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GREEN PORTABLE FOLDING HOME (GPFH)

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ABSTRACT

The background of this research based on Rancangan Malaysia Kedua Belas, Green Technology Master Plan and Sustainable Development Goals 7 and 11. This research examines the residential issues of expensive housing, damage to existing houses due to floods,and housing problems resulting from migration to explores the potential of green development solutions such as solar energy and rainwater harvesting tanks, along with innovative housing options like Tesla Tiny House and Boxabl Casita. The aim is to develop existing expandable container houses and tesla tiny house to become green portable folding homes which can help people to have an affordable sustainable house which is practical for any situation. The research adopts a quantitative methodology, employing document review,design thinking and 3D modelling simulation. The key findings of the study reveal that GPFHpresents a viable solution for young families starting their lives, as well as for veterans who intend to utilize their pension funds for home construction. Moreover, individuals residing inflood-prone areas find GPFH practical as they can be easily lifted above floodwaters, preventing damage to the house. GPFH not only provides affordable housing but also promotes sustainable living through the incorporation of green technologies. It is recommended to produce a real product for usability study to test water usage and backup plan for rainwater harvesting. Other than that, implement water filter, measure solar energy and addelectricity backup and determine capacity of green portable folding home.

Keywords: *"Green house", "Sustainable", "Housing problem", "Solar Panel"*

INTRODUCTION

The view on housing economics has been discussed for a long time especially in the 1950s to 1960s where development at that time was discussed a lot by development economists who rejected any extensive investment due to the high ratio of capital output to other investments (Arku, 2006). However, every human being has a basic need for a place to dwell that serves as a barrier against the external dangers of environment such climate, weather and crime. Moreover, study from Muhammad Soffian et al. (2018) state that the National Housing Department signify that a home is a basic necessity since it provides shelter for everybody and the government was working to ensure that all Malaysians can either buy or rent a home. Nevertheless, nowadays it can be seen that there was a dumping of unsold houses in Malaysia and also in foreign countries because of their expensive value. This was because low productivity, income, and savings were considered to be the main contributors to unsold homes (Arku, 2006).

In addition, when the world was getting more developed and there are many houses that use electricity to move its equipment such as lights, fans and other appliances, it will cause global warming because the electricity that results from burning coal leads to the greenhouse effect. Therefore, according to Patnaikuni et al. (2013) nowadays, it was important to design sustainable homes because sustainable house design will have a significant positive impact in order for civilization can fight global warming, therefore people must make changes to the way they live which requires adopting environmentally sustainable lifestyles inside of their own homes. Thus, current housing must be consistent with the objectives of the Habitat Agenda and the guiding principles of Agenda 21. It was a plan for sustainable development in the 21st century adopted by 179 countries including Malaysia in Rio de Janeiro in June 1992 (Bakar et al., 2011). The aim of this research is to innovate existing expandable container houses and tesla tiny house to become green portable folding homes which can help people to have an affordable house which is practical for any situation. This innovation project is important because it can help people who have problem related to house and can reduce the use of electricity in the house resulting from the burning of coal.

BACKGROUND OF STUDY

The COVID-19 pandemic has had a negative impact on Malaysia's economy, resulting in job losses and financial difficulties for many individuals (Cheng, 2020). In response, the Rancangan Malaysia Kedua Belas 2021-2025 (RMKe-12) was established to restore socioeconomic development and promote long-term focuses on themes such as regenerating the economy, strengthening safety and inclusivity, and boosting sustainability, with policy catalysts that include accelerating technology adoption and innovation (Rancangan Malaysia Kedua Belas 2021-2025, 2021). Additionally, Malaysia has recognized the importance of addressing climate change and greenhouse gas emissions through the Green Technology Master Plan, aiming to achieve a low-carbon and resource-efficient economy (Green Technology Master

