

# BIO-SOLAR HOME

## The Integrated Design Approach for Renewable and Sustainable Solution

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### ABSTRACT

ite design and land use concepts are extremely important for housing design and urban renewal concept, especially when their relates to energy conservation and sustainable development. The solution presented will include the investigation of microclimate elements along with the actual monitoring data. The solution is finally used for designing the future bio-solar home which has proved to be very successful.

***Keywords:** Solar, energy, design, sustainable, architecture, bio-gas, photo voltage, renewable*

### INTRODUCTION

#### The Inspiration for the Bio-Solar Home

Development will never cease as long as people never stop thinking. Even a small event in daily life can become inspiration for a wonderful work. Notice a mango seed left on the ground, it will sprout and grow bigger naturally. Its power of surviving independently without human intervention is amazing. The tree adapts itself and becomes stronger, through heavy rain and sunshine. Three years later, the mango tree was big enough to yield its fruit. This is the inspiration

to design a home that could stand alone, using only natural factors such as daylight, moisture, and rainwater to produce its own facilities, while touting its surplus energy back to the public at the same time.

With this new concept, the home was built as an example of modern habitation that can stand alone in any region with a hot-humid climate, be built under a reasonable budget and with low maintenance cost. Just like the mango tree, the house has a unique capability to transform natural assets to its own advantages. Its combination of techniques makes it self-reliant. This practical innovation, home powered by the sun to create a better standard of living and distribute surplus energy to the public, is called the ***Bio-Solar Home***.

As the energy crisis grows more severe, the concept of a home that requires no power from the national grid is more attractive. The possibility for this kind of home was revealed by Dr. Soontorn Boonyatikarn's home. The academic papers about this innovation were presented in a national conference and were well accepted by the world-class audience.

***“The Bio-Solar Home is a choice that can maximize the solar potential while maintaining the superior standard of living with a reasonable price.”***



*Figure 1: The outside atmosphere of Dr. Soontorn Boonyatikarn's Bio-Solar Home that reflect the design concept of a sustainable and a superior standard of living.*

## DESIGN APPROACH

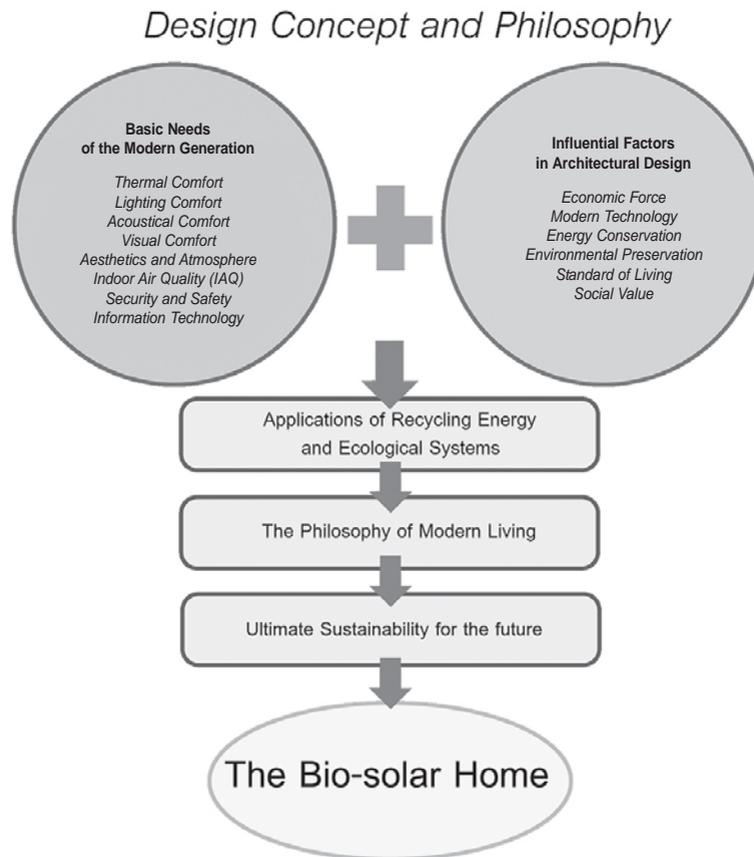


Figure 2

### Design to Control Cost

For the concept of the sustainable house, solar technology is one of the key factors to make it possible. Solar cells are the device that transforms solar energy to electricity for housing applications. With current technology, the transformation of solar energy to electricity is only 12-15 percent efficient. One way to avoid this problem is the efficient use of energy that helps reduce the air conditioning load.

