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The Concept of Green Building in The Application of Solar Panels on the Roof of Residential Houses for CO_2 Emission Reduction

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A B S T R A C T

The development of sustainable development with the concept of the green building creates environment-friendly and energy-efficient buildings with solar panels as a source of electrical energy, uses energy-saving lamps, uses indoor vegetation, creates noise reduction system, and maintains environment temperature and humidity. The application of green building solar panels is influenced by several factors, such as the intensity of solar radiation, wind speed and direction, humidity, distance and height of surrounding buildings, and the level of pollution from the residential area. This study aims to develop the concept of green building in the application of solar panels on the roofs of residential neighborhoods to reduce CO_2 emissions. The analytical method used is descriptive and qualitative analysis, with a literature survey related to the types of solar panels, identifying the conditions of existing houses in the study area, and analyzing the suitability of the space for the placement of the solar panels to be placed by taking into account the provisions of the shape and area of the roof of the house. The results of the analysis stated that the green concept house strategy, for the 86m^2 type house at BNP 2 Makassar City, is rated platinum with a score of 77. The real impacts of environment-friendly houses are the installation of renewable energy, replacement of LED lamps, and installation of light sensors. Solar panels produce 19.5% carbon gas emission in a month compared to carbon gas emissions generated from the use of PLN electrical energy by using 10 panels for an 86 m^2 house type, which means an 80.5% reduction in carbon gas emission.

Keywords: Energy Analysis, CO_2 Gas Emissions, Green Building, Solar Panels.

1. Introduction

Environmental problems, especially global warming, have become a topic of problems that have emerged recently. health problems and discomfort due to air quality and air pollution in occupied buildings that affect occupant productivity, poor air ventilation, and lack of natural lighting. This is caused by several things, for example, photocopier ozone emissions, pollution from furniture and wood panels, cigarette smoke, etc. Energy-saving buildings or known as green buildings are continuously being promoted as one of the anticipatory steps towards global climate change. With the right energy-saving concept, the energy consumption of a building can be reduced by up to 50%, by only adding 5% investment during construction. Green building was built with modern energy planning. Apart from the design that is considered to minimize the entry of sunlight to reduce the use of air condition loads, solar panels can be installed on the roof of the building that can be used as an energy source. Several points of view can be considered in the planning including aspects of passive design, active design, room air conditions, management, and service and maintenance. In Indonesia, power plants are dominated by coal-fired steam power plants (48%), gas and steam power plants using gas (22%), and diesel power plants using diesel fuel (11%) [1, 2]. However, the presence of fossil fuels used in most power plants is dwindling and producing carbon dioxide emissions. The development of sustainable development with the concept of the green building creating environmentally-friendly and energy-efficient buildings can help save the energy crisis. One of the renewable energies that have great potential to be used as a source of electrical energy in Indonesia is solar cells.

Solar power generation is an alternative to replace fossil fuel power plants. Analysis of the potential for reducing CO2 emissions through solar power plants is carried out by reducing the amount of electrical energy from fossil fuel plants. Based on the use of electrical energy from fossil

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fuel plants, it can be seen that the average CO_2 emission factor from fossil fuel plants is 0.743 kg CO_2/kWh, meaning that to produce 1 kWh of electrical energy through fossil fuel plants, CO_2 emissions of 0.743 kg are generated [3]. In conditions like today with electricity bills that tend to increase, we need to make savings. solar power plant investment which is quite high at the beginning is not an obstacle if you want to save electricity in the future. The value you spend will be proportional to the benefits obtained. In addition, the maintenance can also be done by the owner of the house every 6 months.

Techno-economic simulation of a grid-connected PV system design as specifically applied to residential in Surabaya, Indonesia. This inquires was conducted to assess the specialized, financial, and natural perspectives of a PV framework to supply family electrical vitality needs. 1 kW grid-connected reenacted with PVsyt and RETScreen computer program. Normal day-by-day worldwide radiation accessible in Surabaya is 5.17 kWh m-2 d-1, or around 1887 kWh m-2 yr-1. The most noteworthy insolation level was recorded at 1005 W m-2. Based on this sun-oriented vitality potential, a 1 kW grid-connected PV framework can send power to the network at around 1.3 MWh yr-1 on normal. The return on this venture is gotten after 17.6 a long time. Grid-connected PV frameworks are not fiscally attainable to meet private power needs in Surabaya. In the interim, by executing a feed-in tax at USD 0.25 (kWh)-1, the payback period will be around 6.5 a long time. The rate of diminishment of nursery gasses (GHG) by executing the 1 kW PLTS framework is assessed to be around 1.66 kg SO_2; 3.46 kg NOx; 1 295 kg CO_2; and 91 kg of cinder per year.

