Reflection of Graduation Research

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Topic: A-Brick ASTF: Exploring feasibility of engineering an Active Solar Thermal Façade (ASTF) product based on A-Brick system

1. **What is the relation between your graduation project topic, your master track (Building technology), and your master program (MSc AUBS)?**

   The graduation project – developing Aberson's A-Brick ventilated ceramic façade into an effective Active Solar Thermal Façade (ASTF) – is tightly aligned with both the studio's theme and the master track's focus. The project is in the direction of **Façade design** and **climate design**, which bridges architectural design with sustainable energy technology, which is a core objective of the Building Technology track in the architecture program. By turning a façade system into an energy-harvesting envelope, the work embodies the master track's emphasis on integrating technical innovation into building design.
   My two-year master's program provided a strong foundation for my graduation research. Through the **Climate Design course**, I gained essential knowledge in building physics, particularly in thermal calculations, heat pump principles, and heating and cooling load analysis, all of which were fundamental to my project. The **Research Methodology course** taught me how to structure and write a scientific report, design experiments, and analyze data effectively. The **Bucky Lab course** developed my hands-on skills, enabling me to construct various laboratory-scale prototype models for experimental testing. Additionally, the **Technology Façade course** equipped me with the ability to design architectural façades, which proved critical when developing the construction details and assembly sequence of the A-Brick ASTF for real-world application.

2. **How do you assess the value of your way of working (your approach, your used methods, used methodology)**

   My research working is comprehensive and structured which combines theoretical research, experimental testing, simulation, and design. This multi-method strategy enabled me to thoroughly explore both the feasibility and performance of the A-Brick ASTF system. I began with a **literature review** to establish a foundation of relevant theories and technologies in solar thermal façades and building energy systems. Then I used Aberson's A-Brick prototype to construct a **laboratory testing model** to measure real-time performance parameters such as collector efficiency and heat transfer coefficients using both **steady-state** and **transient methods**. These experimental findings were cross-validated through **CFD simulations** in ANSYS Fluent The system-level performance is manually **calculated by mathematical method** and validated in **TRNSYS software**. Finally, the technical design phase translated the research into practical **facade integration details**. The iterative feedback loop between testing, simulation, and design proved especially valuable in refining the concept and ensuring engineering feasibility. Therefore, I consider the methodology highly effective in bridging theory and practice, and in delivering a well-rounded, application-ready solution.

3. **How did your research influence your design/recommendations and how did the design/ recommendations influence your research**

My research had a direct and iterative influence on the design and recommendations of the A-Brick ASTF system. The experimental results—such as collector efficiency, heat transfer coefficient, and transient thermal response—provided quantitative inputs for system sizing and configuration. For example, both **front-mounted** and **back-mounted** configurations are proposed, and the research results show that front-mounted configurations are more suitable for DHW-preheating and back-mounted configuration is in favor of heat pump applications. Besides, the research results show that **pipe material** has a relatively moderate influence on system efficiency, thus it suggests using steel rather than copper considering the cost. Meanwhile, the measured collector efficiency of 17% and a heat-transfer coefficient ($\mathbf{h_{sys}}$) ranging from 14–25 W/m^{2}K shaped the recommendations on **required façade surface area** for DHW preheating and heat pump operation.

Conversely, the design intentions and feasibility considerations also shaped the direction of the research. For instance, the choice to maintain the **modular nature** of the original A-Brick system led me to explore installation details, structural integration, and assembly sequencing in Rhino, ensuring that research results could be applied in real architectural projects. The need to preserve **aesthetic integrity** without compromising energy performance influenced which configurations I tested and simulated.

This reciprocal relationship between research and design ensured that the final recommendations were not only technically validated but also architecturally viable and constructible.

4. **To what extent are the results applicable in practice?**

The results and design are highly applicable in practice. First, the design is based on Aberson's A-brick system which is a commercial façade product that has been applied to lots of real buildings. My design is slightly modifying original product and keeping the original structure of it. The use of standard materials (e.g. steel piping) and simple assembly and connections make system easy to construct. So technically it is applicable to all building cases.