The Bio-Solar Home, with a usable area of 140 m<sup>2</sup>, is 24 hours a day air-conditioned but requires only a 9,000 BTU/H air-conditioner. This is a result from a special design that considers every detail ranging from electricity, lighting, household appliances, pumps, and fans. Consequently, the energy demand is only 22 kWh/day, which is much less than that of a typical house

(315 kWh/day with an area of 300 m<sup>2</sup>). Therefore, it would not be possible for a single typical house to install solar cell since it needs 15 roofs to supply electrical demand. For Bio-Solar Home, it needs only 62.5m<sup>2</sup> on the southern roof to supply its entire electrical consumption.

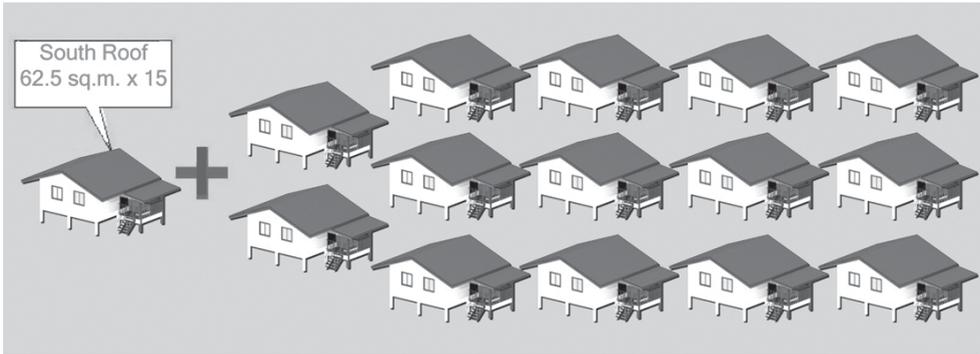


Figure 3: For a typical house, it requires the space of 15 roofs for solar cell installation in order to supply its electrical demand.

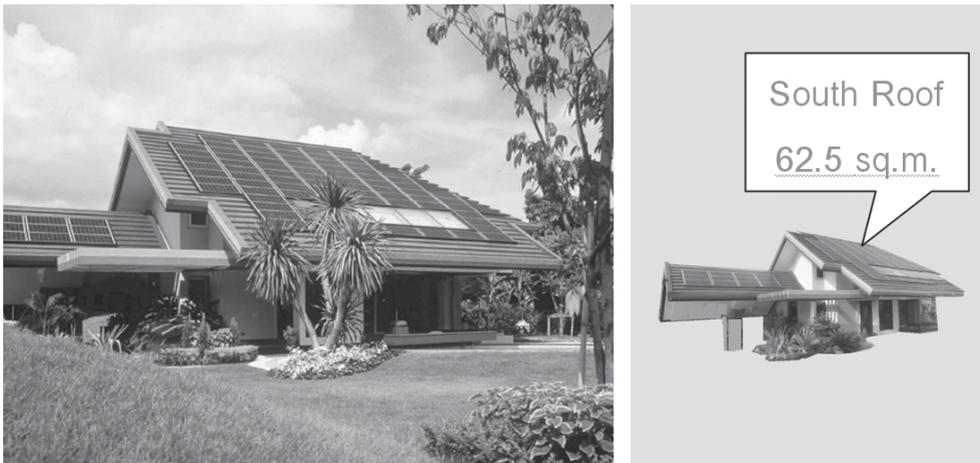


Figure 4-5: Only 1 roof (62.5 m<sup>2</sup>) of the Bio-Solar Home can supply its entire electrical demand.

## Design to Improve Site and Microclimate

### *The Advantage of Large Trees and Ground-Covering Plants*

In a hot-humid climate, many large trees are necessary for reducing the impact of heat in the daytime. The trees use energy from direct sunlight. They reduce heat in the environment by extracting water from the ground and evaporating

it through their leaves. In photosynthesis water is evaporated. During daytime, about 12 hours, one large tree can extract enough water from the ground, and evaporate, to reach approximately 65 liters per day.

From this process, the trees have an ability to reduce the heat in the environment equal to the capacity of a one-ton air conditioner (12,000 Btu/H). Planting large trees around the house will help reduce nearby temperatures.

