NEW CHALLENGES IN SOLAR ARCHITECTURAL INNOVATION

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ABSTRACT

Among the century's main challenges, climate change and the need for energy sources diversification are of great importance. In this context, renewable energies undoubtedly have an important role to play. Photovoltaic (PV) electricity is especially well suited to face these energy challenges. It is now established that the low thin film photovoltaic panels production costs will allow, even in continental climate, to reach low electricity cost, providing easy installation, public acceptance and high reliability. However, architectural considerations are often neglected in the current integration of PV panels. Taking into consideration specific architectural aspects like the surface appearance and the colour of the PV modules can become the key for the successful development of new, well integrated solar systems.

To achieve this goal, our team, within the Archinsolar [1] project framework, works on the development of new generation of photovoltaic elements based on silicon thin films technologies (amorphous and micromoph). These new elements will be ultra-reliable and manufacturable at a very low cost, allowing a good architectural integration, respectful of the environment, landscape and built environment.

General context

The renewed debate on nuclear energy following the recent events in Japan, the numerous political decisions made in favor of the development of renewable energies as well as the attitude of the public, which is always more concerned about environmental issues, lead to the development of new and more adequate technologies adapted to our current energy needs.

Photovoltaic energy is particularly well positioned as it is proven that a large part of the electricity needs of our modern society could be covered by photovoltaics, providing intelligent energy management if applied. In the long-term, solar energy should even be used to provide a significant part of the world's energy consumption. As an example, the well oriented roofs of Switzerland (130 km^2) could cover around $1/3^{rd}$ of the 58 annual TWh with standard crystalline modules.

It is then reasonable to argue that, today, there is no "versatile" solution available on the market which is inexpensive, aesthetically acceptable and easy to install. Nowadays photovoltaic energy is still limited by to heavy investments. These investments are notably associated to the unit prices, to the BOS costs (mounting, support, inverter) and to the planning costs (linked to the experience). Indeed, the price of the modules proposed on the market is still one of the most important factors which retain potential purchasers. In the built-environment and in specific landscape, aesthetic aspects will play an increasingly important role, as the pressure not to install PV in areas reserved to agriculture is increasing.

These crucial aspects are of utmost importance to succeed in competitively positioning photovoltaic energy either on the electricity market or for internal use. Only then photovoltaic electricity will be able to contribute significantly to the general electricity production.

Simplicity of installation and multi-functionality for lower costs

Technologies based on thin-films such as amorphous or microcrystalline silicon [2-3], have the potential to lead to a stronger cost reduction of the solar kWh (<30€/m^2 for the thin layers) and offers the unique potential to cover large surfaces at a particularly low cost. Furthermore, thin film Silicon technology is based on abundant and non hazardous materials.

To reduce the high expenses related to the installation of photovoltaic modules, solutions to simplify the installation of system is required. Currently, an installation of photovoltaic modules on a roof remains complex and needs the intervention of several working corporations, from engineers to roofers. A general simplification of the systems, in particular an improvement of the mechanical stability and a simplification of the electrical connections are taken into consideration. Furthermore, the size and the weight of the module, using composite materials [4] is taken into account and should be adapted to allow only one roofer to be able to install the system.

Integration solutions allowing the replacement of other building components by photovoltaic panels will reduce the overall cost of the installed system. Simple and modular building elements such as roof tiles and slates, or solar roof windows (semi-transparent), and other components are certainly the most innovative aspects. These elements should then ensure multifunctionality such as mechanical stiffness, water vapour barrier [5-6], building element, insulation, sun protection or capturing the heat energy in addition of solar power generation.

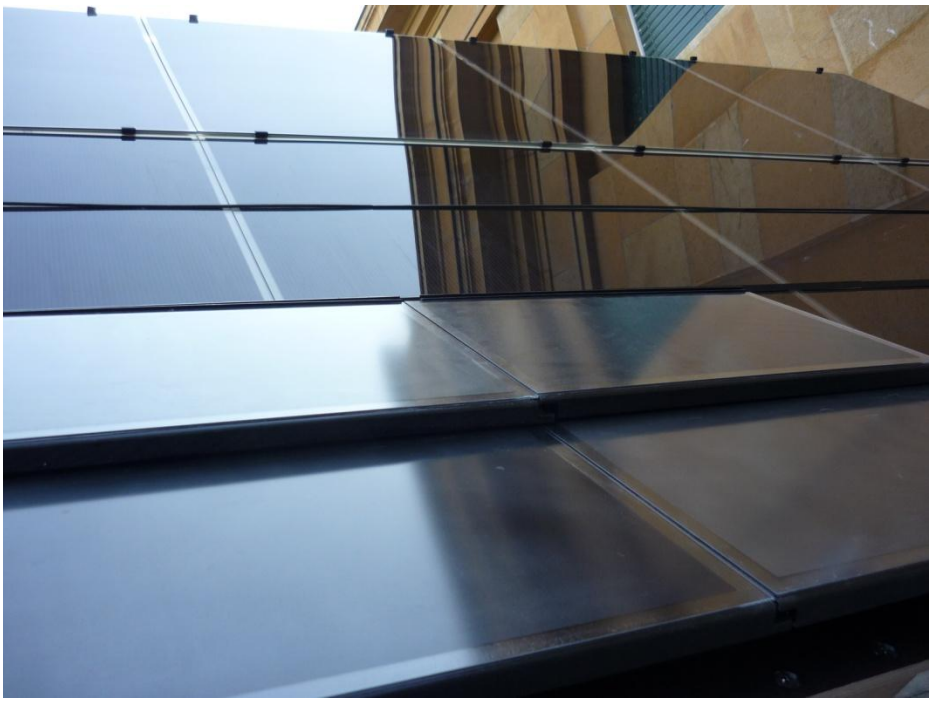

Figure 1: Demonstration of multifunctional solar tiles. In addition of generating electricity, the tiles ensure to the roof its water tightness which therefore allows an installation without additional aluminium frame and resulting costs. By using textured glasses which act as anti-reflectors, it is possible to improve the general aesthetic of the roof.

Architectural aspects and aesthetics of the PV modules in their environment

From an esthetic point of view, the color variation, going from the typical brown of amorphous silicon to the typically black for micromorph, constitutes one of the great starting advantages of these kinds of modules.

The desire for optimum equipment performance is sometimes in conflict with site and building conditions [7]. While effective in establishing proper orientation of solar panels, these installations give a discontinuity in the building and its architecture.

Figure 2: The saline of Bad Dürkheim in Germany is a very good example where the combination of photovoltaic modules (here thin silicon films modules) and historic building has been done harmoniously.

Providing architects with a pallet of various products, with amongst other aspects, different color levels, is essential. A recent survey [8] showed that a majority of architects would prefer other colors than the classical blue of crystalline solar modules, even if a lower efficiency is the price to pay. In the long term, we can imagine that every roof could be completely covered with suitable tainted photovoltaic modules and cost effective. Due to the inherent homogeneous aspect of the thin films based modules, as well as the possible modification of these colors by the introduction of colored filters [9-10] or polymers, it is possible to consider a whole pallet of modules aesthetically interesting which will be better integrated in their environment.

Figure 3: a) The possibility to modify the colour of the PV modules, according to the color of the roof tiles give to the architects a pallet of aesthetically interesting elements. b) Example of a modified amorphous thin film module by the use of colored polymers.

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