. The Hydrogen Hub is focused on integrating hydrogen into the energy distribution system and developing a hydrogen cylinder refilling station for offsite applications of renewable hydrogen. The Advanced Manufacturing Readiness Facility (AMRF), an innovation accelerator set to officially open soon, is being established to commercialise, advanced manufacturing capabilities, particularly in filament winding technology relevant to producing composite pressure vessels used in hydrogen fuel systems, thereby supporting the development and growth of hydrogen infrastructure and applications.

Australia's hydrogen industry is advancing through strategic investments and policy frameworks, but recent project cancellations highlight significant challenges in scaling production and securing market demand.

Over $200 billion is earmarked for hydrogen and derivatives in the investment pipeline, representing 20% of global renewable hydrogen projects. State/federal governments have allocated $8 billion in hydrogen-specific support and $35 billion in hydrogen-eligible funding.[45]

High profile failures such as the Trafigura's Port Pirie Plant, Queensland's Central Hydrogen Project and Fortescue's abandoned targets must be acknowledged. Despite setbacks, the Federal Government maintains support, recently pledging $814 million for Western Australia's Murchison project.[46] The focus now shifts to smaller-scale, modular systems and leveraging hydrogen for value-added exports (e.g. green steel) to sustain long-term growth.

Industry Skills Accelerator (ISA)

Co-located with the AMRF is the ISA, which develops and delivers micro credential-based short-form training for workers to acquire specific knowledge, skills and experience required by employers in approximately 40 hours.

ISA's catalogue of micro-credentials includes 'Introduction to Manual Composite Layup Techniques', a course developed for Quickstep in collaboration with Western Sydney University. While still in its early stages, the ISA plans to expand education and training programs that align closely with the AMRF's portfolio, fostering a skilled workforce to meet the demands of advanced manufacturing.

7.1.6 Composite repair and sustainment

Industrial equipment across mining, aerospace, marine and infrastructure sectors faces a range of stressors— corrosion, environmental exposure, mechanical impact, fire damage, and ageing. Sustaining these assets requires a nationally coordinated capability in composite repair, underpinned by technical expertise, standards and education pathways. Composite repair involves restoring or reinforcing damaged composite components and, in many cases, enhancing other materials, such as

[45] https://www.ga.gov.au/aecr2024/hydrogen
[46] https://arena.gov.au/news/murchison-green-hydrogen-project-given-a-headstart/

metals or concrete, through composite overlay techniques. This field is diverse, reflecting the wide array of materials, repair types, applications and end-user industries involved.

Composite Repair Dimensions

By Composite Material Type:

- Carbon Fibre Reinforced Polymer (CFRP)
- Glass Fibre Reinforced Polymer (GFRP)
- Aramid Fibre Reinforced Polymer (AFRP)
- Natural Fibre Reinforced Polymer (NFRP)
- Hybrid Composite Materials

By Application Area

- Aerospace: fuselage panels, flight surfaces
- Automotive: body panels, chassis reinforcements
- Marine: hulls, deck structures
- Civil Infrastructure: bridges, pipes, protective cladding
- Sporting Equipment: bikes, rackets, paddles

By Repair Type

- Surface repair
- Structural repair
- Reinforcement repair
- Bonding and rending
- Impact damage restoration

By Repair Method

- Manual techniques
- Automated Technologies
- Composite patch pystems
- Vacuum bagging
- Adhesive bonding
- UV curing

By End-User Sector

- Aerospace and Defence
- Automotive Manufacturing
- Marine and Offshore
- Construction and Infrastructure
- Pools and spas and recreational goods

Several industries, particularly aerospace, have developed comprehensive repair standards to ensure safety and performance. In Australia, the Civil Aviation Safety Authority (CASA) provides detailed requirements for the maintenance and repair of composite aircraft structures, which are incorporated into both national aviation regulations and approved training programs.

Education and Industry Alignment

For both VET and higher education, a key challenge is embedding composite repair standards into training and assessment materials to ensure job-ready competencies. Section 9.9 further outlines relevant competencies in the VET sector.

The ACM CRC supports this national capability through its partnerships. FUZE Solutions delivers customised composite repair and reinforcement services, including on-site maintenance in remote environments. ACS Australia complements this with end-to-end solutions across wind energy, aerospace, marine and civil infrastructure, while also offering workforce training programs in composite repair.

7.1.7 Wind Energy

Achieving the targeted emissions reduction by 2030 will require a substantial investment in wind energy, with thousands of turbines needing to be installed over the coming years at a significant pace.[47] Turbine blades, nacelles and hubs, typically made from composites, are currently imported by international renewable energy companies, creating a need for local repair, maintenance and refurbishment services.

[47] https://reneweconomy.com.au/offshore-wind-farm-map-of-australia/

The following is an excerpt from an email by a provider of technical and engineered services at height, illustrating the high demand for qualified workers in wind energy:

'We have become a main subcontractor to one of the biggest wind turbine manufacturers and installers in Australia…Whilst there is some work we do on the towers, the bulk of work is composites (or at least filling, fairing and coating) on the blades. We could quite easily put on 20 staff tomorrow and have work for them for the next year.'

The Asia Pacific Renewable Energy Training Centre (APRETC),[48] was established by Federation University in 2021 to serve the emergent demand for skilled workers in the wind energy sector.

One of its key programs, the Wind Turbine Blade Technician Certificate (using Certificate III in Engineering – Composites Trade (MEM31119) is a three-year apprenticeship adapted to train technicians to repair material fatigue, damage from weathering and bird strikes, and to ensure that turbine blades remain operational and efficient.

7.1.8 Recycling

According to the Clean Energy Council's Winding Up: Wind Turbine Recycling Report 202347, most end-of-life wind turbines in Australia can avoid landfill, with between 85% and 94% of their mass—primarily steel, aluminium and copper—being recyclable. Turbine blades, however, which are typically made from composite materials like fibreglass and carbon fibre, pose a significant challenge.

The report notes that 31 wind farms—comprising 599 turbines—are already more than 15 years old, indicating an emerging need for large-scale, economically viable end-of-life strategies for composite components.

Given the vast distances between wind farm sites in Australia, reclaiming and transporting turbine blades for recycling—whether by mechanical, thermal, chemical or electrical processes— presents a serious logistical barrier. The road distance from the westernmost turbines in Geraldton, WA, to Coopers Gap, QLD, is approximately 4,300 km, while the distance from southern Tasmania to northern Queensland sites is about 2,800 km.

Every kilometre of freight and each handling instance increases the cost burden and reduces the commercial viability of recovery processes. Without cost-effective solutions, recycling remains unfeasible in practice.

