Bioclimatic Solar Home Design in Bangkok Thailand

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Abstract
This research aimed to study the bioclimatic home design in Bangkok, Thailand, and the installation of Photovoltaic System on the roof. By collecting the climate data from sample single-story house in Bangkok, having an open courtyard of dimension 4.00 x 4.00 meters. It is observed that the key of bioclimatic solar home design comprises of house orientation with the pitch roof of 15 degrees south, and an open courtyard that gives good ventilation, adequate natural light and a suitable landscape. The garden contains various species of plants that are homes for small creatures such as squirrels and birds, and together formulating a biotope and balanced ecological system. By connecting the courtyard to kitchen, dining and living area creates a bond between the house inhabitants and nature, promoting a healthy emotional and physical well-being. The courtyard generates a micro climate in which helps reducing the ambient temperature. When adapting the bioclimatic home with 30 square meters of Photovoltaic System installed on the roof, using grid connected PV system. The inverter, with maximum power generation capacity of 3.3 kW, can supply electrical energy at an average of 12kWh/day. This helps in lowering the monthly electricity cost by 30% and decreasing the amount of carbon dioxide gas consumed in the electricity process by 8.8 kilogram per day. The return on investment will be about 10 years and 7 months. This will help to further develop zero energy home design.

Keywords: Bioclimatic house, Solar Home, Alternative Energy House, Low energy House

Introduction

This research presents a sample house that features the design of Bioclimatic Home, with the focus on saving electricity energy utilization from air-conditioning, also known as "Passive and low energy architecture (PLEA)" and with the installation of Photovoltaic System on the rooftop to generate electricity in supplement to the electricity supply from the Metropolitan Electricity Authority.

This sample house is located in Bangkok, the capital city of Thailand in the Southeast Asian region. The sample bioclimatic solar home in Bangkok is situated in a populated business district surrounded by high-rise buildings, and at 3 kilometers from Chatuchak Park, a large recreational public park in Bangkok. The house compound also comprises of a home garden that foster an urban ecological system, and also helps to reduce the urban heat island effect, thus promoting happiness for the inhabitants with a pleasant climate and green environment. The home garden also accommodates small birds and squirrels, and maintains the temperature inside the house to be within the comfort range and helps to reduce the utilization of air-conditioning system.

Bangkok is situated on the eastern bank of the Chao Phraya River at Latitude $13^0$45' North, Longitude $100^0$30' East, and with the intensity of solar radiation (irradiation) measured at 4.75 kWh/m^2/day±15%, and the average daily peak measurement of solar energy at 850Watt/m^2, which is ideal for installation of the Photovoltaic system.

Figure 1: Site and surrounding of a sample house in Bangkok, located 3 kilometers from Chatuchak Park. The site has an area of 730 square meters, and is surrounded by high-rise buildings.

