Criteria Formulation for a Web-based Assessment Tool for the Net-Zero Healthy Building

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ABSTRACT
Indonesia has the potential to achieve net-zero energy building because it has the ability to meet building energy needs from sources that are cheap, locally available, and renewable, e.g. solar energy. The current pandemic conditions force the building design to adapt so that it can be a place that reduces virus transmission, safe and comfortable for its users. Likewise, with the concept of net-zero energy building needs to be adapted to the concept of a healthy building. Net-zero building needs to consider the identification of indoor health aspects that affect the health and comfort of building occupants. The purpose of this research is to formulate criteria for a user-friendly website-based initial assessment tool, to provide accurate recommendations and help stakeholders to make decisions regarding energy conditions and criteria for healthy buildings. The methods used in this research are observation, focused group discussions with stakeholders and a guide scheme formulation for the initial assessment tool. This tool is expected to be able to simulate the achievement of energy efficiency for net-zero energy buildings and healthy buildings and produce outputs in the form of energy use predictions and building designs' health conditions that can be used as a design in decision-making.

Keywords: *Criteria, Net-zero healthy building, Web-based assessment tool.*

1. INTRODUCTION

Buildings consume energy both in construction, operation, or in the demolition phase. Electrical energy used during building operations has become an important issue because of the large amount of energy consumption. The amount of energy consumed in buildings contribute to 1/3 of the world's total energy consumption [1], where non-renewable energy sources play a role as the major contributor to global warming and climate change. In response to this issue, three strategies can be applied:

1) Reduce energy consumption through the selection of energy-efficient equipment and management.
2) Improve energy efficiency by converting waste energy into reusable energy.
3) Using renewable energy sources.

The third strategy can be realized in the form of net zero energy building concept. Net-zero energy building is the concept of a building that can meet all of its energy needs from cheap, locally available, non-polluting, and renewable sources [2]. Energy consumption in Indonesia is dominated by electrical energy, which mostly comes from non-renewable resources. Indonesia has the potential for renewable resources, with the largest portion coming from solar energy. Based on this fact, Indonesia has the potential to achieve net-zero energy building due to the ability to fulfill building energy needs

Apart from energy issues, another striking global issue is the COVID-19 pandemic. This pandemic has forced people to adapt to changes in life. With regard to the pandemic, the concept of net-zero energy buildings needs to be adapted to the concept of healthy buildings. Net-zero strategies should include the identification of the indoor health aspects that affect the health of the building occupant. Criterias issued by Green Building Council of Indonesia (GBCI) also need to be reviewed again in accordance to pandemic conditions. Before the pandemic, people mostly have done their activities inside buildings [3], and now, especially during the pandemic, with the lockdown policies, social distancing, and the new normal, occupants spend even more time inside the building. Based on this fact, strategies to reduce the transmission of COVID-19 (Sars-Cov-2) can be done through changes in building planning parameters, one of which is Greenship Interior Space Parameters, especially Indoor Health and Comfort [4,5].

Towards net-zero healthy building, several criterias are being compared, GBCI already has provided categories of Energy Efficiency and Conservation assessment (Energy Management Policy and Plan, Building Energy Minimum Performance, Optimal Building Energy Performance, Testing, Re-commissioning and Retro-commissioning, Energy System Performance, Energy Control and Monitoring, Operations and Maintenance, Energy from Onsite Renewable Sources, and Energy with Lower CO2 Emissions) and Indoor Health and Comfort (No Smoking Campaigns, Outdoor Air Introduction, CO2 Monitoring Levels, Chemical Pollutants, Control of Pollutants Sources Indoors, Biological Pollutants, Visual Comfort, Outside Views and Daylight, Thermal Comfort, Indoor Plants, Pest management and Building Occupant Survey) (see figure 1).

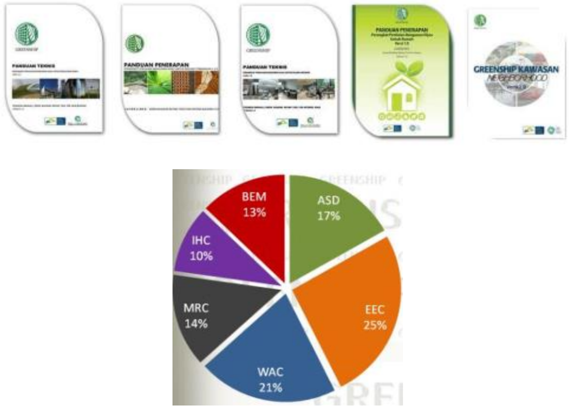

Figure 1 Greenship criteria.