[48] https://assets.cleanenergycouncil.org.au/documents/Clean-Energy-Australia-Report-2023.pdf

Figure 20 Capital wind farm. View from Federal highway lookout. Bungendore. NSW. Australia. Ilia Torlin

In comparison, legacy recycling collection models for household goods, like paper, glass and e-waste are, managed and executed by councils and funded by property owners' council rates. The service is facilitated by an efficient logistics system developed over decades, with the rates ensuring a steady revenue stream to maintain and upgrade the infrastructure required for delivering the collected materials to recycling facilities across the country.

The development and maintenance of recycling infrastructure is facilitated through a combination of government initiatives, private investments and funding mechanisms. Collaboration between waste management and recycling sectors validates investment in automated sorting systems, material recovery facilities and advanced recycling technologies. The system works synergistically with commercial recyclers that have developed take-off relationships both domestically and globally, fostering collaboration between the waste management and recycling sectors, which in turn validates investments in automated sorting systems, material recovery facilities, and advanced recycling technologies.

One promising approach is in-situ recycling, which involves processing waste materials or using portable equipment directly or at local the site of decommissioning. This reduces transportation costs and enables the feedstock to re-enter production streams locally, offering a potential pathway to overcoming Australia's geographic and logistical constraints.

For both VET and higher education, a key challenge lies in embedding composite repair standards and emerging end-of-life strategies into accredited qualifications. Section 9.9 provides further details on the relevant competency units within the VET sector.

The ACM CRC supports this effort through partnerships with organisations specialising in composite repair and life extension.

7.1.9 Life cycle analysis on composites products

The Life Cycle Engineering and Management Research Group at the University of New South Wales conducted a comprehensive study in 2006[49] to quantify the life cycle embodied energy and total environmental impact of a range of composite products manufactured in Australia. This research provided valuable insights by comparing the environmental performance of composite products against those made from traditional materials and has since been used extensively by specifying agencies (engineering and architectural firms) and procurement agencies such as local councils.

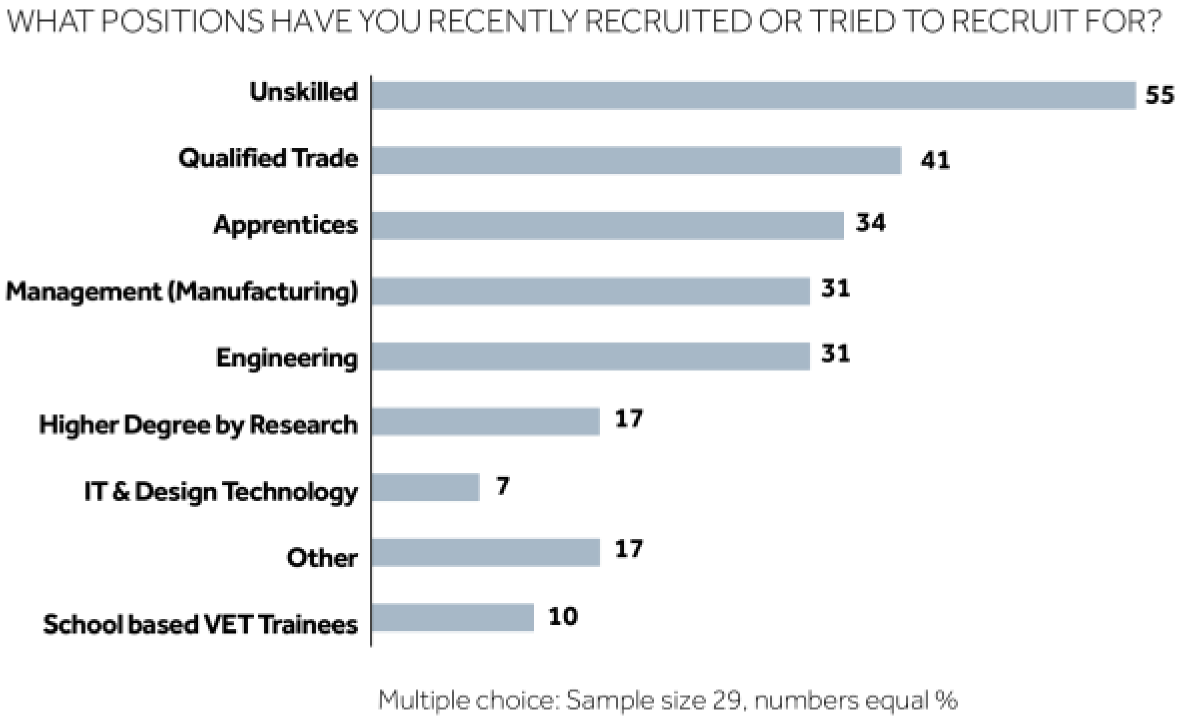
The study, undertaken as part of a multi-partner collaborative project, effectively evaluated the full spectrum of environmental impacts associated with a range of Australian made products. The research used two LCA approaches–cradle-to-factory and cradle-to-grave–ensuring a thorough assessment of the environmental footprint from raw material extraction to manufacturing and end-of-life disposal. Given the efficacy of this initiative, it is recommended that this research is expanded into an ongoing research program to further advance sustainability in composite manufacturing.

[49] https://www.compositesaustralia.com.au/wp-content/uploads/2024/06/Final-Report-Composites-Embodied-Energy-Study.pdf

8 Recruitment Challenges and Skills Gaps

8.1 Identification of gaps in knowledge and skills

Recruitment challenges in the composites industry were examined through one-on-one interviews with industry personnel and an online survey. Insights from the interviews were corroborated by survey responses, with nearly 60 per cent of participants indicating they had recently attempted to recruit unskilled production workers—roles typically assessed as having a ‘moderate’ level of complexity.



Qualified tradespeople and apprentices emerged as the next most sought-after positions, reflecting the effects of the national skills shortage compounded by the disruption to student training and education pathways during the COVID-19 pandemic.

Few companies in the composites industry employ in-house engineers or designers, apart from those with engineer-centric workforces, such as RPC, Carbon Revolution and Quickstep. Instead, many businesses outsource their engineering and design requirements to specialist consultants. Survey responses indicated that nearly 30 per cent of participants had recently attempted to recruit for engineering and management positions, highlighting the demand for these roles within the industry. Additionally, nearly 20 per cent of respondents indicated they were seeking candidates with HDR qualifications.