Based on a literature study, as long as the solar panel is operating, there are no costs to be incurred for maintenance and replacement because the age of the solar panel can technically reach 25 years and the maintenance method only needs to be wiped and cleaned [5]. Solar panels can harm air traffic due to light that is not fully absorbed reflected upwards. This hot light can also disrupt the ecosystem because it can kill animals that pass above it [6].

Based on the above, the purpose of this study is to analyze to develop the concept of green building in the application of solar panels on the roofs of residential neighborhoods as a reduction in CO_2 emissions.

2. Literature Review

a. Green Building

Green building refers to a structure and uses environmentally responsible and resource-efficient processes throughout the building life cycle: from siting to design, construction, operation, maintenance, demolition, and renovation. This practice extends and complements classical building design concerns of economy, utility, durability, and comfort. Green building is a concept for 'sustainable building' and has certain requirements, namely location, planning and design systems, renovation, and operation, which adheres to energy-saving principles and must have a positive impact on the environment, economy, and society. Although new technologies are constantly being developed to complement the current practice of creating green structures, the general goal of designing green buildings is to reduce the overall impact of the built environment on human health and the natural environment by:

1) Efficiently using energy, water, and other resources; designing the equipment to cost less to operate and to have excellent energy performance.
2) Protecting occupant health and increasing employee productivity
3) Reducing waste, pollution, and environmental degradation
4) Focusing on natural buildings, which are usually on a smaller scale and tend to focus on the use of locally available natural materials.
5) Not specifically prioritizing retrofitting existing homes.
6) Reducing environmental impact.

According to Green Building Council Indonesia [7], a house is a building that functions as a place to live or a residence and a means of fostering a family. The concept of an environmentally friendly house should fulfill the basic habit of living by meeting the building safety requirements and the minimum adequacy of the building area and the health of its occupants. An eco-friendly house is a house that is wise in using land, efficient and effective in the use of energy and in using water, paying attention to the conservation of natural resource materials as well as being healthy and safe for the occupants of the house. Environmentally friendly and safe home care is also an important factor because the sustainability of an environmentally friendly home must be accompanied by environmentally friendly behavior by its residents. Understanding the concept of an environmentally friendly house is the main factor that must be prioritized to avoid misunderstanding the notion that an environmentally friendly house or green home is a house that requires high maintenance costs or is a house that only has a lot of green lands.

b. Solar Panel

A solar power plant is a power plant that converts solar energy into electrical energy. Electricity generation can be done in two ways, namely directly using photovoltaics and indirectly by concentrating solar energy. Photovoltaics converts light energy directly into electricity using the photoelectric effect. The concentration of solar energy uses a system of lenses or mirrors combined with a tracking system to focus solar energy to a single point to drive a heat engine.

A solar cell or photovoltaic cell is a device that converts light energy into electrical energy using the photoelectric effect. First created in 1883 by Charles Fritts.

The majority of electricity used in Indonesia comes from power plants with coal as raw material. The problem is, from this process a lot of carbon emissions

are released which is the biggest source of global warming.

Meanwhile, the electricity demand is getting bigger day by day. Take a look at how many appliances at home cannot run without electricity, from lights, cell phones, TVs, to air conditioners and refrigerators. Not to mention the wasteful use of electricity. As a result, power plants are no longer able to provide electricity as much as they demand. That's why blackouts are happening more and more often.

