Balinese green building model emphasizing on criteria of energy efficiency and conservation

I D M C Santosa[1], M E Arsana[1], I B P Sukadana[1], P W Sunu[1]

[1] Mechanical Engineering Department, Politeknik Negeri Bali, Kampus Bukit Jimbaran, Bali, Indonesia

E-mail: idmcsantosa@pnb.ac.id

Abstract. As an international tourist destination, Bali becomes an island which has thousand tourist accommodation. Energy consumption for the accommodation getting increased year by year. This study was examined the energy efficiency and conservation for some commercial building and hotel in around Bali using green building standard approach. Firstly, auditing energy has been done and analysis to get energy consumption index comply with green building standard. Secondly, the energy efficiency model and conservation has been developed based on audit data, standard, references, and Balinese green philosophy "*Tri Hita Karana (THK)*". As a result, obtained that Balinese green Building emphasizing on energy efficiency and conservation aspect have some criteria including, inhabitant's behaviour, energy regulation, energy saving appliances/devices, building aesthetic and energy consideration, renewable energy, and VAC load control. This aspect was examined in this research. This aspect involved 13.59 percent weighting from overall assessment point which are including: energy conservation campaign, simple commissioning, MVAC control, lighting power density and control, energy monitoring and control, electrical equipment and appliances. These criteria have average similar weight point and integrated one and each other. The next goal for this model implemented is net zero energy building technology.

1. Introduction

In the presence of external factors, the increasing global environmental problems, especially with regard to the increase in greenhouse gases (carbon dioxide) as a result of excessive energy use from fossil fuels, the efforts of fossil energy efficiency and renewable energy applications (renewable energy) will continue to be encouraged. But the global climate change is very fast and in accordance with the existing developments in the year 2014. The central government regulation has issued a regulation of the Minister of Energy Regulation No. 13 year 2012 on electricity consumption, which targets the 20% savings of existing conditions. While one of energy saving targets is energy saving on the government building, with the saving of water conditioning system, lighting system, and supporting equipment. Following this ministerial regulation has been drafted energy saving guidelines on government building in general is "Energy saving guide in government building". This is a very good stimulus from the government to save energy buildings in general. For the observation of the energy consumption condition of the building today continue to be carried out energy audits either simple audits or energy audits detail. So that, Bali seems to be very important to underscore from this energy policy is efforts to encourage people in the energy efficiency.

As a world tourist destination, Bali should apply the green tourism concept with *Tri Hita Karana (THK)* philosophy become main reference. THK is a local wisdom which become more popular in green tourism development in Bali, as a Balinese local wisdom. As a tourism destination it becomes very urgent to get more serious handling to achieve green tourism or sustainable tourism [2]. As a large hospitality building in the neighbourhood of Bali province is a building with a lightweight construction where each room comes into contact with the surrounding environment (ambient condition) that is hot and humid. Besides, the isolation of buildings (walls and roofs) is still conventional with relatively high thermal conductivity, building with construction like this has a relatively high refrigeration load [2]. Thus, detailed assessment is indispensable for this type of building to obtain a significant energy saving strategy.

So, this study is aimed to obtain a model of energy saving (energy conservation in commercial buildings) and the use of renewable energy as well as other environmentally friendly alternative energy. This concept is urgent to be implemented in Bali to achieve the sustainable tourism and development.

2. Green building standard and research method

Green Building Certification in Indonesia refers to standard which was developed by GREENSHIP [3]. The instrument green building tools analyse a building has categorized as a green building. One of the urgent categories in the developed of Green building is energy efficiency and conservation aspects. This aspect was examined in this research. This aspect involved 13.59% weighting from overall assessment point which are including energy conservation campaign, simple commissioning, MVAC Control, lighting power density and control, energy monitoring and control, electrical equipment and appliances. This standard becomes main reference and combined with original other sources covering, *Tri Hita Karana* concept, journals references and local government regulations.