Plan Malaysia, 2017). The plan aligns with global efforts and targets, such as reducing gas emission intensity and promoting the application of green technology (Green Technology Master Plan Malaysia, 2017). Furthermore, Malaysia acknowledges the risks posed by climate change, including rising sea levels, and emphasizes the need for sustainable development practices (Cheema, 2019). These efforts align with the Sustainable Development Goals (SDGs), particularly SDG 7 on affordable and clean energy, and SDG 11 on sustainable cities and communities (SDG Goal and Target Booklets, 2015). The goals aim to ensure access to energy services, promote renewable energy, improve housing conditions, and enhance urban planning for climate resilience and disaster risk reduction (SDG Goal and Target Booklets, 2015).

LIMITATION

The scope of study was impacted by several limitations. The availability of research on expandable container houses and Tesla tiny house was limited, leading to less detailed content. Information regarding power and water sources for the container house was unclear, and the procedure for relocating the Tesla tiny house lacked clarity. Other than that, developing a flawless prototype was challenging due to budget constraints and the need to consider alternative materials such limited funding hindered the integration of solar panels to showcase solar energy application. Additionally, absence of the expandable container house in the Malaysian market restricted access to first-hand information, relying solely on virtual observations. Lastly, simulation and operation were confined to SketchUp, without market evaluation for affordability and accessibility.

LITERATURE REVIEW

Shipping Container House

A shipping container home is a house made from reusable intermodal containers used for transporting commodities. These containers come in two sizes, 20 ft x 8 ft and 40 ft x 8 ft, offering living areas of 160 square feet and 320 square feet, respectively (Master, 2021). Shipping containers are being considered for various architectural uses, including housing, due to their modularity and quick assembly capabilities (Dhongde & Anagal, 2020). They provide sustainability benefits such as easy material access, energy efficiency, and reduced waste formation during production (Akar, 2017). Other than that, container homes contribute to waste reduction in the construction industry and are cost-effective for those on a tight budget. Despite their thermal and acoustic limitations, containers can withstand weather resistance (Dhongde & Anagal, 2020; Ismail et al., 2019). Therefore, container homes have been successfully implemented in various climates worldwide, showcasing their modularity and adaptability (Ismail et al., 2019).

Residential Property Issues in Malaysia

According to the Ministry of Finance Malaysia and Valuation and Property Services Department (2022), Malaysia currently faces a significant number of unsold residential properties, with 34,092 units recorded in the first half of 2022 as shown inthe Table 1. The total value of these overhang residential properties amounts to RM21.73 billion. Despite the surplus, many Malaysians still lack residential property assets due to various issues. This is because high housing prices and damage caused by recurring floods, particularly in the east coast states, contribute to the challenges faced by individuals in affording or owning homes (Valuation and Property Services Department, 2022; Cambridge University, 2022).

Table 1: Overhang Residential Property in 2022 (Valuation and Property Services Department, 2022)

State	New Launches	Overhang		Unsold			
				Under Construction		Not Constructed	
	Units	Units	Value (RM Mil)	Units	Value (RM Mil)	Units	Value (RM Mil)
WP Kuala Lumpur	435	3,371	3,130.76	10,321	7,174.78	4,030	2,235.79
WP Putrajaya	28	245	299.04	229	189.14	0	0.00
WP Labuan	0	65	21.25	37	25.87	0	0.00
Selangor	1,256	5,156	4,707.13	8,750	5,822.97	1,718	1,037.78
Johor	2,509	6,040	4,730.61	6,985	3,946.72	469	143.79
Pulau Pinang	281	5,508	3,637.11	4,551	2,732.82	2,075	1,163.49
Perak	1,317	2,611	837.44	8,372	2,045.46	2,344	401.37
Negeri Sembilan	379	1,031	554.22	3,704	1,453.08	749	205.09
Melaka	940	651	254.46	2,901	750.15	961	320.72
Kedah	68	1,971	607.87	2,170	681.46	6	2.31
Pahang	953	1,364	534.80	2,043	682.86	1,492	389.30
Terengganu	305	638	220.79	585	192.40	0	0.00
Kelantan	161	456	187.97	2,769	761.67	1,042	312.04
Perlis	136	47	9.22	252	63.94	0	0.00
Sabah	1,335	2,932	1,120.88	4,710	2,720.21	1,731	530.66
Sarawak	449	2,006	879.74	4,025	1,666.92	486	296.61
MALAYSIA	**10,552**	**34,092**	**21,733.28**	**62,404**	**30,910.44**	**17,103**	**7,038.94**

