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SUSTAINABLE FLOATING ARCHITECTURE PROTOTYPE AS ENERGY EFFICIENCY METHODS IMPLEMENTATION IN INDONESIA

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Abstract

Indonesia has a coastline of 54,716 km whereas, the second-longest coastline in the world after Canada. However, coastal architectural planning is limited to high-traffic areas, such as recreation areas or harbors. Meanwhile, local coastal settlement areas developed without proper planning. It goes with the local people's lack of understanding for decent settlement also, the bad habits that have been carried out from generation to generation, like throwing garbage into the sea where contribute to the marine pollution index increment. Therefore, it is necessary to develop sustainable coastal settlement architectural planning.

Therefore, we tried to make a floating house architectural plan for the coastal area with a prototype idea that applies the energy efficiency concept. Where combines a qualitative explorative approach to the coastal buildings concept and quantitative energy studies with computer simulations. Emphasized within this study is the utilization of marine waste also renewable energy technologies such as waves, solar heat, wind, and other natural resources applications in buildings. Whereas capable of contributing to reducing the marine pollution index and adequate to create energy sources independently. Which later on feasibly implemented as an architectural planning reference for coastal areas in the world.

Keywords: Coastal Architecture, Floating House, Sustainable Architecture, Energy Efficiency Architecture, Indonesia

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1. Introduction

1.1. Background

Coastal areas are the island nation's main assets. Yet, there is no on-point construction of sustainable architectural planning, resulting in uneven development and slum occurring in most coastal areas. Escalation concerning sustainable buildings that are environmentally friendly need to be implemented, considering Indonesia's location around the equator with a humid tropical climate and rich in natural resources that possibly put to good use.For example, reducing and utilizing sea waste; applying renewable energy technologies derived from solar heat, wind, waves, and other resources in buildings can create energy sources independently.

The concept of energy-efficient buildings is considered vital for sustainable planning. When studying energy use globally, the building sector absorbs a tremendous amount of energy use which is 45% of the total global energy demand, approximately 50% of energy use in buildings spent on room thermal comfort establishment. The energy-saving concept means to produce an energy-efficient index for the coastal building based on the use of renewable technology derived from computer software simulations such as 3D Modeling and the EDGE by the International Finance Corporation (IFC), building analysis program which will later play a role in implementing sustainable architecture and reducing marine pollution, especially in Indonesia.

1.2. Research Question

Based on the explanation above, the research question is observable as follows:

1. How is the application of energy-efficient floating buildings in the coastal areas of Indonesia?
2. What is the energy-efficient index of floating buildings in Indonesia's coastal areas?

1.3. Research Methods

The design research used a qualitative exploratory method.Exploratively, since we propose various possible forms and materials that possibly suitable for the location that will be studied and analyzed up to the convenient and efficient material. Qualitatively, considering the research object is focus on a design model with energy consumption simulation.

The research started by precedent studies, exploratory studies of three dimensionalshapes, and software simulation studies regarding energy consumption with Edge software.

a. The first stage is a precedent and comparative study
   Precedent study of several architectural works that have been constructed based on the Apung house concept. Research results from the precedent study have different problem solutions according to the problems at hand. The design concept method is the feasible problem-solution that suitable for this challenge. To get a floating house design recommendation, the parameters used are; first, the material used: includes floor, wall, and roof materials. The second parameter is Kinds of technology application and structural systems and mechanisms.
b. The second stage is an exploratory study of 3D shapes.
   The simulation uses Sketchup by considering the recommendation results from the precedent study to implement the floating house design recommendations.
c. The third stage is testing the design through a simulation of energy consumption software with EDGE software.

d. The software simulation can predict energy consumption amounts in a building based on the material, direction toward, and site location.

The scope of this research is how to recommend a floating house design that is energy efficient. The target is a floating house design that answers energy sustainability in coastal areas.

The expected test variables in this study are floating house models with fixed variables of location and climate (wind speed and sunlight intensity). Meanwhile, building materials are non-fixed variables. The limitations in this study have not considered the site sea depth and only apply the logic of the floating structure with simple structural calculations.

1.4. Purpose and Objective

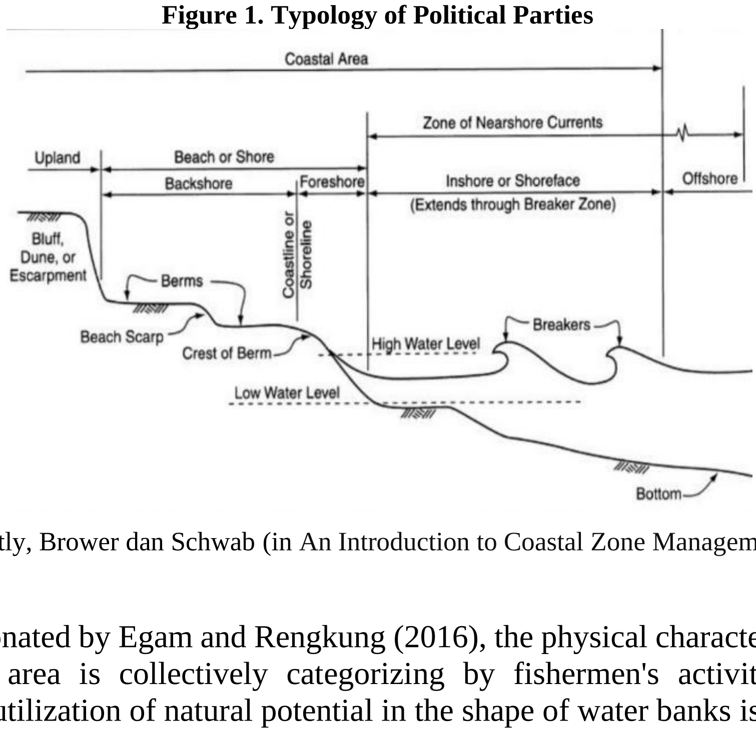
This policy research is conducted qualitatively by collecting data through a literature review from previous research and government documents. According to Pantjar Simatupang, policy research is a process of synthesizing information, both research results and performance reports, to produce a recommendation for a public policy (Simatupang 2003, 4). Policy research was initiated because of an underlying problem. According to Majchrzak in Supriyadi (2018, 152), these problems are processed through research to find recommendations for policymakers. Conducted descriptively from government policies issued with the motivation to provide an overview and guidance for actors with interest in the policy.Policy research is conducted with a general and open scope so that the results can be re- evaluated, replicated, and implemented.

