Future design in an energy efficient building as an identity of a Malaysian tropical architecture with emphasis on photovoltaic technology and passive solar building design elements

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Abstract

There has been indicators that global warming is now approaching towards dangerous levels. The world over is now into sustainable development and as far as energy is concerned many countries are looking towards Renewable Energy as alternatives and the most promising is the energy from the sun, i.e. the solar electricity. Due to the awareness and education there is an increase demand on photovoltaic technology and subsequently an increase in cost as well. High cost dampens demand and the eventual lack of demand prevents further research into lowering the cost of the system thus setting a vicious circle. Therefore government intervention is necessary to kickstart this promising clean fuel by introducing the necessary initiatives to bring down the cost of PV technology because the advantages of using sun power are enormous. This paper suggest solutions by stipulating four strategies to overcome high cost of solar installation by passive design combining with energy efficient active systems manage by a favourable and passionate mindset and employing the solar technology. Though the PV technology is pretty straightforward, solution incorporating passive solar design elements to a building design needs an Architect's creativity. There is a dire need for research into these design elements to make an effective reduction in indoor air temperature and also cooling the surrounding outdoor without using much energy.

Keywords: passive solar design elements, energy efficient, photovoltaic technology, building design, solar electricity

1. Introduction

In tropical countries, as dependence on cooling systems and air-conditioning increase in pace due to economic growth, growing concern over the future global environment problems and a possible drain on energy resources require to place importance on development of the passive design cooling technology as well as incorporating the renewable energy into the building fabric.

For many years Malaysia has been blessed with oil and natural gas both obtained from burning of fossil fuels. As energy cost continue to rise and fossil fuels depleting, maintaining a balanced socio-economic fabric is getting terribly expensive for the Government. Thus renewable energy now become the fifth fuel adding to the energy policy of the existing four fuel, namely, oil, gas, electricity and hydro. Renewable Energy (RE) has been set aside by as much as 5% of Malaysian energy supply.

While RE initiatives are beginning to gain some inroads into the market, the concept and initiatives of Energy Efficiency (EE) are to run parallel to it. EE is not the same as energy savings. While the later connotes a cutting down of activities, thereby a drop in living standards, the former encourages the opposite and to use energy efficiently, thus maintaining competitiveness internationally. The Fifth Fuel Policy is silent on how much from the 5% is apportioned to solar energy, biomass, wind, etc. It is up to the industry players to convince the government which RE initiatives in Malaysia to be economically viable to gain competitiveness and get the support of the government. Buildings in Malaysia has been noted to consume almost a third of the overall energy consumption and therefore warrant some attention.

Other alternative renewable energy have little infuence in building design. Industry players are more interested in researching and manufacturing in heavy machineries that consume huge amount of energy. For example energy from hydrogen is very promising but for the moment they are heavily researched into for car technology. Malaysia learned a lot from the scientific development from overseas. Research would take not only a long time but also a hug e amount of the country's economic budget. Along with striving for Malaysian Nobel Laureates, certain well-tested technologies can be adopted and adapted. To start anew would be unwise. Buildings that are designed to use solar energy need to consider the storage of hydrogen later in the future.

Wind is unreliable in Malaysia as the characteristics of wind is that it is erratic, unpredictable in air velocities and multi-direction. It cannot be relied fully to influence the design of buildings. Biomass need a lot of space and for urban design, space is not that generous. What Malaysia has is continuous supply of sunlight and the energy source is totally free. With photovoltaic technology sunlight can be converted into electricity. The photovoltaic (PV) system is silent in operation, maintenance free and very friendly to the enviroment because no toxic gases are released. Architects and others from the building industry must take note that eventually a benchmark on energy consumption by a building will have to be met before building approval can be given to proceed with construction. At the moment any industry that consumes 6 million kWh of energy is mandatorily required to employ an energy manager. The Ministry of Energy, Water and Communication Building at Putrajaya has given itself a standard of 135kWh/m2/yr as the benchmark to achieve and it has done so. The Malaysian Energy Center Building has gone even lower of 120kWh.m2/yr. Future buildings may eventually take the same approach set by authorities. For the moment it is by persuasion. This paper aims to show presently that solar energy is a promising alternative for future energy demands in buildings. Though the Malaysian consumer market can be flooded with all kinds of energy saving appliances, equipment, and machineries over time, the design of buildings do not take the same approach as design is site specific. One has to do a stie analysis by studying the sun path, the prevailing wind (if any), the surrounding terrain and make use of the natural endowment to help reduce heat buildup onto the building fabric first before ever considering to use any energy saving mechanical aids. By doing so it further will reduce energy consumption. In Malaysia about 70% of energy consumption is

for cooling the environment. When the price is reasonable, photovoltaic system seemed to be the answer for Malaysia.