Expensive House

According to the Valuation and Property Services Department (2022) as shown in the Figure 1, the high-end category, with prices exceeding RM500,000, accounted for the majority of overhang units in the residential market, capturing a market share of 43.4%. This category comprised 14,794 units, while the remaining units were evenly distributed across other price ranges. The report also highlights the significant gap between inexpensive units (priced at RM300,000 and below) and mid-range units (priced between RM300,001 and RM500,000), representing 28.3% of the market share. These findings indicate that house prices in Malaysia are relatively high compared to the average income, posing affordability challenges for many individuals, particularly the younger population (Valuation and Property Services Department, 2022).

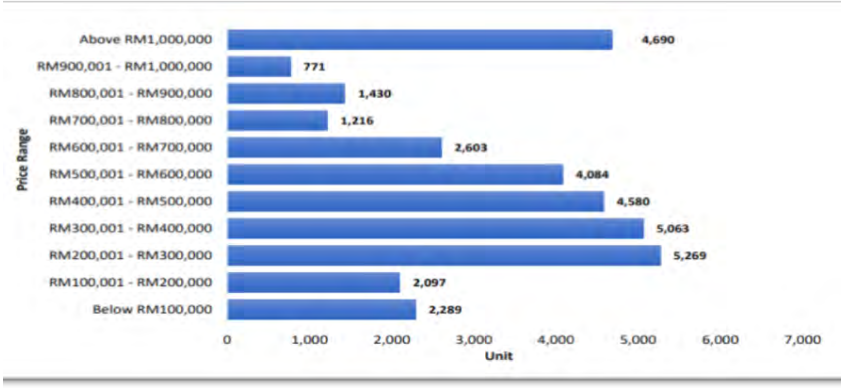

Figure 1: **Residential Overhang by Price Range H1 2022 (Source: Valuation and Property Services Department (2022)**

Damage of Existing House Due to Flood

Residential properties in Malaysia face the issue of flood damage, which leads to significant losses for homeowners. Approximately 22% of the population, or over 4.82 million people, reside in flood-prone areas, resulting in extensive damage to residential properties (Department of Irrigation and Drainage, as cited in Razali et al., 2020). Flash floods occur frequently during the monsoon season, causing disruptions and property damage in major cities (Razali et al., 2020). In 2022 alone, catastrophic floods caused damages amounting to RM5.3 billion to RM6.5 billion, with residential property accounting for RM1.2 billion to RM1.4 billion of the totals (Ikram, 2022). Other than that, rising sea levels contribute to the increased occurrence of floods, with Malaysia being particularly vulnerable due to its extensive coastal areas (Ehsan et al., 2019). In addition, predictions indicate that significant portions of land and coastal infrastructure, including cities and highways, may be submerged within the next 30 years (Cheema, 2019; Ehsan et al., 2019).

Issue Related Housing Worldwide

The housing crisis or problem related to housing has become a bigger problem year by year, especially in urban areas regardless of any country in the world. Cities with a higher population especially suffer from this problem such as the UK, US, China and India.