2. Literature Review

2.1. Coastal Architecture

According to Dahuri; et al. (2013), the coastal area is a transitional area between land and sea. When viewed from the coastline, a coastal area has two boundaries perpendicular to the coastline (cross-shore). So far, there has been no agreement on these because each coast has its own (unique) environmental characteristics, resources, and government system.

Figure 1. Typology of Political Parties



(Source: Beatly, Brower dan Schwab (in An Introduction to Coastal Zone Management 2002, 14)

As opinionated by Egam and Rengkung (2016), the physical character of settlements as a coastal village area is collectively categorizing by fishermen's activity. Therefore, the conclusion of the utilization of natural potential in the shape of water banks is the main focus of coastal architectural features. According to Alamsyah in Putri (2013), the types of housing buildings according to the culture of the island settler community in Indonesia are dividing into six categories, namely:

1. Non-stage house located on the mainland
2. Stilt houses in freshwater
3. Floating house in freshwater
4. Houses on stilts located in the tide area
5. Houses on stilts above sea level
6. Floating house above the sea

2.2. Floating House

Floating architecture is a water-centric approach to design in which flood-risk management, development pressure, and adaptation to climate change simultaneously allowing buildings to live and work together with water. Floating buildings design criteria development (not intended for navigational use) should also include a series of guidelines and frameworks such as global and environmental issues related to water and understanding emotional and psychological aspects of living in floating buildings. Along with concepts of sustainable design in architecture that are summarized as follows: promoting renewable energy generation, accessibility, reuse, recycling, and self-supporting.

To create a sustainable floating building, it needs to consider key design points. However, there is not any leading design standard. For example, Queensland Development Code 2006 is the only reference that provides recommendations and design criteria for permanently moored floating buildings.

According to the mentioned guideline, the main principles and concepts of the environmental design process in floating buildings are as follows:

1) Access: Must have adequate means of access to and from the shore appropriate to the likely number of people accommodated in the floating building.
2) Flotation system: Must have a floatation system that maintains an acceptable stability level, likely for the building not to be affected by the minor impact, and able to withstand the most adverse combination of loads possibility.
3) Mooring piles: Must be designed to adequately and safely resist all lateral loads resulting from the most adverse combination of loads that are likely to act on the flotation system and superstructure of the floating building and any attached vessel.
4) Materials (generally): All materials and any structure used in a floating building must be suitable for the site conditions.
5) Materials (fastenings): All fastenings and any structure used in a floating building must be suitable for the site conditions, taking into account their maintaining and replacement ability when necessary.
6) Location: The location must maintain an acceptable level of amenity between any other building and any proposed building.
7) Safety equipment: Floating buildings must have appropriate life safety devices suitable for marine use.
8) Firefighting equipment: Must have easy access to firefighting equipment to safeguard against fire spread.
9) Minimum water depth: Water depth under a floating building must at all times be sufficient to prevent grounding of the building.

The development of floating building concepts for solving environmental issues should include a series of considerations such as waste management systems, the durability of materials, and accessibility. Therefore, environmental performance assessments of floating buildings can play a leading role in forming and planning floating offshore bases. The design process methods consider many factors in the floating architecture that summarized in the following steps, long-term lifecycle, long-term GHG emissions, resource usage strategies, minimal environmental impacts, also recycled and recyclable.

The concept of a floating structure means a substitute for land in the construction of a building. In addition to being alternative prearrangement for areas besides reclamation, because the structure can float on water. (Personal, 2011).

There are two types of floating structures, namely semisubmersible and pontoon types: (Cahya, Mahardika, Dan Wp, 2017).

Semisubmersible type, a floating structure above sea level using column tubes or ballast structural elements to minimize the effect of waves and keep them floating. This structure type appliance to offshore platforms, such as semisubmersible and tension leg platforms.

Often found in ports. *Pontoon* is a floating structure type placed in calm water areas that have, such as bays. In terms of construction, the application of floating structures is much more efficient because it does not require the manufacture and construction of conventional foundation designs such as piles and the like. With a mooring system, this floating construction can be bind to the seabed.

2.3. Sustainable Architecture for Energy Efficiency

Sustainable design is one of the fundamental factors in the building and planning process. Sustainable construction has emerged as a guidance paradigm for a new kind of built environment creation: one that meets the needs of humans in the present without limiting the ability of future generations to meet their own needs.

For building a sustainable future vision, it has to meet several demands. According to the Green Building Council Indonesia (GBCI), the sustainable architecture target for energy savings has several components, particularly:

Appropriate Site Development, includes access to public facilities, site management according to climate, attention to surrounding buildings or facilities.

Energy Efficiency and Conservation. This category incorporates the energy use efficiency optimization in a building, renewable energy utilization, and energy emissions reduction.

Water Conservation, combines the efficiency of clean water use, use of recycled water, filtration systems employment for drinking water production, reducing water use from deep wells, and use of auto-stop faucets.

Material Resources and Cycle, introduce environmentally friendly materials, B3 and waste management, also distribution of used goods.

Indoor Health and Comfort, this category includes environmental regulation of indoor air quality, carbons monitoring, calculation, and surveying overall building comfort.

Building Environment Management, incorporates innovation on building quality improvement, building documents availability, and team training for the green building aspects operation and maintenance.

