REVALUING AFFORDABLE HOUSING IN MALAYSIA
THROUGH ADVANCED TECHNOLOGY AND INNOVATION

CIDB TECHNICAL PUBLICATION NO: 203

CIDB MALAYSIA

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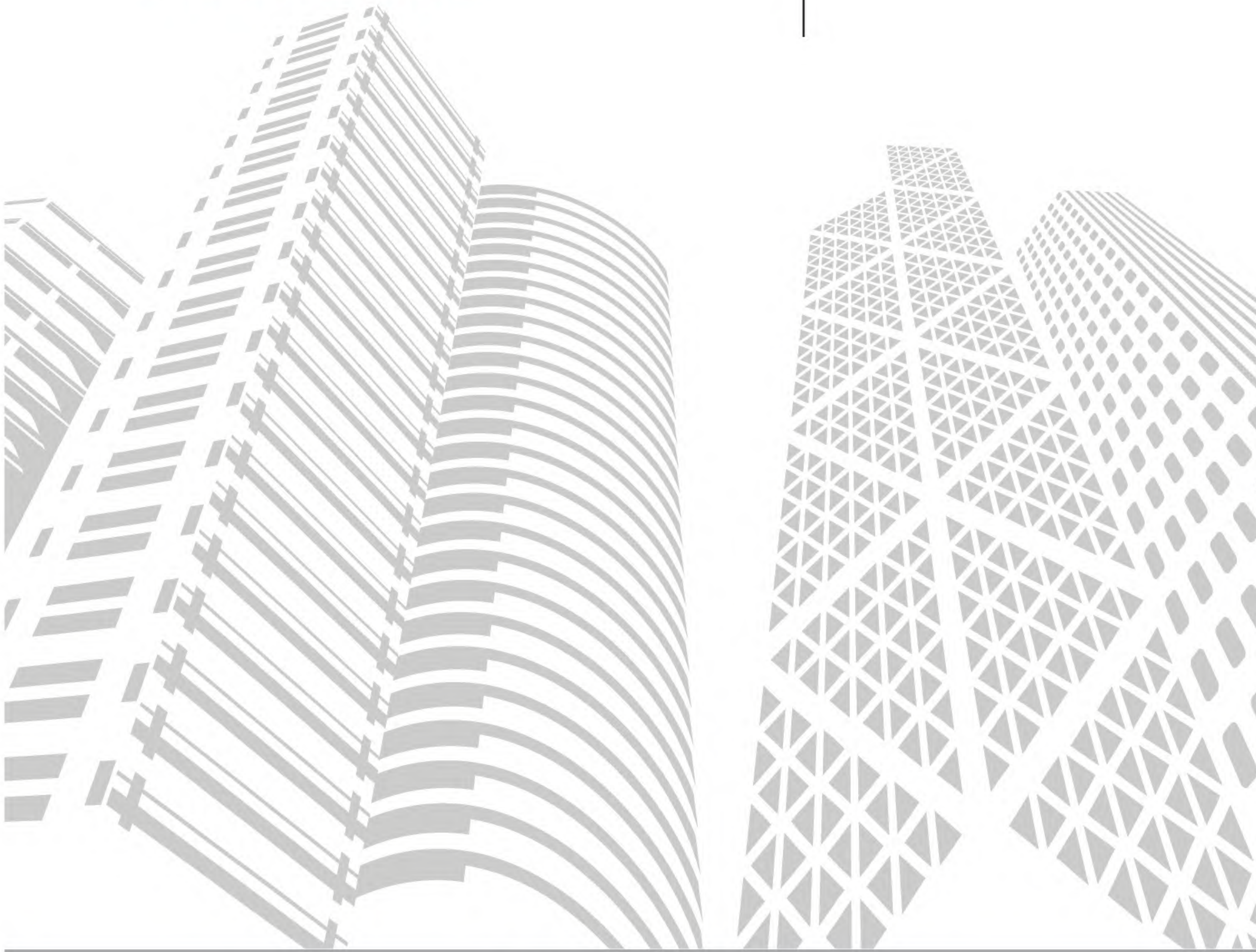

Research Collaboration

CREAM
CONSTRUCTION RESEARCH INSTITUTE OF MALAYSIA

KPKT

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Preface

Humanising Low-Income Group's Housing Through Technology and Innovation aspires to turn issues on affordable housing into a good account. The government has anticipated and initiated numerous programmes to resolve the issues in delivering affordable housing. Yet, Malaysia is still facing issues in ensuring the availability of quality houses to the people, mainly to those in the low-income group.

Thus, Construction Industry Development Board (CIDB) Malaysia has funded a research study, performed by Construction Research Institute of Malaysia (CREAM), to examine the issues in the technical aspect of delivering and constructing affordable housing. Research on Humanising Low-Income Group's Housing, which was performed in two phases, has resulted in the publication of three books. The first publication entitled **Delivering Affordable Housing in Malaysia: Issue and Challenges** was published in 2019. This book is the second in the series and published with the title of Revaluing Affordable Housing in Malaysia through Advanced Technology and Innovation, while the final output from the research study is **DeLIGHT Homes: A Sustainable and Innovative Affordable Housing Design Handbook.**

This book aims to serve as a reference for housing players in providing quality and affordable housing. The National Housing Department (JPN) under the Kementerian Perumahan dan Kerajaan Tempatan (KPKT)is the collaborative agency in this research. Existing affordable housing and interventions by the government for the low-income group are re-evaluated in this book. The technology and innovation used in the construction of affordable housing are also discussed. Residents' basic needs in the present low-income group's housing are also highlighted to ensure that houses are liveable and humanised for the family and community. The results of this book serve as a basis for the final research output. From there, various designs have been developed, which would change the perception of affordable housing in Malaysia.

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Executive Summary

One thing that billions of people around the globe can relate to is the sticker shock feeling they get whenever they try to purchase a house. Rental and house price have risen faster than income in most countries. The people living in big cities, especially, are struggling to find themselves a home that they can afford without the need to forego other essentials.

The imbalance between housing supply and demand is at the heart of the housing issue, especially in this day and age with the ongoing trend of urbanisation worldwide. In 1950, New York City and Tokyo were the only cities in the world, with populations of over 10 million. Today, there are more than 20 cities on earth of that size. Over the last three decades, approximately 65 million people have migrated every year to big cities in which job opportunities are concentrated (Nations. U, 2019; Woetzel et al., 2017).

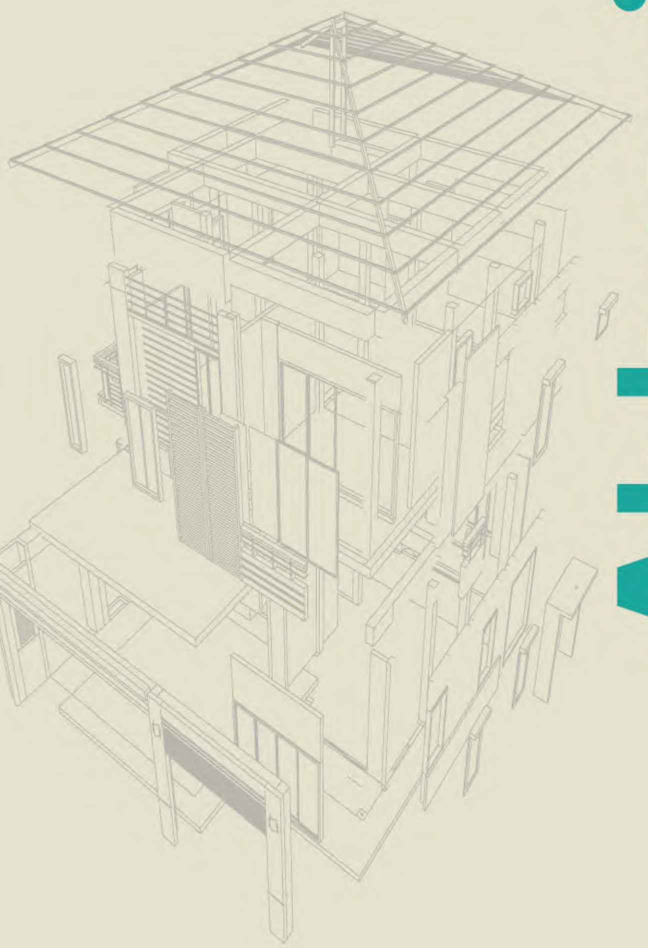
Governments around the globe, including Malaysia, have taken steps to resolve this inextricable issue. This book traces the housing interventions initiated by the Malaysian government from the country's pre-independence era until the present time. The government has provided numerous incentives on both supply and demand sides to help every Malaysian realise their dream of owning a house. This book also compares the housing interventions in Malaysia with those adopted by neighbouring countries such as Singapore, Australia, and Hong Kong.

Despite the government's considerable effort to build public housing for those in need to address the lack of affordable houses issue in the country, at least one thing has not been resolved, which is providing the people with a home instead of a house. George Moore once wrote, "A man travels the world over in search of what he needs and returns home to find it". Thus, it is essential to provide a house that satisfies the needs of its residents in order to make it their home.

In ensuring that this book can properly guide housing industry players in providing the people what they need, CREAM reached out to some residents of public housing to ensure that their voices are heard by conducting a survey to understand their needs or demands regarding the features that should be included in any housing. The findings of the survey are also highlighted in this book.

To ensure the delivery of quality and the demand of the affordable house is met, this book also elaborates the usage of advanced construction technologies or Modern Methods of Construction (MMC) such as lean construction, Industrialised Building System (IBS), and Building Information Modelling (BIM) in the construction project lifecycle to improve construction productivity, particularly in housing construction. This book also highlights some sustainable features along with quality and safety features that should be implemented to humanise housing for the low-income group.

List of Abbreviations



AHG Additional CPF Housing Grant
APO Asian Productivity Organization
BCA Building and Construction Authority
BEP BIM Execution Plan
BIM Building Information Modelling
BNM Bank Negara Malaysia
BTO Build-to-Order
CFD Computational Fluid Dynamics
CIDB Construction Industry Development Board Malaysia
CIS Construction Industry Standard
CITP Construction Industry Transformation Program
CNC Computer Numerical Control
COAG Council of Australian Governments
CREAM Construction Research Institute of Malaysia
CSHA Commonwealth State Housing Agreement
DE Digital Engineering
DfMA Design for Manufacturing and Assembly
DIBS Developer Interest Banking Scheme
EIR Employer's Information Requirements
EPF Employees' Provident Fund
EPS Expanded Polystrene
EPU Economic Planning Unit
FHOG First Homeowners Grant
HDB Housing and Development Board
HLE HDB Loan Eligibility
HOS Home Ownership Scheme
HPS Home Protection Scheme
IBS Industrialised Building System
ICT Information and Communications Technology
IH Interim Housing
IoT Internet of Things
IPD Integrated Project Delivery
IR Industrial Revolution
JIT Just-In-Time
JPN National Housing Department
JSS Joint Singles Scheme
KPKT Kementerian Perumahan dan Kerajaan Tempatan
LOD Level of Detail
LPDS Lean Project Delivery System
MBI Majlis Bandaraya Ipoh
MBSB Malaysia Building Society Bhd
MCPS Married Child Priority Scheme
MGPS Multi-Generation Priority Scheme
MHPI Malaysian House Price Index
MMC Modern Methods of Construction
MOHSS Ministry of Housing State of Sarawak
MP Malaysia Plan
MPC Malaysia Productivity Corporation
MRTA Mortgage Reducing Term Assurance
MSS Mean Satisfaction Score
MTR Mass Transit Railway
MyCREST Malaysian Carbon Reduction and Environmental Sustainability Tool
MyHome Youth Housing Scheme
NAPIC National Property Information Centre
NEP New Economic Policies
NRAS National Rental Affordability Scheme
OBS Open Building System
PBU Prefabricated Bathroom Unit
PPA1M Perumahan Penjawat Awam 1Malaysia
PPHS Parenthood Provisional Housing Scheme
PPR Program Perumahan Rakyat
PPS Parenthood Priority Scheme
PR1MA Skim Perumahan Rakyat 1Malaysia
PRH Public Rental Housing
QFD Quality function deployment
QLASSIC Quality Assessment System in Construction
QoL Quality of Life
RA Commonwealth Rent Assistance
RFID Radio-frequency identification
RIBA Royal Institute of British Architects
RIR Rumah Idaman Rakyat
RMR1M Rumah Mesra Rakyat 1Malaysia
RUMAWIP Rumah Mampu Milik Wilayah Persekutuan
SAPS Studio Apartment Priority Scheme
SBF Sale of Balances Flats
SCHS Sandwich Class Housing Scheme
SDP Sime Darby Property
SHASSIC Safety and Health Assessment System in Construction
SHG Special CPF Housing Grant
SJKP Syarikat Jaminan Kredit Perumahan Berhad
SPA Sale and Purchase Agreement
SPEF Skim Pembiayaan Fleksible
SPNB Syarikat Perumahan Negara Malaysia Berhad
SSC Single Singapore Citizen
TPS Scheme
TVD Tenants Purchase Scheme
UK Target Value Design
USA United Kingdom
United States

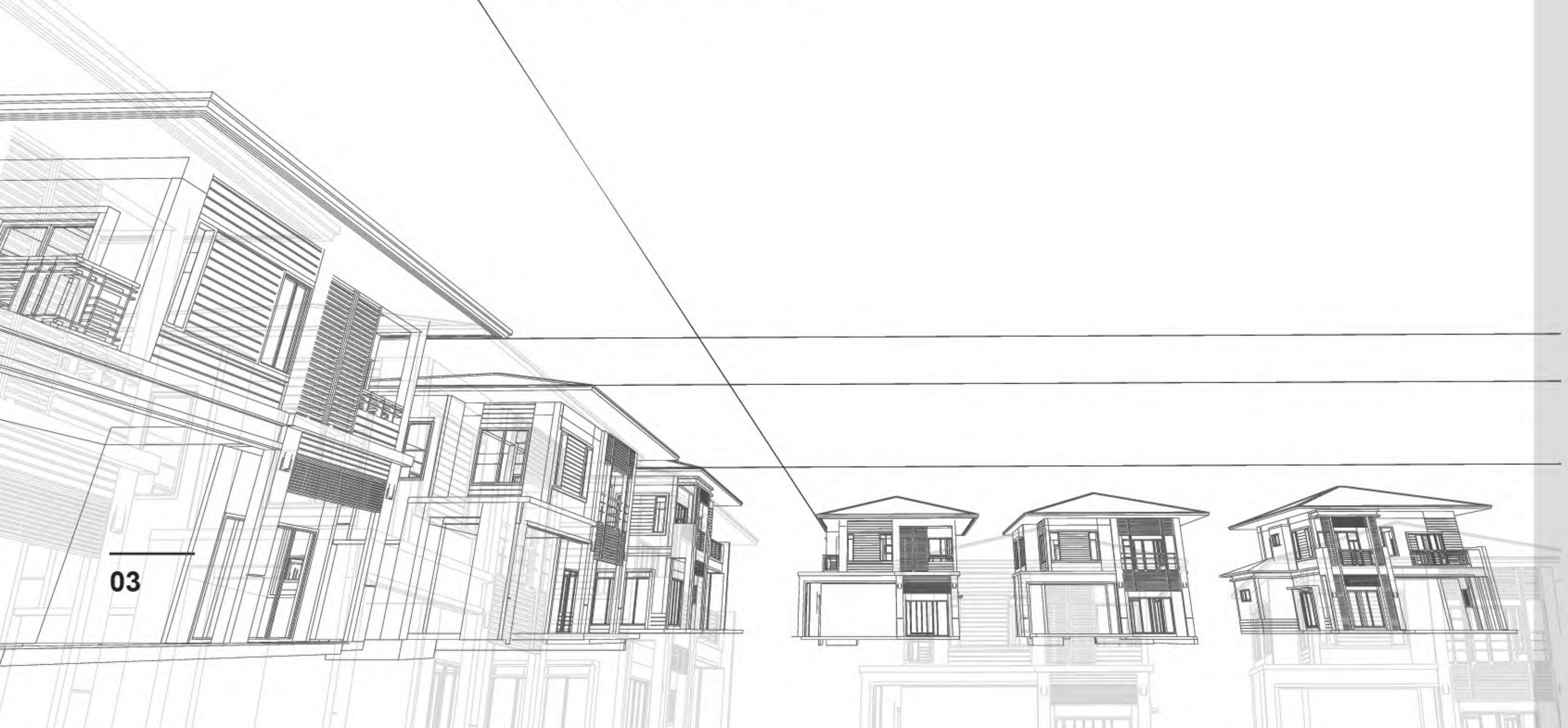
SECTION 1

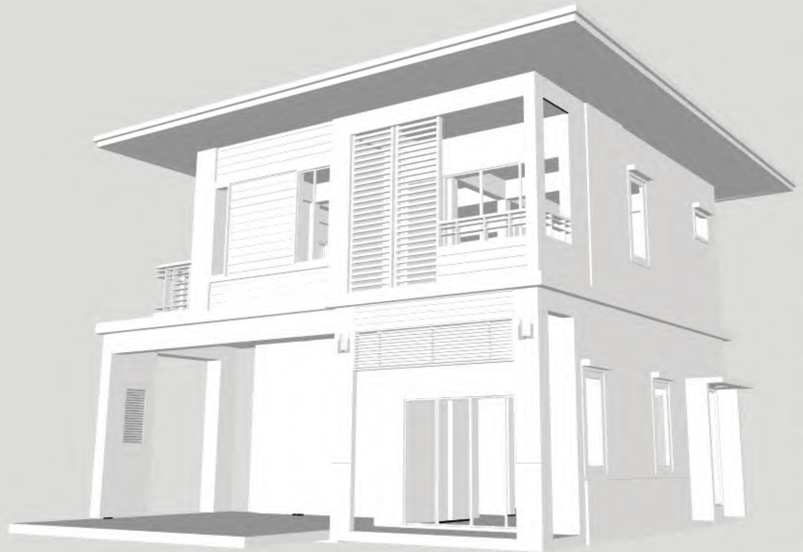
Empowering Housing For The Nation

- Malaysian Government Policies and Interventions in Housing
- Global Affordable Housing Provision
- Satisfying Needs and Demands
- Identifying Essential Features for Housing
- Addressing Crime Activities in Low-Income Group Housings

1.1 Malaysian Government Policies and Interventions in Housing

Malaysia is a multiracial nation. In yesteryear, different economic activities stemming from this diversity had somehow mapped out the development and planning of the housing industry. For example, the majority of the Malays lived in rural areas, most Chinese lived in urban areas, and the Indians mainly lived in estates.





To promote national unity and a harmonious society, the government had implemented the New Economic Policies (NEP) in 1970 with the two-pronged objectives of eradicating poverty and restructuring the society irrespective of race, economic function, and geographical location. As a result of the NEP, the Malays started migrating to urban areas leading to rapid population growth in those areas. This had resulted in severe shortages of affordable housing, leading to the formation of extensive slum and squatter settlements (Tan, 2011).

However, these settlements were inadequate for people to live in due to overcrowding and the poor state of the accommodations (Idrus & Siong, 2008). This problem caught the government's attention and motivated the government to frame housing policies and programmes as an effort to reduce slum and squatter settlements and to ensure that adequate housing is accessible to all Malaysians, particularly the low-income group.

In the First Malaysia Plan (MP) (1966–1970) and the Second MP (1971–1975), various housing programmes were designed to promote the welfare of all Malaysians by providing enhanced housing, community facilities, and other services. The goals of the Third MP (1976–1980) were to eradicate poverty and restructure society, which were continued in the Fourth MP (1981–1985). The Fifth MP (1986–1990) emphasised on providing the housing areas with social facilities such as schools, clinics, and community halls. In the Sixth MP (1991–1995), the focus was on home owning for various income groups. The low-medium cost house was introduced in the Seventh MP (1996–2000), and this priority was continued in the Eight MP (2001–2005) by encouraging the development of more low and low-medium cost houses. Under this plan, the public and private sectors were urged to unite and work hand in hand to meet the increasing demand for housing. Consequently, the objective of the Ninth MP (2006–2010) was ensuring that all Malaysians, especially those in the low- and low-medium-income groups, would have access to adequate, quality, and affordable housing (Tan, 2011). Various housing programmes were implemented during the Tenth MP (2011–2015) to provide sufficient affordable housing to poor, low- and middle-income households. The main objectives of the Eleventh MP (2016–2020) are to increase access to affordable housing for targeted groups and to provide financial assistance for home buyers. Following diagram summarises the housing provisions by the government since the pre-independence until the current Eleventh MP.

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Before 1956

Colonial Administration and Pre-Independence

- Provision of government quarters
- Resettlement of Malayan population from their land to New Villages (Kampung baru)
- Housing Trust was established by British government to launch the development of rural public low-cost housing

1956 1960

First Malaya Plan

- Assisted the provision of housing in providing more adequate low-cost housing
- Ministry of Housing and Local Government was established to facilitate and improve the Housing Trust

1961 1965

Second Malaya Plan

- Provision of housing in urban areas for low-income groups
- Khaw Kai Boh-the first low cost housing built:
- 40% of low-cost housing was built in West Malaysia throughout the 1960s and 1970s
- 1964 - Pilot IBS project was launched at Jalan Pekelling
- 1965 - Second IBS project was lauched at Jalan Rifle Range

1966 1970

First Malaysia Plan

- Focused on the low-income group to promote their welfare
- The government encouraged and assisted the private sector to start low-cost housing developments
- Addressed the squatter problem in urban areas
- New construction techniques that could accelerate construction while minimising cost were explored

1971 1975

Second Malaysia Plan

- Eliminated slum dwellings and squatters living
- "Core Housing" concept was introduced as basic shelters for lower-income groups
- At least 30% of houses were allocated for Bumiputera
- Housing Trust was dissolved and replaced by the National Housing Department

1976 1980

Third Malaysia Plan

- Ensured all Malaysians had access to adequate housing
- Improved rural living state through various private and public housing development schemes
- HDA Perumahan Berhad was established tobuild private low-cost housing
- Kampung Rehabilitation Program was launched in 1979
- Home Ownership Policy offered incentives topromote national unity
- A financing scheme through Malaysia BuildingSociety Bhd (MBSB) was launched

1981 1985

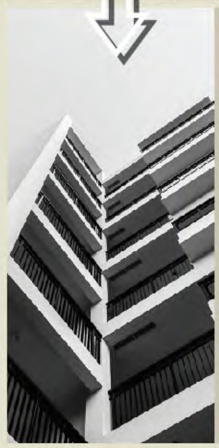
Fourth Malaysia Plan

- Ensured all Malaysians had access to adequate housing
- Improved housing quality and provide adequate amenities in rural areas
- Houses for settlers in land development schemes
- Ceiling price for low-cost housing = RM25,000

1986 1990

Fifth Malaysia Plan

- Provided housing for all levels of groups withemphasis on social facilities
- Resettlement of new villages to upgrade conditions
- Human development based on "Human Settlement Concept" to create a lively and comfortable environment



1991 1995

Sixth Malaysia Plan

- Emphasised subsidised housing for the verypoor, low interest housing loans, element of cross-subsidies in mixed developments and intensified research and development activities

1996 2000

Seventh Malaysia Plan

- Launched several strategies to accelerate the implementation of housing programmes such as low-cost Housing Revolving Fund
- Syarikat Perumahan Negara Malaysia Berhad (SPNB) was established to coordinate and implement all low-cost housing funds on behalf of the public sector
- SPNB is also responsible to address abandoned housing projects
- The ceiling price for low-cost housing was revised

2001 2005

Eighth Malaysia Plan

- Encouraged the development of more low- and low-medium cost houses

2006 2010

Ninth Malaysia Plan

- Provided low-medium cost houses in urban and rural areas
- Promoted the use of Industrialised Building System and designs based on the modular coordination concept housing construction

2011 2015

Tenth Malaysia Plan

- Rationalised and streamlined the of federal agencies involved in public housing
- Housing Maintenance Fund was established to assist residents of both public and private low-cost housing units for major repair and maintenance works
- Ensured quality in the provision of affordable housing developments
- Encouraged environmentally friendly neighbourhoods through Green Guidelines and Green Rating System

2016 2020

Eleventh Malaysia Plan

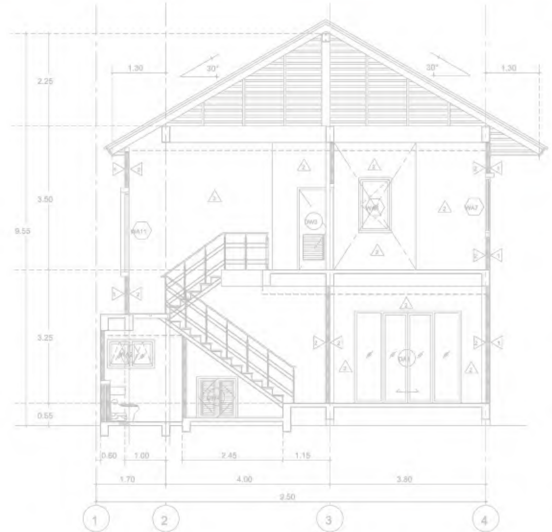
- Increase access to affordable housing for targeted groups
- Provides financial assistance for home buyers
- Strengthens planning and implementation for better management of affordable housing
- Encourages environment-friendly facilities for enhanced liveability

Over 1 million housing units were built throughout the period from the Second Malaysia Plan until the Ninth Malaysia Plan, as illustrated in Table 1.1.

Table 1.1. No. of Housing Units based on Housing Categories in Malaysia Plans.

No. of Housing Units based on Housing Categories						
Malaysia Plan (MP)	**Poor**	**Low Income Housing**	**Low-Medium Income Housing**	**Medium Income Housing**	**High Income Housing**	**TOTAL**
MP-2 (1971–1975)	-	55,209	30,867	-	-	86,076
MP-3 (1976–1980)	-	63,020	58,490	-	-	121,510
MP-4 (1981–1985)	-	106,290	95,610	-	-	201,900
MP-5 (1986–1990)	-	74,332	21,354	-	1,440	97,126
MP-6 (1991–1995)	-	46,497	35,195	-	2,850	84,542
MP-7 (1996–2000)	17,229	60,999	18,782	21,748	2,866	121,624
MP-8 (2001–2006)	10,016	103,219	22,826	30,098	22,510	188,669
MP-9 (2006–2011)	31,700	42,300	9,600	27,200	-	110,800
TOTAL	**58,945**	**551,866**	**292,724**	**79,046**	**29,666**	**1,012,247**

(Source: Adapted from the period from the Second Malaysia Plan to the Ninth Malaysia Plan)



To accommodate the country's growing population, an estimated 200,000 public affordable housing units are expected to be delivered within the remaining period of the Eleventh Malaysia Plan which is almost double the 102,200 affordable houses built under the Tenth Malaysia Plan (Economic Planning Unit, 2018). **Figure 1.2** shows the housing programmes initiated to help every Malaysian realise their dream to own a house while **Table 1.2** provides some demand-side strategies such as housing subsidies and privileged financing to offer much-needed relief to the low-income group.