Migration of People Leading to Housing Problem

Australia, with an area of 7,741,220 km² and a population of 25.7 million, has experienced population growth primarily driven by migration as state by The World Bank Group (2022); Erol & Unal (2021) and leading to a surge in housing demand and subsequent price increases in regions such as Queensland (Erol & Unal, 2021). Is because, the largest arable land and migration patterns of country after World War

II resulted in a large population and subsequent housing challenges. For example, housing market of China faces high and persistent costs due to rapid urbanization and the increased demand for limited land (Cai, 2011). This is because, over the past decade, approximately 200 million people have moved from rural to urban areas in China (Cai, 2011)

Shortage of Labour Lead to Problem in Construction of Housing

According to recent research by the Home Improvement Research Institute (HIRI), alack of trained workers has caused delays in housing projects, with 27% of experts acknowledging this issue (Stiver, 2019). The shortage of manpower is significant, ashalf of the survey participants reported turning down up to 5% of projects due to the lack of skilled workers (Stiver, 2019). For example, delays and cost overruns were observed in the construction of football stadiums during the 2010 FIFA World Cup inSouth Africa, attributed partly to the labour shortage issue (et al., 2016). Additionally,a shortage of skilled labour can lead to defects in new buildings, as specific equipment or building structures may not be installed properly without skilled workers (Berding, 2022). Thus, hiring foreign workers who may not have undergone union training programs further exacerbates the situation (Berding, 2022).

Affordable Housing

Affordability of housing in Malaysia is a persistent challenge due to rising house prices. The World Bank Group and Khazanah Research Institute highlight the decreasing housing affordability in Malaysia, with some states experiencing severe unaffordability (Hassan et al., 2021). The house price to income ratio (PIR) is commonly used to measure housing affordability, with Malaysia categorizing income brackets as T20, M40, and B40 as shown in Table 2 (Hassan et al., 2021). The B40 group, comprising the bottom 40% of income earners, may struggle to afford housing, particularly in urban areas where living expenses are high (Hassan et al., 2021). Increasing costs for basic necessities further strain household budgets, leading some individuals to choose renting or sharing family homes to mitigate expenses (Hassan et al., 2021).

Table 2: **Household income in Malaysia (*Source: Department of Statistic Malaysia (DOSM), 2022***

Household group	Median income 2019 (RM)	Median income 2016 (RM)	Compound annual growth rate (AGR) (%)	Median income 2016 (RM)	Median income 2014 (RM)	Compound annual growth rate (AGR) (%)
T20	15,301	13,148	4.5	13, 148	11,610	6.2
M40	7,093	6,275	4.1	6, 275	5,465	6.9
B40	3,166	3,000	1.8	3, 000	2,629	6.6

Green Development

The environmental development view, as part of the sustainable development outlook, emphasizes the interconnectedness of economic, social, and natural systems (Hu & Zhou, 2014). In line with this, Malaysia has introduced The Green Technology Master Plan (GTMP) to promote green growth as one of the key drivers of the development of country (Green-Technology-Master-Plan-Malaysia-2017-2030.Pdf). The GTMP, which aligns with The National Green Technology Policy (NGTP), focuses on energy, environment, economic, and social aspects, providing a framework for integrating green technology into planned developments in Malaysia. The GTMP targets the energy sector by diversifying resources, investing in new infrastructure, and adopting cutting-edge technologies (Green-Technology-Master- Plan-Malaysia-2017-2030.Pdf).

Solar- energy

Solar power is a highly sustainable and abundant source of energy, with the amount of solar energy incident on Earth in one hour being equivalent to the total annual energy consumption of humanity (Sohail, 2019). While solar grids currently supply only a small fraction electrical energy of the world, they have the potential to reduce CO2 emissions by 40 million tons annually (Sohail, 2019). Utilizing solar energy in Malaysia is particularly important as the electricity production of country was from coal contributes to global warming and greenhouse gas emissions (Kiray, 2021; Ali et al., 2022). The Green Technology Master Plan highlights the significance of renewable energy, such as solar power, in reducing the carbon footprint and offering cost savings of up to 20% (Green-Technology-Master-Plan-Malaysia-2017-2030.Pdf;Shaikh et al., 2017). Solar energy can be harnessed through photovoltaic panels, allowing for direct conversion of sunlight into usable energy (Shaikh et al., 2017). While initial installation costs may be high, solar energy offers long-term benefits andcan be generated freely (Shaikh et al., 2017).

