# Profiling the nature and context of the Australian prefabricated housing industry

**Authors:**
Steinhardt, Dale A.
Manley, Karen
Miller, Wendy

**Affiliation:**
School of Civil Engineering and Built Environment
Science and Engineering Faculty
Queensland University of Technology

**Project partners:**
Australian Research Council
Building Codes Queensland
Western Australian Building Commission

27/11/13

# Abstract

The current state of the prefabricated housing market in Australia is systematically profiled, guided by a theoretical systems model. Particular focus is given to two original data collections. The first identifies manufacturers and builders using prefabrication innovations, and the second compares the context for prefabricated housing in Australia with that of key international jurisdictions. The results indicate a small but growing market for prefabricated housing in Australia, often building upon expertise developed through non-residential building applications. The international comparison highlighted the complexity of the interactions between macro policy decisions and historical influences and the uptake of prefabricated housing. The data suggest factors such as the small scale of the Australian market, and a lack of investment in research, development and training have not encouraged prefabrication. A lack of clear regulatory policy surrounding prefabricated housing is common both in Australia and internationally, with local effects in regards to home warranties and housing finance highlighted. Future research should target the continuing lack of consideration of prefabrication from within the housing construction industry, and build upon the research reported in this paper to further quantify the potential end user market and the continuing development of the industry.

# Table of Contents

# Introduction and rationale

The use of prefabrication, otherwise described using terms such as offsite construction, modern methods of construction or manufactured housing, has been promoted in recent academic literature as a means to improving the efficiency, quality and environmental performance of housing construction. This research has commonly highlighted the well-established prefabricated housing industry in jurisdictions such as Japan (Barlow et al., 2003; Gann, 1996; Johnson, 2007). Such research can conflate the influences of immediate business or process decisions with localised, contextual influences (Yunus & Yang, 2011). The current paper seeks to separate these influences and describe their relationship to the current state and future of prefabricated housing in Australia.

There has also been little theoretical structure to previous research, with a particular weakness in defining the context and various actors that influence the prefabricated housing industry. A previous, related paper (Steinhardt, Manley, & Miller, Unpublished) outlined a theoretical Prefabricated Housing Innovation System and applied it to understanding the industry as revealed in the published literature. This model accounted for the influence of intermediaries, suppliers, end users, the policy context and technical issues on uptake rates. This previous paper identified a number of key barriers and drivers that impact the adoption of prefabricated housing. These influences included both negative and positive perceptions towards the innovation from within the building sector; economic factors such as business risks, incentives, and financial regulation; consumer demands for flexibility and low-cost products; and the ability of material suppliers and builders to integrate their businesses (Steinhardt et al., Unpublished).

The current paper systematically profiles the current state of the prefabricated housing market in Australia, guided by the theoretical model previously applied to the review of the existing academic literature. The profile covers influences both specific to prefabricated housing and more generally affecting the housing market. The discussion also considers how these influences compare to other international contexts with varying degrees of uptake of prefabricated housing.

# Prefabricated Housing Innovation System

The Prefabricated Housing Innovation System used as the guide for this paper is shown below in Figure 1. Further details of the theoretical framework applied for the current paper have been described previously in (Steinhardt et al., Unpublished). This review established the basic structure of a systems model for explaining the uptake of prefabricated housing as an innovative product, and drew on the internationally available published literature to reinforce the validity of using this model.

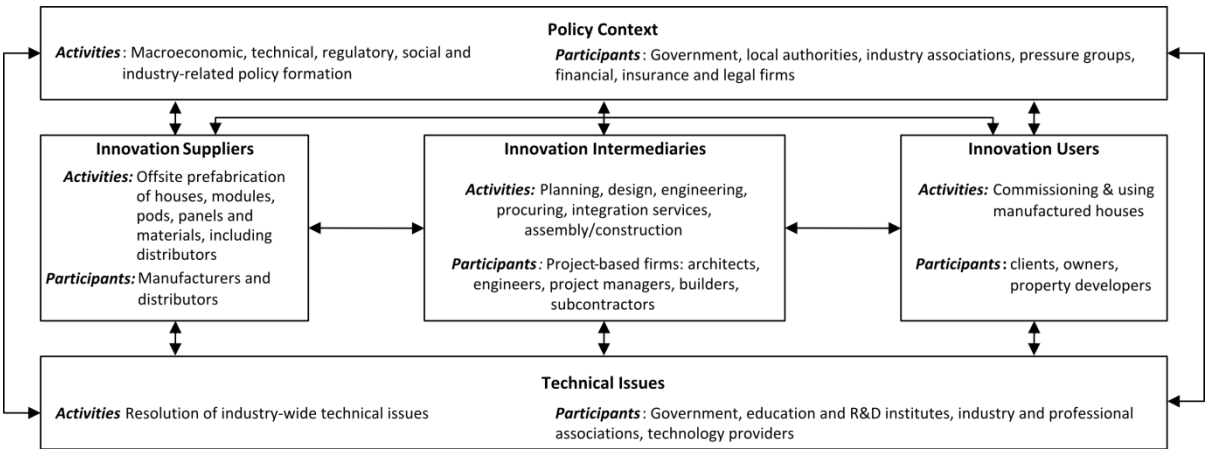


*Figure 1*. Prefabricated Housing Innovation System

The uptake of prefabricated housing innovations are likely to be influenced not only by the characteristics of the product, but also the people, technology, and business processes surrounding it (Nadim & Goulding, 2011). The systems conceptualisation of the housing industry expands the scope of investigation beyond intermediaries such as builders to investigate the actors and actions of other supply-chain members such as manufacturers, distributors and users, within the broader policy and technical contexts. The focus is on prefabricated houses, modules, pods and structural panels. Although builders are the key intermediary, architects and engineers also employ these products to deliver a prefabricated house. The innovation users in the system are individual consumers and developers commissioning houses. The supply chain operates within the policy and technical contexts, comprising higher order macroeconomic, social and regulatory influences; and technical issues, referring to industry-wide technical challenges and efforts to resolve them by researchers and the industry itself.

# Scope

## Building types

The current paper focuses on the permanent residential housing market, specifically detached single-unit houses, townhouses and multi-residential housing blocks. This scope aligns with Classes 1(a) and 2 of the Australian National Construction Code, which cover single detached houses, as well as multi-residential builds such as townhouses, terrace houses, villa units, and unit buildings containing two or more sole-occupancy dwellings (Australian Building Codes Board, 2013b). Temporary housing such as that used in mining camps, as well as caravans, trailer homes and other mobile housing were considered out of scope, as low adoption rates are less of a problem in these sectors.

## Prefabricated housing

Prefabricated housing was defined for the current study as the manufacturing of whole houses or significant housing components offsite in a weather-proof factory prior to installation or assembly onsite. The continuum of prefabricated house construction methods used to define the scope of the paper is shown below in Table 1.

Table 1. *Continuum of prefabricated house construction methods housing*

| Prefab. level | Type | Definition |
|---|---|---|
| **High** | **Complete** | Box-form, volumetric, completed buildings delivered to a building site |
| | **Modular** | Structural, volumetric, potentially fitted-out units delivered to site and joined together onsite |
| | **Pods** | Volumetric pre-assembly. Fully fitted-out units connected to a structural frame onsite, such as bathroom or kitchen pods |
| | **Panels** | Structural, non-volumetric frame elements which can be used to create space, such as Structural Insulated Panels (SIPs) and precast concrete panels |
| | **Component sub-assembly** | Precut, preassembled components such as doors, and trusses not feasible to produce on site |
| **Low** | **Materials** | Standard building materials used in onsite construction |

The scope of prefabrication considered in the current study includes structural building panels, volumetric pre-assembly, modular units and complete buildings. Smaller, non-structural prefabricated elements such as pre-assembled trusses were not considered within the scope of the current research as they are already highly represented in traditional building. Tilt-up concrete panels poured and lifted into place on the building site and walling systems requiring onsite filling by concrete were also considered out of scope. On the other hand, 'hybrid construction' was considered in the current study, if it involved some high level prefabrication.

## Participants and Activities

The manufacturers considered in this paper are undertaking activity within an enclosed weather-proof factory setting. Suppliers that assemble houses or modules offsite in a yard exposed to weather are also discussed as a related group, referred to as offsite assemblers. The term 'builder/s' is used throughout the paper to refer to those intermediaries assembling houses onsite using prefabricated components.

In the case of prefabricated housing, there is not necessarily a clearly distinct role for manufacturers and builders, when a manufacturer may subsume traditional onsite construction tasks, and builders become offsite manufacturers (Blismas & Wakefield, 2009). In the case of fully constructed houses delivered to the building site, or fully constructed modules which are simply placed together, the manufacturer delivers the product to the user often with no significant builder involvement. Builders using prefabricated pods or structural panels to build onsite do however serve this intermediary role between the manufacturers and the end user more clearly

# Aims and Methods

This paper aims to outline the Australian prefabricated housing industry in part by identifying and describing key individual manufacturers and builders using prefabrication innovations. The analysis will also compare the broad housing context in Australia to that of several international jurisdictions.

## Profile of suppliers and intermediaries

The profile of suppliers and manufacturers was undertaken through a search of publicly available information. The Google search engine was used as the primary method of identifying businesses, using key terms comprising prefabricated, manufactured, container, offsite, modern methods of construction, panel, ready made, pre built, pre assembled, factory, modular, industrialised, transportable, and relocatable. Variations of these terms were also included in searches, such as modular and module. These key terms were combined with 'house', 'home', 'apartment' and 'unit' in individual searches.

The additional search terms of 'Australia', the Australian state names or respective abbreviations (e.g. Queensland, Qld), or the ".au" domain name extension were used to limit the scope to Australian-based businesses. The Google search engine automatically expands some of these search terms to include similar terms or variations (e.g. Australia expanding to Australian). It was considered appropriate to use the general Google search for this review given that unlike the published academic literature, the state of the prefabricated housing industry is continually changing. The returned search results were reviewed by the researchers to determine if the businesses and their activities were in scope. The business' publically available information on their websites served as the primary data source. In instances where information was not available or was unclear, businesses were contacted by phone to provide clarification.

A trade association, prefabAUS (2013a) has now been established to act as a portal for the prefabricated construction industry in Australia. The small number of companies listed as members on their website were also reviewed for inclusion in the current review.

Companies or design firms that only showed proof of concept renderings or designs were not considered as part of this review, unless they indicated a partnership with a builder or manufacturer and a capacity to deliver a finished housing product. Companies with activities limited to importing products manufactured outside of Australia were also not considered within the scope of the current review Similarly, companies producing non-structural facades, boards or 'kit home' sets for onsite owner-builders were not considered. Imported and owner-builder products were excluded as they do not contribute directly to the development of an Australian-based manufacturing industry that would support the uptake of prefabrication innovations.

## International policy context comparison

The international policy context comparison sought to compare the macro level influences on Australia's prefabrication market with those in a number of other jurisdictions. The jurisdictions profiled as part of this study were chosen specifically to encompass those that have an acknowledged high application of prefabricated housing (Japan, Sweden) (Barlow et al., 2003), those that have been identified as having both relatively high levels of prefabrication and highly efficient traditional or 'craft based' house-building industries (Germany, Netherlands – see Clarke and Wall (2000) ) and major economies that have comparatively infrequent application of prefabricated housing innovations (United States / United Kingdom). In terms of facilitating

comparison to Australia, the countries are all developed nations and members of the Organisation for Economic Cooperation and Development (OECD, 2013) with relatively strong economies.

A focus was given to empirical evidence available through publicly accessible and verifiable data. This evidence comprised the size of each housing industry; the distribution between social and privately built housing; the types of housing being built (e.g. detached, multi-residential); investment in new housing versus renovations; relevant regulations and governance; key events, and other contextual factors. National statistics departments for each jurisdiction were initially searched for empirical evidence on the uptake of prefabrication and other housing market characteristics. Further searches of building authorities and relevant government departments for each jurisdiction were undertaken where available. Where official statistical information was not found through these sources, basic internet searches using Google and Google Scholar were used to identify data published in academic articles or industry reports. The key events and other contextual factors were less easily quantifiable and by the broad nature of the current review were limited to highlighting only some of the most clearly specified issues. These factors provide an evidence-based and systematic view of a number of key influences on the uptake of prefabricated housing.

# Outline of Australian Industry

This section presents evidence corresponding to each section of the prefabricated housing innovation system. Specific focus is given to the two original data collections consisting of the profile of individual suppliers and intermediaries and the international policy context comparison.

## Suppliers and Intermediaries

### Overview

The review identified a significant number of businesses fulfilling the roles of either a manufacturer supplying prefabricated housing products or a builder applying such products. A summary of the characteristics of the businesses is presented in Table 2. The market penetration of the different business types was ranked as low (a developing industry), moderate (evidence of a significant number of well-established businesses) or high (dominant or prominent use). In the instance of precast concrete panels for multi-residential apartments, a clear list of active businesses was not practical to collect given its almost universal application in large, multi-residential projects (Boyd, Khalfan, & Maqsood, 2012). Excluding this group, 169 individual companies were identified, some having multiple business interests spanning across both manufacturing and building activities, and a range of prefabricated products.

