ADVANCED MANUFACTURING GROWTH CENTRE

PREFAB INNOVATION HUB: FEASIBILITY STUDY

SUBMISSION TO THE DEPARTMENT OF INDUSTRY, SCIENCE, ENERGY AND RESOURCES

AMGC
ADVANCED MANUFACTURING GROWTH CENTRE LTD

Foreword

The building and construction industry is centuries old. However, the success factors that helped create the building and construction businesses of today will not necessarily help future-proof those businesses for tomorrow. What we can be sure of is that prefabricated manufacturing methods will become more prevalent, because they offer better construction solutions for all Australians.

In this report, the Prefab Innovation Hub Steering Committee examines the viability of a collaborative Innovation Hub for the prefabricated building industry. The Steering Committee has concluded that the Prefab Innovation Hub is feasible, and strongly recommends establishing it to address the findings and requirements identified in the feasibility study.

We believe a Prefab Innovation Hub will enable Australian companies to take steps towards adopting all the benefits of prefab construction methods. As you will read in the opening pages, prefab construction offers five core benefits: speed, safety, sustainability, quality and productivity.

The 2019/20 bushfire season destroyed thousands of homes and buildings, and the rebuilding process will take several years. The Steering Committee and AMGC acknowledges the recent bushfire situation and believe that the application of prefabricated construction methods to assist in disaster relief and recovery, such as bushfires, cyclones and tsunami, as well as international aid relief, provides further evidence of the need to promote and grow the prefabricated building industry.

Prefab homes and buildings can be established in remote towns and communities more quickly than those built using traditional construction processes. The arrival of Industry 4.0 technologies enables more customised designs. New materials appeal to a wider range of customer preferences, offering basic and practical options as well as high-value solutions.

The Australian prefabrication market has several success stories – companies that have excelled because they pushed forward with a mix of relentless innovation, collaboration and knowledge of the factors that make them competitive. In their own ways, they exemplify the potential outcomes of the proposed Prefab Innovation Hub. The objectives include:

- **Increasing collaboration** and engagement between industry and research, to improve the global competitiveness of Australian prefabrication manufacturers, increase exports, encourage growth and create more jobs
- **Supporting new technologies** and innovations that enable the building and construction industry to provide smarter, more affordable and more sustainable solutions for Australians
- **Growing the manufactured buildings ecosystem** to help businesses in the industry incorporate advanced technologies and processes.

We trust you will find that the recommendations in this report provide a pathway to a Prefab Innovation Hub that is highly feasible, realises significant industry potential and offers all Australians the benefits of prefabricated construction methods.

Paul Cooper
Chairman
Advanced Manufacturing Growth Centre Ltd

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OzWall
Palmer Group
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Portable Buildings by Design
Porter Davis Homes
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XLam

Prefab: Helping Australia's construction industry

Diagram 1: The benefits of prefab: Helping Australia's construction industry

Speed

- Faster construction times
- Faster occupancy
- More predictable delivery
- Reduced defects and rework

Safety

- Fewer safety incidents
- Less heavy machinery
- Improved work environments
- Less work at heights

Sustainability

- Improved thermal efficiencies
- Improved whole-of-life performance
- Reduced noise and traffic congestion
- Reduced CO_2 emissions and less waste to landfill

Quality

- Reduced defects and rework
- Quality-controlled factory environments
- Weather-protected work environments
- Opportunity to create a more diverse and highly skilled workforce

Productivity

- Lower costs
- Less labour on site
- Advanced processes, technologies and systems
- Reduced financing through faster occupancy

Introduction

Prefabricated (prefab) construction methods, systems and technologies have progressed in Australia to a point where their application in the built environment can now be found throughout our cities and suburban streets, and across our rural and regional landscapes.

Prefab and its associated advanced manufacturing processes are quietly changing the face of building and construction, and helping to unlock a range of benefits and new efficiencies.

Prefab is now an accepted part of the design and construction of a whole range of buildings including but not limited to: schools; railway and police stations; childcare, community and healthcare centres; hospitals; hotels; aged care villages; correctional, sporting and student-accommodation facilities; high-rise apartment buildings;and residential houses and holiday homes.

Most Australians would be unaware that many of these buildings, or significant components of them, have been manufactured off site, as part of an evolving construction industry supply chain.

"The adoption of prefab has helped Australia's construction industry to create high-quality, energy-efficient and aesthetically pleasing buildings, delivered in demonstrably faster, safer, and more productive and environmentally sustainable ways, at increasingly lower costs."
Industry participant, AMGC workshop

Despite its merits and obvious momentum, prefab is estimated to account for less than 5% of Australia's $150 billion building and construction industry. Prefab has a much larger market share in countries such as Sweden (84%), The Netherlands (20%) and Japan (15%).[1,2]

The UK and Singaporean governments are investing significantly in prefab programs to meet current and future housing and infrastructure demands. Meanwhile, in the US, major investors are funding the growth of prefab by investing in start-ups like Katerra, a prefab technology company with a growing number of domestic and international office, factory and building projects. Founded in 2015, Katerra is now valued at between US$3 billion and US$4 billion.

"Australia's largest cities are facing a watershed moment in their growth and development. In the coming 30 years, the size of the Australian population will grow substantially. Between 2017 and 2046, Australia's population is projected to increase by 11.8 million people. That's equivalent to adding a new city, roughly the size of Canberra, each year for the next 30 years."[3]

Projected population growth, an ageing workforce and skilled labour shortages provide Australia with an unprecedented and critical opportunity to address our future housing, commercial building and infrastructure needs, by more widely adopting prefab construction.

"To scale prefab and modular construction, collaboration will be key. It's a case of disrupt or be disrupted."
Industry participant, AMGC workshop

Prefab construction's value proposition has changed radically as digital tools have matured. Automated design, building information modelling (BIM), advanced manufacturing processes and just-in-time delivery are just some of the developments that have changed the prefab industry. Increased adoption of digital tools, along with design for manufacture and assembly (DfMA) principles, will further enhance prefab's value proposition.

As with any new and potentially disruptive technology, prefab faces headwinds and barriers to growth. For example, the industry is still dealing with perception issues based on historical misconceptions about prefab.

Substantial progress has been made in overcoming some of these challenges, but significant regulatory, financial and procurement-process hurdles remain. More needs to be done to address these hurdles if Australia is to have a prosperous and globally competitive prefab industry.

1 http://www.globalconstructionreview.com/trends/why-sweden-beats-world
2 The overseas shares reflect prefab 'housing' markets only
3 Infrastructure Australia, **Future Cities: Planning for our growing population**, 2018

The Prefab Innovation Hub

Initiated by the Minister for Industry, Science and Technology, The Hon. Karen Andrews, this study seeks to assess the feasibility of establishing a Prefab Innovation Hub (Hub). The Hub would support the development and growth of prefab in Australia, creating a platform for a globally competitive industry and thousands of new jobs.

“The Hub must be a unifying force that helps create greater cohesion throughout the supply chain, stimulating growth, new jobs and more vibrant and productive manufacturing, building and construction industries.”
Industry participant, AMGC workshop

The Hub aims to:

- Increase collaboration and engagement between industry and research, to grow the global competitiveness of Australian manufacturers, increase exports, encourage growth and create jobs
- Support new technologies and innovations enabling the transformation of the industry to provide smarter, more affordable and more sustainable construction solutions for Australians
- Grow the manufactured buildings ecosystem to improve business capability to incorporate advanced technologies and processes within industry. [Recommendation 9]

The feasibility study draws on nationwide input from a broad cross-section of stakeholders directly and indirectly linked to the prefab industry and the broader building and construction supply chain.

The consultation process included five AMGC-sponsored workshops around Australia (involving 90 participants), dozens of individual consultations with key industry stakeholders, and an extensive review of local and overseas literature.

The study includes a series of brief case studies highlighting the success stories of Australian businesses large and small. These case studies help demonstrate what is possible in the prefab industry today. They also reveal the potential of a prefab as a value-adding complement to traditional construction.

A Steering Committee, comprising representatives from the prefab industry, the broader construction industry and academia, has overseen the development of the study and endorsed its recommendations and findings.

The Prefab Innovation Hub will establish a network of Innovation Labs to connect stakeholder groups throughout the building and construction supply chain. It will help showcase prefab; educate and inform participants about the benefits of prefab and how to optimise them; and inspire new partnerships and connections that stimulate research and development (R&D) and jobs growth through six key prefab growth drivers.

Diagram 2: Prefab Innovation Hub network

Key recommendations

Recommendations for government

1. **Approve $1.5 million of funding to establish the Prefab Innovation Hub** for an initial two-year period (July 2020 to June 2022).

   This amount is considered the minimum funding to enable a viable Hub of the national scale and prefab growth-driver focus proposed, and acknowledges the initial investment of up to $500k for the conduct of this feasibility study and the associated detailed project and implementation planning that will be undertaken with university and industry stakeholders in the lead-up to the Hub's launch in July 2020.

2. **Approve an Advisory Board, comprising representatives from the prefab manufacturing supply chain and the broader building and construction supply chain**, to help guide and support the delivery of the Hub's program and to monitor the execution and outcomes of its activities.

3. **Authorise AMGC to administer the operations of the Hub.** This includes resourcing stakeholder, project and event management activities, and providing related marketing and promotional support. As a first step, AMGC should develop a project plan and associated budget to ensure the timely and effective delivery of the study's key recommendations and findings.

Recommendations for industry

4. **Leverage Hub foundation funding through** matched industry contributions (cash and/or in-kind), especially with respect to the use of university resources and facilities ($1 million), and industry sponsorship of key Hub activities and events ($200,000).

5. **Aim to develop an industry-led, self-sustaining and collaborative future business model** by the end of the two-year funding period, in line with industry interest and value realised.

Recommendations for the Prefab Innovation Hub

6. **Form the Hub around a coordinated national network of Innovation Labs**, harnessing existing infrastructure and facilities, expertise and industry networks (including relevant industry associations, professional bodies, universities and government agencies).

7. **Deliver a national program of coordinated activities focused on six prefab growth drivers.** These include Smart Prefab and Industry 4.0, Design for Manufacture and Assembly, Better Buildings and Bottom Lines, Prefab Procurement Pathways, Prefab Funding and Financing, and Navigating Regulations with Prefab.

   Individual Innovation Labs will host local prefab and advanced manufacturing R&D updates, and, where local demand exists, forums on prefab skills and training. Annual supply chain roundtables will validate Hub outcomes and identify future priorities.

8. **Adopt three core operating principles of 'showcase', 'educate and inform', and 'inspire and stimulate'** across the Hub's network of Innovation Labs, and demonstrate these principles via a national program targeted activities focused on prefab growth drivers.

9. **Use the Hub and its network of Innovation Labs as a program delivery platform** to help (i) increase collaboration and engagement between industry and research, to improve the global competitiveness of Australian manufacturers, increase exports, encourage growth and create jobs; (ii) support new technologies and innovations enabling the transformation of the industry to provide smarter, more affordable and more sustainable construction solutions for Australians; and (iii) grow the manufactured buildings ecosystem to improve business capability to incorporate advanced technologies and processes within industry.

10. **Maintain relevance to all recognised prefab methods, systems and technologies, and all prefab manufacturing businesses, small, medium and large**, while generating sustained interest and buy-in from key stakeholder groups throughout the broader supply chain.

