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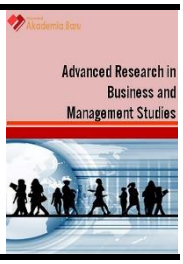

Towards A Sustainable Supply of Affordable Housing with Prefabrication Technology : An Overview

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ABSTRACT

The involvement of private sector in offering affordable housing price for the public is very crucial in the long run. It is relevant as the developing country like Malaysia is experiencing the arising of population and urbanisation process. Therefore, a well-established method such as the approach of utilising the prefabrication technology must be strategised by the stakeholders albeit many issues regarding the practice have been debated in the construction and real estate industry. Thus, this literature study is conducted to explore the arising issues in prefabrication technology so that the strategies can be well adapted by all the parties involved to ensure the sustainable supply of the affordable houses. For the purpose of this study, a systematic literature review was reviewed based on 60 papers published between the years of 2003-2017. The analysis found that the prefabrication technology issues was focus on five main themes: assemble, workmanship, financial, logistic and project information system. Hence the issued could be further strategised by various stakeholder and drive by three main components which are people, process and technology. The findings provide sensible technologies utilisation related to the supply chain systems in the development of affordable houses. All in all, although there were some issues in the practice of prefabrication technology, the more holistic driver approach is needed from all parties towards the sustainable supply of affordable housing with prefabrication technology.

1. Introduction

The notion of using prefabrication technology to meet the demand of scarce housing supplies which are affordable is not new in a developing country like Malaysia. A study by Thanoon *et al.,* [1] advocated that the potential of prefabrication technology that is familiarly known as Industrialised

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Building System (IBS) will grow due to the increasing demand for housing in Malaysia. Hence, the involvement from the private sector is vital in realising this mission. However, a survey by Hung *et.al* [2] indicated that only 14% of private project were using IBS. While, Shuid [3] emphasised the involvement of the private sector in completing the affordable house for middle income group is crucial. This has been associated with the estimation from Bank Negara Malaysia [4] saying that this country needs a million houses to be built for middle income group between the year of 2016 and 2020. This estimation is approximately 2.5 times more than the last five years (between the year 2010 and 2015). Whereas only 255, 341 home have been completed by the various public and private sector players, between year 2013 and October 2017 [5]. This is can be the evidence of the need to further strategies sustainable supply of affordable houses using the prefabrication technology, in which it is believed to produce and supply houses faster, of better quality and reduce more of construction costs.

In order to meet the demands for affordable housing properties, the involvement of private sectors utilizing the IBS systems is very much required. Hence, the demand for the IBS utilization is closely related to the market demands of the affordable houses. However, numerous studies have discussed issues of prefabrication technology in the construction industry [6-9]. Only few studies have explored on the relation between prefabrication technology and affordable housing supply in Malaysia and they are not that comprehensive[10,11]. Therefore, to fill in this gap, this research work aims to explore on issues concerning prefabrication technology. Then, the strategies should be laid out among all stakeholders to build and supply affordable houses to consumers, especially the middle-income group. The extensive literature review pertaining to the topic was conducted using various journal articles, past research reports, statistical data and recent news.

2. Literature Review

2.1 Affordable Housing Demand and Sustainable Supply

The increasing of the prices of houses in Malaysia are not in tandem with median household income [4,12]. Only 21% of new housing launches were priced below RM250,000 in year 2014 [4]. While Malaysians who earned median income of RM4,585 only afford to buy a house with the price of RM165,060 in year 2014 [4]. On the other hand, houses priced at RM500,000 were found to be oversupplied in the high end property market [4]. This shows that the supply of housing market is not in tandem with the median household income growth. Therefore, this has created supply gap of affordable houses among the median income group.

In general, Malaysia faces scarce affordable housing supply due to rapid population growth, socioeconomic changes and urbanisation [4,13]. According to statistical data (see figure 1), Malaysia's population is projected to further increase by almost 41.5% from the year 2010 to 2040 [14]. Hence, the increase of population significantly creates demand for houses [15,16]. Thus, the issue of insufficient supply of affordable houses has raised great concern among Malaysians [4,13,17].