Table 2. *Overview of identified prefabricated housing businesses by business type*

| Business type | n | Market Penetration |
|---|---|---|
| **Manufacturers/Builders** | | |
| Complete houses and finished modules | 74 | Moderate |
| **Manufacturers** | | |
| SIPS panels | 19 | Moderate |
| Precast concrete panels | 30 | Moderate |
| Pods | 9 | Low |
| Other structural panels | 3 | Low |
| **Builders** | | |
| Using SIPs panels | 25 | Low |
| Using precast concrete panels… | | |
| …for detached housing | 11 | Low |
| …for multi-residential apartments | Many | High |
| Using other structural panel systems | 4 | Low |

## Location

In line with the population distribution of Australia, the majority of manufacturers and builders identified in the current review were based along the east coast of Australia, with a strong clustering around the major metropolitan centres of Brisbane, Sydney and Melbourne. Smaller clusters were present around the other state capitals of Perth, Adelaide, Hobart and Darwin. While regional centres such as Broome and Cairns were represented, few distinctly rural or remote locations were the base for businesses. Table 3 shows the summary of active states for prefabricated housing businesses by business type.

Table 3. *Prefabricated housing businesses by business type, by Australian State/Territory*

| Business Type | n[1] | Qld | NSW | Vic | Tas | SA | NT | WA | ACT |
|---|---|---|---|---|---|---|---|---|---|
| **Manufacturers/Builders** | | | | | | | | | |
| Complete houses and finished modules | 74 | 20 | 20 | 19 | 7 | 5 | 2 | 14 | 0 |
| **Manufacturers** | | | | | | | | | |
| SIPS panels | 19 | 10 | 7 | 6 | 1 | 2 | 1 | 6 | 0 |
| Precast concrete panels | 30 | 9 | 9 | 11 | 2 | 3 | 1 | 8 | 0 |
| Pods | 9 | 3 | 2 | 4 | 0 | 0 | 0 | 0 | 0 |
| **Builders** | | | | | | | | | |
| Using SIPs panels | 25 | 6 | 4 | 5 | 1 | 2 | 1 | 6 | 1 |
| Using precast concrete panels… | | | | | | | | | |
| …for detached housing | 11 | 0 | 7 | 2 | 0 | 0 | 0 | 2 | 0 |
| …for multiresidential apartments | Many | - | - | - | - | - | - | - | - |
| …Using other structural panel systems | 4 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |

[1] – Row totals do not equal the group totals size due to businesses being active in multiple states

## Major players

There are several relatively large construction and manufacturing companies adopting prefabricated housing innovations in their processes in Australia.

Hutchinson Builders have three factories producing modular building materials in urban and rural Queensland centres (Yatala and Toowoomba respectively), and in Perth in Western Australia (Hutchinson Builders, 2011). They have a diverse series of building interests ranging from mining camp accommodation to standard homes and multi-accommodation projects. As these interests are supplied by their own factory locations for the production of building materials, they are able to source components more quickly and engage in their own research and development to establish new materials, designs and processes. Hutchinson has also established modular building partnerships such as that used for the architecturally-designed Happy Haus modular structures. Happy Haus is a Brisbane-based company that uses the significant resources of Hutchinson as a production partner to deliver the completed modules (Happy Haus, 2011).

BGC is a large group of companies based in Western Australia with interests spanning residential building; property development; manufacturing of bricks, blocks, insulation and plasterboard; contract mining; transport, and insurance. As such, they have a large number of business interests, including 5 dedicated house building companies as well as an arm of the company specifically producing modular buildings including residential, commercial, and mining quarters (BGC Modular, 2013a). Although they state that they are capable of delivering single home projects, evidence suggests the majority of their work is housing projects in conjunction with resource industry partners such as Rio Tinto to deliver modular houses in townships near major projects. Through an ability to draw on their own companies to source raw materials and sub-assembly products, these projects are delivered through in-house partnerships (BGC Modular, 2013b).The

high production and application of traditional brick building products in Western Australia by BGC is however likely to be a barrier to shifting their focus to prefabricated building methods. Abandoning traditional brick construction would ignore the economies of scale they have established as well as the strong consumer attachment to double-brick housing in the region (Master Tradesman Western Australia, 2013).

Ausco Modular is an affiliate of Algeco Scotsman, an international group of companies specialising in modular space and storage options (Algeco Scotsman, 2013; Ausco Modular, 2013). Ausco is a significant business within the industry, with 12 factories in 5 locations in all the mainland states and territories of Australia. They produce a range of modular buildings including amenity blocks, site offices, classrooms and traditional residential projects. Their modular residential housing business is currently only focused on the West Australian market and produces detached houses, townhouses and apartment blocks. While not focused exclusively on income from housing, they are well placed to have input into the developing the industry through their existing infrastructure.

By their nature, multi-residential projects such as apartment blocks are large in both scope and costs. A small number of such projects have been undertaken in Australia recently by major construction firms. For example, Lend Lease was the construction partner for the 10 storey 27 apartment Forte development recently completed in Melbourne. This project utilised prefabricated Cross Laminated Timber panels imported from Europe and then assembled together onsite to create what is being promoted as the world's tallest timber high rise apartment. While this method of construction has been used on more than 20,000 projects in Europe, predominantly in the last decade, it is only now being applied in Australia (Collins, 2013). Lend Lease is well positioned to push for future prefabricated projects, given their worldwide business interests in large scale residential, commercial and infrastructure construction and large number of staff and partners. They additionally already promote their use of prefabricated modules in the construction of hotels and resorts (Lend Lease, 2011).

The Hickory Group and their Unitised Building system have also shown the utility of using modular, shipping container like structures to build medium and high-rise residential facilities in Australia. This developing modular method is notable for its adoption of a very high level of prefabrication. These modules are produced in their own factory, which operates using robotics and assembly line processes (Boyd et al., 2012). From their first Little Hero prototype apartment block in Melbourne, they have successfully completed several other projects including the 3:East building which was installed in just 11 days of onsite work (Hickory Group, 2013a). Their KLIK range of modules expands this concept further, using a series of predefined designs which can be combined together to form structures ranging beyond apartment blocks to detached houses. The flexibility of their build system also extends beyond residential purposes to industrial applications such as a power station terminal in regional Victoria.

In summarising the nature of these large-scale businesses interests in the prefabricated housing market within Australia, there is a common thread: the residential component of their business does not represent their sole source of income. Diversification of products either in terms of concurrent international business interests, or in non-residential construction projects is common.

## Potential major players

There are also a number of large organisations that develop prefabricated solutions, but which do not currently directly target the traditional housing market. As an example, APB modular, who assemble a range of building products from classrooms to hospitals to mining camps, would potentially have the ability to adapt as they already have established manufacturing facilities nationwide in Sydney, Brisbane, Townsville and Perth (APB Modular, 2010). Similarly, BRB

Modular is a public company in Australia that produces relocatable buildings primarily for the government and commercial markets. They have also been involved in one-off projects building remote, modular housing and partnering with developers for display housing villages (BRB Modular, 2013), showing the potential for such businesses to adapt to serve the residential market. Whether other non-residential prefabricated building suppliers which currently produce disposable or relocatable buildings can adapt to produce longer-lasting housing remains to be seen.

Sekisui House, one of the largest Japanese prefabricated housing manufacturers, has also recently moved into the Australian market. In 2010, the company purchased the contract homes division of the Australian-owned building company AV Jennings and at the time of writing had extended their business to Queensland, New South Wales and the ACT (Sekisui House Australia, 2013b). Since moving into the Australian market, they have begun a business alliance agreement with the developer Lend Lease and begun work on several master planned housing communities including their Ripley Valley estate in south-east Queensland which claims to be Australia's "first sustainable village" (overlooking the award-winning Currumbin Ecovillage). Like their original operations in Japan, they have begun to establish factories to prefabricate building materials such as the one already existing in Ingleburn outside Sydney. Unlike their Japanese operations they are not yet building fully factory-produced homes, instead relying on their Shawood building system which uses precut timber frames assembled onsite (Sekisui House Australia, 2013a). As a large company with significant capital and assets, no reliance on income from the small Australian market, and with a history of innovation in building practices, they have ample opportunity to drive greater practice of prefabrication in Australia.

## Complete house and finished module manufacturers/builders

The current review identified a substantial industry in Australia producing prefabricated volumetric units for detached housing, commonly referring to the products as transportable, manufactured or modular homes. Each of these terms generally refers to houses which are typically shipped to site on a flat-bed truck as a whole unit, or as a series of 2-4 large modules which join together to form the final dwelling. The current review identified 74 companies working with this model of building that operated from undercover offsite factories (e.g. Ecoliv, 2013; Glendale Homes, 2013; Modscape, 2013; Prebuilt, 2013b; Swanbuild, 2013). Onsite activities are kept to a minimum, as exemplified by Glendale Homes (2012) promoting their houses as "*absolutely complete, ready to connect to your services, and move in!*". The traditional builder's role is assumed by an in-house installation team that can complete the process of placing and joining the modules the same day as they are delivered to the prepared building site (e.g. Hoek Modular Homes, 2013; MBSWA, 2012; Modscape, 2013). The onsite building processes primarily constitutes crane operation or other methods to place the modules (or entire house) onsite and basic connections to services such as water and power. These companies are thus not supplying housing modules as a product for use by other builders but are rather using it as their own building process to deliver complete products.

As with the major players these businesses also commonly held broader commercial interests such as the construction of holiday park cabins, worker accommodation, school buildings or ablution blocks as shown in Table 4. While such activities are out of scope for the current investigation, they do signal an overlap between the participants in the prefabricated residential and non-residential markets.

Table 4. *Product types supplied by modular manufacturers/builders (n=74)*

| Product type | n[1] | % |
|---|---|---|
| Houses | 74 | 100.0 |
| Granny flats / extensions / cabins | 42 | 56.8 |
| Commercial / industrial builds | 37 | 50.0 |
| Mining camp services | 18 | 24.3 |

[1] – Category totals do not equal the total sample size due to the categories not being mutually exclusive

These companies typically constructed their houses in a traditional manner inside the factory setting, with little automation. Traditional framing methods such as timber and steel co-dominated, with the application of upstream prefabricated panel elements uncommon, as shown in Table 5.

Table 5. *Structural framing system used by modular manufacturers/builders (n=74)*

| Structural framing system | n[1] | % |
|---|---|---|
| Timber | 38 | 51.4 |
| Steel | 39 | 52.7 |
| Structural panel | 5 | 6.8 |
| Other (e.g. zinc alumina) | 3 | 4.1 |

[1] – Category totals do not equal the total sample size due to the categories not being mutually exclusive

While the geographic distribution of businesses outlined earlier noted few businesses in rural locations, there are a small number of exceptions. Remote Building Solutions (2013), with a manufacturing plant based in Cairns, reported being able to specifically service extremely remote locations such as the Gulf of Carpentaria to the far north-west of the state of Queensland with transportable houses. Similarly, Austwide Homes (2013a), based in the New South Wales (NSW) town of Wagga Wagga note that they can supply to a significant area covering the entirety of the coastal areas of Southern NSW and northern Victoria. The market for new houses in Tasmania is relatively minor compared to the large urban centres on the Australian mainland, and this may be reflected in a number of companies offering transportable house solutions which can be delivered to a larger geographic area (Tasbuilt Homes, 2013; Tassie Homes, 2013). One such example is Tassie Homes, who deliver a range of traditional-build and transportable homes from their own building centre. As noted with several of the other companies already discussed, the house construction business in this case is just one arm of a larger company, in this case managing a quarry and offering machinery hire (Edwards Trading Company, 2012).

## Dual traditional / prefabricated builders

There were a number of businesses employing both traditional and prefabricated building methods. For instance, Summit North West, a part of the Summit Homes Group based in the northern regions of Western Australia, offer a choice of both onsite built homes as well as modular steel-framed homes (Summit North West, 2013). Perth-based Norfolk Homes similarly utilises a variety of building methods including steel frame, brick veneer, and an insulated panel system using an expanded polystyrene core (Norfolk Homes, 2013). Melbourne-based Arkit offers both a site-built S-Series and a factory-built F-Series for their architect designed prefabricated houses. Both of these methods use the same prefabricated wood panels in the build process (Arkit, 2007, 2013), but allow

adaptability to challenging building sites. Similarly, Unique Modular Buildings (2013) state that they can arrange to build onsite instead of using offsite modular methods in circumstances where a truck or crane cannot access the site. These businesses highlight (1) how traditional builders with enough capital can expand their operations to include prefabrication innovations, (2) how factory-based builders using a panellised approach can shift the assembly processes onsite to improve efficiency, and (3) how those builders using traditional building methods in a factory do not have to abandon onsite work.

## Offsite assemblers

Outside of the factory-based manufacturers, a small group of 13 outdoor offsite assemblers were also identified during the review. These businesses produced either complete houses or large housing modules in their own weather-exposed yard settings (e.g. Austwide Homes, 2013a; Hassall Free Homes, 2013; Rod Stephens Modular Homes, 2009). They were nearly evenly divided between urban and rural locations. While not having the same advantages as a covered factory with regard to weather or vandalism, these businesses have the potential to adopt factory-based processes. The use of a common yard for construction alone would foster advantages such as centralising staff and reducing travel times to and from building sites, without incurring the establishment costs associated with building or hiring a factory location.

## Panel manufacturers

*Structural insulated panels*

There is a significant and growing industry in Australia manufacturing structural panels for use in housing. A number of the large companies within this business space are international companies with local operations servicing the domestic Australian market. Bondor is a large manufacturing company in Australia, operating as part of the worldwide Metecno Group, which produces foam inline panels for the North American, European, South American, and Asian markets (Metecno Group, 2011). In Australia, they have manufacturing facilities and offices near the capital cities of all Australian states (excluding the Northern and Australian Capital Territories) (Bondor, 2011). Bondor's housing-specific products include their integrated InsulLiving system consisting of load bearing insulated wall panels and roofing panels. Bondor's reliance on the housing market for income is limited, with their products targeting a broad range of markets including agricultural, industrial, storage, and applications.