2.4. Case Study

NO	BUILDING INFORMATION	DESCRIPTION
1.	Floating Home by i29 (2020) Location : Amsterdam, Netherlands Climate : Sub-Tropical	Have strong links with industrial areas, Floating House (2020) located in the Amsterdam river which encounters strong links with industrial. Consists of 3 floors with a combination of floating concrete and

	Figure 2. Building view from the river  (Source: archdaily.com) **Figure 3. Courtyard view**  (Source: archdaily.com) **Figure 4. Kitchen interior view**  (Source: archdaily.com)	hollow metal as the main structure. The facade material is using burned wood planks that make them more durable against the weather. In this floating house, the first floor is below the water level with the details as living room, bathroom and two bedrooms. Second floor used as communal room, bathroom and master bedroom. As for third floor occupied by outdoor space, pantry and dining room. *Material* **Laminates Wood (EGGER)** Benefit: Strong, long durability, easy maintenance, and anti-bacterial easy cleaned surface. **Fiber Cements Facade Panel (ULMA Architectural Solution)** Benefit: Non-porous, lightweight panels, resistant to weather, industrial or tangy, chemicals and shocks, and easy maintenance.
2.	A Productive Floating Habitat by Juan Carlos Bamba & Natura Futura Arquitectura (2020) Location : Babahayo, Ecuador Climate : Tropical	This simple floating house is a one-bedroom and lounge capacity only. Using artisanal techniques to the floating house's construction, the integral use of laurel wood, the main product of the local coastal community regarding utilization of plastic drums as floating platforms. The slope and roof height consider the space productivity with nine sqm areas and mean as a storage area. The slanted wooden panels on the walls are covering in waterproof. Besides the wood bridge as the focal access, the building also utilizes artificial lighting with photovoltaic

	Figure 5. Building river view  (Source: archdaily.com) **Figure 6. Building aerial view**  (Source: archdaily.com)	cells and food production for independent sources by the river. *Material* **Timber-GLT Hybrid Wood (HESS TIMBER)**. Benefit: Strong, dynamic, and aesthetic. **Accoya Canals Wood (Accoya)**Benefit: Tropical hardwood, strong, long-durability, water resistant, and aesthetic. **Accoya Cladding, Siding & Facade Wood (Accoya)**. Benefit: Thermal durability (esp. UV), upholstery coating is strong, doesn't contain chemicals or toxic, and durable. **Rainscreen Cladding Double Skin Facade.** Benefit: Good insulator, strong, durable and made of steel.
3.	Hi-Sea Floating Hotel by Balance Design (2020) Location : Zhangzhou, China Climate : Sub-Tropical **Figure 7. Hotel aerial view**  (Source: archdaily.com) **Figure 8. Bedroom interior view**  (Source: archdaily.com)	This floating hotel emphasizes the natural resources use for natural enrichment and ventilation. Considering the sea waves and the concept of the relationship between humans, nature, and architecture are well intertwined. This five hundred sqm floating hotel consists of one floor with room details: living Room, family room, double bedroom, two master bedrooms, and outdoor space. The structure uses floating concrete and steel and solid wood and aluminum materials with an anti-corrosion coating. *Material* **Timber Click-on Battens Wood (Scluptform).** Benefit : Fast installation, applicable in outdoor/indoor and good acoustic value. **Curtainwall Double Skin Facade.** Benefit : Good insulator with alumunium prefab material.
4.	Ecoloft Apartment Jababeka Golf Location : Cikarang, West Java Climate : Tropical Source : ecoloft.co.id/ ; edgebuildings.com/project-studies/ecoloft-jababeka-cikarang/	Modern eco-efficient and green building aparment concept. A ninety-six sqm cluster town house type building with three levels floor. Ground floor occupied by parking area, utility room, and locker. Balcony,

	Figure 9. Building aerial view  (Source: ecoloft.co.id) **Figure 10. Building green concept**  (Source: ecoloft.co.id) **Figure 11. Building view from courtyard**  (Source: ecoloft.co.id)	living room, bathroom, pantry and dining room situated on first floor. Second and third floor consecutively dominated by balcony, master bedroom, roof deck and jacuzzi. This apartment implements the green building component described by GBCI using adequate insulating materials to use renewable energy. With majority material concrete combined with bamboo as local material, solar power production, safe and clean water, and high comfort through efficient cooling. From edgebuildings.com sources, this building has 82% energy saving, 31% water saving, and 47% less embodied energy materials. *Material* Thermal Roof Insulation, Brise Soleil Screen, Autom Sunshades, DoubleGlazed Glass, Low-E Glass, Thermal Facade Insulation, Exposed Structure as Thermal Buffer. *Energy Efficiency* Water Supply, Rainwater Infiltration, Energy Consumption Monitoring, Hybrid Cooling (Natural Ventilation, Electric Fan, Cooling), AC Inverter Technology, Water Efficient Fixtures, Filter System to Provide Drinkwater, Natural Ventilation, Solar-Thermal Water Heating, LED Lights, and Photovoltaic Panel. *Green Area* Evaporative Cooling by Landscape Design, Green Facade, and Water Permeable Surface

(Source: Various source)

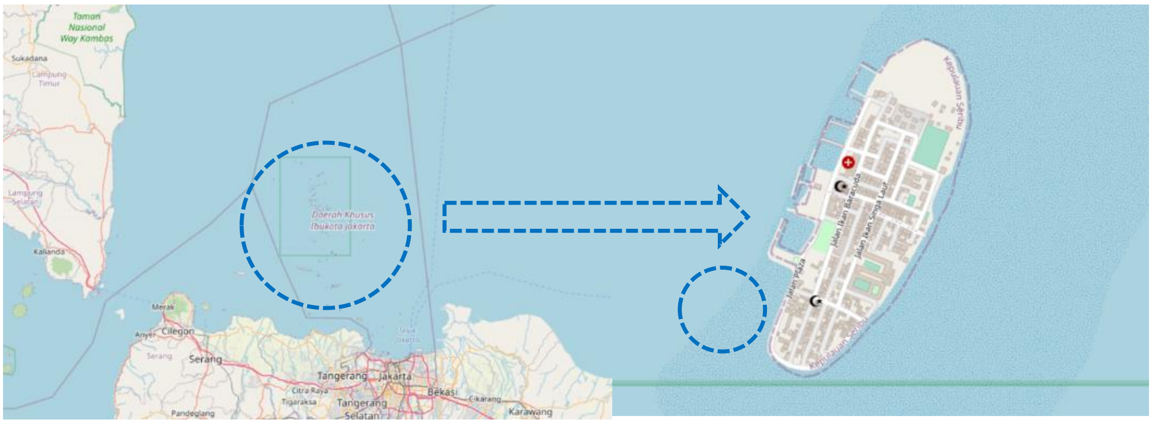
3. Results and Discussions

3.1. Site Analysis

3.1.1. Location and Climate

The site location is on the capital island of Kepulauan Seribu island, namely Pramuka Island. Kepulauan Seribu itself is an administrative district that divides into two primary districts and six sub-districts. As a lowland area with an average height of ± 1 meter above sea level. The width of the KepulauanSeribu based on the Governor's Decree No. 171 of 2007 is 8.700 km² with no less than 110 islands.