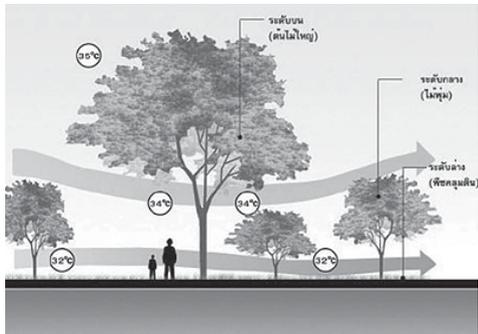


Figure 6: The application of large trees to create lower temperatures in the surroundings that allow wind currents to pass through the upper and lower part of the tree, and especially at the ground surface. This process offers low temperatures from evaporation. Large trees also reduce heat from direct solar radiation. Microclimate modification of the Bio-Solar home includes the use of trees and ground covering plants, the use of pond to reduce air temperature, etc.



Figure 7-8: Leaves at the upper part of the tree will provide shade and prevent heat. On the other hand, shrubs will not add humidity to the environment. These adaptations to the environment will lower temperatures to 30°C.

### ***The Advantage of Ground Covering***

Besides the obvious advantage of having large trees and ground covering plants, a good ground covering material will help reduce temperatures. Properties of the appropriate materials include low absorption (low specific heat) and high emissivity. They absorb underground water and evaporate it. In practice in the hot humid climate, dark colors and high absorptive materials must be avoided. For example, asphalt or a dark concrete block are bad choices because these materials will absorb heat and release it in the air causing the temperature to increase.

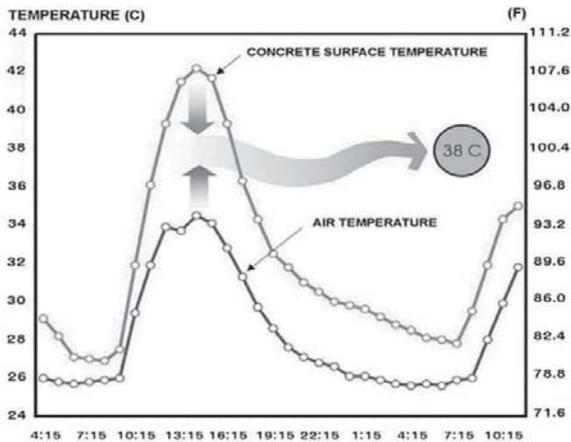


Figure 9: A comparison of concrete surface temperature and the air temperature. The concrete surface temperature with direct sun has a mean temperature much higher than the mean temperature of the air. It has a maximum temperature of 42°C. If the wind blows over the concrete surface, the air temperature will increase from 35°C to 38°C.

The graph demonstrates air temperature for a well-known concrete material, which absorbs heat. When the wind passes through the area, it will develop higher temperatures resulting in an undesirable environment that is not suitable for saving energy

Wet grass has a low temperature. Wind that passes through the area will have low temperatures that help create a more comfortable environment. Therefore, the use of wet grass under the shaded area will provide a more desirable environment.

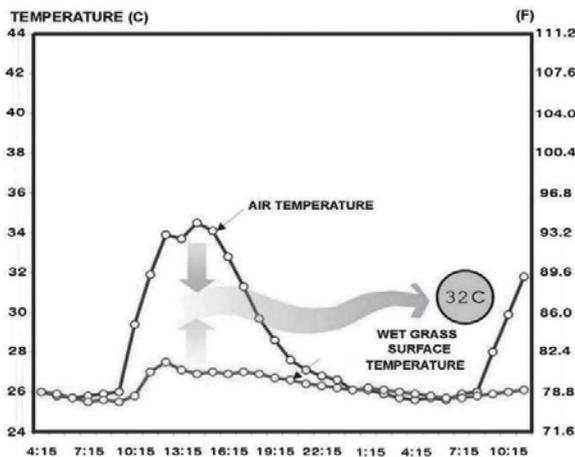
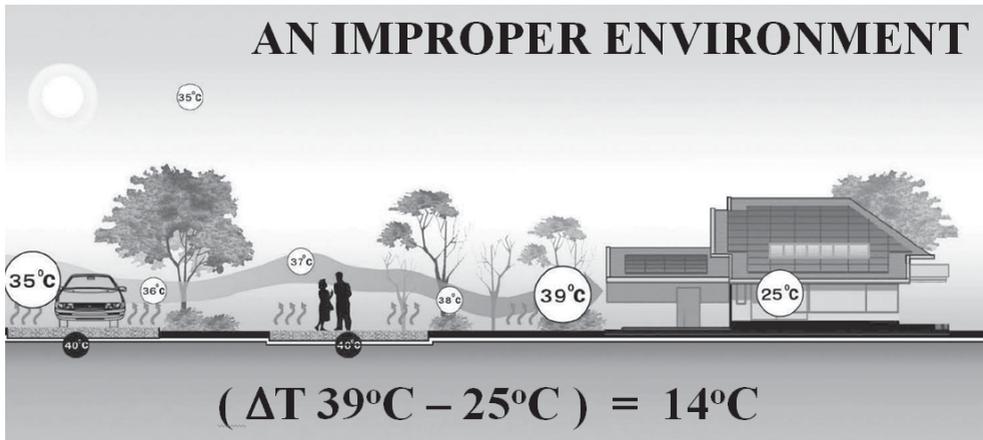


