Planning Prefabricated Homes Using The Faster, Better, Cheaper Concept, Proceeding of International Conferences SDGs 2030 Challenges and Solutions

by Muzayyanah Lppm Unmer Malang

PLANNING PREFABRICATED HOMES USING THE FASTER, BETTER, CHEAPER CONCEPT

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ABSTRACT

Prefabrication as a technology that has long been used in Europe, have a big potential to help fulfill the housing backlog in Indonesia. Project time and cost efficiency along with multiple other benefits have proven that prefabrication system is a valid alternative to the conventional construction system. One of the biggest problem delaying the implementation was the perception of construction practitioners and home buyers about the structural and visual quality, and a prefabricated home owners'satisfaction when compared to a conventionally built home owners'. Faster, Better, Cheaper concept may be the guide to planning a house building project that can be finished faster, be more cost efficient, while achieving higher user satisfaction.

Keywords: prefabrikasi, faster, better, cheaper

1. Introduction

A prefabricated home is defined as the production of the entire or parts of the house's component in another area before being transported to the project site to be assembled (Steinhardt et al., 2013). Prefabrication system in building quality, affordable homes has been widely implemented since the end of the Second World War in affected countries. (Thanoon et al., 2002).

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Table 1 Median prices of conventional-built homes compared to median annual incomes
(Source: Luther, 2009; Demographia International Housing Affordability Survey, 2009)

Country (city size considered)	Affordability Index*	Median House Price	Median Household Income
Australia (Population 50,000+)	6.3	A $357,407	A $57,078
Canada (Population 100,000+)	3.7	CAN $212,398	CAN $57,682
Ireland (Population 50,000+)	5.3	£306,220	£57,960
New Zealand (Population 75,000+)	5.7	NZ $316,113	NZ $55,125
United Kingdom (Population 150,000+)	5.5	£145,300	£26,181
United States (Population 400,000+)	3.6	US $188,699	US $52,706

Affordability Index* – 'slightly unaffordable' >3.0, 'seriously unaffordable' >4.51, 'severely unaffordable' >5.1

The definition of prefabrication as discussed in this paper is a house building project with relatively high content of prefabricated using Panel, Pod, Modular or Complete (Volumetric) systems that allows executing the project with high time and cost efficiency.

Table 2 Types of prefabricated building systems
(Source: Steinhardt et al., 2013; Bell, 2010; Gibb & Isack, 2003)

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
	Pods	Volumetric pre-assembly. Fully fitted-out units connected to an existing structural frame 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), precast concrete panels and structural wooden 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

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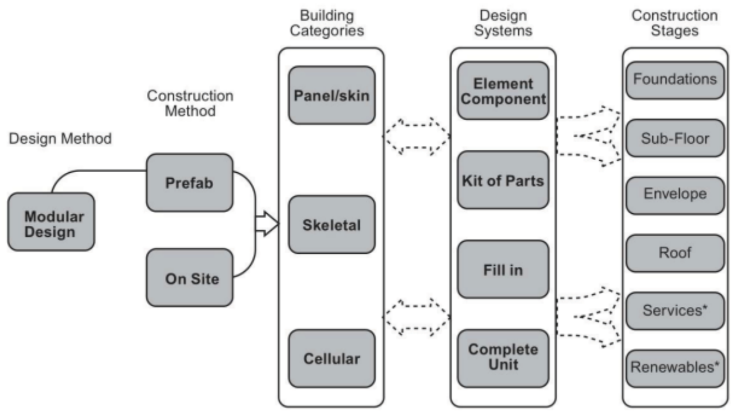

Figure 1 Categorization of prefabricated sytems
(Sumber: Luther, 2009; Luther, Morechini, and Pallot, 2007)

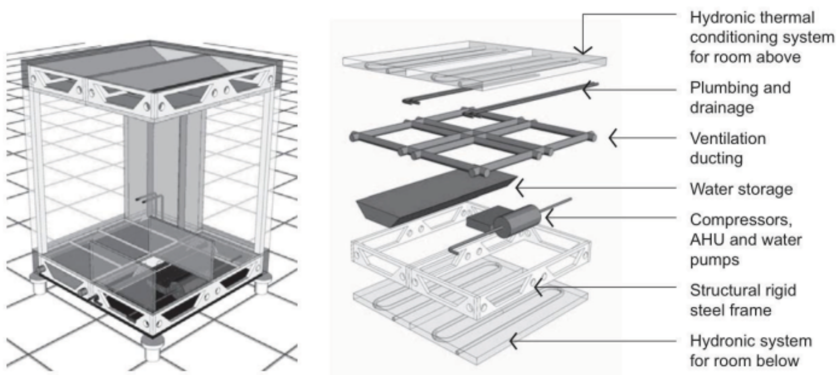

Figure 2 Volumetric prefabricated material example
(Source: Luther, 2009; Multihouse and Digitales Bauen, 2009)

Prefabrication technology in a building construction project is judged to be effective in finishing the project faster, better and cheaper in comparison to conventional construction projects (Wong et al., 2003).