Rain Water Harvesting

Access to clean water is essential for human life and socioeconomic activities (Green-Technology-Master-Plan-Malaysia-2017-2030.Pdf). However, many people worldwide still lack access to adequate potable water (Oka et al., 2019). Climate change is predicted to increase the risk of droughts, particularly in vulnerable areas with high population growth and food security issues (OCHA, 2022). Rainwater harvesting is an effective solution to address water scarcity during droughts (Green-Technology-Master-Plan-Malaysia-2017-2030.Pdf). Malaysia, with its significant annual precipitation, has the potential to collect and optimize rainwater resources for and enhance water security (Green-Technology-Master-Plan-Malaysia-2017-2030.Pdf).

RESEARCH METHODOLOGIES

This research innovation project used quantitative study method aimed to develop existing expandable container houses and Tesla tiny houses into green portable folding homes, offering practical housing solutions for various situations. Firstly, a document review was conducted, examining brochures from Well camp Steel Structure & Modular Housing Co., Ltd, and Boxabl Pitch Deck to gather information from past studies and existing products. The features on existing product has been listed to decide what type of feature should be added into the innovation project that do not have on previous product. Other than that, simulation methods using Sketchup version 2022 were employed to create 3D modelling of GPFH, allowing for visualization and presentation of the assembly and performance. Lastly, design thinking was incorporated to foster creative problem-solving which consist of empathise, define, ideate, prototype and test.

RESULT

Introducing the revolutionary container house, an innovative solution that transforms the idea of mobile housing. This Green Portable Folding Home (GPFH) blends sustainability, adaptability and functionality to produce a truly amazing living place. Itprovides an unmatched level of ease and environmental friendliness and it is built toadapt to different demands and settings.

The uniqueness capacity of GPFH is to expand and contract as shown in Figure 2, makes it the perfect option for anybody looking for flexibility in their living arrangements. The house turns from a small house to a large house with ease because of folding mechanism, allowing residents to customize the size to suit their needs. This house easily adapts to a variety of demands whether it is a private retreat or a larger living space. Besides, the GPFH has a rainwater harvesting tank as part of its dedication to sustainability as shown in Figure 3. This ground-breaking device collects and preserves rainwater to offer a dependable and environmentally responsible water source. This is a great option for those who care about the environment because it promotes water conservation while also reducing dependency on conventional water sources. Its sustainability attributes are further improved by the addition of a solar panel system. These solar panels harness the power of the sun to produce clean and renewable electricity, ensuring an independent and energy-efficient living environment