The Kingspan group produces building products, including insulated panels, at multiple sites across mainland Europe and the United Kingdom, and in Canada and the United States (Kingspan, 2013). Their locally-based major manufacturing plant is in western Sydney, with sales offices in all mainland states. As such, they market themselves as 'global leaders' in the provision of insulated wall and roof panels and facades. Their 2011 annual report noted a 20% growth in orders and dispatches of insulated panels for the Australasia region, though this was not specific to residential applications (Kingspan, 2012).

Another emerging manufacturer of materials is Pearls MiiHome, operating from a large factory facility based at Coomera between Brisbane and the Gold Coast. They specialise in the production of modular building systems for residential housing, the resource industry sector and temporary and emergency housing (Pearls MiiHome, 2013). The company is backed by the Pearls Global group of companies, based in India (Pearls Australasia, 2013). They are able to provide structural panels, as well as fully constructed building and housing modules. They have particularly focused on in-house research and development, using their own architectural designers and construction managers to oversee entire projects from development, to fabrication, to onsite installation. They have recently also acquired the insulated panel manufacturing arm of Retracom, a local

Queensland-based business also supplying transportable buildings. They have partnered with government organisations to (1) quickly deliver housing after the 2011 floods in Queensland; (2) build permanent, modular housing for a rail-company to house their staff in central Queensland, and (3) supply affordable social housing options through the Brisbane Housing Company.

ASKIN is a group of companies, formed in 2013 as a result of the joining of a number of panel and foam core manufacturers which in the majority formerly sat under the banner of Austral Australia. They are self-promoted as the "largest manufacturer and installer of insulated, fire rated and architectural facade systems, roofing systems and temperature controlled facilities in Australasia" (Askin, 2013) and have 7 sites based in each mainland state of Australia and the Northern Territory. As with several of the other companies discussed in this section, Askin has primarily applied their products to large scale commercial projects. This has been facilitated using their in-house engineering team for research and development along with a team of installers that can actively take part in construction as well as manage projects.

SIPS Industries (2013), has also expanded into the Australian market from its UK origins and established itself with a Perth facility, after having already established a South African office. The company is also seeking to open offices on the east coast of Australia to better serve the current large population centres. Their list of projects covers both commercial builds as well as residential extensions and complete house builds.

The large companies discussed above operate at a level above smaller suppliers in terms of their scope, financial backing and opportunities to engage in internal research and development, without necessarily engaging with other businesses to apply their end products. For smaller companies, there are existing opportunities to supply materials direct to the public or small builder, as is done by Austech Panel Systems (2008), who manufacture their own Sustainable Insulated Panels and are able to fill orders for small scale jobs. The company has taken advantage of the high insulation performance of SIPs panels and applied their materials for use in a sustainable housing estate in a New South Wales alpine region (Samanita Developments, 2011). The focus of the company also extends to the industrial application of the insulated panels for coolrooms and other temperature controlled areas. There is the potential for these products to find niche residential applications, such as the Panelphen fire-retardant panel for bushfire resistant buildings.

Other smaller companies include Structural Panels Australia (2013), which operate from their own CNC (Computer Numerical Control) enabled processing factory in Melbourne, Versiclad (2012) from Moorebank in New South Wales that manufacture a large range of prefabricated materials including insulated wall panels and sound-absorbing barriers and Paneco (2012), a Queensland company based in the Brisbane suburb of Eagle Farm producing structural, foam-cored Magnesium Oxide boards specifically targeting home builders. Of particular note with Paneco is that they stipulate that any builder utilising the panels for a first-time installation will be subject to mandatory supervision to ensure their product is installed appropriately.

Other smaller companies such as Paneltech (2013) develop insulated panels but primarily target industrial applications. Having said this, they also specifically promote the distribution of kit homes as part of their Shack in a Pack system utilising prefabricated structural roof and wall panels (Shack in a Pack, 2013), as well as promoting the use of their products for house extensions. Indeed, there is a substantial ability for primarily commercial or industrial construction companies to apply their knowledge regarding the use of insulated panels in contexts such as coolrooms or food supply to the construction of residences as is the case with SBP construction (2011) in Brisbane.

There is thus a strong core of both major and smaller operations producing SIPs panels for the Australian market. While the manufacturers, with the exception of Bondor, are not generally

focused on residential applications, there is significant scope for this segment to grow.

*Precast concrete panel manufacturers*

There are several large companies producing precast concrete panels for residential applications. Boral Precast estimates that it holds the top market position for precast concrete in Australia, alongside its other construction interests in formwork, scaffolding and windows. They have acquired and commission work from five manufacturing sites: four based in major east coast centres and one in Perth. Austral Precast similarly have factories across four Australian states that produce load bearing walls, floors, parapets and beams for use in construction (Austral Precast, 2013). Austral and Boral's precast divisions are part of much larger companies which also produce traditional building products such as bricks. The majority of the residential applications of their precast products are in the multi-residential sector, and they also have significant interests in the industrial and commercial construction sectors. All of the 30 precast concrete panel manufacturers identified in the current review were suppliers for multi-residential build projects.

There is some evidence of the application of pre-cast concrete panels to the detached housing market increasing gradually. Formcraft, a Western Australian based company supplies SIPs panels along with insulated concrete forms and walls to residential, commercial and resource sector projects. As a means to linking with other members of the construction industry, they provide a training and accreditation program specifically for the use of their products (Formcraft, 2013). Other examples include (1) Victorian-based Profast which has partnered on specific projects with local builders that also typically use traditional building methods (Profast, 2013); (2) The Precasters in Tasmania whose products are being used for residential home applications alongside larger commercial, marine and civil projects (The Precasters, 2011); and (3) Monarch Building north of Brisbane that produce finished structural wall panels for project housing using their own lightweight concrete Calsonite material (Monarch Building, 2013).

Pre-cast concrete manufacturers can be broadly characterised as having substantial input to commercial and industrial builds, with comparatively little input to the residential housing market outside of multi-residential developments.

## Builders using panels

The specific promotion of house builders' use of SIPs is not common outside of a small number of businesses with a sustainability focus, with only a total of 25 such builders identified. While there are almost certainly builders who have utilised SIPs on housing projects outside of this identified group, this core group actively promote the use of the products, rather than circumstantial or one-off use of the innovation. The aforementioned InsulLiving system by Bondor is promoted through their own InsulLiving Builders Network, which currently lists a small group of 18 affiliated builders nationally. These include both modular builders employing the products within larger prefabricated products, as well as traditional onsite builders adopting the panellised method. These builders are typically producing single-level, detached houses using the panels. Whether this network model between manufacturers and builders will encourage uptake of Bondor's innovation and SIPs more generally remains to be seen, and is the subject of further research to begin in 2014.

Outside of this network, few other builders using SIPs as part of their business model were identified. Bellisimo Homes (2013) in Perth publically promote their use of Paneco Magnesium Oxide (MgO) structural panels. It is worth noting that the manufacturer of these panels is based on the east coast of Australia in Brisbane, more than 3500km in a direct line from Perth, and considerably more by road or rail transportation. A more geographically co-located partnership exists with the previously mentioned Pearls Miihome and Brisbane-based Prospect Builders through

the Insulated Panel Homes (2012) branding.

As mentioned above, the majority of the precast panel manufacturers in Australia target the multi-residential section. The method is "currently fundamental to most apartment building construction, although it is limited to a more refined use in external walls" (Boyd et al., 2012, p51). The National Precast Concrete Association of Australia (NPCAA) project gallery shows a significant number of recent precast multi-residential projects, most undertaken by large multinational building firms such as Brookfield Multiplex (e.g. Rowlands Apartments, Adelaide), ABI Group (e.g. Atherton Gardens Social Housing Estate, Fitzroy), Mirvac (e.g. Panorama Luxury Apartments, Perth) and Grocon (e.g. Oracle Apartments, Broadbeach) (NPCAA, 2013). In line with this, Boral's internal documents note that precast's penetration is mature for industrial applications, strong in high-rise multi-residential, increasing in low-rise and niche detached dwellings, and only just starting to be applied to project housing (Boral, 2010). Smaller scale multi-residential and standalone houses are however feasible with precast concrete, as evidenced by Baseline Constructions' projects in Sydney producing a set of terrace houses (NPCAA, 2008) and the Small House, a single vertically-oriented house built in a narrow laneway (NPCAA, 2011).

The use of precast concrete in detached housing remains novel, with the example Hillside project built in the Adelaide Hills using concrete sandwich panels between 2009 and 2011 being the first such house to be built in South Australia (Hillside Project, 2011). Perth-based Richard Harris Homes (2013) attributes the low uptake to the greater costs involved in precast, stating: "*To be cost effective a concrete house must be 2 storeys or more. If you compare houses of a similar size and specification, the concrete house will be cheaper to build.*" In a similar fashion to Bondor's network for its SIPs product, there is a small network of precast panel housing businesses under the Panel Homes Australia branding, which at the time of writing has 7 franchisees servicing New South Wales and Victorian coastal regions (Panel Homes Australia, 2013). This franchisee model allows for the sharing of a set of house designs tailored for precast, and also provides support in applying for permitting and building assessments. As with the Bondor network, further evidence is required regarding the effectiveness of franchising as a means to promote specific prefabrication technologies.

A small number of builders were identified employing internally-devised panel systems in the build process such as Gumpy Homes plantation wood, tilt-up panels (Gumpy Homes, 2013), Arkit's insulated, short-length timber panels (Arkit, 2007) and mgwHomes' use of imported German Baufritz prefabricated timber products. They claim that "a Baufritz home has 1/5th to 1/50th the carbon impact of the average Australian home and that includes transporting it from Germany" (mgwHomes, 2011). While such a claim could be contested, mgwHomes concede that greater benefits will be realised once local production of the building materials begins.

The results of the current review suggest that, with the exception of the multi-residential sector's use of precast concrete, there has not been substantial uptake of panellised methods in the Australian residential markets, or at least little promotion of the use of these products. The establishment of supportive networks of builders forming around specific products may however indicate a growing market.

## Pod manufacturers

The review only identified a small group of 9 businesses producing pods such as separate wet area modules to integrate into a house build. A distinguishing characteristic of the products delivered by some of these companies was the ability to deliver the products either as fully-assembled and finished volumetric modules that could be positioned and connected, or as disassembled flat-packs

that facilitate transferring sub-assembly elements through smaller openings in existing housing (e.g. Bathroom In A Box, 2013; pub Bathrooms, 2010).

The utility of wet-area pods for the multi-residential market in Australia is highlighted by Sync Building Systems, a subsidiary of the Hickory Group which also includes the modular high-rise Unitised Building business. Sync is providing 794 prefabricated bathroom pods for a 65 storey residential building in central Melbourne, harnessing the potential economies of scale which can be generated for large-scale prefabrication (Hickory Group, 2013b). Similarly, Queensland-based Project Modular (2013) has highlighted the ability of their prefabricated bathroom modules to integrate with differing build methods by acting as the supplier of bathroom units for the previously mentioned Forte timber-high rise constructed by Lend Lease.

SIPs have also been integrated into pod products by Tensor Building Technologies (2013). A part of the larger international Winport Group of companies, they produce their own wall and panel systems in a factory setting. Targeting both residential and commercial markets, they use their own panel systems to produce a range of pods including powder rooms, bathrooms and kitchens. Through the use of their own structural component elements, freedom is given to custom designed layouts within the bounds of the volumetric pods.

While it is difficult to characterise the few producers of pods in Australia, the opportunity for the repeated application of pods to multi-residential projects is of particular relevance to prefabrication uptake.

## Summary of company characteristics

There are a small number of major players invested in the residential prefabrication market in Australia, yet this constitutes only a small part of their total business interests. While there are a substantial number of companies with a primary interest in delivering complete and modular prefabricated housing products, these companies have largely just moved their onsite processes into a factory setting without significant redesign of either their processes or materials. There are also a relatively small number of businesses producing SIPs with applications to the housing market. Though there is less evidence of the widespread use of these manufactured products in houses, networks of builders using SIPs are beginning to form.

The multi-residential apartment construction industry in Australia frequently employs precast concrete panels as a prefabrication innovation, but this has as yet not significantly trickled down to smaller projects and detached house builds. There is currently a minor market for the production of specialised pods for incorporation in existing builds, also with a focus on multi-residential application. There is limited evidence to suggest that such businesses may grow with a greater application of modular systems to the multi-residential sector, though this may be more likely to grow as part of in-house developments as it has for Unitised Building.

Across all of the businesses discussed within this section, the diversification of the industry is clear. Both the small and large businesses producing prefabricated houses or modules also produce other buildings for use in a variety of industrial and commercial applications. The same can be said for the structural panel and precast manufacturers, with frequent cross-over application to other business segments.