And another web-based assessment tool, issued by EDGE and has 3 category ratings, energy, air, and material. The measurement of energy use includes heating energy, pump energy, computers, cooling energy, others, food field/kitchen, fan energy, and lighting. In total there are 34 measurement parameters of energy efficiency used in EDGE (see figure 2).

Figure 2 EDGE – energy efficiency parameters.

Comparing the three criterias, the GBCI assessment process is done manually (by labor), and these criterias need to be adjusted to respond to the pandemic conditions. The EDGE assessment process is web-based but does not provide criteria for healthy building. Based on the previous assessment tools, there are innovation opportunities to formulate the criteria for a web-based initial assessment tool for net-zero healthy buildings, which include: energy efficiency parameters to achieve net-zero energy building, as well as health and comfort parameters in rooms that have been adapted to pandemic for the achievement of healthy buildings. These two parameters have become optimization parameters in net-zero healthy buildings, where optimal conditions are reached when the energy consumption index decreases and the healthy building index increases. The criteria for web-based initial assessment tool is expected to digitalize the assessment and simplify the process for stakeholders to do the assessments in a fast and accurate manner and help make design decisions for optimal achievement in energy and healthy building conditions, in planning and operational stages. The purpose of this research is to formulate the criteria for a user-friendly website-based preliminary assessment tool, which makes it easier to provide accurate recommendations and design decisions for stakeholders regarding energy conditions and healthy building criteria. The preliminary assessment criteria consist of two parameters: energy efficiency, and indoor health and comfort parameters that have been adapted to pandemic conditions for the achievement of healthy buildings. The criteria for the preliminary assessment tool are needed to compose a flowchart of a website-based rating tool that can be used at the early stages of design to predict energy use conditions and criteria for healthy buildings. This initial assessment tool is expected to be able to simulate the achievement of energy efficiency for net-zero energy buildings and healthy buildings and produce outputs in the form of predictions of energy use and building design health conditions that can be used as a basis in design decision making.

2. RESEARCH METHODOLOGY

2.1. Observation

Initial observations were made to look for several studies related to net-zero energy building and healthy building as well as the criteria included and ways to measure them. In addition to the literature study on net-zero healthy building, observations were also made on the scheme developed by the GBCI on Greenship Net Zero Healthy. From the literature study and the results of the study of the scheme developed by the GBCI, initial criterias were compiled for the preparation of the preliminary assessment tool.

2.2. Focus Group Discussion with Stakeholders

The initial criteria for preliminary assessment tool that have been formulated are then discussed with stakeholders from GBCI to receive feedback. The input that has been obtained from the stakeholders are then used as the basis for the development of the preliminary assessment tool criteria.

2.3. Schematic Guide for Preliminary Assessment Tools

Based on the results from the stakeholder input, the criteria for the preliminary assessment tool are developed in more detail for the parameters that need to be considered for net-zero healthy building. From the results of the discussion of these criterias, the next step is to create a schematic guide that can be used to create a website flowchart that will then be compiled by the web developer.

3. RESULTS AND DISCUSSION

3.1. Criteria Formulation for Preliminary Assessment Tools

GBCI already issued a scheme for Greenship Net-Zero Healthy Building, which considers passive design (through building mass, orientation, microclimate and noise level, and placement of renewable energy), indoor health and comfort are interrelated with the active design and passive envelope design, as well as a renewable strategy to realize a net-zero healthy building (see figure 3).

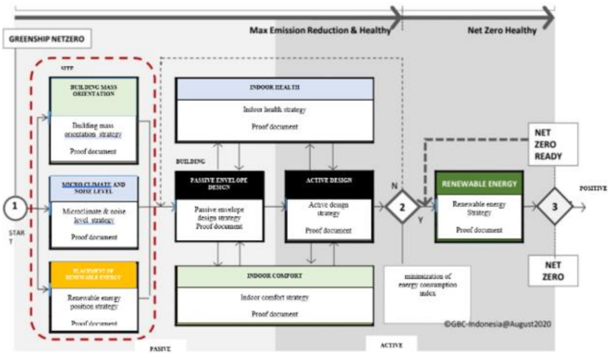

Figure 3 Scheme for net zero healthy building.

Source: GBCI, 2020

This scheme is then compared with literatures and other studies related to net-zero energy and healthy buildings. Some of these studies are used as the basis for formulating the criteria for the initial assessment tool.