Green building model in this study was developed based on survey through some hotel in Bali or collecting some data from the hotel management (Engineering Department). In this study the hotel data are the energy assessment/auditing results and also refer to previous assessment result which already published. Some secondary data also obtained from ASHRAE standard.

Data has been analysed in order to obtain the energy building requirement comply with green building criteria especially in Energy aspect. This result was referred in order to develop the model green building in Bali which in recent time is not finish yet. Same recommended for energy efficiency and conservation will be tabulated and shown in table and figures.

In this study also develop a road map for the energy building which final goal is net-zero energy building technology in Bali. It was being arranged six step development saving energy building which starting on audit energy building, especially hotel, develop the green building standard (module and guidelines) and then standard application on building. The step is shown in Figure 1.

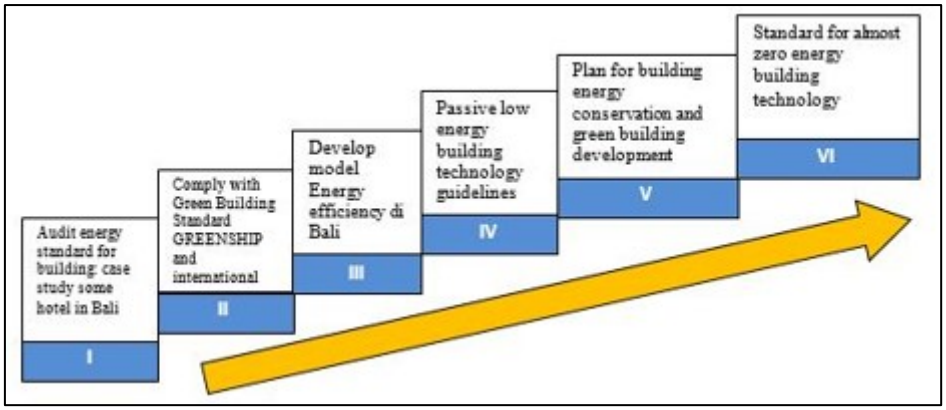

Figure 1. Development of green building of energy efficiency and conservation.

3. Green building model development

This study was performed with three main stages, firstly, reviewing energy building and standard in countries that have similar environment condition with Indonesia (warm and humid). Review was focus on energy efficiency and conservation including renewable energy application, passive cooling technology, etc. Secondly analysing audit energy result from several hotels in Bali comply with Green Building Standard and finally develop an energy building model in term of efficiency and conservation.

3.1. Energy saving and conservation in building

Building energy consumption are considerable influenced by various factors, especially internal and external factors. Lam *et al*. [4], Utama [5] and Zhao [6] were studied those factors. The external factor examined are climate and surrounding environment effect to energy demand in the building. Characteristics of annual energy use was analysed in different climates (cold, temperate, and warm climates). It was obtained that a temperate climate (subtropical) gained the lowest peak energy compared to other areas of hot, cold and quite cold climates. The internal factors mainly are building construction and material. They found that the construction of residential buildings has a significant impact on the air conditioning energy demand from air conditioning. Roof and wall cause high gain with total approximately 50-60% of the total heat gain in building. Second internal factor is lighting operation and HVAC (heating, ventilation and air conditioning), and third is the number of occupants and behaviours of the occupants.

Energy saving efforts and energy consumption in building are observed by assessment or auditing method. For energy saving efforts was done by designing the control of the use of lamps with the method daylighting saving time and can lower the peak electricity demand by 0.14% based on data of government, commercial and household buildings, it was found 20% energy saving that is largely from air conditioning systems. For industrial needs is also researched by implementing automation system to lighting, heat recovery and door opening and gained energy decreases in power [7-9]. In addition, Campaniço *et al.* was implementing methods of passive cooling and obtaining estimation of best energy saving at the day resolution (31%) and also the lowering of energy on monthly data ranges from 6-11% [10]. With retrofit method measured can be created annual energy saving of 33% for lighting and 37% for air conditioning [11].

