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SOLAR INTEGRATED ENERGY SYSTEM FOR GREEN BUILDING

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Abstract: *Green building is a kind of sustainable development and energy-saving building, has a very important significance for alleviating strained resources, protecting the environment to reduce pollution. And the solar energy is not only an energy, and a renewable energy, but which rich in resources. It not only free use of, but also not to be transported, and it produces no pollution to environment and more widely using in the green building. Early, solar building just passed the light and heat of the Sun in order to light up and heat the building. But now, the green building obtains solar energy by adopting 'active'. This 'active' green building is a kind of heating system consists of solar energy collector, radiator, pump and fan, or air conditioning-building combined with absorption chiller. One of the green building which is Shanghai Research Institute of Building Science contain multiple green energy technologies, such as solar thermal technology, solar photovoltaic, natural ventilation, natural lighting, and indoor virescence. Here, there an example of solar integrated energy system including heating, air conditioning, natural ventilation and hot water supplied which applied in the green building*
Keywords: *sustainability, thermal, solar, photovoltaic, renewable energy*

Introduction

The field of „green technology" encompasses a continuously evolving group of methods and materials, from techniques for generating energy to non-toxic cleaning products [1]. The present expectation is that this field will bring innovation and changes in daily life of similar magnitude to the „information technology" explosion over the last two decades. In these early stages, it is impossible to predict what „green technology" may eventually encompass. The goals that inform developments in this rapidly growing field include [2]:

- *Sustainability - meeting the needs of society in ways that can continue indefinitely into the future without damaging or depleting natural resources. In short, meeting present needs without compromising the ability of future generations to meet their own needs.*
- *„Cradle to cradle" design - ending the „cradle to grave" cycle of manufactured products, by creating products that can be fully reclaimed or re-used.*
- *Source reduction - reducing waste and pollution by changing patterns of production and consumption.*
- *Innovation - developing alternatives to technologies - whether fossil fuel or chemical intensive agriculture - that have been demonstrated to damage health and the environment.*
- *Viability - creating a center of economic activity around technologies and products that benefit the environment, speeding their implementation and creating new careers that truly protect the planet.*

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs this is a common definition of the sustainable that been use all wide world [2]. In other word sustainability is the approach in which development that provide to ensure the need of today generation but not forgetting the need of future generation. The benefit of sustainability and green technologies is divided to three components, which are environment, social and economic.

*The **environmental** benefits of sustainability and green technologies are as follows:*

- ***Lower Air Pollutant and Greenhouse Gas Emissions***

One of the benefit of sustainability and green technologies is it reduce emission of CO2 this reduce by decreasing energy use through energy-efficient design, use of renewable energy, and building commissioning. When the CO2 is reduced it will lower the greenhouse gas emissions as CO2 is one of the gases that produce greenhouse effect [1].

- ***Reduced Volumes of Solid Waste***

Green construction practice such as using recycle material, waste prevention, storage and collection of recyclables will reduce the volume of solid waste that can contribute to pollution.

- ***Decreased Use of Natural Resources and Lower Ecosystem Impacts***

Sustainable design principle also assists in lessening the impacts on natural resources and ecosystems. One of the principles is sustainable sitting approach. It avoids built building on prime agricultural land, floodplains, and habitats for threatened species or near wetlands, parklands, and cultural or scenic areas. This will reduce the impact of the building to the ecosystem. Other than that; the use of rapidly renewable material such as bamboo will help reduce the use not renewable materials and help maintaining the forest and biodiversity.

*The **social** benefits is of sustainability and green technologies*

- ***Better health of building occupants***

The benefit of sustainability and green technologies in health is focus on the indoor environment and specially put in intention on the air quality. The indoor air quality is very important in maintaining the health of the occupant this is because usually the diseases are transmitted through the air. So, enough air ventilation is needed to remove harmful air outside and allow fresh air to the building through a sustainable site orientation and planning this can be achieved.

Usually sustainable building is design with many opening or louvered to allow the movement of air [2].