Many studies also explain the importance of good indoor quality to respond to the covid-19 pandemic, the indoor design that supports occupant health through the creation of good indoor air quality in addition to achieving energy efficiency [4–6]. The health and comfort of occupants in the building is also an important consideration in net-zero energy building were to achieve performance in energy efficiency especially at the evaluation stage. Net-zero energy building composed of three main design elements: passive design, service systems, and renewable energy sources (RES) power generation. These design elements of net-zero energy building can be explained by the following graph (figure 4).

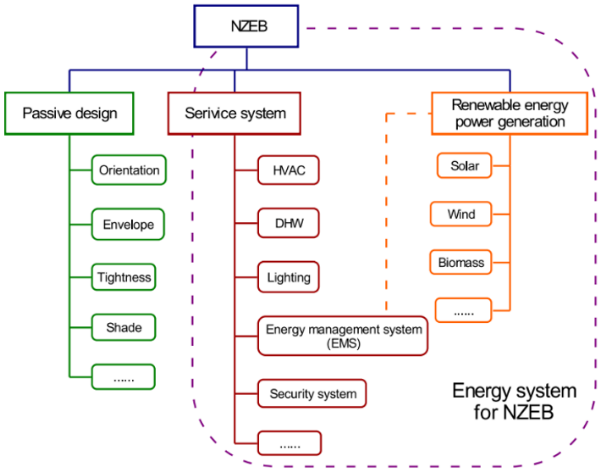

Figure 4 NZEB design elements [7].

To respond to pandemic conditions, good air quality can be created by increasing the outdoor air exchange rate (6-12 Air Changes per Hour) [8], stop air recirculation and maximize outside air through windows or other mechanical systems and reducing space capacity to up to 50% to reduce viral aerosols [4,5,9-13].

The importance of natural ventilation and introduction of outside air into the building changes the concept of thermal comfort and needs to be integrated into adaptive thermal comfort. In adaptive thermal comfort, the temperature range that is comfortable for users vary depending on the characteristics of the room, where users can adjust their own comfort level through various ways such as opening or adjusting clothing, and/or insulation [14,15]. Where in adaptive thermal comfort it is necessary to find a combination of temperature variables (temperature, humidity, air movement, clothing) that is considered comfortable or neutral [15].

3.2. Evaluating Criteria with the Stakeholders

Based on the scheme that has been issued by the GBCI and the literature studies, the initial criterias that are needed to be compiled for preliminary assessment tools are explained as follows:

3.2.1. Building Data Input

3.2.1.1. Building Data

This input including the data such as location, gross floor area, total floor number, occupancy density, operational and non-operational hours, building orientation, etc. (see table 1).

Table 1. Occupancy density

Occupancy Category	Occupancy Density (#/100m2)
Office Buildings	
Office Space	5
Reception area	30
Telephone/data entry	60
Main entry hobbies	10
Miscellaneous Spaces	
Bank vaults/safe deposit	5
Computer (not printing)	4
Electrical equipment	-
Elevator machine room	[16]-
Pharmacy (prep. area)	10
Photo studios	10
Shipping/receiving	-
Telephone closets	-
Transportation waiting	100
Warehouses	-
Public Assembly Spaces	
Auditorium seating area	150
Places of religious worship	120
Courtrooms	70
Legislative chambers	50
Libraries	10
Lobbies	150
Museums (children's)	40
Museums/galleries	40
Residential	
Dwelling unit	F
Common corridors	
Retail	
Sales (except as below)	15
Mall common area	40
Barbershop	25
Beauty and nail salons	25
Pet shops (animal areas)	10
Supermarket	8
Coin-operated laundries	20

Source : [17]

3.2.1.2. Building Typology

Based on the building typology options, the baseline of Energy Consumption Index (kWh/m2 per year) and the Building Health Index are measured using standards given by Direktorat Jenderal Energi Indonesia, GBCI, SNI, and any other related councils. For example, energy consumption index for homes is 240 kWh/m2 per year, for apartment is 300 kWh/m2 per year [18].

3.2.2. Building Health Indexes

3.2.2.1. ACH

Air changes per hour are measured based on room volume per person, as seen in Table 2.

Table 2. Air changes per hour

If room volume per person (m3)	Then fresh air supply rate per person	
	Minimum	*Recommended*
3	12	17
6	7	11
9	5	8
12	4	6

Source : [19]

3.2.2.2. Access to Outside View

The default for all building typologies, at least 75% of the area has access to outside view.