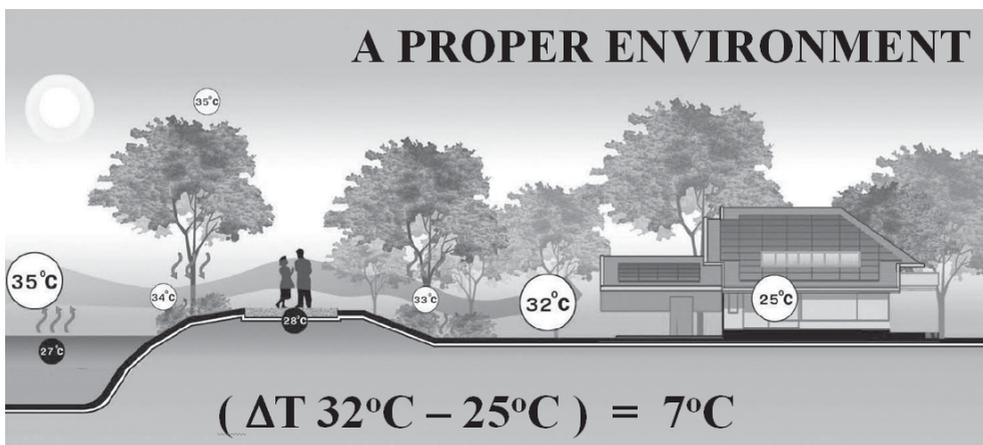
Figure 10: A comparison of wet grass surface temperature and air temperature. The wet grass temperature with sunshade has a mean temperature lower than the mean temperature of the air temperature all day. It has a maximum temperature at 27°C and minimum at 24°C. If the wind blows over it, the air temperature will reduce from 35°C to 32°C. This case helps to lower the surrounding temperature.



*Figure 11*

An improper environment arises from the application of concrete surface to an open area. For example, the road surface or concrete area exposed to the sun will accumulate heat (up to or more than 40°C). When wind temperature of 35°C passes through the area, it will increase to a temperature of 39°C or higher.

When there is a need to control room temperature at 25°C (for thermal comfort), lowering the temperature 14°C will consume more energy. Compared with a well adjusted environment, the improper environment will be two times higher in temperature.



*Figure 12*

This environment can be adapted by growing trees for heat reduction. When the wind passes through 35°C, it will decrease the temperature by 3°C.