When asked about the top technical and non-technical skills and knowledge gaps in new hires, 70 per cent of respondents identified a lack of understanding of 'material inputs', while 63 per cent highlighted gaps in 'manufacturing techniques'. These issues have remained a persistent concern for many years.

The significant cost of management time spent supervising recruits is largely driven by safety concerns inherent to materials and manufacturing environments. New hires, whether process workers or those holding higher education qualifications, require supervision to meet duty of care obligations in production settings – a sentiment expressed by most interviewees.

Respondents also emphasised the importance of non-technical skills, with over 50 per cent identifying 'problem-solving and analytical skills' and 'communication skills' as critical.

Respondents identified several key areas of concern when asked which specific composites or manufacturing roles are expected to be the most difficult to recruit over the next 1–5 years. At the forefront are process workers skilled in standard fibreglass lamination, resin transfer moulding

(RTM) and closed moulding techniques, alongside machine operators for advanced manufacturing processes, including CNC programmers and operators essential for precision manufacturing.

Additionally, there is a demand for manufacturing quality control (QC) personnel, supervisors and managers to ensure production standards and operational efficiency.

Management and technical roles, including science-focused positions, are challenging to fill because they require a combination of highly specialised expertise and a research background in specific manufacturing technologies. Candidates with the relevant blend of skills and experience are perceived to be in short supply.

Similarly, design specialists with a deep understanding of structural and tooling design principles are scarce, as are engineers across various disciplines who are needed to drive innovation and support operations.

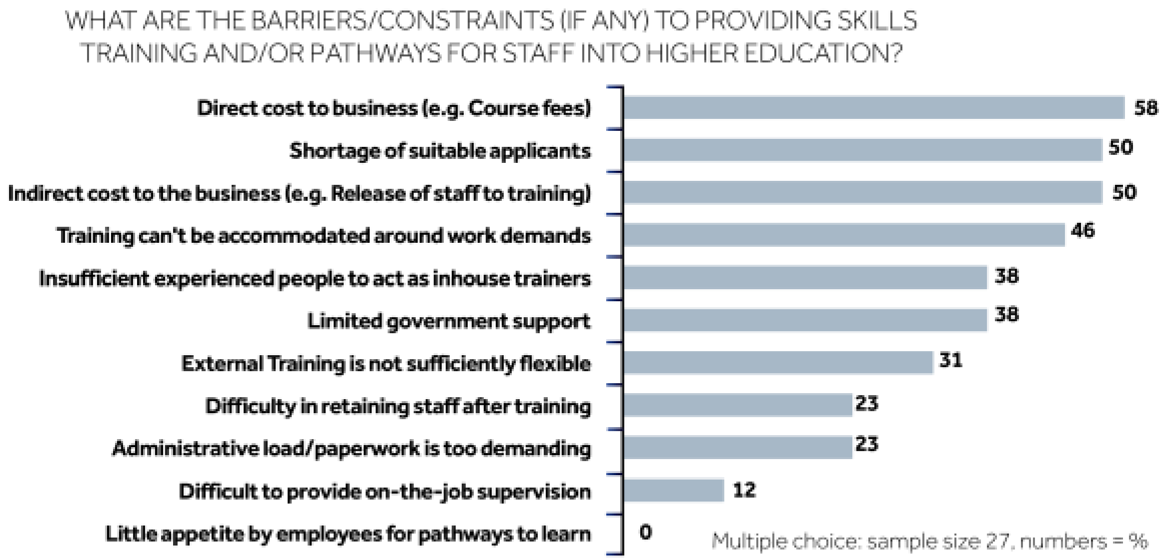
These recruitment challenges reflect a growing demand for both technical and management expertise in the composites sector, highlighting the need for targeted workforce development and training strategies.

8.1.1 Advancing through up-skilling and re-skilling

Most survey respondents indicated that the timeframe for up-skilling new employees or re- skilling existing staff in production technologies typically ranges from six months to three years. Many interviewees emphasised, however, that this timeline is difficult to quantify due to the highly specialised and varied nature of said technical processes.

When asked about barriers to providing skills training and pathways into higher education, respondents frequently pointed to the bespoke nature of composite technology. Many noted the lack of formal courses tailored to their specific processes, making it challenging to access structured training. The infographic on page 11 highlights the wide range of composite processing technologies.

Despite these challenges, a common theme emerged during interviews. That is, employees committed to furthering their education to enhance their skills and knowledge to potentially advance within the company, are met with strong support from employers, particularly those with aptitude, ambition and attention to detail.



8.1.2 Barriers to women and under-represented groups

Interviews and survey responses on women and under-represented groups in the workplace revealed a range of perspectives, from comments that 'there are no barriers' to those around structural and practical workplace challenges, including access to changing rooms, family responsibilities and the physically demanding nature of the work.

These findings align with the concept of Social Learning Theory discussed in Section 4.7, which posits that individuals are influenced by observing the behaviours, successes and acceptance of others.

The ACM CRC Constitution emphasises increasing the proportion of women in training, research, high-potential career roles and leadership positions. It provides less explicit focus on addressing barriers to other under-represented groups–a term that was not clearly defined for survey participants–leaving room for further policy development and subsequent programs.

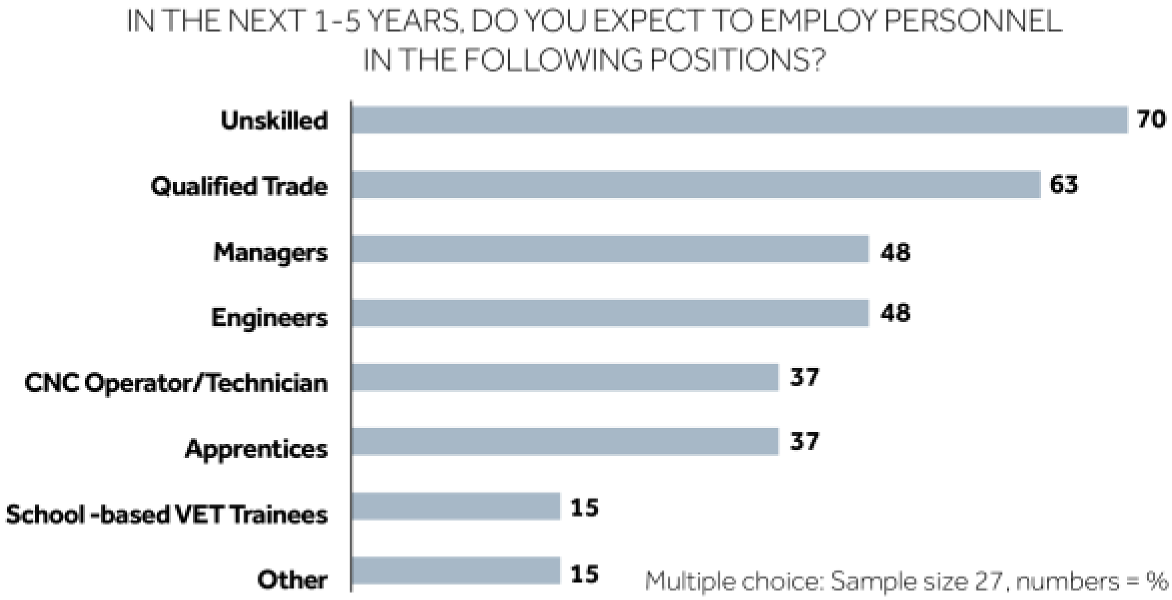
8.1.3 New training programs or micro-credentials