- ***Improved comfort, satisfaction, and Well-being of building occupant***

Psychological effects (e.g., comfort, satisfaction and well-being) are generated through perceptual and sensory processes that interpret environmental information in terms of its effect on current needs, activities, and preferences. Some of the sustainable feature like natural daylight, views, connection to nature, and spaces for social interaction, appear to have positive psychological and social benefits.

- ***Community and societal benefit***

Sustainable construction practices tend to generate lower amounts of dust, pollution, noise, traffic congestion, and other community disturbances. These improvements will likely contribute to improved public health, safety, and well-being. Construction practices and building operation practices that foster recycling and reduce waste generation will decrease the public nuisance this is because it will reduce the will demand for new landfills, electric utility plants, transmission and gas pipelines, and wastewater treatment. Furthermore, the use of local product in sustainable building will increase the local economy and provide job for community [2].

*The **economic** benefit of sustainability and green technologies*

- ***Reduce First Cost***

Sustainability and green technologies provide financial rewards for building owner's. This is because it lower the first costs. this can be seen when it use recycle material instead of other virgin material. the sustainable approach to site orientation will ensure the building capture enough sunlight and balancing the sunlight penetration with vegetation reduce the use of HVAC system which then reduce the first cost [2].

- ***annual energy cost saving***

Sustainable design approach will lead to annual energy saving. For example, reducing the use of HVAC system because of the sustainable design approach like good building orientation and good site planning may reduce the use of energy.

- ***annual water cost saving***

the annual water is save by using green technologies such as rain water harvesting. the rain water is use for the domestic use and lead to water cost saving. Some of the technologies such as

ultra-low-flow showerheads, no-water urinals, and dual-flush toilets will lower indoor water consumption [1].

- ***lower costs of facility Maintenance and repair***

Sustainable design aims to increase durability and ease of maintenance which will reduce the maintenance cost and repair cost. Some of the sustainable design approach is using local material to reduce the maintenance cost this is because the material is easy to get and the material is cheap.

SOLAR INTEGRATED ENERGY SYSTEM FOR BUILDING

In the era where the energy future is uncertain. The amount of fossil fuel is no longer enough for the future. This cause the improvement of technologies in renewable energy sources. There are several of renewable energy sources available today. Some of the renewable energy sources is wind, biomass, and hydroelectricity and solar which now becomes a trend for the green building [3].

Solar energy is radiant light and heat from the sun. The technology enable the sun radiant light to be transform into electrical energy that can be used for the daily purposed. Some of the solar technologies are solar heating, solar photovoltaic, solar thermal electricity and solar architecture.

Solar technologies are basically divided into two which are active solar energy system or passive solar energy system depend on the way they capture, convert and distribute solar energy. Active solar energy system is the use of photovoltaic panel and solar thermal collectors to harness the energy. While, passive solar energy system is the technique to harness the solar energy passively. For example, by adjusting the building orientation to capture natural sunlight and to capture the heat from the sun to provide comfortable environment in the building [4].

It has become a trend for the large firms, and some of the famous architect to joining the forces with energy specialist to design the building based on the solar integrated energy system. Solar integrated energy system is no longer a system that only provides renewable energy either provide the passive solar energy system or active solar energy system. This is because it is a combination of all the technologies such as solar heated and cooled, photovoltaic powered building. Solar integrated energy system is also can be called as "solar building".

The word integrated in the solar integrated energy system is solar system become one of the part of the general building design. It cannot be separated or added after the building is completed. In fact, it becomes one of the building elements. Solar integrated energy system is sustainable system that combining all the solar technologies system that integrated with the building to make the building more energy efficient and reduce the use of depleting energy sources [3].