Figure 12. Floating House Concept ramework



(Source: personal data)

Based on its geographical position, the Thousand Islands Administrative District has the following boundaries:

North : Java Sea / Sunda Strait
East : Java Sea
South : North Jakarta, West Jakarta and Tangerang Regency
West : Java Sea / Sunda Strait

According to BPS data, Kepulauan Seribu Administrative District in Figures 2018-2020 has climatic conditions such as the following table

Table 1. Kep. Seribu Climate Conditions 2018-2020

Parameter (Satuan)	Bulan											
	Jan	*Feb*	*Mar*	*Apr*	*Mei*	*Jun*	*Jul*	*Agt*	*Sep*	*Okt*	*Nov*	*Des*
												2018
Suhu Udara *(°C)*	28	27,5	28,1	29,1	29,5	28,9	28,5	28,5	28,9	29,7	29,2	28,9
Intensitas Penyinaran Matahari *(jam)*	104,4	130,7	169,8	202,5	212,5	190,9	219,6	228,2	238,9	232,2	150,8	146,5
Kelembapan Udara *(%)*	75	82	79	77	73	74	68	69	68	71	75	74
Tekanan Udara *(mb)*	1008,9	1011,2	101,1	1010	1010,4	1011,3	1011,2	1011,7	1012,1	1011,7	1010,9	1010,5
Kecepatan Angin *(Knots)*	5,8	3,8	3,4	3,1	3,3	3,7	2,9	3,6	6,6	3,8	3	5,8
Intensitas Hujan *(hari)*	21	24	17	13	9	5	0	2	3	7	13	16
Intensitas Guntur *(kali)*	4	11	14	9	3	0	0	0	0	4	7	5
Arah Angin Terbanyak	B	B	B	T	T	TL	TL	TL, U	TL	TL	TL	B
												2019
Suhu Udara *(°C)*	28	27,5	28,1	29,1	29,5	28,9	28,5	28,5	28,9	29,7	29,2	28,9
Intensitas Penyinaran Matahari *(jam)*	104,4	130,7	169,8	202,5	212,5	190,9	219,6	228,2	238,9	232,2	150,8	146,5
Kelembapan Udara *(%)*	75	82	79	77	73	74	68	69	68	71	75	74
Tekanan Udara *(mb)*	1008,9	1011,2	101,1	1010	1010,4	1011,3	1011,2	1011,7	1012,1	1011,7	1010,9	1010,5
Kecepatan Angin *(Knots)*	5,8	3,8	3,4	3,1	3,3	3,7	2,9	3,6	6,6	3,8	3	5,8
Intensitas Hujan *(hari)*	21	24	17	13	9	5	0	2	3	7	13	16
Intensitas Guntur *(kali)*	4	11	14	9	3	0	0	0	0	4	7	5
Arah Angin Terbanyak	B	B	B	T	T	TL	TL	TL, U	TL	TL	TL	B
												2020
Suhu Udara *(°C)*	31,6	32,6	34	34	35,2	35,2	33,6	34,6	35	34,4	34,9	34
Intensitas Penyinaran Matahari *(%)*	50	39	61,8	77,2	70,1	76,9	70,8	88,4	86,3	77,5	70,6	47,6
Kelembapan Udara *(%)*	90,8	93,3	89,3	86,3	83,5	80,8	83,3	82,8	87	83,3	85,5	91,3
Tekanan Udara *(mb)*	101,1	1010,8	1010,1	1010,1	1009,5	1009,9	1009,4	1009,8	1009,9	1009,2	1008,4	1008,4
Kecepatan Angin *(Knots)*	2,3	2,1	2,2	2,3	2,5	2,6	2,3	2,7	2,4	2,3	2,6	3,6
Intensitas Hujan *(hari)*	25	25	19	10	12	9	9	5	8	11	15	21
Curah Hujan *(mm)*	607,2	784,5	211,1	142,2	52,5	63,3	99,9	77,9	131,9	98,3	114,6	236,5

(Source: BPS Indonesia)

The Kepulauan Seribu Administrative District has thermal conditions that are not much different from most regions in Indonesia, such as having an annual average temperature of around 28-32 ºC, air humidity around 65-75%, wind speed around 2.5-4 Knots with the most cardinal directions from the west and northeast.

3.1.2. SWOT Analysis

Figure 13. Kep. Seribu SWOT Analysis

STRENGTH

- The area is surrounded by the sea
-Density category is medium
-Most of the livelihood in the field of fisheries
- Potential for travel developers

WEAKNESS

-Have a high marine pollution index in Indonesia
- Coastal settlements that are not well planned

THREAT

- Increasing population density

OPPORTUNITY

-Improve the quality of life of coastal communities
-Add value to land use and tourism
-Helps reduce the marine pollution index

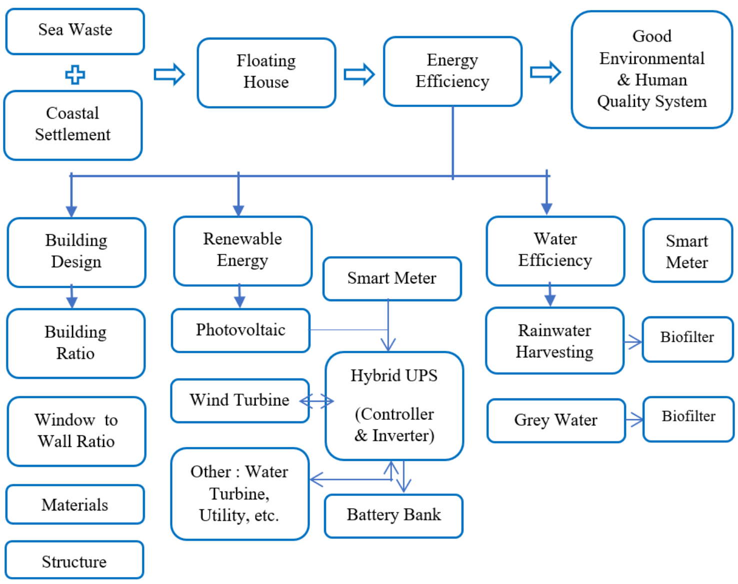
Source: Personal Data

3.2. Building Implementation

3.2.1. Building Concept

The design strategy implements by achieving a building design that emphasizes running a circular system of sustainable architecture (environmental, social, and economy) with energy savings through the use of waste such as plastic drums as the base of buildings, the use of local materials such as ironwood and bamboo, water conservation, passive building and the application of renewable energy that concentrates on solar panels and wind turbines as the most supportive energy for coastal floating houses in Indonesia.