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Table 3 Prefabricated system benefits when compared to the conventional system (Source: Wong et al., 2003)

Factor	Prefabrication	On-site
Quality	In a climate-controlled environment using efficient equipment operated by well-trained people.	Uncertain weather can result in less-than expected construction.
Speed	Speedy process (up to 70% less)	Time consuming. The process can be delayed by weather or scheduling conflicts.
Cost	Greater control over manufacturing results dramatically reduces the chance of cost overruns.	Uncontrollable variables such as weather and scheduling can increase the construction cost
Versatility	Less	More
Site space	Panels arrive on a flat-bed trailer and are installed with sufficient listing plants.	Bigger space is needed. In addition costly scaffolding is often necessary for installation.
Site refuse	Less waste is generated at the site.	A significant amount of waste produced and removed from the site, which often adds to cost.

Table 4 Benefit in implementing prefabrication system to the stakeholders (Source: Luther, 2009; Multihouse©)

Owner	Architect/ Engineer	Manufacturer	Government	University & TAFE	Builders
affordability	organised building services	material optimisation	meeting housing demands	engagement with local industry	greater simplification of assembly
fast delivery	modularisation	structural integrity	providing affordability	manufacturing process R&D	cost benefits
improved quality	engineered building envelope	labour efficiency	regional employment	product innovation & development	speed of assembly
lower energy bills	manufactured quality	reduced material handling	showing leadership in a new industry	develop research potential of Higher Degree Research students	lightweight handling
improved IEQ (Indoor Environmental Quality)	lightweight system	24 hour operation	exportability of product & skills workforce skill development	skills and training	compatibility of components
sustainable materials	improved strength to weight ratio	less assembly time	spin-off industry	Aust. Research Council research grants	reduced source supplier
integrated renewable energy systems	minimised waste	lean manufacturing	replication of factories provides employment	product design innovation	reliability of construction quality
superior fire protection	better environmental & energy rating	improved quality	innovation	materials research	predictability of delivery
increased guarantees	greater repetition of components	quick and easy change over	meeting GHG environmental targets	modular design research	reduced environment al impacts
reduced environmental impact	superior fire rating	inventory control		construction innovation	improved OH&S
reduced air leakage (increased thermal efficiency)	improved acoustics	flexibility of manufacturing		automation research	traceable products offer greater quality assurance
greater piece-of-mind	reduced air leakage	greater output		national recognition	reduced air leakage
		component repetitions			improved energy performance
		flexible labour use			

Although prefabrication have lots of benefit to offer, the system's popularity in UK can not be compared to the conventional house building system (Lovell, H. & Smith, S., 2010). Japan, US, Australia and other countries in Europe and Asia also experienced challenges in trying to implement prefabrication (Thanoon et al., 2002). Some challenges facing the

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implementation of prefabrication system in Malaysia have been identified by Thanoon et al. (2002) as follows:

a) Drastic fluctuations in the housing makes large initial investment unattractive to investors
b) Lack of trained workers capable of doing high precision constriction work
c) Plurality of the.construction industry made it difficult for homeowners, contractors and engineers to make informed decisions on prefabrications system at the planning stage
d) Lack of research and development of prefabrication systems that incorporate local material content.
e) Benefits of implementing prefabrication in house building projects is not well documented enough to compete with the conventional building system
f) Many projects implementing prefabrication ended up producing lower quality but higher costing buildings when compared to the conventional system.
g) Lack of government support in socializing the prefabrication system