ACTIVE SOLAR ENERGY vs PASSIVE SOLAR ENERGY

Active Solar Energy uses of mechanical devices in the collection, storage, and distribution of solar energy for building. An example is in active solar energy water heating systems a pump is used to circulate water through the system. There are a numerous solar applications that acan use to take full advantage of active solar energy. These include [5]:

- *Active Solar Heating is a method of heating the air inside of the building. This method uses mechanical equipment including: pumps, fans and blowers to help collect, store and distribute heat throughout the building.*
- *Active Solar Heating is a method of heating the building with water using the sun and pumps to circulate the water or heat-transfer fluid through the system.*
- *Passive Solar Energy refers to the harnessing of the sun's energy without the use of mechanical devices. Using south-facing windows to provide natural lighting and heat for home are examples of passive solar energy.*

There are a variety of solar applications that a homeowner can use to take full advantage of passive solar energy. These include:

Passive Solar Heating is a type of solar space heating that can be accomplished by the following methods:

- *Orienting the building so that the majority of it's windows face south.*
- *Sizing windows for optimal heat gain and making sure have the right type of windows.*

– *Utilizing thermal mass to absorb the solar energy entering the windows for release during the night. Thermal mass is simply a solid or liquid material that will absorb and store warmth and coolness until it is needed. Examples of thermal mass include: brick, stone, concrete and water.*
– *Insulating the building to minimize heat loss.*

Passive Solar Cooling utilizes many of the methods listed below to minimize the impact the summer sun has on the building and thereby reduce or eliminate building need for mechanical cooling systems. Passive Solar Cooling techniques include [5]:

– *Orienting building and landscape so that it can take advantage of cooling breezes.*
– *Designing building to minimize barriers to air paths through the buildng to allow for natural ventilation.*
– *Using the right size and type of windows in order to minimize the heat gain in the summer and that enable ventilation by opening.*
– *Using both structural features and landscaping to create shading.*
– *Insulating the building to maintain a comfortable temperature.*

Solar energy is receiving much attention in green building energy system because of its abundant and clean being. Generally, the newer green buildings combine several of solar technologies. As for example, they may be both energy efficient, solar heated and cooled, and PV powered in one building. They are simply just solar buildings. Solar integrated energy system is the combination of different solar-related technologies. Solar energy is a renewable resource that can be used in many ways for water heating, space heating and cooling in buildings [2].

An integrated energy system based on solar thermal technologies are:

a) Solar Water Heating System

The beauty of a solar hot water system is its relative simplicity and durability. There are two types of collectors used in a solar hot water service as been shown in Figure 1:

– *flat plate collectors (suitable where tank roof mounting is required)*
– *evacuated tubes (more efficient and great for frost prone areas)*

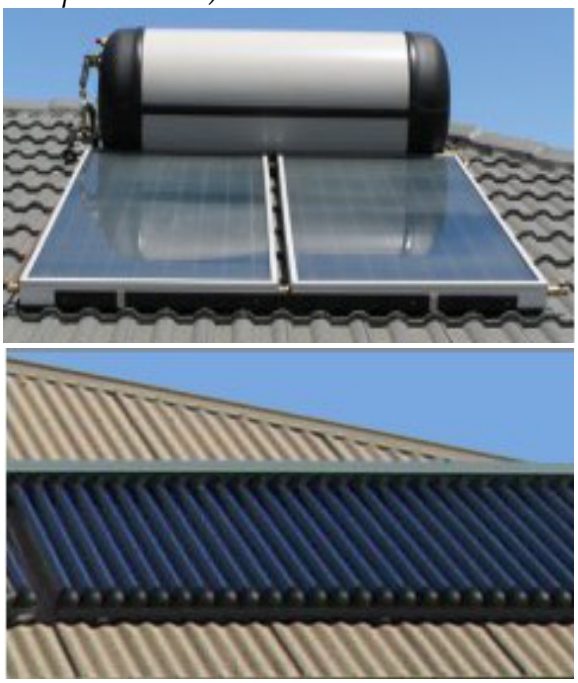

Figure 1. Flat panel (left) and evacuated tube collectors

i. Flat plate solar collectors

Flat plate collectors' work on copper pipes running through a glass covered collector, often connected to a water storage tank on the roof. The hot water can then thermo-siphon itself in and out of the tank, thus heating the water [5].

ii. Evacuated tube solar collectors

Evacuated tubes use a glass tube with a vacuum inside and copper pipes running through the centre. The copper pipes are all connected to a common manifold which is then connected to a slow flow circulation pump that pumps water to a storage tank below, thus heating the hot water during the day. The hot water can be used at night or the next day due to the insulation of the tank [4].