01 Skim Perumahan Rakyat 1Malaysia (PR1MA)
Target group: Middle-income earners in urban areas
Eligible criteria: Income: RM2,500 – RM10,000
Age: 21 years old and above
Property value: RM100,000 – RM400,000

02 Perumahan Penjawat Awam 1Malaysia (PPA1M)
Target group: Civil servants
Eligible criteria: Income: Under RM10,000
Age: 18 to 60 years old
Property value: RM150,000 – RM300,000

03 Program Perumahan Rakyat (PPR)
Target group: Low-income group
Eligible criteria: Income: Under RM2,500
Age: Above 18
Property value: West Malaysia: RM30,000 – RM35,000
East Malaysia: RM40,500

04 Rumah Mesra Rakyat 1Malaysia (RMR1M)
Target group: Low-income land owners
Eligible criteria: Age: 18 – 60 years old
Property value: RM45,000 – RM65,000
Owns a land size not lesser than 2800sqft

05 Rumah Mampu Milik Wilayah Persekutuan (RUMAWIP)
Target group: Middle-income earners who stay and work in Wilayah Persekutuan
Eligible criteria: Income: Under RM15,000
Age: Above 21 years old
Property value: RM52,000 – RM300,000

06 Rumah Selangorku (RSKU)
Target group: Middle-low-income earners within the area of the Selangor region
Eligible criteria: Income: RM3,000 – RM10,000
Age: 18 years old and above
Property value: RM42,000 – RM250,000

07 Rumah Idaman Rakyat (RIR)
Target group: Middle income groups (First time buyers, disabled persons, single mothers
Eligible criteria: Income: Below RM10,000/monthly (Household)
Below RM7,500/monthly (Personal)
Age: 21 years old and above
Property value: Under RM350,000

Figure 1.2. Current Housing Provision in Malaysia

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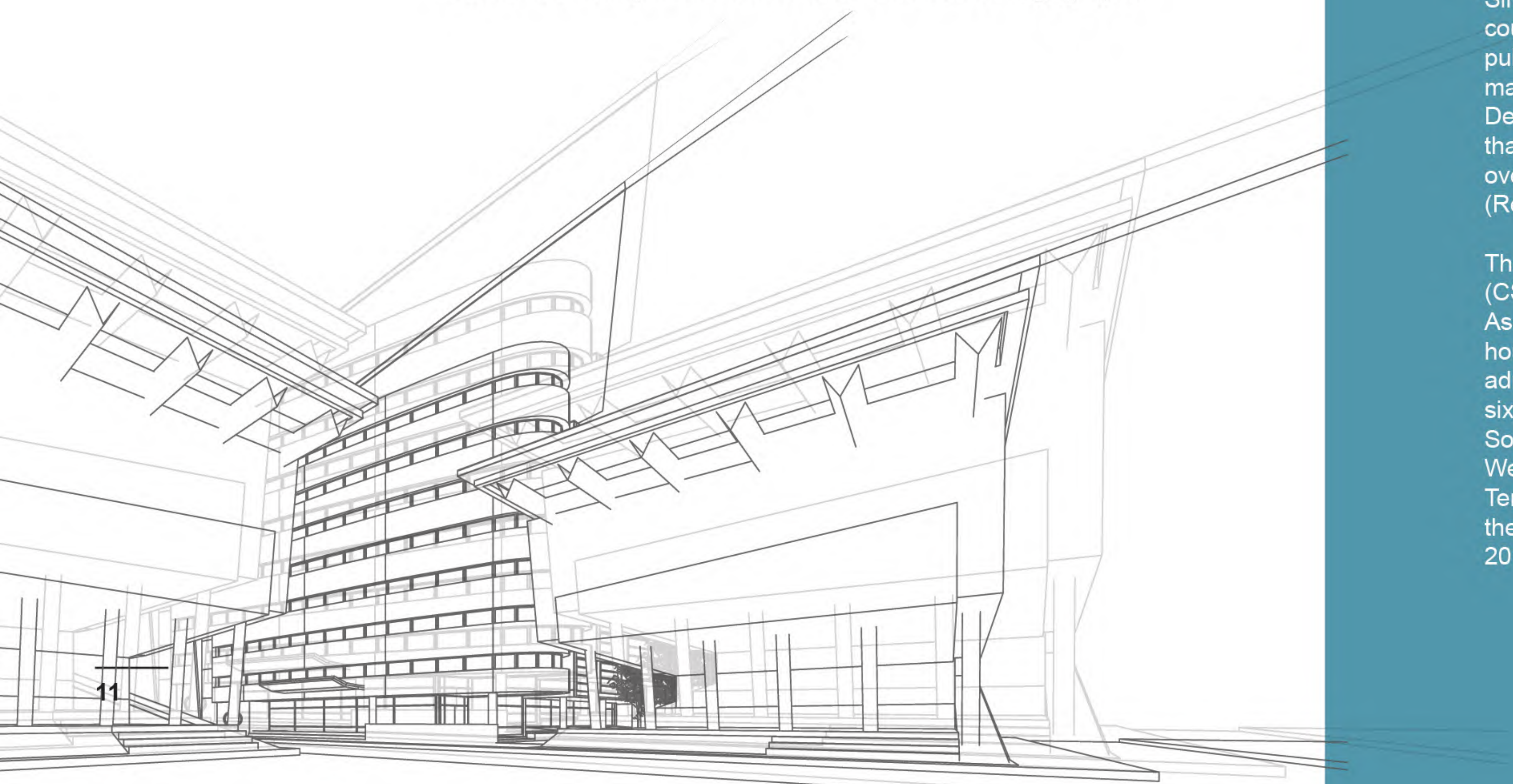
Table 1.2. Current Financing Provisions in Malaysia

Financing Schemes	Benefits
PRIMA	(a) End Financing ● Up to 110% of financing including Mortgage Reducing Term Assurance (MRTA), stamp duty, and legal fees financing ● Up to 35 years tenure or 70 years of age ● No down payment required if the applicant is able to secure the maximum loan ● Serve the interest during construction and commence instalment only upon completion of the property ● 5 years moratorium from the date of the Sale and Purchase Agreement (SPA) for houses that cannot be sold, disposed or rented out (b) Skim Pembiayaan Fleksible (SPEF) ● Offers a financing package that includes: - Stepped-up financing with fixed instalments for the first 5 years of the loan - EPF Account 2 withdrawal for instalment up to retirement or end of tenure ● Homebuyers who opt for the stepped-up end-financing scheme can choose to do it with or without the EPF Account 2 withdrawal option ● Homebuyers can choose to start early repayment of both principal and interest within the first 5 years ● Offers financing of up to 110% of the SPA price with no down payment ● Housing loan covers all expenses ● Loan tenure up to 35 years or until the age of 70, whichever is earlier
Syarikat Jaminan Kredit Perumahan Berhad (SJKP)	● Facilitates home ownership amongst the lower-income or non-fixed income group ● Offers up to 100% financing for low, low-medium, and medium-cost properties up to a maximum loan amount of RM300,000 ● The shortfall between loan recovered and loan outstanding is guaranteed by SJKP in the event of default and the guarantee fee is borne by the bank
My First Home Scheme	● Allows young adults to obtain 100% financing from financial institutions without the need for a down payment ● Eligible for first-time homebuyers from the private sector whose salary is less than RM5,000
EPF Withdrawal	● EPF contributors have the option to withdraw from EPF Account 2 for housing purposes ● EPF contributors are eligible: - To finance the purchase of a house - To fund the building of a house - To reduce or redeem the housing loan balance - To apply for monthly instalments subject to the application being made with 3 years of signing the SPA
MyDeposit Scheme	● Helps middle-income Malaysians to purchase their first home (Limited to residential properties priced at RM500,000 and below) ● RM200 million has been allocated to cover the 10% of down payment or a maximum of RM30,000, whichever is lower
Smart Selangor First Homebuyers Scheme	● RM15 million has been allocated to help those who reside in Selangor ● Provides an interest-free loan for the first 10% down payment
Rent to Own	● An initiative by MAYBANK ● Purchasers of selected projects can opt to lease the unit for a minimum period of one year up to the expiry of the lease before making an actual purchase ● No down payment is required except for 3 months lease deposit
MyHome (Youth Housing Scheme)	● Help single or married youths own their first home ● Offers financing for the purchase of either completed or under construction properties ● Aids with monthly instalments of RM200 monthly that will be credited to the customer's financing account for a period of 2 years
Developer Interest Banking Scheme (DIBS)	● An initiative offered by private property developers ● Buyers do not have to pay the home loan interest during the first 36 months of the construction period

Adapted from Rehda Institute (2018)

1.2 Global Affordable Housing Provision

Malaysia is not the only country facing a perilous housing situation. Every other country in the world is struggling to meet housing needs and demands, and they are coming up with many different ways to minimise the housing gaps.



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Singapore has set a stellar example to other countries around the globe on how to manage public housing. Public housing in Singapore is managed solely by the Housing and Development Board (HDB) and today, more than 1 million flats have been completed and over 30% of the population own HDB flats (Rehda Institute, 2018).

The Commonwealth State Housing Agreement (CSHA) and the Commonwealth Rent Assistance (RA) have been providing affordable housing in Australia. These initiatives are administered independently within the country's six states: New South Wales, Queensland, South Australia, Tasmania, Victoria, and Western Australia. Besides that, the Northern Territory and Australia Capital Territory have their own agencies for housing (Rehda Institute, 2018).

The governments also work together with the Council of Australian Governments (COAG) under the A$1.3 billion annual National Affordable Housing Agreement to address the housing affordability issue (COAG,2008).

In Hong Kong, the housing market is managed by the Hong Kong government, which is the sole land supplier and the largest property developer in the administrative region. The government aims to ensure an adequate supply of affordable homes and rental units are made available for the low-income population. The Hong Kong Housing Authority works closely with the Mass Transit Railway (MTR) Company to ensure these homes and rental units have access to a good transportation system (Rehda Institute, 2018).

Table 1.3 to Table 1.5 summarise how these three countries are tackling the housing issue to provide affordable homes to their citizens.

Singapore

Table 1.3. Government Provisions in Housing in Singapore

Provisions	Description
HDB Loan Eligibility (HLE)	For buyers who would like to obtain an HDB loan to buy a new flat, HLE: ● Calculates the maximum loan eligibility amount and expected monthly instalments ● Ensures buyers are not financially overstretched
Home Protection Scheme (HPS)	● Ensures flat owners would not lose their home if they are unable to finance their loan in the event of death or permanent incapacity of the breadwinner
CPF Housing Grants **Additional CPF Housing Grant (AHG)** **Special CPF Housing Grant (SHG)**	● Ease the financial burden of first-time buyers to afford their first flat ● These housing grants allow eligible buyers to make the initial payment or to reduce the mortgage loan
Step-Up CPF Housing Grant	● Offers families in non-mature estates to upgrade their subsidised 2-room flats to 3-room standard flats
Parenthood Priority Scheme (PPS)	● Allocates a percentage of Build-to-Order (BTO) flats and Sale of Balances Flats (SBF) to first-time buyer families with at least one Singaporean child under 16 years old ● Also applicable to divorced or widowed parent
Parenthood Provisional Housing Scheme (PPHS)	● Temporary housing for couples with children while waiting for their new flats to be completed ● Applicable to married couples, engaged couples, divorced parents, and widowed parents
Married Child Priority Scheme (MCPS)	● Allocates up to 30% of the flats for MCPS first-timer families and up to 15% for their second-timer families
Assistance Scheme for Second Timers	● Allows second-timer buyers to buy a new 2- or 3-bedroom BTO flat in non-mature estates 30% of BTO flats are allocated for second-time buyers - 5% are allocated for divorced or widowed parents with children below 16 years old
Multi-Generation Priority Scheme (MGPS)	● Offers parents and their married children who submit a joint application to buy a 3-generation (3Gen) flat
Single Singapore Citizen (SSC) Scheme or Joint Singles Scheme \ (JSS)	● Allows eligible singles to buy a new or a sub-sale flat from the open market
Studio Apartment Priority Scheme (SAPS)	● A quota-based scheme that allows senior citizens to age in a familiar environment ● Provides another housing option for senior citizens aged 55 and above, equipped with elderly-friendly and other safety features.

Adapted from Rehda Institute (2018)

Australia

Table 1.4. Government Provisions in Housing in Australia

Provisions	Description
The National Partnership Agreement	● A$1.1 billion is allocated to fund new social housing dwellings and specialist homelessness projects across Australia ● Targets to build 600 new houses across Australia for homeless families and individuals ● A$5.6 billion is also allocated to provide accommodation for people who are homeless or at risk of homelessness ● Funds 20,000 additional public and community housing ● A$400 million of Commonwealth funding is provided to build almost 2,000 social housing units ● Over A$5 billion was allocated to build up to 4,200 new homes and upgrade around 4,800 existing homes to reduce homelessness and overcrowding as well as to improve poor housing conditions
National Rental Affordability Scheme (NRAS)	● A$4.5 billion is allocated to stimulate the construction of 50,000 high-quality homes and apartments ● Provides affordable private rental properties for Australians and their families ● Offers financial incentives to build and rent houses to low- and middle-income households at rates that are at least 20% below the prevailing market rates
National Housing Supply Council	● Monitors housing demand, supply, and affordability
Commonwealth, State and Territory	● Identifies surplus land that could be developed to provide additional housing
The Commonwealth State Housing Agreement (CSHA)	● Provides affordable homes for residents with low income ● States and territories are allowed to access CSHA funds for public housing constructions and to fund homebuyers in purchasing homes
Commonwealth Rent Assistance (RA) Scheme	● Aided low-income households and others seeking private rentals in the form of a non-taxable income supplement
First Homeowners Grant (FHOG)	● Introduced in mid-2000 to compensate for the earlier enforcement of the goods and services tax on national home ownership ● Assists young adults and new families to participate in the property market

Adapted from Rehda Institute (2018)

Hong Kong

Table 1.5. Government Provisions in Housing in Hong Kong

Provisions	Description
Public Rental Housing (PRH)	• An ongoing subsidy scheme for low-income families that cannot afford private accommodation
Home Ownership Scheme (HOS)	• HOS estates are subsidised-sale public housing estates for low-income residents
Tenants Purchase Scheme (TPS)	• Allows existing tenants in rented public housing estates to purchase their flats • Sale prices are lower than the market prices of private flats due to subsidies and restriction on selling
Flat-for-Sale Scheme	• A housing development scheme that sells flats at concessionary prices
Sandwich Class Housing Scheme (SCHS)	• A subsidy offered to middle-income households that are not eligible for PRH scheme and the HOS (known as the sandwich class) • Sale prices are at slightly below market value and comes with a five-year restriction
Home Starter Loan Scheme	• Assists first-time homebuyers to purchase private-sector flats • Provides qualified buyers with low-interest loan rates of between 2.0% and 3.5% • Eligible for applicants who earn less than HK$70,000 per month and do not own a property in Hong Kong
Reverse Mortgage Programme	• Encourages banks to offer the namesake reverse mortgages to individuals aged 55 and above
Interim Housing (IH)	• A temporary public rental housing for those awaiting placement into public housing estates or not immediately eligible for flats in public housing estates • Accommodates residents who have been displaced by natural disasters, fire, redevelopment, or other reasons

Adapted from Rehda Institute (2018)

1.3 Satisfying Needs and Demands

1.3.1 Liveability of Affordable Housing in Malaysia

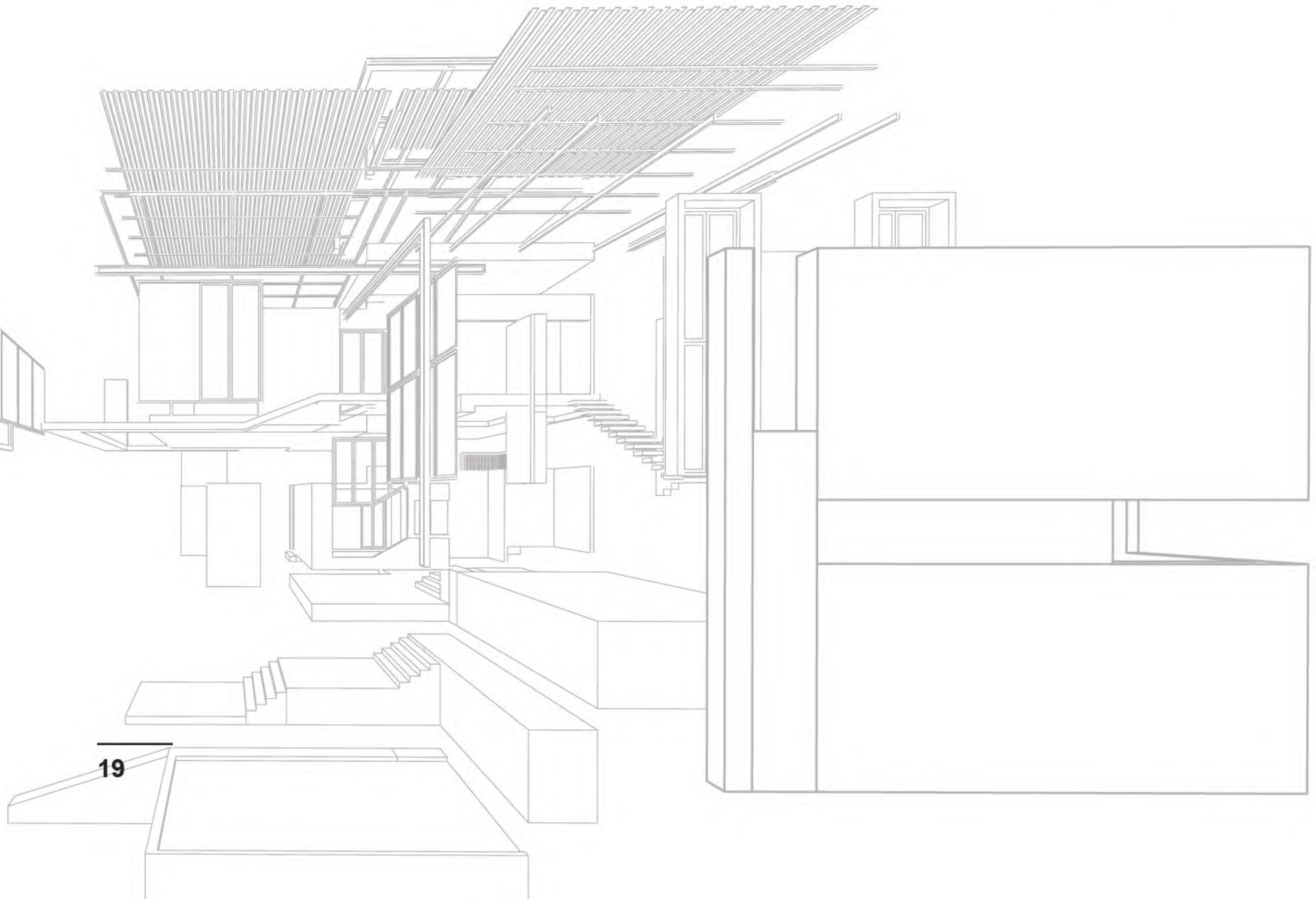
When designing affordable housing, the word “affordable” is typically mistaken for being “cheap”, signifying “low quality”.

This is one of the main problems associated with local affordable housing; they lack the quality of life that represents the well-being of individuals and societies. Thus, it is essential to provide a house that satisfies the needs of its residents. This can be done by listening to their voices regarding their needs for housing and the surrounding environment – not just in terms of a bedroom, bathroom, and kitchen but also the quality of life that gives its residents a sense of belonging. The liveability aspect of affordable housing is important to improve the quality of life of poor, low- and middle-income households. The government believes the provision of quality affordable housing will improve the social wellbeing of Malaysians.

Liveable communities are defined as places that are safe, attractive, socially cohesive and inclusive, and environmentally sustainable. The places should be connected with convenient public transport, walking and cycling infrastructure, employment, education, public open space, local shops, health and community services, and leisure and cultural opportunities (Lowe et al., 2013).

1.4 Identifying Essential Features for Housing

Various studies have been conducted to determine the liveability attributes such as functional, physical, and social environments.



REVALUING AFFORDABLE HOUSING IN MALAYSIA THROUGH
ADVANCED TECHNOLOGY AND INNOVATION

In this study, a survey was conducted among residents living in affordable housing programmes to identify the needed features to create a liveable housing design. A questionnaire was developed to understand the needs of the residents and community living in a type of housing development programme and to gather their views and opinions regarding the features that should be present in housing in the aspects of physical, social, facilities, and environment.

The respondents who participated in the survey were those living in a public housing programme named Program Perumahan Rakyat (PPR). A total of 14 PPRs were selected for the survey, as listed below:

- **PPR Taman Wahyu**
- **PPR Kg Batu Muda**
- **PPR Lembah Pantai Kerinci**
- **PPR Intan Baiduri**
- **PPR Pantai Ria**
- **PPR Seri Semarak**
- **PPR Kg Baru Air Panas**
- **PPR Kg Muhibbah, Jalan Puchong**
- **PPR Cochrane**
- **PPR Malaysia Permai**
- **PPR Bukit Jalil I**
- **PPR Bukit Jalil II**
- **PPR Lembah Subang**
- **PPR Serendah KTM**

1.4.1 Physical Aspect

Table 1.6. The mean scores of respondents' degree of agreement regarding the physical features that need to be present in affordable housing.

Features	Mean
Garbage disposal	4.37
Near to city centre	4.31
Type of the house: terrace and apartment	4.17
Food stall	4.13
Ventilation of the house	4.13
Size of the house	4.07
Location of emergency stairs	4.06
Prayer hall	4.01
Size of living room	4.01
Number of bedrooms	4.00
Size of bedrooms	3.98
Size of bathrooms	3.95
Number of bathrooms	3.93
Size of dining room	3.93
The quality of the exterior construction	3.90
Community hall	3.84
Number of sockets	3.82
The quality of the interior construction	3.73
Size of kitchen	3.72
Washing room area	3.60

Table 1.6 shows the mean scores of residents' satisfaction with the physical aspect at PPR housing, which were between 3.60 (washing room area) and 4.37 (garbage disposal) based on a 5-point Likert scale from 1 to 5. A higher mean score portrays a higher level of residents' satisfaction with the physical aspect and vice versa. According to Ginsberg and Churchman (1984), the physical characteristics of a house influence the level of residents' satisfaction with their house. The housing characteristics as mentioned by Mohit and Al-Khanbashi Raja (2014) include the number of bedrooms and toilets, size and location of the kitchen and living room, and quality of the housing unit, each of which affects residents' satisfaction differently at cross-cultural levels.

The findings show almost all of the physical features of PPR Housing achieved moderate to high mean score values for residents' satisfaction. This study supports the study done by Salleh, Yusof, Salleh, and Johari (2011) in Ipoh, Perak, Malaysia that found residents of Majlis Bandaraya Ipoh (MBI) public housing were satisfied with the building features of the houses they were residing in, recording a mean score of 3.42.

In contrast, the study done by Sulaiman and Yahaya (1987) revealed that the majority of the residents were dissatisfied with the characteristics of their dwelling units. In the present study, the three (3) physical features that obtained the lowest mean scores are washing room area (3.60), size of the kitchen (3.72), and the quality of the interior construction (3.73). This finding is supported by the study done by Salleh et al. (2011) in which the size of the kitchen (3.17) and internal construction quality (3.54) reported low mean scores. Size and layout of the housing unit need to be improved to provide a decent living for the low-income group.

The highest mean score was attained by garbage disposal (4.37), followed by near to city centre (4.31) and type of the house (4.17). From the finding and visual inspection, the researcher found the garbage line is important in resident satisfaction in terms of the location and also the architect's perspective. Therefore, garbage disposal obtained the highest mean score. Meanwhile, the study by Ibem, Adeboye, and Alagbe (2015) and Barrie (2014) support the finding that the proximity of the location of a housing estate to the city centre is an important factor of resident satisfaction, recording a mean satisfaction score (MSS) of 4.31. The distance from a housing estate to the workplace, schools, healthcare facilities, and shopping malls in the city centre is important for residents for their daily life convenience. The study by Sam, Zain, and Saadatian (2012) supports the statement that the location characteristics of a house are important to architects, urban planners, and designers as well as to policymakers.

1.4.2 Social Aspect

Table 1.7. The mean scores of respondents' degree of agreement regarding the social features that need to be present in affordable housing.

Features	Mean
Child Education	4.28
Landscape/Scenery/Green Areas	4.21
Kindergarten	4.15
Health Care	4.13
Playground	4.09
Communication with Neighbours	4.06
Cultural Diversity	4.05
Behaviour of Neighbours	3.94
Low Incidence of Burglary Activities	3.94
Sense of Community	3.93
Social Isolation	3.37

The well-being of children in a residence should not be neglected. Children should have an opportunity or the freedom to move around in public spaces without being exposed to danger (Mizrachi & Whitzman, 2009). Generally, families that come from a low-income group are the most likely to experience deplorable and unsafe housing conditions as they cannot afford to live in a decent place that provides a safe and secure environment. This argument was expressed by this study's survey respondents who concurred that affordable housing should have proper security capable of protecting the residents from harmful exposures such as burglary activities (3.94).

To protect their children, the respondents also voiced out that a residence should have access to child education (4.28), kindergartens (4.15), and the playground (4.09). These features can provide parents with a sense of trust to allow their children to travel to school or to let their children be with friends who live in the same residential area without being exposed to dangerous road crossings. Providing a playground (Figure 1.3) for children also allows them to do physical activities that can promote good physical health and are beneficial for their development (Mizrachi & Whitzman, 2009).

Figure 1.3. A playground located at the ground floor within a residental premise

Regarding planting, the majority of the respondents agreed that affordable housing should have access to landscape, scenery, or green areas (4.21). Landscape or green areas and physical activities can help improve mental health while providing a great source of stress relief in our day-to-day life (Streimikiene, 2015). Previous studies show that open-air areas have the potential to enhance residents' social, physical, and mental health (College, 2009). Furthermore, such public facilities offer residents an opportunity to have social contact and in effect, create a sense of community (Shukur, Othman, & Hadi, 2014).

A sense of community is essential for residents, especially when living in high-rise buildings, and this is agreed by the majority of the respondents with a mean score of 3.93. A past study has shown that feelings of isolation and loneliness are common among residents of high-rise dwellings due to limited social contact with neighbours (Kearns, Whitley, Tannahill, & Ellaway, 2015). Good neighbourhood conditions reflect a good quality of life, which consequently improves the residents' physical and mental health (Balestra & Sultan, 2013).

A friendly social environment can promote a good neighbourhood as it creates a degree of mutual trust among the neighbours, thus increasing the feeling of safety and security in the neighbourhood. This statement is proven valid by the survey responses in which the majority of the respondents ranked communication with neighbours (4.06) and their behaviours (3.96) as among the essential features that need to be present in affordable housing and hence, provide a good sense of community. In addition, cultural diversity (4.05) was also chosen as a feature that should be promoted.

As significant as the neighbourhood is in a residence, it should be noted that high-rise dwellings can be overcrowded and the residents can suffer a lack of privacy (Aydogan, 2005). Therefore, it is equally important for a residence to offer privacy to its residents and this statement received support from the respondents who also demanded social isolation (3.37) in their houses.

Past research has revealed that transportation is a major barrier for people, especially those from the low-income group, in getting access to health care (Cronk, 2015). Some households cannot afford to own a vehicle and there is no access to public transportation due to its distant location. The proximity of public services such as clinics and hospitals are hence important indicators of the quality of life pertaining to housing (Streimikiene, 2015), and this is consistent with the finding from the survey where the majority of the respondents agreed that affordable housing should have access to health care (4.13).

1.4.3 Facilities Aspect

This section will discuss the key findings with recommendations on improving housing liveability. Table 1.8 shows the distribution of residents' needs for facilities, the understanding of which is considered as fundamental towards providing a liveable housing design.

Table 1.8. The mean scores of respondents' degree of agreement regarding the facilities features that need to be present in affordable housing.

Features	Mean
Natural lighting at pedestrian walkway areas	4.38
Playground	4.13
Public transportation: LRT, bus, train, etc.	4.05
Perimeter road	3.92
Sufficient parking lots	3.61

According to the survey results, the availability and accessibility of facilities such as schools, healthcare, banking, and shopping centres is the most important feature needed by the residents. The physical location of a residence is key in improving the liveability of a community. Affordable housing locations should be within reasonable distances to a range of public transportations that provide good commuting options for residents. Thus, the public transportation network and affordable housing planning can indirectly affect the liveability of affordable housing. Planners must ensure that the physical location of affordable housing should have access to services, employment, education, and recreational facilities.

Concerning the residents' perception of the importance of a playground, almost 81.7 per cent of the respondents agreed that a playground area is important in providing living satisfaction.

However, the planning hierarchy for recreation areas encompasses a playground, neighbourhood field, local parks, urban park, regional park, and national park (Latfi, Karim, & Zahari, 2012). The effectiveness of the quality and quantity aspects of recreational areas or open spaces must be given adequate attention. Open spaces should be designed according to the community's characteristics. Several researchers have suggested that user-oriented studies provide information for the creation of spaces that are responsive, meaningful, and appropriate for the users (Bakar, Malek, & Mansor, 2016). Moreover, the current status of citizens' health requires designers to shift their design thinking by incorporating innovative elements to improve the health and wellbeing of communities.

1.4.4 Environmental Aspect

Table 1.9. The mean scores of respondents' degree of agreement regarding the environmental features that need to be present in affordable housing.

Features	Mean
Sustainable/green	4.18
Recreation area	4.15
Quietness	4.10

Sustainable/Green

Sustainable or green features for affordable housing is recognised as an important element of sustainable development goals. As shown in Table 1.9, the majority of the residents (mean = 4.18) support the provision of sustainable features for their houses. Making a housing development sustainable requires, among others, using sustainable building and design techniques to increase the energy efficiency of dwellings, reducing the use of non-renewable materials, utilising local sources of renewable materials, and facilitating the recycling of resources such as water, energy, and waste (Winston, 2010). Based on the survey conducted, Table 1.10 summarises the residents' perceptions of the features that need to be present in sustainable affordable housing in terms of design consideration.

Table 1.10. The mean scores of respondents' degree of agreement regarding the sustainable features that need to be present in affordable housing.

Features	Mean
Natural lighting at pedestrian walkway areas	4.38
Air circulation between blocks	4.29

Housing features of good air circulation and maximum natural lighting require the designer to utilise sound design techniques. The application of digital tools such as Building Information Modelling (BIM) enables the designer to improve the sustainable features of affordable housing during the design stage. The integration of BIM during the design stage provides options for the designer to optimise the building design efficiently with better solutions (Wong & Fan, 2013).

Quietness

In this study, quietness was identified as an important factor for residents' satisfaction. As shown in Table 1.9, most of the residents (mean = 4.10) agreed that quietness should be an important consideration in designing affordable housing. Due to compact neighbourhoods, residents tend to have less privacy and more noise exposure. This requires a good design approach and landscaping to maximise privacy (Litman & Institute, 2010). Moreover, the housing design in Malaysia should consider the concept of privacy in Islam, which refers to segregation between males and females and the security of family members (Alitajer & Molavi Nojoumi, 2016).

In light of the above, modern architectural thought has to bring forth privacy and space. Architectural privacy is defined by five parameters consisting of accessibility, visibility, proximity, vocals, and olfactory (Georgiou, 2006). All the five parameters directly represent the sense of kinesthesis (muscle and skin), sight (eyes), touch (hands and feet), hearings (ears), and smelling (nose). Those parameters affect the ways human beings perceive their surroundings and accordingly, the mechanism by which privacy is being controlled.

The five parameters of architectural privacy are explained below:

a) Accessibility

The accessibility graph represents the interconnection between spaces via a door, a passage, or an accessible opening. This context emphasises the concept of privacy and the influence of spatial configuration. Spatial relationships, social events, and their interrelation will assist the designer to improve the degree of privacy. Space syntax theory is one of the methods used to examine the spatial morphology and to detect the level of privacy in every configuration (Mustafa, Hassan, & Baper, 2010).

b) Visibility

Figure 1.4 shows an example of the visibility graph that indicates which spaces are connected via an opening that permits views from one space to another. This graph encompasses all the connections (Visibility graph) and views from each opening (e.g. a door and a window).