When asked about the focus of new training programs or micro-credentials, interviewees and survey respondents preferred foundational subjects, with 'Back to the Basics: Composites 101' rated highly. Among these, composite manufacturing and fabricating processes emerged as a top priority. Equally important were areas such as 'tool/mould design and manufacture' and 'chemical: resins & catalysts', as confirmed during interviews. Additionally, there was notable interest in topics such as 'adhesives and bonding technologies,' 'lean manufacturing,' 'repair of composites', and 'workplace health and safety',reflecting the industry’s evolving priorities and the need for targeted skill development with the proviso that acquired skills can one day be counted towards a qualification.

Many interviewees emphasised the duty of care to ensure employees and recruits develop an intuitive knowledge base that guides their work and fosters respect for the manufacturing environment and materials. These foundational topics were anticipated to align with VET qualifications, potentially contributing to apprenticeships and credits recognising prior learning.

Regarding expectations for hiring across various positions, respondents indicated that 70 per cent of hiring is anticipated to focus on unskilled local workers, followed by individuals with trade qualifications who would receive technology-specific, on-the-job training. Managers and engineers were rated equally with nearly 50 per cent of respondents planning to hire in these roles.

Apprentices and CNC Operators were identified at a lower percentage, which aligns with the typical distribution of manufacturing workplaces, where unskilled and trade-qualified workers make up a greater proportion than those in specialised expertise or managerial positions. These findings, supported by interview insights, demonstrate the value of unskilled and trade-qualified workers in maintaining operational efficiency, while also recognising the strategic importance of skilled professionals in driving innovation and supporting industry growth.



8.2 Education needs and collaboration with universities

Engagement with universities and research centres remains a selective process for many organisations, with just over 77 per cent of respondents indicating minimal to moderate collaboration and only four per cent reporting extensive engagement.

At the same time, partnerships hold the potential to drive innovation efficiencies and past experiences shared during interviews highlighted challenges, mainly when there is a perceived disconnect between academic expertise, the company's specific manufacturing technologies and the practical realities of working with composite materials.

Interviewees and survey respondents frequently perceived that universities and research centres may be unaware or disconnected from the specific needs of the manufacturing industry, particularly regarding specialised processes. Conversely, it was also possible that companies lack awareness of the areas of specialised capabilities and expertise available within the university sector. A recurring concern was the need for education, training and research to align with specific composite technologies. Confusion persists, however, about where expertise resides among the various research centres across the country, as outlined in section 9.5.

8.3 Support for HDR and ECR

The support for Higher Degree by Research (HDR) students and Early Career Researchers (ECR) transitioning into industry has a growing focus. Various programs, reports and initiatives focus on bridging the gap between academia and industry, aiming to enhance skills and career opportunities for researchers. Some examples of these programs and initiatives include:

- Industrial Transformation Research Program (ITRP)[50]
- Early Career Industry Fellowships[51]
- Measures to Support Early & Mid Career Researchers[52]
- TRaCE Higher Degree Researchers Program[53]
- RACE for 2030 Industry PhD Program[54]

Internships, however, were rated highly in the online survey (65 per cent) and interviews, viewed as valuable practical workforce engagement providing participants with essential hands-on experience while allowing employers to assess candidates' skills, suitability and commitment to ongoing learning. Internships help produce job-ready individuals who contribute effectively to the workplace.

Internships alone do not fully address the challenges of integrating inexperienced individuals into industrial environments. Despite their academic and theoretical knowledge, new entrants often lack familiarity with processes, equipment and workflows. Survey responses and interviewees highlighted the practice of placing new hires on the factory floor for hands-on training. While effective, this approach incurs costs to employers, including time, resources and temporary disruptions to productivity.

The location of a university plays a significant role in shaping the opportunities available for Higher Degree by Research (HDR) candidates and Early Career Researchers (ECRs), particularly in relation to internships and employment pathways. Proximity to manufacturing hubs or industry partners enhances the likelihood of meaningful placements for applied research and long-term career development, however, the vastness of Australia and the broad geographic distribution of universities can present challenges. These constraints may limit access to industry placements, particularly for those based at regional institutions, unless researchers are willing to relocate to be closer to key manufacturing sites.

Professional networking is a key skill for career development, enabling individuals to establish their reputation as knowledgeable and engaged members of the profession. It is a practical avenue to connect with the broader industry. Encouraging and funding participation in industry events fosters valuable connections and understanding of industry needs.

Despite these benefits, data on event registrations show that university personnel, including academics, HDR students and ECRs, seldom attend industry events[55]. A constructive approach to addressing this would involve actively encouraging and supporting HDR and ECRs to participate in domestic events to build meaningful relationships with industry stakeholders and gain insights into the practical applications of composite manufacturing technologies. Similarly, targeted initiatives to attract industry representatives to academic conferences could help industries build valuable

[50] https://www.arc.gov.au/funding-research/funding-schemes/linkage-program/industrial- transformation-research-program
[51] https://www.arc.gov.au/funding-research/funding-schemes/linkage-program/early-career-industry- fellowships
[52] https://researchaustralia.org/reports/supporting-early-and-mid-career-researchers/
[53] https://trace.org.au/education-skills-training/industry-phd-programs/
[54] https://racefor2030.com.au/industry-phd-program-getting-involved/
[55] Registrations for Composites Australia events over 10 years