3.2.2.3. Visual Comfort

Homes	200-300 lux
Apartment	200-300 lux
Office	300-500 lux
Mall	500-750 lux
Hotel	200-300 lux
Hospital	500-1000lux [20]

3.2.2.4. Thermal Comfort

Thermal comfort based on a temperature setting of 25°C according to Greenship standards with an RH of 40-60%. The standard of thermal comfort from GBCI is still relevant because the adaptive thermal comfort still need to analyzed further to get the right combination that to be considered comfortable.

3.2.2.5. Acoustical Comfort

Homes	30 – 35 dBA
Apartment	30 – 35 dBA
Office	30 – 45 dBA
Mall	40 – 55 dBA
Hotel	30 – 35 dBA
Hospital	30 – 35 dBA [21]

3.2.3. Passive Design Strategy for Building Envelope

Entering building envelope data that covers parameters such as OTTV, SHGC, and WWR.

3.2.4. Active Design Strategy

Active design strategy calculates energy consumption from lighting, AC, Appliances, Utility, and Plug.

3.2.4.1. Lighting

Lighting Energy Consumption can be measured by design, or based on lighting power density standard given by the GBCI. The lighting power density itself is divided into two kinds, lighting power density for operational and non-operational hours. LE during operational hours daylight area [daylight area x operational hours x LPD during operational hours].

3.2.4.2. AC

The AC cooling load is a summary from the Building Sensible Load, People Sensible Load, People Latent Load, Lighting Sensible Load, Infiltration Load, and Ventilation Load. The heat load numbers used in this calculation refers to the average heat load in the tropical area.

3.2.4.3. Appliances

Energy consumption for appliances is calculated from the total number of appliances multiplied by watts and operating hours of use.

3.2.4.4. Utility

Utility here refers to the energy consumption used by lifts and escalators, pumps, STPs, and Mechanical Ventilations.

3.2.4.5. Electrical Sockets

Energy consumption for electrical sockets is calculated from the power density, both during operational hours and non-operational hours. Sum of electrical socket Energy Consumption divided by GFA to get kWh/m2 per year).

3.2.5. Building Health and Comfort Design

3.2.5.1. Outdoor Air Introduction

It is necessary to explain whether there is potential for outside air intake, and it is necessary to calculate the minimum flow rate based on calculations that concerns airflow rate required per person, zone population, outdoor airflow rate required per unit area, and zone floor area (m^2) (see table 3).

Table 3. Minimum ventilation rates

Occupancy Category	People Outdoor Air Rate (Rp)		Area Outdoor Air Rate (Ra)	
	Cfm/person	L/s person	Cfm/ft2	L/s m2
Office Buildings				
Office Space	5	2.5	0.06	0.3
Reception area	5	2.5	0.06	0.3
Telephone/data entry	5	2.5	0.06	0.3
Main entry hobbies	5	2.5	0.06	0.3
Miscellaneous Spaces				
Bank vaults/safe deposit	5	2.5	0.06	0.3
Computer (not printing)	5	2.5	0.06	0.3
Electrical equipment			0.06	0.3
Elevator machine room			0.12	0.6
Pharmacy (prep. area)	5	2.5	0.18	0.9
Photo studios	5	2.5	0.12	0.6
Shipping/receiving	-	-	0.12	0.6
Telephone closets	-	-	0.00	0.00
Transportation waiting	7.5	3.8	0.06	0.3
Warehouses	-	-	0.06	0.3
Public Assembly Spaces				
Auditorium seating area	5	2.5	0.06	0.3
Places of religious worship	5	2.5	0.06	0.3
Courtrooms	5	2.5	0.06	0.3
Legislative chambers	5	2.5	0.06	0.3
Libraries	5	2.5	0.12	0.6
Lobbies	5	2.5	0.06	0.3
Museums (children's)	7.5	3.8	0.12	0.6
Museums/galleries	7.5	3.8	0.06	0.3
Residential				
Dwelling unit	5	2.5	0.06	0.3
Common corridors	-	-	0.06	0.3
Retail				
Sales (except as below)	7.5	3.8	0.12	0.6
Mall common area	7.5	3.8	0.06	0.3
Barbershop	7.5	3.8	0.06	0.3
Beauty and nail salons	20	10	0.12	0.6
Pet shops (animal areas)	7.5	3.8	0.18	0.9
Supermarket	7.5	3.8	0.06	0.3
Coin-operated laundries	7.5	3.8	0.06	0.3

Source : [16]

3.2.5.2. ACH

Air change per hour is calculated based on air ventilation speed inside the room and the room volume.

3.2.5.3. Access to Outside View

The criteria are measured by the percentage of area with outside view, compared to the total building area. The standard recommended by the GBCI for areas with an outside view at least 75% of the total GFA.

