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Editorial Open Access

Building Integrated Active and Passive Solar Design

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Editorial

The development of sustainable building needs to have tactful manipulation of energy flow at its envelope. There are general principles to follow, i.e. to reduce services system consumption like (i) air-conditioning and artificial lighting without affecting occupancy health and comfort; (ii) to minimize life-cycle energy in the building construction; and (iii) to employ facade-integrated renewable energy technologies. Recently, there are more and more interests in zero carbon and even positive carbon building developments. This makes it important to maximize the renewable power outputs and thus favors the use of hybrid generating systems.

Combined active and passive solar design is an evolving science in building technology. Traditionally, building facade is one crucial element in architecture. Nowadays, it has escalating importance in services engineering owning to its significant influence on the engineering system performance and energy use. Building integrated solar devices may be installed either at the building façade or on the roof. The system can be designed as invisible, aesthetically appealing, or appearing as an architectural concept. Examples are quoted below.

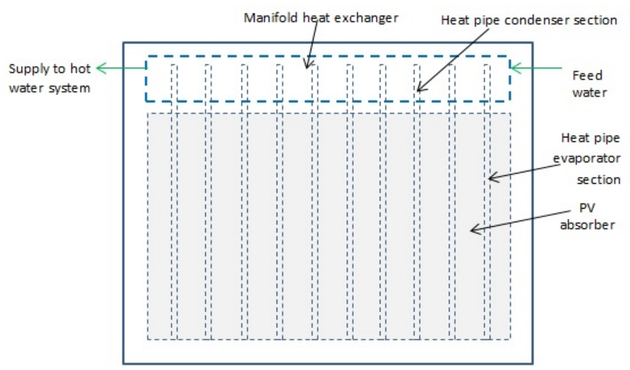

Figure 1: Front view of a heat-pipe BiPV/T collector unit.

The combined photovoltaic/thermal (PV/T) technology integrates the solar thermal and photovoltaic technologies into a single device, through which thermal and electric power can be generated simultaneously in a controlled manner. With solar cells as (part of) the thermal absorber, the hybrid design is able to maximize the energy output from all allocated spaces eligible for solar application. Either air or water or both can be used as coolant (s) to lower the solar cell working temperature. Comparatively, water-cooling is more effective than air-cooling because of the higher heat capacitance and more favorable convective heat transfer as a result. Those with flat plate collectors meet well the low temperature hot water system requirements. They are also applicable as preheating devices for high temperature services. Just like the building-integrated solar thermal collector or PV system, the "BiPV/T" provides additional thermal insulation at the external facade. The replacement of the expensive absorber material like copper or aluminum with pre-coated steel is possible, and can be structurally robust.

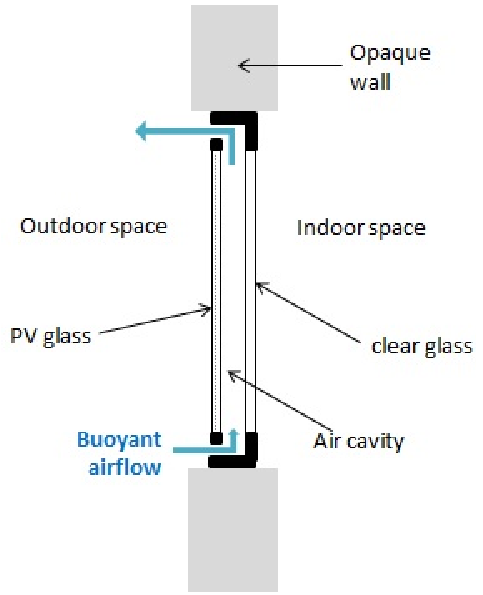

Figure 2: Cross-section view of PV ventilated glazing.

In principle, there can be no straight-forward rules in the selection of PV/T collector and/or system for building projects. The decision will depend on the geographical location and the actual application case by case. At a high-latitude location with low levels of solar radiation and ambient temperatures, space heating is required most of the time and air-based PV/T can be useful and cost effective. At locations with higher solar input as well as ambient temperature, the water-based options can be useful for supporting year round hot water services and on top of this, there can be additional features for intermittent air heat extraction to provide space heating in winter and natural ventilation in summer. There are also good opportunities for extension to solar cooling application as well as heat pump and/or heat pipe integration. Figure 1 shows a BiPV/T collector unit with an array of heat pipes attached to a thermal absorber with solar cells laminated at the top surface. The condenser end of each heat pipe is inserted to a manifold heat exchanger where the feed water stream passes through. Thermal efficiency can be enhanced when front glass is provided. Besides, the facade thermal insulation is improved. The aesthetic impact of arrays of BiPV/T panels is evidently a matter of taste and may not be always negative. Advances in the development of multi-functional PV/T facades may provide an important stimulus for architectural expression.

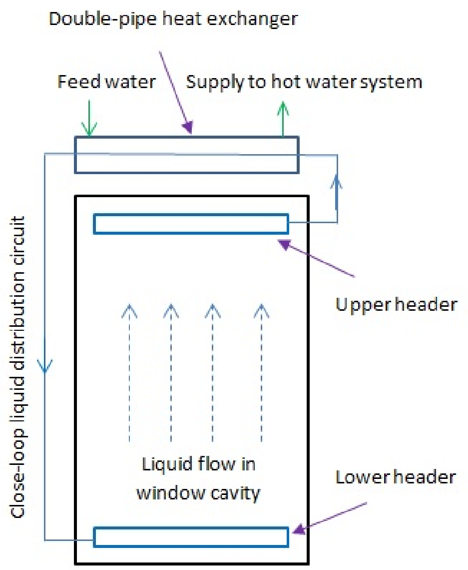

Figure 3: Flow circuit of thermosyphon liquid-flow window.

The design of extensively-glazed building is a world-wide architectural trend. The positive side of this lies in its transparency, natural brightness, modernity and indoor-outdoor interaction. But energy wastage is the key drawback. At this end, the PV ventilated glazing technology offers substantial energy saving opportunities through air conditioning load reduction, more favorable daylight penetration, and solar energy utilization. Figure 2 shows the configuration of a PV ventilated glazing for use in warm climate. The fenestration system has two glazing assemblies. The inner one is simply a clear glass pane. The outer assembly carries a PV glass pane with vent openings at its top and bottom ends to provide the buoyant flow of ventilating air from the outside on sunny days. With the heat absorbing effect of the semi-transparent PV glazing together with the cooling air stream in the cavity, the solar transmission to the indoor space is much reduced. The system also improves disability glare and local thermal discomfort caused by radiation asymmetry. An alternative for moderate climate application is to have controllable vent openings at both the outer and inner glass panes so that a seasonal switching between outdoor and indoor airflow is feasible for summer cooling and winter heating applications.

As an economical alternative, one promising design is the replacement of airflow channel by colorless liquid flow like water. In the liquid-flow option, a thermosyphon-induced liquid stream flows up the cavity to the heat exchanger at the top for feed water heating. Figure 3 shows an indicative liquid flow circuit. Solar transmission through glazing is then reduced and so the space cooling load is lowered. Natural light is enhanced since the liquid layer has negligible effect on the visible light spectrum. The advantages are then thermal load reduction, natural light preservation and utilization, and useful heat gain for hot water supply in one goal.

The building integrated active and passive solar designs ask for the consideration of all building components and services systems at one shot, well at the project commencement stage. In other words, site planning, aesthetic design, system equipment and construction material selection, financing, construction, commissioning, and long term operation and maintenance have to be well coordinated. This can be another challenge to be overcome.

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