The evacuation tube systems are superior as they can extract the heat out of the air on a humid day and don't need direct sunlight. Due to the vacuum inside the glass tube, the total efficiency in all areas is higher and there's better performance when the sun is not at an optimum angle - such as when it's early in the morning or in the late afternoon.

b) Integrated solar Energy System

The integrated solar energy system mainly includes two adsorption chillers, floor heating pipes, finned tube heat exchangers, circulating pumps and a cooling tower. Hot water storage tank

is employed to collect solar heat, thereby providing hot water for the integrated solar energy system. The integrated solar energy system can be switched to different operating modes through valves located on the pipes according to different seasons [5].

This silica gel-water adsorption chiller is composed of three working vacuum chambers including two desorption/ adsorption chambers and one heat pipe working chamber. In the adsorption chamber, water is taken as the refrigerant, while in the heat pipe working chamber; methanol is used as the working substance. The evaporation cooling in evaporator 1 or 2 is transferred to the methanol chamber via heat pipe evaporation/condensation process. Chilled water is cooled down in the methanol chamber directly. This design idea has made two water evaporators (Evaporator 1, Evaporator 2) integrated into one methanol evaporator.

Generally, the supply water temperature of floor heating system is relatively lower, which leads to the feasibility of low-grade heat source. As a result, solar energy is suitable for floor heating system. The floor heating coil pipes are made of high-quality pure copper with the dimension of F12 _ 0.7 mm, fixed on the 30-mm thick polystyrene insulation layer with spacing interval 200 mm. And then crushed stone concrete was poured with the thickness of 70 mm. Figure 2 shows the arrangement of floor heating coil pipe [5].

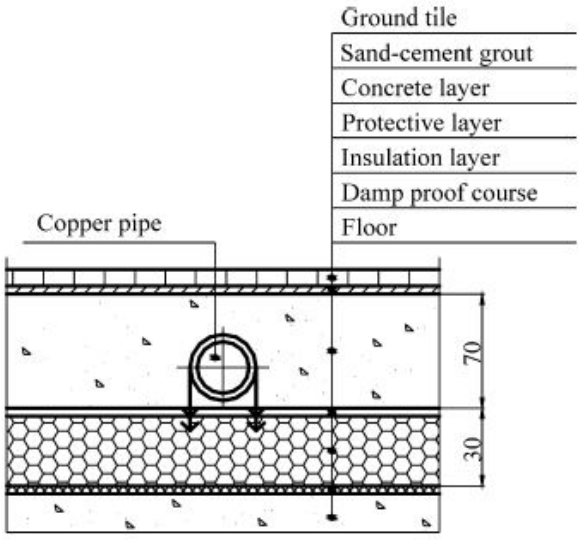

Figure 2. Arrangement of floor heating coil pipe

c) Natural Ventilation Enhance

There is an air channel under the roof of the green building, which is designed for indoor air exhaust through natural ventilation. In order to enhance natural ventilation by stack pressure, we installed seven groups of heat exchange elements inside the air channel. Each group consists of three parallel finned tube heat exchangers as shown in Fig. 8. The finned tube heat exchanger is made of a 3-m long copper tube with 540 square fins. The diameter of the tube is 20 mm and the sectional dimension of the square fins is 102 mm [3].

SOLAR INTEGRATED SYSTEM APPLIED IN GREEN BUILDING

The green buildings of Shanghai Research Institute of Building Science include an office building for the demonstration of public building and two residential buildings which are for the demonstration of flat and villa, respectively. As demonstration projects, they contain multiple green energy technologies, such as solar thermal technology, solar photovoltaic, natural ventilation, and natural lighting [6]. Here, we designed a solar-powered integrated energy system including heating, air-conditioning, natural ventilation and hot water supply for the office building. However, only solar hot-water systems were designed for the flat and villa. All the three systems have continuously run for 2 years.

