Convective heat transfer enhancement for Building Integrated Photovoltaic applications and new solar PV-T collector design

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Abtract

Recent increased interest in the development of high-performance buildings is strongly related to the *world-wide* efforts to reduce greenhouse gas emissions and to increase fissile and fossil energy savings facing fissile and fossil resources depletion. The building sector constitutes one of the most significant energy consumers, and energy reductions combined with diversification of energy production through renewable energy will have a major impact on energy savings and by reducing greenhouse gas emissions could limit actual fast climatic change. Most of European countries are now targeting for 2050 to reduce by a factor 4 the greenhouse gas emission. This drastic reduction relays on a reduction of building energy needs which can be reach by efforts on insulation, inertia for example and relays also on a diversification of the energy production, electric or thermal with co-generation solutions.

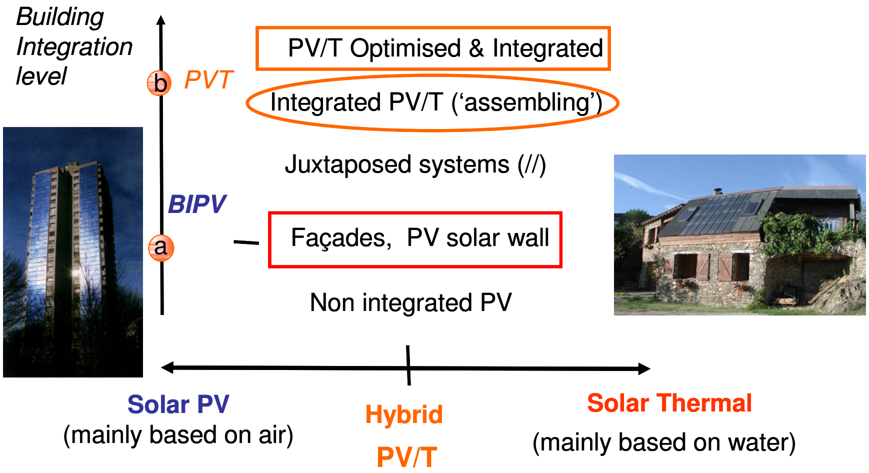

Figure 1 : classification of PV integration in buildings.

One of the promising solutions in the development of energy efficient buildings is increasing PhotoVoltaic (PV) systems which provide local electricity but can also be developed as source of cooling and/or heating by natural or forced convection. This kind of multifunctional envelop component which are under study since recent time can be ranked in two categories : Building Integrated PhotoVoltaic (BIPV) systems as double-skin (figure 1.a) type (facade and roof) or hybrid Photovoltaic/Thermal (PVT) solar collectors (figure 1 b). We are focusing on facade configuration which represents the most important potential of available surface for BIPV (Figure 1.a). Integrated solution presents some barrier linked to the PV heating risk. Indeed, the major limiting factor relays on the strong temperature dependency with an electrical efficiency [1] which falls down with the temperature (loss of 0.3%/°C to 0.5%/°C for silicone PV cells). These configurations are then composed by the primary façade of the building separated from a secondary photovoltaic façade by an air gap. These concepts of integration is to use this air gap to cool the PV panels and to recover this heat for the building needs during the winter and use it as a solar chimney for driving natural ventilation within the building in the summer, whilst during both periods producing electricity from the PV panels. The aim of the studies led is to promote better cooling of the PV facade for the most critical thermal conditions (summer/natural convection) working on its typical geometrical arrangement. It consists of an alternation of PV cells (localized heat sources) and semi-transparent window panes (unheated zones). Fundamentally, the flow of natural convection that develops within the vertical channel appears to be subjected to boundary-localized thermally active areas and adiabatic areas, evenly distributed throughout the height. This requires numerical [2-3] and experimental [4] investigations on parametric variations of magnitude and space frequency of the heated areas as well as intermediate spacing. Other complementary solutions can be explored such as wall thermal properties that obviously play a role on the flow regime and heat transfer in the channel.

Research led on the second category of concepts (figure 1.b) is related to the development of hybrid components PV-T which are fully bi-functional solar collectors. Studies seek to valorise the share of collected solar energy which is not converted in electricity by the components (80-85%). The majority of the studied components tend to recover energy arriving at the back face using a fluid flow (air or water heat exchanger). The studied collectors with water are most numerous because of the fluid which allows a better recovery of heat. Recovered heat is with low or average temperature. The control of this level of temperature is a crucial parameter. However, the design and the control of the performances of such components remain delicate even if when the cells are cooled, the electric production increases : elevated level of stagnation temperature, no-uniformity of temperature field which is likely to degrade the PV function, pressure losses, etc … Investigations led experimentally and numerically on different solar water hybrid concepts will be presented [5-7].

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