Figure 14. Floating House Concept Framework

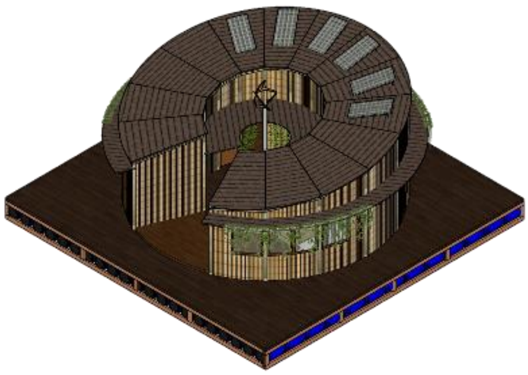


(Source: personal data)

The cylindrical formis applied based on the analysis of site and thermal environmental conditions that maximize sunlight and wind direction influence. Maximizing natural lighting and ventilation is an implementation of the passive building concept.

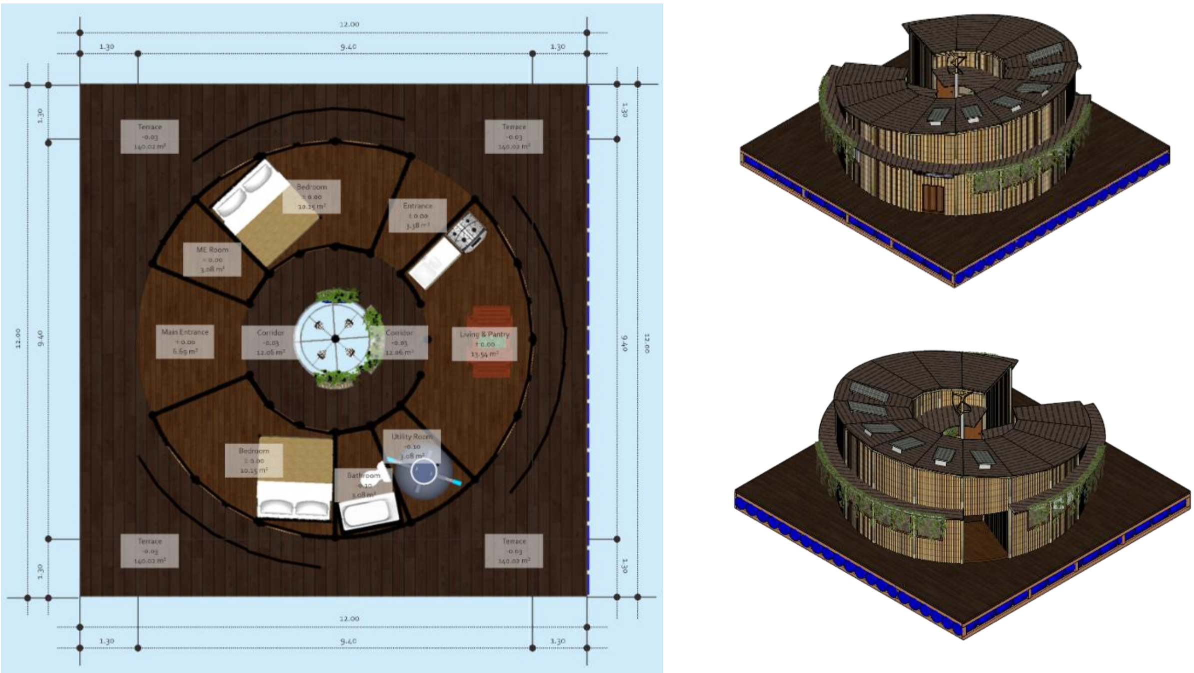
The building form possesses space and corridors concept to increase the building ratio achievement. Also impacting thebuilding ratio, entrances located in the west and northeast minimize the productive space existence, yet still, emphasize the wind coming directions. Specifxically west and east to obtain the optimum level of room comfort.

Figure 15. Floating House Aerial View



(Source: personal data)

Figure 16. Floating House Floorplan (left) and Building 3D (right)



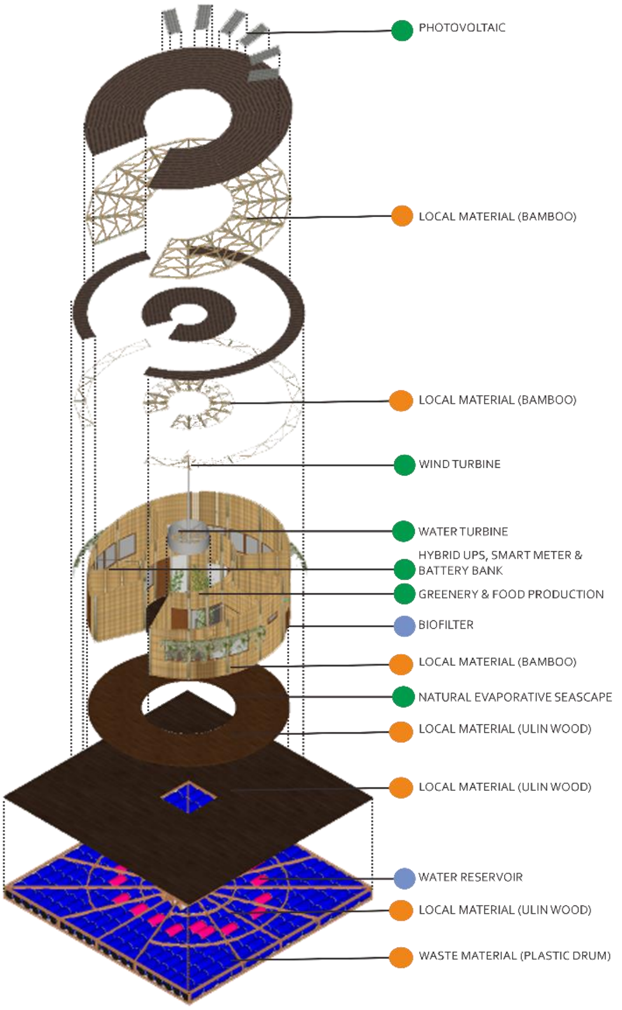
(Source: personal data)

The application of renewable energy such as photovoltaic, wind turbine, and water turbine so that buildings can generate their sources by utilizing the surrounding natural conditions.