i. Integration of solar hot-water system with flat

A three-storey green building was built for the demonstration of flat, where the first floor is for ordinary single-storied flat and the upper two floors are for duplex flat. The solar collectors were installed on the sideboards of balconies. According to the dimension of balconies, we customized evacuated tubular solar collectors with CPC, and placed solar collectors at the first floor, second floor and third floor. Figure below shows the effect of integration of solar collectors and the flat. Here, solar collectors act as not only the heat source of hot-water system, but also the decoration of balconies [4]. This demonstration project serves as a good example of both building integration and of a sensible combination of functions. Moreover, it provides a feasible design method for multi-story buildings and high-rise buildings especially for residential buildings. Besides solar collector arrays, the solar hot-water system of the single-storied flat is mainly composed of a solar collecting pump, a

constant pressure tank and a heat storage water tank. They are connected through copper pipes and valves to form a closed circulating system [5]. The domestic hot water is heated by the heat exchanger inside the heat storage water tank. Similar solar hot-water system was constructed for the duplex flat by the parallel connection of solar collector arrays on the second floor and the third floor.

ii. Integration of solar hot-water system with villa

In the villa, because the whole roof is occupied by technologies of solar photovoltaic then U-type evacuated tubular solar collected is customized with CPC in terms of the dimension of awning, as shown in below. Such design provides another example of how a solar element could be used in the original design in a logical manner, especially for those without enough roof area. The solar hot-water system in the villa is similar with those of flat (Figure 3).

Figure 3. Solar hot-water system in villa

iii. Integration of solar collectors and green office building

As the power to drive adsorption chillers and the heat source for the floor heating and natural ventilation, the solar collectors are the most important parts. We installed solar collectors on the roof of the green building, wherein U-type evacuated tubular solar collectors with CPC of area were placed on the west side (SCW), and the other heat pipe evacuated tubular solar collectors on the east side (SCE). For the purpose of efficient utilization of solar energy, the architects designed a steel structure roof, facing due south and tilted at an angle of 40° to the ground surface, on which the solar collectors were mounted and integrated with the building perfectly [6].

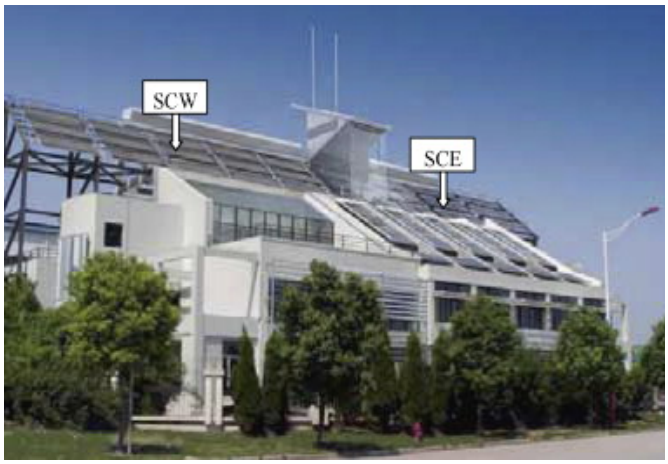

Figure 4. Appearance of the green office building integrated with solar collectors

Figure 4 shows the appearance of the green office building integrated with solar collectors. All solar collectors of both sides were divided into three parallel rows. The collector units in each row were connected in a series arrangement for the purpose of obtaining hot water with relatively high temperature, which plays an important role in improving performance of the solar energy system. Such an arrangement of solar collectors not only guarantees high system performance but also enhances the architectural expression of the building. Besides, it provides a feasible idea for integration of solar collectors and civil buildings especially for public buildings [3].

iv. Design of solar-powered integrated energy system

An integrated energy system based on solar thermal technologies was designed and set up for building area of 460 m². As an office building, the hot water demand is not as significant as that in residential buildings. So, the solar-powered integrated system design of the green building is mainly focused on floor heating in winter and air-conditioning in summer. Another design is natural ventilation enhanced by solar hot water, which is effective and necessary to solve the problem of surplus hot water in transitional seasons. Moreover, it provides a new method for the design of solar-enhanced natural ventilation [4].