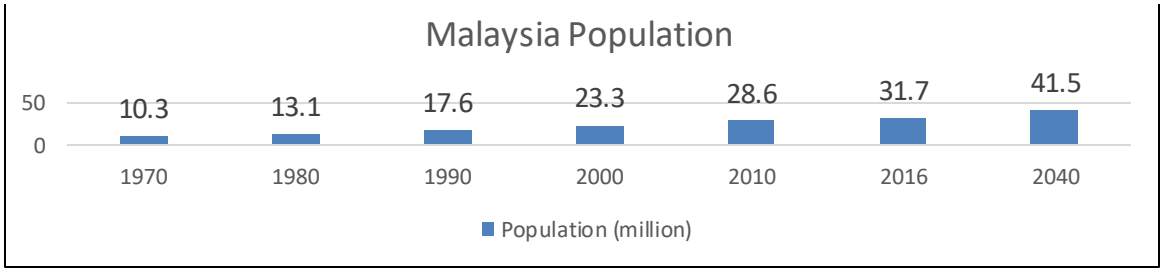

Fig. 1. Malaysia Population Growth [14]

Urbanisation is also a significant factor that contributes to the gap in supplying affordable houses. Urbanisation refers to a spill over effect created by the development efforts in the transmission process at the centre which spreads out into the surrounding areas [18]. Urbanisation entices migration among Malaysians who are living in rural areas to stay in urban areas where job opportunities are greater [19]. In Malaysia, urbanisation increased significantly from 34.2% in 1980 to 72% in 2010 [3,20]. It is estimated that 37 million or 87% Malaysians will live in urban areas by 2050 [20] (see figure 2). Thus, this proves house supply should be given priority in urban areas and affordable house supply which is fast constructed should be further strategized.

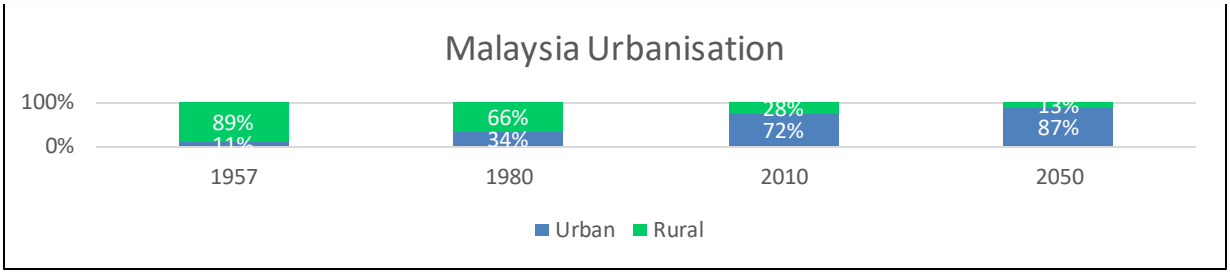

Fig. 2. Malaysia urbanisation [20]

Table 1
Malaysia median income and affordable house price in 2016 (adopted from Department of Statistics Malaysia [23] and Khazanah Research Institute [10]

Malaysia	Monthly Median Income (RM)	Annual income (median income x 12 month) (RM)	Market median-3 price (annual income x 3.0 affordability index) (RM)
Malaysia	5,228	62,736	188,208
Kuala Lumpur	9,073	108,876	326,628
Putrajaya	8,275	99,300	297,900
Selangor	7,225	86,700	260,100
Labuan	5,928	71,136	213,408
Johor	5,652	67,824	203,472
Melaka	5,588	67,056	201,168
Pulau Pinang	5,409	64,908	194,724
Terengganu	4,694	56,328	168,984
Negeri Sembilan	4,579	54,948	164,844
Perlis	4,204	50,448	151,344
Sarawak	4,163	49,956	149,868
Sabah	4,110	49,320	147,960
Perak	4,006	48,072	144,216
Pahang	3,979	47,748	143,244
Kedah	3,811	45,732	137,196
Kelantan	3,079	36,948	110,844