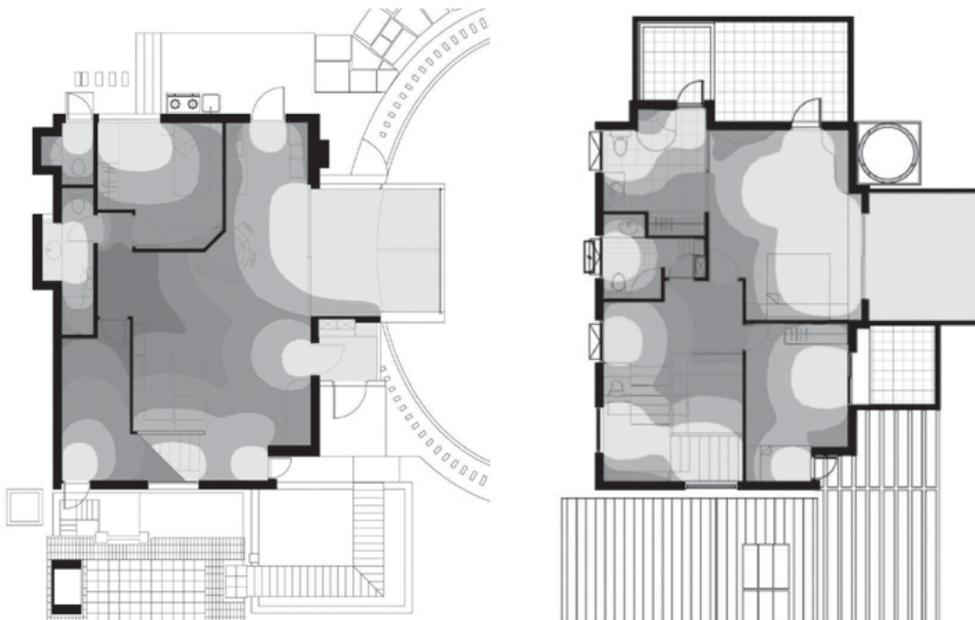
To maintain the 25°C room temperature will require energy to reduce heat only 7°C, which reduce energy consumption compared to an unadjusted environment.

### *Advantage of Natural Light*

The Bio-Solar home has been designed with shading devices and the surrounding trees, when associated with other techniques to reduce solar lighting. The reason is that direct solar radiation penetrates the house and generates too much glare in surroundings, which finally affects the occupants' eyes.

An additional technique that augments the amount of light is the design of the opening at the south, which allows light that is reflected from the pool to bounce off the white ceiling and then finally spread to the whole room.

The lighting quality of this house is adjusted by Heat Stop Glass. Heat Stop Glass is a special insulation which allows only light to penetrate the house. The heat from solar radiation does not enter.



*Figure 13-14: An adequate amount of lighting for all Parts of the house making it unnecessary for artificial lighting.*



*Figure 15-16: The environment of the master bedroom, which takes advantage of natural light and helps create a comfortable atmosphere.*

### ***Energy Saving Wall***

Appropriate wall selection is an important factor for saving energy. External wall is a major element exposed to the external environment. Outside heat can transfer through the wall and then to the inside. It affects room temperature and causes the air conditioner to operate more, which in turn raises electrical costs.

The appropriate wall to be selected should have a low heat transfer coefficient (U-Value). In addition, humidity is a major problem with the building skin. Although buildings are generally painted with several layers at the building envelope, this does not prevent humidity from entering the house. Humidity that penetrates the building envelope will condense into water drops that can cause allergies and respiration disorder.

Water condensation is difficult to prevent. The most effective way to exclude it is by preventing the condensation at the outer layer of the wall.

*An Exterior Insulation and Finished System (EIFS) wall will keep condensation on the outside of the building and force it to evaporate when it is exposed to sunlight the following day.*

The proper wall selection not only helps save energy, but it also raises the standard of living.