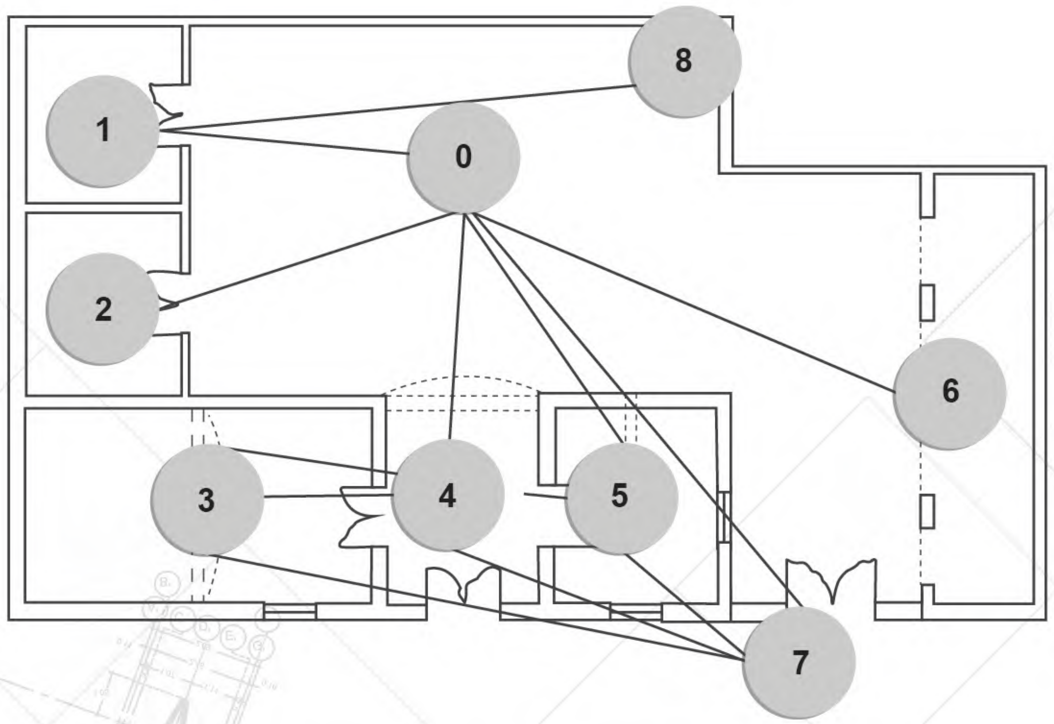


Figure 1.4. Example of a visibility graph

c) Proximity

In terms of the privacy concept, proximity to a space in a house will create the problems of visual, noise, smell, and privacy intrusion (Ahmad Hariza, Harlina, Abu Samah, 2009). Housing provision should offer design solutions that are sensitive to the local context by focusing on issues such as privacy, social cohesion, and perceptions of residential density, presences, and the lifestyles of the target population (Salama, 2006). The concept of privacy is usually influenced by religious or cultural functions. In present-day Malaysia, it is important to include a design that will emphasise on familial privacy.

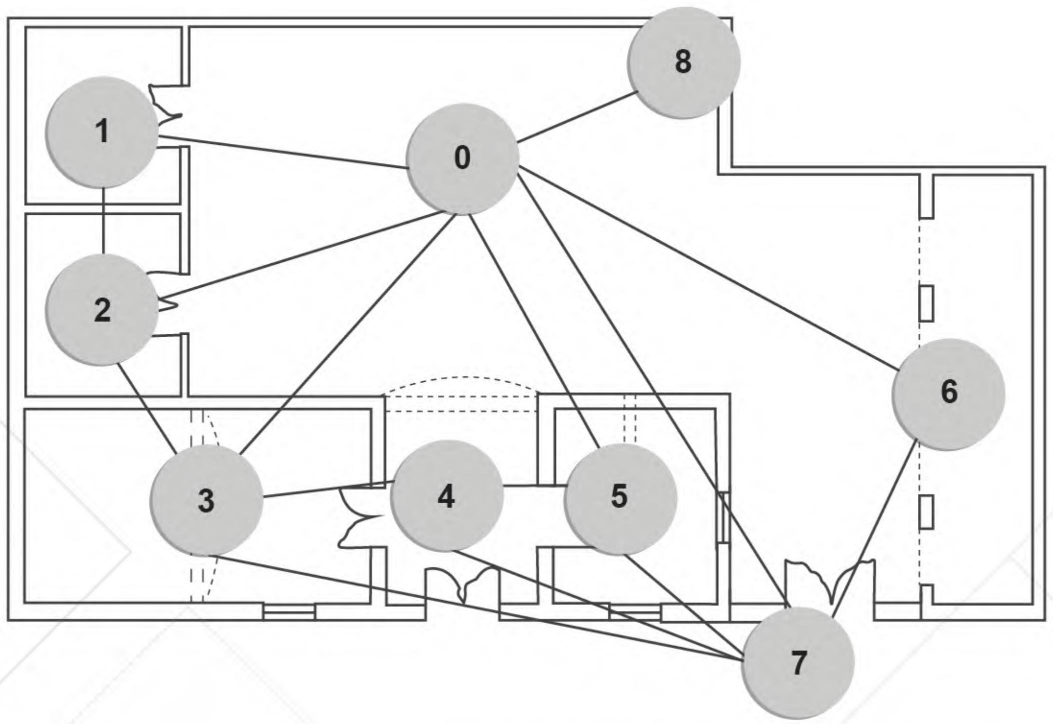
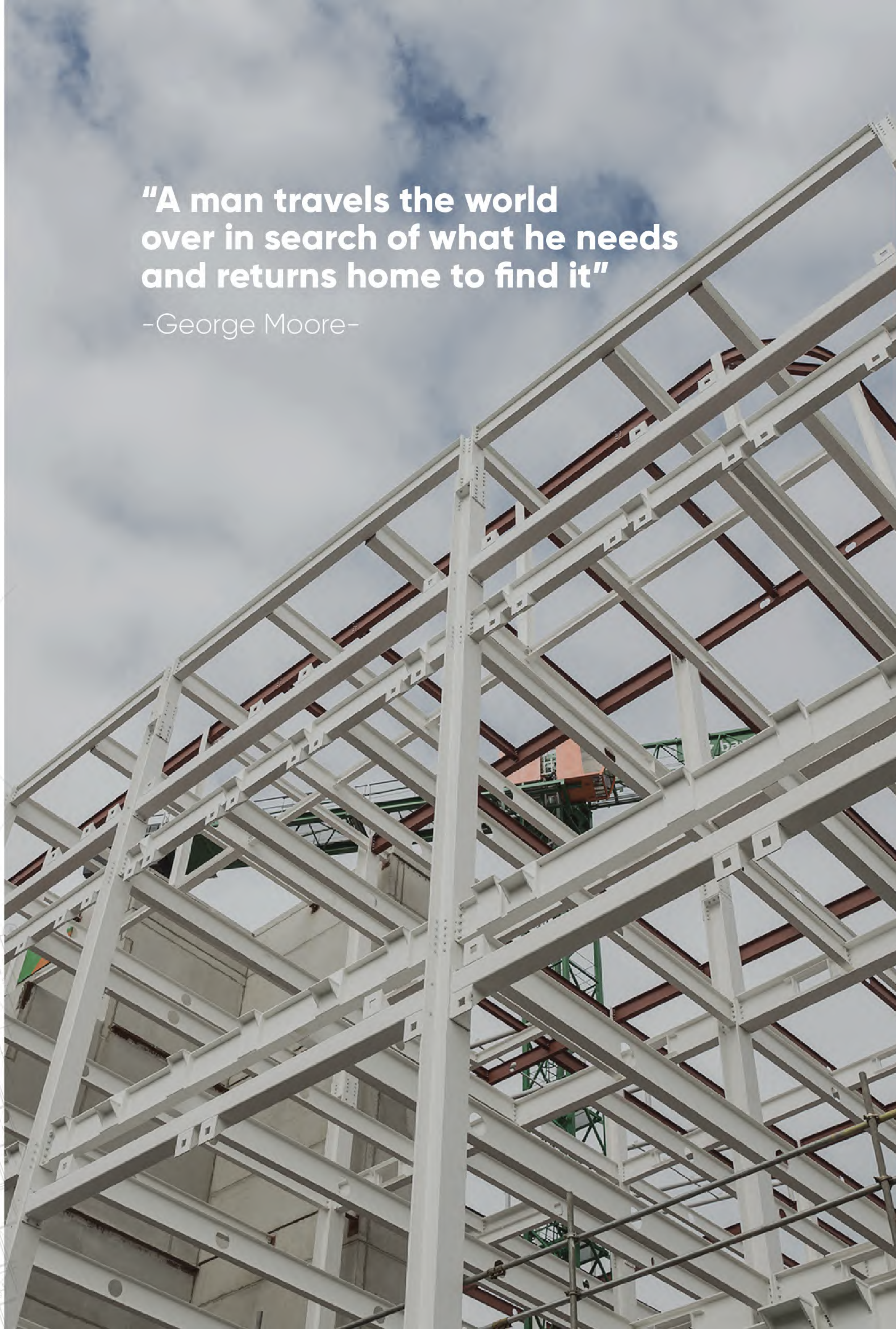


Figure 1.5. Example of a proximity graph

d) Vocals and Olfactory

The diagram in Figure 1.5 would eventually determine the vocals and olfactory graph. A boundary with various features such as doors, windows, blinds, and curtains will enhance user privacy.



1.5 Addressing Crime Activities in Low-Income Group Housings

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The results of the survey undertaken by CREAM indicate that the residents are concerned about theft, vehicle theft, robbery, and gang fights involving young people. The respondents shared their views of the types of criminal activities in PPR housing and identified nine (9) types of criminal activities, namely robbery, theft, vehicle theft, rape, molest, causing injury, fights, murder, and attempted murder, as illustrated in Figure 1.6.

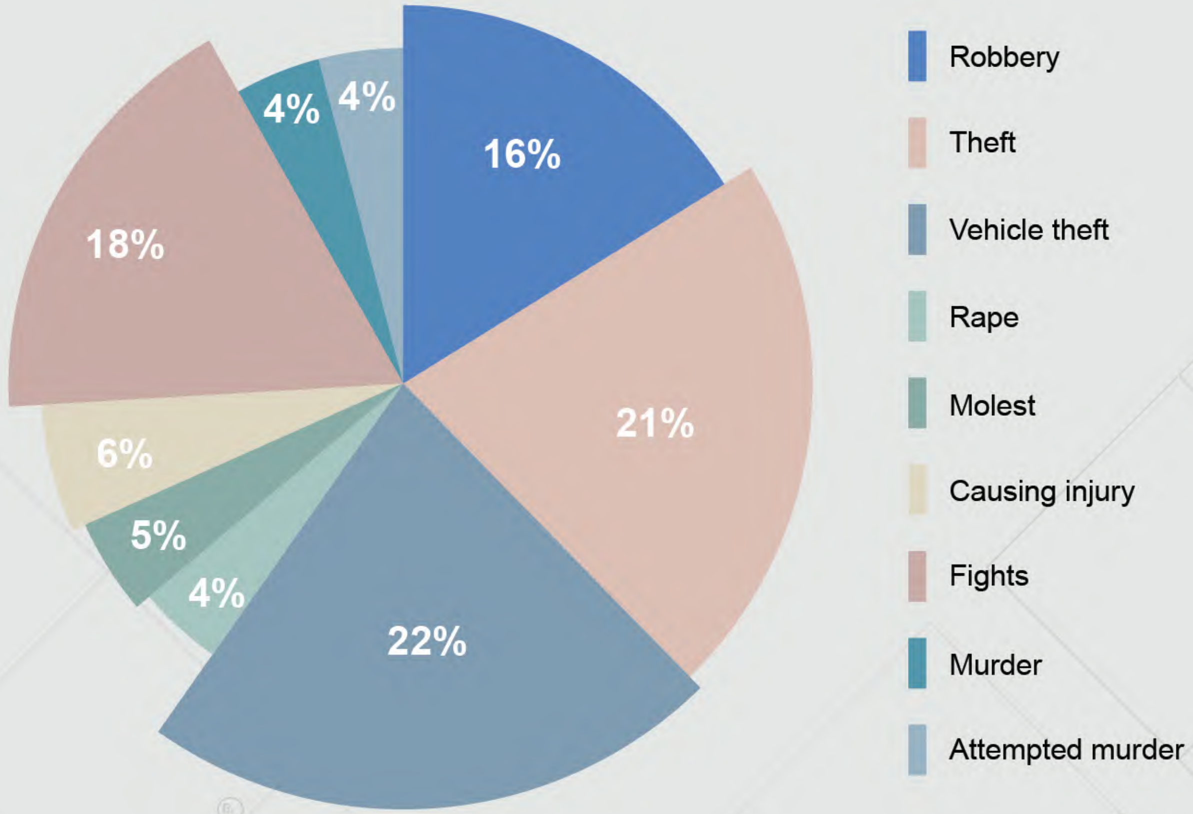


Figure 1.6. Types of crime activities in PPR housing

Vehicle theft was identified as the most frequent type of criminal activities occurring in PPR housing with 22.2% of the respondents stating that it happens more than once in a week (as shown in Figure 1.7 below). Besides, 17.2% and 14.3% of the respondents indicated that theft happens once a week and once in two weeks, respectively. Fights occur once a month, according to 27.2% of the respondents. Robbery rarely happens (24.2%) and attempted murder has never happened (85.1%). According to the respondents, most of the cases in PPR housing are suicides among those suffering from severe stress.

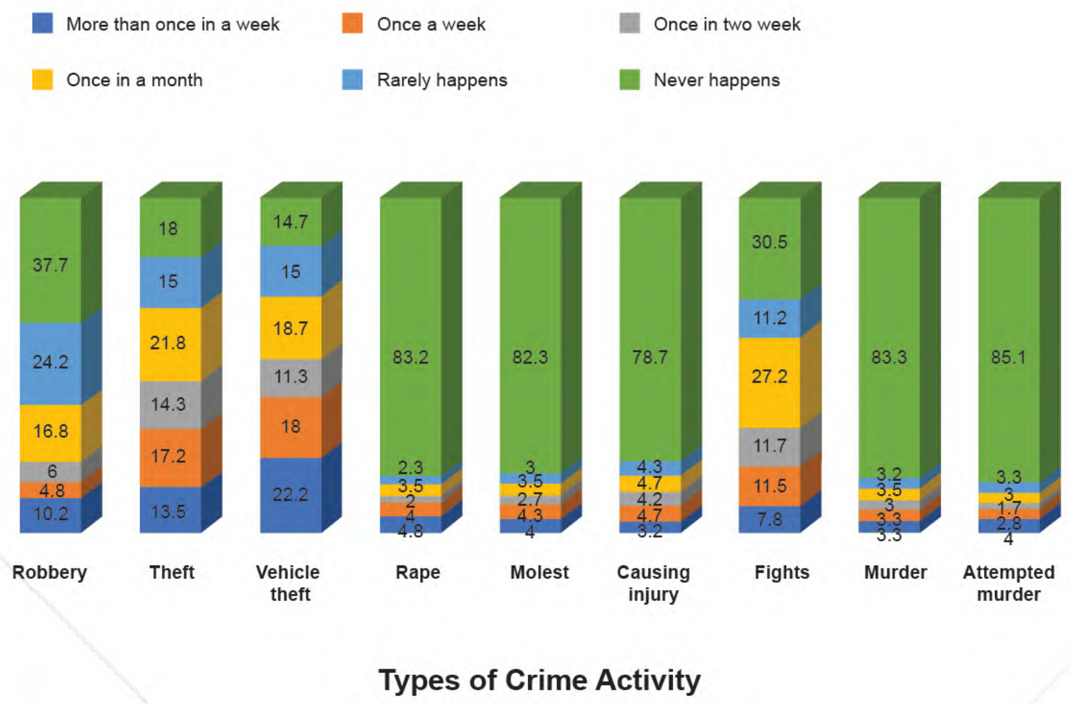


Figure 1.7. Frequency of crime activities in PPR housing

The effects of crime are not only faced by individuals but also felt by whole areas and communities. Safety is one of the most important factors that influence the quality of life and hence, unsurprisingly, one of the main issues that have been highlighted in any housing construction. Therefore, the questionnaire was also developed to understand the respondents' views on this issue and to gather their demands and needs in the aspect of safety features of their house to protect them and their family from crime.

1.5.1 Safety Aspect

Goh and Ahmad (2011.) have carried out a case study in Malaysia on low-cost public housing, mainly focusing on low-cost flats in Kuala Lumpur. The results of the case study also support the statement that house safety plays a crucial role in determining the quality of current PPR low-cost flats. Table 1.11 shows the overall results of the safety aspect that has been surveyed from the PPR residents. The survey highlighted five safety features, all of which need to be present in the future construction of affordable housing.

As shown in Table 1.11, the majority of the residents (mean = 4.40) agreed that access to police protection is essential in ensuring the safety and security of the residents. Sam (2012) conducted research on residential satisfaction and construction. The research highlighted some characteristics that need to be emphasised in urban planning, such as police protection and security control. The current scenario in residential areas in Malaysia would have private security guards monitoring the safety of residents and the surrounding area. However, such an arrangement would incur some costs that need to be borne by the residents. For affordable housing areas, it might create a situation in which some residents could afford to pay the private security guards' fees while others could not. Meanwhile, in ensuring the safety of residents, the government has installed mobile police stations, emergency public telephones, and others. In some areas with high probabilities of criminal activities, the patrolling frequency should be increased to ensure the safety of residents (Che Soh, 2012).

Providing firefighting devices to ensure residents' safety in affordable housing has been mentioned by the respondents. Research by Ramli (2014) stated that several factors such as electricity system, lighting, ventilation, air conditioning, plumbing, sanitary services, fire services, and lift services have a great influence on safety and health performance.

A safe and healthy building must include at least one firefighting device for every ten houses (Innovacia, 2015). Additionally, the residents agreed on the importance of a fire brigade (mean = 4.25). This finding is consistent with the study by Rachel Chew (2017), which found that residential properties had the highest prevalence of fire incidents by premise according to the statistics in 2016. Residential properties accounted for about 54.89% of fire incidents, higher than other premises such as industrial and public places. A study conducted by Ramli (2014) revealed a steep increase in building fire incidents between 2009 and 2010 from 3,017 cases to 5,240 cases. A yearly report by BOMBA (2017) also found that house premise recorded the highest rate of fire incidents with 3,178 cases compared to other types of premise such as shop lots and others. These cases demonstrate that the presence of a fire brigade in PPR residential areas needs to be considered in future housing construction projects.

One common issue faced by many high-rise flats is the absence of trash chutes, causing garbage to be thrown from the upper floors as the residents most likely find it onerous to descend 16 to 20 floors. Children who often play unsupervised on the ground floor are the most likely to be exposed to the hazard of falling objects.

In January 2018, a steel chair was thrown from an upper floor of the Putra Ria Apartments in Jalan Bangsar and barely missed a resident's head. He was sweeping the futsal court on the ground floor when the chair landed right next to him. This incident took place two days after a 15-year-old boy named S. Sathiswaran was killed when an office chair fell on him at the Seri Pantai PPR.

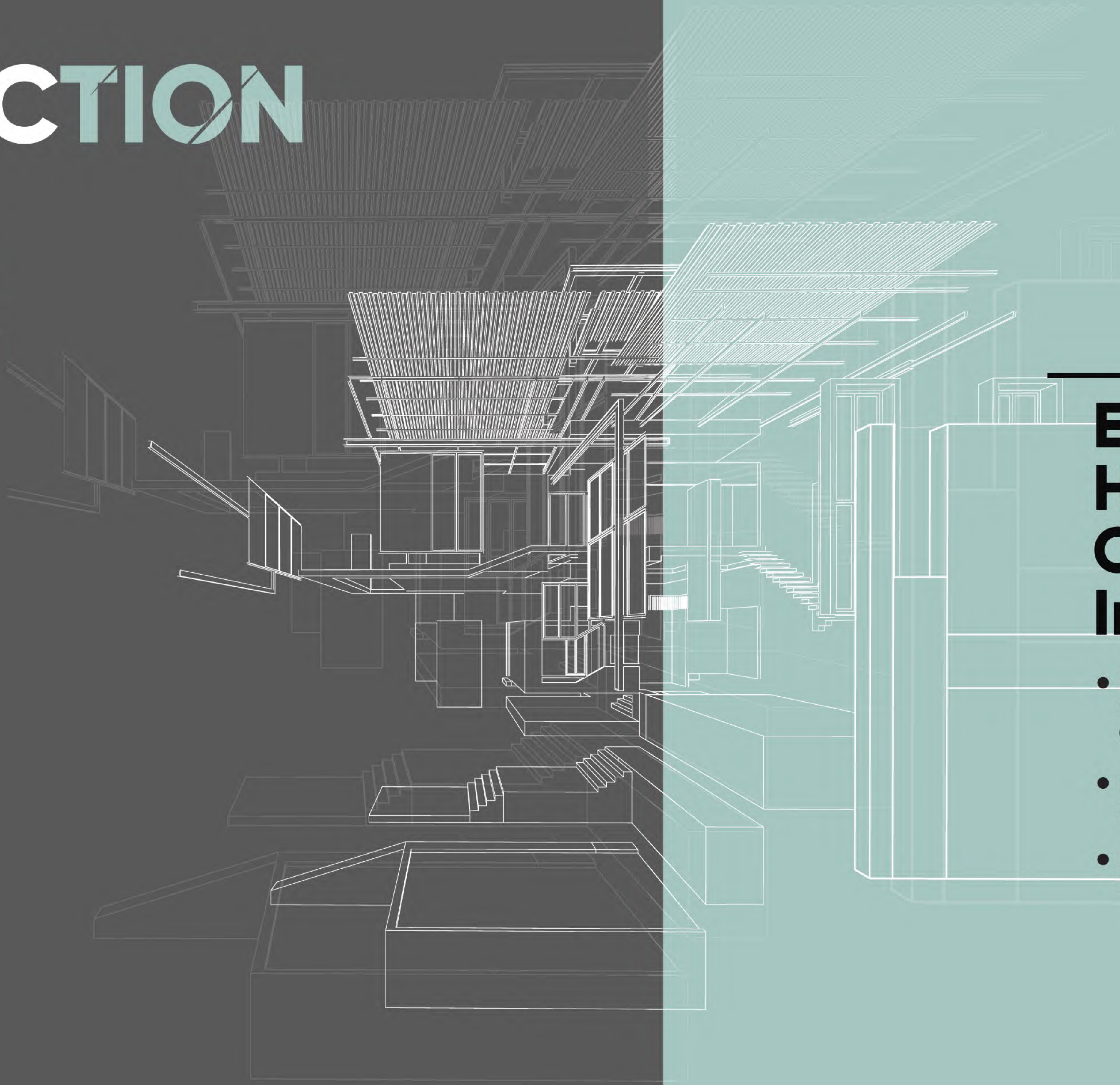
Therefore, safety features and security from accidents also need to be considered and included in future affordable housing construction projects, and this statement is supported by the PPR residents (mean = 4.06). Ramli (2014) remarked on the issue of building maintenance and management, emphasising that consistency in building maintenance and management will reduce the risk of accidents caused by defective structures as well as ensuring that the building remains in good conditions. Besides that, the safety of property also needs to be highlighted. The PPR housing management should act to ensure the safety of residents' property. Kementerian Perumahan dan Kerajaan Tempatan (KPKT, 2017) has listed out the scope of PPR housing management whereby they are responsible for improving the safety of property and helping in maintaining public peace in public housing facilities.

Table 1.11. The mean scores of respondents' degree of agreement regarding the safety features that need to be present in affordable housing.

Features	Mean
Police protection	4.40
Fire fighting	4.31
Fire brigade	4.25
Safety features and security from accidents	4.06
Safety of property	4.00

Figure 1.8. A security post located at the entrance of a residential premise

SECTION 2



Enhancing Housing Construction In Malaysia

- Lean Construction and Productivity Performance in Housing Construction
- Industrialised Building System (IBS) in Mass Housing Production
- More Homes Through Offsite Manufacturing

2.1 Lean Construction and Productivity Performance in Housing Construction

2.1.1 Lean Construction

Over the last few decades, the construction industry has undergone a tremendous transformation to cope with the needs of housing construction.

Transformation of construction technology, application of construction principle and others have been introduced to ensure both short-term or long-term benefits. Lean construction is one of the approaches that have been applied in construction management for decades. Lean construction, inspired by the Toyota Production System (TPS), can be defined as a management philosophy that is applied in the manufacturing industry to improve operational efficiency (Gao & Low, 2014). Indeed, it enhances and emphasises the concept of eliminating waste through continuous improvement (Anvari et al., 2011). Thence, the application of lean principles has been broadened throughout the construction process, for instance, housing construction.

The use of technology such as Building Information Modelling (BIM) in construction seems to provide numerous benefits to the construction process, particularly in terms of time, cost, and productivity. The same outcomes provided by technology, as mentioned before, can be achieved through the application of lean principles throughout the entire housing construction process. This is one of the key points in achieving humanising the housing construction to provide a better quality of life for the residents.

Researchers differ in their interpretation of the lean principles' elements. Höök and Stehn (2008) and Wilson (1997) defined five (5) lean principle elements in their research, consisting of 1) specify the value, 2) identify the value stream for each product, 3) make the product flow without interruptions, 4) let the customer pull value from the producer, and 5) pursue infection. In another research, Koskela (1992) listed eleven (11) lean principle elements that are crucial in total flow process and subprocesses such as reducing the share of non-value adding activities, increasing the output value through systematic consideration of customer requirements, variability reduction, cycle time reduction, and simplifying by minimising the number of steps, parts, and linkages, among others. Several lean principles from the perspectives of different researchers are presented in Table 2.1.

Table 2.1. Elements of Lean Principles from Different Perspectives

No.	Lean Principle/Concepts	Authors
1	1. Specify value 2. Identify the value stream for each product 3. Make the product flow without interruptions 4. Let the customer pull value from the producer 5 Pursue infection	(Höök & Stehn, 2008)
2	1. Reduce the share of non-value adding activities 2. Increase the output value through systematic consideration of customer requirements 3. Reduce variability 4. Reduce the cycle time 5. Simplify by minimising the number of steps, parts, and linkages 6. Increase output flexibility 7. Increase process transparency 8. Focus control on the complete process 9. Build continuous improvement into the process 10. Balance flow improvement with conversion improvement 11. Benchmark	(Koskela, 1992)
3	1. Stop the Line 2. Pull Product Forward 3. One-Piece Flow 4. Synchronise and Align 5. Transparency	(Howell & Ballard, 1998)
4	1. Multifunctional task groups 2. Simultaneous engineering 3. Kaizen 4. Just-in-time-deliveries 5. Co-maker ship 6. Customer orientation 7. Information, communication, and process structure	(Alarcon, 1997)

REVALUING AFFORDABLE HOUSING IN MALAYSIA THROUGH
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Minimal time and cost are the goals of any construction projects and activities. Applying the lean principle in the construction process will result in cost efficiency and shorter construction time. Forbes and Ahmad (2011) stated that better utilisation of resources (labour and material) could be achieved by practising the lean principles. Besides, several aspects such as owner or client satisfaction, a greater level of safety, and high profits are among the outcomes of the lean principles. The lean philosophy has been widely used in the manufacturing industry. In research conducted by Forbes and Ahmad (2011) and Koskela (1992), a new direction for the construction industry was applied by taking manufacturing techniques into consideration. The new philosophy based on manufacturing philosophy in prefabrication and modularisation such as industrialisation, automation, and robotics as well as information technology was introduced to reduce the fragmentation issue faced by the construction industry. Harris and McCaffer (2013) also adapted Toyota Production Development System by integrating lean project delivery system (LPDS) into computer modelling. The integration of information technology with lean principles is expected to enhance the construction process.

Throughout the construction process, Target Value Design (TVD) plays an important role and contributes to the whole lean process management. Forbes and Ahmad (2011) defined TVD from their perspective. By designing according to a specific estimation to meet the stated cost, TVD provides a good platform for the construction process compared to reducing a design or re-designing, which can incur more time and cost. They proposed several lean principles based on TVD, as depicted in Figure 2.1.

Figure 2.1. Proposed lean philosophy by using the target value design (TVD) concept in the construction process (Forbes & Ahmad, 2011)

In the construction process, particularly housing construction, coordination among stakeholders is crucial in ensuring the seamlessness and continuity of the construction process. Usually, specific estimations are developed from the contract drawings and specifications but with the use of TVD, team members can develop estimates from preliminary drawings. The designers must follow the stated cost and constructability of the project, taking into consideration comments by the client. The client also has an important role in balancing project costs with specific building features provided they are given access and sufficient information by the designers. Here, aspects of value engineering will take place to suit life-cycle costs versus form, function, and time, and bring a systematic process to the team. Figure 2.2 explains the TVD process, which can assist the team members in achieving a good construction flow.