Renewable energy application was encouraged by several countries in recent years. Various modifications of solar technology (photovoltaic) are applied to buildings with system of Building Integrated Photovoltaic (BIPV) [12-14]. In Indonesia, this system will be very suitable since available abundant sun all over the year with relatively high intensity and on the other hand, air conditioning on building also need peak electrical source. Commercial buildings, for example has energy consumption profile in line with a trend of daily solar radiation. Energy sourced from renewable energy can be combined with energy from the national grid. Based on this case, obtained that photovoltaic (PV) technologies are more profitable compared with to the wind energy technologies. The BIPV system is very beneficial to be applied mainly on hot and sunny season [15, 16].

3.2. Energy assessment model and development

Based on previous study, energy building show significant increase year by year. Energy domestic building, for example, energy consumption from cooling and heating system take the biggest proportion in last 20 years especially in warm and humid climate [17]. They recommend a net zero building energy. They carried out the building project with a novel concept with review focus on basic guidelines, natural ventilation systems, cooling and dehumidification, insulation and construction materials and also introduce wind tower dehumidification design and ventilated attic. Wimala *et al*. carried out an observation toward inhabitant about obstacles of green building development in Indonesia that have been issued by GREENSHIP [18]. This study was recognised several main obstacles are troublesome implementation, difficulties to conversion, lack knowledge and information, inattention, expensive of green building options, insufficient supervision, readiness of green products on the market, and absence

of building management regulation. In neighbour country, for example Thailand, concern on saving energy building and construction industry, in order to reach sustainable environment [19]. They recommended that in the environment resource crisis solving, the regulation from government is the effective to encourage the greenhouse gas emission from building sector. Chack and Leung introduce Greening the Existing Buildings (GEB), they give a systematic manner to develop strategies of how to reduce energy consumption [20]. They found good achievement with total of energy savings in a range of 40-60%. Qiu and Kahn examined from government incentive policy to encourage the green commercial building [21]. The incentives are including, accelerated construction permits, government grants, and tax incentives. The green application can energy saving as much as 8%, using empirical estimation. Brambilla *et al*. using Greenhouse gas emissions (GHG) indicator to assessment the green building [22]. This study refers to Nearly Zero Energy Building concept. With this concept, there is spectacular goal which can reduce GHG approximately 80% by 2050 the EU carbon emission. Liu *et al*. added nearly zero energy buildings promote Renewable Energy Technologies (RETs) [23]. The RETs concept emphasizing on photovoltaic hybrid system.

Depend on above studies, it can be summarised that green building is significantly urgent to be implemented in recent years. Green concept must be promoting and apply step by step to reach the low energy consumption until nearly zero energy building.

3.3. Balinese Green Energy Building (BGEB) model

Models are developed from previous research reviews, applicable standards and empirical data obtained. The main standard referenced is GREENSHIP, a research review of the latest international journal, and empirical data obtained from the audit results of several hotels in Bali. These aspects are combined with the environmental conditions of Bali area and the concept of *Tri Hita Karana* that has become a living view of Balinese people. Bali as an international tourist destination that provides many accommodations that must be the environment. To support this, the goal of this research is the realization of green tourism for the area of Bali or sustainable tourism. In addition to the conventional energy in the future becomes very rare and expensive, so the concept of nearly zero energy building becomes very urgent to achieve.

According to model which is shown in Figure 2 and clarified by the definition described in Table 1. The main aspects in the development of Balinese Green Energy Building including VAC load control, inhabitant behaviour, energy saving appliances/devices, renewable energy development, building aesthetic (architect) and energy consideration, and energy regulation and incentives. This main aspect should be supported with a campaign in saving energy building at all times for the concern of residents in maintaining the condition of saving energy. In this concept, the goal to be achieved is nearly zero energy building technology in facing the development of green tourism in the future. This concept should continue to assessment with the development of green building standards that are more relevant to the real conditions in the area of Bali. In the future the GREENSHIP standard must also be continuously developed and reviewed so that the assessment and certification become valid. So that the results of the model on this research is expected to contribute to the development of energy saving and conservation category. Which can be the most urgent thing for green building certification in addition to other aspects such as appropriate site development, water conservation, material resource and cycle, indoor health and comfort, building and environment management.