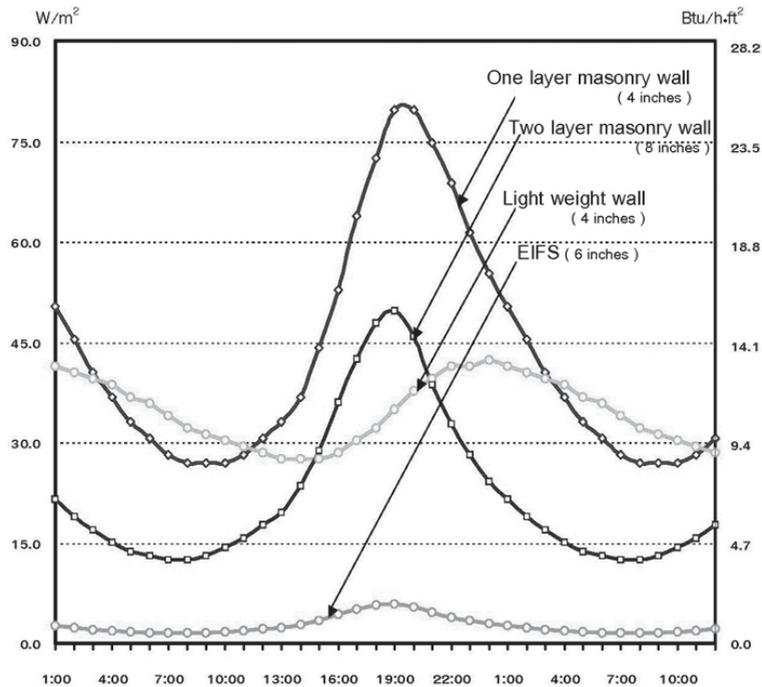


Figure 17: The heat transfers from the opaque wall into the house. The graph indicates that the one-layer masonry wall (4 inches) absorbs the highest heat. The two-layer masonry wall (8 inches) will absorb higher heat than a one-layer masonry wall during 04.00 – 10.00 a.m. The light-weight wall (4 inches) is similar to the EIFS wall (6 inches), but the EIFS wall absorbs much lower heat by 7 times.

## Design to Enhance Integration

### *Chilled Water Storage and Heat Rejection System*

One of the outstanding characteristics of the Bio-Solar Home is its air conditioning system, which combines several systems together. The various systems of air-conditioning can provide positive effects for the environment.

### *The Reduction of Cooling Load in the Building*

Cooling load in the building results from many sources such as walls, floors, roofs, glass, infiltration, equipments and the human body. The integration of design techniques, namely proper form selection, use of natural assets, and the proper material selection associated with new technologies, minimizes these cooling loads. Consequently the Bio-Solar Home consumes much less energy for air-conditioning.

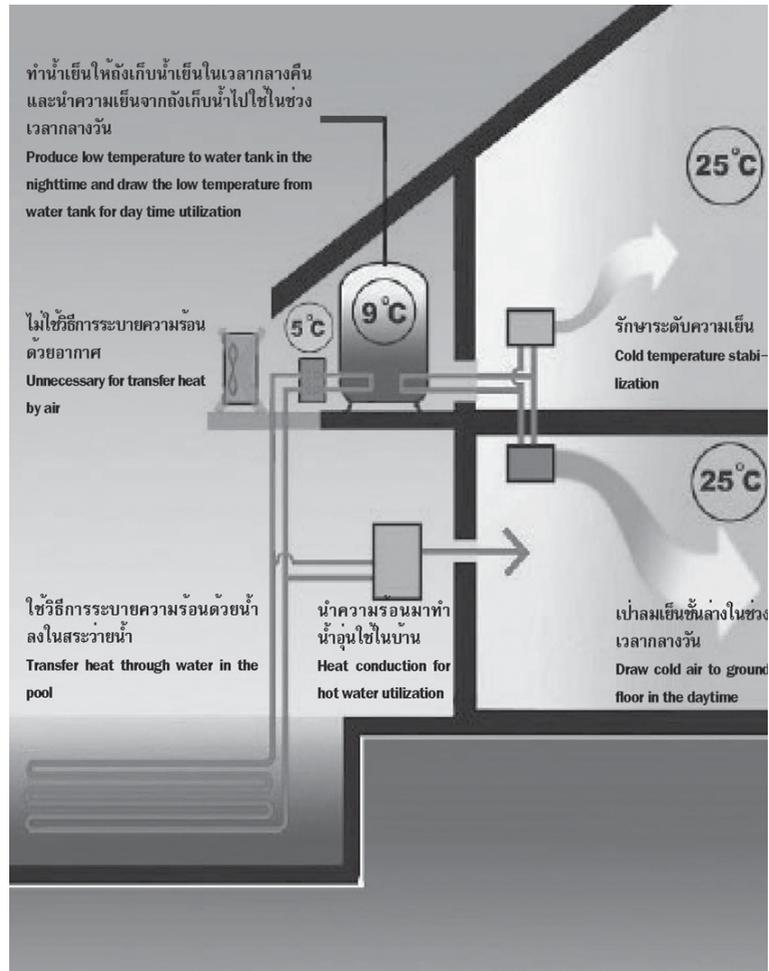


Figure 18: The air-conditioning process produces low temperature in the water tank at night time and transfers heat to the pool by pipe.

## Biogas Technology

Biogas is an energy source that is derived from manure, grass, waste water, garbage, and waste left over from agriculture that passes through the fermentation process to decompose into organic compounds in an anaerobic digestion. Some bacteria that grows during this process will decompose into organic compounds such as carbohydrates, fat, and finally turn into a biogas.

This technique helps the Bio-Solar Home benefit from waste that produce biogas. Energy from this process is adequate for cooking, and the home owner is not required to buy any cooking gas.