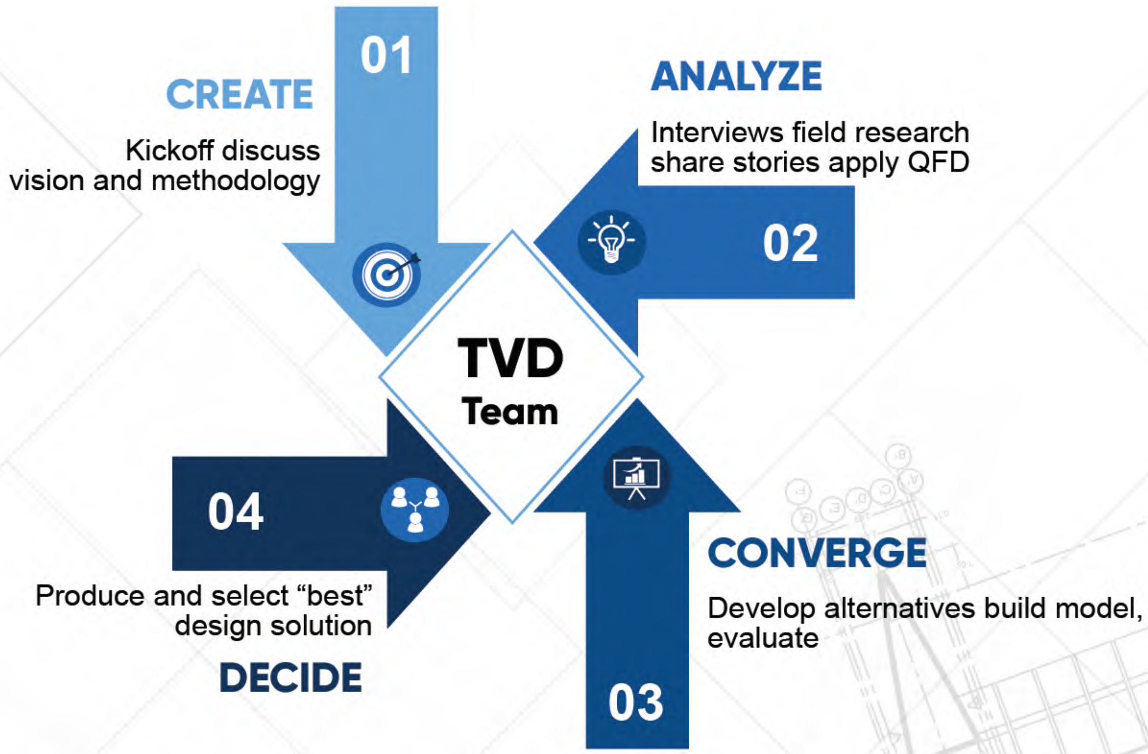


Figure 2.2. Aspects of TVD being implemented into the lean principle (Forbes & Ahmad, 2011)

Lean Versus Waste

Lean has a strong correlation with waste. Waste can be defined as an activity or a process that does not add value in the eye of the customer. Applying the concept of "only do work in request" brings value for customers and eliminates waste. The type and scope of work affect the practicability of the lean principle (Zimina et al., 2012). The lean principle has been applied widely in construction, whether directly or indirectly. In the scope of construction, any generated waste can lead to low project productivity while increasing the total cost and time of the project—for instance, the production of IBS or prefabrication components at the factory. A lower probability of defects, controlled environment and overproduction, less waiting time and others are some of the benefits gained from the production of IBS or prefabrication components at the factory by the applying lean principles. Based on TPS, seven forms of waste have been identified and one form of waste has been introduced by an American to create the DOWNTIME waste concept (Stack, 2010). DOWNTIME waste is illustrated in Figure 2.3.

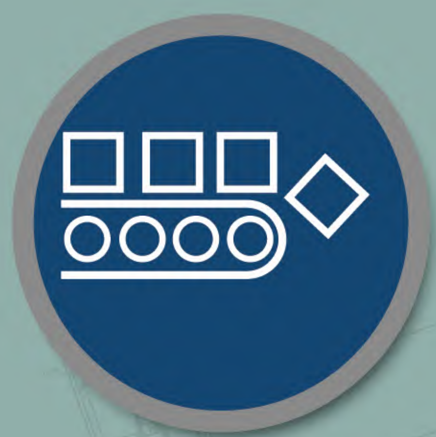
Figure 2.3. DOWNTIME waste which results in a systematic workflow in construction

a) Defects

The elimination of defects in construction can reduce the additional time required to complete a project. Defects lead to the use of more resources and incur additional costs in fixing the defects. Some examples of defects such as poor quality control, poor documentation, and poor handling of materials at the site will affect the quality of life (QoL) of residents. In ensuring the elimination or at least reduction of defects, standardised work plans, stringent quality control, and a checklist of work requirements and customer needs can be applied throughout the construction process (Stack, 2010).

b) Overproduction

In the Mid-term review of Eleventh Malaysia Plan, one of the initiatives to improve the wellbeing of the citizens is by providing adequate and quality affordable housing to poor, low- and middle-income households (Ministry of Economic Affairs Malaysia, 2018). To support this initiative, KPKT (2019) through the Honourable Minister, Zuraida Kamaruddin has pledged to build 1 million units of affordable houses in the next 10 years to help improve the citizens' well-being, focusing on the low-income group. This is one of the good justifications for reducing the probability of overproduction of housing components in the factory. Overproduction is one of the wastes that commonly happen in construction. To avoid its occurrence, customer needs should be clearly justified and production forecasts need to be produced. Just-in-case production, long set-up time, and poor automation system are the reasons behind the occurrence of overproduction in the construction industry, especially in housing development. Apart from it, a reasonable production workflow and well-constructed procedures should be established to benefit all the stakeholders in the supply chain (Stack, 2010).



c) Waiting

Waiting is one of the biggest wastes in any organisation or along the supply chain process. Some causes of waiting such as mismatched production rates, long set-up time, insufficient staffing, and poor communication can delay the completion of the construction process beyond the deadline or cause additional costs to be incurred. In lean construction, the aspect of time is one of the focus areas that should be emphasised to obtain a better outcome (Stack, 2010).

d) Non-Utilised or Underutilised Talents

Good construction cannot be achieved in the absence of proper management. Here, the concept of non-utilised or underutilised talents in management has been highlighted as one of the wastes that contribute to poor construction. This concept originated in America and was not included in the original Japanese list of seven wastes. An organisation should utilise the talent or experience of its workers to have a proper and good construction. Several causes of non-utilised or underutilised talents such as lack of teamwork and training and also poor communication between discipline and management could lead to delay in the completion of a project beyond the agreed period (Stack, 2010). In ensuring the well-being of Malaysian citizens through the provision of good affordable housing, the government has implemented and strengthened the initiatives on affordable housing by enabling data sharing among agencies and state governments as well as improving project coordination (Ministry of Economic Affairs Malaysia, 2018). These efforts can enhance the overall management from the bottom to the top, thus achieving a better outcome for affordable housing in the future.

e) Transportation

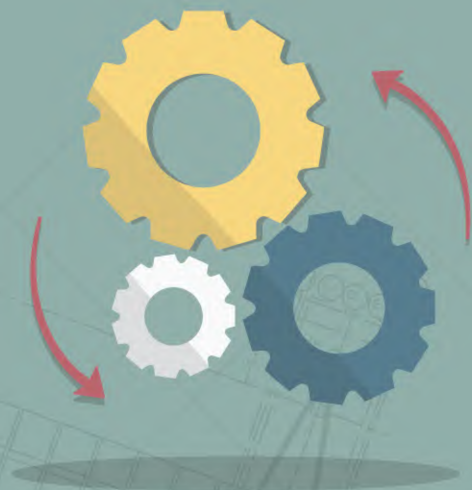
In the production of IBS or prefabrication components in the factory, transportation is considered as one of the main factors that lead to high or low productivity, depending on how a project is managed. Overproduction of IBS or prefabrication components, which is the current practice in housing construction, is caused by the transportation issue pertaining to distance. Distance from the factory must be considered in determining the location of a project because it can incur additional costs, waste time, and increase the likelihood of product damage and deterioration. In some cases, poor site layout, excessive or unnecessary handing, and poor process flow could cause transportation waste in construction. Hence, the distance between the construction site and factory should be taken into consideration in the early planning stage to set it as short as possible so that the possibility of the scenarios mentioned above happening can be lowered, thus reducing transportation waste (Stack, 2010).

e) Inventory

All customer needs must be recorded properly to prevent overproduction and miscommunication. Both the manufacturing and construction industries apply the concept of lean based on the practice of Just-In-Time (JIT) production. This JIT practice firmly uses the principle of "only when needed" and is not based on the practice of forecasting (Stack, 2010). The same concept should be applied in the construction industry to avoid inventory wastage, which ties up capital and could adversely affect company cash flow (Forbes & Ahmad, 2011). Apart from that, poor inventory management leads to high inventory levels, which increase the inventory storage cost and the risk of spoilage or shrinkage when materials are kept for an extended period. Materials in housing construction must be of high quality to fulfil the aim of affordable housing, which is providing quality and affordable housing to improve the quality of life (Ministry of Economic Affairs Malaysia, 2018).

g) Motion

Excessive motion at a construction site can lead to low project productivity. The arrival and storage of materials at the site must be planned and scheduled properly to reduce excessive motion, which can incur extra cost and time. Materials must be organised according to schedule to reduce moving the materials back and forth. This waste can be caused by poor process design and controls and poor site management and housekeeping, leading to congestion at the site (Stack, 2010). Lean production emphasises the principles of good scheduling and housekeeping practices, which enhance construction projects through the best safety performance. These practices will reduce the risks of accidents or contact with hazardous materials through the application of the principles of lean, reducing waste, and increasing efficiency throughout the construction process (Nahmens & Ikuma, 2009).



h) Excess Processing

Poor process control, misunderstanding of customer needs, and producing to forecast are the causes of excessive processing. This waste is almost the same as overproduction, but it mainly focuses on unnecessary effort in completing a task rather than overproducing IBS or prefabrication components at the factory (Stack, 2010). Alarcon (1997) and Koskela (1992) highlighted that excess consumption of materials at the site was about 10% for each project. Excess processing wastes money, time, effort, and resources and leads to delay in project completion. Proper scheduling must be emphasised and followed to prevent over processing of materials and to ensure that their production is according to needs.

Industrial Revolution (IR 4.0)

Vision of the Future: Integration of Lean Manufacturing and 4th Industrial Revolution (IR 4.0)

IR 4.0 has become a new paradigm in the industry, leading to high levels of technology integration with the current systems in both manufacturing and construction industries. Mechanisation and automation in construction have elevated construction efficiency to the next level. Radical changes can be seen in the execution of operations with the introduction of IR 4.0. Information and communication systems have stepped up the game for automation. Manufacturing and construction industries have immensely benefited from changes that bring intelligent and self-optimising machines to the production line. The entire value chain in the production line, starting from the ordering of materials until delivery and transportation to the user has been made easier and faster (Sanders et al., 2016). In addition, Shah and Ward (2007) have suggested four main dimensions of lean manufacturing and their relations with IR 4.0, as illustrated in Figure 2.4 below.

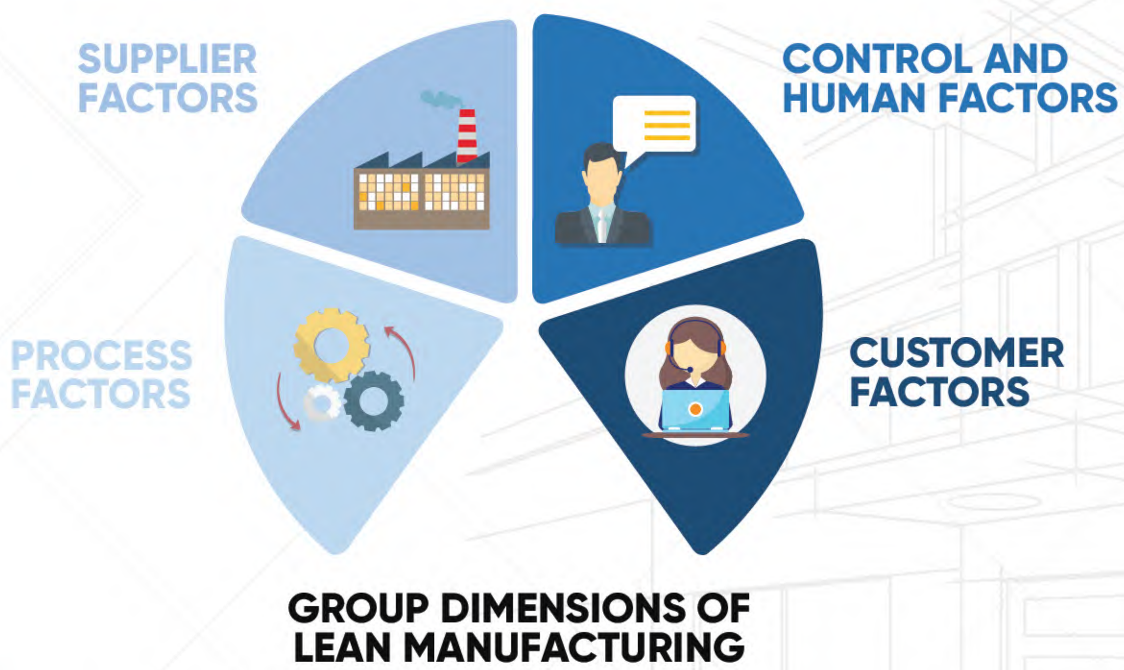


Figure 2.4. Four group dimensions of lean manufacturing with the integration with IR 4.0

The lean principle in manufacturing and construction industries is seen as crucial to be applied throughout the whole process. Integration of the lean principle with the current systems seems to add value, and advancement of technology in the future will accelerate the construction industry, especially housing to a new dimension. Consequently, the aim of the Eleventh Malaysia Plan, which is to improve the well-being of citizens by providing affordable housing, will be achieved.

a) Supplier Factors

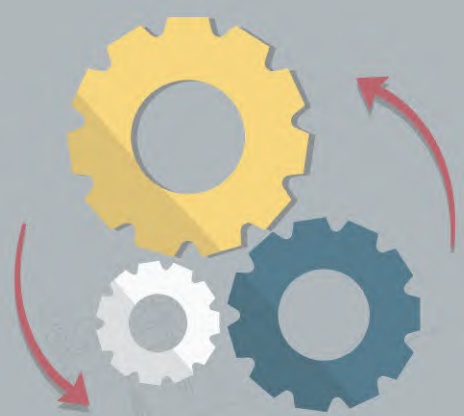
Three supplier factors have been identified, which consist of supplier feedback, Just-In-Time delivery by the supplier, and supplier development. Miscommunication between supplier and user could result in waste and incur additional project cost and time. One way to solve this issue is by integrating data across industries to synchronise the data on products and production processes. Apart from that, the concept of zero inventory level that has been practised in TPS for decades requires manufacturers to produce the right number of products at the right time, thus eliminating the need for storage. In ensuring that materials are of good quality and offer the best performance, Internet of Things (IoT) has been adopted by using integrated devices to manage the transportation of materials.In addition, every material will be tagged to track its location and to ensure that the right products are sent to the user, thus addressing the problem of incorrect delivery. In housing construction, most of the materials used are prefabricated at the factory and transported to the site for storage. After some time, the materials will deteriorate, which will compromise the quality. The use of integrated devices can ensure that the materials are transported not according to forecast but based on the required prefabricated components at the site without the need to store the materials. Coordination issues between supplier and user often emerge in the process. Compatibility of hardware and software and sharing of data are the two most common issues that usually arise in a project. In ensuring the goal of IR 4.0 will be achieved, data formats need to be standardised to provide seamless information flow and sharing (Sanders et al., 2016). According to Sanders et al. (2016) and Weyer et al. (2015), most automation technology solution providers have cooperated to standardise their entities and communication protocols to ease the sharing of information and to solve the compatibility issue.

b) Customer Factors

Customer needs have always been a priority for any projects or throughout the whole construction process. Quality function deployment (QFD) is a traditional analytical tool which has been used to measure customer needs, but it has some limitations regarding quantifying customers' requirements, product design requirements, and the real needs of customers. The application of IR 4.0 to solve this issue through Big Data will ease the process of collecting and analysing data from customers based on different categories and offer more sustainable products and solutions in the future (Sanders et al., 2016). Big Data processing also enables manufacturers to predict and detect critical parameters that influence the quality of materials (Zhong et al., 2017). Affordable housing in Malaysia still has gaps that require improvements. Thus, the adoption of Big Data analysis in construction can assist the government in monitoring and discovering customers' needs by analysing data from various sources.

c) Process Factors

Lean construction consists of the production of materials from the raw form to finished goods. Live tracking of materials through digital devices carrying RFID will help the manufacturer in monitoring the location of finished products or prefabricated components. Effective logistics and supply chain management along the supply chain coupled with strong integration of information technology will improve the manufacturing efficiency (Zhong et al., 2017). Pull production emphasises the production of materials only when there are demands. It highly contradicts normal production which applies the push production concept, leading to excess inventory, unsold goods, and extra manufacturing and maintenance costs. To provide a seamless manufacturing and construction flow, every process needs to add value and be parallel with the flow of operations without causing any disruption. The concept of continuous flow in JIT enhances the overall production process by reducing interruptions, waiting time, and delay. Live inventory tracking using RFID also brings advantages to the user in eliminating errors (Sanders et al., 2016). Self-optimisation of machines and workpiece-machine communication seem to be the solution in reducing the setup time. The use of RFID tags allows direct communication between the machine and components through the RFID receivers. Any instruction for changes will be executed automatically according to the parameters. The overall process is shown in Figure 2.5.



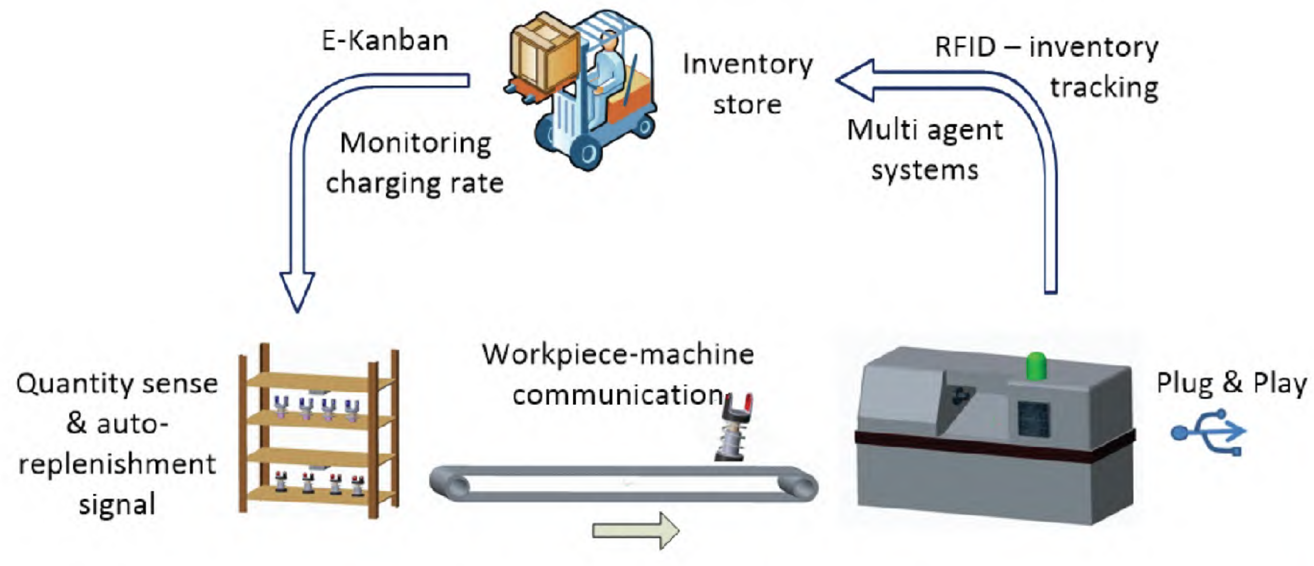


Figure 2.5. Process factor using RFID

d) Control and Human Factors

Automation and mechanisation are always associated with maintenance and breakdown, both of which could lead to delays in project completion and incur additional costs. The advancement of technology in IR 4.0 has propelled the industry into a new dimension. A report by the Ministry of Economic Affairs Malaysia (2018) states that 653,000 housing units are to be completed in the future in various stages of implementation. As such, the construction industry will need to employ high technology in ensuring that the high number of affordable houses to be built will be achieved. Prefabricated components supplied by the factory rarely contain defects. Indeed, high quality with minimal defects is assured under a controlled environment, but some errors could happen, resulting in the production of defective prefabricated components in the factory. This situation is caused by the fault or failure of machines in the production line. To overcome this issue, most smart factories have introduced a manufacturing execution system that can reschedule the jobs along the production line with minimal effects on quality. Human factors are among the factors that affect the completion of a project. Working in an IR 4.0 environment requires workers to express their opinions and provide feedback on real-time using their smartphones and tablets. Mismatched allocation of tasks to workers will affect the production line system (Sanders et al., 2016). The same situation can happen at the construction site when too many tasks are given to each worker, which can lead to low work productivity. Consequently, it contributes to an overall delay of the project with additional costs being incurred to complete the project.

2.1.2 Productivity

The lean principles have always been associated with productivity. The application of lean principles in construction practices leads to cost reduction, thus improving productivity and reducing the time for project completion (Howell & Ballard, 1998). According to Asian Productivity Organization (APO) and Malaysia Productivity Corporation (MPC), productivity refers to the belief in human progress. It is a state of mind that aims at perpetual improvement. Productivity is a ceaseless effort to apply new technology and new methods for the welfare and happiness of mankind. It is also the training of the minds and the development of attitudes amongst people which determine if a nation can realise high productivity and an affluent life or otherwise, low productivity and poverty. The increase in market value results from alterations in the form, location, or availability of a product or service, excluding brought-in materials or services. The wealth of a company is generated by its own and the efforts of its employees. Financial value can be created by the internal activities of an enterprise in the production process, which are added to the original raw materials purchased from outside.

Indeed, productivity is gaining recognition as a major factor in many problems of public concern such as economic growth, inflation, distribution of income wage reform, and international competitiveness.

REVALUING AFFORDABLE HOUSING IN MALAYSIA THROUGH
ADVANCED TECHNOLOGY AND INNOVATION

Productivity in Construction

Productivity is commonly defined as the ratio between the output and input volumes. To be precise, it measures how efficiently production inputs such as labour and capital are used in an economy to produce a pre-determined level of output. Productivity is considered as a key source of economic growth and competitiveness, and as such, is basic statistical information for numerous international comparisons and country performance assessments. For instance, productivity data have been applied to investigate the impacts of product and labour market regulations on economic performance. Productivity growth is an important element in modelling the productive capacity of economies. It allows analysts to determine capacity utilisation, which in turn, enables one to gauge the position of economies in the business cycle apart from forecasting economic growth. In addition, production capacity is used to assess demand and inflationary pressures (OECD, 1994). "Productivity is not everything, but in the long run, it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker." (OECD, 1994).

Techniques for Measuring and Improving Productivity at Construction Sites

The management of site-related issues in construction projects is often complex and difficult. Issues that arise before, during, and after construction can affect the productivity of a project. Quantification of productivity is one of the issues that have consequences on cost and time. Many factors need to be considered to ensure comprehensive and accurate measurement in quantifying and measuring the productivity of construction at sites. Dozzi and AbouRizk (1993) introduced one of the most accurate methods for measuring the productivity of construction by using the number of units produced per person-hour (p-h) consumed or its reciprocal, the number of p-hs consumed per unit produced. In the context of management, the productivity of a process can be indirectly measured by observing the level of activity of its resources. This can be done through work studies and surveys, but it may have a demotivating effect on the workforce. Special precautions must be taken to avoid the perception that the company is spying on its workers. Education and information sessions are recommended to create a team approach to productivity improvement. At the micro-level, workers are a valuable source of information concerning their performance or efficiency. Participation by tradesmen or supervisors can be expected only if requested.

Building and Construction Authority (BCA) Singapore has provided a measurement for trade productivity which offers contractors an in-depth analysis of their productivity performance. At the trade level, the amount of physical output per man-hour is measured. A worker is deemed to be more productive if he produces more output within an hour. The indicator is calculated as follows:

$$\text{Trade Productivity} = \frac{\text{Total units of Output}}{\text{Total Manhours (hr)}}$$

Based on the formula given above, different trades would have different units of measurement for trade productivity. For instance, the area of formwork installed (m2)/manhour is used to measure formwork installation while meter/manhour is used to measure electrical conduit installation (BCA, 2012). The overall productivity measurement is shown in Figure 2.6.

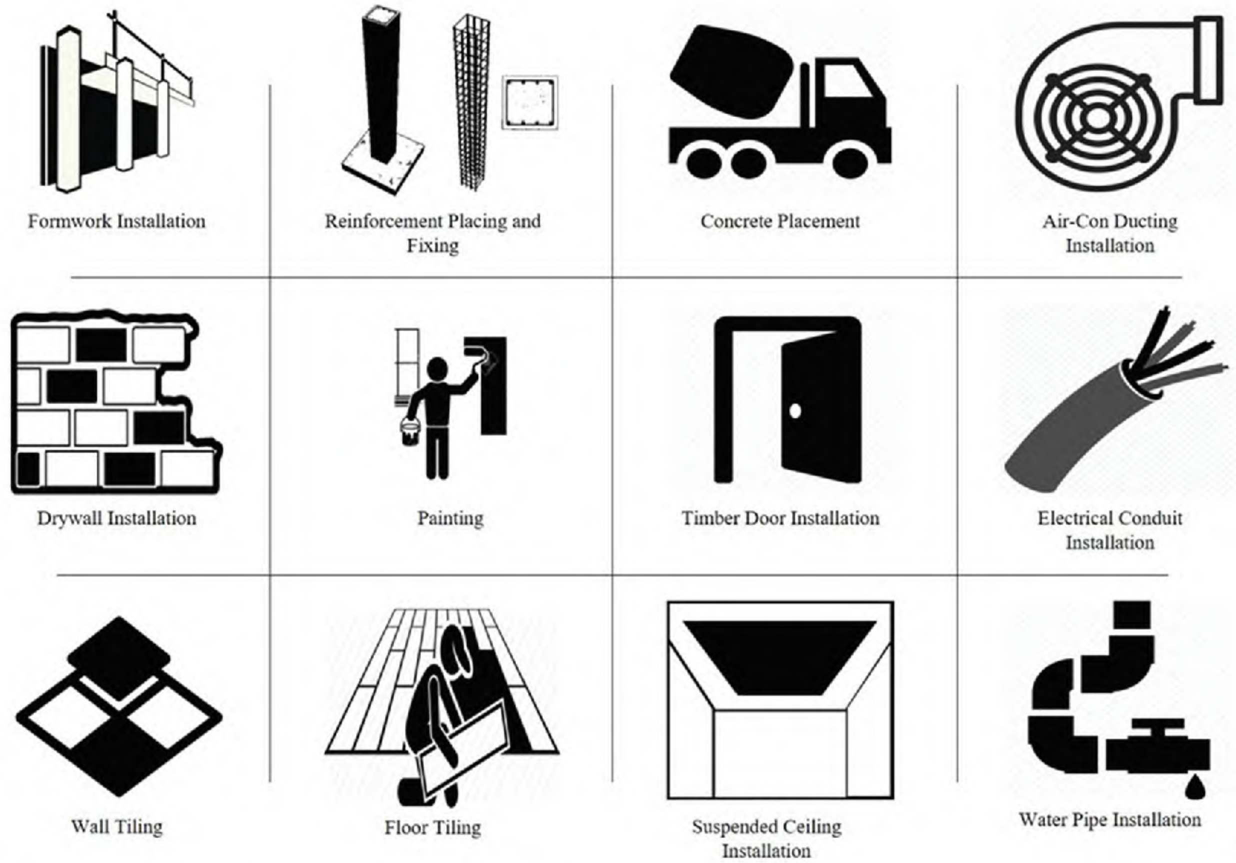


Figure 2.6. Productivity in Construction Measurement

Formwork Installation

Lean construction emphasises the concept of wastage reduction during construction. Its effect is a further improvement in construction productivity. One of the typical processes during construction is the formwork installation. Figure 2.7 depicts the typical processes involved in formwork installation in which each activity has been designed to standardise the monitoring productivity.

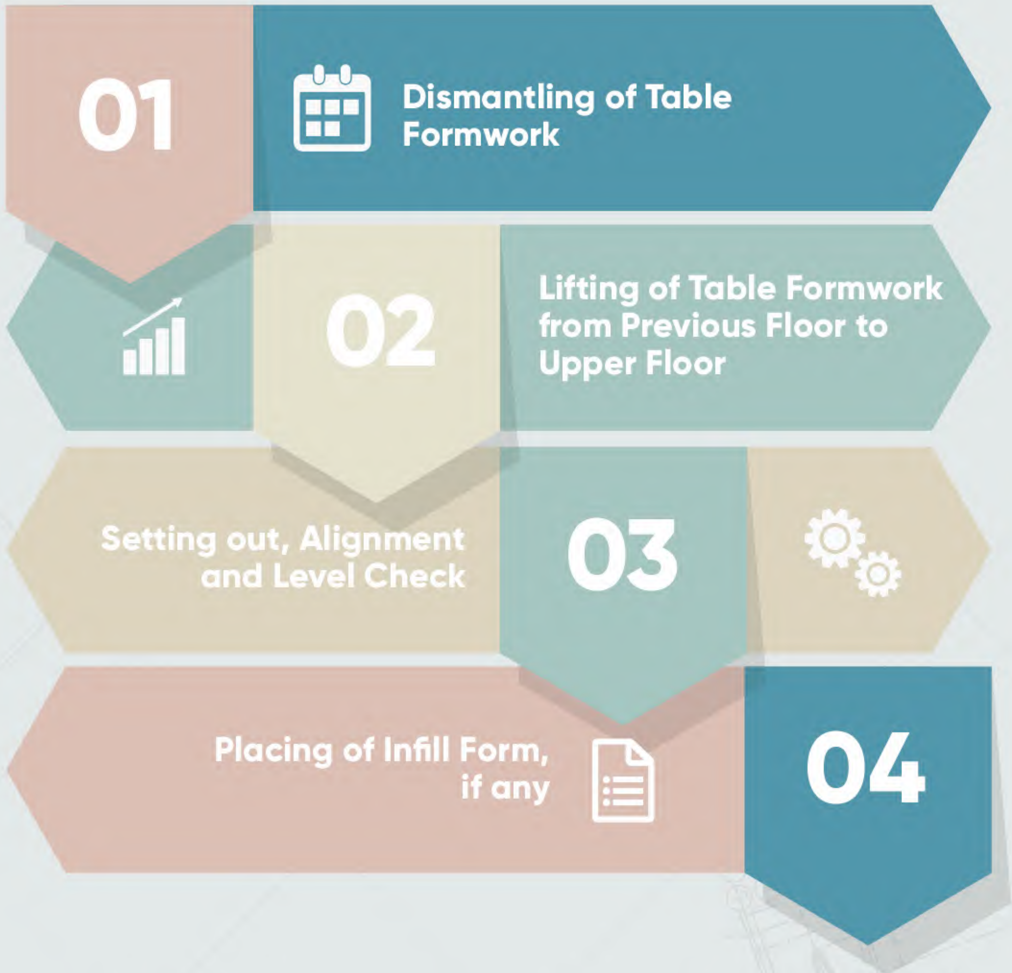


Figure 2.7. Formwork Installation Processes (BCA, 2012)

Dismantling of Table Formwork

Proper handling and management of the table formwork will result in better construction productivity at sites. Since the formwork will be used continuously, its material must have high durability and easier maintenance as well the design should be able to be erected and disassembled efficiently in order to maximise productivity (Nemati, 2005). According to BCA (2012), the activities of dismantling a table formwork include lowering down, securing lifting cable and shifting the table formwork out of a building, as shown in Figure 2.8.