3. Methodology

The research location is the Bukit Nirwana Permai housing complex, Makassar City, South Sulawesi Province. The analysis used is descriptive and qualitative analysis, by conducting a literature survey related to the types of solar panels, identifying the conditions of existing residential houses in the study area, and analyzing the suitability of the space for the placement of the solar panels to be placed by taking into account the provisions of the shape and area of the roof of the house. A green building is a building that meets the requirements based on good performance measurable in terms of saving water, energy, and other resources. One of the conditions and measurable calculations to appraise buildings green in Indonesia is called Greenship which was done by Green Building Council Indonesia (GBCI) which has joined the World Green Building Council (WGBC) with 37 other countries. Greenship is a building measurement system green in Indonesia, which is different from other countries with its benchmark and name. Greenship New Building Version grading system 1.2 is broken down into 6 categories with 8 total prerequisite criteria, 37 credit criteria, and 1 criteria bonus. 6 categories in the evaluation of the Greenship assessment

New Building version 1.2 consists of:

1. Appropriate Land Use (Appropriate Site Development/ASD)
2. Energy Efficiency and Conservation (Energy Efficiency and Conservation/ EEC)
3. Water Conservation (WAC)
4. Material Resources and Cycle (Material Resources and Cycle/ MRC)
5. Indoor Health and Comfort (Indoor Health and Comfort/ IHC).
6. Building Environmental Management (Building Environmental Management (BEM)

Table 1. Greenship Benchmark Criteria, New Building version 1.2

Category	Criteria			Total
	Precondition	Credit	Bonus	
ASD	1	7		8
ECC	2	4	1	7
WAC	2	6		8
MRC	1	6		7
IHC	1	7		8
BEM	1	7		8
Total Point	1	37	1	46

Source: GBC Indonesia, 2013

Credit criteria have certain points that if these points can be achieved by the minimum total points required by the GBCI, a building is certified according to the standard refers to Greenship New Building version 1.1 as in the following table:

Table 2. Greenship Predicate Level, New Building version 1.1

Predicate	Minimum Points	The points that obtained (%)
Platinum	74	73
Gold	58	57
Silver	47	46
Bronze	35	36

Source: GBC Indonesia, 2013

The application of the green building concept with Total Energy (Wh), Solar Panel Efficiency (η_{max}), Output Power (PG), the efficiency that occurs in solar panels is the ratio of the power that can be generated by solar cells with energy obtained from solar radiation and used is efficiency at any time in the data collection process, namely CO_2 Gas Emission Calculation.

4. Results and Discussion

1. Green Building Concept in Residential House

According to GBCI (2011), a house is a building that functions as a place to live or a residence and a means of fostering a family. The concept of an environmentally friendly house should fulfill the basic habit of living by meeting the building safety requirements and the minimum adequacy of the building area and the health of its occupants. An eco-friendly house is a house that is wise in using land, efficient and effective in the use of energy and in using water, paying attention to the conservation of natural resource materials as well as being healthy and safe for the occupants of the house. Understanding the concept of an environmentally friendly house is the main factor that must be prioritized to avoid misunderstanding the notion that an environmentally friendly house or green home is a house that requires high maintenance costs or is a house that only has a lot of green lands.

1. Environmentally Friendly Home Materials
   One of the main characteristics of a house with a green building concept is environmentally friendly house materials. The use of wood and bamboo is the most popular because it is durable and looks attractive. Utilizing environmentally friendly materials will minimize harmful residual substances.
2. Using a Brick Wall
   Brick walls are still the best choice for homes in Indonesia. Bricks are not only cheap but also effective in minimizing heat and not easy to absorb water. In addition, bricks also have good durability. So that the building of the house will be strong for many years.
3. Small Number of Permanent Bulkheads

Houses that carry the concept of green building usually have few permanent partitions because permanent insulation will block the flow of air in the house, so the house will feel cooler and airier without permanent insulation.

4. Adequate Natural Lighting System
   A house that is in harmony with the environment cannot be separated from a natural lighting system. Various natural lighting systems in the form of windows, posters, and skylights to get adequate natural light from morning to evening make the house healthier and always bright with the support of natural light.
5. Using Energy Saving Electronic Devices
   The concept of a green building house is also synonymous with the use of energy-efficient electronic devices. Various types of the latest electronic devices are now equipped with energy-saving systems.
4. Land for Crops
   The existence of plants is important to create a beautiful and cool home. Planting various types of fruit and vegetable crops whose results can be consumed and oxygen-producing plants.
5. Installing the Solar Panel
   The use of solar panels is now increasingly popular in the country. Because the energy produced by solar panels in tropical climates is very large.