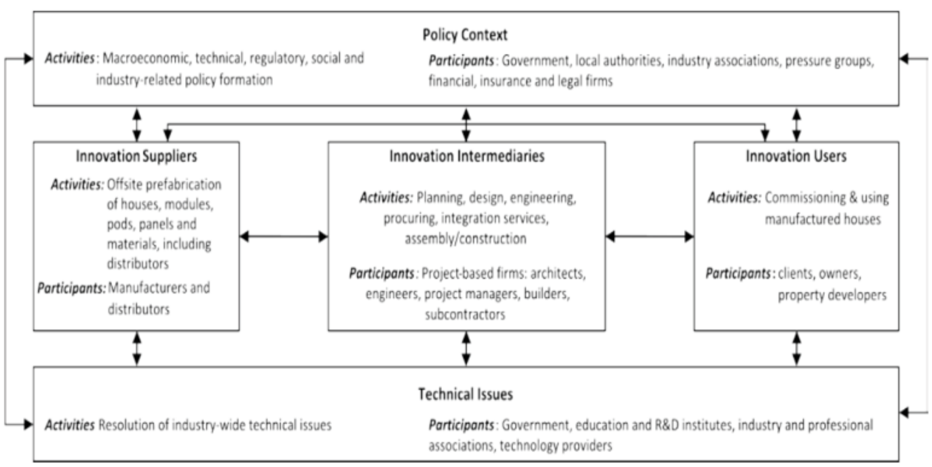

Figure 3 Innovation system of prefabricated housing
(Source: Steinhardt et al., 2013; based on Gann and Salter, 2000)

Indonesia as one of the most populous countries in the world is also facing problems in fulfilling the housing needs of its people.

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Table 5 Housing backlog in Indonesia
(Source: Website PPDPP.id, 4 Agustus 2017)

TAHUN	JUMLAH PENDUDUK (orang)	JUMLAH RUMAH TANGGA (ruta)	PERSENTASE RUMAH TANGGA MILIK (%)	JUMLAH RUMAH TANGGA MILIIK (ruta)	JUMLAH RUMAH TANGGA NON MILIK/ BACKLOG KEPEMILIKAN RUMAH (ruta)
(1)	(2) = BPS	(3) = BPS	(4) = BPS	(5) = (3) X (4)	(6) = (3) – (5)
2010	237.641.326	61.390.300	78.00	47.884.434	13.505.866
2015	255.461.700	65.503.000	82,63	54.125.129	11.377.871

The prefabrication system is one of the ways implemented in other countries to give the people good quality, affordable homes (Thanoon et al., 2002). That's why the planning criterias to maximize the potential and minimize the risk of implementing prefabrication in home building projects in Indonesia need to be researched

2. Discussion

Construction project success is usually measured in three criterias. Time, quality and cost, more commonly known as the Iron Triangle. All three criterias is considered so closely connected that it is impossible to change one without affecting the other (Atkinson, 1999).

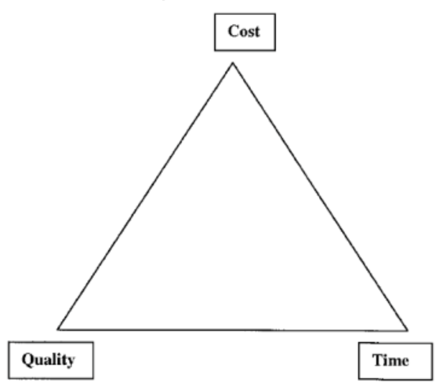

Figure 4 Iron Triangle
(Source: Atkinson, 1999)

In the 90's NASA implemented a concept very similar to Iron Triangle called "Faster, Better, Cheaper" that in essence is the attempt to gain

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improvements in all the above criterias. The early implementations were successful, but were followed by failures, so many expert thought that only two of the three parts of FBC can be optimized at once (El-Rawas and Menzies, 2010).

Research of NASA implementation of FBC (El-Rawas and Menzies, 2010) described FBC as follows:

- Faster is the optimization of time duration needed to finish projects.
- Better is the optimization of quality by reducing work defects.
- Cheaper is optimization of cost which is done by reducing the manhours or mandays needed to complete projects.