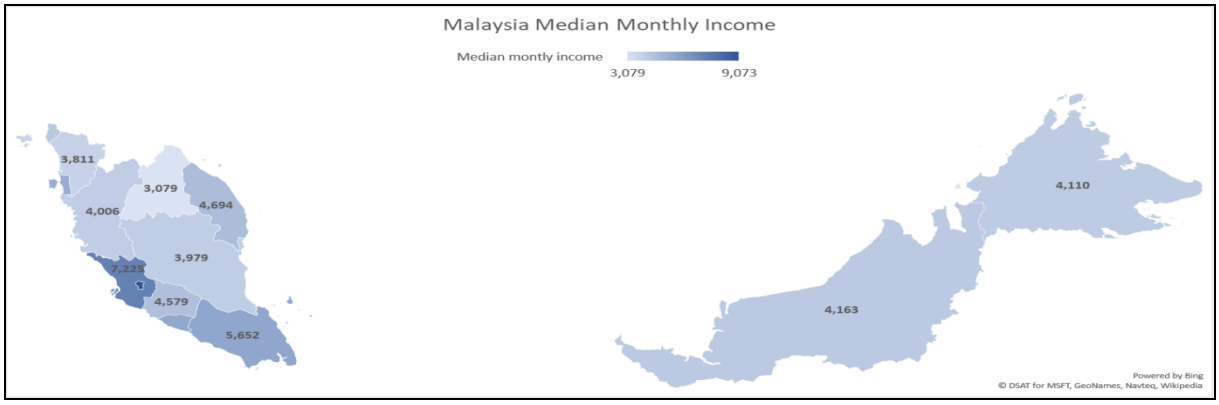

Fig. 3. Malaysia Median Monthly income by state, 2016 (adopted from Department of Statistics Malaysia [24]

Supply refers to the production and availability of the real estate product [21]. The current house supply and price available in the market is above the ideal affordability index for Malaysian median household income group [10]. As a result, Bank Negara Malaysia has estimated a million houses to be constructed within five years as to match with the household income growth. In completing a million affordable houses, it is a must to entail comprehensive understanding of the definition of affordable houses. According to the ``Median Multiple´´ methodology developed by Demographia International and recommended by the World Bank and the United Nations a house is consider affordable if a household can finance it with less than three times its annual household income (house price-to-income ratio of 3.0 and below) [22].

Table 1 shows the average house price in all states in Malaysia [24] This indicates the overall house price for Malaysia was RM188,208 in year 2016 and the distribution of data was varied according to states. The highest median income group comes from the states which are close to the federal territories. This is because the short distance that these states have to the federal territories, so there are many socio-economic developments that take place there. As a result, this has created more middle-income group and the needs to have more affordable houses are more prevalent there.

Hashim [25] suggested that study in sustainable housing supply for the current and the next generation need to be implemented as an endeavour in providing affordable houses. Recent research works discover that the main challenges in providing the affordable housing are to fit the target group, location and prices [10,26,27]. Figure 4 illustrates the harmonising supply and demand of housing.

Fig. 4. Harmonising supply and demand of housing (adopted from Samad *et al.*, [27]

Therefore, the housing initiative needs to be well planned for future benefits. According to Choguill [28], "in order to be sustainable, housing initiatives must be economically viable, socially acceptable, technically feasible, and environmentally compatible". By embracing sustainable housing initiatives, the use of prefabrication technology is theoretically in line with the endeavour of providing sustainable supply of affordable houses. The use of prefabrication technology has been strongly acknowledged in sustainable development because of its ability to minimise construction waste, lower the overall construction cost, provide better quality houses and completes faster [29-34] .

Fig. 5. Housing initiative towards sustainable (adopted from Choguill [28])

2.2 Prefabrication Technology Adoption for Sustainable Supply

The prefabrication technology adoption has been widely implemented by the developing and developed countries in sustaining the supply of the housing demand. Sweden for example, planned 10 years production of prefabricated house between the year 1965 and 1974 in "Million Programme" in which this country faced scarce housing post-war [35,36]. Until today, prefabrication technology is getting more advanced and Sweden construction industry is able to produce 29,164 prefabricated house in year 2014 in targeting many market segments [37,38]. The mature market such as Japan which has achieved automatisation, was highly producing houses in meeting the demand. Interestingly, prefabricated manufacturers in Japan offered different values to customers when compared to the Malaysian market manufacturers. In Japan, the prefabricated house prices are higher compared to the prices of houses built on-site. This is due to the long term services and warranty offered to the purchasers by the prefabricated manufacturers [39]. Japan was able to supply about 892,261 units (in year 2014) to cater the housing demand using prefabrication technology [38].See table 2. Therefore, it can be said that prefabrication technology in construction of houses is becoming more significant and is able to sustain the supply of houses in meeting the high demand from buyers in developed countries.

In Malaysia, the use of prefabrication technology is still low among the private developers. This is in agreement with a study that discovered the use of prefabrication technologies remained unknown in reducing the total cost in building affordable houses [40]. However, the implementation of prefabrication technology has been in use in Malaysia since the 1960's, for the low-cost housing project. Together with strong support given by CIDB, IBS has been widely used for government projects including the low-cost public housing projects. In which, the low-cost public housing projects are under the control of the government. The allocation is regulated in the national budget and the Malaysian Plan that concerns the low-income group. The government is subsidising up to 70% of the public housing projects of the low cost houses [3]. On the contrary, the number of housing projects by the government has not been as huge as the number developed by the private sector.