Water reservoir for clean water and rainwater is available by utilizing several plastic drums located in the lower structure of the building. Also, a biofilter that used as a filter and recycler of gray water and black water.

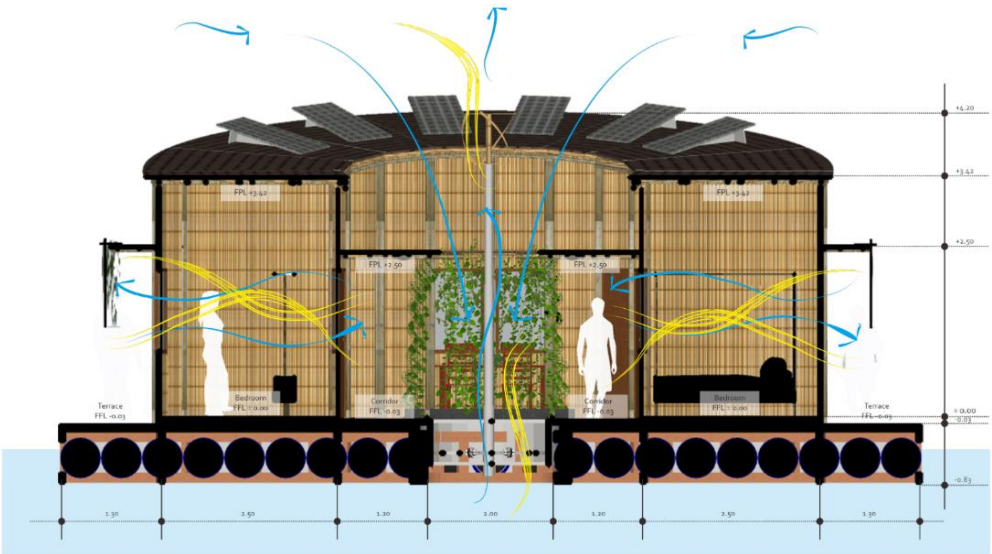
The use of waste materials such as plastic drums, local materials such as bamboo and ironwood as the primary building material, and consider supporting materials such as polymer roofs and single glass is lightweight and has supportive thermal conductivity values.

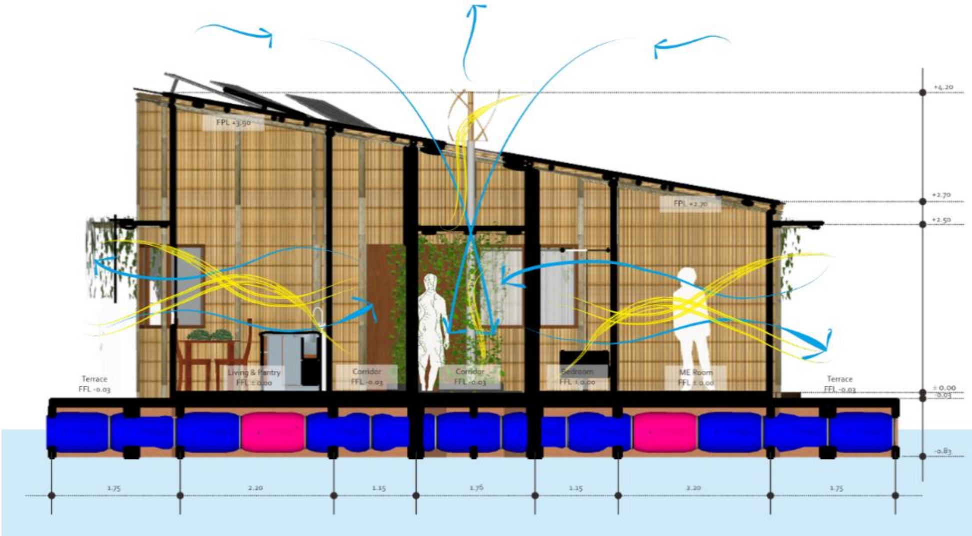
Figure 16. Floating House Isometric



(Source: personal data)

Figure 17. Floating House Sections and Thermal Diagram





(Source: personal data)

The application of room height that meets the thermal comfort standards of the tropics is around 2.5 m - 4.2 m. There is crossing ventilation in each space which facilitates the entry of natural sunlight and air exchange. The central area of the building functions as a place for wind turbines along with water turbines for easy control and maintenance also affects the acceleration of the air exchange process in the building, so the spaces in the building can maintain their optimum thermal conditions.

Figure 18. Floating House Front View and Material Diagram

(Source: personal data)

Figure 19. Floating House Side View and Material Diagram

(Source: personal data)

3.2.2. Building Concept

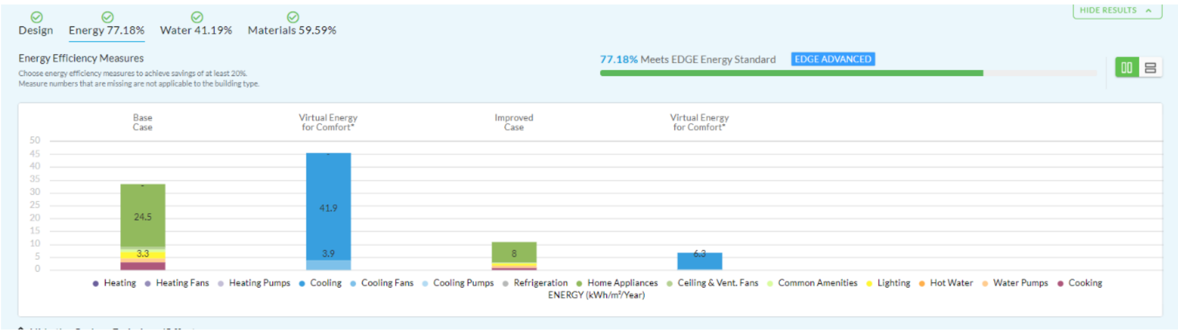
The following is the energy analysis data for building above using the EDGE by IFC software:

Table 2. The Floating House Data Entries for EDGE by IFC Software

Energy (77,18%)	ater Efficiency (41,19%)	Materials (59,59%)
Window to Wall Ratio (WWR)= 22% North = 0,16 ; Northeast = 0,49 ; East = 0,23 Southeast = 0,25 ; South = 0,14 ; Southwest = 0,.23 ; West = 0,07 ; Northwest = 0,21 **Solar Reflectence Index (SRI)** -Roof (Polimer Material) = 21 -Exterior Wall (Petung Bamboo) = 35 **Annual Average Solar Factor** -External Shading (Canopy with Polimer Material) = 0,9 **Insulation Material (U-value)** -Roof (Polimer Material) = 0,7W/m^2.K -Raised Floor Slab (Ulin Wood) = 0,23 W/m^2.K -Single Glass of Window = 0,7W/m^2.K **Lighting Power Density** Internal = 2 L/W and External = 1 L/W **Renewable Energy = 65% with Annual Electricity 1.746 Wh/year** -Photovoltaic Capacity = 60% ; Modules = 6 modules (600x300) ; Energy Solar Module = 348.656 watt ; Energy Output PV = 1,8 kWh ; Energy Yield = 3000 kWh/y ; Ideal Energy = 3600 kWh/year ; Performance Ratio = 82% ; Annual Energy Use = 3.100 kWh/year **-**Wind Turbine Capacity = 30% ; Modules = 1 turbin (d=60;t=70;3 blade); Power Energy Turbin = 1,4 watt; Annual Energy Use = 1.550 kWh/year -Other Capacity = 10% for Water Turbine, Utility, etc. ; Annual Energy Use = 517 kWh/year **Other Efficiency Energy** -Natural Ventilation -Efficient in Refrigerator and Washing Clothes -Smart Meters for Energy -Power Factor Correction -Submeters for Heating and Cooling -Low-impact Refrigerants	**ter Efficient Category** -Showerhead = 5 L/min -Fucetes = 3 L/min -Closets Dual Flush = 10 L/min (High Volume) -Kitchen Sinks = 5 L/min -Dishwater = 30 L/Rack -Pre-rinse Spray Valves for Kitchen = 5 L/min -Washing Machine = 30 L/cycle **Other Efficiency Energy** -Rainwater Harvesting System -Waste Water Treatment Recycling System -Condensate Water Recovery -Smart Meters for Water	**ttom Floor Construction** ype : Ulin Wood hickness : 70 mm -value : 0,23 W/m^2.K **ermadiate Floor Construction** ype : Ulin Wood hickness : 70 mm **of Construction** ype : Petung Bamboo iameter : 60-80 mm -value : 2,08 W/m^2.K **terior Wall** ype : Petung Bamboo iameter : 60 mm -value : 2,08 W/m^2.K **erior Wall** ype : Petung Bamboo iameter : 60 mm **ndow Frame** ype : Ulin Wood hickness : 70 mm **ndow Glazing** ype : Single Glass hickness : 3 mm -value : 0,7 W/m^2.K **of Finish** ype : Polimer Material (Tiled Roof) -value : 0,7 W/m^2.K **ff Insulation** ype : Aluminium Foil hickness : 3 mm **or Insulation** ype : Ulin Wood hickness : 70 mm

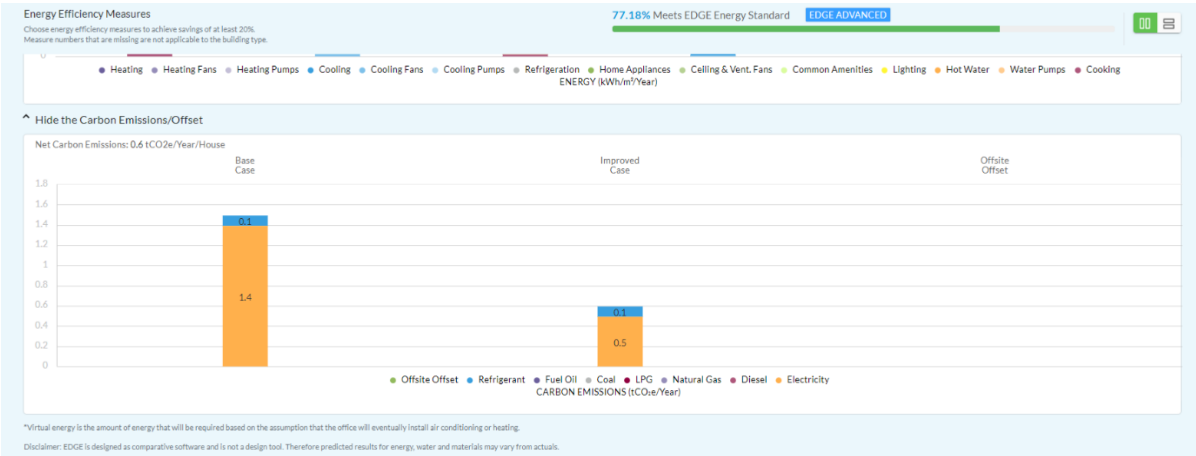
(Source: personal data)

Figure 20. Floating House Energy Efficiency Measures Result Using EDGE by IFC Software



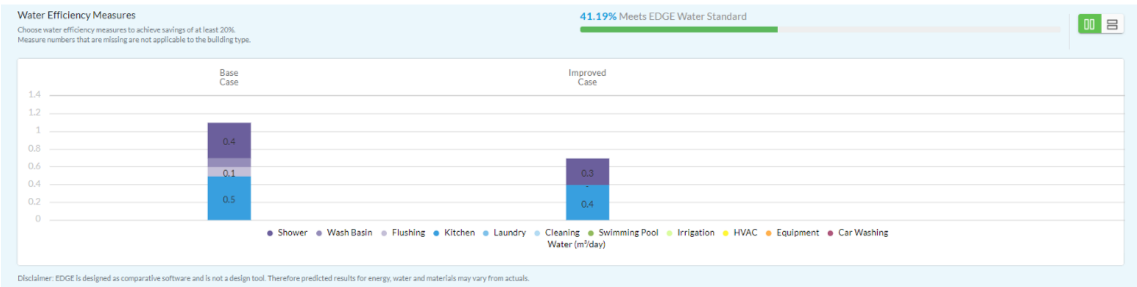
(Source: personal data)