## Supplying of raw materials

A number of the companies discussed in the above review that produce structural materials such as SIPs have their own building arms, though there is not widespread evidence as to a high adoption among individual house builders. Traditional upstream material suppliers are commonly used in the

manufacture of prefabricated products like SIPS, as evidenced by relationships with key construction industry suppliers such as CSR for concrete or plasterboard products, and Hynes for timber bracing materials (Tensor Building Technologies, 2013; Versiclad, 2012). Large groups of businesses such as BGC, which control companies producing raw materials as well as construction arms, show the potential for vertical integration in prefabricated building which benefits from internal product development and research (BGC Modular, 2013a). Alternatively, this may be a barrier in that these companies are heavily invested in traditional materials and have little motivation to adopt construction methods using alternative materials. While issues specific to the supply of materials for prefabricated houses in Australia have not been frequently discussed in the academic literature, one such issue is that builders based in more remote locations away from the heavily-populated east coast may suffer delays or shortages in accessing required materials (Blismas & Wakefield, 2009). These delays are however also common for traditionally built projects. This could however be a potential strength for those companies providing volumetric housing products, in that they can transport completed modules from central urban factories to remote housing sites. Prefabricated panel structures with predefined sizings would have similar benefits by providing a greater degree of certainty to those suppliers providing other products to be integrated into builds.

## Users

The future success of prefabricated house building in Australia has been suggested to lie in the "*co-dependency on public acceptance, volume production and distribution infrastructure*" (Luther, Moreschini, & Pallot, 2012, p3). Any potential impacts on house-purchasers need to be clearly considered as they directly support the manufacturers and intermediaries using prefabricated housing innovations. The Australian construction industry is generally conservative towards innovations such as prefabrication, highlighting a lack of consumer demand for alternative building methods. The Construction and Property Services Industry Skills Council (CPSISC) have stated there are few perceived benefits of prefabrication that builders can sell to consumers to offset any reservations they may hold (The C. I. E., 2013). Despite these comments, there is no empirical research specifically assessing the attitudes of Australian consumers towards prefabricated housing.

A number of organisations reporting a poor consumer preference have a vested interest in doing so. This sets up a 'chicken-and-egg' scenario whereby the builders and developers who could potentially drive customer uptake are either not well placed or not willing to adopt prefabricated housing innovations in the first place. There is recognition from those companies wishing to break into the prefabricated market in Australia that they need to allay consumer concerns. For instance Sekisui House has been quick to distance themselves from perceptions of 'bland' prefabricated housing, noting that their houses will be built on site using factory-made materials to an individual's specifications (Chong, 2011). Poor consumer sentiment was present in the early years after the introduction of prefabricated housing in Japan (Noguchi, 2003). Even if this issue currently appears insurmountable, the current high use of prefabrication in Japanese housing stands as a testimony to this not being the case.

# Policy Context

The results of the examination of contextual factors in a number of international jurisdictions are presented in Table 6, with the corresponding references for each of the parenthesised identifiers (e.g. **[A1]** ) presented in Appendix 1.

Table 6. Prefabrication usage and contextual factors of the housing market

| Prefabrication | Annual dwelling completions[1] | Social vs. private housing | House types | New vs. Renovations | Regulations | Key events | Contextual Factors |
|---|---|---|---|---|---|---|---|
| **Australia** | | | | | | | |
| • Estimated that less than 5% of the new housing market uses prefabrication **[A1]**<br>• Variety of methods, with a dominance of whole house prefabrication | 144,336 **[A2]** | • 3% of new builds not accounted for by the private sector **[A2]**<br>• 4% of all houses are rented from a state or territory housing authority **[A3]** | New residential builds:<br>- 75% detached houses<br>- 14% multi-residential<br>- 9% semi-detached **[A3]** | • 17% of the value of residential building work in Australia is accounted for by alterations, additions or conversions **[A4]** | • Construction Code focus on 'all onsite requirements' with little mention of offsite activities **[A5]**<br>• Energy Efficiency Provisions for Housing exist in the code **[A6]** | • Currently slowing housing market compared to historical averages **[A2]** | • Many small operators with a core of high revenue businesses **[A7]**<br>• Speculative house purchasing and decreasing housing affordability **[A8]**<br>• Low skill, fluctuating labour market **[A9]** |
| **Japan** | | | | | | | |
| • 12-15% of new houses prefabricated **[J1]**<br>• Prefabrication of whole houses and components<br>• Variety of methods and materials used **[J2]** | 882,797 **[J3]**<br>Ratio to Australia: **6.1** | • 80-85% of newly constructed house dwellings are privately financed **[J3/J4]** | • New prefabricated housing units **[J1]**<br>- 46% detached<br>- 35% apartments<br>- 19% rowhouses | • Housing costs breakdown:<br>- 94% new building<br>- 6% extensions or reconstruction<br>• High 'scrap and re-build' ratio **[J5/J6]** | • High house performance standards adopted after earthquakes<br>• 10 year warranty on house manufacturing **[J6]** | • Prefabrication peak at 20% of housing in 1990's<br>• Housing bubble burst in the 1990s, leading to a declining housing market **[J6]** | • High labour costs<br>• High level of research and development **[J7]**<br>• High private land ownership<br>• Preference for modern, fresh housing **[J8]** |
| **Sweden** | | | | | | | |
| • Approx. 50-90% offsite house building historically **[S1/S2]**<br>• Greatest application in private, detached homes **[S3]** | 25,993 **[S4]**<br>Ratio to Australia: **0.2** | • Public construction accounts for 50% of new rentals **[S5]**<br>• Of new dwellings, percentage privately owned:<br>- houses: 95%<br>- apartments: 24% **[S6]** | • New housing units<br>- 64% multi-dwelling<br>- 30% detached<br>- 6% terraced or semi-attached **[S7]** | • 68% of total housing investment on renovations and extensions **[C1]** | • Building subsidies are provided encouraging cartels, the dominance of a small number of firms, and limiting innovation **[S5]** | • Historical use of concrete prefabricated houses for social housing programs **[S8]** | • High construction union membership<br>• High relative construction costs for Europe **[S5]** |

| Prefabrication | Annual dwelling completions[1] | Social vs. private housing | House types | New vs. Renovations | Regulations | Key events | Contextual Factors |
|---|---|---|---|---|---|---|---|
| **Germany** | | | | | | | |
| • 9% of new residential building permits are for prefabricated buildings<br>• 15% prefabrication for 1-2 dwelling buildings, 2% for 3+ dwellings **[G1/G2]** | 161,186 **[G3]**<br>Ratio to Australia: **1.1** | • 6% of new builds are subsidized for social housing<br>• Declining social housing stock **[G3]** | • New housing units<br>- 50% in buildings with 1 or 2 dwellings<br>- 45% 3+ dwellings<br>- 5% other **[G3]** | • Approx. 50% of housing construction output is for repairs, maintenance, extensions and other improvements **[G3]** | • Incentives provided for energy efficient house building **[G4]** | • Historical, post-war use of concrete panel housing<br>• House construction reduced since 1990s **[G3]** | • Skilled work-force **[A2]**<br>• Long period of research and development<br>• Low home-ownership and a high level of self-procured housing **[G5]** |
| **Netherlands** | | | | | | | |
| • Little specific evidence on uptake<br>• Construction methods: 40% onsite tunnel form, 40% onsite brick and block, 20% offsite wood or concrete prefabrication **[C2]** | 57,703 **[N1]**<br>Ratio to Australia: **0.4** | • Building project costs:<br>- 78% private clients<br>- 19% public housing<br>- 3% built for market **[N2]** | • New houses<br>- 55-60% single family houses<br>- 40-45% multi-family houses **[N1]** | • 51% of total housing investment on renovations and extensions **[C1]** | • Historical collusion and government direction, with little product innovation **[N3]**<br>• Established and active federal sustainable development policy **[N4]** | • Recent tightening of regulations concerning collusion due to European Union directive **[N5]** | • Task-based, construction labour force<br>• Stagnating of the market associated with privatisation **[N3]** |
| **United States** | | | | | | | |
| • 4% of single-family houses are built offsite<br>• Declining use of offsite methods **[US1]**<br>• 7% of all dwellings are manufactured or mobile housing [**US2]** | 638,000 **[US1]**<br>Ratio to Australia: **4.4** | • Public housing accounts for 1-2% of all dwellings **[US3]** | • New housing units<br>- 74% single family<br>- 25% multi-family<br>- 1% town houses **[US1]** | • 33% of the value of new residential construction is spent again on additions, renovations and repairs **[US4]** | • Site-built and modular houses covered by various state codes<br>• Manufactured or mobile homes covered by separate Housing and Urban Development (HUD) code **[US5]** | • New house construction in decline due to sub-prime mortgage crisis **[US1]** | • Low investment in research and development<br>• Comparatively low skill workforce **[US6]** |

| Prefabrication | Annual dwelling completions[1] | Social vs. private housing | House types | New vs. Renovations | Regulations | Key events | Contextual Factors |
|---|---|---|---|---|---|---|---|
| **UK / England** | | | | | | | |
| • 2% of the value of the entire construction sector (including civil works) is attributable to offsite work **[UK1]** | 143,580 **[UK2]**<br>Ratio to Australia: **1.0** | • Permanent house builds<br>- 75-80% of completions by private enterprise<br>- 20-25% social housing authorities **[UK2]** | • Detached houses a minority of existing stock<br>• 60-70% of new builds are 'houses' as opposed to 'flats' **[UK3]** | • Approximately 50% of housing construction output value is for maintenance, extensions and improvements **[UK4]** | • Building code 'Part L' targets energy efficiency **[UK5]**<br>• New construction products / systems need to be certified **[UK6]** | •Sharp decline in house construction since 2007<br>• Prefab use in post-war rebuilding **[UK7]** | • High proportion of speculative land acquisition and building **[G5]**<br>• Comparatively low skill workforce **[C2]** |

[1] – Dwelling completion figures are for the 2012 financial year, with the exception of 2011 figures reported for Germany and the Netherlands

The data in Table 1 highlight a number of factors which may support the development or reinforcement of a prefabricated housing industry.

Although financial crises have been universally associated with a reduction in the number of new houses produced, there is a less clear relationship with the prefabricated housing industry. While the Japanese asset price bubble crisis of the early 1990s caused a sharp decline in new builds, the proportion of prefabricated housing actually temporarily increased to an historic high near 20% before plateauing at a slightly lower level (Togo, 2010). Similarly, the slowing housing market associated with the Global Financial Crisis events of 2007 and 2008 actually resulted in a higher proportional uptake of prefabrication in Japan (Japanese Prefabricated Construction Suppliers and Manufacturers Association, 2013). German data shows that prefabrication as a proportion of the total housing market has remained relatively stable around 9% despite significant variation in the total number of dwellings built (Federal Statistics Office Germany, 2013a). Finally, while US data shows a specific decline in prefabricated versus site-built housing, this has been a long-term trend not correlated with the economic crisis (George & Yankausas, 2011; U. S. Census Bureau, 2012b). Since the middle of 2010, the housing market in Australia has also been contracting, including consistent downward trends in new builds of both detached houses and apartments. In line with this, the construction industry has become less profitable overall with rising operating costs and lowering profits (Australian Industry Group, 2013). The international evidence suggests that established prefabricated housing industries are differentially affected by the recent economic crises, though the likely impact on a still developing industry such as in Australia remains unclear. These observations are crude correlations that may be affected by a number of other economic factors and should be interpreted cautiously.

A distinct characteristic of the Japanese housing market is the historically high ‘scrap and re-build’ rate which has allowed greater opportunity for specific research and development into modern construction methods and prefabrication (Togo, 2010). The sheer number of new dwellings built in Japan annually is currently more than 6 times that of the UK and 1.4 times that of the much more populous US (GOV.UK, 2013; Statistics Japan, 2011; U. S. Census Bureau, 2012b). Germany’s prefabricated housing industry has developed gradually over many years including heavy investment in panellised construction during the 1950’s and 60’s (Venables & Courtney, 2004). The U.S. housing industry has been typified by a low level of investment in research and development (Hirschey, Skiba, & Wintoki, 2012; Spencer & Nagarajaiah, 2003) and prefabrication, despite its large size. The Australian industry and similarly sized UK housing industry both predominantly use traditional build methods and may suffer from less scope for experimentation with prefabrication. Industry size alone is however unlikely to account for the difference given Sweden’s higher uptake of prefabrication and their much smaller annual housing output compared to Australia.

Outside of formal ‘scrap and re-build’ policies, historical periods of rapid building using prefabrication have occurred in several of the profiled jurisdictions. Timber, steel and aluminium framed houses were erected post-war in the United Kingdom; concrete and panel structures dominated rebuilding efforts in Germany post-war (Goulding & Arif, 2013), and concrete prefabrication was applied heavily in Sweden during a state-constructed housing push (Hall & Vidén, 2005). While the Japanese consumer preference for new or ‘fresh’ products has led to an embracing of prefabrication (Johnson, 2007), there is a prevailing negative view held towards the rapidly-built post-war houses in the UK. The quality of the housing products themselves may

also be a substantial influence here, with the UK post-war housing being intentionally designed as a temporary measure to only last 10 years (Goulding & Arif, 2013). Australia has never had a universal rebuild phase or nationwide push for rapidly-built housing on the same scale that would either entrench prefabrication methods or provide an opportunity for consumers to form a clear viewpoint either way.

The evidence regarding the impact of social housing on prefabrication is not clear from the current evidence. No clear correlation between the proportion of social housing and prefabrication uptake is present. The UK has one of the highest levels of social housing but a very low level of prefabrication, while the reverse is true for Germany. Sweden likewise has a high rate of both social housing and prefabrication. These data points all indicate no clear correlation. In Sweden prefabrication coexists with the largely privately owned detached house market. Australia has a similarly predominant privately owned detached house market. One could cautiously suggest that this situation may be a good base for prefabrication uptake, though it is difficult to directly equate the substantially different Swedish and Australian markets, and difficult to ignore the benefits of economies of scale in multi-residential developments.