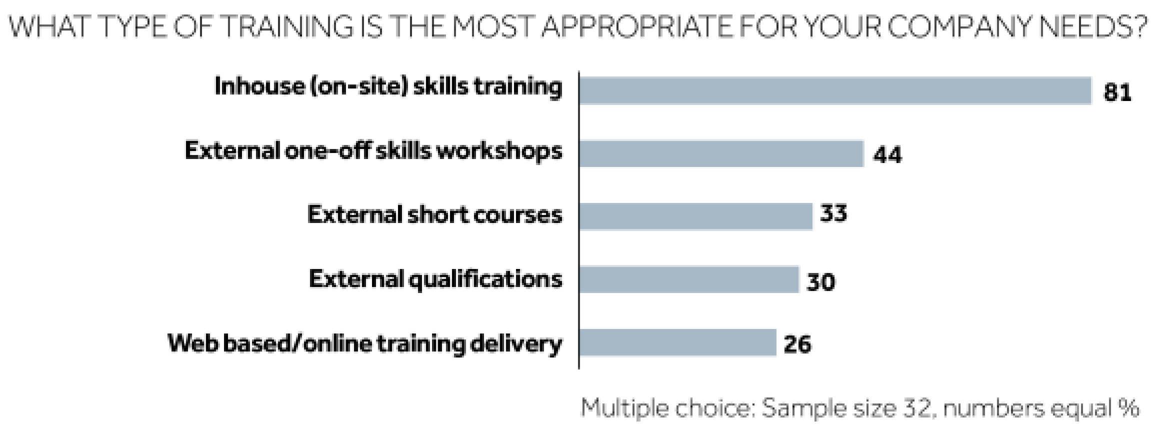
networks and gain a deeper appreciation of universities' and research institutions' breadth of capabilities and expertise.

8.4 Preferred training method

The most preferred mode of training was in-house skills training (81 per cent), followed by web-based/online learning (43 per cent) and external accredited qualifications (35 per cent). 'Offsite training, whether delivered as fee-for-service, skill sets, or flexible qualification pathways, was not widely favoured.

Interviews highlighted reluctance toward offsite learning, particularly in regional areas where long-distance travel to training facilities poses logistical challenges. Concerns about the duty of care for young people and the time and costs associated with travel further reinforce the preference for locally-delivered training options.

An example provided included the Clean Energy Councils 'LearningLab'[56], which includes a comprehensive suite of online teaching resources.



8.5 Training and education pathways

The pathways to becoming a skilled Fibre Composite Technician (alternative titles can include Laminator, Composite Fabricator, Fibreglass Technician/Tradesperson and Shipwright) are as follows:

- Formal VET qualifications – generally a four-year Certificate III apprenticeship
- On-the-job training combined with practical experience of up to four years.

On-the-job training was confirmed as the most used method for all types of skills development:

- Over 70 per cent of respondents frequently provide 'On-the-job training',
- 74 per cent use 'External short courses' and
- Over 68 per cent use 'Accredited qualifications', but only sometimes
- 90 per cent of companies sponsor workers to obtain work tickets and licences either frequently or sometimes.

[56] https://cool.org/stem-futures-energy-careers-education-resources

'The prevailing perspective within industry towards education and training is practical. Qualifications are widely supported when they can be delivered in the workplace and contribute to employees producing higher-value products with greater efficiency and quality.'[57]

Many interviewees expressed a positive view of automation processes; however they noted the required capital investment may not deliver sufficient productivity returns. The ongoing concern about 'uncertain market conditions' was cited as a reason for prudence in expenditure.

[57] Interviewee to remain anonymous

9 Appendices

9.1 Federal Government Policy Framework

Includes, but not limited to the following:

- **The Universities Accord**
- **Manufacturing Workforce Plan 2024**
- **Sovereign, Smart, Sustainable: Driving Advanced Manufacturing in Australia**
- **The National Reconstruction Fund**
- **The National Defence Strategy**
- **The Future Made in Australia Plan**
- **Cooperative Research Centres Program**
- **The National Housing Accord**
- **Industry Growth Program**
- **Modern Manufacturing Strategy**
- **Modern Manufacturing Initiative**
    - Manufacturing Integration Stream
    - Manufacturing Translation Stream
    - Manufacturing Collaboration Stream

9.2 Companies interviewed

- Advanced Composites Structures (Australia) (VIC)
- Allnex (NAT)
- Aquatic Leisure Technologies (WA)
- Australian Institute of Engineering (NAT)
- Beyond Materials Group (QLD)
- Carbon Revolution Operations (VIC)
- Colan Australia (NSW)
- Composites Constructions (VIC)
- Concept Fibres (VIC)
- Corrosion Technology Australia (VIC)
- CST Composites (NSW)
- Curtin University (WA)
- Deakin University (VIC)
- East Coast RV (QLD)
- Edencraft International (VIC) Advanced Manufacturing Research Facility (NSW)
- Envirotank P/L (VIC)
- Freedom Pools Australia (WA/QLD)
- FUZE Group (WA)
- Gilmour Space Technologies (QLD) BI Composites (VIC) BI Composites (VIC)
- Gowing Bros Ltd (VSW)*
- Hybrid Composites (QLD)
- Hypersonix Launch Systems (QLD)

- Industry Skills Accelerator (NSW)
- Innomerix (VIC)
- Jeff Sykes & Associates (VIC)
- JPM Shipwrights (VIC)
- LaserBond Limited (WA)*
- Lavender Composites & Engineering (QLD)
- Lightwave Yachts (QLD) Manufacturing Industry Skills Alliance (NAT)
- LSM Advanced Composites (QLD)
- Maritimo (QLD)
- Marky Industries (QLD)
- Mincham (SA)
- Mission Beach Boats (QLD)
- Omni Tanker Pty Ltd (NSW)*
- Pacific ESI (NSW)
- PARTEC Institute (QLD)
- Pathfinder Australia (VIC)
- Pultron (QLD)
- Quickstep Holdings (NSW)
- Quickstep Holdings (VIC)
- RAAF Amberley (QLD)
- Reef Design Labs (VIC)
- Rheinmetall Defence Australia (QLD)
- Rik Heslehurst (ACT)
- Riviera Australia (QLD)
- RPC Technologies (VIC)
- Rux Energy Pty Limited (NSW)
- Solar Sailor Engineering & Dist. (Ocius) (NSW)*
- Special Patterns (VIC)
- Steber International (NSW)
- Sykes Racing (VIC)
- United Chemicals Composites & Colours (VIC)
- University of Western Australia (WA)
- Vikal International (WA)
- Wagners CFT Manufacturing (QLD)
- World Class Composites (NSW)

**Denotes ACM CRC partner companies yet to contribute to the study*

9.3 Secondary sources

- Manufacturing in Australia Performance Benchmark Report 2024 The UK Composites Strategy – Building Britain's Future
- The Australia Universities Accord Manufacturing Workforce Plan 2024 Transformative Research Acceleration Commercialisation Program The National Plastics Plan
- The National Robotics Strategy
- The Engineering Profession – A statistical overview (15th edition) Prefabricated, Modular and Offsite Construction Handbook
- Engineered Repairs of Composite Structures by Rikard Benton Heslehurst

Note: Additional references are listed in page footers.

