Reflection

An integrated thermoelectric facade; Design of an integrated facade for a typical non-residential building in the semi-arid climate of Tehran using Thermoelectric technology powered by PV panels for heating and cooling.

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1- Graduation process

The graduation process was oriented mainly around providing enough heating and cooling for an office building using thermoelectric modules. The final product of this research and design project is an integrated thermoelectric façade, and therefore the three areas that this project falls upon is façade design, building physics and services, and sustainability.

The thesis started with an investigation into solar cooling techniques and later thermoelectric cooling and heating in specific. The topic was relatively new and therefore the first months of the thesis were spent on understanding mechanical cooling and heating basics and thermoelectric technology itself and how it could be used in such a façade system. Next, a typical office model was developed as an example in which this façade was implemented. Later it became more than just an example but also as a case to prove that this technology was not imposing too many limitations on the architectural design. Tehran was selected as the location of this project, a place where both heating and cooling were required annually, and many new office buildings were being built every year. Office building type was chosen as the worst case scenario, and if proven to work as planned, this façade design could be implemented in any building with any function.

To reduce the system sizing and also to provide heating and cooling for this building only with electricity provided by PV panels, the heating, and cooling demands had to be reduced as a prerequisite. During this process, I learned a lot about how buildings work in terms of energy performance and how passive strategies applied to different buildings and locations would result in different outcomes. Designbuilder that was used in this stage is a user-friendly software that I was familiar with; however, still, some time was required to get acquainted with many topics that as an architect I was not well familiar with.

In the next steps, a design was proposed and developed for a building integrated façade that utilizes ventilation to increase the COP of the system. A new façade type was here designed based on the research done on all the factors that contribute to better performance of a TE arrangement, although not every aspect could be developed within the scope of this research. While the technology used

here is not new, its façade and building integration are limited to a few prototypes. This project followed a design by research approach, and the effort was to prove that this technology with the current limitations can offer a clean and sustainable alternative to commonly used heating and cooling systems by relying on renewable resources.

The methodology used is design and evaluation with a parametric model and optimizations developed in this project using Engineering Equation Solver, EES. The new software used in the assessment section was a beneficial mathematical program especially for being capable of running optimizations and parametric studies.

I found the orientation of the whole studio very helpful in defining, developing and verifying this design; however at times, I felt that lack of knowledge in fields such as of thermodynamics was holding me back. This topic at many times relied more on mechanical and electrical engineering aspects than architecture and helped me to broaden my horizons as an architect, and this is after all the main reason for choosing this studio.

2- Societal impact

Many considerations require more profound studies and future developments are required before a real façade product is built and widely applied. Assumptions were made that need to be proved by building proper mock-ups and more detailed simulations. Many aspects such as CFD analysis to measure pressure drops and design of the ventilation ducts and the heat sinks, were not studied. Another area which needs improvement in this design is dealing with the excess heat released from the ventilated air into the surrounding environment which would contribute to urban heat island effect. As an example, the heat could be used in a heat recovery system to preheat the required hot water in summer.

Also, it is essential to mention that in the future where the technology has grown more mature, investments in such façade products will be even more beneficial and promising. As it gains more favor, its availability and cost feasibility improve which further help in launching such facades in the near future. It is seen that many of the leading façade companies today are investing more on such integrated facades that combine functions such as ventilation, cooling, heating, and shading into the building envelope. The innovation in the façade product proposed in this project is in the combination of thermoelectric modules used in façade with ventilation system to reach the highest COP possible in this configuration.

As energy consumption in the building sector is gaining an increasing attention among researchers and designers, more developments are being done in providing required thermal comfort by renewable resources, decreasing the heating and cooling demands, increasing the efficiency of systems to consume less energy, and use of refrigerants with less or no global warming and ozone depletion potential. The designed thermoelectric façade in this project provides a refrigerant free system with an acceptable COP capable of providing sufficient heating and cooling all around the year with electricity only provided by PV panels. Other advantages of this façade that make it a competing system with commonly used ones are its easy integration with façade, silent operation and its capability to easily switch between cooling and heating as well as low maintenance.

Moreover, it is proved that the annual heating, cooling and lighting loads in such office building could be reduced by 37 percent, the cooling, and heating design capacity by 39 and 49 percent respectively. Moreover, compared to the commonly used air-conditioning products, this integrated façade system contributes to decreasing the water consumption in buildings as a critical issue in such hot and dry climates.

A comparison must be made between the costs associated with this façade and the ones of a commonly used HVAV system to prove the feasibility of this project and measure the extent to which all different social levels could benefit from. This is especially important in the context of Iran where sustainability approaches are limited to how they would profit the owner and not the entire, city, country and the planet.