Figure 1. Example of a Type 86m^2 BNP 2 House

Based on the parameters of the greenship home [7] above, the results of testing the type 86m^2 house with a green concept include:

Table 1. Greenship Home Checklist Assessment

Criteria	Description	Score
Appropriate Site Development (ASD)	1. Have minimum vegetation of 30% of the land area	1
	2. The planting of protective trees in the yard of the house is more than the minimum standard	1 1
	3. Build in an area that is equipped with at least 5 of the city's facilities	1
	4. There are a minimum of 5 types of public facilities within the distance of reaching the main road as far as 1 km from the site	1 1 1 1 1
	5. There are house design efforts for mosquito control	**9**
	6. There is a termite control management effort	
	7. Access to public transport routes within 500 m	
	8. There is the handling of rainwater runoff for the roof.	
	9. There is the handling of rainwater runoff for the yard.	
	Score	
Energy Efficiency and Conservation (EEC)	1. Provide sub-metering for lights	1
	2. Provide sub-metering for the contact box (socket)	1
	3. Knowing the average use of lamps in the calculation of units of Watt/m2	3
	4. Using building materials that can reduce heat on the entire roof	2 **8**
	Score	
Water Conservation (WAC)	1. Has a total water saving score of 4-5, namely 6 liters for all toilets, 9 liters for showers, and 7 liters for all faucets.	1
	2. Provide rainwater storage facilities with a minimum capacity of 200 liters	3 3
	3. Meet point 1 and use rainwater to flush the toilet	**7**
	Score	
Material Resource and Cycle (MRC)	1. Using old materials for a minimum of 45% of the total cost of materials used	
	2. Using materials derived from the recycling process of a minimum of 30% of the total cost of materials used	3
	3. Using materials whose production process has an environmental management system of at least 30% of the total cost of materials used.	3 3
	4. The use of wood is legal	1
	5. Using materials that use a prefabricated off-site system of at least 30% of the total cost of materials used	3 3 1
	6. Using materials from within the country	3 **20**
	7. Using materials from a radius of 1000 km	
	8. Segregation of organic and inorganic waste	
	Score	
Building Environment Management (BEM)	1. Following routine activities around the house area as an effort to increase environmental awareness and maintain the sustainability of the area around the house.	3 3
	2. Involving a minimum of an expert who has competence in house construction starting from the planning (design) stage to the completion of the construction stage (including fit-out activities)	2 2 2
	3. The existence of a health and safety system for both workers and residents of the house during the construction period	2
	4. The existence of an environmental	**14**

	management system in the land during the construction period 5. Innovation in design, technology, and house performance so that they can provide benefits to the area around the house and contribute to environmental issues beyond the GREENSHIP HOME criteria by involving all residents of the house 6. There is a plan that anticipates the house growing	
	Score	
	Total Score	**58**

Source: Analysis Results 2021

From the table above, it can be seen that following the green concept house strategy, the condition of the 86m^2 type house in BNP 2 Makassar City is rated platinum with a score of 77 [7]. The real impact of eco-friendly homes is the installation of renewable energy, replacement of LED lights, and installation of light sensors. The green building concept has been applied with buildings following the contours of the land, providing less than 40% green open space at a distance from the building, as well as a system for reducing rainwater runoff with infiltration wells, paving, and grass blocks, using inefficient energy-saving lamps, lighting, and circulation. natural air is less than optimal, use of AC as needed, street lighting, wastewater treatment system as a new water source only for watering plants, installation of light sources and air circulation with light, temperature, and humidity levels per SNI, addition of vegetation, and provision of temporary landfill without segregation and liquid waste treatment system.