9.4 List of Composites Technologies (From Page 16)

9.4.1.1.1.1.1 Closed Mould Resin Infusion by Vacuum

Dry fibre reinforcements are placed into a rigid mould with a flexible silicone bag placed on the top layer. The mould is sealed with the silicone bag, which conforms to the shape of the part. A vacuum is applied to the mould, drawing resin into the fibres through strategically placed inlets, ensuring even distribution across the part. This process is used in various applications, including boat hulls and decks, yacht and ship components, aerospace structural components, transport body panels, marine components, railway components, large structural beams, bridge decks, architectural façade panels and recreational vehicle (RV) parts.

2. Open Mould, Hand Layup Process.

The process involves manually placing layers of fibre reinforcement into an open mould. Resin is applied to each layer by hand, brush or roller to ensure proper impregnation. The assembly is consolidated by rolling to remove air bubbles and ensure even resin distribution. Once complete, the part is left to cure at room temperature or under heat. This method is used in the production of boat and dinghy hulls, swimming pools, bathtubs and shower enclosures, automotive body panels, water tanks, spa shells, playground equipment, architectural mouldings, roofing panels, marine components, fibreglass sculptures and truck fairings.

3. Closed Mould Infusion by Pressure

The process uses 'tooling' – a broad term for moulds, jigs, fixtures and equipment to shape or form a part. The process involves placing dry fibre reinforcements into a sealed tool, which is then injected with resin under pressure. The resin permeates the fibres throughout the mould cavity, often with heat application. This manufacturing method is used to produce boat hulls and decks, transport body panels, aerospace components, train and tram components, structural beams, bridge components, recreational vehicle (RV) parts, large industrial tanks, architectural panels and pressure vessels.

4. Hand Layup Autoclave-Cured Process

This process involves manually placing layers of prepreg (fabric pre-impregnated with resin) into a mould. The assembly is vacuum-bagged and then placed in an autoclave a high-pressure high-temperature chamber where the resin is cured, compacting the laminate. It is used for aerospace and aircraft structural components, UAV components, satellite components, racing car body panels, medical prosthetics and pressure vessels.

5. Glass-Reinforced Cement (GRC)

Also known as glass fibre-reinforced concrete (GFRC), this composite material IS made from a mix of cement, fine aggregate, water, chemical admixtures and alkali- resistant glass fibres. It is commonly used in utility poles, architectural cladding panels, sound barriers, bridge parapets, interiors, bench tops and balustrades, façade and decorative mouldings, planters and landscaping features and **roofing tiles.**

6. Sheet Moulding Compound (SMC)

Compression moulding involves placing fibre-reinforced polymer sheets into a heated cavity and core steel mould. Heat and pressure are applied using a hydraulic press to shape the materials. This process is used for automotive body interior and exterior panels, tactile ground surface indicators, roofing tiles, electrical enclosures, truck cab components, stadium seats, construction panels and cladding, aircraft interior panels, bumpers and grilles and utility boxes.

7. 3D Printing Additive Manufacture

This process involves building parts layer by layer, typically with an extruded polymer deposited in a fill pattern programmed into the driving software onto the build platform or previous layer. In the Additive Manufacturing (AM) process using the filament-based extrusion technique of Fused Deposition Modelling (FDM), the material is processed into a filament form before being deposited onto the build platform or previous layer.

8. Braiding Radial/Central

This technology involves interlacing continuous fibres around a core or mandrel in a circular or helical pattern, producing continuous, seamless structures with uniform fibre placement. Applications include pressure vessels, aircraft and transport components, fibre-reinforced pipes, aerospace structural components and energy transmission components.

9. Automated Tape/Fabric Layup (ATL/AFP)

This technology uses robotic systems to precisely place composite tapes or fabrics onto a mould, ensuring consistent fibre alignment. It is commonly applied in producing aircraft wings, wing spars, fuselage sections, spacecraft components, satellite structures, helicopter rotor blades, pressure vessels and unmanned aerial vehicle (UAV) structures.

10. Pultrusion

This process produces long, straight composite profiles with consistent cross-sections. Fibres are pulled through a resin bath, where they are impregnated then passed through a heated die that shapes and cures the material. The resultant composite profiles are commonly used in construction, infrastructure and industrial applications such as utility poles, cross arms, boardwalks and bridge beams.

11. Filament Winding

This technology involves winding continuous fibres soaked in resin around a rotating mandrel to create hollow, cylindrical structures. Applications include pressure vessels, pipes, tanks, cylinders, rocket motor casings, yacht masts and marine spas, oil and gas pipelines, structural beams and poles.

12. Spray up Open Moulding

This process involves spraying a mixture of resin and chopped fibreglass strands onto an open mould. Subsequent rolling removes air pockets, ensuring even distribution of the resin. Common applications of this technology include the production of boat hulls, transport body panels, bathtubs and shower stalls, swimming pools, water tanks, truck bed liners, spa shells, architectural cladding, playground equipment and fibreglass domes.

9.5 The Coomera Cluster

The Coomera Marine Precinct, situated on Queensland's Gold Coast, is Australia's leading marine manufacturing and services centre. It covers approximately 250 hectares and is home to over 100 businesses, including boat builders, maintenance providers and marine equipment suppliers. This clustering of enterprises fosters collaboration and drives innovation and operational efficiency within the marine industry, all of which contributes to local economic growth.

Key players within the precinct include Riviera and Maritimo, producers of luxury motor yachts. Riviera operates a 16.8-hectare facility, recognised as the largest motor yacht manufacturing site in the southern hemisphere. Employing more than 950 craftspeople, Riviera produces around 150 yachts annually for domestic and international customers. Maritimo, headquartered in the precinct, has achieved global reach, establishing a network of 44 dealer partners across 16 countries.

The precinct is also home to The Boat Works, a major shipyard that recently completed a $100 million expansion, doubling its size to 43 acres. This expansion includes 'The DOCK', a dedicated yacht sales precinct featuring prominent brands such as R Marine Jones, Alexander Marine, and The Yacht Sales Co.

9.6 University research centers specialising in composites

This section highlights specialist research centres within universities that focus on composite materials and technologies. These centres, often co-funded through initiatives such as the Australian Research Council, advance the field through dedicated research clusters and collaborative projects.