3.2.5.4. Visual Comfort

To measure the visual comfort, the designed illuminance level should be compared to the illuminance standard. The designed illuminance level itself depends on the lamp's specification used in the building (watts, lumens, light loss factor, utility factor) (see table 4).

Table 4. Illuminance standard

Location/activity	Standard E
(a)	(b)
Public entrance halls, foyers	200
Public passageways, stairs	100
Restaurant: bars, tables	150
Retailing: sales areas, displays	500-750
Office: general	500
Office: workstations	300-500
Office: drawing boards, fine work	750
Workplace: fine work	1000
Workplace: medium work	300
Workplace: casual work	200
Eduacation: general classrooms	300
Education: display boards	500
Home: kitchens, study areas	300
Home: halls, landings	150

Source : [20]

3.2.5.5. Thermal Comfort

Thermal comfort based on a temperature setting of 25℃ according to GBCI standards with an RH of 40-60%.

3.2.5.6. Acoustical Comfort

Here, noise level in existing condition is compared to the noise level standard based on building typology.

3.2.6. Renewable Energy Resources

Prediction of electrical energy from photovoltaic (PV) depends on the potential facade area, and PV specification. From this criteria, percentage of electrical energy generated by PV is compared to the total energy consumed by building.

3.2.7. Design Portfolio, Design Recommendation

Design portfolio shows the final results that need to be displayed from the data that has been inputted on the criteria previously mentioned. In the final result form, the following points will appear:

3.2.7.1. Towards Net Zero Building

- Consumption Energy Index
- Consumption Energy Percentages
- Mix Energy Consumption

3.2.7.2. Towards Healthy Building

- VBz
- ACH
- Access to Outside View
- Visual Comfort
- Thermal Comfort
- Accoustical Comfort

3.2.7.3. Design Recommendation

The form of recommendations that need to be applied to buildings to achieve healthy building conditions and apply health protocols can be explained as follows:

- Installation of CO2 sensor, for any area with occupancy level under 2.56 person/m2.
- Cigarette smoke control: giving designated smoking areas and installation of no smoking signs in any public area.
- Management of chemical pollutants: low Volatile Organic Compound (VOC) and formaldehyde for a minimum of 75% for ceilings, walls, floors, and furniture finishes, 100% non-asbestos materials.
- Provide temperature checking areas and tools.
- Provide self-assessment systems for all the users.
- Provide public hand-washing areas.
- Provide signs of mask mandatory areas.
- Provide signs for social distancing alert.

The six criteria and sub-criteria found in the initial assessment tool was then discussed with GBCI as a stakeholder. From the results of the discussion, we proceed to create a schematic guide that can be used to create a website flowchart that will be compiled by the web developer.

3.3. Schematic Guide for Preliminary Assessment Tools

The schematic guide is compiled to summarize the criteria that have been found for net-zero healthy building and can be used as an initial scheme to help web developers to develop flowcharts (figure 5).

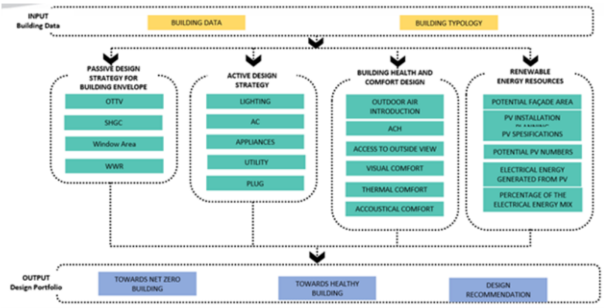

Figure 5. Schematic guide for net zero healthy building.

4. CONCLUSION

In the building design that focused on energy efficiency and the potential of renewable energy to respond to the pandemic condition, it is mandatory to include the category of healthy buildings in planning. The focus on these two things is intended to provide occupants health and comfort, create good indoor air quality, and the effort to lower operational and maintenance costs compared to conventional buildings. As natural ventilations play an important part in achieving healthy building, the thermal comfort, in this case adaptive thermal comfort must be analyzed further to find a combination of temperature variables (temperature, humidity, air movement, clothing) that can be considered comfortable. The criteria found from the results of this research can be further developed in more detail for the measurement method for each sub-criteria and become a guide to develop a flowchart for the prototype of a preliminary assessment tool for net-zero healthy building. This preliminary assessment tool is then expected to produce an output simulation to predict the condition of energy use and building health that can be used as a basis for decision making to achieve the target of net-zero healthy building.

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