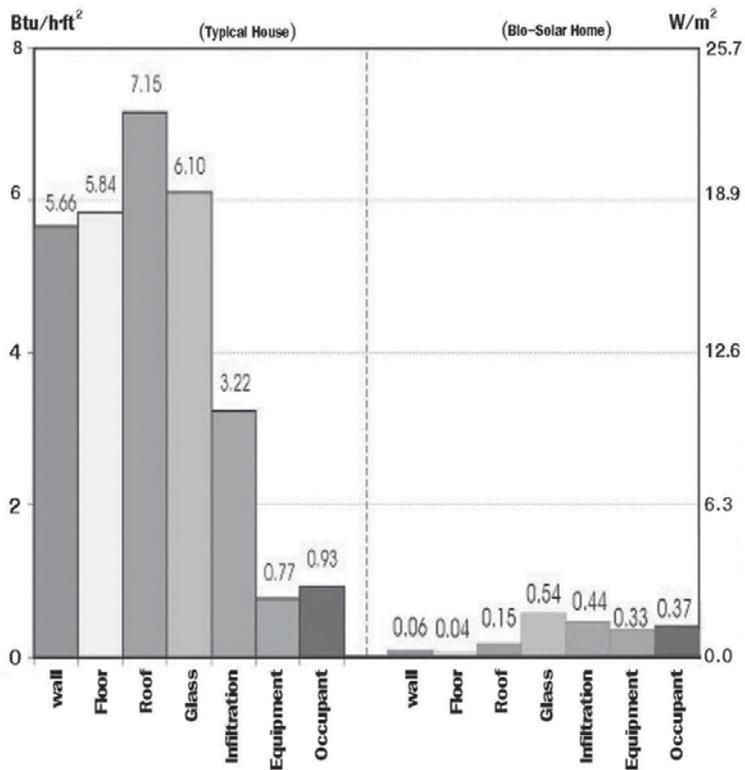


Figure 19: The ratio of the cooling load of the Bio-Solar Home to a typical house. The Bio-Solar Home has a 15 times lower cooling load than a typical house.

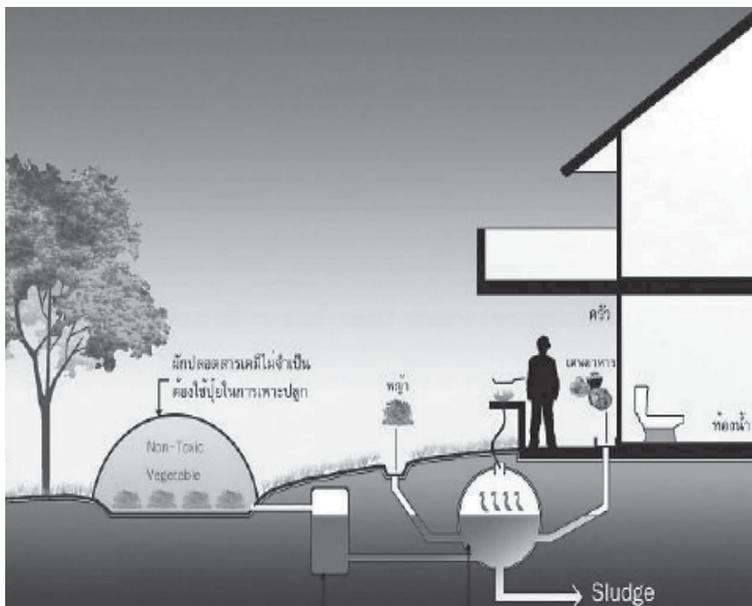


Figure 20: The process of biogas that is applied to the Bio-Solar Home resulting in cost savings

## CONCLUSION

The Bio-Solar Home has been designed as a prototype for self-sufficient economists. The house is one effort to comply philosophy, knowledge, and technology to create a new pattern of housing that is appropriate for today's applications.

From the design concept, applying an appropriate system, material selection, and decoration, the Bio-Solar Home can create a superior standard of living which harmonizes with nature and the development of a country.

In summary, it can be concluded that Bio-Solar Home improves the occupants' quality of life, while maintaining an affordable investment cost as the same range of a typical house. The idea to apply recycling energy and ecological systems causes the emission of greenhouse gas from Bio-Solar Home nearly zero. Moreover, the energy gained from solar cells is more than the energy used in the house; therefore, the Bio-Solar Home can be a so-called Plus-Energy Home.

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