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The technical options for installing solar energy systems on modern buildings

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Abstract. Solar power is almost a good idea for home owners interested in saving money on electricity costs and supporting a healthier environment. But there's no denying that some homes are more well suited to solar power systems than others. Your sun exposure, roof, climate, even state policies can influence how well you'll do with a residential solar power system.
It is true that the initial cost might be a bit heavy, but it makes more economic sense in the long run. This is a onetime expenditure that serves cost free for the next thirty years or so. And about its effectiveness, people should feel comfortable that the technology itself has been proven, as a reliable and clean energy source.
This article introduces the methodology and the results of an integrated design approach to optimize both structural system and building energy performance through architectural design process. The book titled Intelligent Design using Solar-Climatic Vision, introduced a number of practical and effective design approaches towards the creation of energy-efficient building façades as well as comfortable urban environments. Applying solar-climatic vision, especially during the procedure of optimizing tall structural systems, can develop sustainable frameworks that maximize thermal comfort while minimizing waste of resources.

1. Introduction

Solar systems are available in different designs: They can be installed on the roof (flat or steep roof), integrated into the roof skin or even replaced with it. Solar systems can also be installed on balconies, in the open field or on the facade of a building. This article is intended to give an overview of how to build and use solar systems - both solar power systems and solar heating systems - on the house facade. Will find out which advantages and disadvantages solar facades have and which extraordinary technical solutions are already available for solar facades [1-3].

Solar heat and solar power from the roof or from the façade**.** Solar systems on roofs are now commonplace. But can't always use your own roof to generate solar heat (solar thermal, ST) and / or solar power (photovoltaic, PV) using free solar energy. Reasons for the unsuitability of the roof can be of a static nature, because the roof does not have the necessary load-bearing capacity for the solar system and cannot be stabilized accordingly. Or the roof is a northwards oriented pitch roof, which promises little income. Sometimes there are just visual reasons that speak against a solar system on the house roof [3-5].

As an alternative mounting location for a solar system, the offers facade of the building. Both solar power modules and solar heat collectors can be attached to the facade (usually when retrofitting existing buildings) or integrated into the facade (mostly in new buildings) (Fig.1) [5-8]. The latter assembly method saves the costs that would be required for the facade design if no solar facade were integrated. Even with a solar facade it is of course about the highest possible yield that it should generate: The solar facade must therefore be strategically placed and aligned so that they capture as much solar energy as possible. It is also important to ensure that the solar facade is not shaded by trees, neighboring buildings or your own roof overhang. Because shade is also a major reason for yield losses [8-12].

Figure1. Apartment building designed as a solar house with a modern, futuristic-looking solar architecture. A total of 317 square meters of solar collectors were integrated into the east facade and the south-facing gable side.

2. Methods and materials

One reason why solar facades are installed less often than solar roofs is not the supposedly higher cost, but rather the fact that many architects and builders know too little about this technical alternative to solar roofs.

An important difference between a solar roof and a solar facade is the angle of inclination at which the system receives the sun's rays. The following applies: A module / collector mounted vertically on the facade harvests around 30 percent less solar energy than a component positioned at an angle on the solar roof. But vertical is not the only type of installation when it comes to solar facades: The PV modules or ST collectors can both be installed vertically on the facade or with the help of a special device (elevation, etc.) can be removed from the vertical at an angle.

Solar power facade with facade modules. While photovoltaic systems "on the roof" predominantly in the form of crystalline solar modules are used, are employed in solar facades rather thin-film PV modules, which have a comparatively better efficiency than crystalline modules at this angle of incidence. But not only the efficiency alone is the reason for their use as a solar facade, but also the fact that thin-film modules, due to their technical structure, give the architect of the building more scope for design. Good to know: Classically, the topic of solar facades is about the actual facade of a building, although there are now also solar power systems, that can be integrated into windows or awnings.

The aim here is not only to find the optically matching solar modules for a facade, but also to exhaust the facade design options (with glass, ceramics, plaster or natural stone) that match the solar module.

The following variants of PV solar facades have already proven themselves in practice (Fig. 2):

- Glass-glass solar modules
- Thin-film PV solar facade
- colored SIS solar cells
- flexible solar films
- printable photovoltaic modules

The transparent, monocrystalline glass-photovoltaic module (Elegante) from solar can be integrated into architecturally sophisticated glass roofs, as windows or in buildings as a solar façade (fig.2).

Figure 2. Monocrystalline -glass-photovoltaic module.

The thin-film module "Architectural PV Module SKALA" is available in different colors and different sizes and is particularly suitable for ventilated facades. Because it is attached to the back of the module, the module fits into any solar facade without any visible clamping on the front (Fig.3).

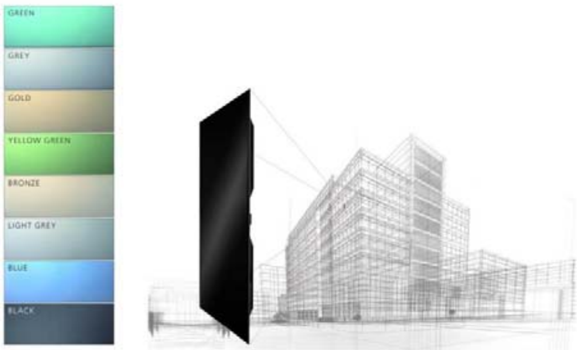

Figure 3. Architectural PV Module SKALA.