The application of prefab to bushfires, natural disasters and international aid relief

The devastating 2019/20 bushfire season has highlighted the critical role that prefab construction can play in the post-disaster rebuilding process, as well as enabling improved building performance during ember attacks and bushfires.

The key benefits of prefab construction are widely accepted. Speed, safety, reliability, ease of decommissioning and reusability are key features that can contribute to the rebuilding process following bushfires, cyclones and tsunami, as well as international aid programmes.

Response time is critical for communities affected by disasters, and prefab construction can provide timely short-term, and potentially long-term, solutions. Prefab construction has the proven potential to reduce the time required to deliver housing solutions, business premises, and community infrastructure.

A variety of prefab solutions can be utilised to support the bushfire rebuilding process, including temporary shelters and permanent buildings. Temporary shelters may be provided within a matter of days as immediate disaster relief. In this scenario, the flexible nature of prefab construction allows for additional modules to be easily added over time, or decommissioned, as required.

Supported by advanced manufacturing processes, prefabricated construction can enable better building performance against bushfires via R&D, product design, and utilising the latest fire-resistant and fire-retardant materials. Prefab buildings can achieve the highest fire safety ratings (Bushfire Attack Level – Flame Zone).

The following AMGC project is an example of how advanced manufacturing techniques can be used in the construction industry to eliminate gaps in buildings and combat an ember attack during a bushfire. This technology will be commercialised via global value chain partners.

Corrugated Metal Sheet Bending

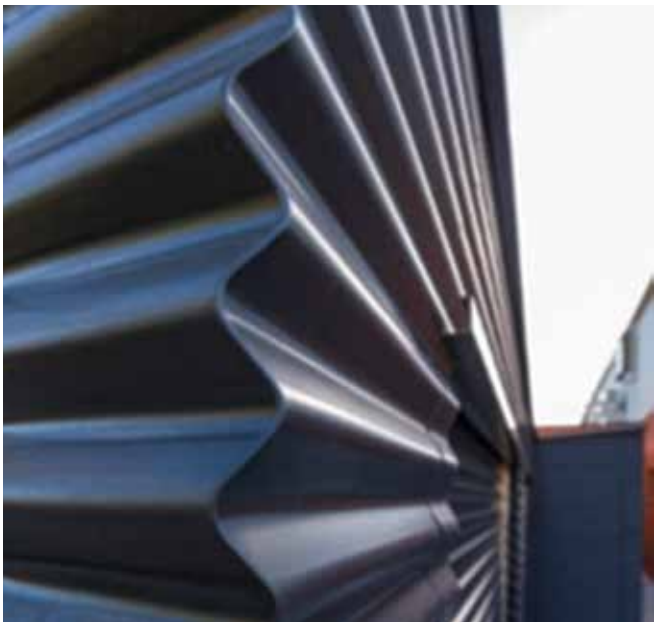
FormFlow in collaboration with its project partners has developed a patented process for bending corrugated metal sheets which and has the potential to realise new market opportunities in the $1 bn per annum global sheet metal market.

The process overcomes deficiencies in corrugated sheet metal roofing constructions and delivers the following advantages: elimination of gaps that facilitate ember attack during bushfires; elimination of gaps where moisture can enter during severe tropical storms; Improved insulation by elimination of gaps and drafts.

AMGC PROJECT IMPACT:

- Estimated $20–30 million per year (medium term) by taking a 2–3% stake in the global sheet metal roofing industry
- Five to 10 skilled jobs at FormFlow, including research engineers, and 50 new jobs across domestic project partners and prospective future partners
- Introduction of a world's-first patented technology

More information here: **https://www.amgc.org.au/project/corrugated-metal-sheet-bending/**



FormFlow

Hub form and function

Hub form

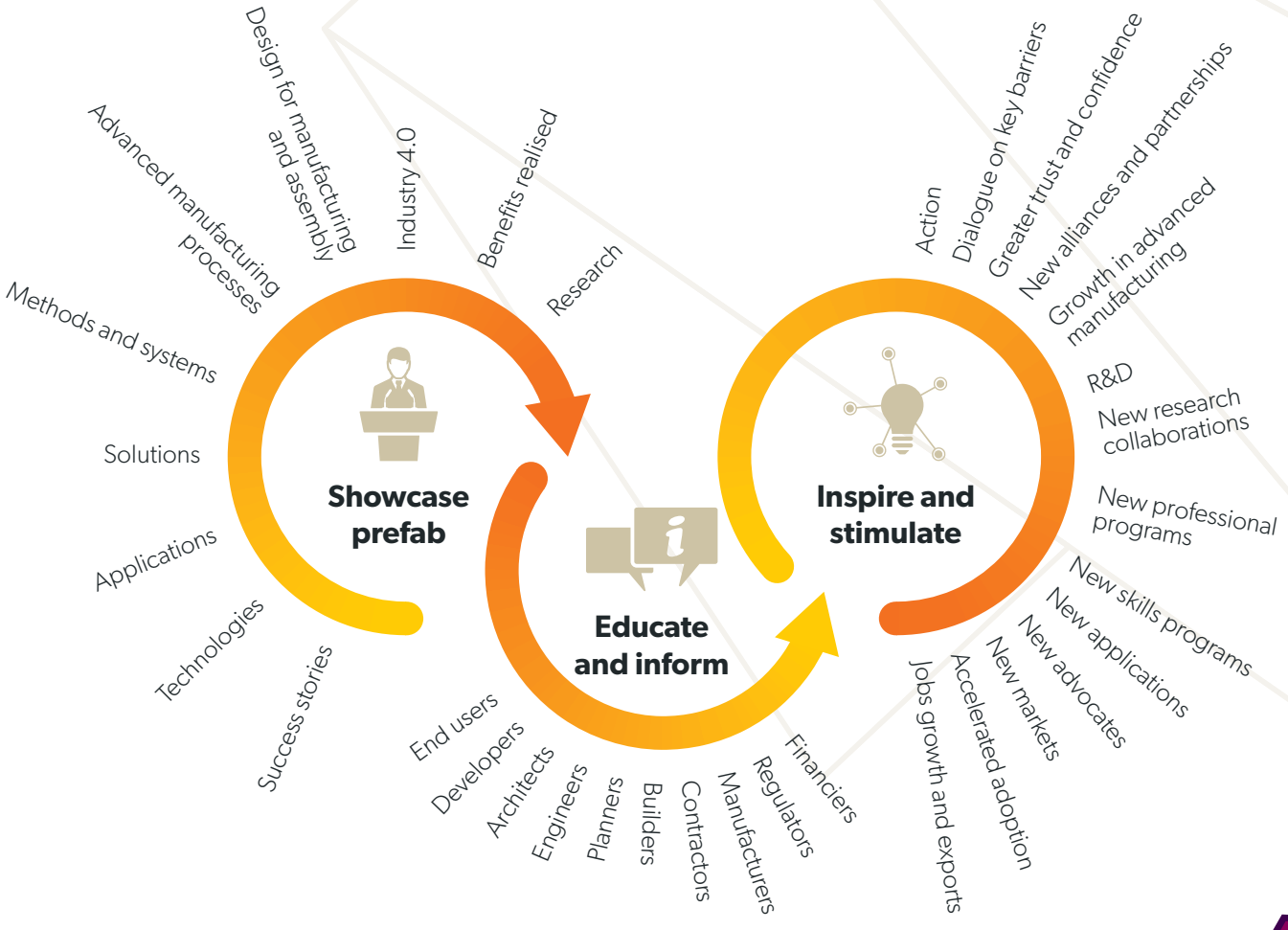
The core aims of the Hub will best be achieved through a network of nationally coordinated and linked Innovation Labs, harnessing existing infrastructure and facilities, expertise and industry networks (including relevant industry associations, professional bodies, universities and government agencies). [Recommendation 6.]

The Hub will be governed by a voluntary Advisory Board made up of representatives from the prefab manufacturing supply chain and the broader building and construction supply chain. The Advisory Board will help guide and support Hub program planning and monitor the execution and outcomes of its activities. [Recommendation 2]

AMGC will administer the operations of the Hub. This includes resourcing stakeholder, project and event management activities, and providing related marketing, promotional and knowledge sharing support. A dedicated Program Director will lead the Hub, coordinating activities across the network and ensuring strong connections between individual Innovation Labs. As a first step, AMGC should develop a detailed project plan and associated budget to ensure timely and effective delivery of the study's key recommendations. [Recommendation 3]

> **"The maturity of the Hub should be measured by the extent to which connections transform into real, collaborative structures where people work across disciplines, sectors and institutions to create new growth opportunities."**
> Industry participant, AMGC workshop

Diagram 3: Hub operating principles



Target stakeholders for Hub activities will include manufacturers; end users (public, private, residential and commercial); developers; architects and designers; engineers and planners; builders and contractors; building surveyors and certifiers; and banking and finance representatives.

Operating principles

The Hub will adopt three core operating principles – 'showcase', 'educate and inform' and 'inspire and stimulate' – across its network of Innovation Labs, reinforced by peer-to-peer industry engagement and leadership. [Recommendation 8]

- **Showcase prefab**

  The Hub will showcase prefab and associated advanced manufacturing success stories, benefits, applications, methods, systems, technologies and research to targeted audiences throughout the manufacturing, building and construction supply chain.

- **Educate and inform**

  The Hub will educate and inform targeted supply chain groups about the key mechanisms to optimise the benefits of prefab, in its various forms. The Hub will improve understanding and awareness of existing barriers and hurdles to growth, with a view to identifying, exploring and actioning potential solutions. The Hub will prioritise regulatory, financial and procurement barriers.

- **Inspire and stimulate**

  The Hub will inspire and stimulate demonstrable action and greater cohesion throughout the supply chain, in the form of new alliances, partnerships and collaborations; new skill development pathways and professional programs; new markets and applications; and an accelerated adoption of advanced manufacturing processes.

Collectively, the Hub will maintain relevance to all recognised prefab methods, systems and technologies, and all prefab manufacturing businesses, small, medium and large, while generating sustained interest and buy-in from the key stakeholder groups throughout the broader building and construction supply chain. [Recommendation 10]

The Hub will deliver these operating principles via a program of activities focused on prefab growth drivers.