The processes involved in procuring houses in each of the jurisdictions may also have a substantial impact on the house-building market. While in Japan and Germany, there is a relatively common procurement of land and houses by individual owners, speculative land acquisition and house-building by developers is far more common in the UK, US and Australia (Johnson, 2007; Select Committee on Housing Affordability in Australia, 2008; Venables & Courtney, 2004). Speculation has been directly linked to the shortfall in housing in Australia. While speculative developers profit by turning over houses as quickly as possible with little risk and no long term interest in product quality or performance, individual owners building on their self-procured land may be substantially more motivated to research different build methods to meet long-term whole-of-life needs. Further efforts to encourage less short-term profit-driven development and encourage new innovative methods are required in Australia. The consistent shortfall in supply and consequent low affordability of housing in Australia (Gurran, Milligan, Baker, Bugg, & Christensen, 2008; Luther, 2009) presents an opportunity for the introduction of a high-quality prefabricated alternative. The executive director of prefabricated builder Sekisui House Australia has noted "*a growing population, stable demand for housing, a marked growth in demand, and a market with potential for future economic development*" (Blundell, 2010).

The nature of the construction labour market in each of the jurisdictions may also be a significant source of the variation in uptake of prefabrication methods. A common thread between the high prefabrication users of Japan (12%), Sweden (50%), Germany (15%) and the Netherlands (20%) is the comparatively high use of skilled, high-cost labour, which is in contrast to the greater use of untrained labourers within the U.K. and U.S (Clarke & Wall, 2000). The result is that greater specialisation and clearly defined skill sets typify the construction labour market in Germany and the Netherlands. With prefabrication noted for its lower tolerance levels, potentially greater build complexity, and faster execution times, a specially-trained higher-cost workforce is likely to better facilitate industry development than untrained labourers. The ability to train the Australian workforce is compromised by excessive volatility occasioned by the large number of small business operators (Blismas, Wakefield, & Hauser, 2010; Dalton, Chhetri, Corcoran, Groenhart, & Horne, 2011). While there is a threat of resistance against the specialisation of trades to prefabricated methods in Australia from unions and industry bodies (Daly, 2009), the workforce

has already experienced a strong growth in specialisation and sub-contracting starting in the 1990s and continuing today (McGrath-Champ, Rosewarne, & Rittau, 2010; Toner, 2000). The debate continues over whether training programs should focus on specialised and targeted skills development or the more traditional broad-scope training. How the new skills required for 'green' construction methods such as prefabrication is unclear (McGrath-Champ et al., 2010).

Except for the U.S., where there is a separate Housing and Urban Development (HUD) code for mobile and manufactured housing, there is a general lack of legislation or governance specifically surrounding the use of prefabrication in housing. There are however a number of regulations specifically concerning sustainable housing or development which have been enacted in recent years. These have been introduced in jurisdictions with both high and low use of prefabricated housing innovations. With these being relatively recent developments, there is currently little evidence clarifying the specific relationship between sustainability legislation and the adoption of prefabrication in housing.

The regulatory uncertainty also extends to Australia with the focus of legislation on onsite building processes. The National Construction Code, including the Building Code of Australia, specifically states it was "*developed to incorporate all onsite construction requirements"* with minimal reference to activities occurring prior to onsite installation (Australian Building Codes Board, 2013b). Ultimately though, all permanent residences in Australia are required to comply with the Building Code once they are permanently affixed to a property. The challenge for those using new or innovative building methods is in proving their structural integrity against the rules and regulations which have not been written with them in mind. Along with several of the international jurisdictions reviewed earlier, Australian requirements for energy efficiency have been introduced for new house builds which may be relevant to the future of the prefabricated housing industry in Australia. However, the existing complexity of regulation in the Australian building industry provides conflicting messages at federal, state and local levels (Shearer, Taygfeld, Coiacetto, Dodson, & Banhalmi-Zakar, 2013), which may hamper the ability for regulation to drive performance improvement.

There is some evidence from the data in Table 1 to suggest that detached, single-family homes have seen the greatest application of prefabrication. Specifically, nearly half of all Japan's prefabricated houses are detached (with another fifth being rowhouses or townhouses), and the German prefabrication industry is heavily weighted towards application in residences containing two dwellings or less. As noted previously in this section there is some implication that this relationship also applies for Sweden. The UK and US industries are in contradiction to the trend, with low levels of prefabrication but a preference for detached housing in new builds. With Australian housing typified by single, detached houses as a long-term trend, there is mixed evidence as to whether this is a driver or barrier towards prefabrication uptake.

In summary, the review of the six jurisdictions presented in Table 1 has identified a number of potential key influences on the prefabricated housing industry. Factors promoting uptake include industry-wide investment in research and development, large markets, skilled workforces, and less speculative property procurement and house building. There is additionally mixed evidence to suggest that greater building of detached housing may foster the use of prefabrication, although in Australia we have seen that multi-residential developments provide economies of scale that suit prefabrication. A lack of clarity still remains however on the effect of various

regulatory decisions on the industry.

# Other policy context influences

## Defining 'building'

Defining 'building' may not be straight-forward in the Australian prefabricated housing industry. Examples of complexity are provided by WA and NSW. The WA Building Commission states that a building permit (registration) is generally required for "*the construction, erection, assembly or placement of a building*" along with adjustment of ground levels or any other onsite work. On the other hand, offsite work such as the construction of prefabricated components or whole transportable buildings is specifically excluded (WA Department of Commerce, 2013). While in New South Wales, the placing of transportable homes onsite does not count as 'building', with this process considered as an 'install' rather an 'erection' of a structure. While certifications by structural engineers and compliance plates are required, a construction certificate is not required. As with other houses, the installation still however needs to be cleared by the local government as judged by submitted plans and specifications (NSW Government Department of Planning, 2009). Flat pack homes, or houses erected from a kit of partially prefabricated materials are, on the other hand, still considered as construction. Refinement and clarification of the role of building authorities and their permitting for prefabricated houses, as well as how this may vary from state to state is required.

## Home warranty schemes

Home warranty schemes covering residential building work are common in Australia, such as the Queensland Home Warranty Scheme (QWHS), New South Wales Home Warranty Insurance Fund, and the Victorian Domestic Building Insurance. As an example, the QWHS protects consumers (and builders) in the instance of contracted work not being completed, work being defectively completed, or the building moving after construction through shifting or settling (Building Services Authority, 2013).The Queensland Building Services Authority (BSA) specifically notes that "*offsite prefabrication in a factory of the whole of a building*" (Building Services Authority, 2011) is excluded from the QHWS. The BSA recommends that those purchasing transportable or modular prefabricated homes built offsite should not enter a formal building contract, only pay a 10% upfront deposit, and pay the bulk of payments when the house is delivered and installed (Building Services Authority, 2009). Such suggestions may concern manufacturers by limiting their deposit and operating capital, while highlighting to end users the lack of protection offered for prefabricated building methods. A 2013 review of the BSA has thus recommended '*extending the Queensland Home Warranty Scheme to the construction or renovation of all homes irrespective of the method of construction*' (Department of Housing and Public Works, 2013, p69). This recommendation was driven by the perceived increasing prevalence of prefabricated housing, and may be a signal of potentially greater flexibility in warranty schemes.

## Financing

With the prefabricated housing industry in Australia still developing, there are a number of largely unresolved issues relating to the financing of non-traditionally constructed homes. There is an inherent conflict between the application of the newer, prefabricated building methods and

the conservative nature of the banking industry wishing to ensure the viability of its investments (Boyd et al., 2012). There is a practical issue to consider in that lenders do not see a gradual progression onsite in terms of the finished product that can be linked to the increasing provision of funds.

This has led some modular builders such as Modscape to provide a stop-gap solution of privately financing the build process, and then transferring this loan to the consumer via their own banking institution at the completion of the project (Modscape, 2013). Other companies (1) offer to advise on financing matters (Austwide Homes, 2013b), (2) have established relationships with lenders within their own group of companies (e.g. TR Homes (2011) and Resolve Finance), (3) have links with local lending businesses (e.g. Gateway Constructions (2013)) or (4) directly facilitate deferred payment options (e.g. McGrath Homes (2013) ). Nevertheless, financial barriers need to be acknowledged as potentially raising uncertainty among users, manufacturers, lenders and related parties within the prefabricated housing innovation system.

There are conversely benefits to the financing of house builds using prefabricated materials such as SIPs in onsite building projects. Interviews with a Queensland based builder found that the time to progress a build to 'lock up' using SIPs is typically 10 days, compared to an average of 30 days using brick veneer (Miller, 2010). At this point, the builder can claim 65% of the build costs (slab, frame and lock up) and cover any outlays before their suppliers' accounts are due. For a 200m2 brick veneer construction of approximately $180,000, a builder would need only $50,000 - $70,000 to finance a build with commercial integrity.

## Planning regulations

Local government legislation may also affect the penetration of prefabricated housing. Building Codes Queensland has recently introduced 'ban the banners' legislation which prevents developers stipulating certain design features that may conflict with energy efficient building. The sorts of requirements that developers can no longer mandate cover roof colours, external finishes, minimum floor areas, and numbers of bedrooms or bathrooms (Building Codes Queensland, 2010). Such changes to legislation may indirectly benefit prefabricated housing systems in that the range of finishes would not necessarily need to be adapted to meet locally applied covenants. Ultimately though, land developers still have significant power in terms of establishing restrictive covenants that may either encourage or discourage the use of prefabricated housing innovations. This is particularly important, given that covenants are assigned to the land, not the owner, and are transferred indefinitely until they can be removed. Additionally, removing or varying a covenant may incur significant financial and time costs on behalf of the builder and owner (Victorian Department of Planning and Community Development, 2013).

## Advocacy and peak groups

In a review of the housing labour force in Australia, Dalton and colleagues (2011) identified a number of industry groups representing the housing industry generally in Australia. These include the residential building associations such as the Housing Industry Association (HIA) and Master Builders Association (MBA), and the property industry advocacy group the Property Council of Australia (PCA) including its subsidiary committee the Residential Development Council of Australia. The Construction and Property Services Industry Skills Council (CPSISC)

represents the workforce training and skills elements of the industry, while industry associations such as the Australian Industry Group and National Precast Concrete Association of Australia also have substantial input. The lack of a dedicated organisation specifically for those individuals, businesses or organisations related to prefabrication in Australia has been previously noted (Blismas & Wakefield, 2009). As of 2013 however, prefabAus (2013a) has been established with a mission '*to represent, showcase and advance Australia's prefabricated building Industry through collaboration, innovation and education.*' In both its name and vision, prefabAUS aligns itself closely with the work of PrefabNZ, which was established in New Zealand in 2010 (prefabAus, 2013b). Currently, membership in the group is open to industry members spanning manufacturers, builders, designers, other supply chain members and researchers. This group is very new and the full scope of their potential influence as yet unknown.

While the Housing Industry Association (HIA) in Australia does not specifically support prefabricated housing, it does run a GreenSmart accreditation scheme for sustainable building which shares the common aims of improved efficiency and sustainability that are potential drivers for the use of prefabricated housing. GreenSmart houses are accredited against a number of minimum and leading practice criteria covering energy management, water management, indoor air quality management, material selection, universal design (accessibility), landscaping, stormwater management and resource efficient practice. Specifically in regards to resource efficient practice, Objective 8.4 is that "*prefabricated construction systems are used, where appropriate, to minimise building waste during construction*" (Housing Industry Association, 2013). The Master Builders Association (2013) similarly runs training courses to accredit residential house, apartment and unit builders as 'Green Living Builders'. The process involves annual re-accreditation and includes sustainability assessments targeting waste and energy efficiency, though no specific mention is made of prefabrication.

There may be growing recognition of the value of prefabrication within the Australian housing market, with support for its uptake specifically aligned with the efforts to improve the sustainability and environmental performance of building.

## Technical Issues

There is a low level of interest in R&D within the Australian construction industry due to a lack of foreign competition, and an industry-stated position that there are few benefits to be gained from new technologies such as prefabrication (Australian Industry Group, 2013). It is difficult to say for sure whether this is true or whether statements such as these are indicative of the reluctance of the Australian construction industry to innovate and change practices (Australian Industry Group, 2008). There is a trend for formal training to have been overlooked in the current house construction labour force, with this having potentially negative effects as untrained or self-trained builders began to teach and pass on their methods and practices to those next in line to learn the trade (Daly, 2009). This situation impinges directly on the uptake of innovative building practices by reinforcing traditional building methods and processes. One can draw a number of parallels between the U.K., U.S. and Australian construction industries, where there is low profitability and little investment in innovation, research and development or training (Egan, 1998; Hirschey et al., 2012; Kulatunga, Amaratunga, & Haigh, 2010).