New South Wales

UNIVERSITY OF NEW SOUTH WALES (UNSW)

- Automated Manufacture of Advanced Composites (AMAC)
- Centre for Advanced Materials Technology UNIVERSITY OF SYDNEY
- Centre for Advanced Materials Technology (CAMT) UNIVERSITY OF TECHNOLOGY SYDNEY (UTS)
- Advanced Manufacturing and Materials Research Program

UNIVERSITY OF WOLLONGONG

- Australian Institute for Innovative Materials (AIIM)
- Sustainable Buildings Research Centre (SBRC)

Victoria

DEAKIN UNIVERSITY

- Carbon Nexus
- Institute for Frontier Materials (IFM) RMIT UNIVERSITY
- Advanced Manufacturing Precinct (AMP) MONASH UNIVERSITY
- Materials Science and Engineering Department SWINBURNE UNIVERSITY OF TECHNOLOGY
- The Aerostructures Innovation Research (AIR) Hub
- Swinburne–CSIRO 4.0 Testlab

Queensland

UNIVERSITY OF QUEENSLAND (UQ)

- Centre for Advanced Materials Processing and Manufacturing (AMPAM)

GRIFFITH UNIVERSITY

- Advanced Design and Prototyping Technologies Institute (ADaPT)

QUEENSLAND UNIVERSITY OF TECHNOLOGY (QUT)

- Composites for Infrastructure

Western Australia

UNIVERSITY OF WESTERN AUSTRALIA (UWA)

- Engineering Materials Research Cluster
- Materials and Structures Innovation Group
- RiverLab Projects

CURTIN UNIVERSITY

- Materials and Structures Research Cluster
- Advanced Composite Materials and Structures

South Australia

UNIVERSITY OF SOUTH AUSTRALIA (UNISA)

- UniSA STEM (Science, Technology, Engineering & Mathematics)
- Future Industries Institute FLINDERS UNIVERSITY
- College of Science and Engineering

Tasmania

UNIVERSITY OF TASMANIA (UTAS)

- Australian Maritime College (AMC), focusing on marine composites

Australian Capital Territory

AUSTRALIAN NATIONAL UNIVERSITY (ANU)

- Research School of Physics – Nanocomposites UNIVERSITY OF CANBERRA
- Composites Lab

9.7 Pathways to Cert IV Eng. & Dip. Eng. – Advanced Trade

MISA recommends that the following qualifications be undertaken through a Training Contract associated with an Australian Apprenticeship or through a formal skills and knowledge recognition process:

MEM40119 Certificate IV in Engineering
MEM50119 Diploma of Engineering – Advanced Trade
The minimum requirements for the above qualifications can also be met by holders of one of the following qualifications or its equivalent, subject to meeting the additional requirements set out below:

- **MEM30219 Certificate III in Engineering** – Mechanical Trade
- **MEM31922 Certificate III in Engineering** – Fabrication Trade
- **MEM30719 Certificate III in Marine Craft Construction**
- **MEM30919 Certificate III in Boating Services**
- **MEM31119 Certificate III in Engineering** – Composites Trade
- **MEM31219 Certificate III in Engineering** – Industrial Electrician
- **MEM31322 Certificate III in Refrigeration and Air Conditioning**
- **MEM31419 Certificate III in Engineering** – Fixed and Mobile Plant Mechanic
- **MEM31719 Certificate III in Engineering** – Casting and Moulding Trade
- **MEM40119 Certificate IV in Engineering** – Requires holders of the above qualifications, or equivalent qualifications, to complete additional units of competency drawn from Specialisation units Group A to a minimum value of 12 points and Specialisation units from

Group B to bring the total value of additional units to at least 36 points (note that additional units are those units not included in the Certificate III qualification already held).

- **MEM31519 Certificate III in Engineering** – Toolmaking Trade

Note: The holder of the MEM31519 Certificate III in Engineering – Toolmaking Trade qualification is only required to complete additional units of competency drawn from Group A to a minimum value of 12 points and Specialisation units drawn from Group B to bring the total value of additional points to 24 points.

MEM50119 Diploma of Engineering - Advanced Trade – Requires holders to complete the core units of competency as specified for this Diploma as well as additional Specialisation units of competency drawn from Specialisation units Group A to a maximum value of 24 points and Specialisation units in Group B and Group C (maximum of 12 points from Group B) to bring the total value of additional units to at least 44 points (note that additional units are those units not included in the Certificate III qualification already held).

Note: The holder of the MEM31519 Certificate III in Engineering – Toolmaking Trade qualification is only required to complete the Core units of competency specified for this Diploma as well as additional Specialisation units of competency from Group A to the total value of 12 points and Specialisation units in Group B and Group C (maximum of 12 points from Group B, to bring the total value of additional units to 44 points.

In addition to the above, the minimum requirements for this qualification can also be met by holders of the **MEM40119 Certificate IV in Engineering** or equivalent, subject to the completion of the Core units of competency as specified above as well as additional Specialisation units drawn from Specialisation units Group A to bring the total value of additional units to at least 8 points. Where higher level Core units (i.e. those required beyond Certificate IV) were included in the Certificate IV as Specialisation units then additional Specialisation units from Group C to the same points value will also need to be completed.[58]

9.8 Standards for CNC

A growing trend is the integration of CNC machining and 3D printing into hybrid processes. This combines the strengths of both methods by using 3D printing for initial part creation and CNC machining for precise finishing. As both technologies evolve, their integration will likely drive further innovation in composite manufacturing.

In parallel with the growth of CNC machining and 3D printing, industry standards are developing to ensure that parts and processes meet quality, safety and performance expectations, particularly as 3D printing becomes more prevalent in critical industries such as aerospace, medical and transport. A notable example is the recent Australian adoption of ISO/ASTM 52924:2023, which outlines qualification principles for additive manufacturing of polymers.

Other standards include:

AS ISO 52900:2022
Additive Manufacturing – General Principles – Terminology.
This standard adopts the ISO 52900 standard and provides a set of terms and definitions used in additive manufacturing, covering the various processes and technologies involved.

[58] Advice from Chris Hudson, Industry Engagement Partner, MISA

AS ISO 52901:2020

Additive Manufacturing – General Principles – Requirements for Purchased AM Parts.

This standard specifies the requirements for parts produced by additive manufacturing and is intended for buyers and suppliers of 3D printed parts. It includes guidelines on ensuring part quality and conformance.

AS ISO 52921:2021

Additive Manufacturing – General Principles – Standardized Data Format for Additive Manufacturing Information.