Activities and prefab growth-driver

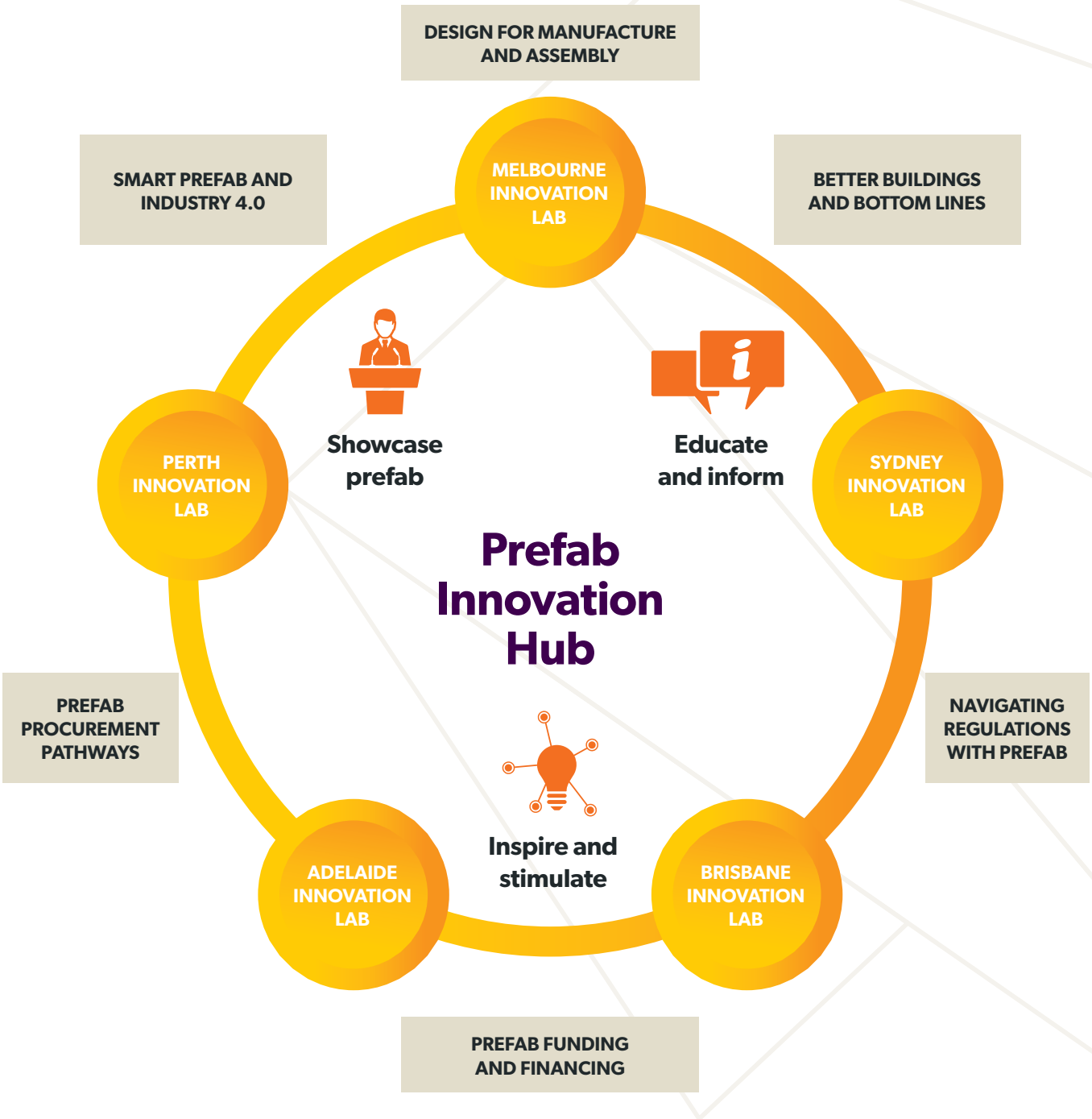
Each Innovation Lab will be expected to function in line with a national program of coordinated activities focused on six prefab growth drivers. All activities will be tailored to the local prefab market, taking into account factors such as maturity, relevant growth drivers and supply chain stakeholder interest (Diagram 4). [Recommendation 7]

Innovation Labs will also have the opportunity to further customise programs based on their local research capabilities, and the skill and training solutions of special interest to stakeholders. Some Labs may need to provide support to satellite and regional sites where demand and interest are strong.

> The Hub will form a central knowledge base for the prefab industry – capturing, consolidating and promoting relevant research and educational programs across university and industry networks.

The Prefab Innovation Hub will establish a network of Innovation Labs to connect stakeholder groups throughout the building and construction supply chain. It will showcase prefab, educate and inform participants about the benefits of prefab and how to optimise them, and inspire new partnerships and connections that stimulate R&D and jobs growth through six key prefab growth-drivers.

Diagram 4: The Prefab Innovation Hub network and growth drivers



Growth driver 1: Smart Prefab and Industry 4.0

The future of Australia's building and construction industry will be heavily influenced by industrialisation, digitalisation and globalisation. The industry is ripe for disruption and Australian construction must secure a first-mover advantage to ensure it can compete with emerging international competitors.[4]

Prefab provides a platform for the construction industry to embrace a range of advanced manufacturing capabilities and characteristics beyond the wider adoption of Building Information Modelling (BIM). These include automation and digitalisation, robotics, artificial intelligence, augmented and virtual reality, the Internet of Things and blockchain.

"There are two stages involved in the transition to off-site manufacturing. The first is simply moving construction off site and into a facility, even though tasks are still carried out by hand. This will result in significant productivity benefits. However, companies can achieve another step change in productivity by introducing robotics and other automation technologies into the manufacturing process." [5]

"The Hub will enable manufacturers and their industry-based engineers and designers to apply advanced manufacturing characteristics to the production of prefab and modular buildings, including the application of advanced knowledge, advanced processes, and advanced business models.

Key outcomes associated with this stream of activity will include:

- Increased collaboration between industry and research
- Increased prefab innovation and R&D
- Improved business capability to incorporate advanced technologies and processes
- Improved business capabilities to transition to more advanced knowledge systems, manufacturing processes and business models in prefab manufacturing
- Increased adoption of state-of-the-art technologies and digitalisation by prefab manufacturers
- Increased recognition of the concept of value, and new roles outside production
- Industry access to Industry 4.0 skills, training and professional courses
- Pathways to new smart prefab and Industry 4.0 training and professional programs
- Integration with, and use of, the Building 4.0 CRC[6]
- New jobs.

4 **Building 4.0 CRC Prospectus**, 2019
5 McKinsey & Company, **Modular construction: From Projects to Products**, 2019
6 This is subject to the bid being successful

Growth driver 2: Design for Manufacture and Assembly (DfMA)

DfMA uses a wide range of tools and technologies to make manufacturing easier and assembly more efficient. The underlying goal is to use design processes that help facilitate a collaborative approach along the whole value chain, embracing design teams, clients, contractors and off-site manufacturers.

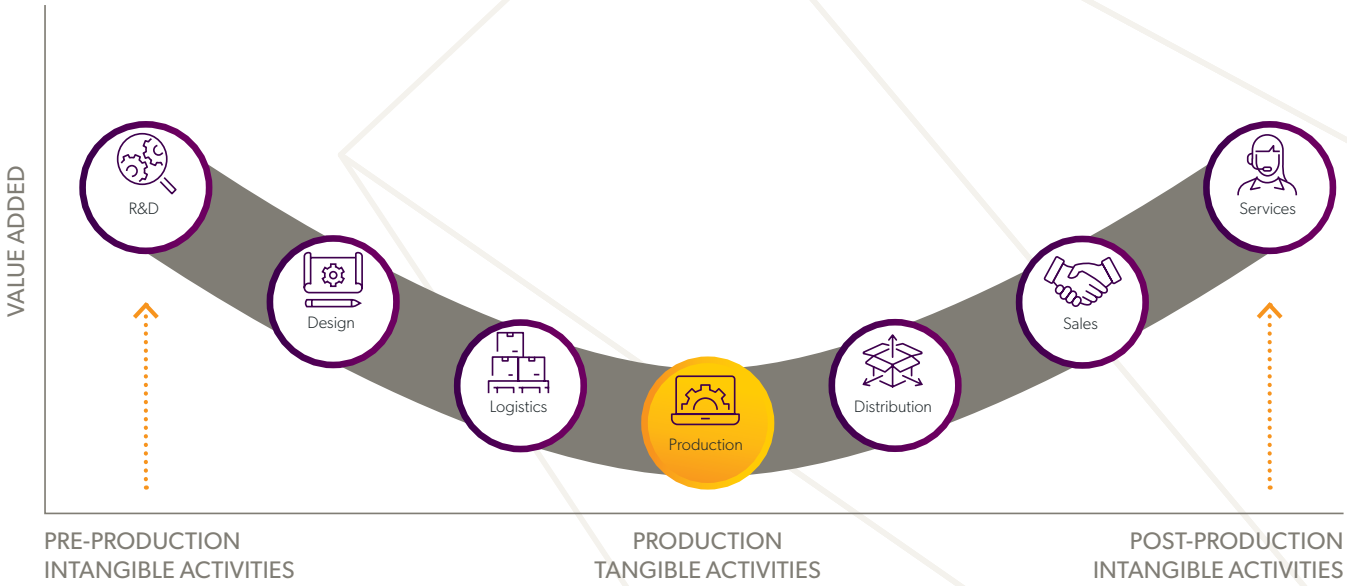
Prefab projects tend to take longer to design than traditional projects, as the construction industry learns to align to the manufacturing process. Design decisions need to be made upfront, as changes later in the process are more costly and more difficult.

AMGC research highlights design and R&D as high-value activities in the manufacturing process. Prefab is naturally aligned to the AMGC smiley curve (Diagram 5), which illustrates how value creation in manufacturing has shifted over the decades. The same shift in value creation can be seen in the construction industry.

“The industry is not used to working in this way, and historically there tends to be a lack of supply chain cohesion in this regard. I’d say with DfMA, you spend around 30% more time in initial planning and you gain 40% to 50% in productivity.”

Industry participant, AMGC workshop

Diagram 5: High-value pre-production activities such as R&D, design and logistics are well aligned to the prefab industry



A holistic approach using DfMA is emerging in Australia, facilitated by the availability of high-performance, low-cost computer hardware and software. This has enabled project stakeholders to efficiently implement and interrogate the virtual reality models required by DfMA.

“Words traditionally associated with the prefab industry like ‘low value’, ‘unsophisticated’, and ‘demountable’ are being replaced with ‘architecturally led’, ‘customisable’ and ‘high quality’.”
Industry participant, AMGC workshop

“The Hub must create a far greater understanding of the fundamentals of DfMA, and the tools and technologies that support it. Critically, it must demonstrate to all stakeholder groups that early collaborative engagement of architects, designers and engineers in the development planning process is necessary to optimise the quality, cost and time benefits of prefab.

Key outcomes associated with this stream of activity will include:

- Growth of the manufactured building ecosystem and greater supply chain cohesion
- Increased number of collaborative DfMA exemplars
- Increased application of DfMA principles and associated technologies by Australian prefab manufacturers and their partners
- Increased adoption of prefab by developers, builders and government procurement agencies
- Increase in architects considering prefab as an option
- Industry access to computational architecture and associated DfMA training programs and professional courses
- Pathways to new DfMA training programs and professional courses.

Growth driver 3: Better Buildings and Bottom Lines

The adoption of prefab has helped Australia's construction industry create high-quality, energy-efficient and aesthetically pleasing buildings, delivered in demonstrably faster, safer, and more productive and environmentally sustainable ways, at increasingly lower costs.

Unfortunately, there remains a lack of confidence in the stated benefits among many in the building and construction supply chain.

Capturing the full cost and productivity benefits of prefab and modular construction is not straightforward. It involves carefully optimising the choice of materials; choosing between 2D panels, 3D modules and hybrid designs; and overcoming design, manufacturing, technology, logistics and assembly challenges.

"Let's work with industry and stakeholders to understand the hurdles and objections – and use scientific evidence to resolve these issues."
Industry participant, AMGC workshop

"The Hub must seek to actively demonstrate evidence-based cost, time and safety benefits achieved in the Australian context, and educate and inform how these benefits can be optimised across a range of Australian building applications and prefab solutions.