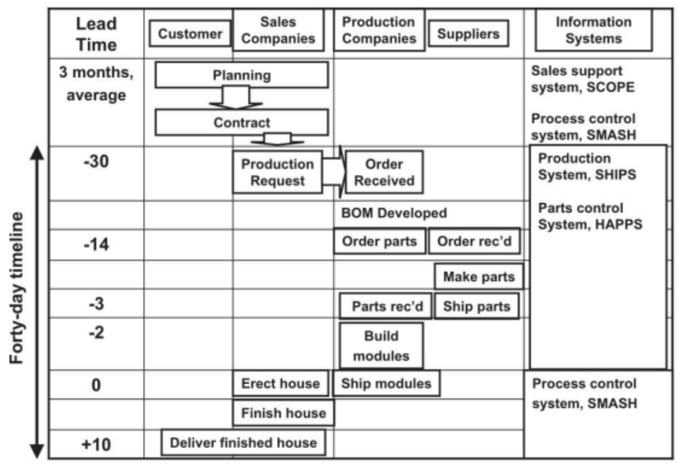

Figure 5 Typical prefabrication schedule of Sekisui House
(Source: Atkinson, 1999)

Prefabrication system as an effort to optimize a project's duration has been proven to be able to fufill the "Faster" criteria. When compared to equal conventional projects, well planned and well controlled prefabrication projects can save up to 70% of duration (Wong et al., 2003). To reach such savings, effects of the material supply chain on the project duration must be considered. Good coordination and communication between all the parties involved to keep the supply chain working efficiently, is a vital requirement in implementing the prefabrication system in a project (Steinhardt et al., 2013).

Prefabrication system as an effort to optimize a project's budget has also been proven to be able to fufill the "Cheaper" criteria. With good planning and control, the cost to finish the project can be more accurately predicted and cost overrun can be minimized (Wong et al., 2003). One of the main financial challenges facing prefabrication housing projects is the relatively large initial

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investment, limiting small and medium sized businesses ability to compete with larger companies (Steinhardt et al., 2013).

Some common problems affecting the project process and preventing the effort to reach time and cost efficiency (Steinhardt et al., 2013) areas follows:

a) Project planning that is too flexible and disorderly, preventing the implementation of prefabrication system
b) Difficulty in modifying parts of the building already installed at the project site and lack of design choices
c) Disruption of project flow due to the lack of financial and knowledge capital. This problem is especially troublesome to small and medium business.
d) More complex process, bigger design load, error correcting process that is more time consuming and smaller construction tolerance. Pioneer companies in prefabrication are especially vulnerable to these problems.
e) Difficulty in coordinating with subcontractors that are unknowledgable and untrained in prefabrication system.
f) Management problems arising from conflicts between traditional and prefabrication methods.

Table 6 SWOT analysis on implementing modern construction systems in Australia (Source: Luther, 2009)

Modular Industrialisation & Automation in Housing	
Strength	Affordability, quality, energy, waste reduction, environmental reduction. Quantity of product, on-time delivery
Weakness	Perception of singular non-flexible product, minimal diversity, selective material & tooling for it.
Opportunity	Spin-off business, skill training, exportability, innovation in products, designs & manufacturing
Threat	Non-flexibility in machine use and tooling. Mono use of material selection and cost increases. Government regulations and codes to new innovations and systems.

Unlike "Faster" and "Cheaper" which are quantitative concepts, the performance of prefabrication system to fulfill "Better" as a qualitative concept is much harder to prove. Some things that affect the market's perception to prefabricated housing quality (Steinhardt et al., 2013) are as follows:

a) The decision to buy a home is very tightly connected to the consumer's feeling
b) In the US, Europe, Australia and Asia, prefabricated housing bear a stigma as cheap and low quality products due to similarities to semipermanent housing.
c) Prefabricated housing is perceived to lower the image of the occupants

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d) The effect on the house's resale value
e) The homeowners does not want to be restricted in their choice to renovate their own homes.

Figure 6 dan 7 Volumetric prefabricated houses
(Source: Luther, 2009; Modscape®, Prebuilt®)

To anticipate the homeowners' wishes to modify the homes' design to their own specifications, housing contractor companies in Japan (Barlow, J., Ozaki, R., 2005) have implemented the following steps:

a) Every company on average have up to 300 standard design alternatives for the buyers to choose throughout the price ranges. In comparison. UK companies in average only have 30 unmodifiable standard design alternatives. Sekisui House company even offered 22 building models, each allowing over 50 alternative plans. The buyers may choose between timber or steel frame, numerous external finishes, and 3 interior finishing style (Japanese, Western, and hybrid). Buyers can also choose multiple types of interior fittings and fixtures. There is very little possibility of Sekisui House producing two 100% identical houses.