2. Photovoltiac technology in building design

The world over is now into sustainable development and therefore among other things, the demand for PV technology has risen thereby pushing the prices which makes it an expensive technology to champion. Research and efforts are geared to find ways to reduce PV prices. One of the ways is to increase demand. This can be done by creating awareness of the need for PV technology which can save the world from climate change thence global warming. But the common public needs more convincing and must be encourage with examples closer to home rather than overseas.

The recent introduction of the Malaysian Building Integrated Photovoltaic (MBIPV) project or campaign will provide a great opportunity to address this issue holistically. Government can help create an environment where consumers and industry can drive the PV market. Apart from appropriate policies as incentives and legislations to ease the dilemma, RE requires a conducive and supportive financing system to allow private developers to apply them. This would help encourage property developers and the building industry to incorporate the PV technology into their developments. Developers would not feel hesitant to incorporate the design and construction of sustainable buildings.

PV technology is without doubt the best form of renewable energy to be used in buildings only if the price for the whole system is affordable to the ordinary public. While waiting for the price of PV technology to be affordable there are other options which can be initiated almost immediately firstly by persuasion, later by mandatory regulations and expedited by EE products in the market, before installing solar electricity. Malaysia is still far behind in the PV technology (15 years behind) as compared to Germany who is the market leader. A national program (Figure 1) assisted and funded by the United Nations Development Program (UNDP) is under way to change the mindset of the Malaysian population into accepting the idea of solar electricity. It is hoped that with increase in demand, prices would eventually drop.

The campaign starts off with "SURIA 1000" ("suria" means solar) and the figure 1000 is to represent that the stakeholders aim for 1000 roofs to be fixed with solar panels by 2010. And it specifies the system to be integrated into the building design as the name implies – Building Integrated Photovoltaic (BIPV). This means that no reftrofitting is allowed. Those who opted to be in this program will have their cost of installing the PV technology be subsidized (Figure 1).

It is aimed at successful completion of this long term program to be in 2030. It was also predicted that the whole world supply of petroleum would already be diminished by the year 2040. There may be some reserves here and there but not economically viable to access to it.

There are four strategies available for those in the building industry to play their part in helping with curbing the growing global warming. The main players are the Architects, the M&E Engineers and the clients (building owners and/or developers) themselves. Consumers too must play their part in being rational in energy issues and must be made aware of the world situation. Their cooperation collectively will be translated into action to whatever extent possible. Any small efforts, collectively, would make a great impact in savings over a period.

Figure 2 advocate for a design with PV technology consciousness by first designing using appropriate passive solar design elements and install the solar panels at strategic location so as the aesthetic values are not compromised. Figure 3 shows a general guide of all the passive design elements made available in Malaysia that can reduce heat gain on a building fabric and finally the PV panels are placed on top of the jack roof. Architects are left to their ingenuity and creativity to make the integration of solar panels aesthetically pleasing to the common people otherwise rows and rows of stright forward panels in linked houses can have a psychological impact over a long period. Most Malaysian would prefer to have attachment to organic materials and a rustic look to their private homes. Rustic effect and PV technology conflicts in this sense as one is organic and the other manufactured, and may not be successful as a selling point in the idea and also the property. All the passive design elements must not be applied as any additional element may not give a significant drop in internal air temperature and therefore may add up unneccessary building cost . Architects are to study the surrounding site and emphasis its natural strength and endowment and design accordingly before integrating the roof with solar panels.

(a) (b)

Figure 2: (a) A high rise neighbourhood with comprehensive incorporation of passive design elements (*courtesy of Ken Yeang*) (b) A building integrated photovoltaic after passive elements have been considered (in this instance it is the wall with the small surface area faces the sun).