Key outcomes associated with this stream of activity will include:

- Increased collaboration and engagement between industry and research
- Smarter, more affordable and more sustainable construction solutions
- New research programs aimed at expanding the evidence base of quantifiable benefits
- New research to capture the prefab industry's baseline scale, scope and share of the broader building and construction market
- Increased adoption of prefab by developers, builders and government procurement agencies, leading to substantial job creation
- Industry access to prefab-related skills, training and professional courses across the supply chain
- Pathways to new training and professional programs across the supply chain that will equip people with the skills to optimise the benefits of prefab
- Integration with, and use of, the Building 4.0 CRC.

Growth driver 4: Prefab Procurement Pathways

More collaboration and investment is needed to establish resilient prefab supply chains. However, for this to happen, manufacturers need greater certainty about the demand for prefab products and developers need to be sure they have access to a range of suppliers.

With a few notable exceptions, most states and territories have given little consideration to prefab in their procurement and tendering processes for government buildings and construction.

The Victorian Government's Permanent Modular School Building Program[7] was set up as a pilot to provide a structured and supervised way to test current and new Victorian School Building Authority (VSBA) providers. The pilot aimed to give participants the opportunity to increase their knowledge of prefab permanent buildings.

The Hub Advisory Board can play an important advocacy role to encourage state governments to increase the use of prefab in public construction projects and contracts.

"The objectives of this pilot program included introducing to VSBA some contractors who are expert in the production of high-quality and architecturally pleasing prefabricated buildings."[8]

Other objectives of the pilot included ensuring mass production capacity was available when required to deliver architecturally designed buildings; ensuring capability to address one-off and nonstandard requirements where bespoke designs may be warranted; and promoting local jobs and local content.

"As with most clients, governments need to start thinking about and implementing off-site into their planning and business cases early on. Too often off-site is looked at as a last resort, the knight in shining armour, to come and save the day. This puts unnecessary pressure on off-site construction and it has the opportunity to negatively impact its perception further."[9]

States such as South Australia and New South Wales have announced modular programs for the delivery of government education infrastructure, similar to that of the VSBA.

"The Hub must connect with government agencies around Australia to showcase the benefits of prefab, the diverse range of applications available, and the specific enabling procurement programs that have already been established and their associated key lessons learned.

Key outcomes associated with this stream of activity will include:

- Growth of the manufactured building ecosystem
- Increased consideration of prefab as a low-risk and cost-effective option by government agencies
- Increased number of prefab-specific government procurement programs, leading to substantial jobs growth
- Increased value of prefab contracts nationally, and in all States
- Increased diversity of prefab building applications sought by government agencies
- Pathways to scale through a variety of affordable housing programs around Australia
- An education program for government procurement officers.

7 See the state government procurement case study on page 29
8 http://builtoffsite.com.au/issue-15/from-policy-to-program/
9 Ibid

Growth driver 5: Prefab Funding and Financing

Australian financial institutions have been reluctant to offer traditional mortgage products to aspiring prefab home owners, largely because of the complex issues around security while the house is being built in a factory.

"Many of our prospective clients simply can't secure mortgage finance."
Industry participant, AMGC workshop

Financing of prefab houses is further complicated by the fact that prefab necessarily straddles the manufacturing and housing industries. Financing for traditional house builds relies on the gradual release of funds as milestones are reached, such as the pouring of a concrete slab, the erection of the frame and full completion. In contrast, the only on-site work in prefab construction is installation which means the builder or manufacturer needs funding upfront. Adding to the complexity is the variation in state building laws with respect to maximum deposits and the scope and nature of progress payments.

Westpac NZ was the first bank in the region to launch a dedicated mortgage product aimed at helping people secure prefab homes. Its Prebuilt product was introduced in 2019, following a successful nine-month pilot.

"For the first time, we're offering a simple and streamlined process for prefab buyers and builders. Our new way of funding essentially means we have security before the house is delivered, which removes much of the uncertainty for buyers and builders partnering on a build." [10]

"The Hub must facilitate a series of roundtable discussions with the Australian banking and finance sector to educate and inform lenders about contemporary prefab and to develop pathways to financing solutions such as the one developed by Westpac NZ.

Key outcomes associated with this stream of activity will include:

- Increased awareness and understanding of prefab in the banking and finance sector
- Prefab mortgage product pilot programs
- New mortgage product offerings
- Pathways to solutions around completion risk and the traditional progress payments schedule in the context of prefab
- Pathways to an industry-wide prefab education program for lenders
- Greater confidence among those looking to invest in prefab manufacturing equipment and facilities.

10 https://www.westpac.co.nz/rednews/property/westpac-offers-prefab-choices-in-new-zealand-first-scheme/

Growth driver 6: Navigating Regulations with Prefab

All building work in Australia must comply with the Building Code of Australia (BCA), which is contained in the National Construction Code (NCC). The BCA sets out the minimum safety, health, amenity and sustainability requirements that must be met when designing and constructing new buildings.

A frustration for many prefab manufacturers is that these codes have been developed with the traditional construction industry in mind and as a result they do not always address the nature and circumstances of off-site construction.

This is true of building approvals and certification processes. The situation is complicated further by policy and procedural variations among the states and local government jurisdictions.

There is also the broader issue of material standards and the lack of standards for modular systems.

At a policy level, the Hub must work with relevant regulatory agencies to resolve any critical prefab-related matters relating to NCC compliance and modular system standards. At an operational level, the Hub must collaborate with building surveyors and local and state government representatives to explore the regulatory challenges associated with prefab and the extent to which they may be addressed through an education and information program.

Key outcomes associated with this stream of activity will include:

- A pathway to resolving any critical prefab-related NCC compliance and building standards matters through state and national building approval frameworks
- Pathways to a broad-based prefab education program for building surveyors and certifiers
- Increased awareness and understanding of prefab throughout the Australian building surveyor and certifier community.

Prefab Innovation Hub network of Innovation Labs

Innovation Labs

Each Innovation Lab in the network will be selected based on its capacity to showcase prefab and advanced manufacturing technologies; its ability to host regular events, forums and roundtable discussions for targeted audiences throughout the manufacturing, building and construction supply chain; and its willingness to provide cash and/or in-kind co-contributions to support the Hub's development and success.

This section briefly describes the Innovation Lab candidates. Each Lab in the network will have nominated leads to help coordinate local events and industry workshops in line with the Hub's national program and to drive interest from local stakeholder groups. Joint industry and academic Lab leaders will be advantageous.

Labs will, where feasible and appropriate, draw on a broader local and regional network to help strengthen the ecosystem and optimise stakeholder interest and participation. In practice, this may mean rotating activities and events across multiple university campuses, innovation precincts or industry sites. It may also mean establishing specific satellite or regional Hub forums.

Given the breadth of the supply chain groups that will be targeted, it may be useful, wherever possible, for relevant professional bodies and industry associations to co-sponsor and co-promote individual forums.

Customised local prefab forums

Each Innovation Lab will have opportunities to tailor prefab programs to their specific local research expertise, and to develop prefab skills and training solutions where there is demand and interest among local industry.

> **"The future of construction and our approach to it require a bifurcated skill set. We still need carpenters, electricians, plumbers, and the traditional skills and roles, but because we're also approaching construction as a product, we have to train those people specifically for that approach. That whole process alone takes two to three years."** (Michael Marks, CEO and founder of Katerra)[11]

Key outcomes associated with these local streams of activity may include:

- Collaborative R&D projects with industry
- Advanced manufacturing technology trials
- More prefab content in university and TAFE programs
- Prefab architecture and engineering design competitions.

Annual Innovation Lab programs

AMGC expects that each Lab will host six to eight formal activities and events a year, aligned with industry interest, demand and program outcomes. Smaller satellite Labs will host one to two events a year.

The Innovation Labs will also host an annual prefab building and construction roundtable to discuss the progress and value of the Hub, and to identify priorities for the year ahead. These annual events will be critical in connecting and aligning each Lab in the network.

11 McKinsey & Company, **Scaling modular construction**, 2019

Innovation Lab candidates

Victoria

Administered by the University of Melbourne, the Australian Research Council (ARC) Training Centre for Advanced Manufacturing of Prefabricated Housing (CAMP.H) is dedicated to collaborative, environmentally sustainable prefab housing research in Australia. It strives to deliver breakthrough product and process innovations that enable the Australian housing industry to compete globally.

CAMP.H aims to unlock the potential of Australia's prefab building industry by creating a cooperative training system involving industry and universities that will help to encourage local employment growth and exports of prefab products and services.

CAMP.H is a highly collaborative venture involving four universities and 12 prefab industry partners.

Monash (a CAMP.H member), Swinburne, RMIT and Deakin universities all have advanced manufacturing lab facilities and could be viable alternative sites for Hub activities and events.

New South Wales

The Centre for Smart Modern Construction (c4SMC) at Western Sydney University focuses on industry and academic collaboration aimed at informing and preparing tomorrow's construction professionals, and readying the construction industry for Industry 4.0. The Centre has initiated a series of biannual industry and inter-university roundtables with the theme of 'joining up construction'.

New South Wales has a strong network of university-based prefab and advanced manufacturing capabilities, and associated showcasing and event-hosting facilities.

The University of Wollongong's Sustainable Buildings Research Centre is a multidisciplinary facility that hosts a wide range of research and industry collaborations aimed at addressing the challenges of making buildings sustainable. The centre has a six-star Green Star – Education Design v1 rating from the Green Building Council of Australia.

The University of Technology Sydney (UTS), UNSW Sydney and the University of Sydney could also be viable alternative Hub event hosts. UTS offers a short course program – Construction as Production – to help construction managers more effectively adopt prefab principles.

Queensland

The Future Timber Hub is an Industrial Transformation Research Hub focused on tall timber buildings. Funded by the ARC, this leading timber research collaboration brings together experts from industry, government and academia who are committed to the future development of tall timber buildings in the Pacific region.

The hub aims to transform Australia's timber construction industry by developing the skills, knowledge and resources to overcome the current technological and social barriers that limit the use of timber in tall structures. The hub was founded as an interdisciplinary partnership between the University of Queensland (UQ), the Queensland Government, Arup, Hyne Timber, Lendlease, the Queensland Fire and Emergency Services, Scion and Griffith University.

The Queensland University of Technology could be a viable alternative site for Hub activities and events, based on its prefab and advanced manufacturing expertise. The University of South Queensland is another option, as its composite materials expertise is particularly relevant to the Hub.

Western Australia

Enabled by CAMP.H ARC funding, the Curtin University and Development WA Legacy Living Laboratory (L3) serves as a functioning modular display and meeting space. It features a visualised data portal displaying leading research on large-scale sustainability initiatives.

L3 is also home to the iHUB project, a network of national research collaboration focused on smarter urban planning, design and management. The project connects Curtin University with four other universities – UQ, UNSW Sydney, Swinburne and Monash – enabling test data to be instantly collated and shared.

Curtin University is well positioned as the key lab, as it has links with relevant local expertise from the University of Western Australia (relating to architecture) and other local universities.

South Australia

The Tonsley Manufacturing Innovation Hub (TMI) is a catalyst for the growth of advanced manufacturing and the adoption of Industry 4.0 in South Australia. It is located at the Tonsley Innovation Precinct in Adelaide, the former site of Mitsubishi's automotive manufacturing operations in Australia.

Working closely with the Innovative Manufacturing Cooperative Research Centre, the South Australian and Commonwealth governments, and industry, TMI is working with companies to accelerate the uptake and diffusion of digital and automation technologies in manufacturing across a broad range of sectors.

TMI currently hosts two regular interest-group forums on emerging technologies and robotic technologies that attract strong industry participation. Flinders University is also located at the Tonsley Innovation Precinct and leads TMI.