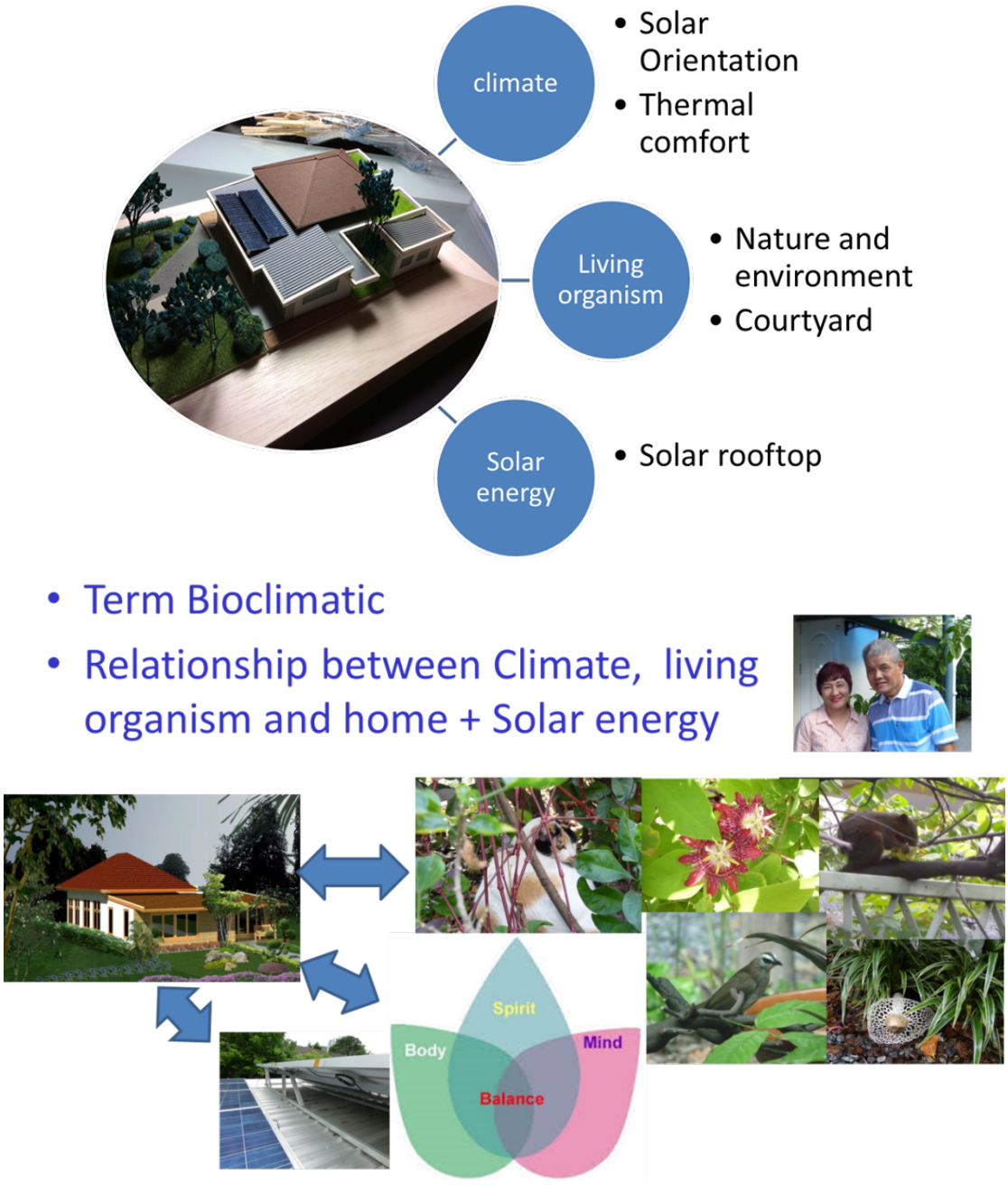

Figure 2: Diagram of the bioclimatic solar home design in Bangkok.

The climate of Bangkok, Thailand

Bangkok has the tropical climate with 3 seasons: summer season starting from mid-February until mid-May; rainy season starting from mid-May until mid-October, and winter season starting from mid-October until mid-February. The average temperature throughout the year is around 28.5^{0}C, the highest average temperature during April month measures at 35.8^{0}C, the lowest temperature falls in December month at 21.0^{0}C. The annual average relative humidity is around 72.3%, the highest relative humidity measures at 92.3%, and the lowest relative humidity measures at 43.8%, the average wind speed records at approximately 2.6 Knot, the annual average precipitation in depth of 1,337.5 millimeters (as recorded by The Thai Meteorological Department,

1980-2009). Bangkok exhibits the urban heat island effect, in which the temperature in urban area is higher than the outer city area.

Figure 3: Bangkok city situated on the eastern bank of the Chao Phraya River at Latitude: 13°45′ N, Longitude: 100°30 ′ E.

Method of research

1. Studying the comfort climate by collecting the climatic data from a sample house, and plotting the data on bioclimatic charts.
2. Studying the eco-friendly environment, from observation of the ambiance within the garden and courtyard.
3. Studying the installation of Photovoltaic system on the rooftop, from the survey and selection of Grid tied system and Off-grid system.
4. Studying the electricity energy that is generated from solar panels, by adjusting the inclination of solar panels to correspond to the roof gradient. And the inclination of 15 degrees by theory will yield the maximum output.
5. Recording the data of electricity energy that is generated from the inverter.
6. Calculating the period for return of investment for the installation of the Photovoltaic system.

Figure 5: Photovoltaic system on the rooftop of a sample house.