Table 2
Prefabrication Technology Production

Countries	Prefabrication Technology	
	Year Start	Annual Production
Sweeden	1960s [41]	29,164 unit on year 2014 [38]
Japan	1940s [42]	892, 261 unit on year 2014 [38]
Malaysia	1960s [43]	No formal record. However, IBS manufacturer such as Gamuda IBS capable to produce 2000 units apartment a year [43]

In the context of this study, it is hoped that the supply of affordable houses can be met by the private sector and this will assist in minimising the subsidy by the government, especially among the middle income group, as stated by Mahalingam [44] through an interview with Khazanah Research Institute Director. Although the adoption of IBS is still low among the private sector [2], Khazanah Research Institute has strongly emphasised that using prefabrication technology can lower the costs as informed by Mahalingam [44]. Figure 6 illustrates the timeline of IBS initiative and affordable housing demand.

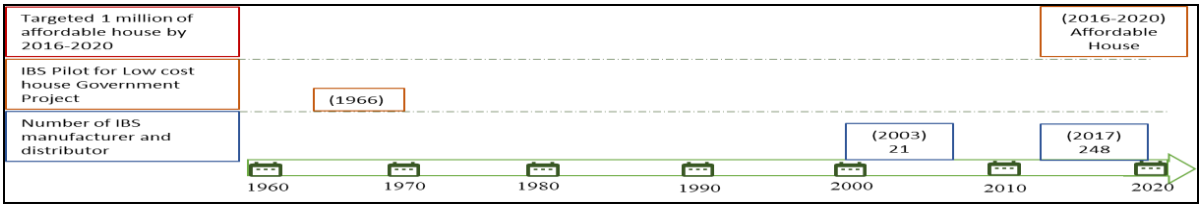

Fig. 6. Timeline of IBS initiative and affordable housing demand

3. Research Methodology

To further explore the issues of prefabrication technology and strategies that laid out for better sustainable supply of affordable housing, systematic literature review was employed. Thematic analysis was synthesised from various journals and conference proceeding. The search terms used were industrialised building system, affordable housing, prefabrication technology and sustainable. Articles searched were published from the year 2003 until 2017. Articles were selected based on the titles with search terms. Then the articles were screened and finalised based on the related contents. Almost 60 articles and reports were selected and reviewed.

Twelve sub themes related to prefabrication technology issues was analysed and merge into five main themes. Then several strategies were reviewed and commensurate accordingly with the main issues discussed.

4. Discussion

4.1 Prefabrication Technology and Housing Development

In order to comprehend the prefabrication process in housing development, Figure 7 has been created. Figure 7 illustrates the housing development and prefabrication housing process that is adopted from Khazanah Research Institute [10], Li *et al.,* [45] and Pan and Goodier [46]. Housing development comprises the inception stage where the developer as the owner of the housing project acquires the proposed land. The Prefabrication housing processes involved various parties from the designing stage until the assembling of the components on site. This comprises the designer, the manufacturer supplier, the transporter and the contractor. The house project will be handed-over to the purchaser after settling the mortgage loan with the financial institution. Some housing projects

like high-rise apartments, the maintenance will be taken care of by the subsidised company of developer's cooperation.