Solar thermal facade with facade collectors. A solar thermal solar facade is a functionally optimal component for installation on a vertical facade, provided it is not only intended to be used for heating drinking water, which has long been its main purpose, but also for heating support. Because there - unlike roof systems - it also picks up the solar energy supplied by a low-lying (morning, evening, winter) sun. When constructing a solar thermal solar facade, you can choose between rear-ventilated or non-rear-ventilated collectors. There are correspondingly designed solar heat collectors with and without rear ventilation. Anyone who opts for a solar collector type without ventilation and integrating it into the facade or mounting it on the facade, kills two birds with one stone: because the solar facade is also thermal insulation.

The solar absorber mats from MEFA Energy Systems (here as facade assembly) are used to generate energy from solar and environmental heat, exhaust air, process heat, etc. as a source for heat pumps (Fig.4).

Figure 4. MEFA Energy Systems

3. Results and discussion

Facades for solar support for ventilation systems. The Solar Wall system is a special solar air heating system for generating solar heat through the facade. A special collector is used, which transfers the sun's heat to the air and then feeds this naturally heated air into the building's ventilation system. For this purpose, the SolarWall technology is installed as a facade element on the building and creates an air cavity (Fig.5).

The solar facade collector consists of a coated steel profile sheet with thousands of specially developed perforations on its surface. This "solar active" wall acts as a simple and robust air collector that collects the heated air [6]. Where the sunlight hits the steel surface, energy is absorbed, which heats the surface and forms a thermal boundary layer. The heated air layer is then sucked through the perforated surface onto the back of the facade collector and fed into the building's ventilation system.

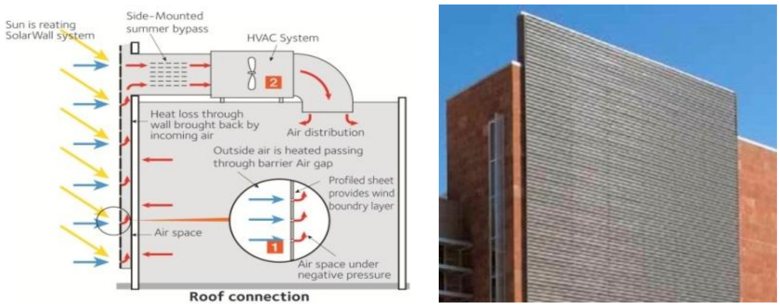

Figure 5. Schematic representation of the functional principle of the SolarWall and Facade with elements of the solar air heating system SolarWall.

Facades for solar support for thermal insulation. Transparent or translucent thermal insulation is based on a very similar principle. The term "transparent thermal insulation" refers to semi-transparent (translucent) components made of plastic or clearly cast glass, which are either installed in front of a house wall in order to heat the facade with solar energy and limit the heat loss of the house or heat into the interior via the To guide the house wall, and optical components that serve to protect against heat and at the same time allow brightness into the room. Here, transparent insulation materials are used primarily in glass facades in single-family houses through to commercial buildings or parking garages (Fig.5).

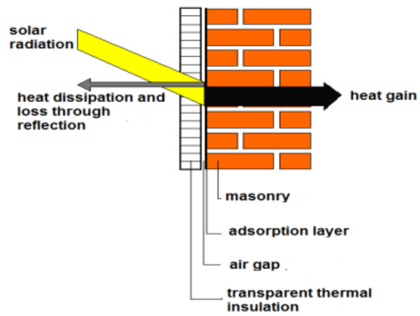

Figure 6. Schematic representation of the functional principle of a solar facade with transparent thermal insulation.

An energy clinker system was developed, which consists of multi-layer composite pipes that are inserted into grooved clinker bricks. A fluid that has been cooled down by a cooling unit circulates in these tubes. The combination of the multilayer pipe and the sunlit clinker then acts as a simple heat exchanger (fig.7).

If the solar radiation hits the clinker brick surface of this solar facade, it is converted into thermal energy. The energy remaining in the masonry leads to the heating of the clinker. Depending on the thermal conductivity and storage capacity of the clinker, the masonry is heated more or less quickly. The energy brought in is then extracted with the help of the composite pipes integrated in the clinker facade and can then be added to a heat pump.

Figure 7. Energy clinker system.

4. Summary

Facades are the defining element of a building; In the cityscape, they are the faces of the house and give the first important impression for users and passers-by. With the energy transition, all planners involved are faced with a design challenge: How can clean energy production and architecture come together photovoltaics (PV) play a central role in this. In the building sector, PV modules on the roof have established themselves. As a facade element, conventional PV modules have seldom been convincing to date. Its technical appearance and the dark crystalline sheen have a repellent effect and leave architects little scope for design. In addition to the higher costs compared to a simply plastered facade, the maintenance, the feel and the structural integration pose further challenges for the architects and builders. In order to give architects more creative freedom, the industry developed more flexible products and manufactured solar modules for specific projects.

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