This standard provides a framework for the data and information used in additive manufacturing. It helps in standardising the way information is communicated, ensuring compatibility between different systems.

AS 9100D

Quality Management Systems – Requirements for Aviation, Space and Defence Organisations.

Though not exclusively for additive manufacturing, AS 9100 is widely adopted by companies involved in aerospace-grade additive manufacturing. It provides quality management requirements, which include the quality standards applicable to 3D printed components used in aerospace and defence sectors.

ISO/ASTM

Standards Adopted in Australia:

Several standards developed jointly by ISO and ASTM have been adopted or followed in Australia to guide additive manufacturing processes, such as:

- **ISO/ASTM 52910** – Guidance on design for additive manufacturing.
- **ISO/ASTM 52915 –** Specification for data exchange in AM, specifically the AMF (Additive Manufacturing File) format.

For both VET and higher education, the challenge lies in incorporating newly developed standards into learning and assessment materials to ensure students are educated with an awareness of these standards as they are developed and released.

9.9 Advancements in composite repair: a legacy of Australian innovation

Australia has played a leading role in advancing composite repair technologies. Bonded patch repair technologies, initially pioneered by the Defence Science and Technology Group (DSTG), have been instrumental in extending the service life of military aircraft. The application of bonded composite patches to address fatigue and stress corrosion cracking in metallic structures has kept Australian Air Force aircraft operational for extended periods, saving millions of dollars in maintenance costs. These innovations have also been exported globally, showcasing Australia's expertise in composite repair.

In civil applications, composite repairs are equally important. From pipelines to recreational vehicles, composites are increasingly used to extend the life of assets while maintaining structural integrity. A prominent example is the West Gate Bridge reinforcement project in Melbourne– one of the largest carbon fibre reinforcement undertakings in the world–where over 20 tonnes of carbon fibre were used to strengthen the 336-metre bridge. Through these innovations, Australia demonstrates its capability to lead in the repair and sustainment of critical assets, ensuring reliability and cost-efficiency across industrial sectors.

Published works on repair of composites structures

Engineered Repairs of Composite Structures[59] is written by Rikard Benton Heslehurst and published in 2019. It explores repair design for advanced composite structures. The book covers damage identification, its effects on structural integrity and the development of repair schemes to restore integrity and damage tolerance.

Rik, currently the Structural Integrity Manager and Mechanical Instructor Engineer at Boeing Aircraft Canberra, highlighted a gap in skills related to conducting analyses and achieving accurate repair designs during our interview.

Initiative: develop and introduce short courses focused on composite repair, addressing the identified gaps in analysis and design processes

Marine Repair

Composite materials are a staple technology used in marine repair, providing durable and corrosion-resistant solutions for restoring and enhancing the performance of vessels and structures in demanding maritime environments. As a nation surrounded by sea, Australia hosts numerous marine repair facilities along its coastal regions.

The Australian Marine Complex (AMC) in Henderson, Western Australia, is an extensive industrial precinct supporting shipbuilding and marine services. Established in 2003, it spans approximately 400,000 square meters and is located south of Perth's central business district. Recognised as one of Australia's two primary naval shipbuilding hubs, the AMC houses essential services required by the marine, defence, energy and resources industries.

The AMC's **Marine Support Facility**, operated by BAE Systems, has significant capacity for vessel repair and refit of naval vessels, commercial ships, recreational boats and specialised vessels such as research ships, tugs and pilot boats. Each of these vessel types often requires unique repair solutions tailored to their operational needs.

South Metropolitan TAFE (WA)

South Metropolitan TAFE (SM TAFE) Naval Base Campus offers comprehensive training in marine repair through its **Certificate III in Marine Craft Construction**, equipping students to work in the marine sector. Notably, SM TAFE has provided contracted training for Australian submarine maintenance, leveraging its expertise in advanced composite repair techniques.

[59] https://www.amazon.com.au/Engineered-Repairs-Composite-Structures-Heslehurst/dp/1498726267

9.9.1 Standards for Repairs

The application of composite repairs is extensive and the benefits are many. Some industries have established standards to guide the design and application of composite repairs, ensuring consistent quality and performance. These include:

ISO 24817:

This international standard provides requirements and guidelines for the qualification and application of composite repairs for pressure equipment and pipelines, ensuring safe and reliable operations.

ASME PCC-2:

Published by the American Society of Mechanical Engineers, this standard outlines methods for repairing pressure equipment and piping systems, including a detailed section on composite repair methods and materials.

DNV-RP-C301:

Developed by DNV, this recommended practice focuses on structural assessment and the use of composite materials in repairs, offering comprehensive guidelines for offshore and maritime applications.

New standards are likely to be integrated into the regulatory frameworks of the Defence Aviation Safety Authority (DASA) and the Civil Aviation Safety Authority (CASA).

At the VET level, qualifications include units specifically focused on the repair of composite materials.

The **MEM31119 Certificate III in Engineering** – Composites Trade features units dedicated to composite repair. A key unit, **MEM26015 – Select and apply repair techniques**, focuses exclusively on this area.

The PMB50121 Diploma of Polymer Technology incorporates units addressing composite material repair. A standout unit, PMBTECH405E – Repair damaged fibre-composites structures, provides training in repairing cosmetic and structural damage to composite products.

The MEM30719 Certificate III in Marine Craft Construction covers both construction and repair of marine vessels, with the elective unit **MEM25008 – Repair marine vessel surfaces and structures** focusing on methods to address cosmetic and structural damage.

The **MEA41322 Certificate IV in Aeroskills (Structures)** is designed for individuals specialising in the repair and modification of aircraft structures. It is particularly relevant for employees in Civil Aviation Maintenance Organisations (AMOs) and members of the Australian Defence Force (ADF). It is a requirement for individuals working in organisations governed by the regulatory frameworks of the DASA and CASA.

- Aviation Australia, BAE Systems, the Department of Defence, the Sigma Aerospace College, TAFE NSW and Aerospace Training Services are among the RTO's that have **MEA41322** on their scope.

Documentation Page

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Abstract: Australia's composite manufacturing industry has evolved through innovation, research, and entrepreneurial drive, creating a unique sector of specialised SMEs serving diverse markets. This scoping study explores education and training challenges in this rapidly advancing field, highlighting the need to align workforce development with emerging technologies like automation and robotics. Through industry interviews, surveys, and policy analysis, the study reveals strong confidence in local production, increasing investment in skills, and growing demand for trained professionals. It proposes strategic initiatives to bridge training gaps, strengthen academic-industry collaboration, build future talent pipelines, and champion diversity, ensuring the industry remains globally competitive and locally sustainable.	
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