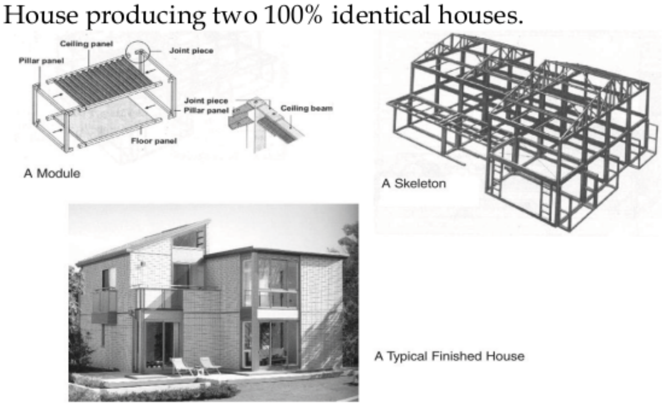

Figure 8 A Sekisui House home
(Source: Hall, Target Magazine, Second Issue 2008, www.ame.org)

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Figure 9 and 10 Volumetric module's production line in Sekisui House
(Source: Hall, Target Magazine, Second Issue 2008, www.ame.org)

Figure 11 Volumetric module stock in Sekisui House
(Source: Hall, Target Magazine, Second Issue 2008, www.ame.org)

Figure 12 Transporting a volumetric module of Sekisui House
(Source: Hall, Target Magazine, Second Issue 2008, www.ame.org)

b) The companies worked with suppliers of bathroom, storage and lighting fixtures to offer various models of standard interior designs. The catalogs are usually updated every 6 months. Some standard fittings like

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ventilation systems can also be replaced by the buyers' choice at a premium.

c) Some companies offer renovating services and repair services for damaged housing after natural disaster like hurricanes, floodings and earthquakes.
d) Big companies conduct thorough post-occupancy evaluations regularly to gauge and keep customers' satisfaction.

3. Conclusion

By referring to the success of the companies that used prefabrication system in housing construction projects, we can surmise that the meaning of "Better" that has the biggest influence on the successful implementation of prefabrication system, is the buyers' satisfaction of their purchases. Some actions that can be undertaken to ensure that are:

a) Providing plenty of alternatives of building and plan design
b) Regular updates to anticipate public trends
c) Providing well trained people to help buyers in mixing and matching the numerous alternatives of building, interior and fittings/fixtures design
d) Providing show houses to convince buyers of the quality and esthetics of prefabricated buildings
e) Providng after sales services such as renovation, modification and repair services.

Other than that, the project initiation stage needs to include feasibility studies to identify the characteristics that affect the buyers' perception of the esthetics value and building quality of homes, since the concept "Better" may hold different meanings to construction practitioners and home buyers. An effective quality planning may then be undertaken, helping to popularize the usage of prefabrication system in housing construction projects.

References

Thanoon W.A., Lee, W. P., Kadir, M. R. A., Jaafar "M. S., Salit, M. S., (2003). *The Experiences of Malaysia and other countries in Industrialised Building System*, Universiti Putra Malaysia, Faculty of Engineering, 43400 UPM Serdang

Wong, R. W. M., Hao, J. J. L., Ho, C. M. F. (2003). *Prefabricated Building Construction Systems Adopted in Hong Kong*, Division of Building Science & Technology City University of Hong Kong

Lovell, H. & Smith, S. (2010). *Agencement in housing markets: The case of the UK construction industry*, School of Geosciences, University of Edinburgh, Drummond Street, Edinburgh, UK, EH8 9XP

Atkinson, R. (1999). *Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria*, Department of

Information Systems, The Business School, Bournemouth University, Talbot Campus, Fern Barrow, Poole, Dorset BH12 5BB, UK

El-Rawas, O., Menzies, T. (2010). *A second look at Faster, Better, Cheaper*, LCSEE Department, West Virginia University, Morgantown, WV, USA

Steinhardt, D. A., Manley, K., Miller, W. (2013), *Reshaping housing-the role of prefabricated systems*, School of Civil Engineering and Built Environment, Science and Engineering Faculty, Queensland University of Technology

Barlow, J., Ozaki, R. (2005), *Building mass customised housing through innovation in the production system: lessons from Japan*, Tanaka Business School, Imperial College London, South Kensington Campus, London SW7 2AZ, England

Luther, M., (2009), *Towards prefabricated sustainable housing - an introduction*, BEDP environment design guide, vol. TEC 28, pp. 1-11

Hall, R., (2008), *Sekisui House*, Target Magazine, Second Issue 2008, www.ame.org

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