Other South Australian universities that may be viable alternative sites for Hub activities and events, should this help to maximise stakeholder participation, interest and outcomes, include the University of Adelaide and the University of South Australia.

Satellite sites

Some Labs may need to provide support to satellite and regional sites where demand and interest are strong. This may include Tasmania and the Northern Territory.

The University of Tasmania (UTAS) has advanced manufacturing capabilities in Hobart. Its School of Architecture in Launceston also has excellent facilities to help showcase prefab and host targeted Hub forums as a satellite site. In addition, UTAS is home to the Centre for Sustainable Architecture with Wood. HobartBIM is another viable option. This community-led forum fosters the use of BIM and computational design within the built environment industry.

The Darwin Innovation Hub (DIH) is home to the Northern Territory's leading incubator and conference facilities. A partnership between Paspalis, Charles Darwin University, the Northern Territory Government and AusIndustry, DIH may be a viable satellite site for Hub activities targeted at northern Australia.

Hub funding model and budget structure

Diagram 6 describes the recommended funding model and budget structure for the Hub. This is based on the Minister's original $2 million funding proposal.

The Hub will operate for an initial two-year period (July 2020 to June 2022) with $1.5 million of funding. This amount is considered the minimum funding to enable a viable Hub of the national scale and prefab growth-driver focus proposed, and acknowledges the initial investment of up to $500k for the conduct of this feasibility study and the associated detailed project and implementation planning that will be undertaken with university and industry stakeholders in the lead-up to the Hub's launch in July 2020. **[Recommendation 1]**

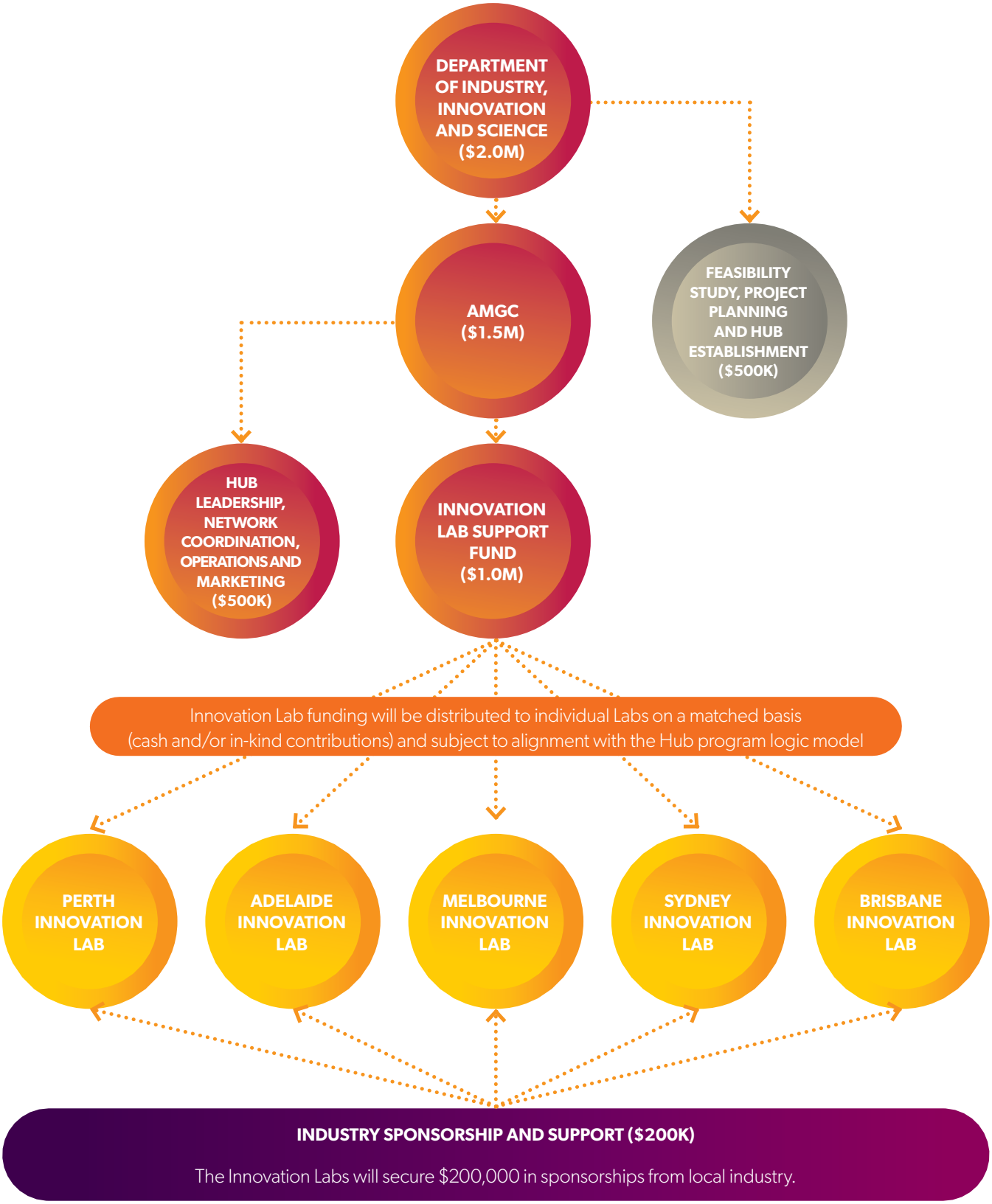
Once the Hub is established, AMGC will use a third of the $1.5 million in funding ($500,000) over two years for national Hub leadership, network coordination, operations, marketing, knowledge sharing and the delivery of a program focused on prefab growth drivers.

AMGC will administer up to $1 million in funding to the Innovation Labs over two years (matched by cash and in-kind contributions from the Labs and their participating networks). The Labs will also secure $200,000 in sponsorships from local industry. **[Recommendation 4]**

A pathway towards self-sustainability as an industry-led collaborative Hub platform will be established before the end of the two-year funding period. This will be developed in line with industry's perception of value attained and future potential. **[Recommendation 3]**

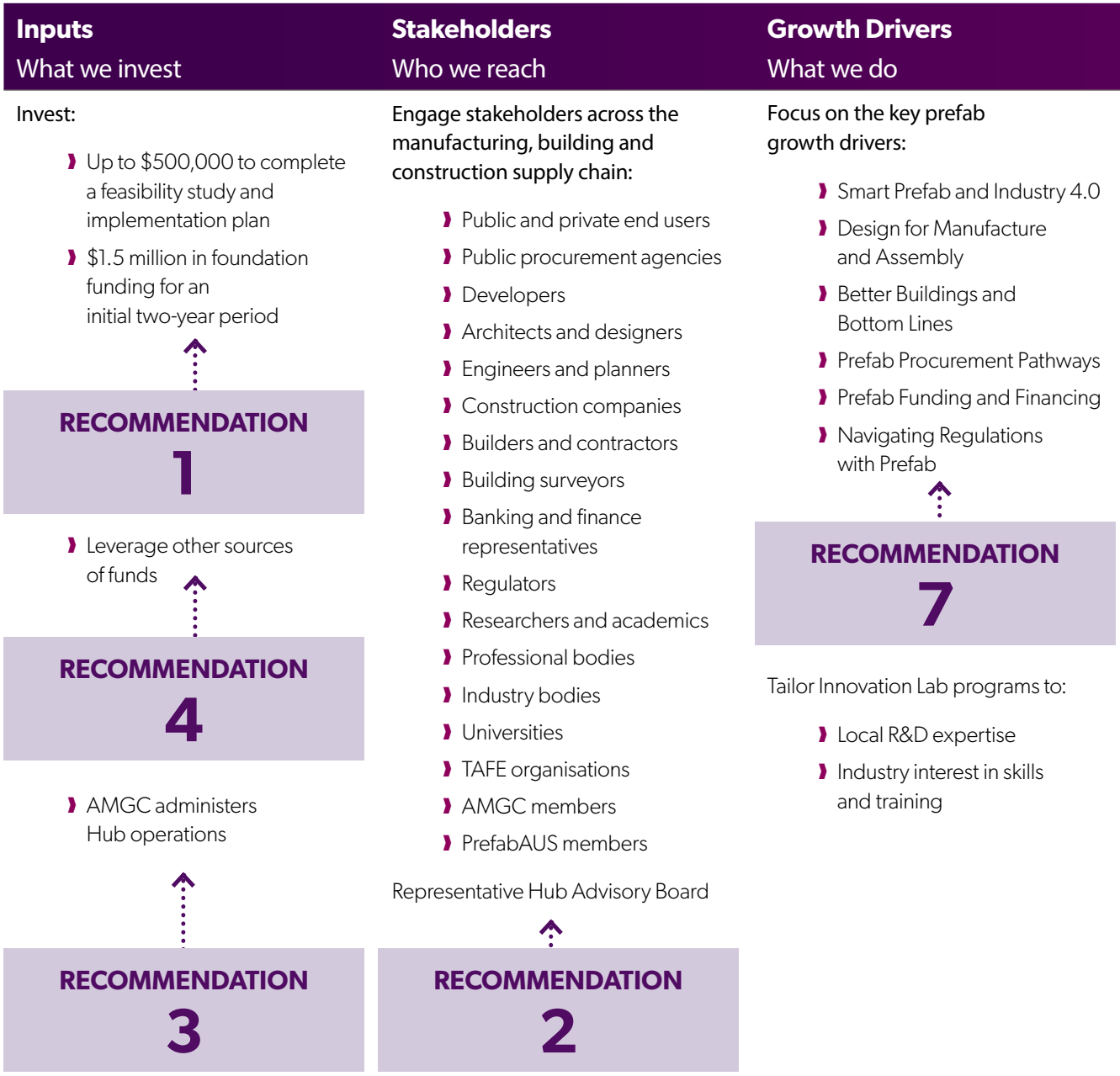
> The Hub must support the manufactured buildings ecosystem and create a platform for accelerated adoption and jobs growth.

Diagram 6: Hub funding model



Prefab Innovation Hub program logic model

Diagram 7: Prefab Innovation Hub program logic model



Hub Activities
How we do it

Through a network of local innovation labs engage stakeholders across the supply chain to:

- Showcase prefab and associated advanced manufacturing success stories, benefits, applications, methods, systems and technologies
- Educate and inform targeted supply chain groups about the key mechanisms, to optimise the benefits of prefab
- Inspire and stimulate demonstrable action and greater cohesion throughout the supply chain

RECOMMENDATION
6,8,10

Hub Outcomes
July 2020 to June 2022

The Hub aims to:

- Increase collaboration and engagement between industry and research, to grow the global competitiveness of Australian manufacturers, increase exports, encourage growth and create jobs
- Support new technologies and innovations enabling the transformation of the industry to provide smarter, more affordable and more sustainable construction solutions for Australians
- Grow the manufactured buildings ecosystem to improve business capability incorporate advanced technologies and processes

RECOMMENDATION
9

Industry Potential
June 2025

By 2025:

- Increase prefab's market share from ~5% to 15%
- Create 20,000 new Australian jobs
- Add $30 billion to our economy

RECOMMENDATION
5

- Develop a pathway towards self-sustainability as an industry-led Hub platform before the end of the foundation funding period

Prefab methods, systems and technologies

2D cross-laminated timber (CLT) panels: Xlam[12]

3D timber panel: Timber Building Systems[16]

3D timber panel: Pryda[13]

Unitised (modular) building system: Hickory[17]

2D steel frames: Dynamic Frames[14]

Bathroom pods: Schiavello[18]

Modular House: Thermeco Windows[15]

Flat-pack home: Ecoshelta[19]

12 xlam.co.nz
13 prefabaus.org.au
14 Ibid
15 Ibid
16 Ibid
17 Ibid
18 schiavello.com
19 ecoshelta.com.au

Prefab industry composition and scope

What is prefab?