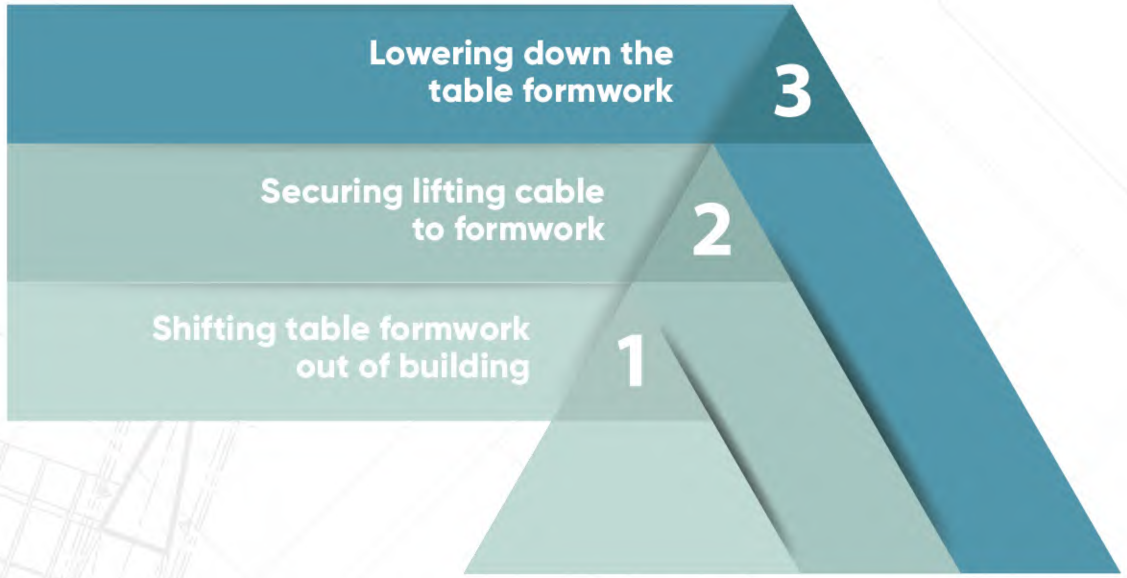


Figure 2.8. Procedure for Dismantling a Formwork (BCA, 2012)

Lifting of a Table Formwork from the Current Floor to an Upper Floor

Table formwork is one of the most common methods being used in high-rise building construction. Installation, dismantling, lifting, and re-installation are done by machines which can reduce the construction time and labour cost (Lee et al., 2017). In addition, the table formwork will be pushed to lifting deck machines and lifted to the upper floor by using a crane. Figure 2.9 shows an example of lifting deck machines being used to lift the formwork from the current floor to an upper floor.

Figure 2.9. DOKA Lifting System to lift a table formwork (Kang, 2013)

Setting Out, Alignment, and Level Check

Formwork positioning is one of the fundamental elements in formwork processes. Poor setting out will result in the wrong positioning of the building, which will compromise the productivity of the entire construction processes. Ko and Kuo (2015) stated that specification of shop drawing, location, quantity, worker, and previous and next construction items need to be prepared for setting out using the Kanban method for construction. This will be followed by the workers implementing the formwork operations. The Kanban method provides continuity in operations by specifying the previous and next construction items. This method ensures a smooth flow of construction processes, for example, the next work item such as the delivery of materials to the site will not proceed until the previous work item such as concrete pouring has been completed. This is to prevent site congestion and disruptive workflow, which can cause low productivity in construction. A strong relationship can be seen between the application of the Kanban method (lean principle) and productivity. BCA (2012) has also suggested several setting out, alignment, and level check processes to improve construction productivity. Following dismantling and lifting, the new position of the table formwork must be checked and adjusted precisely according to the drawing. Next, the table formwork needs to be positioned. Lastly, the table formwork level should be checked and adjusted to ensure even concrete pouring. All these works need to be checked and approved by a qualified formwork engineer. The steps are shown in Figure 2.10.

Figure 2.10. Crucial elements in setting out, alignment, and level check (BCA, 2012)

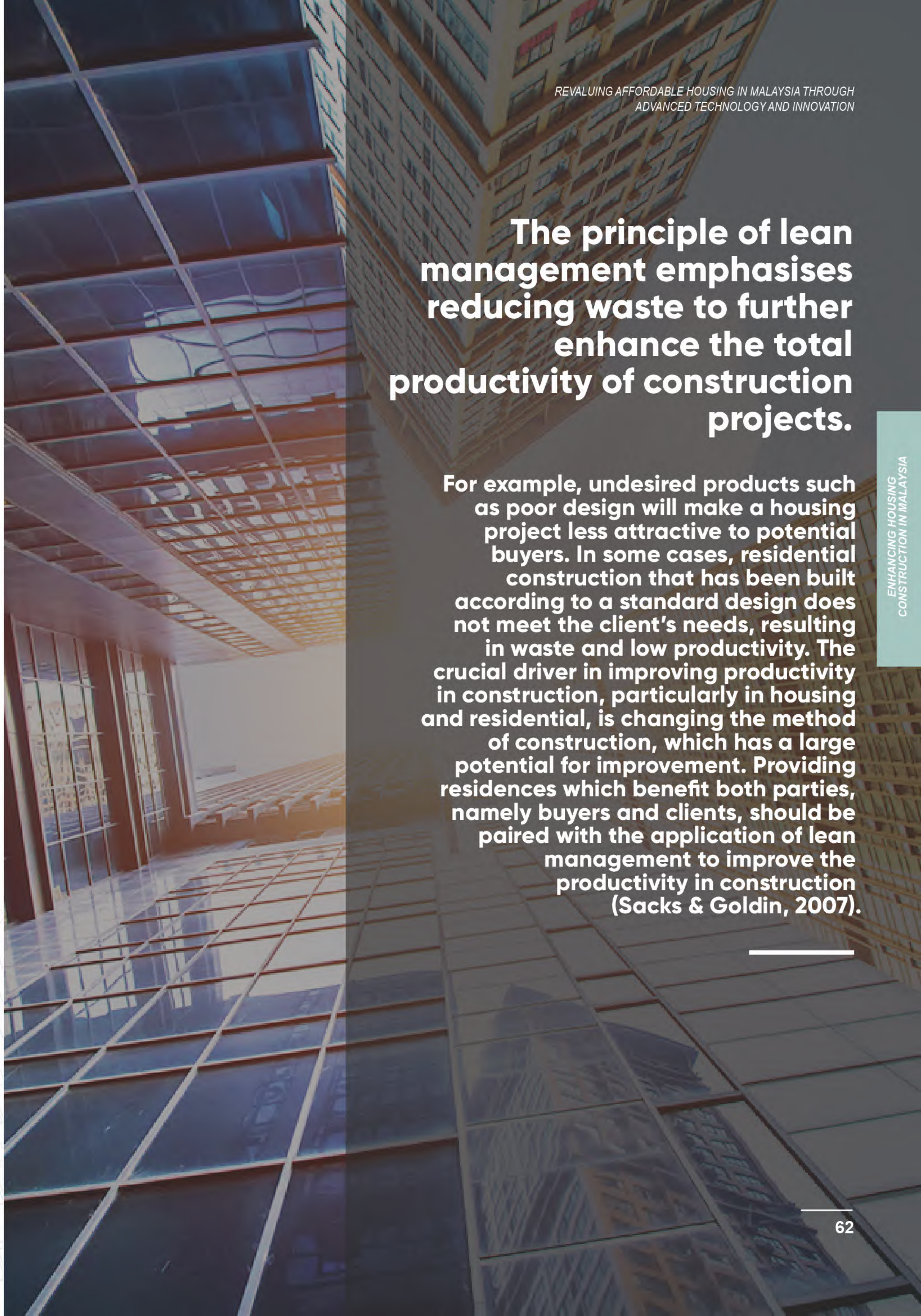
Placing the Infill Form, if any

In some cases, infill walling is built in between the floors of the primary structural frame of a building. Among the commonly used types of infill form are light steel, concrete, and timber. Its use will reduce the construction time and usage of construction materials, among others (SteelConstruction.info, 2019), which can enhance the productivity in construction and produce a better outcome.

2.1.3 Housing Construction Productivity vs Lean Management

Housing construction often involves high-rise buildings and from time to time, townhouses or terrace houses. Sacks and Goldin (2007) have discussed how lean management affects the productivity of high-rise residential projects. Seven types of waste in high-rise residential projects are listed in Figure 2.11.

Figure 2.11. Seven types of waste which affect the productivity in housing construction (Sacks & Goldin, 2007)



The principle of lean management emphasises reducing waste to further enhance the total productivity of construction projects.

For example, undesired products such as poor design will make a housing project less attractive to potential buyers. In some cases, residential construction that has been built according to a standard design does not meet the client's needs, resulting in waste and low productivity. The crucial driver in improving productivity in construction, particularly in housing and residential, is changing the method of construction, which has a large potential for improvement. Providing residences which benefit both parties, namely buyers and clients, should be paired with the application of lean management to improve the productivity in construction (Sacks & Goldin, 2007).

2.2 Industrialised Building System (IBS) in Mass Housing Production

Thrust 2 of Eleventh Malaysia Plan (11MP), which is to improve the wellbeing of all citizens, targets to raise the standard of living and quality of life of the rakyat irrespective of their socioeconomic background and geographical location.

Affordable housing agenda is included in this thrust to increase the house ownership among the poor, low- and middle-income households (Economic Planning Unit [EPU], 2018). Throughout 2020, the government has targeted to build 200,000 houses for the poor, low- and middle-income households (Pakatan Harapan, 2018).

As reported by Trading Economics, in Quarter 2 2018, the preliminary Malaysian House Price Index (MHPI) moderated to 1.7% (1Q 2018: 4.3%), particularly in the high-rise segment. In Malaysia, Housing Index is measured using the annual change in the House Price Index. The MHPI provides actual values, historical data, forecasts, charts, statistics, economic calendar, and news. Figure 2.12 illustrates the MHPI up to Quarter 2 2018.

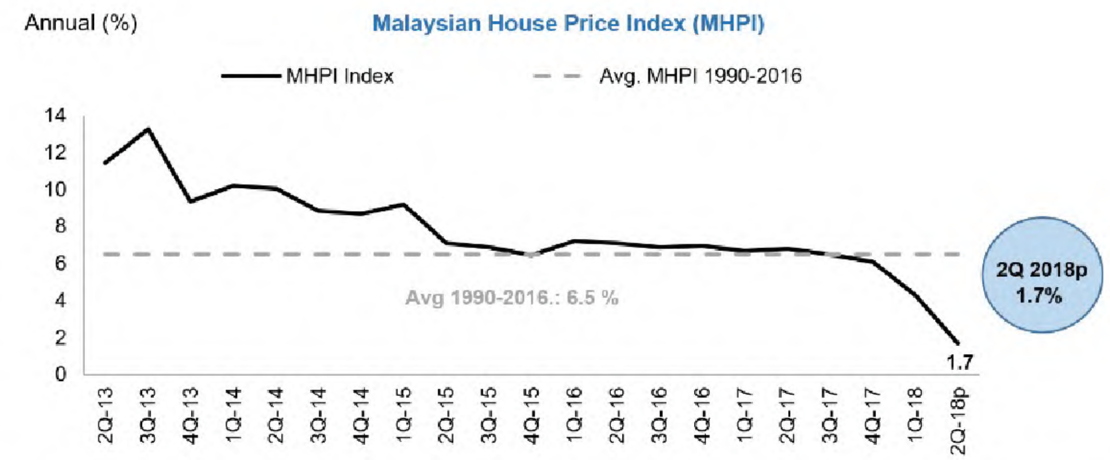


Figure 2.12. Malaysian House Price Index (MHPI) (Source: National Property Information Centre [NAPIC])

The slower increase in the MHPI reflects the moderating trend across all key states, namely Kuala Lumpur, Selangor, Penang, and Johor, as shown in Figure 2.13.

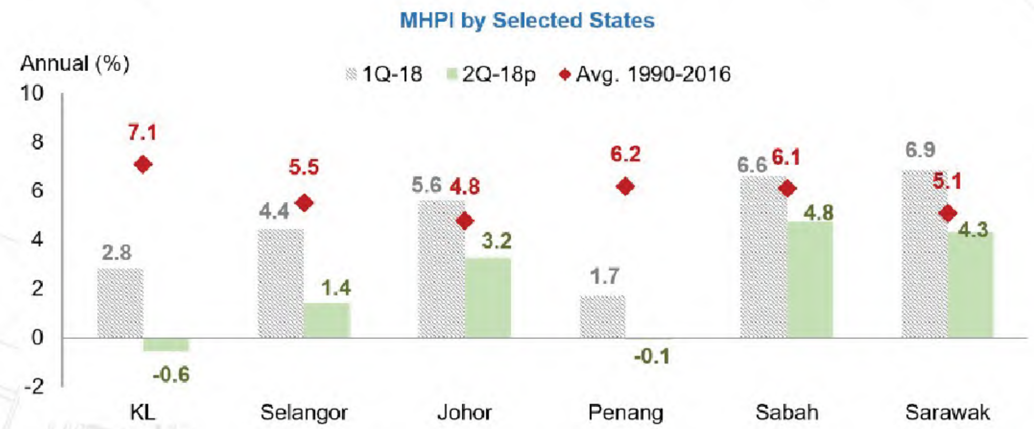


Figure 2.13. Malaysian House Price Index (MHPI) by Selected States (Source: National Property Information Centre [NAPIC])

The affordable housing scheme was initiated by the government in the Seventh Malaysia Plan (1996–2000) with the introduction of the Low-Medium Cost Housing category due to the increasing demand for housing in this category. The intention is to ensure that the middle low-income group with salaries ranging from RM1,501.00 to RM2,500.00 per month could own a house. IBS is the most suitable method to be used in this type of housing due to the high volume and demand stability. Its use also results in lower sales prices of low-medium cost houses as compared to using conventional construction methods.

Table 2,2 shows the People's Housing Programme statistics for the year 2016 with a total number of 102,896 units. To date, the number of completed units is 81,352 (79%), which proves that the usage of IBS can enhance the speed of construction of public projects as compared to using conventional construction methods. An IBS project typically takes about two (2) years to complete, less than half of the time taken to complete a conventional project, which is more than four (4) years (Ministry of Urban Wellbeing, 2016).

Table 2.2. People's Housing Programme, 2016

Programme	Total Project		Completed Project		Project Under Consruction		Project Under Planning	
	Project	Unit	Project	Unit	Project	Unit	Project	Unit
PPR for Rental	88	75,805	82	72,479	6	3,326	-	-
PPR for Ownership	81	27,091	33	8,873	30	13,036	18	5,182
TOTAL	**169**	**102,896**	**115**	**81,352**	**36**	**16,362**	**18**	**5,182**

(Source: National Housing Department [JPN], 2016)

As mentioned by the Ministry of Local Government & Housing Sarawak, housing development cost comprises four (4) main components, which are illustrated below:

Figure 2.14. Housing Development Cost

Construction cost, comprising building and infrastructure costs, constitutes the major cost of a housing development project. Building cost forms a larger percentage of the overall construction cost as compared to infrastructure cost. The minimum building cost in Malaysia under the conventional or traditional construction method was RM90.00 or USD22.17 per square feet (per sqft) (Ministry of Housing State of Sarawak [MOHSS], 2015). In this respect, the innovative construction method developed by Malaysian construction industry players only affects the building cost.

Industrialised Building System (IBS) is known for its advantages in speeding up construction, reducing wastage at the site, increasing productivity, and lowering the overall construction cost as compared to the conventional construction method. According to CIDB (2003), IBS is defined as a construction technique in which components are manufactured in a controlled environment (on- or off-site), transported, positioned, and assembled into a structure with minimal additional site works.

Construction Industry Transformation Program (CITP) has highlighted the need to improve the productivity of the Malaysian construction industry. It is possible to enhance the productivity of the Malaysian construction industry through the improvement in human capital development, adoption of technology, and mechanisation and modernisation of the construction process that would be made possible by employing IBS (CIDB, 2015). Table 2.3 shows the number of IBS manufacturers available in all states in Malaysia as of October 2018.

Table 2.3. IBS Manufacturers in Malaysia by all States

No	State	Precast	Onsite Precast	Formwork	Steel Structure	Metal Roof Trusses	Timber Frame	Block	Innovative	Total
1	Johor	21	3	2	3	4	1	4	9	47
2	Kuala Lumpur	0	2	0	1	1	0	0	3	7
3	Kedah	4	0	2	2	1	0	1	2	12
4	Kelantan	1	0	0	0	3	0	1	2	7
5	Melaka	3	1	0	1	1	1	2	0	9
6	Negeri Sembilan	7	2	3	0	1	0	3	2	18
7	Pulau Pinang	2	0	1	1	2	0	1	0	7
8	Pahang	2	1	0	0	2	0	3	0	8
9	Perak	3	1	0	1	2	0	1	9	17
10	Perlis	1	0	0	0	0	0	0	0	1
11	Sabah	6	0	0	3	3	0	5	4	21
12	Sarawak	5	1	0	5	3	1	2	2	19
13	Selangor	17	6	27	10	7	0	11	31	109
14	Terengganu	2	1	0	0	2	2	1	0	8
	Total	**74**	**18**	**35**	**27**	**32**	**5**	**35**	**64**	**290**

Source: IBS Centre (2018)

Due to the demand for affordable housing in Malaysia, the government is keen on using IBS in their projects to increase the speed of affordable housing construction. This statement is supported by Bank Negara Malaysia (BNM) in their strategic plan for affordable housing that the adoption of IBS could reduce the overall cost of construction, increase productivity, and accelerate the speed of construction (Ling, Almeida, & Wei, 2017). BNM has proposed to offer incentives and tax exemptions for heavy machinery and equipment to the IBS implementers.

The adoption of IBS in public housing will provide better productivity, quality, and safety alongside savings in the total construction time and cost. Currently, IBS has become popular in government projects in Malaysia due to the early effort by the government of Malaysia in promoting the usage of IBS and developing the Open Building System (OBS) that shall achieve at least 70 IBS Score.

Though the concept of IBS is relatively new to local house buyers, its technology has been used for decades in Scandinavian countries such as Germany and also in Singapore and Thailand. The usage of IBS is not limited to buildings only. IBS can be employed in building a Prefabricated Bathroom Unit (PBU). PBUs are built in the factory and then transferred and hoisted for easy installation in buildings, complete with electrical, plumbing, and ventilation connections. An example of the usage of PBUs in public housing is in Rumah Selangorku in Elmina by Sime Darby Property (SDP).

The development of IBS could reduce the total construction cost. The findings of an IBS Lab discussion reveal that with the usage of precast method, the cost could achieve RM87 per square feet. From the discussion, the members have identified three (3) key actions, as shown in Table 2.4.

Table 2.4. Key Actions and Cost Strategies

Action	Strategy
Action 1	Standardisation of design High volume
Action 2	Selection of technology to increase productivity
Action 3	Strategic material procurement Incentives (tax, approval, etc.)

Housing construction cost is a critical issue in Malaysia, as a high building cost makes it difficult to provide affordable housing. The case study done by Mohammad, Musa, and Ahmad (2018) compared five (5) building construction projects between conventional and IBS construction methods. Table 2.5 shows the comparison of the building cost per house built using IBS or Modern Methods of Construction (MMC). The benefits, type of IBS/MMC, and features of every house and conventional construction method are illustrated in the table.

2.2.1 Case Study A

The method used in this project is modular prefabricated house using modular prefabricated building system or modular construction. At the moment, modular prefabricated building and modular construction are still new in Malaysia. Developed countries such as the United States (USA), United Kingdom (UK), Japan, and European countries have already been using this method, which is also known as off-site prefabrication and modern methods of construction (MMC). In this project, the floor area of the house is 800 sqft. The structure of the modular prefabricated house is made from lightweight galvanized steel. The building cost of the modular prefabricated house including the foundation cost is RM75,000.00. The total construction period of the modular prefabricated house including the manufacturing process of the modular units and site installation is about two weeks.

2.2.2 Case Study B

In this project, the components are shipping containers. The container house is popular due to its strength, wide availability, and relatively cheap price. The container house for this project comprises two units of 40' x 8' x 8⊠2' shipping containers. The floor area of the container house is 700 sqft. In this case, the container house is combined with Primer X. Primer X is a thermal insulation coating applied to the external surface of shipping containers. The building cost of the shipping container house is RM68,000.00. The total construction period of the shipping container house including the refurbishment process of the shipping containers and site installation is about three to four weeks.

2.2.3 Case Study C

This building applied the monolithic building method. This system is widely recognised as one of the most practical and economically and technically feasible solutions to the problem of building cost-effective, durable, and earthquake-proof housing on a mass scale quickly and efficiently. The floor area of the monolithic house is 890 sqft. The structure cost is RM33,000.00 while the building cost for mass production is RM66,000.00. The minimum units of 25 units were constructed to achieve cost-saving, repetitive usage of the formworks, and a standardised building plan. The total construction period of the monolithic house using the system developed by the manufacturer is about one to two weeks.

2.2.4 Case Study D

This project used the IBS steel framing system known as Enduro frame building system, which adopts the Malaysian housing features. The total construction period of an 800 sqft house using the Enduro frame building system is only seven days and the building cost is RM64,000.00 However, the limitation of the system is it only caters for single storey landed houses.

2.2.5 Case Study E

The house in this project used 100% recyclable raw material of Expanded Polystrene (EPS) panels that have a lightweight characteristic. The house size is 1000 sqft and the building cost is RM80,000.00. The construction period for the house in this case study is about three to four weeks.

2.2.6 Summary

The adoption of IBS in public housing in Malaysia can resolve the issues of slow construction, wastage, quality, and other related issues. Previous studies have proven that the adoption of IBS on a large scale could reduce the overall construction cost if it achieves a certain volume. IBS and MMC can successfully deliver and contribute to an affordable housing solution in Malaysia.

Table 2.5. Comparison of the building cost per house built using IBS and MMC

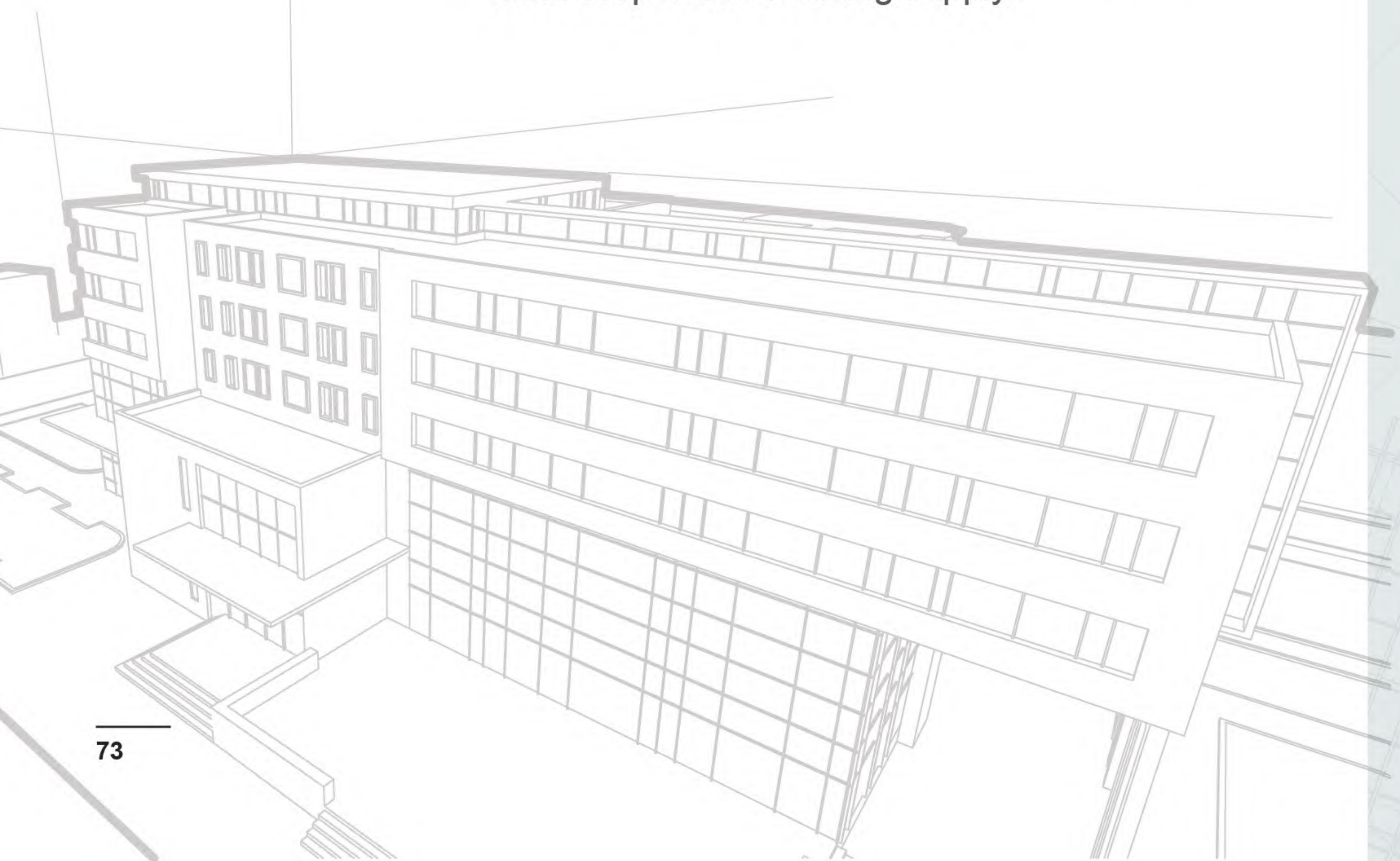
Features	Conventional Construction Method	Case Study A	Case Study B	Case Study C	Case Study D	Case Study E
House Features	-	800 sqft 3 bedrooms & 2 toilets	700 sqft 3 bedrooms & 2 toilets	890 sqft 3 bedrooms & 2 toilets	800 sqft 3 bedrooms & 2 toilets	1000 sqft 3 bedrooms & 2 toilets
Building Cost	-	RM75,000.00	RM68,000.00	RM66,000.00	RM64,000.00	RM80,000.00
Building Cost per sqft	RM90.00 (The current building cost per sqft for conventional construction method in Malaysia)	RM93.75 (RM75,000 / 800 sqft)	RM97.14 (RM68,000 / 700 sqft)	RM74.15 (RM66,000 / 890 sqft)	RM80.00 (RM64,000 / 800 sqft)	RM80.00 (RM80,000 / 1000 sqft)
Type of IBS/MMC used		Modular prefabricated building system	Shipping container construction	On-site monolith building system	IBS steel framing system	IBS innovative system
Benefits of using the IBS/ MMC	Cheap	Fast High-quality construction workmanship of the product	Fast High-quality construction workmanship of the product	Cost-efficient Fast High-quality construction workmanship of the product	Cost-efficient Fast High-quality construction workmanship of the product	Cost-efficient Fast High-quality construction workmanship of the product

Source: Mohammad, Musa, and Ahmad (2018)

The adoption of IBS in public housing in Malaysia can resolve the issues of slow construction, wastage, quality, and other related issues.

2.3 More Homes Through Offsite Manufacturing

The introduction of offsite manufacturing has provided a potential solution in creating more responsive housing supply.



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Offsite manufacturing offer advantages such as improved build time, environmental benefits, and reduced on-site labour costs. It incorporates a broad range of technologies and innovation to improve project delivery.

Housebuilding should be turned to offsite manufacturing for several reasons:

Time-Saving: Rapid deployment on-site ensures practical completion is achieved faster compared to under conventional construction.

Safety: Most of the construction is completed in manufacturing facilities; reduces on-site labour and on-site storage requirements.

On-site Labour Reduction: Most of the construction process is performed off-site.

Environmental: Minimal impact on the environment since most of the construction process is performed off-site. Little waste generated will reduce cost and create a clean, safe, and sustainable site.

Quality: Maintains complete control over the manufacturing environment. The manufactured house is fitted out before transporting to the site; quick smart technology can assure a level of quality, consistency, and certainty that site-based construction can rarely offer.

2.3.1 Types of Offsite Manufacture

Offsite manufacture is a catch-all term to describe the technology where a component or a significant proportion of a house is built away from the site, usually in a factory.

Volumetric

These units are 3D modules assembled in a factory. The main market for volumetric is closed modules. One of the main advantages is that these can be whole rooms that are fully plumbed and wired, and then transported to the site and stacked on top of each other on a ready laid foundation to form a building.