The CPSISC's Future Forecasts report for 2016-2026 (The C. I. E., 2013) notes that structural adjustment of residential construction methods is likely to be slow given the predominance of small businesses involved in the industry. Although recognising the potential improvements in efficiency flowing from the greater use of prefabricated housing, the CPSISC sees the barrier of a lack of appropriately skilled staff as a key roadblock preventing prefabrication uptake. Having said this, a relatively unskilled construction workforce may drive the adoption of SIPs and other easy-to-assemble prefabricated products (McIntosh & Guthrie, 2008). This is demonstrated in a case study of the Bondor InsulLiving system where a house was quickly assembled using a small team including relatively low skill apprentices (Miller, 2010). A criticism of simplified prefabricated methods would however be the lack of transferability of skills to traditional build methods, and the risks of contractors becoming locked-in to a particular system. Establishing a fit and cooperation between the emerging prefabrication industry and the skills within the existing housing industry is thus a key challenge. PrefabAUS (2013a) encouragingly promotes prefabrication as a complimentary, rather than adversarial approach to onsite construction in Australia.

Unlike traditional building processes, prefabricated houses utilising large, pre-built components, raises potential issues with the transport of the completed structure or module to a building site. Local transport authorities legislate the maximum sizes of buildings that can be normally transported by trucks, and restrict the hours and locations of these movements (e.g. VicRoads, 2013). These restrictions impose technical constraints on the maximum size of any single component that can be prefabricated offsite. These size limitations have a direct impact on the designs employed in modular building and may negatively affect the flexibility and customisability of the buildings. Developing new engineering solutions and interfacing with architects so that builders and manufacturers are not restricted in their build options is a significant challenge. Australian builders such as Prebuilt have dealt with this challenge by formally partnering with local architects to work within the limitations placed on their modular system by transportation requirements (Prebuilt, 2013a).

Similarly, there are also technical challenges associated with needing to move large units or panels from a transport vehicle to their final installation point. These challenges are particularly pertinent for urban areas where space may be limited. As identified in the review of businesses undertaken earlier in this paper, companies such as Unique Modular Buildings (2013) are forced to build onsite if a truck or crane cannot get suitable access to place large modules. While builders using panellised methods such as SIPs can potentially move panels by hand, larger panels and precast concrete would still require the use of a crane. The size of the crane required to move the panels or models, and the degree of access available can substantially impact on both the efficiency and ultimate cost of the installation procedure (Cement & Concrete Association of Australia, 2001). Unitised Building's pilot Little Hero apartment project in the Melbourne CBD required the permanent installation of a crane in an adjacent parking lot (Boyd et al., 2012), a luxury that not all urban projects are likely to have. Further research into the best methods to reduce the burden of both transporting of large elements and their placement onsite is required.

Australia faces a number of unique challenges regarding climate, and distance between urban and rural centres. Australia has a harsh climate in some regions, particularly in regards to heat, which needs to be addressed by the types of housing that are provided (Daly, 2009). This is in contrast to the extremely cold conditions in other jurisdictions such as Sweden and Japan. Both extremes

can be addressed effectively by the use of panel systems and other prefabrication methods that go above and beyond the current insulation and thermal requirements for housing. Numerous efficiencies have been realised by moving house building undercover during the northern European winter, when construction would normally slow due to the effects of snow and shorter days (Hedlund, 2006). The Australian corollary would be the effect of extreme heat in summer, where a movement undercover would offer a number of workplace health and safety benefits to offset the increasing number of extremely hot days (Hanna, Kjellstrom, Bennett, & Dear, 2011). Managing the desire for certain contractors to work outside, as well as potential issues with noise, lighting or inhalation of materials such as sawdust are all considerations in effectively implementing factory-based processes for prefabrication (Hedlund, 2006).

As mentioned in the earlier overview, there are practically no identified prefabricated housing businesses directly located in the remote inner or northern gulf regions of Australia. Therefore, transportable housing has a key role in these regional centres. The relative remoteness of some housing locations in Australia should not however be a major issue affecting the viability of the prefabricated housing industry in general. Firstly, the challenges and inefficiencies of accessing all but the most extremely difficult or remote construction sites would not especially disadvantage prefabricated versus traditional building methods and may even benefit prefabricated methods by reducing the number of site visits. Secondly, remote housing would only be a small segment of the entire market, as 2.7% of the Australian population resides in areas considered by the Australian Bureau of Statistics to be remote or very remote (Australian Bureau of Statistics, 2013c).

# Conclusions

The current state of the prefabricated housing market in Australia has been systematically profiled, guided by a theoretical systems model. Particular focus was given to identifying individual Australian manufacturers and builders using prefabrication innovations, and to comparing the context for prefabricated housing in Australia with that of key international jurisdictions. The results indicate a small but growing market for prefabricated housing in Australia, often building on expertise developed through non-residential building applications.

The international comparison highlighted the complexity of the interactions between macro policy decisions and historical influences and the uptake of prefabricated housing. The data suggest factors such as the small scale of the Australian market, and a lack of investment in research, development and training have not encouraged prefabrication. A lack of clear regulatory policy surrounding prefabricated housing is common both in Australia and internationally, with local effects in regards to home warranties and financing of builds highlighted. Future research should target the continuing lack of consideration of prefabrication from within the construction industry, and build upon the research reported in this paper to further quantify the potential end user market and the continuing development of the industry.

This paper has presented novel findings, as a detailed national review of the prefabricated housing industry has not been previously published. A related, but less comprehensive examination undertaken in 2009 counted 41 non-volumetric manufacturers, 5 completing volumetric pre-assembly and 8 completing modular buildings, though this was neither

comprehensive nor discussed in-depth (Blismas & Wakefield, 2009). The current review identified a substantially larger number of house builders, in particular a larger number of companies producing fully prefabricated volumetric houses or modules. The current results may thus be indicative of a growing market for prefabricated housing in Australia, though the certainty of such a claim could be contested in light of the methodological limitations in both the earlier and current review.

A recurring theme throughout the profiling of the businesses within the current review is the diversification of business interests. The majority of both building companies and panel manufacturers had interests in industrial and commercial projects alongside their residential projects. Likewise, there were a number of builders identified employing both traditional and prefabricated methods side-by-side within their businesses. All of these findings indicate the potential for businesses to expand their investment in residential prefabrication, building on their existing expertise. Nevertheless, Australia has a relatively flat housing market, a historically low investment in R&D, a relatively unskilled and transient workforce, and a highly speculative housing market. These issues constrain adoption and pose significant policy challenges.

As the prefabricated housing industry in Australia is still within its infancy, there is a continuing need to address how it will interact with the regulatory environment. While the rules and regulations discussed within this review raise a number of issues including the scope of home warranty schemes and the role of the financial sector, there is currently little regulation specifically targeting prefabricated housing. Unfortunately, there is also a dearth of evidence regarding appropriate regulatory issues that can be borrowed from international jurisdictions. Alignment with the sustainability movement, which has been adopted internationally in legislation and is promoted by local peak representative bodies may be a method through which greater uptake of prefabrication could be pursued. The existing evidence regarding the nexus between Australian financial systems and the prefabricated housing industry suggests the potential for significant conflict. The current review suggests some efforts have been made from both prefabricated builders and financial instructions to address the issues, though these appear to be isolated efforts which ‘reinvent the wheel’ each time. Further research which acknowledges these challenges and outlines in detail the practical considerations is required.

There is additionally a need to engage with builders and owners/developers in Australia if prefabrication is to be accepted. The traditionalist skill-set of the workforce and the substantial risk that changing business practices carries have been strongly noted by industry bodies. The opinions of both local builders and the potential consumer market have not however been explored in significant detail or with strong empirical evidence. With a conservative culture, the ability of the construction industry to effectively set research priorities and guide future practice is questionable. It is difficult to know if there is a currently under-developed market for prefabrication that could be harnessed. Further detailed and widespread evidence collection is required to answer these queries, with the authors planning research into builders’ attitudes.

Other significant drivers of adoption stem from the technical characteristics of prefabrication. These include the lack of relevant skills among the construction workforce, the transporting of large modules and the resultant design impact; and the opportunities in rural and remote populations, and in tailoring builds for our harsh climate.

Further research to determine the scope of prefabrication activities and possible influences on adoption is required. Most studies, including the current review, are based on inconsistently recorded evidence to profile the industry. Central collection of data via the Australian Bureau of Statistics, government departments, or peak industry bodies such as the HIA or MBA may serve to facilitate better research and more focused policy in the future.

## Appendix 1. References for Table 1

**[A1]** (The C. I. E., 2013)
**[A2]** (Australian Bureau of Statistics, 2013a)
**[A3]** (Australian Bureau of Statistics, 2007)
**[A4]** (Australian Bureau of Statistics, 2013b)
**[A5]** (Australian Building Codes Board, 2013b)
**[A6]** (Australian Building Codes Board, 2013a)
**[A7]** (Dalton et al., 2011)
**[A8]** (Select Committee on Housing Affordability in Australia, 2008)
**[A9]** (Daly, 2009)

**[J1]** (Japanese Prefabricated Construction Suppliers and Manufacturers Association, 2013)
**[J2]** (Linner & Bock, 2012)
**[J3]** (Statistics Japan, 2011)
**[J4]** (Horita, 2006)
**[J5]** (Statistics Japan, 2013)
**[J6]** (Togo, 2010)
**[J7]** (Raftery, Pasadilla, Chiang, Hui, & Tang, 1998)
**[J8]** (Johnson, 2007)

**[S1]** (Gibbons, 1986)
**[S2]** Fernstrom and Kampe, 1998, as cited in (Fröjdfeldt & Leijon, 2008)
**[S3]** Fernstrom and Kampe, 1998, as cited in (Andersson, 2005)
**[S4]** (Statistics Sweden, 2013)
**[S5]** (Hüfner & Lundsgaard, 2007)
**[S6]** (Statistics Sweden, 2012)
**[S7]** (Statistics Sweden, 2013)
**[S8]** (Hall & Vidén, 2005)

**[G1]** (Federal Statistics Office Germany, 2013a)
**[G2]** (Federal Statistics Office Germany, 2013b)
**[G3]** (Zentralverband Deutsches Baugwerbe, 2012)
**[G4]** (Baden, Fairey, Waide, de T'serclaes, & Laustsen, 2006)
**[G5]** (Venables & Courtney, 2004)

**[N1]** (Statistics Netherlands, 2012)
**[N2]** (Statistics Netherlands, 2013)
**[N3]** (Bremer & Kok, 2000)
**[N4]** (Steurer & Martinuzzi, 2005)
**[N5]** (Sminia, 2011)

**[US1]** (U. S. Census Bureau, 2012b)
**[US2]** (U. S. Census Bureau, 2012a)
**[US3]** (US Department of Housing and Urban Development, 1995)
**[US4]** (U. S. Census Bureau, 2011)
**[US5]** (US Department of Housing and Urban Development, 2013)
**[US6]** (Hirschey et al., 2012)

**[UK1]** (Gibb & Goodier, 2004)
**[UK2]** (GOV.UK, 2013)
**[UK3]** (Department for Communities and Local Government, 2013a)
**[UK4]** (Office for National Statistics, 2013)
**[UK5]** (Department for Communities and Local Government, 2013b)
**[UK6]** (Parliamentary Office of Science and Technology, 2003)
**[UK7]** (Goulding & Arif, 2013)

**[C1]** (Baek & Park, 2012)
**[C2]** (Clarke & Wall, 2000)

# References


Algeco Scotsman. (2013). Algeco Scotsman: World Leader in Modular Space. Retrieved August 1, 2013, from http://www.algecoscotsman.com

Andersson, D. (2005). *Prefabricerade väggelement med pelar-balkstomme [Prefabricated wall panels with beam and post frame]*. (Masters), Luleå Tekniska Universitet, Luleå, Sweden.

APB Modular. (2010). APB Modular: Company Profile. Retrieved July 26, 2013, from http://www.apb.com.au/files/pdfs/APB-Modular-Company-Profile.pdf

Arkit. (2007). Advanced. Retrieved August 16, 2013, from www.arkit.com.au/s/ARKit-advanced-rst2.pdf

Arkit. (2013). ARKit :: Advanced Prefab. Retrieved August 16, 2013, from http://www.arkit.com.au/index#