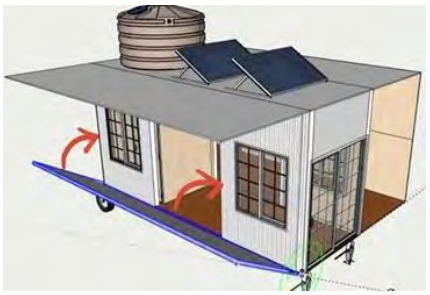

Figure 2: Expand and contract

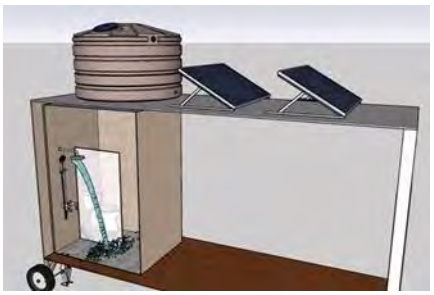

Figure 3: Rainwater harvesting tank

Additionally, the GPFH has a lifting jack mechanism as shown in Figure 4 since the challenges presented by erratic weather are recognized. This feature makes it simple to level the house during floods or on uneven terrain. This element guarantees the safety and comfort of occupants even under difficult circumstances by offering stability and adaptability in unfavourable conditions. Moreover, this GPFH alsoskilfully addresses mobility and transportation. The container house may be easily towed because an anchor is included, allowing for quick movement to other locations.This adaptability gives up a variety of opportunities, including the possibility of relocating or investigating temporary housing options for travel, employment or emergency scenarios. It can be concluded that in the area of portable housing, the GPFH marks a considerable advancement. Its capacity for expansion and contraction, along with rainwater collection, solar energy generation, a lifting jack mechanism, and a towing anchor, demonstrate its adaptability, sustainability, and versatility. This container house offers the ideal fusion of practicality, utility, and environmental awareness whether people are looking for a mobile living option or aneco-friendly home.

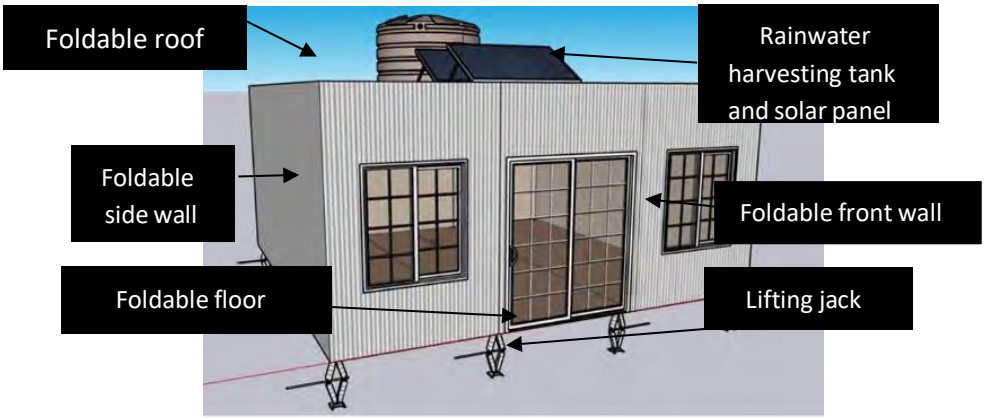

Figure 4: Green Portable Folding Home

CONCLUSION AND RECOMMENDATION

In conclusion, the innovation project research which leads to the idea to develop green portable folding home is very useful since the rising customer interest in versatile, environmentally friendly, sustainable and affordable house. Those, the firstobjective for this innovation research project has been achieved which is to create green portable folding home design ideas. The design ideas were achieved from literature review and problem statement to determine what features should beincluded to cater the problem and how the house should be designed. Next, second objective has also been achieved when the assembly of sustainable container housecan be demonstrated during simulation to prove that the materials, components andinstallation methods was good enough to solve the problem. Other than that, third objective also has been achieved since the performance of solar energy and rainwater harvesting tank can be demonstrated as was describe in operational procedure and the detail in features of product and advantages. Therefore, the feature is very useful and good because it can be concluded with the solar panel andrainwater harvesting tank, this house can be categorized as a sustainable house. Lastly, objective four has also been achieved since a few recommendations has beenlisted for marketability potential such as identify target market, engage in content marketing, collaborates with influencers, participate in showcase and collaborate withfinancial institutions.

However, a few recommendations to continue or improve this project in the future such as to produced real product to study more on its usability instead of simulation in Sketchup only. Other than that, to test the product feature such as measure how long the amount of collected water in the rainwater harvesting tank can be used andwhat if the water runs out, what is the backup plan. Moreover, recommendation on how to put water filter for the rainwater harvesting tank to ensure the water is clean. Next recommendation to measure the amount of solar energy obtained and how longit can be used since this country receives rain and heat throughout the year. Therefore, the next researcher can add an additional feature as backup to generate electricity. Last but not least, with the existence of real product, the capacity of peoplethat can be accommodated in the green portable folding home can be measured

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