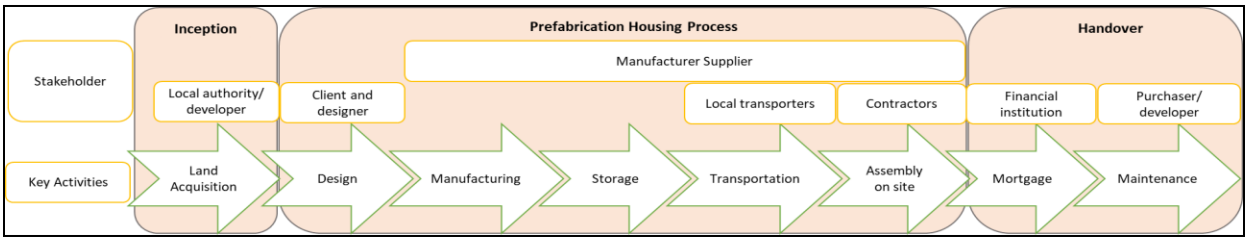

Fig. 7. Housing development with prefabrication housing process

4.2 Prefabrication Technology Issues and Strategies for Sustainable Supply of Affordable Housing

Past literature review by Jabar *et al*., [7] identified various issues in the IBS entire construction phase starting from pre-construction, construction and post construction in Malaysia. Various authors have also highlighted IBS issues touching the prefabrication housing process in their scope of research with several suggestions and improvements [33,47,48]. While Goulding *et al.,* [49] highlighted key driver of people, process and technology should be further focussed on the entire prefabrication process on taking up the prefabrication technology in creating a new business model.

Issues		Strategies for various stakeholder	Driver		
Main Issues	Related issues		**People**	Process	Technologies
Assemble	-Improper component assembly -Insufficient knowledge of installation		**Skill worker**	-training -construction method statement	-Virtual training
Workmanship	-Low quality -Leakages		**Skill worker, training**	Quality assurance and control (on and off site) guideline	-Laser scanning
Financial	-Low profit margin -Capital investment -conventional payment method		**Encourage foreign investment**	-Production of components through break-even analysis -Reduce waste cost -Procurement	-BIM estimation -E-commerce and payment -E-procurement
Logistic	-Transportation -delay of arriving IBS component -infrastructure		**Transporter**	Appropriate IBS component selection by clients	-RFID -GIS
Project Management system	-Stakeholder coordination -Lack of integration between project team		**Skill technical proffesional and skill worker**	-integration of data sources -ICT support tools -training	-Mobile computing -Cloud computing -BIM -Technology support tools -Virtual training

Fig. 8. Issues in prefabrication technology and Strategies for various stakeholder

Aris *et al.,* [40] emphasised that the strategies and planning should be further studied to avoid drawback issues, thus sustainable supply for affordable housing in using prefabrication technology by stakeholders could be embraced. According to Lessing *et al*., [37] one of strategy to enhance efficiency through the entire business model of prefabrication technology approach was by implementing the technical and process innovations, to achieve cost reductions, increased quality and more reliable deliveries. All past studies are summarised in figure 8. Figure 8 indicates fundamental issues highlighted from previous research works and strategies proposed for various stakeholders, covering the three major drivers that are people, process and technology.

4.2.1 Assemble Issues and Strategies

Many research works have reported that to get better performance of using IBS in construction project, highly skilled workers are needed [7,50,51]. The effect of employing unskilled workers in assembling IBS components on site will result in improper installation, which eventually would cause the arising in maintenance cost. To improve this, strategically the improvement process should be undertaken by the organisation via providing a proper training module of the method employed. Since technology evolves and it is highly influential, the effective knowledge sharing, through technology like virtual training is well-suited to be used in the assembly process. Rashidi and Ibrahim [33] proposed virtual reality technology for better people training in the IBS processes, as they looked at the potential of IBS to be productively employed in the future. They cited that the integration of information technology would improve IBS productivity in the construction industry. In lieu of sustainable supply of affordable houses, this review suggests that the stakeholders or any institutional body that provide technical education should take up knowledge sharing as one of the initiative in providing sustainable supply for affordable houses.

4.2.2 Workmanship issues and strategies

IBS offers high quality products in completing a construction project. However, it has several drawbacks; one of them is leakages as highlighted in the past studies [52-54]. This issue is related to workmanship which is also related to contractors' competency [9]. To overcome this issue, the owner (people) of project should closely and regularly monitor and control the process at the casting yard (factory) during the production, and during the installation of IBS products. According to Chen [29] rigorous quality supervision system is required in assuring owner to receive high quality products. He cited that certified quality process combined with factory-controlled system has been practically implemented in the precast concrete products in USA. Recently, the laser scanning technology is a popular method for quality assurance and quality control due to its high reliability and accuracy [55]. In relation with housing supply, key stakeholders were required to employ those who are highly capable of technical command. This will result in the owner of housing development project to deliver good quality houses.

4.2.3 Financial issues and strategies

One of the reasons of lower adoption of IBS is the capital investment to set up new production facilities [56]. It is believed that the construction cost will be reduced since the break-even of high production cost can be gained from the total production facilities investment [29]. Another major issue highlighted in the past research works is financial problem. Completing a housing project requires effective cash flow, and payment is an issue in the adoption of IBS [6,48]. Thus, better

procurement methods and strategies are needed as suggested by previous research works [47,57]. The applications of e-commerce and e-procurement for instance are able to improve the construction business process [58]. However, practitioners in the industry are highly concern of economies of scale before embarking in the market which means that the high demand of IBS components is able to reduce cost [56,59]. The consistency in using IBS components by the active owner of housing projects will contribute to the economies of scale.