Askin. (2013). Askin | About Us | Performance Rated Insulation Material. Retrieved August 15, 2013, from http://www.askin.net.au/askin
Ausco Modular. (2013). Ausco Modular - Welcome. Retrieved August 15, 2013, from http://www.ausco.com.au/
Austec Panel Systems. (2008). Eco Housing Panels. Retrieved July 30, 2013, from http://www.austecpanels.com.au/structural/index.php?option=com_content&view=article&id=22&Itemid=24
Austral Precast. (2013). Austral Precast - Home. Retrieved August 16, 2013, from http://australprecast.com/qld/
Australian Building Codes Board. (2013a). ABCB - Residential Housing. Retrieved September 20, 2013, from http://www.abcb.gov.au/en/major-initiatives/energy-efficiency/residential-housing
Australian Building Codes Board. (2013b). National Construction Code. Canberra: ABCB.
Australian Bureau of Statistics. (2007). Tenure Type and Landlord Type By Dwelling Structure for Time Series. Canberra: ABS.
Australian Bureau of Statistics. (2013a). Building Activity, Australia: Number of Dwelling Unit Completions by Sector, Australia. Canberra: ABS.
Australian Bureau of Statistics. (2013b). Building Approvals, Australia, April 2013. Canberra: ABS.
Australian Bureau of Statistics. (2013c). Census Data: TableBuilder. Retrieved July 26, 2013, from https://www.censusdata.abs.gov.au
Australian Industry Group. (2008). State of Play: The Australian Construction Industry in 2008. Sydney: Australian Industry Group.
Australian Industry Group. (2013). Performance of Construction Index: Downturn in Construction Industry Extends to Three Years. Retrieved June 18, 2013, from http://www.businessspectator.com.au/sites/default/files/AIG%20PCI%20MAY.pdf
Austwide Homes. (2013a). Austwide Homes. Retrieved July 29, 2013, from http://www.austwidehomes.com.au/about.html
Austwide Homes. (2013b). Austwide Homes - Financing Your home. Retrieved August 16, 2013, from http://www.austwidehomes.com.au/finance.html
Baden, S., Fairey, P., Waide, P., de T'serclaes, P., & Laustsen, J. (2006, 2006). *Hurdling financial barriers to low energy buildings: experiences from the USA and Europe on financial incentives and monetizing building energy savings in private investment decisions*.
Baek, C.-H., & Park, S.-H. (2012). Changes in renovation policies in the era of sustainability. *Energy and Buildings, 47*, 485-496.
Barlow, J., Childerhouse, P., Gann, D. M., Hong-Minh, S., Naim, M., & Ozaki, R. (2003). Choice and delivery in housebuilding: lessons from Japan for UK housebuilders. *Building Research & Information, 31*(2), 134-145.
Bathroom In A Box. (2013). Bathroom In A Box, Instant Bathroom Solution And Disability Bathroom. Retrieved August 15, 2013, from http://www.bathroominabox.com.au/
Bellissimo Homes. (2013). Structural Insulated Panels (SIPs) - Bellissimo Homes. Retrieved July 30, 2013, from http://www.bellissimohomes.com.au/x/?page_id=31
BGC Modular. (2013a). Modular Buildings | Transportable Homes and Buildings | Modular Homes | Portable Buildings | Prefabricated Buildings - Home - BGC Modular. Retrieved August 15, 2013, from http://www.bgcmodular.com.au/
BGC Modular. (2013b). News - BGC Modular. *BGC Modular Involved in the Expansion of Regional Town for Rio Tinto.* Retrieved August 15, 2013, from

http://www.bgcmodular.com.au/news_articles/2
Blismas, N., & Wakefield, R. (2009). Drivers, constraints and the future of offsite manufacture in Australia. *Construction Innovation: Information, Process, Management, 9*(1), 72-83.
Blismas, N., Wakefield, R., & Hauser, B. (2010). Concrete prefabricated housing via advances in systems technologies: Development of a technology roadmap. *Engineering, Construction and Architectural Management, 17*(1), 99-110.
Blundell, L. (2010). Sekisui House: Japanese green wave rolling out in the land of Oz - The Fifth Estate. *Sekisui House: Japanese green wave rolling out in the land of Oz.* Retrieved July 26, 2013, from http://www.thefifthestate.com.au/archives/15886/
Bondor. (2011). Bondor - About Us. Retrieved July 30, 2013, from http://www.bondor.com.au/bondor/about.html
Boral. (2010). Boral - Construction Related Businesses. Retrieved 2013, October 4, from http://boral.com.au/Images/common/pdfs/June2009_CRB_Pres_Syd.pdf
Boyd, N., Khalfan, M. M. A., & Maqsood, T. (2012). Off-Site Construction of Apartment Buildings. *Journal of Architectural Engineering, 19*, 51-57.
BRB Modular. (2013). BRB Modular Buildings Australia - Solutions - Residential. Retrieved August 16, 2013, from http://www.brb-buildings.com/brbmodular/display.asp?entityid=4364
Bremer, W., & Kok, K. (2000). The Dutch construction industry: a combination of competition and corporatism. *Building Research & Information, 28*(2), 98-108.
Building Codes Queensland. (2010). Ban the banners: New covenant and body corporate by-law rules. Retrieved August 1, 2013, from http://www.hpw.qld.gov.au/SiteCollectionDocuments/new-covenant-and-body-corporate-by-laws-factsheet.pdf
Building Services Authority. (2009). Building or Renovating? Protect Your Hard-Earned Cash: BSA.
Building Services Authority. (2011). Insurable Residential Construction Work. Brisbane: BSA.
Building Services Authority. (2013). When Home Warranty should be Paid. Retrieved July 31, 2013, from http://www.bsa.qld.gov.au/builderscontractors/queenslandhomewarrantyscheme/pages/WhenHomeWarrantyshouldbePaid.aspx
Cement & Concrete Association of Australia. (2001). The Concrete Panel Homes Handbook. A guide to the design and detailing of concrete panel construction for housing. St Leonards: C&CAA.
Chong, F. (2011). Sekisui plans a revolution with industrialised homes. *The Australian.* Retrieved July 26, 2013, from http://www.theaustralian.com.au/archive/business-old/sekisui-plans-a-revolution-with-industrialised-homes/story-e6frg9gx-1226014867894
Clarke, L., & Wall, C. (2000). Craft versus industry: the division of labour in European housing construction. *Construction Management & Economics, 18*(6), 689-698.
Collins, G. (2013). Forté – Building Australia's First Timber Highrise. Retrieved October 4, 2013, from http://woodworks.org/wp-content/uploads/2013-WSF-ATL-Collins.pdf
Dalton, T., Chhetri, P., Corcoran, J., Groenhart, L., & Horne, R. (2011). Understanding the patterns, characteristics and trends in the housing sector labour force in Australia. Melbourne: AHURI.
Daly, G. (2009). Prefabricated housing in Australia. Skill Deficiencies and Workplace Practice: International Specialised Skills Institute Inc.
Department for Communities and Local Government. (2013a). House building in England: April

to June 2013 - Publications - GOV.UK. Retrieved August 29, 2013, from https://www.gov.uk/government/publications/house-building-in-england-april-to-june-2013

Department for Communities and Local Government. (2013b). Planning Portal - Approved Document L - Conservation of fuel and power. Retrieved August 29, 2013, from http://www.planningportal.gov.uk/buildingregulations/approveddocuments/partl/approved

Department of Housing and Public Works. (2013). Queensland Government Response to the Transport, Housing and Local Government Committee: Inquiry into the Operation and Performance of the Queensland Building Services Authority. Brisbane: Department of Housing and Public Works.

Ecoliv. (2013). Ecoliv Sustainable Buildings - Factory. Retrieved August 16, 2013, from http://ecoliv.com.au/factory

Edwards Trading Company. (2012). Tassie Homes - Edwards Trading Company. Retrieved July 29, 2013, from http://www.etc.com.au/about/

Egan, J. (1998). Rethinking Construction: The Report of the Construction Task Force. London: Department of the Environment, Transport and the Regions.

Federal Statistics Office Germany. (2013a). Baugenehmigungen im Fertigteilbau (Neubau): Deutschland, Jahre, Gebäudeart/Bauherr. Retrieved August 22, 2013, from https://www-genesis.destatis.de

Federal Statistics Office Germany. (2013b). Baugenehmigungen im Hochbau: Deutschland, Jahre, Gebäudeart/Bauherr. Retrieved August 22, 2013, from https://www-genesis.destatis.de

Formcraft. (2013). ICF Accredited Builder - Formcraft. Retrieved August 17, 2013, from http://www.formcraft.com.au/business-opportunities/icf-accredited-builder/

Fröjdfeldt, I., & Leijon, A. (2008). *Prefabricerade Byggelement: En konceptbeskrivning [Prefabricated building elements: A conceptual description]*. University of Gävle, Gävle.

Gann, D. M. (1996). Construction as a manufacturing process? Similarities and differences between industrialized housing and car production in Japan. *Construction Management & Economics, 14*(5), 437-450.

Gateway Constructions. (2013). Gateway Homes | sustainable, eco friendly, transportable, relocatable, modular, kit homes, prefabricated home builders. Retrieved August 15, 2013, from http://gatewayhomes.com.au/

George, L., & Yankausas, J. (2011). Preserving Affordable Manufactured Home Communities in Rural America. Washington D.C.: Housing Assistance Council.

Gibb, A. G. F., & Goodier, C. (2004). The Value of the UK Market for Offsite. London: Buildoffsite.

Gibbons, J. (1986). Technology, Trade and the U.S. Residential Construction Industry: Special Report. Washington D.C.: U.S. Congress, Office of Technology Assessment.

Glendale Homes. (2012). Glendale personal benefits. Retrieved October 5, 2013, from http://www.glendalehomes.com.au/PersonalBenefits.htm

Glendale Homes. (2013). Glendale Homes. Retrieved July 26, 2013, from http://www.glendalehomes.com.au/index.htm

Goulding, J., & Arif, M. (2013). Offsite Production and Manufacturing - Research Roadmap Report: CIB.

GOV.UK. (2013). Live tables on house building - Statistical data sets - GOV.UK. Retrieved August 29, 2013, from https://www.gov.uk/government/statistical-data-sets/live-tables-on-house-building

Gumpy Homes. (2013). Gumpy Modular Homes - Tasmanian built, Environmentally and User friendly kit homes. Retrieved July 30, 2013, from http://www.gumpyhomes.com.au/index.html
Gurran, N., Milligan, V., Baker, D. C., Bugg, L. B., & Christensen, S. A. (2008). New directions in planning for affordable housing: Australian and international evidence and implications. *Research and Policy Bulletin, 105*(Final Report: No. 120), 1-143.
Hall, T., & Vidén, S. (2005). The Million Homes Programme: a review of the great Swedish planning project. *Planning Perspectives, 20*(3), 301-328.
Hanna, E. G., Kjellstrom, T., Bennett, C., & Dear, K. (2011). Climate change and rising heat: population health implications for working people in Australia. *Asia-Pacific Journal of Public Health, 23*(14S), 14S-26S.
Happy Haus. (2011). Happy Haus - Frequently Asked Questions. Retrieved July 26, 2013, from http://www.happyhaus.com.au/FileLibrary/frequently_asked_questions.pdf
Hassall Free Homes. (2013). Toowooomba Hassall Free Homes Queensland. Retrieved July 26, 2013, from http://www.hassallfreehomes.com.au/
Hedlund, A. (2006). The attractiveness of the work is affected when production of hand-crafted log houses moves indoors. *Silva Fennica, 40*, 545-558.
Hickory Group. (2013a). 3 East > Projects > Hickory Group:. Retrieved October 4, 2013, from http://www.hickory.com.au/projects/3-east/
Hickory Group. (2013b). 568 Collins > Projects > Hickory Group. Retrieved October 15, 2013, from http://www.hickory.com.au/projects/568-collins
Hillside Project. (2011). The Hillside Project... a fire-safe zero energy, sustainable home. Retrieved October 17, 2013, from http://www.hillsideproject.net/
Hirschey, M., Skiba, H., & Wintoki, M. B. (2012). The size, concentration and evolution of corporate R&D spending in US firms from 1976 to 2010: Evidence and implications. *Journal of Corporate Finance, 18*(3), 496-518.
Hoek Modular Homes. (2013). FAQ. Retrieved October 4, 2013, from http://www.hoekmodularhomes.com/faq.html
Horita, Y. (2006). Local Authority Housing Policy in Japan: Is It Secure To Function As Safety Net? *Housing Finance International, 20*(4).
Housing Industry Association. (2013). 2013 HIA GreenSmart House Requirements. Campbell, ACT: HIA.
Hüfner, F., & Lundsgaard, J. (2007). The Swedish housing market: better allocation via less regulation: OECD Publishing.
Hutchinson Builders. (2011). About Modular: Hutchinson Builders. Retrieved July 26, 2013, from http://www.hutchinsonbuilders.com.au/about-modular/
Insulated Panel Homes. (2012). About us. Retrieved July 30, 2013, from http://www.insulatedpanelhomes.com.au/about-us/
Japanese Prefabricated Construction Suppliers and Manufacturers Association. (2013). Current Status of Manufactured Housing - translated from Japanese. Retrieved May 31, 2013, from http://www.purekyo.or.jp/main3-1.html
Johnson, W. (2007). *Lessons from Japan: A comparative study of the market drivers for prefabrication in Japanese and UK private housing development.* University College London, London.
Kingspan. (2012). Annual Report and Financial Statements - 2011. Cavan, Ireland: Kingspan.
Kingspan. (2013). Kingspan Worldwide - Kingspan Group PLC. Retrieved July 30, 2013, from http://www.kingspan.com/site-services/kingspan-worldwide.aspx