Prefab is short for prefabrication. It refers to any part of a building that has been fabricated somewhere other than its final location. Prefab is also referred to as off-site fabrication, off-site construction or off-site manufacture.

“It’s important that we try to find a common language – it’s probably very confusing to the construction industry with the various terms we use.”

Participant, AMGC workshop

Prefab complements traditional construction and comes in all shapes and sizes, from components such as wall frames, roof trusses and insulated wall panels to modular construction elements, pods and complete buildings. Prefab usually uses timber, concrete, metal or plastic, or a combination of these materials.

2D and 3D are the two main families of prefab systems. These systems can be used on their own, with each other to create hybrids, or in conjunction with traditional construction approaches. The possibilities are incredibly diverse.

2D prefab

2D prefab components are pre-cut, pre-sized, pre-moulded or pre-shaped elements that are assembled or installed on site.

Panelised, or non-volumetric, systems may make up the building envelope, stair cores, internal load-bearing walls or lighter partitions. They may be open or closed panel systems, precast concrete panels or other panel types, including CLT. And each one is created through a range of advanced off-site manufacturing technologies.

These 2D elements may be structural, architectural or services elements, or a hybrid of these.

3D prefab

Modular, sectional, volumetric or unitised systems are three-dimensional structural units that are combined on site with other units or systems. It is also possible to create an entire building from one system.

In general, pods are used for bathrooms or kitchens rather than as structural modules.

3D prefab has a number of key advantages. It is a fast way to build, as the modules can be manufactured while the site is being prepared. Individual modules can be joined to create larger spaces. And modular systems can be used in high-rise environments.

Some manufacturers are vertically integrated with in-house design, engineering, project management and installation teams, while others choose to work with dedicated partners throughout the building and construction supply chain.

“The Hub must be relevant to all facets of 2D and 3D prefab, and to the small, medium and large manufacturers and suppliers of these products, solutions and technologies.

The benefits of prefab

Speed

Lean and advanced off-site manufacturing processes are considerably faster than the equivalent building process on site. This is due to the enclosed and controlled factory environment, the ability to coordinate and repeat activities, and higher levels of automation. Manufacturing can take place in parallel with foundation work, unlike the linear timeline of a traditional project.[46] In the words of one Australian prefab and modular home manufacturer:

“An average house usually takes 12 months or more to build. Our homes, however, will be built, transported and installed on your land in approximately 12–14 weeks, whether you choose one of our pre-designed or custom homes.”

Faster construction times can lead to faster occupation, generating income for clients earlier and lowering site overheads as less time is spent on site.

These factors, together with fewer weather disruptions and reduced defects and rework, can help reduce construction times by 20–60%.[47]

Safety

Health and safety is easier to control in a factory. In conventional construction, there are several safety issues, including working at height, congestion and weather-related workplace accidents.

In addition, well-planned off-site logistics can dramatically reduce the number of necessary vehicle movements, improving safety at and around the site.

It is estimated that workplace health and safety incidents could be reduced by as much as 80% by using off-site manufacturing methods.[48]

Sustainability

Minimum site disturbance, tightly managed material flow and construction waste, and pre-planned assembly and disassembly can significantly reduce the environmental impact of construction. Factories can be optimised to achieve waste levels below 1%, in comparison with waste levels of between 18% and 22% for traditional construction.[49]

Studies have shown that prefab modular construction can reduce landfill by at least 70%[50] and that prefab households produce up to 50% less CO_2 operating emissions due to improved thermal efficiency.[51]

Quality

A predetermined level of quality can be achieved in a factory-controlled process. In addition, the indoor environment means buildings and components are protected from climate extremes and vandalism.

Quality control is much easier and better in a factory environment than on a construction site, which has a big impact on rework. Reducing or eliminating rework significantly improves construction schedules, potentially by up to several months. There is also the risk of defects not being identified on site until many months or years later, when they are far harder and more expensive to rectify.[52]

In the context of an ageing construction workforce and skilled worker shortages, prefab manufacturing supply chains should be designed in a way that appeals to a younger and more diverse workforce. Minimising the need to work in all weather conditions and using technology to reduce physical and administrative tasks could encourage more people to join the construction workforce.

46 McKinsey & Company, **Modular Construction: From projects to products**, 2019

47 RIBA, **RIBA Plan of Work 2013: Designing for Manufacture and Assembly**, 2016

48 Ibid

49 http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/housing-communities-and-local-government-committee/modern-methods-of-construction/written/95749.html

50 Lawson, RM, Ogden, RG and Bergin, R, ‘Application of Modular Construction in High-Rise Buildings’, **Journal of Architectural Engineering**, 2012, 18, 148–154

51 Aye, L, Ngo, T, Crawford, RH, Gammampila, R and Mendis, P, ‘Life cycle greenhouse gas emissions and energy analysis of prefabricated reusable building modules’, **Energy Build**, 2012, 47, 159–168

52 McKinsey& Company, **Modular construction: From projects to products**, 2019

Productivity

A factory process should be inherently more productive than a site task. A UK study found that productivity could increase from 30% to 80% in a well-managed off-site factory, which can deliver cost savings.[53]

In the right environment and with certain trade-offs, prefab can cut costs by 20%. This level of savings is perhaps more the exception than the norm today. However, there is some evidence to suggest that prefab may be able to reduce costs by more than 20% based on what has been achieved in some mature overseas markets.[54]

Prefab offers greater cost certainty as it has fewer weather delays and an earlier design freeze compared to traditional construction.

With the right skills and training initiatives, prefab can help create a more productive on-site construction environment.[55]

> The Hub must seek to actively demonstrate evidence-based cost, time and safety benefits achieved in the Australian context, and educate and inform how these benefits can be optimised across a range of Australian building applications and prefab solutions.

53 http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/housing-communities-and-local-government-committee/modern-methods-of-construction/written/95749.html

54 Ibid

55 Hairstans, R, **Building Offsite: An Introduction**, 2015

Prefab applications across Australia

Modular retail: Prebuilt[20]

Modular apartments: Goodland Building Company

Modular student mccommodation: Quicksmart Homes and Hutchinson Builders[21]

Permanent modular school: Victorian Permanent Modular School Building Program[24]

Modular police station: Prebuilt[22]

Modular residential: Weathertex[25]

Medical centre: Prebuilt[23]

Residential home: Modscape[26]

20 commercial.prebuilt.com.au
21 prefabaus.org.au
22 commercial.prebuilt.com.au
23 Ibid
24 sensum.com.au
25 prefabaus.org.au
26 modscape.com.au

Key applications of prefab in Australia

Prefab building methods, systems and technologies enable the delivery of a broad range of public, residential and commercial buildings.

Key public sector prefab projects across Australia include schools, railway stations, police stations, childcare centres, community centres, healthcare centres, hospitals, and correctional and sporting facilities.

"Between 2016 and 2026, Australia's school student population is expected to grow by 650,000, meaning up to 750 new schools will be needed." [27]

Commercial building applications for prefab include everything from offices, hotels, restaurants and cafes to factories, retirement villages and aged care facilities.

Housing continues to be a key source of prefab construction. This includes detached houses, townhouses, apartment buildings, affordable and social housing, and student accommodation facilities.

"Any building being manufactured needs to be designed for the manufacturing process and hence constrain the number of different variations required. For example, affordable housing, student housing and hotels are highly standardised and repeatable. This doesn't mean that all of these buildings now need to be the same – understanding the level of customisation desired by the customer and what can be built into the manufacturing process is a key element of developing the modular solution." [28]

"The Hub must work collaboratively with relevant state government agencies to develop new, and expand any existing, pathways to prefab procurement and tendering.

State government procurement case study

The Permanent Modular School Buildings Program is an initiative of the VSBA. The program aims to replace old buildings at hundreds of schools with newly built modular buildings. More than 30 modular school buildings have been completed so far, and that number is expected to rise to 101 by the end of 2020.

"Our Permanent Modular School Buildings Program is a modern and efficient solution for delivering a high volume of buildings in short timeframes.

Architecturally designed, our permanent modular buildings are constructed off site – minimising disruptions to students, staff and learning programs. We then swiftly assemble the buildings at the school and have them ready for use.

Buildings delivered through this program ensure that schools have an alternative to the typical on-site works, delivering the same high quality but faster than ever before."

States such as South Australia and New South Wales have also announced similar modular programs for delivering government education infrastructure.

In addition, the Department of Health and Human Services recently established a panel of builders to deliver a range of modular homes. This is part of the Victorian Government's $209 million commitment to build 1,000 new public housing properties over three years.

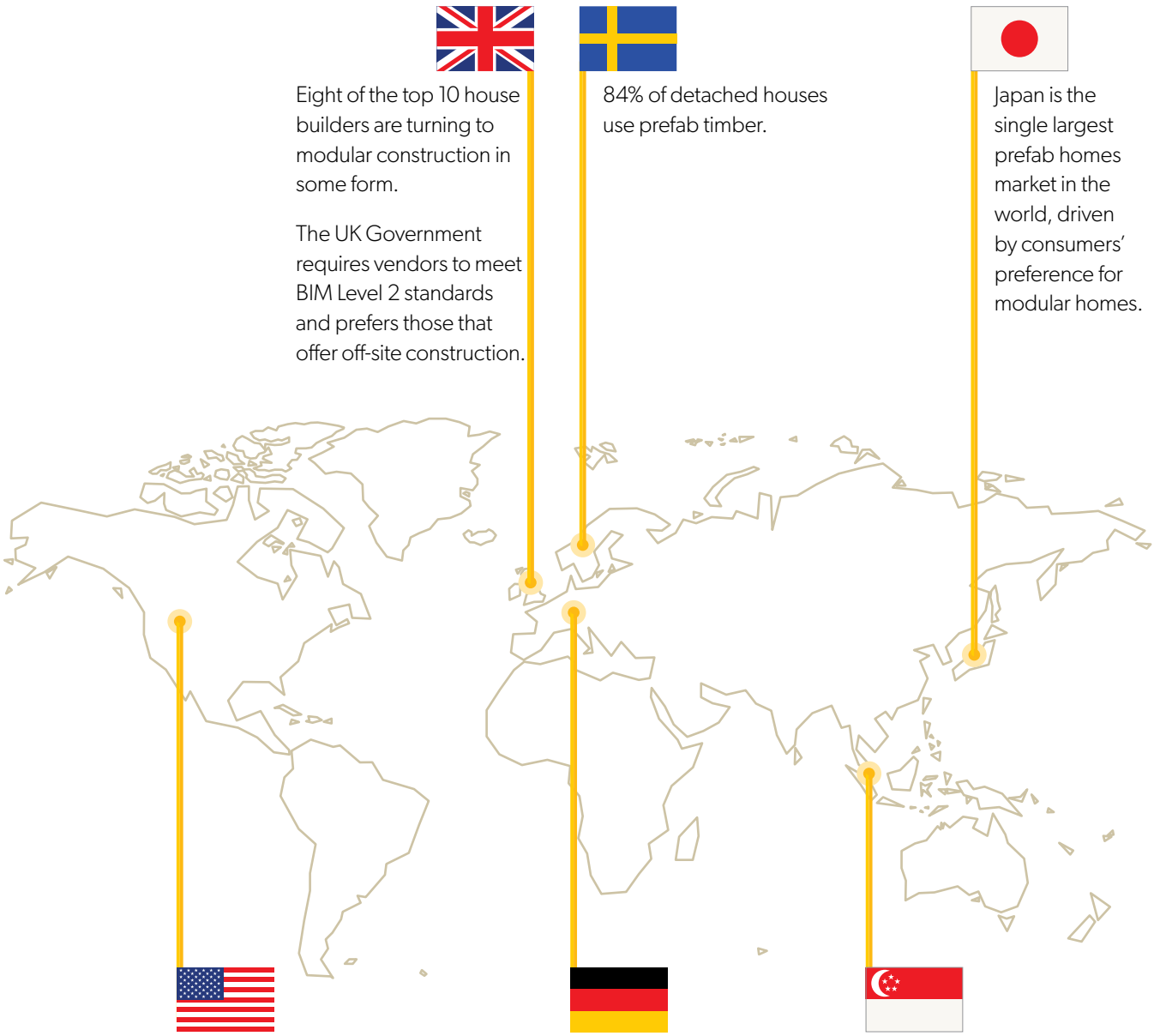
Source: https://www.schoolbuildings.vic.gov.au/Pages/Permanent-Modular-School-Buildings-Program.aspx