The sample house in terms of passive low energy architecture and bioclimatic home in Bangkok

The sample house has a land area of 47.65 x 15.32 square meters, the utilization area of the house is 170 square meters, and the ecological open area totals up to 77%. The characteristic of the house is a single-storey house constructed from steel reinforced concrete; with the flooring as steel reinforced concrete beneath glazed floor tiles which facilitate good heat transfer to the ground; the walls are plastered with cement and glazed tiles, which exhibit high heat tolerance; the roofs are installed with metal sheets and underlined with polyurethane foam at thickness of 5 millimeters, and also installed with heat insulating material at the ceiling, made from fiberglass with thickness of 3 inches.

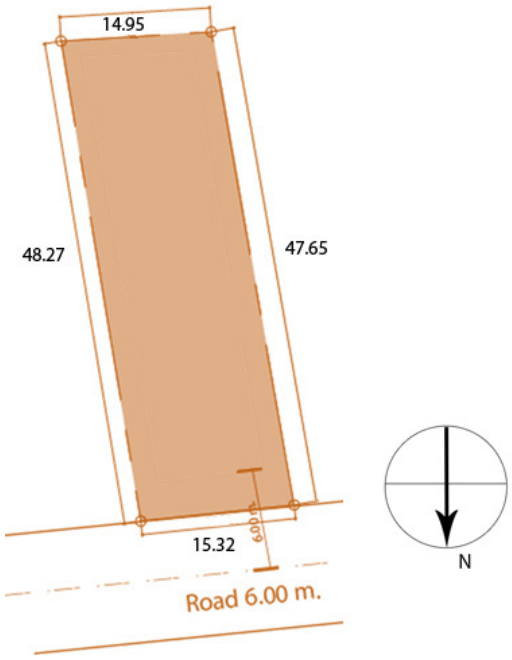

Figure 6: The land area of 47.65 x 15.32 square meters

Solar Orientation

the house plan arrangement is in accordance with the sun path diagram, in which the openings are oriented in the north and south direction to allow for the seasonal winds, whereas the east and west zones have fewer openings and with more trees to create shading against the sunlight.