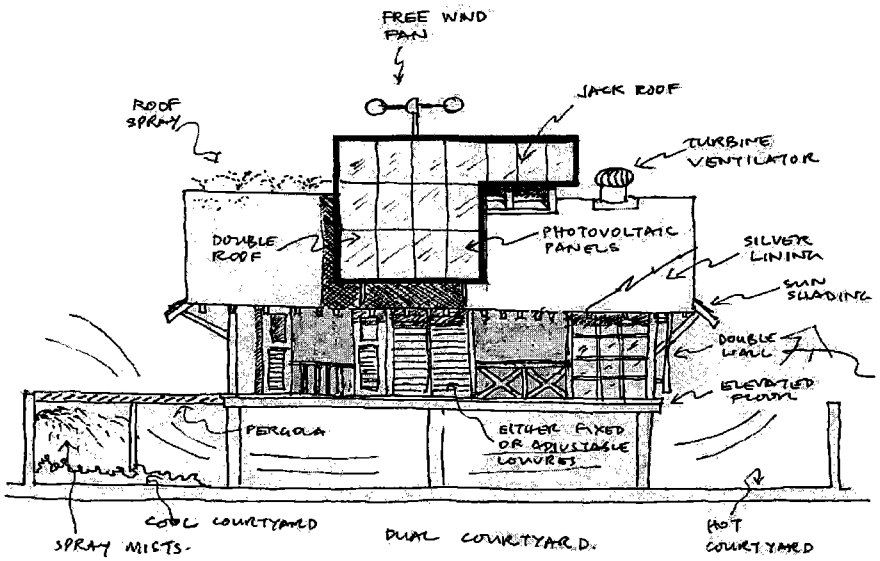

Figure 3: The passive design elements and PV technology

4. Passive solar building design elements.

Refering to Table 1 Architect's Role the section on passive solar design elements are the variables that immediately affect the cooling on the building itself. Option 2 is the direction that should be approached at in order to reduce the cost of PV technology and here it is the Architect's intuition and instinct based on the scientific research and database from Table 2, to concoct a good design where energy consumption is the major influence in how the building would look like and be acceptable to the general public. Building materials are constantly being researched into to find the best thermal performance. But no matter what the materials seem to be, any direct sunlight into the house would defeat the purpose of having a good thermal performance material. Whatever material used for the building envelope it should be supplemented with efforts to reduce radiant heat by the design of building such as the shape and orientation, roof shape and roof pitch, sun-shadings of all sorts, roof and wall sprays, reflective materials including white paint and insulation materials. Once the building fabric is prevented from heat gain at the same time there must be efforts to encourage air movement inside the building. Such initiatives are like having wind deflectors, shape and orient the building shell to maximize exposure to the prevailing wind, open plan, air shafts to encourage stack effect, double wall and double roof and lots of fenestrations. These are known as passive solar elements because they do not incur any running cost, but can enhance the aesthetics of the building.
Table 2 shows the design elements that can prevent heat gain to the building fabric and still requires further research as to the effectiveness of each item. Figure 2 shows the inclusion of all the items from Table 2. Research findings confirm that having all the items do not necessarily bring down the indoor air temperature significantly. The Architect must assess the building site first to use as much natural endowment provided by the site before using selective items from Table 2 to enhance the building performance.

Table 2: The passive solar design elements to prevent heat gain to a building fabric

REDUCE RADIANT HEAT GAIN	BEFORE	AFTER	DIFFERENCE
1. Orientation			
2. Roof shape and pitch			
3. Shape and orientation			
4. Sunshading			
5. Creepers	36.8C (without)	27.7C (with)	9.1C
6. Double roof & double wall			
7. Roof spray mist - surface temp.	44.26C	33.86C	10.40C
- air temp.	36.30C	32.71C	3.59C
8. Wall spray mist	35.0C	32.0C	3.0C
9. Reflective materials			
9. White colour - steel	60.0C(White)	49.0C (Dark Blue)	11.0C
- brick	33.5C	33.0C	0.5C
11. Insulation materials			
12. Construction materials			
GENERATING AIR MOVEMENT			
12 Wind deflectors			
13. Shape & orientation			
14. Open plan			
15. Jack roof or monitors			
16. Openings			
17. Courtyards			
DAYLIGHTING			
HYBRID			

5. Conclusion

Since time immemorial the sun has always been in its present position and will still be there until armageddon. It is time we adopted the idea of solar electricity and incorporate the system with building design. The aim is to reduce the rate of depleting the fossil fuel for energy. Tapping the energy from the sun has manifold advantages but due to high cost of PV technology at the moment the best approach is to design with passive design first followed by purchasing EE products and depending on individual's or company's affordability the fourth strategy i.e. the PV system would be the last resort.

Further researches would not only bring down the prices but also the panels can be smaller in dimensions like the size of existing roof tiles with more efficient absorption capabilites. That would open up to more creativive roof designs and not follow strict technical PV technology rules that can give a monotonous and boring skyline.

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