27 Grattan Institute, 'Should you worry about a schools shortage? It really depends on where you live', 2016

28 McKinsey & Company, **Modular construction: From project to products**, 2019

Prefab around the world

Diagram 8: Prefab around the world[29]



Eight of the top 10 house builders are turning to modular construction in some form.

The UK Government requires vendors to meet BIM Level 2 standards and prefers those that offer off-site construction.

84% of detached houses use prefab timber.

Japan is the single largest prefab homes market in the world, driven by consumers' preference for modular homes.

15% annual expansion in prefab housing through 2017 to 135,000 units.

In 2017, the demand for manufactured housing will rise from approx. 47K units in 2012.

Through 2019, continued growth in housing demand will increase sales of prefab housing.

9% of all new residential building permits are for prefab buildings.

In 2017, it was announced that by 2019, 35% of newly launched housing board projects would be built using 3D modular units that are manufactured and finished in factories.

29 Adapted from https://revolutionprecrafted.com/the-rise-of-the-prefab-market-around-the-world-infographic/#

Japan

Japan has capitalised on synergies with other manufacturing industries. The high volume of modular units ensures economies of scale and lower production costs. Modular homes are seen as a premium product in Japan and they often command a higher sale price because of the strong focus on quality, particularly with respect to earthquake resistance. One of Japan's key enablers has been its decision to rely on inspections by industry-specific trained professionals rather than a general building code.

About a dozen or so major manufacturers, including Sekisui Heim, produce about one out of every six new homes built in Japan each year.[30]

Singapore

Since November 2014, Singapore's Building and Construction Authority has stipulated that selected sites offered in the Government Land Sales program need to use prefab pre-finished volumetric construction methods for at least 65% of the total constructed floor area within residential developments.

In September 2017, the Housing & Development Board announced that by 2019, 35% of newly launched housing board projects would be built using 3D modular units that are manufactured and finished in factories.[31]

Sweden

Short daylight hours and cold weather often constrain work on traditional construction sites in Sweden, making modular approaches a logical alternative. A small number of large companies drive healthy economies of scale. Most manufacturers are located in rural areas near timber supplies, and currently around 85% of new homes are built using some form of manufactured construction.[32]

United States of America

In 2020, shipments from US producers of prefab housing are expected to reach 123,500 units, valued at $7.3 billion. Manufactured housing is the largest segment of the prefab housing market.

US demand for manufactured housing is forecast to reach 85,000 units in 2020. Demand for other prefab housing types – including panelised, pre-cut and modular – is projected to rise 5.6% a year during the forecast period.[33]

Amazon recently invested in Plant Prefab, a Southern California company that uses sustainable construction processes and materials to build custom-designed single- and multi-family prefab houses[34]

One of Plant Prefab's selling points is that it aims to deliver low-cost homes in about half the time of traditional construction, while minimising construction waste.

Design software firm Autodesk and financial services company Citi have made strategic investments in Factory OS, which is based in a former Navy submarine construction facility on Mare Island in California.

The best-funded prefab technology start-up though, is Katerra, which operates out of Menlo Park, California. Founded in 2015, the company has attracted more than $1 billion in funding. In June 2019, Katerra started an apprenticeship program to help train workers in the new technologies and skills associated with prefab.[35]

In 2019, Katerra had 7,500 employees globally, up from 2,800 the previous year.[36]

30 https://www.curbed.com/2017/10/25/16534122/prefab-homes-manufacturing-japan-vs-us
31 https://www.channelnewsasia.com/news/singapore/hdb-to-expand-use-of-prefabrication-building-methods-in-bto-9189786
32 McKinsey & Company, **Modular construction: From projects to products**, 2019
33 The Freedonia Group, **Prefabricated Housing in the US**, 14th Edition, 2017
34 Kim, CNBC Tech, 2018
35 https://www.greenbiz.com/article/why-autodesk-investing-urban-prefab-construction-startup
36 McKinsey & Company, **Scaling modular construction**, 2019

United Kingdom

The UK Government aims to add 1 million additional homes to the housing stock by 2020 and increase annual output to 300,000 by the mid-2020s. However, these volumes will not be achieved unless modern methods of construction (MMC) such as prefab are more widely adopted.

In 2018, 15,000 homes were factory-made[37], but growth in the sector has been slow; this figure represents just 5% of the homes that need to be delivered annually in the coming years if the UK is to average 300,000 net additions.

MMC could help to diversify the market and increase the number of new homes delivered. However, its ability to play a significant role in meeting the Government's home building targets relies on rapidly increasing the country's off-site construction capacity and attracting new entrants to the market.[38]

In a recent report on MMC in the UK, 40% of home builders surveyed said they were already investing in manufacturing facilities or intended to do so in the near future.[39]

In May 2019, Japan's biggest house builder and MMC expert, Sekisui House, announced its move into the UK housing market after striking a £90 million deal. The deal will see it work with Homes England and Urban Splash to deliver thousands of new homes across the country.[40]

The newest entrant, BoKlok, is a joint venture bringing together home furnishings giant IKEA and construction firm Skanska. BoKlok is building 162 affordable factory-built homes in West Sussex, following on from a similar initiative in the Nordic region.

"Growth of modular housing in the UK is being led by new entrants. It's often the case that disruption is created not by the incumbent but by the outsider. There's less apprehension from those whose core business is not house building. New, fresh ways of thinking are having an increasingly significant impact on the UK's living sector." [41]

Eight of the top 10 house builders in the UK are turning to modular construction in some form. Other players are joining the house building industry too. Legal & General launched a modular housing line that will deliver 3,000 homes each year, while developer Ilke Homes announced a target of 4,000 modular homes in the next two years.[42]

The UK Government requires vendors to meet BIM Level 2 standards and prefers those and that offer off-site construction.[43]

Germany

Germany is a global frontrunner in prefab housing. In 2018, more than 20% of all existing homes had been produced in a factory. That number is expected to rise, as the prefab sector is projected to outpace the overall housing market by 3.2% annually in the next five years.[44]

The Asia-Pacific Research Network for Resilient Affordable Housing

The Asia-Pacific Research Network for Resilient Affordable Housing (APRAH) brings together leading thinkers from the prefab industry, building product manufacturers and government agencies, matching them with research expertise throughout the Asia-Pacific region.

Hosted by the University of Melbourne, APRAH spans more than 40 companies and 10 leading universities in 15 countries across the Asia-Pacific region. The network aims to facilitate the rapid development of new prefab building materials and that are cheap, light, reusable, durable, faster to manufacture and assemble, more energy-efficient and more resilient to natural disasters.[45]

37 HL Deb, 24 April 2019, col 678 [Lords Chamber]
38 House of Commons Housing, Communities and Local Government Committee, **Modern methods of construction: Fifteenth Report of Session 2017–19**
39 McKinsey & Company, **Modular construction: From project to product**s, 2019
40 Ibid
41 Adam Challis, JLL Head of UK and EMEA Residential Research, Adam Challis.
42 https://www.jll.com.au/en/trends-and-insights/cities/modular-construction-housing-crisis-answer
43 Ibid
44 https://medium.com/@BlueFuture/our-9-favourite-german-prefab-companies-e1546474b5bf
45 https://infrastructure.eng.unimelb.edu.au/aprah/about/

Australian prefab and advanced manufacturing success stories

Despite the barriers and hurdles to growth facing Australian prefab businesses, there are countless success stories. The following examples highlight 2D and 3D prefab types and a range of prefab applications, delivered across Australia by prefab businesses large and small.

Dynamic Steel Frame and Dynamic Pods

Dynamic Steel Frame is a Victorian business using an advanced steel framing system. The company combines design and engineering software with an automated rollformer to produce wall frames, roof trusses, floor joists and panels quickly and accurately.

Dynamic Steel Frame manufactures for all segments of the building industry, including commercial, light industrial, investment housing, low-cost housing, high-end bespoke homes, apartments and owner-builders.

Erectors and builders appreciate the company's lightweight frames, which are faster and easier to erect. A 7.5-metre wall frame can easily be carried and installed by two people, and roof trusses can be lifted into place by hand. Commercial builders working on multi-storey residential projects also benefit from reduced program times, as the company's frames are faster to erect and require fewer trades on site.

Dynamic Steel Frame delivered Australia's first four-storey light-gauge steel building, and in recent years it has expanded into bathroom pods, developing a patented highly customisable bathroom pod integrating waste plumbing in a cast-in lid.

Dynamic Pods creates a 3D model for every design and then a full-scale prototype to ensure buildability and maintain design intent.

Dynamic bathroom pod[56]

Supaloc

Supaloc Steel Building Systems is a South Australian company dedicated to providing innovative, Australian-made steel framing products to the world. Supaloc steel frames are manufactured at advanced manufacturing facilities in South Australia and New South Wales using innovative machinery driven by computer aided design (SBSCad). The direct link between the SBSCad design and the advanced manufacturing process guarantees pinpoint accuracy in production.

Supaloc supplies builders with pre-assembled house frames, which are packed for transportation and then efficiently assembly on site. The unique patented frame connections simply bolt or clip together, reducing site construction time significantly and guaranteeing structural integrity.

The R&D department works closely with the manufacturing facilities. In addition, the company constantly refines its design software and advanced manufacturing machines. This ensures that Supaloc's steel frames take advantage of the latest and most advanced technology available.

Bondor/Metecno

Bondor/Metecno is Australia's leader in thermal building solutions and lightweight architectural facade systems. The company manufacturers insulated building wall and roof panels in eight manufacturing locations across six states. It is also Australia's only manufacturer of the three internationally accepted panel core types: EPS-FR, PIR and MW.

Supaloc steel frame[57]

56 dynamicpods.com.au

57 https://www.facebook.com/pg/SupalocAU/posts/

Founded in the 1950s, Bondor/Metecno is constantly working on solutions for industrial, commercial and residential building customers across Australia. It also offers the most comprehensive range of insulated panel products and systems available.