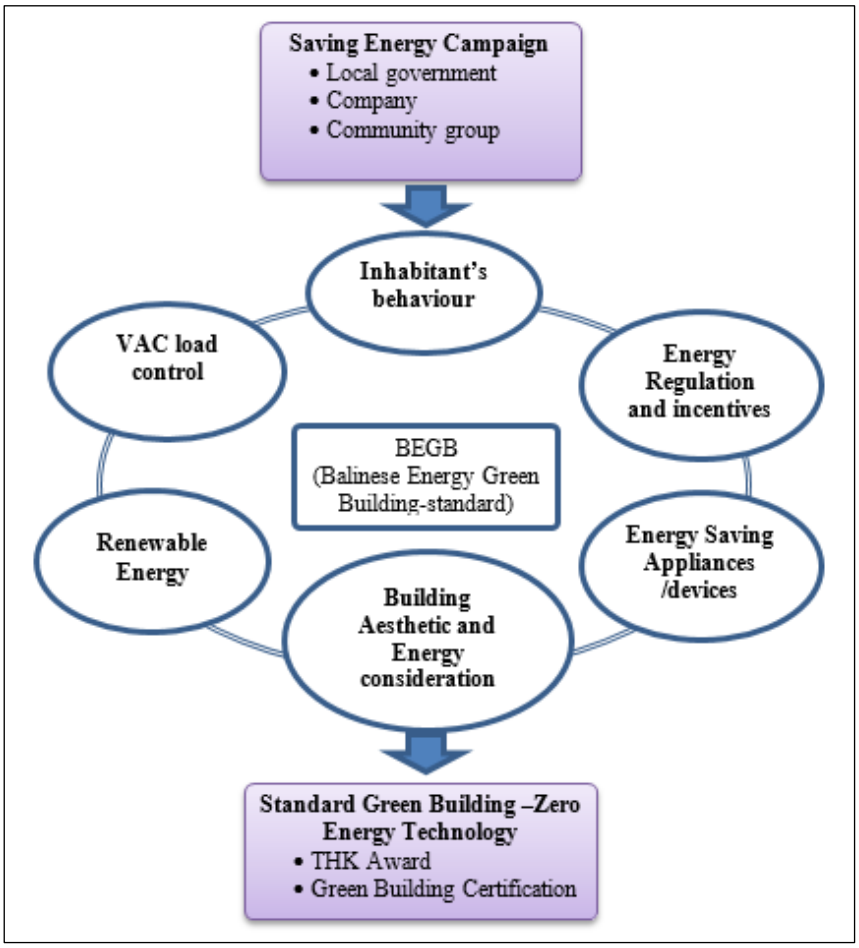

Figure 2. Model of Balinese Energy Green Building (BEGB).

Table 1. Definition of Model of Balinese Energy Green Building (BEGB).

No	BEGB aspects/categories	Definition
1	VAC load control	• envelope insulation • roof (Balinese Architect) • infiltration
2	Inhabitant Behaviour	• Energy use mode • Indoor comfort zone • Occupants livelihood • Retrofit frequency
3	Energy saving appliances /devices	• Daylight • Natural ventilation • LED lighting • Regularly maintenance appliances
4	Renewable Energy development	• BIPV (Building Integrated Photovoltaic) • Biomass • Solar thermal system
5	Building Aesthetic (architect) and Energy consideration	• Door and window insulation and material • roof material • Aesthetic lighting and indoor /outdoor
6	Energy Regulation and incentives	• Local government energy regulation • Renewable energy incentive • THK Concept