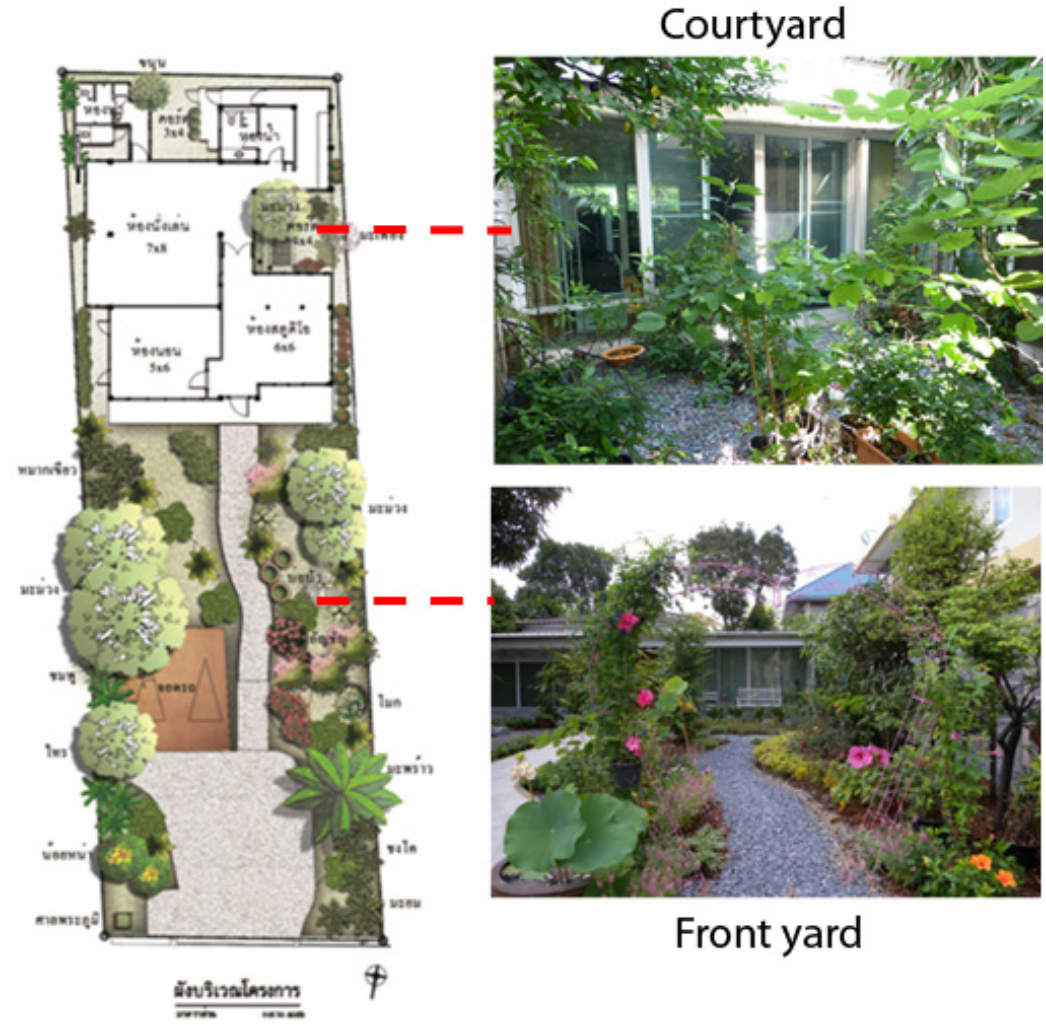

Figure 7: The courtyard with area of 4.0x4.0 square meters, the interior of the house, and the front yard.

Open Courtyard

The design for an open courtyard of size 4.0x4.0 square meters that is adjacent to the kitchen, living room, and studio room, to serve as ventilation zone and allow natural light to enter the house interior, helps to promote a close connection with nature. Whereas the front area that connects with the open front yard promotes cross ventilation and also allow natural light into the rooms. This adaptation of the climate and garden design helps to reduce the ambient temperature, and also maintains living comfort for the interior of the house.

Eco-environment

The nature-inspired garden design helps to foster the microclimate, which reduces the ambient temperature and also allows the inhabitants to connect with nature, as well as maintains happiness and health. In addition, the natural garden also serves as home to small creatures such as squirrels and various species of birds, butterflies, and so on

Figure 8: Image of a squirrel and a small bird that inhabit the courtyard.

Flexible space

The living room is interconnected with the courtyard; without partitions and doors in order to promote excellent air flow. The kitchen is set apart from the living area and next to the courtyard, which benefits proper ventilation.

Figure 9: Illustration of the cross-section of the courtyard, which connects to the living room.