This method is popular for highly standardised accommodation such as hotels, student residential halls, care homes, and flats in urban medium- and high-rise situations. The modular units or pods may just be bathrooms. With pods, the main advantage is that services installation is transferred into factory-engineered conditions. For example, more than 30 trade activities are transferred off-site when bathroom pods are used. This leads to fewer people on-site, easier commissioning, and less rework.

Figure 2.15. Example of Volumetric

Panellised

The use of panellised systems is becoming increasingly popular in housing construction. These systems involve the on-site assembly of flat panel walls to form the internal load-bearing element, cassette floors (again floor panels), and roofs. In addition to aiding the speed of construction, panellised systems offer flexibility in terms of layout and room size.

The integration of BIM in the production of systems has enabled a degree of mass customisation to be achieved at relatively low volumes, giving housebuilders greater flexibility.

Figure 2.16. Example of Panellised

SECTION 3

Embracing The Digital Shift In Housing Construction

- Design for Manufacturing and Assembly (DfMA)
- What is BIM and its Relation to Offsite Construction?
- Developing Processes in BIM-based Projects for Housing Construction

REVALUING AFFORDABLE HOUSING IN MALAYSIA THROUGH
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The construction industry players need to embrace digital technology such as Building Information Modelling (BIM) to improve housing construction. As the industry moves towards the fourth industrial revolution (IR 4.0), Malaysia's construction industry will adapt to a new way of maximising value through a digital manufacturing environment. Manufactured housing production or known as offsite construction has been identified as a solution to housing construction issues, particularly in the affordable segment. Figure 3.1 shows how the utilisation of BIM is able to improve the offsite construction process.

Factory production

Companies are investing in repeatable process for the construction of modular units or component parts.

Supply chain & BIM design

Companies that own both the design and construction process have developed standardized design to maximize materials efficiency procurement.

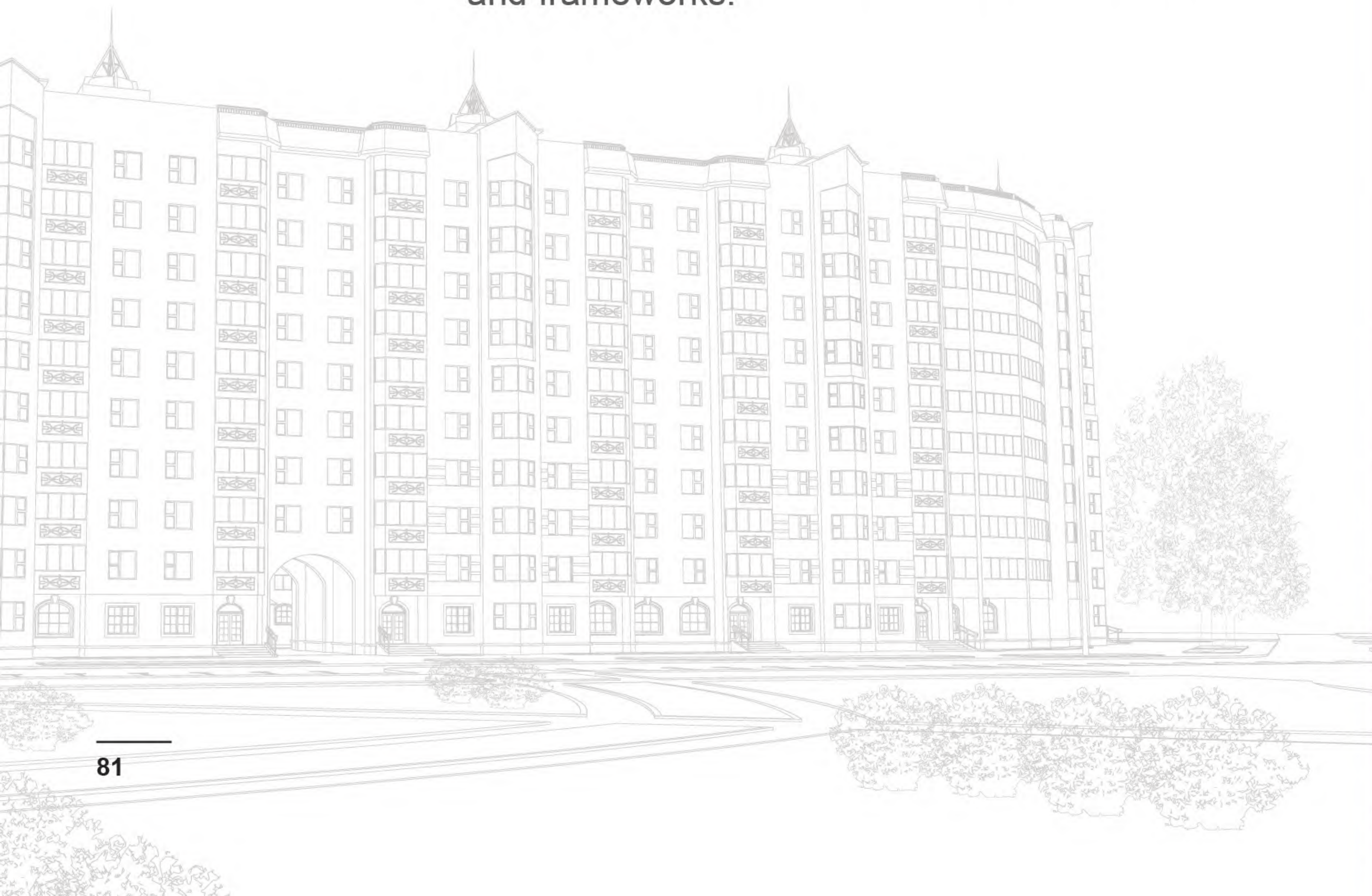
Energy & Sustainability

Builders are turning to carbon neutral and sustainable materials like tall timber and mycelium.

Figure 3.1. Offsite construction processes and benefits (Real Estate Tech, 2018)

3.1 Design for Manufacturing and Assembly (DfMA)

DfMA can be applied to one-off or bespoke projects as well as to large-scale projects and frameworks.



If we are to harness DfMA successfully, it needs to be considered from the outset of a project, particularly as the industry transitions from traditional design-to-construction processes to digitally-driven design-to-assembly ones (Refer to Figure 3.2).

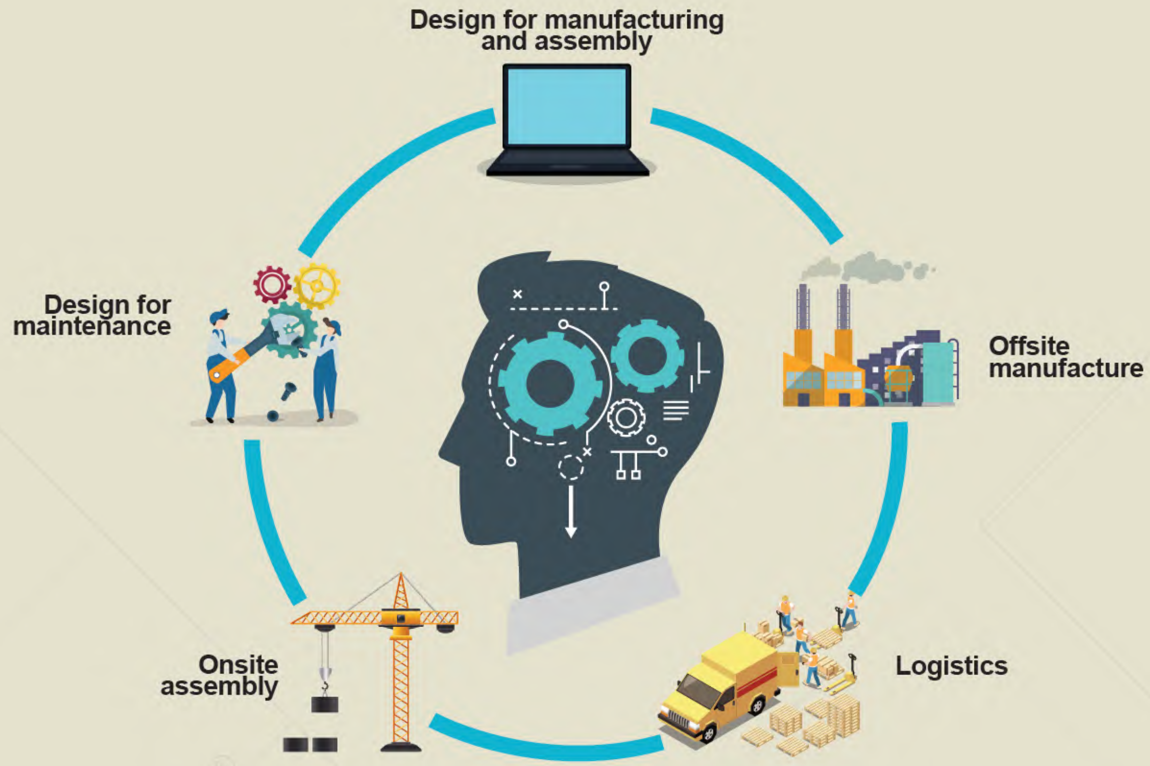


Figure 3.2. A DfMA mindset: through the stages of offsite manufacturing

DfMA is a design philosophy that emphasises a holistic view of the design process. In this overarching view, the Architect and Design Engineer will consider not only the design of the individual elements and the completed structure composed thereof but also the design of the assembly process. Increased focus is placed on how the individual parts are to be fabricated and connected as part of the design process, rather than as an after-thought (Monash University, 2017).

The basis of DfMA is in the form of virtual reality modelling of the project, and it should include the following elements:

a. Discretisation of the construction;

b. 3D design collaboration;

c. 4D construction planning; and

d. 5D quantification and costing

DfMA allows all the project elements to be interrogated by the construction team until the optimum solution is achieved. The key components of the DfMA envelope are described in detail in Figure 3.3.

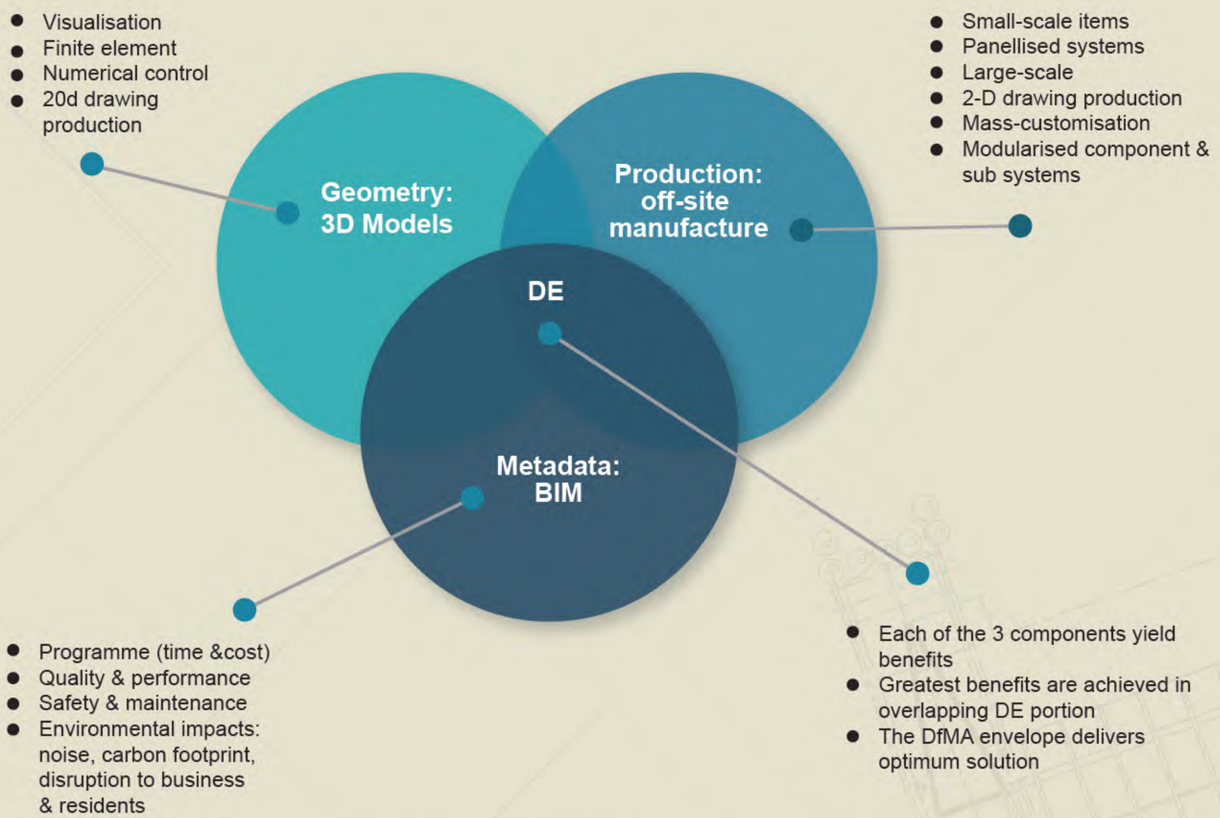
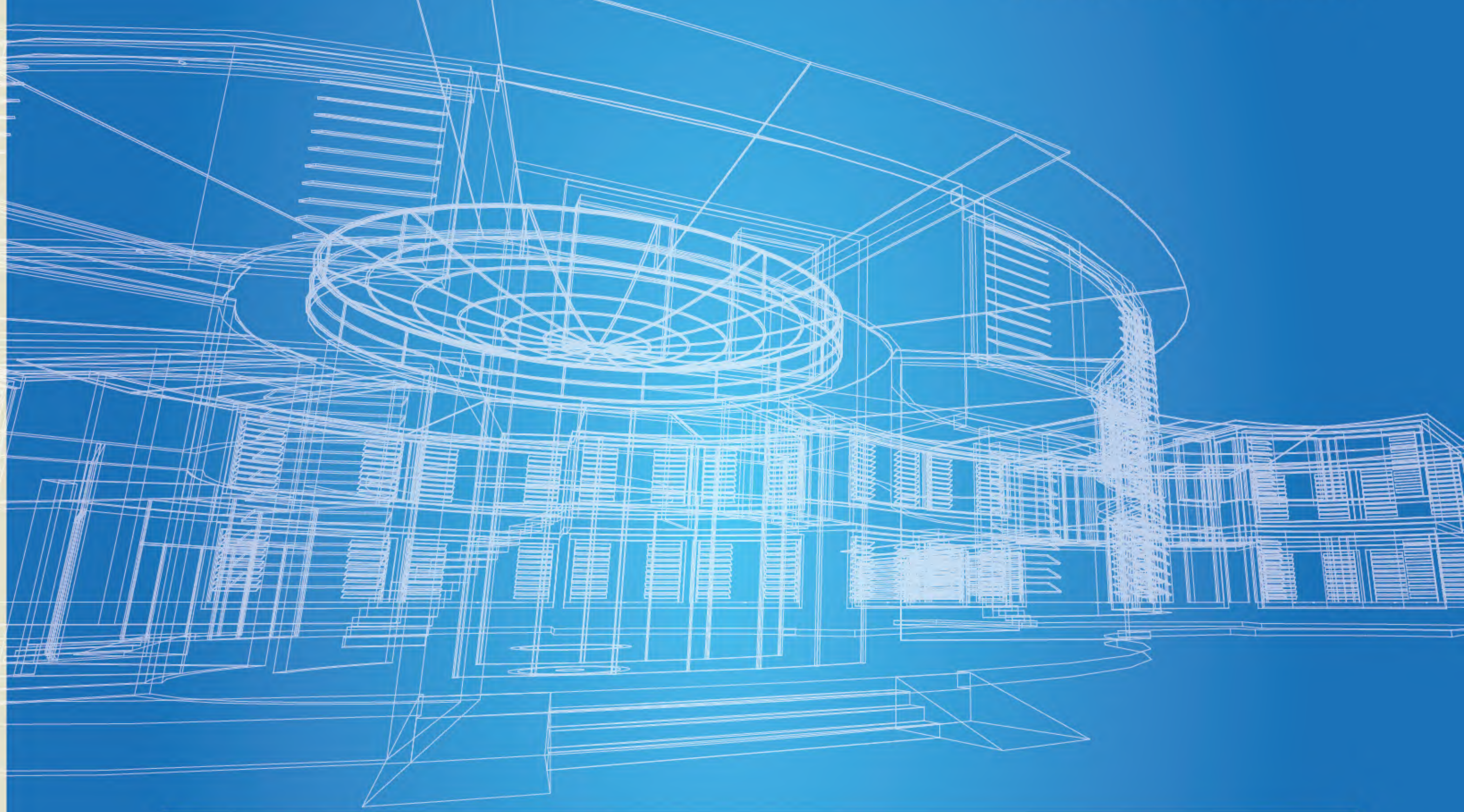


Figure 3.3. DfMA Envelope (Mcfarlane et al., 2014; Monash University, 2017)



DfMA Envelope	Explanation
Geometry	The Geometric Model is a virtual 3D model represented in a software package such as Building Information Modelling (BIM) and allows the technical and non-technical team members to visually understand and interrogate the intent of the design. The main components should include the engineers' finite element models, geometrical components, and computer numerical control (CNC) models, which enable the automated production of the relevant elements of the project. The 3D model with adequate naming convention may also be used to produce 2D drawings, which may be required for non-automated processes such as obtaining approvals from statutory authorities, third-party manufacturing of small-scale items, and so forth. However, this should be minimised with a preference for 3D approvals directly from the full model.
Production	DfMA production covers offsite manufacturing in a factory environment and the modules produced can include small-scale items such as electrical fittings; large scale items including precast concrete floors and panellised systems in steelwork, precast concrete, or timber; and fully enclosed volumetric spaces, such as individual rooms or complete buildings. The entire fit-out process (i.e., structural, electrical, mechanical, and decorative work) is ideally carried out in the factory. Notably, a higher level of quality control and improved overall quality assurance is generally achieved through factory production. Notwithstanding, nowadays, a significant proportion of the work can be automated and performed by robots where the input for the robots should be via computer numerical control software derived from the Geometry Model.
Metadata	The Metadata Model is a multi-dimensional database containing all relevant project parameters. Not only can this model be used to calculate the impacts of time, sequencing, scheduling, and costs but it can also be used to analyse environmental impacts, such as the carbon footprint, sustainability, noise pollution, air quality, and other impacts on the environment. Additional benefits include waste reduction, error avoidance, and cost reduction. When combined with the 3D Geometry Model, the Metadata Model can allow all the stakeholders to analyse the impacts of different design options.

3.2 What is BIM and its Relation to Offsite Construction?

BIM, recognised as the latest advanced information and communications technology (ICT), is defined as "Modelling technology and associated set of process to produce, communicate, analyse and use digital information models throughout the construction project life-cycle" (CIDB Malaysia, 2016).

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The quality of information from a BIM model is the key to producing a digital twin process design and information requirements. Digital twins are poised to revolutionise the discrete manufacturing process including offsite construction. Figure 3.4 explains the manufacturing process that serves to create a digital twin.

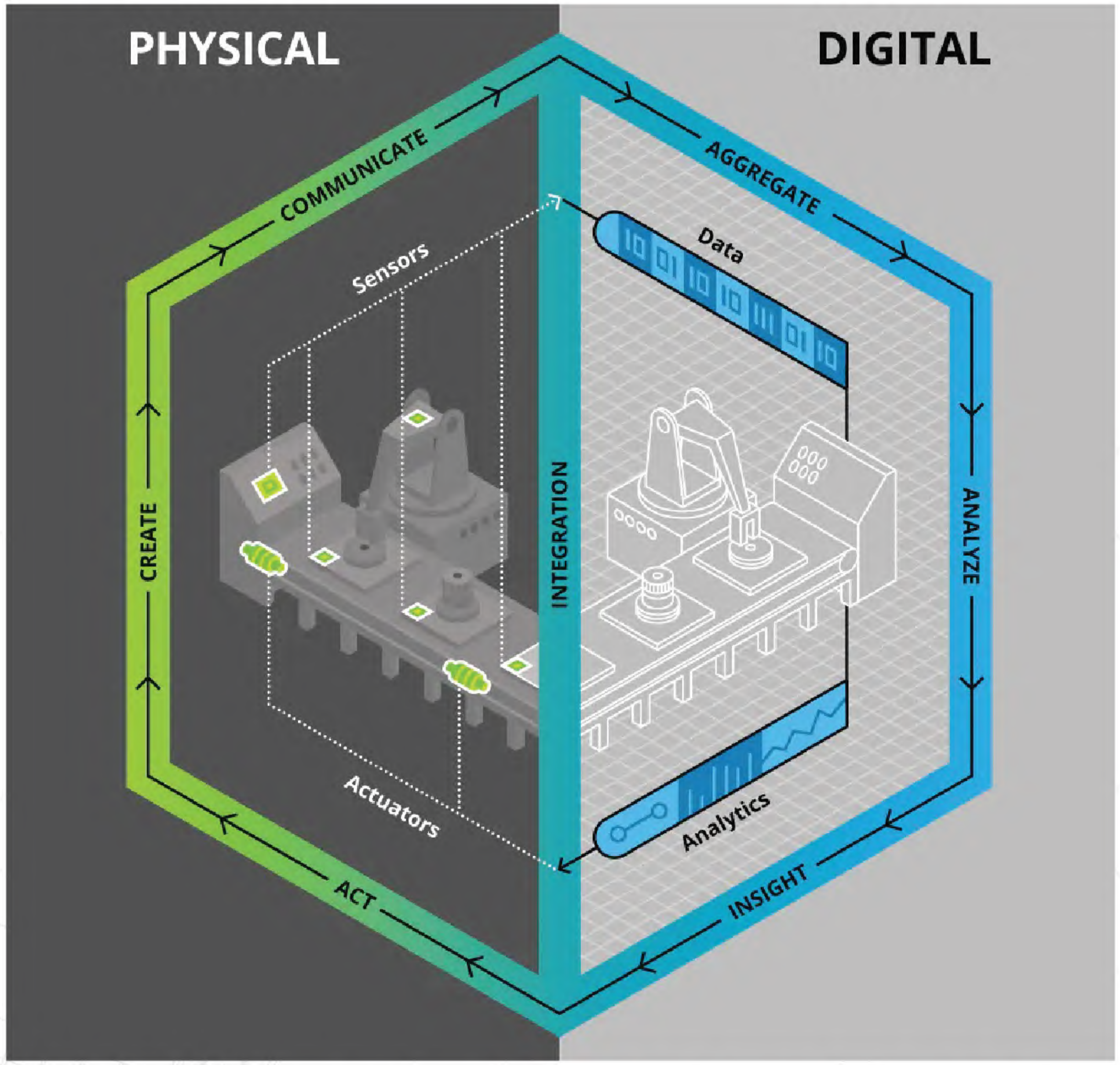


Figure 3.4. Manufacturing process in a digital twin model (Parrott & Lane, 2017)

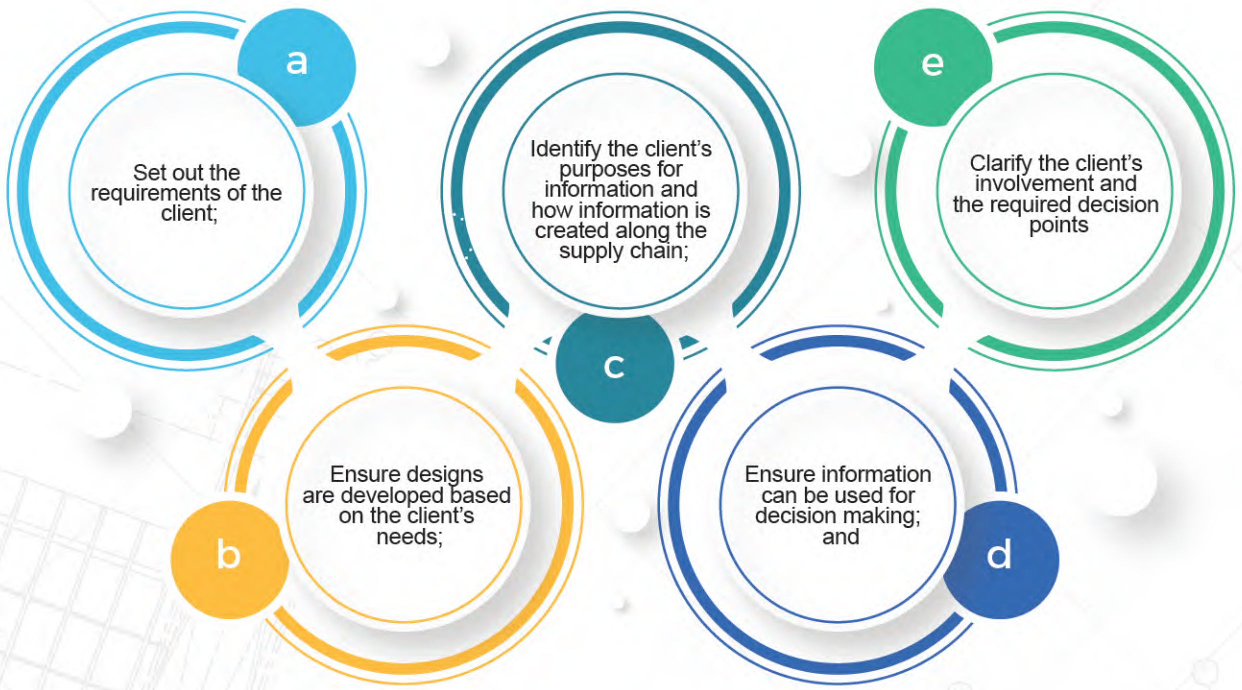
3.3 Developing Processes in BIM-based Projects for Housing Construction

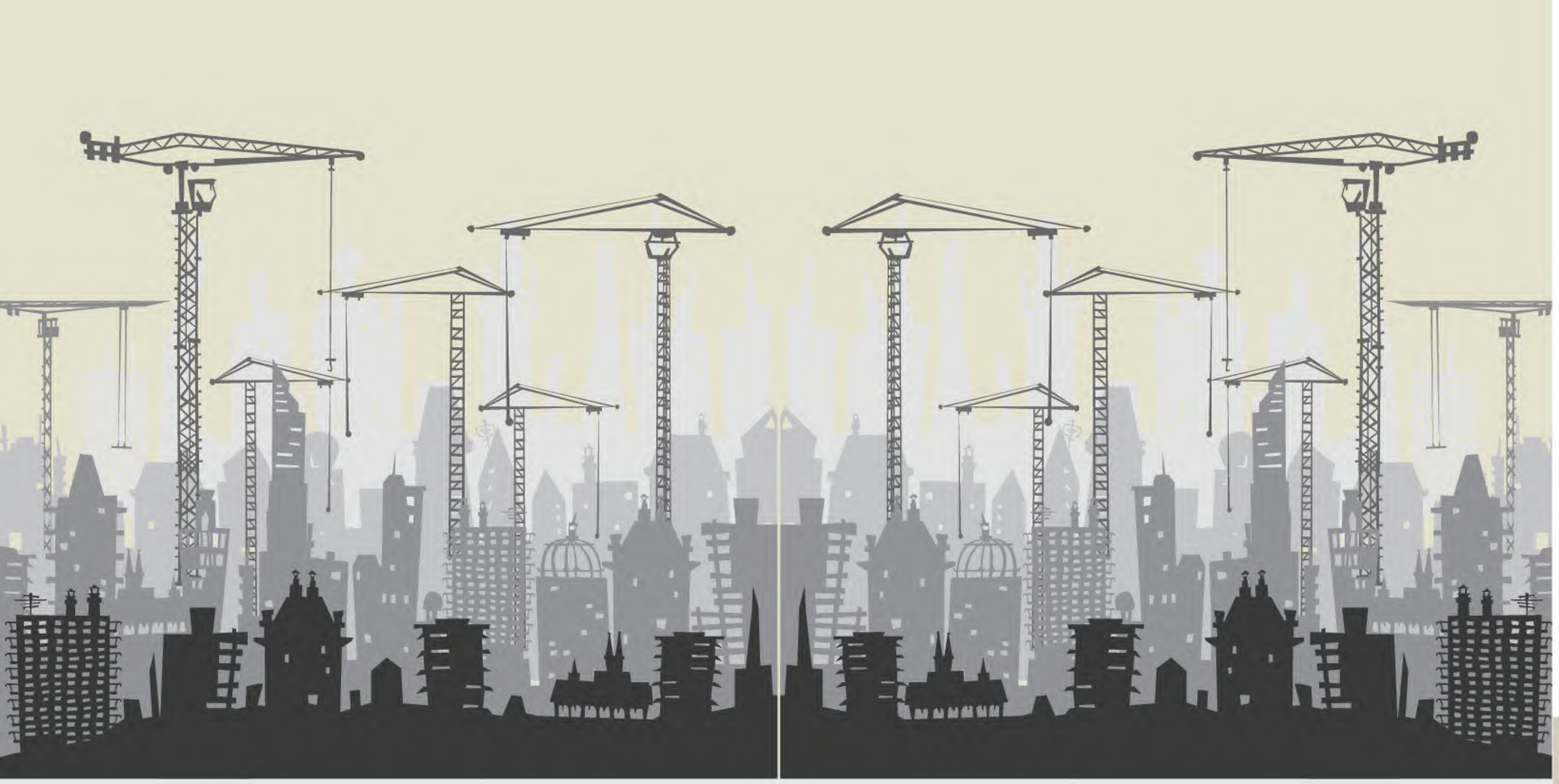
The application of technologies, especially BIM, brings all construction stakeholders to work collaboratively on the digital tools in a model-based environment.

This chapter offers recommendations and knowledge to construction industry players in using BIM for housing construction. This section will explain the step-by-step approach in implementing BIM.