4. Conclusions

By adopting previous green building system, the category of energy efficiency and conservation energy, also referring several standards and references with concept of *Tri Hita Karana* and local regulation combination, it can be summed up as follows. Green building development model from the category of energy efficiency and conservation in accordance with the Bali region introduced BEGB (Balinese Energy Green Building) which is the development of the standard aspect developed earlier with Additional aspect of aesthetic (local architect) that nudge contradictory with saving energy building. Another important aspect is the regulation of local government specific to energy saving of buildings (domestic, hotels and other commercial buildings) as a follow-up of the regulation of Ministry of Energy. This aspect is very important in order to develop green building in Bali in order to reach green tourism in Bali. One of the urgent categories in the developed of Green building is energy efficiency and conservation aspects. This aspect was examined in this research. This aspect involved 13.59% weighting from overall assessment point which are including energy conservation campaign, simple commissioning, MVAC control, lighting power density and control, energy monitoring and control, electrical equipment and appliances. A recommendation for the new commercial building in the wake should apply strict regulations for energy saving standards, while for existing buildings encourage efforts of energy saving toward Green Building Certification.

5. References

[1] Santosa I D M C, Astawa I P, Waisnawa I N, Astawa I P M, Temaja I W and Sudiajeng L 2017 *Advanced Science Letters* **23** 12098-12102.
[2] ASHRAE 2014 *Energy Code for Commercial and High-Rise Residential Buildings* (Atlanta: ASHRAE Inc)
[3] GREENSHIP 2012 *GREENSHIP Rating Tool for Interior Space Version 1.0* (Jakarta Selatan: Green Building Council Indonesia)
[4] Lam J C, Wan K K W, Tsang C L and Yang L 2008 *Energy Conversion and Management* **49** 2354–2366
[5] Utama A and Gheewala SH 2009 *Materials and Design* **30** 2173–2180
6] Zhao H X and Magoulès Z 2012 *Renewable and Sustainable Energy Reviews* **16** 3586-3592.
[7] Krarti M and Hajiah A 2011 *Energy Policy* **39** 2319–2329
[8] Roslizar A, Alghoul M A, Bakhtyar B, Asim N, and Sopian K 2014 *The Scientific World Journal*
[9] Katunsky D, Korjenic A, Katunska J, Lopusniak M, Korjenic S and Doroudiani S 2013 *Building and Environment* **67** 138-146
[10] Campaniço H, Hollmuller P and Soares P M M 2014 *Applied Energy* **134** 426–438
[11] Mohit O K and Oree V 2013 *AFRICON Conference*
[12] Yoon J H, Song J and Lee S J 2011 *Solar Energy* **85** 723–733
[13] Good C, Andresen I and Hestnes A G 2015 *Solar Energy* **122** 986–996
[14] Shum K L and Watanabe C 2009 *Energy Policy* **37** 3535–3544
[15] Santosa I D M C, Wirajati I G A B and Temaja I W 2016 *MATRIX* **6** 260-268
[16] Braun P and Rüther R 2010 *Energy Conversion and Management* **51** 2457–2466
[17] Sudhakara K, Maximilian W S and Shanmuga P 2019 *Case Studies in Thermal Engineering* **13** 100-400
[18] Wimala M, Akmalah E and Sururi R M 2016 *Energy Procedia* **100** 469 – 474
[19] Lohmeng A, Sudasna K and Tundee T 2017 *Energy Procedia* **138** 417–422
[20] Chak B and Leung M 2018 *Energy Reports* **4** 159–206
[21] Qiu Y and Kahn M E 2019 *Energy Economics* **80** 461–475
[22] Brambill A, Salvalai G, Imperadori M and Sesana M M 2018 *Energy & Building* **166** 271-283
[23] Liu Z, Liu Y, He B J, Xu W, Jin G and Zhang X 2019 *Renewable and Sustainable Energy Reviews* **101** 329–345

Acknowledgments
This study was supported by the Bali State Polytechnic – Politeknik Negeri Bali for the in-cash contribution. The authors wish to acknowledge the contributions of Mechanical Engineering Department - Bali State Polytechnic for the in-kind contributions, also Centre for Research and Community Service (P3M) for all administrative support.