Except for solar collectors, the solar-powered integrated energy system mainly includes two adsorption chillers, floor heating pipes, finned tube heat exchangers, circulating pumps, and a cooling tower. Besides, a hot water storage tank is employed to collect solar heat, thereby providing

hot water for the integrated solar energy system. All components are connected by tubes and valves to form the whole circulating system.

BENEFITS OF SOLAR INTEGRATED ENERGY SYSTEM

First of all advantages of solar energy is that Solar energy offers the highest energy density among all the renewable energy resources (a global average of 170 W/m^2). The amount of solar energy received by the Earth every minute is greater than the amount of energy from fossil fuels consumed each year worldwide.

In areas with a well-developed power grid, solar energy leads green energy in the network. In the case of grid-connected, photovoltaic energy can be stored and used at times of peak demand, reducing the network load. A solar energy system can generate electricity all year round, not just in the days of sunshine. Solar energy does not cause pollution, which is one of the most important advantages of solar energy. The maintenance, or structures, after an initial set-up, is minimal [7].

The solar energy connected to the network can be used locally minimizing in this way the losses related to transmission / distribution (approximately 7.2%). The grid-connected photovoltaic systems produce electricity from conventional clean and sustainable. Are environmentally friendly, the usual costs of transport and energy allow any user to become a producer of green energy in an easy and profitable.

Supported the initial cost of installing a solar power plant, operating and maintenance costs are minimal (<10% of revenues), as compared with existing technologies. The lifetime of a solar energy system over 20 years, this is also one of many important advantages of solar energy.Solar cells are long lasting sources of energy which can be used almost anywhere. They are particularly useful where there is no national grid and also where there are no people such as remote site water pumping or in space [5].

Solar cells provide cost effective solutions to energy problems in places where there is no mains electricity. Solar cells are also totally silent and non-polluting. As they have no moving parts they require little maintenance and have a long lifetime. Compared to other renewable sources they also possess many advantages; wind and water power rely on turbines which are noisy, expensive and liable to breaking down [6].

Rooftop power is a good way of supplying energy to a growing community. More cells can be added to homes and businesses as the community grows so that energy generation is in line with demand. Many large scale systems currently end up over generating to ensure that everyone has enough. Solar cells can also be installed in a distributed fashion, i.e. they don't need large scale installations. Solar cells can easily be installed on roofs which means no new space is needed and each user can quietly generate their own energy.

Solar Energy Advantages are often discussed in the news, the biggest advantage may be that this is an option to achieve energy independence on an individual basis and at your own speed [7]. You can add a solar powered attic fan or water heater or migrate a little faster with solar panels to supplement a portion of your electrical needs or get completely off the grid or somewhere in between. We took for granted that electricity would continue to be easy to acquire, relatively cheap to consume and reliable.

While it is still convenient, we know it is no longer easy to acquire or cheap to consume and in the past few years many of us have experienced rolling blackouts, power outages that lasted longer than a few days and these instances are happening multiple times and more regularly. Taking into consideration the environmental disasters of oil spills in just Alaska and in the Gulf, it's clear that oil companies have no backup plan in the case of mishap. Now maybe the best time to really explore the advantages of solar energy and how to transition to this source of energy for our homes and businesses.

CONCLUSIONS

In conclusion, solar technologies can be divided into two which are active solar energy system or passive solar energy system depended on the way they capture, convert and distribute solar energy. Active solar energy system is the use of photovoltaic panel and solar thermal collectors to harness the energy while, passive solar energy system is the technique to harness the solar energy passively. For example, by adjusting the building

orientation to capture natural sunlight and to capture the heat from the sun to provide comfortable environment in the building. Solar integrated energy system is sustainable system that combining all the solar technologies system that integrated with the building to make the building more energy efficient and reduce the use of depleting energy sources. Solar integrated energy system involves heating, air-conditioning, natural ventilation and hot water supplying was constructed for the green building, which realizes high integration of solar thermal technologies.

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