4.2.4 Logistic issues and strategies

The prefabrication products such as the precast concrete panels are heavy to be transported and assembled on site. In Sabah and Sarawak, the development activities have just begun to emerge actively. However, the recent research by Hadi *et al*., [6] in Sarawak stated that the transportation cost was crucial while number of IBS manufacturers and distributors was small in that state. He suggested the infrastructure there needed to be upgraded and additional incentives should be given to the project owners in the rural areas. Besides, the appropriate selection of types of IBS components was also vital to avoid cost overrun due to logistic problem. To overcome that, the application of technology such as the geographical information system (GIS) which is able to visualise the logistic delivery of materials more efficiently is used. Research conducted by Irizarry *et al.,* [60] represent the use of GIS and radio frequency identification (RFID) as a method to improve the integration process of construction supply chain management.

4.2.5 Project management information system and strategies

According to Sanchez *et.al.,* [61], the development of information system is the key to success in organizations, that is by leveraging the technology. Ismail *et.al.,* [62] found that management factor such as lack of teamwork and coordination between all parties were factors that needed improvement concerning the on site management for IBS. It was said that the IBS practitioners were still at small in designing system in managing the project. According to Deirkesen and Ozorhon [63] the firms that executed effective process integration activities were able to perform better. By embracing changes in the integrated processes, all stakeholders including client, suppliers and manufacturer needed to strategically cooperate [56].

Table 1
The Summary of Findings

No	Findings
1	Five main issues of prefabrication technology was assemble, workmanship, financial, logistic and project information system could be further strategised by various stakeholders with the main driver are people, process and technology.
2	Understanding the arise issues within prefabrication technology will lead better supply chain management for prefabrication materials
3	Understanding the housing development with prefabrication housing process and stakeholders involvement will lead to better sustainable supply chain of affordable housing.
4	Affordable housing development involve various stakeholders from inception stage until handover

The use of Building Information Modelling (BIM) which is highly recommended by CIDB should be further strategies by all stakeholders and not any stakeholder should be working in silo. BIM enables integration among key stakeholders and significantly enhances project's performance. Mobile computing with many data collaboration support tools could be used in enhancing the sustainability of affordable houses supply. Chen *et al.,* [29] stated that the integrated design environment by key

stakeholders will be valuable in minimising defects and it should start from the earlier stage through effective communication. With regard to the completion of a housing project, the project management information system is beneficial.

5. Conclusions and Recommendation

A model on providing a sustainable supply of affordable houses that fits the target group, location and price by using the prefabrication technology is needed. The use of prefabrication technology will increase the performance of project owners in supplying affordable houses and eventually will reduce the overall construction cost. The adoption of IBS among the developers as investments in the initial capital can provide sustainable supply of affordable houses. Despite various issues highlighted by previous studies, the prefabrication technology can be further strategized by the key stakeholders in the entire prefabrication process. The technology evolves as drivers in the business model emerge in tackling key issues in the prefabrication technology, however implementation of the overall technology has not been further explored in the local context.

The housing property business model that takes up prefabrication technology for Malaysia's affordable house segmentation may change and stimulate competitive advantage within the construction industry players hence this would increase the performance of housing developers in delivering houses. It can be concluded that the prefabrication technology employed in meeting the increasing housing demand can be more innovative in the sense that technology such as 3D printing can be applied in home fabrication [64]. Close monitoring and controlling by owners of project are crucial in applying the technology to achieve the desired goals.

There is a gap to be further explored since there are only several institutional and a small number of developers who have implemented the business model of a prefabricated house in the construction business. Hence, more research works are needed to fill in this gap and thus, it would enable the market to increase the number of affordable houses by using prefabrication technology business model.

This study also recommends that the extension of research of business model of prefabrication technology for affordable housing supply to areas which are densely populated rather than the Federal territories areas. These are the areas where urbanisation and migration take place at a fast rate. The state of Selangor, for example can be a good case study since it has all the mentioned aspects and demands for affordable houses are also high there.

The findings of this paper concluded that further study based on case studies of current business model should be conducted for better improvement within the business model for affordable housing supply.

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