CHAPTER V

CONCLUSION

When considering the general energy usage of buildings in Thailand, it is found that between 75-80% of total energy usage originates from air conditioning system and lighting systems. From the idea of Green Building design of trying to solve energy and environment crisis, Shading Device Integrated Photovoltaic system: SIPV is considered one of design strategies providing more benefit than electricity generation alone. This system includes the reduction of heat gain from sunlight affecting cooling load reduction of an air conditioning system and natural lighting control affecting energy saving of lighting system. It is still considered beneficial despite the fact that its installation causes less solar radiation receiving than other installations on rooftop.

The purposes of the study to create suitable design ideas in order to gain the most advantages out of utilization of installations affected by shading on solar modules are as follows: first is optimization of solar heat reduction and increase of daylight utilization of Shading Device Integrated Photovoltaic system including price and economic benefits optimization of Shading Device Integrated Photovoltaic system.

However, estimation of solar radiation appeared on inclined plane of sun shading and reflectance of solar radiation from buildings envelope down on sun shading cannot be calculated by applying normal equations presented by ASHRAE. It is because there is a condition of shading and patterns of buildings causing half of diffuse sky radiation. Therefore, adjustment of some variables in equations is a must through data collection using models. Besides, there is the study of illuminance level on working plane in a form of Daylight Factor (DF) and the study of heat reduction due to diffuse solar radiation in a form of Shading Coefficient (SC_d) in term of entire prevention of direct solar radiation. Features of shading device design are decided by proportion of extension distance of sun shading to the height of window (W/H ratio) and clear obstruction in front of the window.

The result of analyzing the weather and solar radiation from database of Thai Meteorological Department in Bangkok where it was considered as an example of the areas with potential in installing the mentioned system and as it is located in the middle of the country or at latitude 14 degrees North, it was found that the energy calculated averagely per day was at 18 MJ/m^2, the ratio of diffuse solar radiation was at 40%, the air temperature was higher than comfort zone from 8.00 AM., total solar irradiance was decreased lower than the maximum value of diffuse solar radiation providing less heat at 16.00 PM; and quite small amount of light. Calculation of energy value of 3 systems such as photovoltaic energy generating system, air conditioning system and lighting system were determined to be at the period of time mentioned above.

The condition of calculation determined by the reference from the National Energy Conservation Promotion Act (Revised Edition) B.E.2550 was to calculate lighting level in the working area at 300 lux and use air conditioning system containing Coefficient of Performance: COP of 3.22. The indicator in suitability evaluation determined for this calculation was the benefits from energy use for the whole year. In addition, the determined variables used in the study for the design were as follows: window direction specified in the pattern of shading device suitable for sun protection in each direction in W/H ratio, variable of incline angle of solar module, variable of room size affecting number of light bulb being used and variable of lighting level control technique. When considering the system working all year long for 30 years, cost of electricity is at 4 Baht per unit and MRR loan rate is at 8%. There are 2 levels of stages of cost price: 70 and 86 THB/W_p. For 25 years of usability, efficiency of energy generation has been reduced 20% and amorphous silicon and polycrystalline silicon modules have been used as case study.

From calculating values, there are many points found as follows:

1. The installation directions appropriate to electric power generation are such as South, South West, South West, East and West arranged from the most to the least. Other directions only provided less energy due to sun orbit encircling more to the south all this period of time

2. Cooling load value as a result of diffuse solar radiation causing heat transfer, heat conduction of air temperature outside and heat from light bulbs located in South West, South East, West, East and South directions arranged from the least to the most. It is because the stretched out parts of shading device in descending order from the most to the least and the difference between south west and south is only 5%

3. Incline angle of solar module should do an angle of 30 degrees to the horizontal plane to be able to produce most energy although incline angle at 0 degrees is receiving solar radiation reflecting from building envelope the most

4. The stretched out parts of shading device in the South, East, West, South East and South West directions will allow daylight in arranged in order from the most to the least

5. Stacking vertically of shading device integrated photovoltaic system causes the decrease in energy generation due to the devices covering one another

6. Rooms with more distance from windows will receive averagely less light according to order of distance

7. Glare in case of any usability facing the windows will happen less as it is manageable through working area arrangement and change in eyesight direction

8. Dimming technique creates most efficient daylight use and helps room located long distance from the light save energy in total per square metre

9. Proportion of energy generation as a result of shading device integrated photovoltaic system was less than the rooftop installation, in case of comparing to the maximum case, about 20%

10. The influence of shading of the buildings slightly affected efficiency of inverter

When considering the optimization in design from the determined purposes, it can be concluded as each purpose as follows:

The optimization of solar heat gain reduction and increase in daylight usability of shading device integrated photovoltaic system by considering an amount of energy being saved for the whole year, it is found that shading device integrated photovoltaic system should be installed in the south side which allows solar radiation in the most. Besides, there should be the stretched out parts of shading device gaining heat from diffuse solar radiation moderately most suitable for structure and angles of windows. In addition, there should be solar module making an angle of 30 degrees to the horizontal plane and rooms with less distance from light to allow daylight in the most.

The optimization of economic price and benefit of shading device integrated photovoltaic system by considering from benefit, investment and payback in suitability evaluation when determining energy saving strategy, it is found that

1. As solar module only being used to generate energy, there was no cases of design worth for investment (B/C<1) and no payback during life cycle operation

2. As for the utilization of energy generation and heat reduction, the benefit of shading was more than benefit in electric power production creating the fact that the installation of shading device integrated photovoltaic system should be in the South West or South East direction. However, if the utilization is mainly for energy generation, installation in the south side should still be considered which provides similar benefit of total energy, solar module making an angle of 30 degrees to the horizontal plane and rooms with less distance from windows. This is to say that there was only a slight difference between lighting control system and light dimming at about 5%

3. The utilization of energy generation, heat reduction and electricity saving causes one-third of total energy benefit of producing electricity from solar cell and lesser when using dimming technique. Therefore, besides the installation of shading device integrated photovoltaic system in the south side which receive more benefit from daylight, there is solar module making an angle of 30 degrees to the horizontal plane, rooms with less distance from windows in case of controlling light by using lighting control technique and rooms with long distance from the windows in case of controlling light by using dimming technique

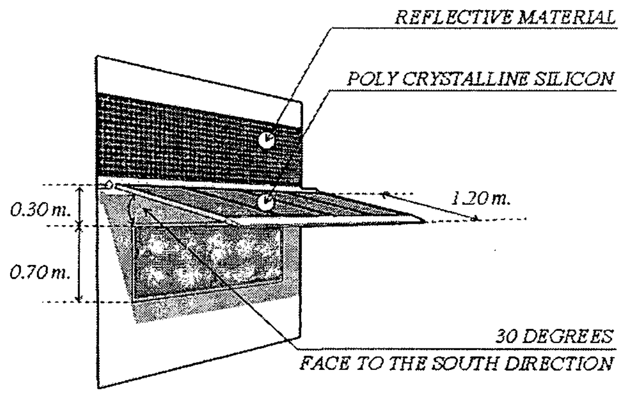

Figure 219 The design guild line of SIPV

In conclusion, it showed that the utilization with shading device results in the decrease of electricity production comparing to rooftop installation. However, more benefit has been shown in more proportion and it is enough for gaining payback which is faster than rooftop installation design. The example of installation presented in Figure 219.