Kulatunga, U., Amaratunga, D., & Haigh, R. (2010). Implementation of critical success factors in construction research and development process. *International Journal of Engineering Science and Technology, 2*, 96-106.
Lend Lease. (2011). Hotels and Resorts. Retrieved October 4, 2013, from http://www.lendlease.com/en/australia/sectors/hotels-and-resorts-development
Linner, T., & Bock, T. (2012). Evolution of large-scale industrialisation and service innovation in Japanese prefabrication industry. *Construction Innovation: Information, Process, Management, 12*(2), 156-178.
Luther, M. (2009). Towards prefabricated sustainable housing-an introduction. *BEDP environment design guide*, 1-11.
Luther, M., Moreschini, L., & Pallot, H. (2012, 2012). *Revisiting prefabricated building systems for the future.* Paper presented at the ANZASCA 2007: Proceedings of 41st annual conference. Towards solutions for a liveable future: progress, practice, performance, people.
Master Tradesman Western Australia. (2013). MBA - Master Builders Western Australia A-Z Building Information Directory - Bricks. Retrieved October 28, 2013, from http://mastertradeswa.com.au/custom/mba_directory.asp?SID=13
Masters Builders Association of Victoria. (2013). Green Living - Builders. Retrieved August 2, 2013, from http://www.mbav.com.au/vpLink.aspx?ID=000000008048
MBSWA. (2012). Modular Building Solutions WA :: Pre-Built Homes. Retrieved October 4, 2013, from http://www.mbswa.com.au/products-and-services/transportable-homes/
McGrath-Champ, S., Rosewarne, S., & Rittau, Y. (2010). Education, skill and unions and in the Australian construction industry. *Labour & Industry, 21*, 438-462.
McGrath Homes. (2013). McGrath Homes - Affordable modular homes, Perth, WA – don't compromise your dream, location or budget | McGrath. Retrieved August 15, 2013, from http://www.mcgrathhomes.com.au/
McIntosh, J., & Guthrie, C. (2008). Structural Insulated Panels: A Sustainable Option for House Construction in New Zealand. *International Journal for Housing Science and Its Applications, 32*(1), 15-27.
Metecno Group. (2011). Metecno Group. Retrieved July 30, 2013, from http://www.metecno.com/Metecno_group/equipment/equipment.html
mgwHomes. (2011). mgwHomes - german techology creating australian homes. Retrieved July 30, 2013, from http://www.mgwhomes.com.au/faq.html#q8
Miller, W. F. (2010). Energy and Environmental Benefits of Structural Insulated Panels for Residential Construction in Australia. Brisbane: Metecno Pty Ltd, trading as Bondor.
Modscape. (2013). Modscape - FAQs - Frequently Asked Questions. Retrieved July 31, 2013, from http://modscape.com.au/faqs/
Monarch Building. (2013). About: Monarch. Retrieved July 30, 2013, from http://www.monarchbuilding.com.au/about/
Nadim, W., & Goulding, J. S. (2011). Offsite production: a model for building down barriers: A European construction industry perspective. *Engineering, Construction and Architectural Management, 18*(1), 82-101.
National Precast Concrete Association Australia. (2008). Four Commercial Terraces – A Completely Precast Solution. *National Precaster, 48*, 4-5.
National Precast Concrete Association Australia. (2011). Grand design for small house. *59*, 5.
National Precast Concrete Association Australia. (2013). Projects Gallery. Retrieved October 4, 2013, from http://www.npcaa.com.au/members_products/projects_gallery/index.php

Noguchi, M. (2003). The effect of the quality-oriented production approach on the delivery of prefabricated homes in Japan. *Journal of Housing and the Built Environment, 18*(4), 353-364. doi: 10.1023/B:JOHO.0000005759.07212.00

Norfolk Homes. (2013). Sustainability - Norfolk Homes. Retrieved July 31, 2013, from http://www.norfolkhomes.net.au/sustainability/

NSW Government Department of Planning. (2009). Supporting Affordable Rental Housing - Granny Flats (Secondary Dwellings). Retrieved June 18, 2013, from http://www.planning.nsw.gov.au/Portals/0/plansforaction/affordablehousing/docs/Affordable%20Housing_Fact_Granny%20Flats.pdf

Office for National Statistics. (2013). Output in the Construction Industry, June and Q2 2013. Retrieved August 29, 2013, from http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-295369

Organisation for Economic Cooperation and Development. (2013). Members and partners. Retrieved September 29, 2013, from http://www.oecd.org/about/membersandpartners/

Paneco. (2012). Paneco - Building Professionals. Retrieved July 30, 2013, from http://www.paneco.com.au/building-professionals/

Panel Homes Australia. (2013). Home | Panel Homes. Retrieved November 1, 2012, from http://www.panelhomesaustralia.com.au/

Paneltech. (2013). Insulated Roofing Panels / Panel Tech Industries. Retrieved July 30, 2013, from http://www.paneltech.com.au/

Parliamentary Office of Science and Technology. (2003). Modern Methods of House Building. London: POST.

Pearls Australasia. (2013). About | Pearls Australasia. Retrieved July 30, 2013, from http://www.pearls-a.com/about/

Pearls MiiHome. (2013). Capabilities | Pearls MiiHome. Retrieved July 30, 2013, from http://miihome.com.au/capabilities

Prebuilt. (2013a). Can I have a custom designed home? The company - Help. Retrieved September 30, 2013, from http://www.prebuilt.com.au/index.php?pageID=7906&sectionID=6510&action=help&helpcatID=491&helpID=3096#3096

Prebuilt. (2013b). Prebuilt. Retrieved August 16, 2013, from http://www.prebuilt.com.au/

prefabAus. (2013a). prefabAUS. Retrieved August 1, 2013, from http://www.prefabaus.org.au/

prefabAus. (2013b). prefabAUS - Prefab Lessons from Abroad. Retrieved August 2, 2013, from http://www.prefabaus.org.au/what-is-prefab/prefab-lessons-from-abroad/

Profast. (2013). Profast Precast Panels - Past Works. Retrieved August 16, 2013, from http://www.pro-fast.com.au/index81bf.html?id=pastworks

Project Modular. (2013). Modular Homes, Modular Bathrooms, Prefabricated Houses, Building Systems: Bathrooms. Retrieved August 17, 2013, from http://www.projectmodular.com.au/Bathrooms-pg12466.html

pub Bathrooms. (2010). Home. Retrieved August 15, 2013, from http://www.pubaustralia.com.au/index.html

Raftery, J., Pasadilla, B., Chiang, Y.-H., Hui, E. C. M., & Tang, B.-S. (1998). Globalization and construction industry development: implications of recent developments in the construction sector in Asia. *Construction Management and Economics, 16*(6), 729-737.

Remote Building Solutions. (2013). Remote Building Solutions for Australia & Beyond. Retrieved July 26, 2013, from http://www.remotebuildingsolutions.com.au/

Richard Harris Homes. (2013). Frequently Asked Questions. Retrieved October 4, 2013

Rod Stephens Modular Homes. (2009). Rod Stephens Modular Homes - Modular Home Specialist - Warrnambool Victoria. Retrieved August 16, 2013, from http://www.rodstephensmodularhomes.com.au/index.php

Samanita Developments. (2011). Khancoban Alpine Estate - Introduction. Retrieved July 30, 2013, from http://www.khancobanalpineestate.com.au/introduction.htm

SBP Australia. (2011). Construction. Retrieved July 31, 2013, from http://www.sbpa.com.au/construction

Sekisui House Australia. (2013a). Exquisitely designed for life. Retrieved September 30, 2013, from http://www.thecoolumresidences.com.au/Living-Options/~/media/Communities/AU/The%20Coolum%20Residences/Documents/2613SHAWOODtechnicalFlyerV4.ashx

Sekisui House Australia. (2013b). Sekisui House Australia. Home Builder and Community Developer. Retrieved July 1, 2013, from http://www.sekisuihouse.com.au

Select Committee on Housing Affordability in Australia. (2008). A Good House is Hard to Find: Housing Affordability in Australia. Canberra: Commonwealth of Australia.

Shack in a Pack. (2013). Shack in a Pack Distributors. Retrieved July 30, 2013, from http://www.shackinapack.com.au/distributors/index.php

Shearer, H., Taygfeld, P., Coiacetto, E., Dodson, J., & Banhalmi-Zakar, Z. (2013). The capacities of private developers in urban climate change adaptation. Gold Coast: National Climate Change Adaptation Research Facility.

SIPS Industries. (2013). About SIPS Industries. Retrieved July 30, 2013, from http://www.sipsindustries.com.au/about-sips-industries

Sminia, H. (2011). Institutional continuity and the Dutch construction industry fiddle. *Organization Studies, 32*(11), 1559-1585.

Spencer, B. F., Jr, & Nagarajaiah, S. (2003). State of the art of structural control. *Journal of Structural Engineering, 129*(7), 845-856.

Statistics Japan. (2011). Dwelling construction started by type of construction, owner occupant relation, source of fund, kind and type of investor (1990-2010). Retrieved August 28, 2013, from www.stat.go.jp/data/nenkan/zuhyou/y0907000.xls

Statistics Japan. (2013). 2012 Construction Starts Statistical Survey - translated from Japanese. Retrieved June 18, 2013, from http://www.e-stat.go.jp/SG1/estat/GL08020103.do?_toGL08020103_&listID=000001106391&disp=Other&requestSender=search

Statistics Netherlands. (2012). CBS StatLine - Residential buildings by region. Retrieved August 30, 2013, from http://statline.cbs.nl/StatWeb/publication/?DM=SLEN&PA=7413ENG&D1=32-33&D2=0,13,131,340&D3=21-23&LA=EN&HDR=G2&STB=G1,T&VW=T

Statistics Netherlands. (2013). CBS StatLine - Construction; costs of alteration and new buildings, by building phase. Retrieved August 29, 2013, from http://statline.cbs.nl/StatWeb/publication/default.aspx?DM=SLEN&PA=7076eng&D1=1&D2=a&D3=0-3&D4=%28l-7%29-l&LA=EN&VW=T

Statistics Sweden. (2012). Bostads- och byggnadsstatistisk årsbok 2012. Stockholm: SCB.

Statistics Sweden. (2013). Completed dwellings in newly constructed buildings by type of building, tenure and period. Retrieved May 30, 2013, from http://www.scb.se

Steinhardt, D., Manley, K., & Miller, W. (Unpublished). Reshaping housing - the role of prefabricated systems.

Steurer, R., & Martinuzzi, A. (2005). Towards a new pattern of strategy formation in the public

sector: first experiences with national strategies for sustainable development in Europe. *Environment and Planning C: Government & Policy, 23*(3), 455-472.
Structural Panels Australia. (2013). Structural Panels Australia - Services. Retrieved July 30, 2013, from http://www.structuralpanels.com.au/page6.php
Summit North West. (2013). Summit North West - Transportable & in situ home builders. Retrieved July 29, 2013, from http://www.summitnorthwest.com.au/
Swanbuild. (2013, 2013
2013/08/16/01:18:25). Prefab Houses Australia | Executive Living - Swanbuild Manufactured Homes. Retrieved August 16, 2013, from http://www.swanbuild.com.au/arlington/
Tasbuilt Homes. (2013). Our Process - Tasbuilt Homes Tasmania. Retrieved August 16, 2013, from http://www.tasbuilthomes.com.au/our-process
Tassie Homes. (2013). Tassie Homes high quality homes Tasmania. Retrieved July 29, 2013, from http://www.tassiehomes.com.au/why-choose-us/
Tensor Building Technologies. (2013). PodTEK | Tensor Building Technologies. Retrieved August 15, 2013, from http://tensorbt.com/products/podtek/
The C. I. E. (2013). Future forecasts: Construction and Property Services Skills 2016-26. Canberra: CPSISC.
The Precasters. (2011). The Precasters | Precast Suppliers to the Building Industry | Tasmania. Retrieved August 16, 2013, from http://www.theprecasters.com.au/index.html
Togo, T. (2010). Translated from Japanese: Transition of the Industrialized Housing-Prefab Housing-in Japan, its Industry and Engineering. Tsukuba: Center of the History of Japanese Industrial Technology.
Toner, P. (2000). Trade apprenticeships in the Australian construction industry. *Labour & Industry, 11*, 39-58.
TR Homes. (2011). Modular and Transportable Home Builders | Perth, W.A | TR Homes. Retrieved August 15, 2013, from http://www.trhomes.com.au/
U. S. Census Bureau. (2011). Industry Statistics Sampler: NAICS 236115 - New single-family housing construction (except operative builders). Retrieved August 5, 2013, from http://www.census.gov/econ/industry/ec07/a236115.htm
U. S. Census Bureau. (2012a). American Housing Survey. Retrieved August 5, 2013, from http://www.census.gov/housing/ahs/
U. S. Census Bureau. (2012b). Characteristics of New Housing > Completed. Retrieved August 5, 2013, from http://www.census.gov/construction/chars/completed.html
Unique Modular Buildings. (2013). FAQ. Retrieved October 4, 2013, from http://www.uniquemb.com.au/faq
US Department of Housing and Urban Development. (1995). USHMC 95: Public Housing: Image Versus Facts. Retrieved August 5, 2013, from http://www.huduser.org/periodicals/ushmc/spring95/spring95.html
US Department of Housing and Urban Development. (2013). HUD- Manufactured Housing and Standards. Retrieved August 18, 2013, from http://portal.hud.gov/hudportal/HUD?src=/program_offices/housing/ramh/mhs/faq
Venables, T., & Courtney, R. (2004). Modern Methods of Construction in Germany - Playing the Off-site Rule. Westminster: DTI.
Versiclad. (2012). Versiclad – Walls. Retrieved July 30, 2013, from http://versiclad.com.au/walls/
VicRoads. (2013). Transporting prefabricated buildings : VicRoads. Retrieved August 1, 2013, from

http://www.vicroads.vic.gov.au/Home/Moreinfoandservices/HeavyVehicles/InformationBulletins/TransportingPrefabricatedBuildings.htm
Victorian Department of Planning and Community Development. (2013). Restrictive covenants - Department of Planning and Community Development. Retrieved August 1, 2013, from http://www.dpcd.vic.gov.au/planning/theplanningsystem/legislation-and-regulations/restrictive-covenants
WA Department of Commerce. (2013). Do I need to be a registered builder? Retrieved July 31, 2013, from http://www.buildingcommission.wa.gov.au/licensing/builders/do-i-need-to-be-a-registered-builder-
Yunus, R., & Yang, J. (2011). Sustainability Criteria for Industrialised Building Systems (IBS) in Malaysia. *Procedia Engineering, 14*, 1590-1598.
Zentralverband Deutsches Baugwerbe. (2012). Baumarkt 2012. Berlin: ZDB.