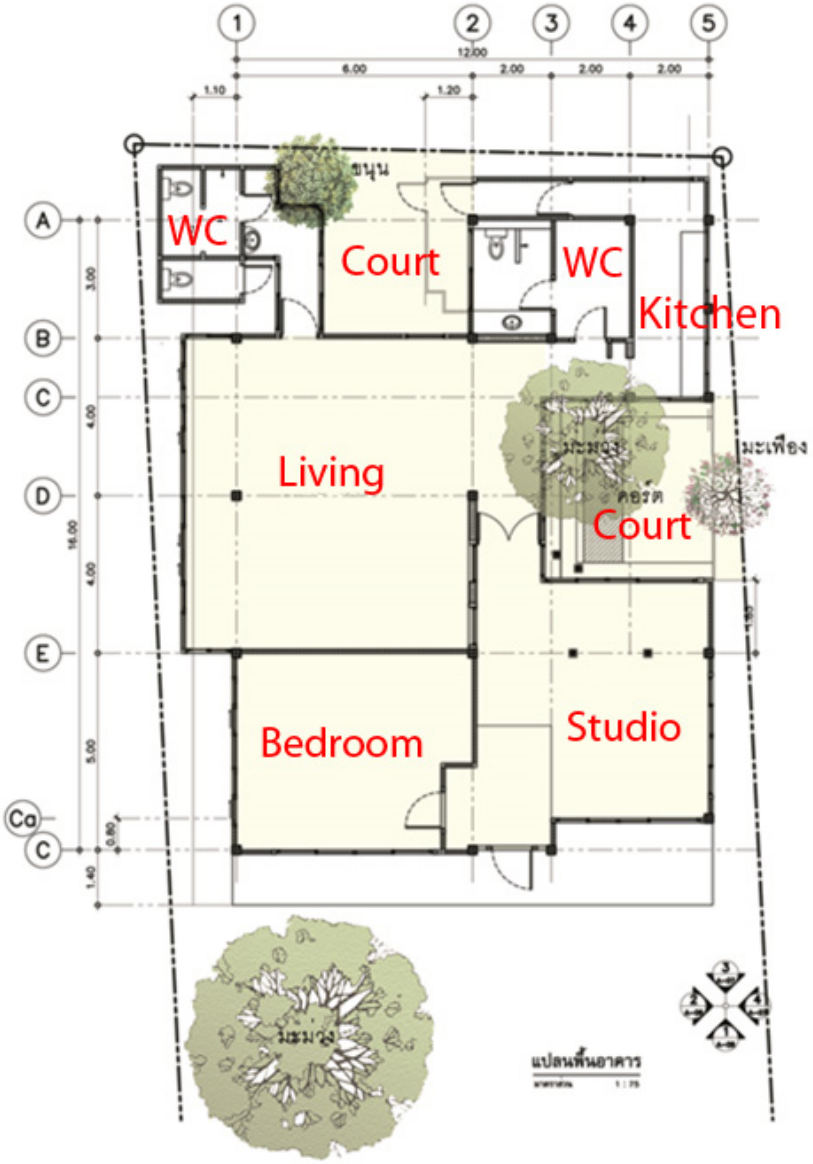

Figure 10: Illustration of the house plan and courtyard.

Materials and Insulation

The utilization of construction and insulating materials installed at the roofs effectively helps in protection against heat intrusion into the house.

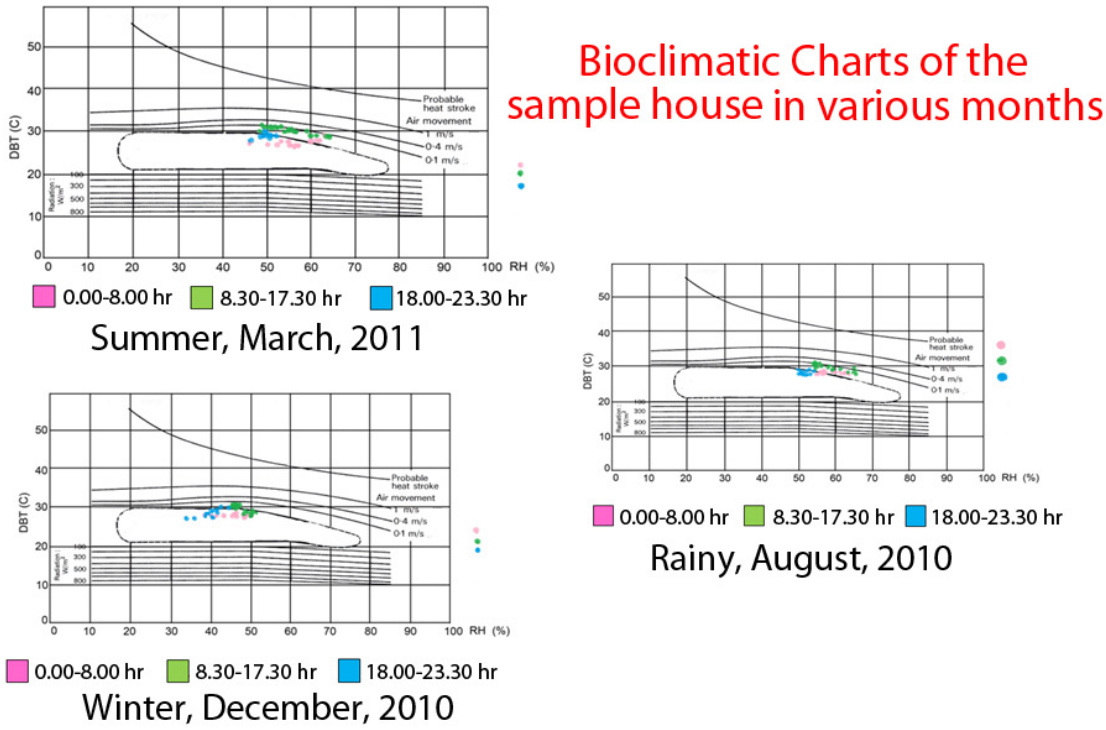

Figure 11: Illustration of Bioclimatic charts of studio room at the sample house

Photovoltaic System

the installation of solar panels on rooftop in order to generate alternative energy helps to reduce the amount of carbon and greenhouse gases, and also save electricity cost for urban houses. The selected system for implementation is the Grid tied system and installation of solar panels on the rooftop in the north direction, since this is the roof area that is not shaded by high-rise buildings and trees. The installation is tested with inclination of 5 degrees north to match the roof gradient, and elevated to an inclination of 15 degrees south; total number of 15 solar panels occupies the roof area of 40 square meters, and connected to an inverter grid tied with capacity of 3.3Kw, and then recording the electricity energy readings for comparison.

