

PERSONAL REFLECTION

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Graduation Topic:	SOLAR - COOLING FAÇADES: An integrated façade design with thermoelectric cooling systems for office buildings in Athens
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Graduation process

The graduation projects explores the application of a solar cooling façade system on an office building in Athens, Greece. It utilizes photovoltaic and thermoelectric modules with the purpose of transforming the solar power to DC current and subsequently to temperature difference, which is responsible for the cooling effect. The main focus is on Façade and Climate Design, which are two of the basic directions of the Building technology sustainable graduation studio. The graduation project deals extensively with research on PV, TE technology as well as the most outstanding climate characteristics and vernacular bioclimatic strategies in Greece. It also involves field research and passive optimization, which provide a solid case study for the development of the façade design concept.

The project involves a large part of research (literature review) on the various aspects that are important in order to answer the research question and sub-questions. The research itself could be abstractly separated into two parts: the location/context-related and the technology-related. While the location was very familiar to me and has been easy to access and retrieve the necessary information, the technology (PVs and TEs) has been a completely new field. Especially, the sources about the thermoelectrics are not at all related to HVAC applications, only with few exceptions. Also, the COP of the thermoelectric modules is dependent on a number of factors such as the dT [°K], the I [A] and the U [V] and this leads to a rather complex calculation of the system cooling capacity. During this part of research and optimization it felt that the progress was stumbling on such factors and not providing a good timing for the prompt start of the façade design. Moreover, the calculations of the system performance have been rather complicated as they involve not only the passive design strategies, but the PV and TE systems. Besides these, the whole 'route' has been interesting and challenging up to the end, where the final performance test was done in order to find out how well this system can cope with the cooling demands of the case study office building.

Relationship between research and design

Both research and design are strictly connected to the main research question "How can a façade regulate the indoor temperature in an office building located in Athens by using bioclimatic strategies and thermoelectric technology in order to reduce the amount of energy needed for cooling?" Big part of the

research deals with identifying the most outstanding parameters for the design. Furthermore, the research provides a basis of technological knowledge, perception of environmental and topological context, cooling demands, all of which feed the design process.

Societal impact

Even though thermoelectric technology has been explored and used in multiple areas since the discovery of the Peltier effect in 1830's, it is currently on R&D stage regarding the façade integration. Within this scope, this project takes into consideration the specific characteristics of Athens as a location and provides with an applicable design product. It does not aim to exhaust all design possibilities, rather propose a more general component. Of course, it can be applicable in practice, but it could also be subject of further design.

Also, it is important to consider the current development of the technology, as it has a direct impact on the effectiveness of the cooling generation. It is estimated, according to literature, that in the future the involved technologies will be able to provide with higher COPs, so possibly the total cooling loads of an office building can be covered.

The proposed façade module is innovative in the sense that it integrates the thermoelectric technology, which is only in a developing phase. The whole system has the benefit of being low-maintenance, however if compared to similar technologies for cooling, it can only achieve partially same good results. For instance, the thermoelectric module system has limited cooling capacity compared to vapor-compression systems. For this reason we can claim that the design product is innovative, yet there is further space for future development.

Sustainable development contribution

The project contributes significantly to sustainable development. Mainly it addresses the problem of scarcity of the available energy resources and the imperative need for use renewable energy resources. This is achieved by using the solar energy as input and with the PV and TE modules it can eventually be used for cooling generation. Moreover, there are examined and applied several passive strategies, which lead to an optimum passive scenario. This is a very important step, as it can help reduce drastically the cooling loads in the hot period of the year only by means of passive design.

With the use of solar energy, a renewable energy resource, we achieve to minimize the use of any other non-renewable energy source (eg electricity generated from fossil fuels). Apart from being a legal requirement nowadays, the use of renewable energy resources is linked to plenty of beneficial environmental practices. Therefore, it is not only a necessity, but a moral statement to a more sustainable future.

As an intervention that focuses on the façade and climate design, it improves the indoor comfort (thermal and visual) and also signifies an important role on the daily working conditions of the people.

Relation to architecture and the built environment

The relation of the project to architecture and the built environment is very evident. The building envelope is the link between interior and exterior, acts like the skin of the building. It is the filter that plays both the separating and the linking role. It constructs the image of a building within its urban context and simultaneously it defines the indoor environment of the users.

Lastly, the building envelope is often connected to the problem of the urban heat island effect. Particularly in Athens this phenomenon is very intense and hardly solvable. This is also taken into consideration during the design process and confronted by using 'cool' materials with small heat capacity. The problem occurs naturally in a dense city like Athens and even though the proposed design will not be able to solve it, it contributes to a better level.