Bondor/Metecno has a strong commitment to product development and research, with an in-house NATA-certified structural testing laboratory.

Bondor/Metecno used the inherent advantages of insulted panels – such as good thermal performance, ease and speed of construction, low weight, excellent vapour seal and air tightness, low maintenance and affordability – to develop products for commercial, education, residential, modular and prefab building markets.

More recently, Bondor/Metecno has developed a range of insulated residential building products that together make up the InsulLiving® system, Australia's next step towards zero-energy housing.

The company has also opened a $20 million state-of-the-art manufacturing facility in Campbellfield, Melbourne. The 14,500-square-metre factory, which includes a production line from leading German equipment manufacturer Hennecke, is capable of producing over 2 million square metres of panels a year.

The facility, like a number of the company's other factories around the country, is a great example of Australia's prefab and advanced manufacturing sectors working hand in hand.

Prebuilt

In 2003, Prebuilt identified an opportunity to move beyond the archetypal boxes being delivered by small kit-home builders and create well-designed, high-quality modular buildings.

Drawing on the owners' background in commercial project management, construction and large-scale asset management, as well as their passion for outstanding architecture, Prebuilt was established as a start-up company manufacturing residential and commercial factory-built buildings. The company's government projects have included permanent modular classrooms, train stations for the Victorian Level Crossing Removal Project and large-scale pilot accommodation for the Department of Defence.

The business operates from its own 40,000-square-metre facility in Melbourne's outer eastern suburbs, and employs up to 150 staff and subcontractors.

With a philosophy of design-led manufacture, the company has a long-standing partnership with architects Pleysier Perkins for its residential homes. It also partners with many of Australia's leading architectural firms to design its commercial buildings.

Using the technology and systems developed for its residential housing, the business has constructed a range of commercial and government projects. It also has extensive experience in large-scale civic construction, multi-residential construction, architecture, engineering and cost estimating.

Prebuilt director Rob Colquhoun helped create PrefabAUS, the national peak industry body for prefab and modular construction, and remains as a founding director of the not-for-profit organisation.

Bondor_Metecno manufacturing facility in Campbellfield, VIC[58]

Prebuilt manufacturing facility in Kilsyth, VIC[59]

58 bondor.com.au

59 commercial.prebuilt.com.au

Hickory

Hickory Building Systems (HBS) is a patented structural system used to deliver high-rise construction projects up to 30% faster while also increasing safety and sustainability. This innovative construction methodology allows Hickory to deliver projects that consistently outperform on measures of efficiency, sustainability and quality.

HBS is a structural prefab system that integrates the core, shear walls, bathrooms and facade of a building into a unified structure that is built off site in parallel with on-site works. Unlike other modular methods, HBS is flexible, making it suitable for a range of high-rise projects, including apartments, hotels, student accommodation, hospitals and other healthcare developments.

Hickory has taken a manufacturing model based on upfront design and procurement and applied it to the construction process. This enables materials to be accurately costed while significantly minimising preliminary, variation and financing costs. HBS requires a greater level of collaboration among the builder, engineers, architects and consultants, offering a best-practice project management model for the industry.

Independent research demonstrates that HBS offers a more sustainable construction solution. The system requires fewer truck deliveries, which reduces waste and carbon emissions and traffic congestion.

A parallel construction program in a controlled factory environment eliminates the risk of weather delays and also allows for better quality control. In addition, preassembly in the factory saves time on the overall construction program.

The company has now successfully completed many high-rise projects using this method, including Australia's tallest prefab building, La Trobe Tower, a 44-level residential tower in central Melbourne; Atira's student accommodation complex on La Trobe Street (pictured below); and the recently completed Collins House residential apartment tower, which is more than 200 metres tall.

Schiavello

Schiavello is a top 100 privately owned Australian company specialising in furniture, construction, consulting and development. It has been manufacturing modular bathroom pods since 2015.

The pods are manufactured in its 65,000-square-metre factory in Melbourne, incorporating timber, glass, aluminium, steel, metal, plastic, solid surface and electricals.

With multiple advanced manufacturing capabilities in one location, the company can design, fabricate and fit out bathrooms to the highest quality in the shortest timeframes.

Schiavello and subsidiary Omvivo have jointly developed a range of bathroom pod designs for use in residential apartments, hotels, student accommodation, aged care villages and healthcare facilities.

Using the best design and modelling tools available, Schiavello works collaboratively to help deliver a wide variety of project visions. The company also uses automated robotic systems to fast-track designs from detailed 3D models to production.

Hickory's Atira student accommodation project[60]

Schiavello's Melbourne headquarters and manufacturing facilities[61]

60 hayball.com.au
61 schiavello.com

Fleetwood

Fleetwood Building Solutions is part of the ASX listed Fleetwood Australia group of companies. With a legacy of over 50 years, providing clients certainty and value.

It is one of the largest vertically integrated offsite construction businesses in Australia, with expertise in the design, manufacture and installation of permanent modular and transportable buildings.

Led by an in-house architectural and drafting team, the company's design group use BIM to oversee the creative landscape of all projects from their inception to conclusion.

Fleetwood Building Solutions offers customers a full turnkey solution from inception to the installation of a project. Its services include design, offsite manufacturing, civil and site works, transportation of modules to site as well as installation and decommissioning of structures. Since 2017 the company has provided design, supply and installation of permanent modular buildings to the VSBA.

Uniplan Group

The Uniplan Group is based in Armidale, in regional New South Wales. The company has been in the prefab and modular building business for more than 20 years and employs more than 130 local staff. The owners also have a controlling interest in a modular home business in the US. The company's Armidale site is also home to a bathroom furniture manufacturer that has recently adopted CNC and robotics.

"One of our core values is 'We innovate to grow'," says Uniplan Group Managing Director Ben Scott. "This means we're always looking for new designs, methods and processes. We thrive on finding exciting new products." Over the last 10 years, Uniplan has delivered an average year-on-year annual growth rate of more than 15%.

The Armidale factory has two production lines, allowing Uniplan to manufacture one large residential home every 8.5 days and a smaller residential village–style home every second day.

Ecoshelta

With operations in New South Wales and Tasmania, Ecoshelta has long been part of the sustainable building revolution. The company makes high-quality, architect-designed prefab and modular buildings with a low environmental impact. Ecoshelta's state-of-the-art building system has been used for cabins, houses, studios, eco-tourism accommodation and villages.

Each Ecoshelta pod has a fully modular frame along with floor, wall and roofing systems that use structural insulated panels. This allows for flexibility in roof forms, room layouts, wall door and window positions, and room fit-outs. The company's e.pods and smaller tough pods (t.pods) can be built anywhere.

The company has a strong focus on technology, and uses a combination of natural and manufactured products, composite panel elements and 3D-printed materials. It also uses the proprietary EcoCost environmental costing system to provide clients with a full life-cycle assessment of the raw materials.

A Fleetwood prefab school building[62]

A Uniplan Group residential prefab home[63]

62 prefabaus.org.au

63 uniplangroup.com.au

Hutchinson Builders

Hutchison Builders is Australia's largest privately owned construction company. Its modular building division includes fabrication facilities at Yatala and Toowoomba in Queensland.

Hutchinson Builders has delivered all types of modular projects – everything from large volumetric buildings to small custom-designed bathroom solutions. The company prides itself on using modular technology to create buildings that look like they were built in situ.

In 2018, Hutchinson Builders completed work on two state-of the-art cancer treatment centres in Queensland for GenesisCare, the largest provider of radiation therapy services in Australia. The client hand-picked Hutchinson Builders because of the company's strong track record in modular design and construction. It delivered both treatment centres in just four months, testament to the value of prefab and modular construction.

"What was unique about the construction was that we did it so quickly," says Andrew Saunders, General Manager of GenesisCare Queensland. "Instead of something that traditionally has taken 12 to 18, even 24, months to build and commission, we were able to get these two new services up and running in about four months."

Sensum

Sensum has successfully led thousands of prefab and modular projects, and is currently working with the Department of Health and Human Services. Sensum has helped the department establish a panel of builders to deliver a range of modular homes. This is part of the Victorian Government's $209 million commitment to build 1,000 new public housing properties over three years.

This initiative is designed to boost the state's public housing, a form of long-term rental accommodation available to people on low incomes, especially those who have recently experienced homelessness or family violence, or who have other special needs.

Sensum is also the program manager for the Victorian Permanent Modular School Buildings Program. In this role, it is responsible for delivering 100 unique projects over three years, including contract management and superintendent services.

An Ecoshelta home[64]

GenesisCare cancer treatment centre in Hervey Bay, Queensland[65]

64 ecoshelta.com.au

65 hutchinsonbuilders.com.au

Dandenong North Primary School[66]

Modscape

Modscape designs and builds modular homes and commercial projects across a range of industries – from health care and education to hospitality and transport.

Each project is designed for the specific site, taking into consideration passive design principles and the client's requirements. Design and finish options are limitless, and every design is the result of genuine collaboration with the client.

Modscape's owners have extensive experience in the design, development and construction industries, which they supplement by collaborating with architects, engineers, sustainable development consultants, industry organisations, suppliers, contractors and specialist consultants.

Modscape won the 2019 Australian Construction award for 'Off-site Construction Project of the Year' for its role in delivering a range of modular projects across Victoria and New South Wales.

Timber Building Systems

Timber Building Systems (TBS) is a unique and revolutionary post-tensioned pre-manufactured building system used in multi-level residential apartments, hotels, student accommodation, aged care facilities and commercial office buildings.

TBS offers clients a sustainable and high-quality solution, fast turnaround times, architectural design flexibility, excellent customer service and lower overall costs. TBS's patented building assembly system features wood-based integrated flat-pack panels that include structural as well as plumbing and electrical service elements.

TBS minimises the carbon footprint of its projects by sourcing as many of its products and manufacturing services from the region as possible. Its unique packaging and connection system also sets it apart, allowing it to provide delivery and installation services that are among the most efficient in the construction industry.

The TBS team has extensive experience in delivering large-scale prefab commercial and residential projects. An Australian Government manufacturing grant allowed the company to invest in equipment and full-time staff, which in turn helped it win four major projects with the New Zealand Government.

TBS has developed a linear production line in its 12,000-square-metre facility in Dandenong, Victoria.

Modscape's 2.6-hectare site in Victoria[67]

A TBS commercial building[68]

66 DevinGoheen-SensumDNPS-0002.jpg
67 modscape.com.au
68 tbsaus.com.au

Glossary of terms

Closed panel: A panelised element that consists of framing with cladding and/or lining

Cross-laminated timber (CLT): Large structural building panels made from boards glued together in layers

DfMA: Design for manufacture and assembly

Flat pack: A collection of prefabricated parts transported in one package to site for assembly

Modern methods of construction (MMC): A term used largely in the UK to describe prefabricated or off-site manufacturing or assembly

Modular building: A building designed using 3D volumes, units or pods

Permanent modular construction (PMC): 3D structural volumes or modules designed for long-term use

Pod: A non-structural volume that typically contains bathroom, kitchen or laundry functions

Pre-cut, pre-sized, pre-shaped: Materials that are cut, sized or shaped off site

Prefab, prefabricate or off-site: On-site assembly of components that are pre-built and manufactured off site

Structural Insulated Panels (SIPs): Insulation materials sandwiched between two structural skins

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