Selected system	Grid Tied system
Photovoltaic system area on roof	30 m^2
Roof area requirement	40 m^2
Inverter	3.3 Kw (ABB), Grid Tied system
Roofing	Metal sheet with insulation
Solar panels' angle and position	5 degrees' north at the north side of the sample house
Photovoltaic cell	Poly Crystalline (Suntech, STP 285) 24/VDC, 15 panels
Connecting safety device	MCCB 2 packs

Figure 12: Table illustrating the installation of photovoltaic system on a sample house rooftop.

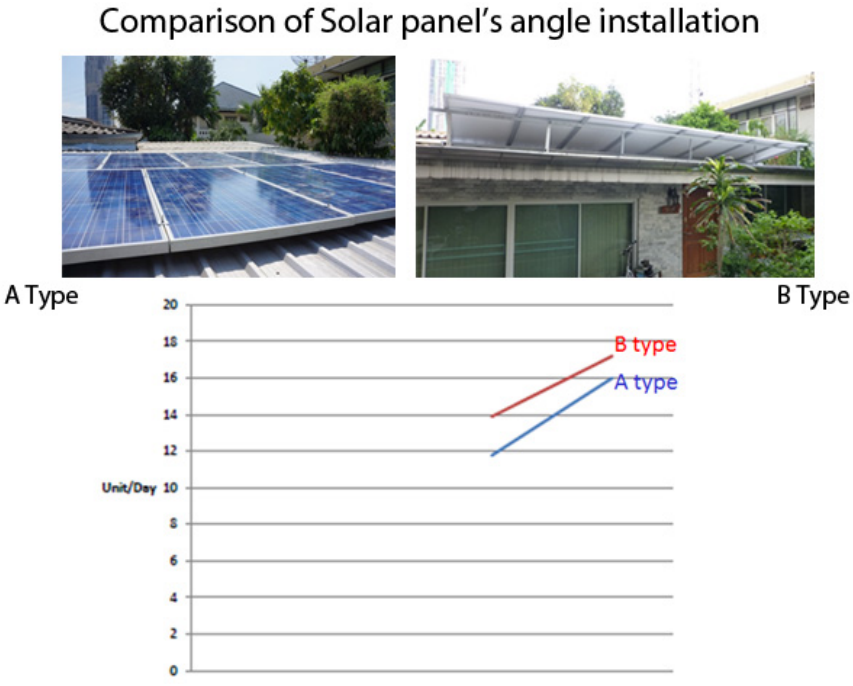

Figure 13: Comparison chart for electrical energy generated from solar panels with inclination at 5 degrees' North (A type) producing electricity of 12-15 unit/day, and solar panels with inclination at 15 degrees' South (B type) producing electricity of 14-17unit/day.

Conclusion

Bioclimatic solar homes in Bangkok, Thailand help to reduce the utilization of air-conditioning, for the design that features an open court and the garden that surrounds the house, as illustrated in the bioclimatic chart for the various rooms in the house.

The measurements of thermal comfort in the studio room in summer, rainy and winter seasons, most of which fall in the comfort zone, as well as measurements that are slightly outside the comfort zone, and in case of utilization of ventilating fan at speed of 0.1-0.4m/sec, this will increase the level of comfort to fit in the comfort zone. Hence the bioclimatic houses help to reduce the electricity utilization from air-conditioning.

The installation of the Photovoltaic system is capable of producing electricity up to 12kWh/day (12 Unit), 4,380kWh/year, with the solar panels oriented at inclination at 5 degrees north, and placed on the rooftop. This can compensate for electricity supply from the Metropolitan electricity Authority for each month up to 30%, and with an investment return period of 9-10 years. The cost for installation is 60,000 Baht/kWp. Then, it saves electricity cost up to 1,500 Baht/month, and reduces the amount of carbon from fossil fuel on the average of 3.2 ton per year.

Suggestions

The installation of thermal insulation at the roofs is essential for reducing the heat penetration into the interior of the house.
Courtyard and plants play an important role in passive design in an urban area.
The solar panels' 'inclination at 15 degrees' south is the most effective orientation for electricity generation.

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