Step 1: Set client requirements

The Employer's Information Requirements (EIR) is an important document that is used to define the client's project and BIM objectives. The EIR are needed to:





The EIR need to be incorporated as part of the tender documentation. This document enables the tenderer (afterwards known as the contractor) to produce their BIM Execution Plan (BEP) according to the client's requirements.

Figure 3.5. EIRs and BEP relationship to align the client's project and objectives

Step 2: Develop a BIM Execution Plan (BEP)

BEP is a reference document that assists in linking the BIM implementation in the overall project work plan. BEP embodies the processes and procedures required to achieve the BIM objectives that consequently allow the accomplishment of the project objectives.

As stated in CIDB BIM Guide: Book 4, the BEP development consists of the following key points:

a. Carried out at the early stage of the project;

b. Defines the deliverable strategy for the BIM process to meet EIR;

c. Treated as a reference for BIM contracts. Each requirement must be delineated clearly and agreed by all the parties involved;

d. A generic document based on the specific needs and requirements of the project;

e. Provides structured procedures to create, assemble, and deliver the information in a BIM model;

f. Specifically assigns the responsibilities and liabilities of each party involved;

g. Encourages the use of common standard, procedure, and protocol;

h. Ensures that the developed design complies with the employer's needs and requirements; and

i. Ensures that the client is able to operate the completed project effectively and efficiently.

The BEP is developed both pre- and post-contract as a direct response to the EIR. Figure 3.6 illustrates the difference between pre- and post- BEP. The pre-BEP will be used by the client to evaluate the proposed approach for project delivery, team capability, and capacity. Once the contract has been awarded, the nominated contractor is required to submit a post-BEP, which sets the framework for delivering the project using BIM.

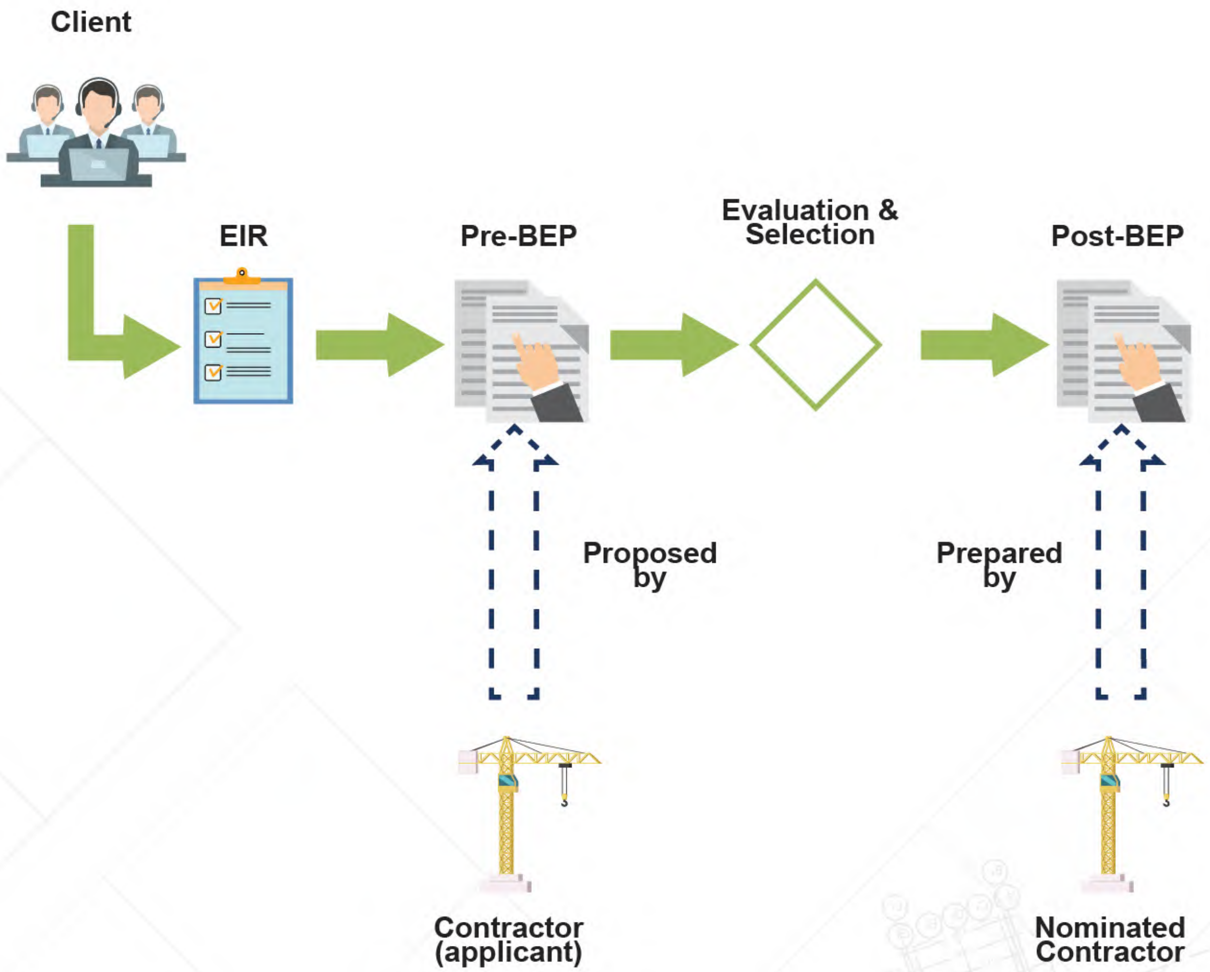


Figure 3.6. The process of developing BEP

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Step 3: Organise contract and team alignment workshops

Contract and Integrated Project Delivery (IPD) team alignment workshops are fundamental for the establishment of a high-performing team. Both contract and team alignment workshops provide a platform for the IPD team to work collaboratively.

The contract workshop aims to achieve the following key items:

- **a.** Address questions and concerns regarding IPD and the project;
- **b.** Provide an opportunity to educate the IPD team regarding the principles, their roles in the IPD project, and how the IPD agreement will function;
- **c.** Assure a common understanding of IPD and provide the correct context for discussion and negotiation;
- **d.** Create honesty, transparency, and ability to view issues from multiple perspectives; and
- **e.** Provide an opportunity for the owner to model these values and set the project's direction.

The team alignment workshop will create a project culture and foster the commitment of the IPD team to achieve the project value and goals. The team alignment workshop has two primary functions:

- **a.** Creates clarity, consensus, and commitment to project goals; and
- **b.** Shapes a project culture that transforms a group of individuals into a high-performance team.

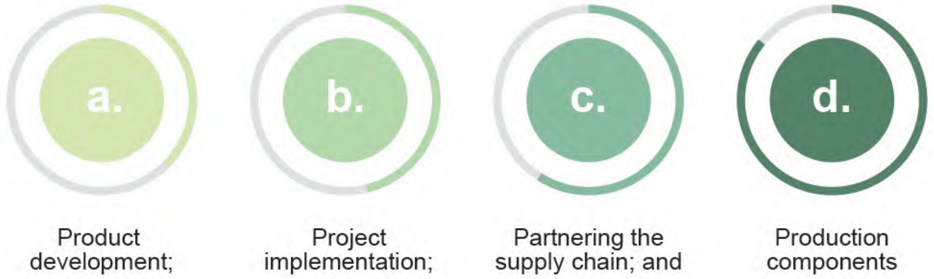
The workshops are intertwined with the BEP development and alignment process. A good workshop should set the stage for project execution.

Figure 3.7. Series of workshops for contract and team alignment

Annexe provides an example of a team alignment workshop process workflow, which consists of client, contract, and IPD teams to simulate the research project Humanising Low-income Group's Housing through Technology and Innovation in a real process.

Step 4: Create an effective work plan

An effective work plan should focus on the integrated processes and teams, whereby four key elements have been identified (adapted from Force and Egan, 1998):



Section 3, subsection 3.1 of this document explains the concept of offsite manufacturing in improving housing delivery. The offsite assemblies should be designed for manufacture and assembly (DfMA) utilising a series of standardised component parts with the aid of BIM.

The lean principle explained in Section 2, subsection 2.1 of this document is applied to facilitate an integrated design and construction process which underlays the foundation for creating an effective work plan. Apart from the lean principle, Target Value Design (TVD) that has been explained in Section 2 will be embedded in the work plan as an approach to designing according to a budget.

Table 2.6 provides a list of references for the development of an effective work plan for offsite manufacturing.

Table 2.6. References for developing an effective work plan

Reference	Publisher/Author
RIBA Plan of Work 2013 Designing for Manufacture and Assembly	Published by Royal Institute of British Architects (RIBA) (Reference available at: https://www.architecture.com/knowledge-and- resources/resources-landing-page/riba-plan-of-work)
Building Offsite: An Introduction	Produced through industry and academic collaboration of CCG (OSM), Stewart Milne Timber Systems, Edinburgh Napier University, and Heriot-Watt University in partnership with Architecture and Design Scotland (A+DS). (Reference available at: https://www.ads.org.uk/building- offsite-an-introduction/)
Building Information Modelling	Website by Scottish Future Trust (URL: https://bimportal.scottishfuturestrust.org.uk/level2)

Step 5: Guide for modelling

To obtain the maximum benefit from BIM, it is important to focus on coordination and communication among members of the project team. BIM has the capability to orchestrate improved communication, coordination, and collaboration on a project. The BIM process embedded in the BEP should be adhered to and delivered by the project team. However, issues concerning model clashes, data loss, misplacement of BIM models in coordination systems, and work being done can affect the coordination process.

As an example, information on handover details such as the level of detail (LOD) at which models should be handed over by the project team needs to be determined. The BEP should cover the requirements for data exchange, communication, and modelling techniques. The project team is suggested to have a modelling guide for each discipline for better coordination and collaboration.

Step 6: Data management and security

As the project is executed according to the BEP, only selected data are transferred into the database. The data can then be used for many purposes such as facilities management and value management, among others. Data management and security needs to be embedded throughout the supply chain. Data security is often related to large data management including permission, data manipulation, and file version control.

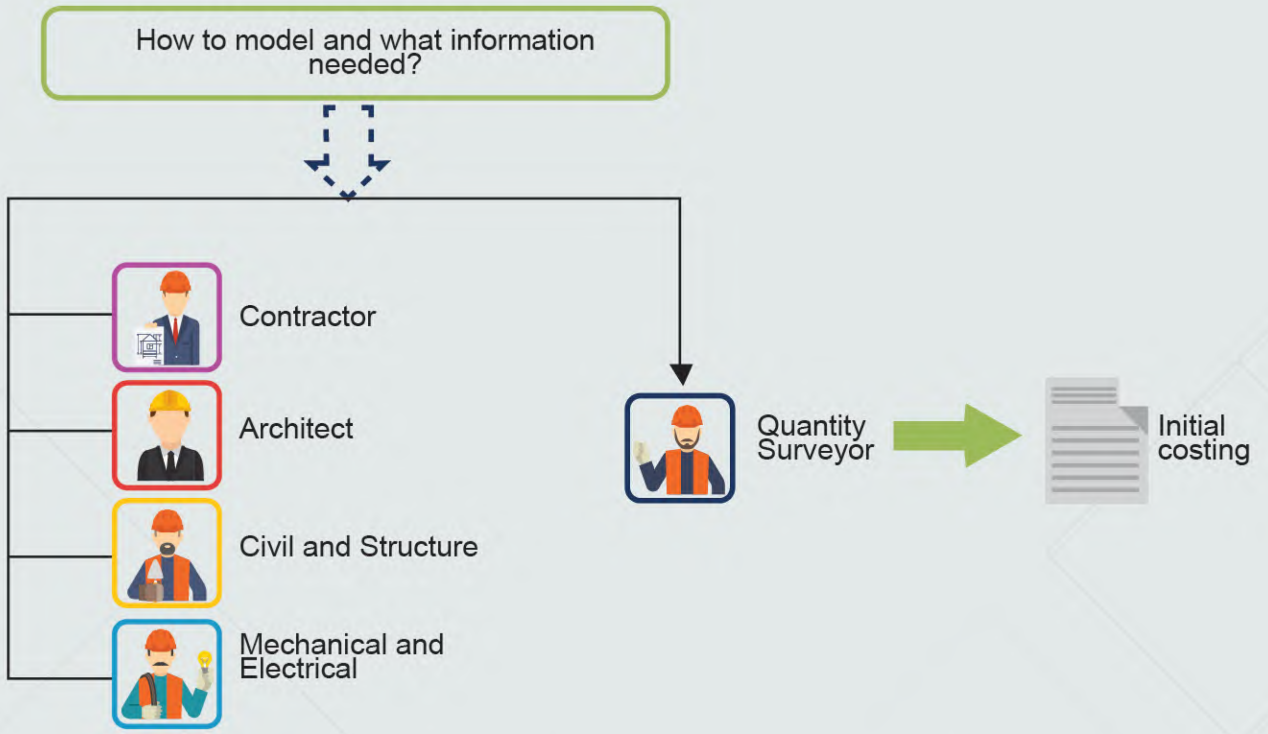


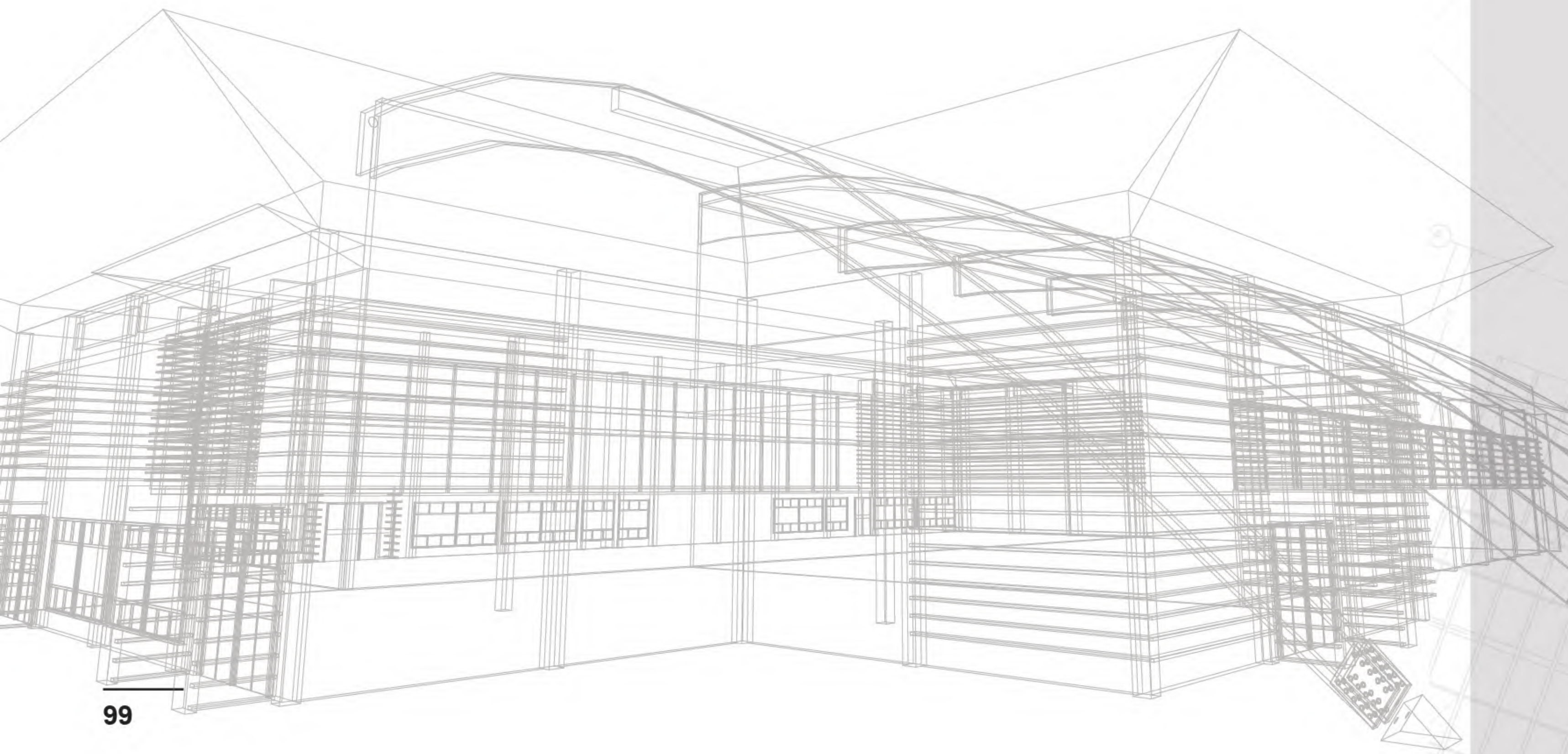
Figure 3.8. Modelling guide for each discipline for a specific purpose

SECTION 4

Embarking On The Sustainable Housing Design Concept In Malaysia

- Sustainable Housing Design
- Quality and Safety Assessment

4.1 Sustainable Housing Design



Sustainable housing consists of three key elements:

01

Environmental Sustainability: A house is designed to reduce greenhouse gas emissions, to be water and energy efficient, and to reduce waste during its construction and lifetime.

02

Social Sustainability: A house is designed with safety features and security elements to improve its residents' sense of security as well as providing flexibility for people with different abilities and life stages.

03

Economic Sustainability: A house is designed to save cost during construction and throughout its lifetime.

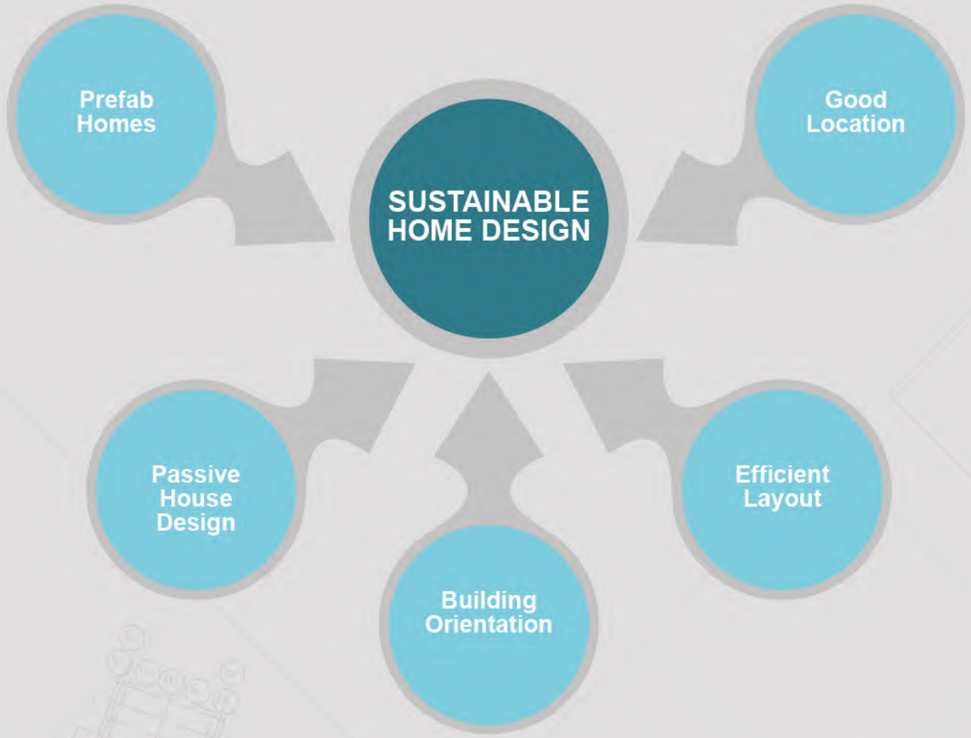


Figure 4.1. Five elements of a sustainable home design

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4.1.1 Good Location

The most important element of a property is its location. Moving a home is not easy and expensive. When people buy a house, they want it to be in a good location to ensure they receive the best return on their solid long-term investment. A good location can mean different things to different people, but below are four subjective characteristics of a good location that determine a home's value.

Safe neighbourhood

People should feel safe and secure in their home. A safe neighbourhood offers an opportunity for the residents to walk freely around the neighbourhood and interact with their neighbours without being exposed to crimes and dangers. Children would also feel safe to be outdoors and play with their friends without adult supervision.

Accessibility

A house or a residential area should have access to public services such as hospitals, schools, and infrastructures. Being close to public transportation is also important as it means a short amount of commuting time. A house should also have access to amenities such as grocery stores, shops, and restaurants.

Besides that, a house or a neighbourhood must be accessible for people with disabilities. Providing physically accessible communal areas and facilities for people with disabilities such as accessible routes, curb ramps, parking, and lifts for the disabled offer them an opportunity to be a part of the community and create a neighbourhood with a quality of life.

Landscape

The elements of a housing landscape are important to support the need of the community to have a better living environment in their residential area. Landscaping promotes healthy community living and contributes to the long-term sustainability and management of a building and its community (Chew, 2018).

Parks and Recreation

Parks and recreation areas can enhance the quality of life in a neighbourhood by allowing social interactions to happen and simultaneously improving the physical and mental health of the society (Shahli et al., 2014). Social interactions within a neighbourhood are important to overcome unfamiliarity, fear, and isolation, as well as to build positive and healthy relationships with people from different cultures and backgrounds.

4.1.2 Efficient Layout

For the most effective daylight harvesting, the classic approach is the split window design. The design consists of a lower vision window and an upper daylight window that are separated by external or internal light shelves.

The lower vision window is designed to provide a lookout point for the occupants. This window could be fitted with blinds to reduce the daylight level and provide privacy. As for the upper daylight window, it should be fitted with glare-protection devices to reduce harshness. The rule of thumb for glare protection for a daylight window is to ensure that the occupants have less than 10 per cent view of the outdoor sky, so the light is not hitting too hard.

Dark-coloured interior fit-outs will absorb light, significantly reducing daylight levels in spaces by up to 50 per cent or more. On the other hand, light-coloured interior fit-outs will deflect the harvested daylight deeper into the building. Also adding features like skylights on the top floor of a multi-storey landed house is a plus and lets in a wealth of natural sunlight.

4.1.3 Building Orientation

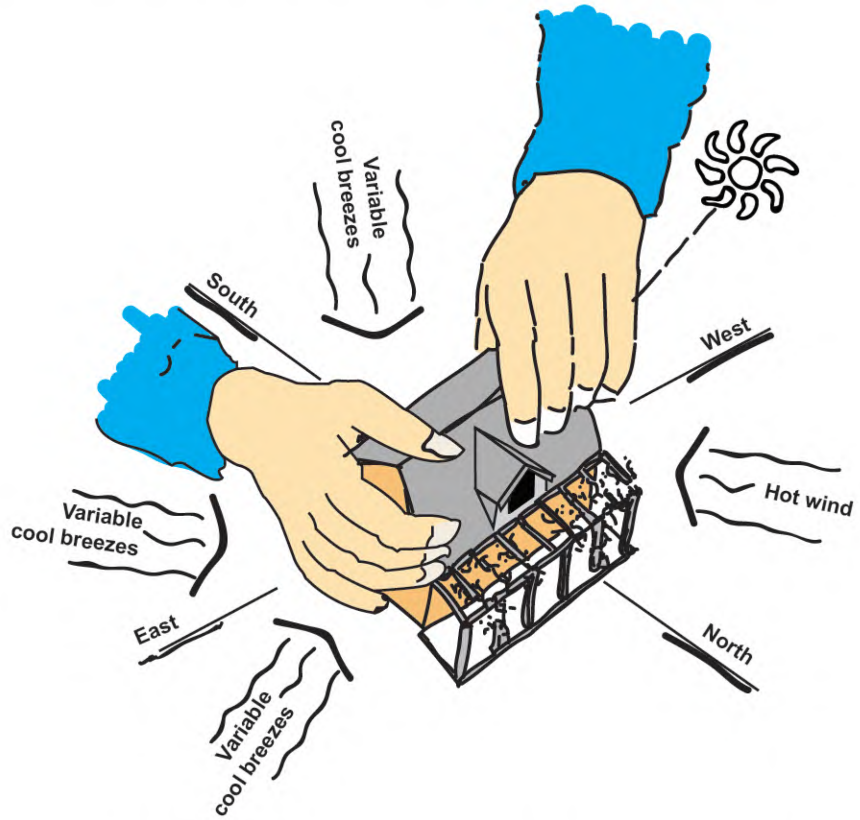


Figure 4.2. Ideal building orientation (McGee, Reardon, & Clarke, 2013)

Malaysia is blessed with an abundance of sunlight, which is the richest source of lighting during the day. To gain the most from this, building orientation is an important consideration for sustainable homes as it determines how and where the light falls. By orientating the building to coincide with the east-west axis as shown in Figure 4.2, it will help to maximise the amount of wall area exposed in the northerly direction where the sun would be at its highest peak. From this, more windows can be provided to allow more lights in, which can reduce the amount of artificial lighting used in the morning and afternoon. At the same time, it is important to ensure glare is reduced. The east-west axis orientation also helps in determining where planting should be positioned. For example, shade trees should be planted and positioned mostly in the north-west direction to filter hot wind and glare. From this orientation, the positioning of each room can be decided accordingly. For example, the living room should face north to optimise the amount of sunshine throughout the day while the kitchen and dining area should be positioned towards the east to catch the morning sun (Auckland Council, 2018).

4.1.4 Computational Fluid Dynamics (CFD)

Computational fluid dynamics (CFD) is the science of predicting fluid flow, heat transfer, chemical reactions, and related phenomena by utilising applied mathematics, physics, and computational software. CFD simulation effectively provides a visual on how fluid flows and interacts with objects considering factors such as velocity, pressure, temperature, and density of the fluid in motion. CFD takes wind speed and prevailing wind directions experienced during different time frames to ensure structural integrity under high wind load to enable engineers and architects to provide a comfortable and safe environment.

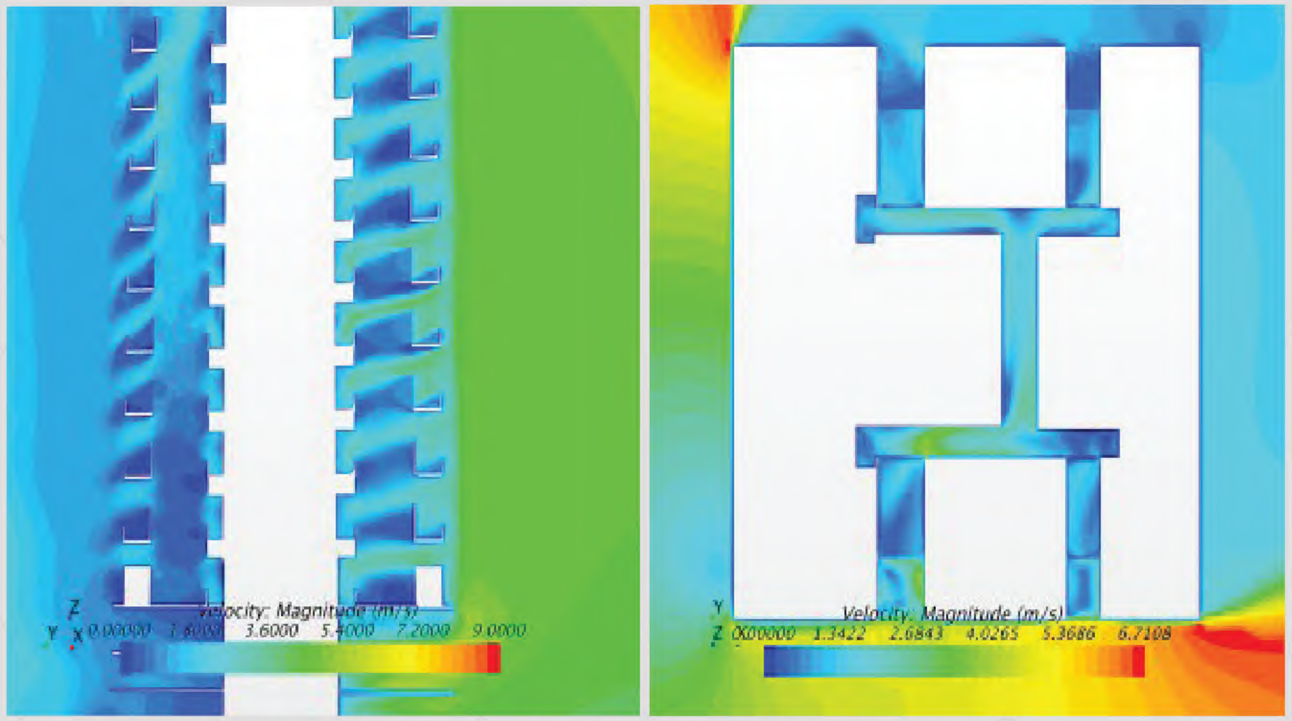
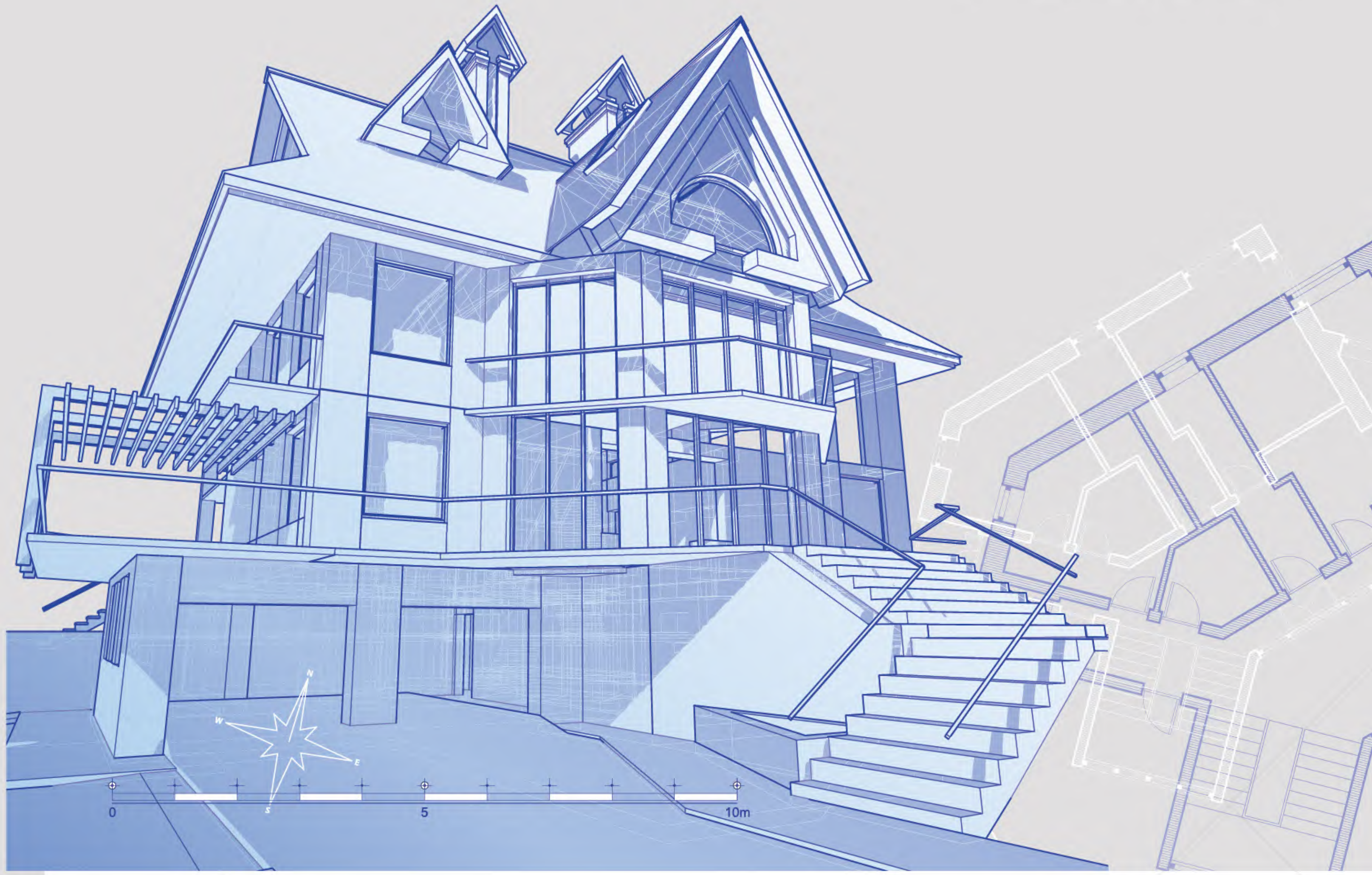


Figure 4.3. Building simulation through Computational Fluid Dynamics Software (GreenA Consultants, 2020)

In urban areas, the prevailing winds are unavoidably modified due to the increasing number of closely laced high-rise buildings that significantly alter natural ventilation behaviour. CFD simulation aids in the design of effective ventilation systems to optimise the efficiency of natural and mechanical ventilation by identifying inefficiency where cold or hot air is being wasted or mixed. The simulation takes advantage of both wind and buoyancy to drive fresh air through a building. CFD simulation predicts airflow and heat transfer to effectively create a comfortable, healthy, and energy-efficient space.