Figure 20. Floating House Carbon Emissions/Offset Result Using EDGE by IFC Software



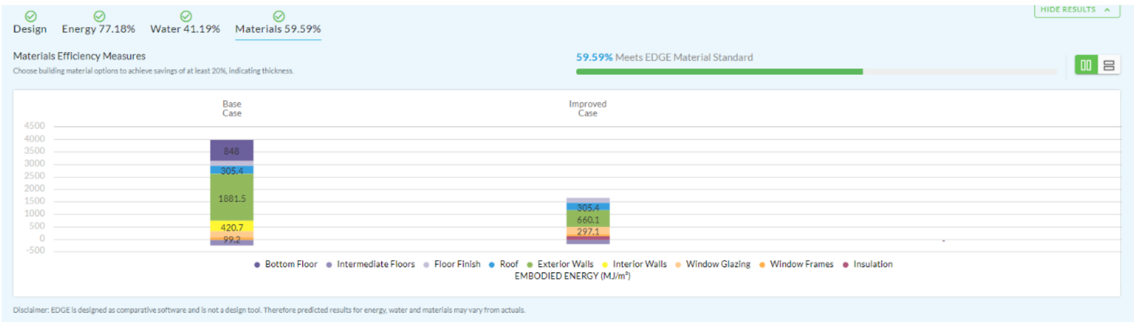
(Source: personal data)

Figure 21. Floating House Water Efficiency Measures Result Using EDGE by IFC Software



(Source: personal data)

Figure 22. Floating House Materials Efficiency Measures Result Using EDGE by IFC Software



(Source: personal data)

Overall result of the energy analysis data for building above using the EDGE by IFC software:

Table 3. The Floating House Overall Result Data Using the EDGE by IFC Software

NO	SAVING TYPE	TOTAL SAVINGS
1	Final Energy Use	62,00 kWh/Month/House
2	Final Water Use	21,00 m^2/Month
3	Final Operation CO2 Emissions	0,04 t CO2/Month/House
4	Final Embodied Energy	1.520 MJ/m^2
5	Final Utility Cost	355.761 IDR/Month/House
6	Energy Savings	1,48 MWh/Year
7	Water Savings	175,24 m^2/Year
8	Operational CO2 Savings	0,92 t CO2/Year
9	Embodied Energy Savings	148.43 GJ
10	Utility Cost Saving	4.010.000 IDR/Year
11	Base Case EPI	34 kWh/m^2/Year
12	Improved Case EPI	12 kWh/m^2/Year
13	Total Building Construction Cost	186.000.000 IDR with 0,5% CostIncrease
14	Refrigerant Global Warming Potential	0,20 t CO2e/Year

(Source: personal data)

3.2.3. Floating Ability

Table 4. The Floating House Structure Weight Calculation

NO.	URAIAN PEKERJAAN	VOLUME (m3/bh)	BERAT JENIS (Kg/m3)	TOTAL MASSA (Kg)
I.	**Lower Structure Dead Weight**			
1	Sloof	40,30	900,00	36.271,03
II	**Upper Structure Dead Weight**			
1	Floor	20,59	900,00	18.531,00
2	Bio Septictank	1,00	1,00	1,00
3	Wind Turbin (Petung Bamboo)	1,47	720,00	1.060,92
	Wind Turbin (Wulung Bamboo)	0,00	470,00	1,65
4	Bamboo Collumn	1,60	720,00	1.150,26
5	Wall	6,27	380,00	2.382,60
6	Bamboo Block	0,28	470,00	133,02
7	Canopy Structure	0,64	470,00	302,89
8	Roof Structure	0,82	470,00	384,20
9	Roof Cover	2,12	260,00	551,20
10	Solar Panel	6,00	10,00	60,00
III	**Life Weight**			
1	Workers	6,00	80,00	480,00
	Lower Structure Dead Weight Total			**36.271,03**
	Upper Structure Dead Weight Total			**24.558,75**
	Life Weight Total			**480,00**

(Source: personal data)

The structure is stated as stable if the buoyancy force (Fa) is greater than the total weight of the floating house structure (G).

Structure stability calculation:

Based on Henny Pratiwi Adi, 2020

Floating House Total Structure Weight (G	=	250.387,45	Newton	(Down ward)		
SF (Safety number)	=	1,2				
Upward Buoyancy(Fa)	=	988.950,72	Newton	(Upward)		
Fa – (G x 1,2)	=	988.950,72	-	250387,45	x	1,2
	=	988.950,72	-	300.464,94		
	=	688.485,78	OK			

Based on Adi, H. P., Wahyudi, S. I., Sudarmono, C. S., & Islam, M. C., 2020

Floating House Total Structure Weight (G	=	250.387,45	Newton	(Down ward)		
SF (Safety number)	=	1,5				
Upward Buoyancy(Fa)	=	988.950,72	Newton	(Upward)		
Fa – (G x 1,2)	=	988.950,72	/	250.387,45	>	1,5
	=	3,95	>	1,5	OK	

After checking the analysis results of the calculation of the weight of the floating structure with 264 plastic barrels and the sloof structure using ironwood material, the results were 988,950.72 Newton (up) compared to the weight of the floating house structure which was 250,387.45 Newton (down). Therefore, the value of structural stability control is obtained between 1.2 and 1.5. Thus, it can be said that the construction of floating houses is declared safe.

4. Conclusions and Recommendations

This research means to comprehend the floating architecture concept efficiency using the EDGE program. It is proving by the shape and material exploration in this floating house that it can save energy and utility costs. The material used in this floating house is ironwood for the construction of floors and window frames. As for petung bamboo, it's applied as walls and roofing materials using a roof cover made of polymer with added aluminum foil insulation. Concerning power generation, it uses six photovoltaics on the roof and one wind turbine. For future research, consideration of sea depth and the structure calculation to identify the project budget plan will be the main focus.

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