2. Potential Analysis and Reduction of CO_2 Gas Emissions in Residential Houses

Table 2. Electrical Load Requirements

Room	**Number (units)**	**Load (watt)**	**Energy/day (wH)**	**Energy/month*30 (wH)**
Carport				
Lamp	1	4	0,048/12 hours	1,44
Terrace				
Lamp	1	4	0,048/12 hours	1,44
Living Room				
Lamp	1	4	0,004/6 hours	0,72
AC ½ PK	1	400	0,4/6 hours	72
TV Led 55”	1	60	0,06/6 hours	10,8
Master Bedroom				
Lamp	1	4	0,004/6 hours	0,72
AC ½ PK	1	400	0,4/12 hours	144
TV Led 43”	1	50	0,005/6 hours	9
Bedroom				
Lamp	1	4	0,004/6 hours	0,72
AC ½ PK	1	400	0,4/12 hours	72
Bathroom	2	8	0,008/8 hours	1,92
Kitchen				
Lamp	1	4	0,004/6 hours	0,72
Refrigerator	1	171	0,171/24 hours	123,12
Washing Machine	1	300	0,3/3 hours	7,2
Jet Pump Etc	1	900	0,9/2 hours	21,6500
			Total Energy	1043,1

Source: Analysis Results 2021

Based on the table above, planning a solar home system for the house simple residence type 86 m2 is done by determining the required electrical load capacity per household presented in Table 3 and Table 4 below.

Table 3. Table Of Average Solar Radiation in Months

Jan	Feb	Mar	Apr	May	June	July	August	Sept	Okt	Nov	Des	Average
3,54	3,59	3,5	4,5	4,29	3,92	4,12	4,51	4,37	4,13	3,82	3,32	3,98

Source: Makassar City Statistics Agency 2021

Table 4. CO_2 Gas Emission Calculation

Total Energy		CO_2 Gas Emission Calculation				Reduction		Percentage of carbon emissions
PLN	Solar Panel	PLN	Solar Panel	Emision Factor	GWP CO_2	Solar Panel	PLN	
15604 x 30 =468120 468120/1000 = 468,12	PG = A x S x n x ηmax = 1,94 m2 x 3,98 kWh/m2/day x 10 buah x 15,46 % = 11,94 kWh/day x 30 hari = 358,2 kWh/bulan	468,12	358,2	0,887	1	961,052 7 kg CO2	4926,4948 kg CO_2	19,5%

Source: Analysis Results 2021

From the table above, it can be seen that the total energy used is 468.12 kWh/month. Meanwhile, the planning of a solar home system for a simple 86 m^2 type house is carried out by determining the capacity of the electrical load requirement of 358.2 kWh/month per household. So, it can be concluded that the use of energy from solar panels in a month can produce carbon gas emissions of 19.5% or carbon gas emissions are reduced by 80.5% when compared to carbon gas emissions generated

from the use of PLN electrical energy by using 10 panels to generate electricity. house type 86 m^2.

The principle of low-carbon development refers to efficiency in the use of energy in urban areas. Measuring carbon emissions is an attempt to better account for carbon so that emission reductions can be measured and verified reliably. Electricity consumption that is carried out at any time can produce carbon emissions in the form of a carbon footprint. In a solar panel, there are 36 solar cells, one solar cell can produce 0.5 volts of electric current which is converted from solar power. Sunlight can be converted into electricity for about 5 hours a day. Although sunlight can be converted into electricity only at certain hours, electricity can be stored in batteries so that it can be used at night or when there is no sun. Utilizing renewable energy with solar panels in everyday life, energy use becomes more efficient and reduces the use of petroleum which is very bad for the environment. So, it can be concluded with the concept of green building in the application of solar panels on the roof of residential neighborhoods as a reduction in CO_2 emissions is influenced by several factors such as the intensity of solar radiation, wind speed and direction, and humidity, as well as the distance and height of the surrounding buildings and the level of pollution.

5. Conclusion

Under the green concept house strategy, the condition of the 86m^2 type house at BNP 2 Makassar City is rated platinum with a score of 77. The real impact of environmentally friendly houses is the installation of renewable energy, replacement of LED lamps, and installation of light sensors. The use of energy from solar panels in a month can produce carbon gas emissions of 19.5% or carbon gas emissions are reduced by up to 80.5% when compared to carbon gas emissions generated from the use of PLN electrical energy by using 10 panels for an 86 m^2 house type. Utilization of renewable energy with solar panels and the concept of green building in the application of solar panels on residential roofs in residential neighborhoods as a reduction in CO_2 emissions is influenced by several factors such as the intensity of solar radiation, wind speed, and direction and humidity, as well as the distance and height of surrounding buildings and pollution levels.

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