4.1.5 Passive House Design

Natural lighting and ventilation are not only energy-efficient and cost-saving features but also known to provide a healthy indoor environment and improve living comfort (Kalcheva, Taki, & Hadi, 2017). To ensure the residents receive optimal natural lighting and air circulation, the building design must implement a smart passive house design. First and foremost, identifying and acknowledging the climatic conditions and environment, and developing an understanding of the appropriate design response by referring to and implementing a design for these conditions is extremely important in maximising the utilisation of the design. Also, the house must be positioned relative to the path that the sun travels to achieve optimal sunlight and to take advantage of prevailing wind patterns for ventilation and air circulation (McGee et al., 2013).

4.2 Quality and Safety Assessment

4.2.1 Malaysian Carbon Reduction and Environmental Sustainability Tool

The process of developing quality built environments should consider the high level of carbon emissions that have a negative environmental impact.

To counter this, the Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST) is looking at making residential buildings in Malaysia sustainable and yet affordable.

MyCREST is a sustainability tool to be used as a building rating system. It aims at quantifying and reducing the built environment's impact in terms of carbon reduction and environmental impact. MyCREST uses key tools and criteria to assess a building for certification ranging across the multiple stages of design, construction, operation, and finally the maintenance stage.

Prior to the later stages, it is especially important to achieve an affordable design concept and approach, as this will drastically reduce costs when it comes to construction, operation, and maintenance during the life cycle of the building.

By using MyCREST's sustainability criteria as a benchmark, developers can consider these key factors when designing their buildings which include pre-design, infrastructure, energy performance impact, occupant and health, lowering embodied carbon, water efficiency, social and cultural sustainability, demolition and disposal factor, sustainable and carbon initiative. Based on these guidelines, the developer can collaborate with the architects and designers to implement passive and low-cost designs that fit the bill.

Figure 4.4. Bay 21 in Kota Kinabalu earned a 3-star rating in the Design Stage

Figure 4.5. Waterside Residence in Penang earned a 1-star rating in the Design Stage

4.2.2 Safety and Health Assessment System in Construction

A safety and health assessment tool known as SHASSIC is used during the construction works of affordable housing. SHASSIC or Safety and Health Assessment System in Construction is an independent method for assessing and evaluating the safety and health performance of a contractor in construction works/projects based on Construction Industry Standard (CIS 10). It was designed and developed to achieve any or a combination of the following objectives:

- **a** To benchmark the level of safety and health performance of the construction industry in Malaysia
- **b** To have a standard system on safety and health assessment for the construction industry
- **c** To assess the safety and health performance of contractor(s) based on this standard
- **d** To evaluate the performance of contractor(s) on safety and health practices at the site
- **e** To improve and take necessary corrective actions on OSH performance and management at the site

Contractors could identify the areas where they have failed or did not score high to improve and enhance the safety and health management at their construction sites. In addition, the tool can be used to establish a proper safety and health assessment system at construction sites, which would facilitate site inspection by the authorities as the OSH system is already in place.

4.2.3 Quality Assessment System in Construction

The quality of affordable housing can be assessed using the Quality Assessment System in Construction (QLASSIC). QLASSIC is a system or method used to measure and evaluate the workmanship quality of a building construction work based on Construction Industry Standard (CIS 7). It enables the quality of workmanship between construction projects to be objectively compared using a scoring system. The objectives of QLASSIC assessment are to achieve any or a combination of the following:

- **01** To benchmark the quality of workmanship of the construction industry.
- **02** To establish a standard quality assessment systemon the quality of workmanship of construction work
- **03** To assess the quality of workmanship of a construction project based on the relevant approved standard
- **04** To be used as a criterion for evaluating the performanceof contractors based on the quality of workmanship

The QLASSIC assessment is carried out through site inspection and uses the principle of one-time inspection after the completion of construction works before handing over to the developer/client. This principle encourages the contractor to "Do Things Right the First Time and Every Time" and indirectly leads to the construction of quality houses and buyer satisfaction with the quality.

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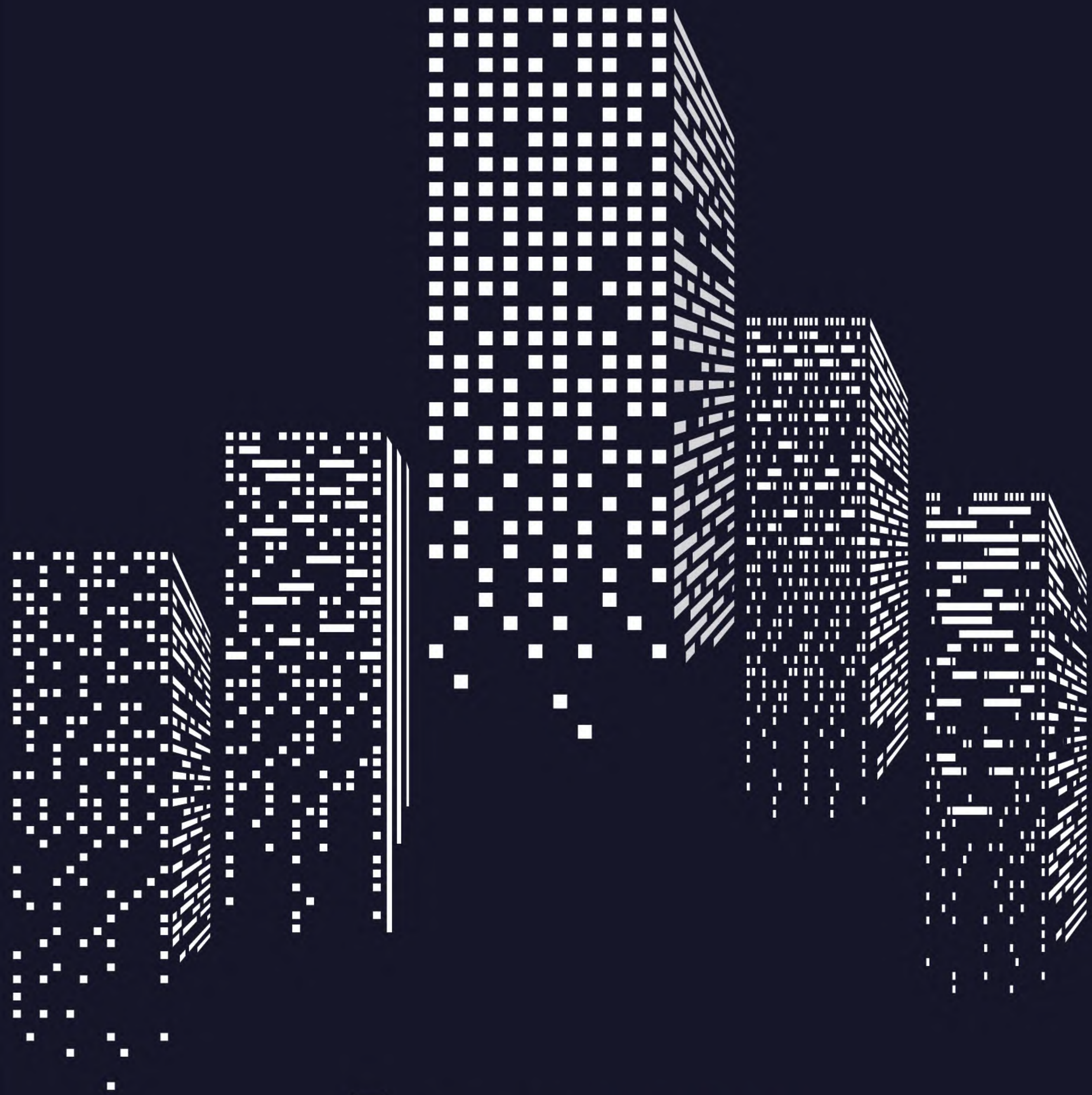

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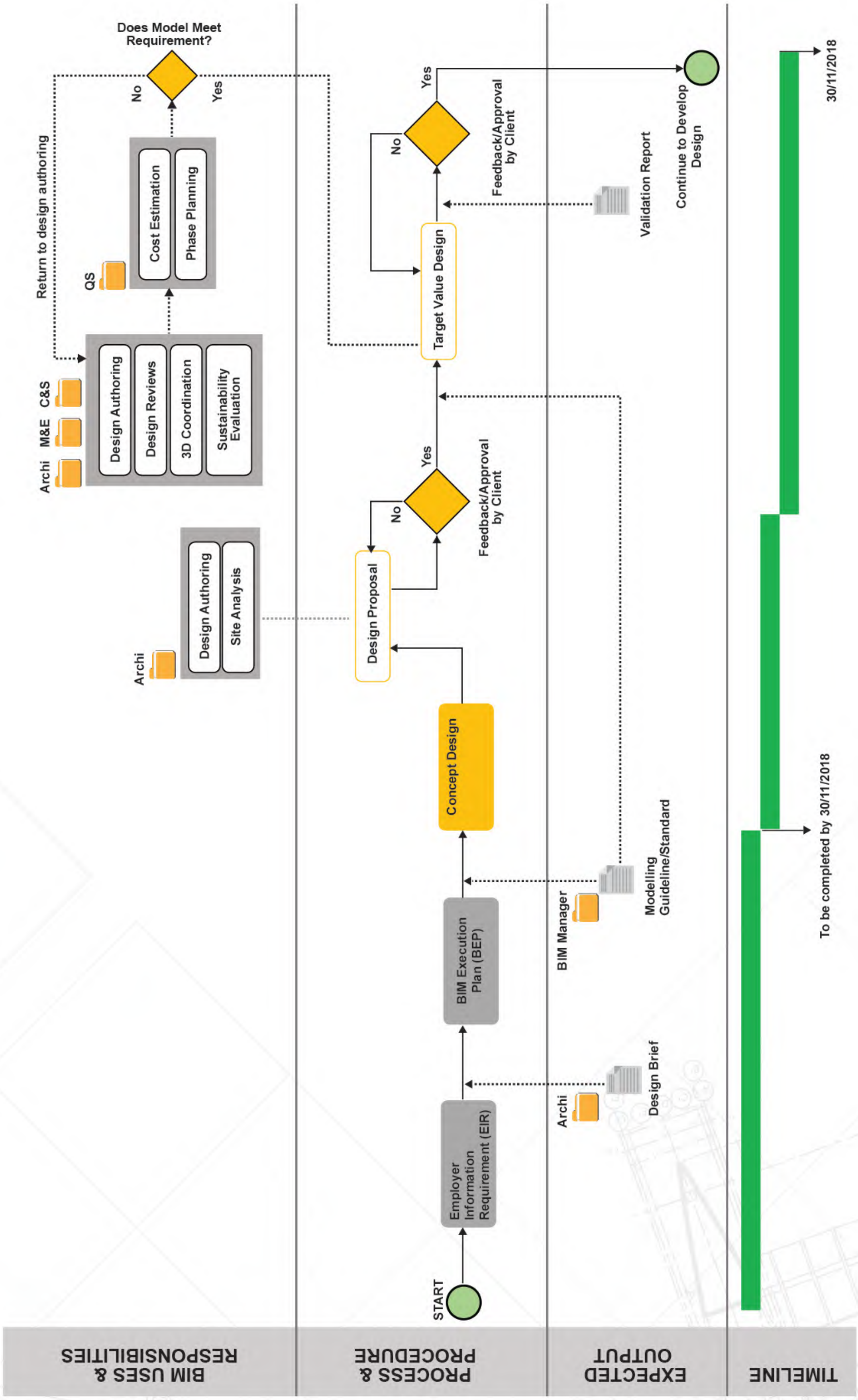

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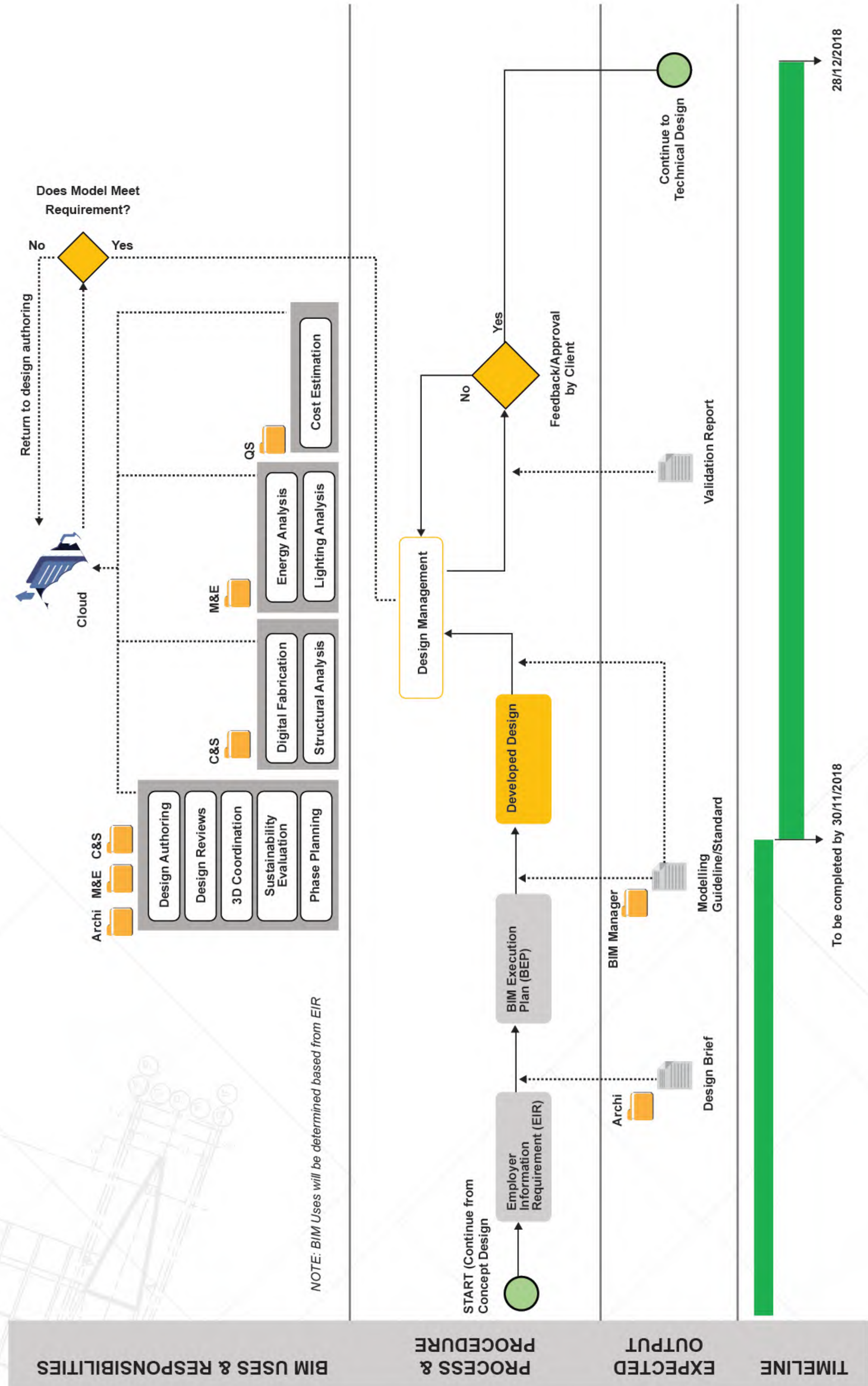

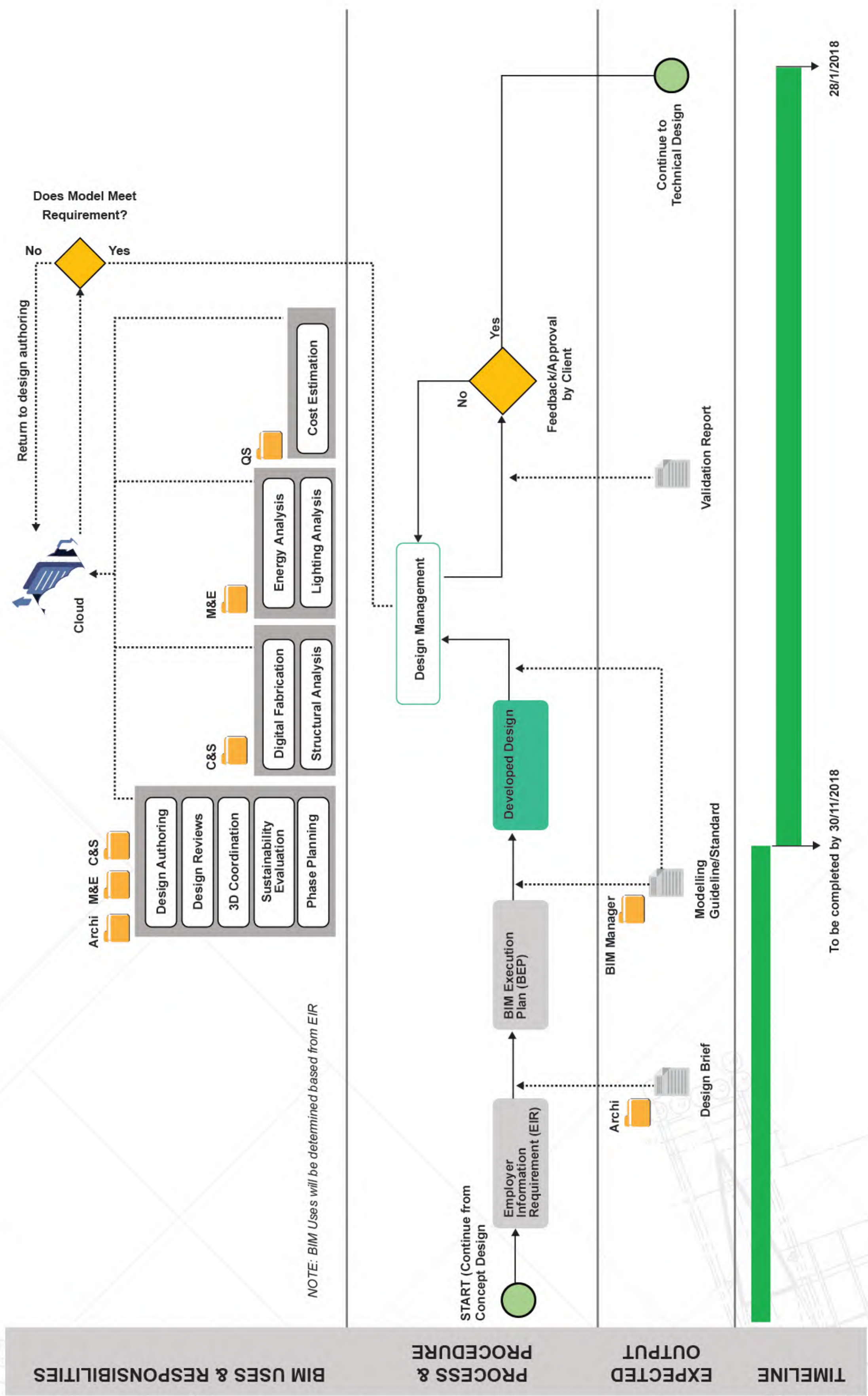

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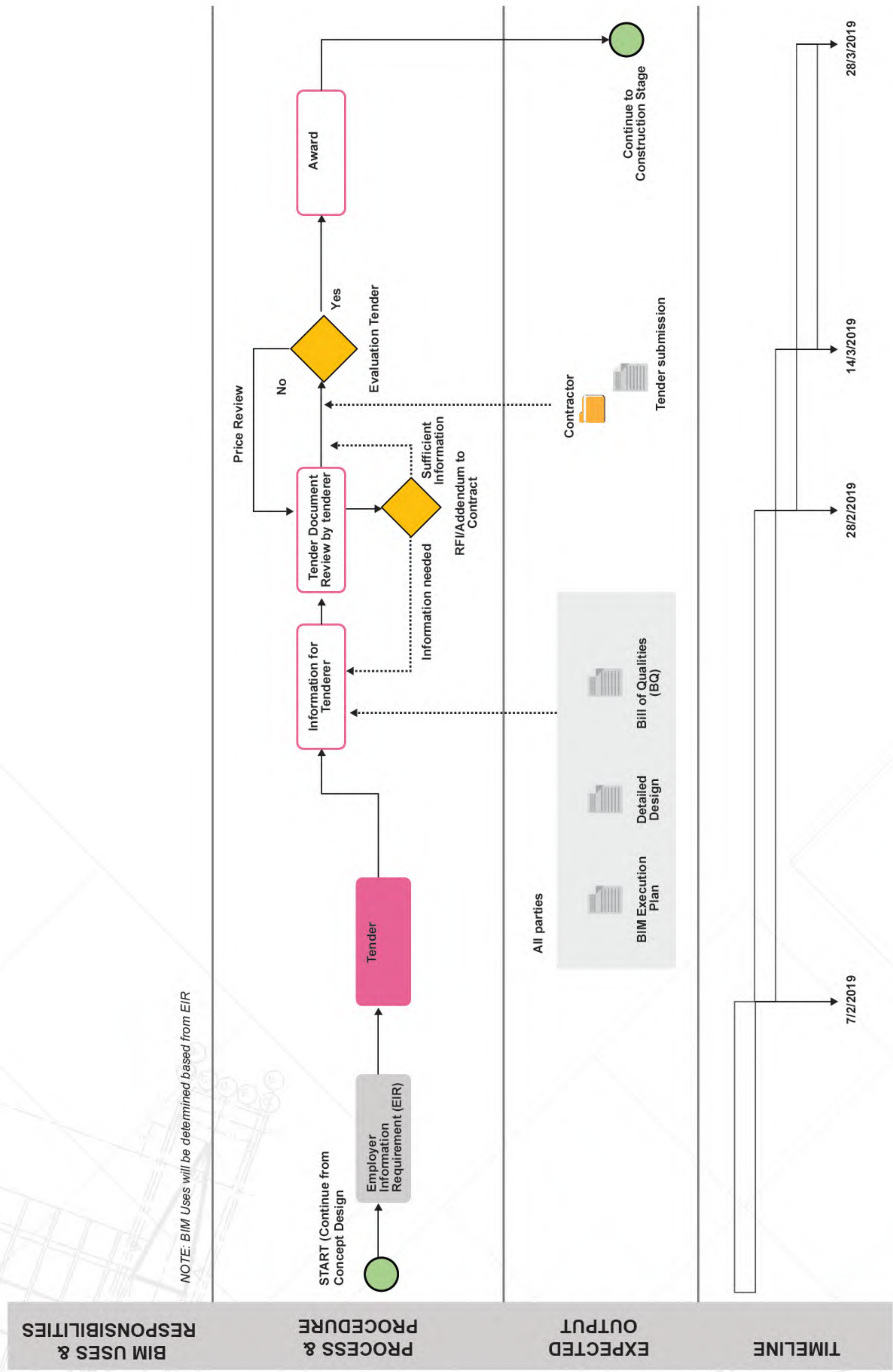

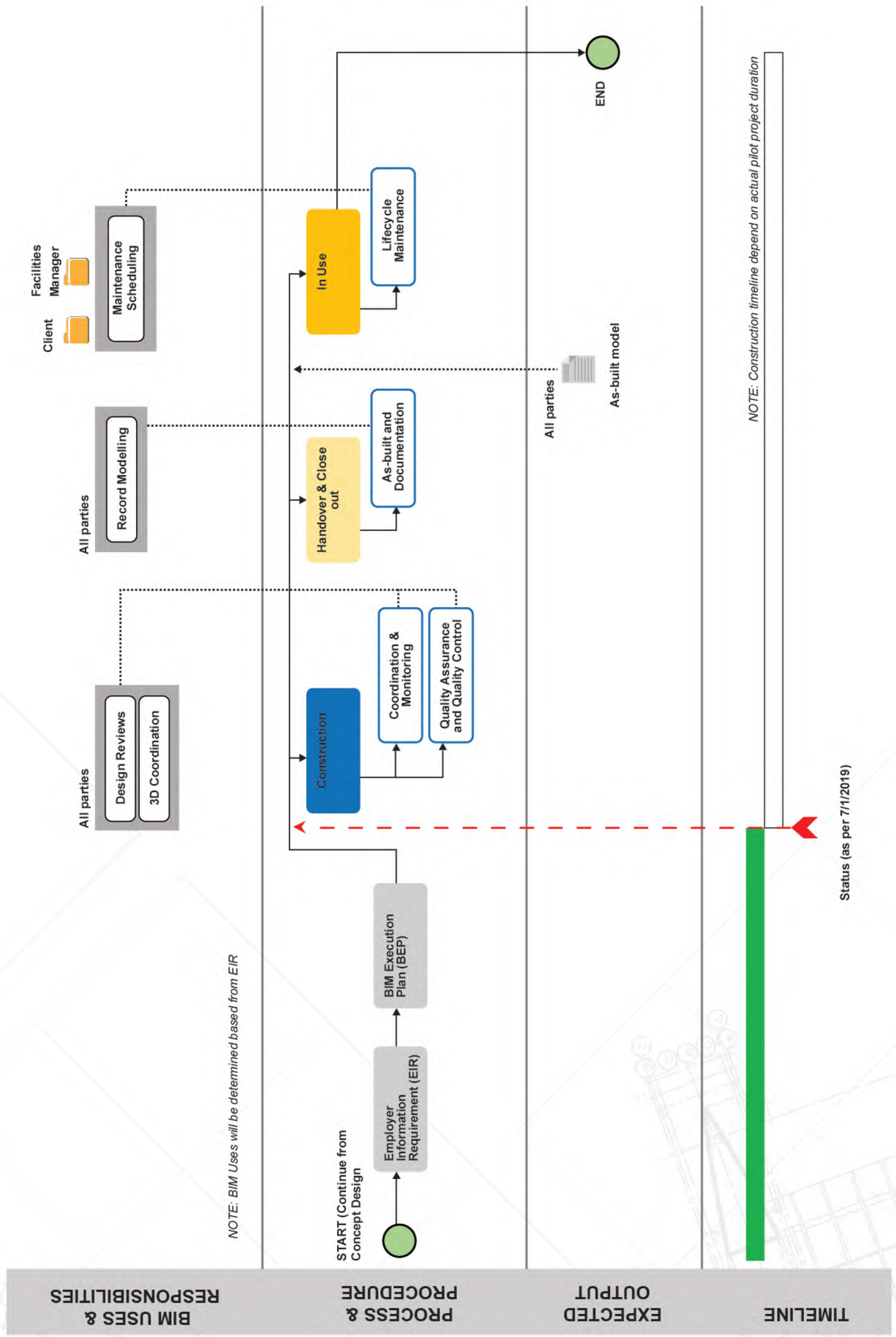

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