Second, the experiment result data is based on laboratory experiments which are tested on real A-brick product prototypes. So, the results are highly reliable. The results show a 3.14 m^2 ASTF panel array can contribute significantly to domestic hot water preheating during spring and summer, and a 22.8 m^2 array is sufficient to support a 6kW heat pump under Dutch winter conditions. Which is feasible in real cases.

However, full-scale application still requires further validation under real outdoor conditions. Factors like wind-driven convection, long-term durability, and maintenance protocols need to be addressed. Nonetheless, the current research lays a solid technical and architectural foundation and offers design guidelines that can directly support early-stage implementation in practice.

5. **To what extent has the projected innovation been achieved?**

This research is innovative as it is the first to explore the use of **ceramic cladding as the absorber plate** in an Active Solar Thermal Façade (ASTF), while most previous studies focus on **metal** or **concrete-based** systems. Additionally, the façade is designed to function as a **low-temperature heat exchanger,** allowing integration with **heat pumps—**a dual-functionality that introduces a novel approach to energy-active envelopes. Previous studies barely use building envelopes as an outdoor unit for heat pump systems. A further innovation lies in the integration strategy: by preserving the original A-Brick system's modular, ventilated design, the ASTF maintains architectural aesthetics while embedding renewable energy functionality, making it practical for real-world applications without compromising façade appearance.

6. **In what ways did technical difficulties or constraints affect or limit the outcomes presented in your thesis?**

The first difficulties are the research conducts in October and November, which don't have enough solar irradiance for solar collector experiments, the experiment is mostly conducted indoor, which excluded real-world influences such as wind convection and sky radiation. As a result, the measured heat transfer coefficients may be underestimated or overestimated compared to outdoor performance. Additionally, halogen lamps were used to simulate solar radiation, but their broader spectral output and the limitations of the solar power meter introduced uncertainty in the irradiance calculations.

On the simulation side, it is my first time using ANSYS fluent and TRNSYS, I have taken a lot of time learning them, but complicated geometry is still not working. Thus, a simplified section of A-Brick ASTF was created, the ceramic cladding was treated as a continuous closed solid, while the actual A-Brick façade contains air gaps between each other that allow air movement. This simplification affects the predicted convection and heat-transfer performance.

7. **How does the project contribute to sustainable development?**

This project contributes to sustainable development by transforming a passive ceramic façade into an **energy-harvesting envelope** that supports the decarbonization of building operations. By integrating solar thermal collection and low-temperature heat exchange into the A-Brick façade, the system reduces reliance on conventional fossil-fuel-based heating and enhances the efficiency of renewable energy systems such as **heat pumps.** The façade can preheat domestic hot water in warmer months and serve as a stable thermal source for heat pumps in winter, helping reduce energy demand and improve system COP. This dual-functionality supports year-round energy performance, which is critical in reaching **net-zero energy** goals in the built environment. Furthermore, the solution leverages **off-site prefabrication**, reuses an existing modular product, and minimizes visual and spatial intrusion compared to traditional solar collectors or external HVAC equipment. These qualities make the A-Brick ASTF adaptable for urban retrofits and new developments alike, aligning with sustainable construction principles of **energy efficiency, system integration, and material reuse**. In sum, the project demonstrates how architectural design can actively participate in climate-responsive energy systems, promoting sustainable, livable, and resilient buildings.

8. **How does the project affects architecture / the built environment**

The A-Brick ASTF introduces a new approach to architectural design, where the envelope contributes to a building's heating demand by harvesting solar and ambient energy. This integration reduces the need for visible rooftop panels or outdoor heat pump units, allowing for **cleaner building aesthetics** and more flexibility in spatial planning.

9. **If given additional time and resources, which aspects of your research would you further develop or explore, and why?**

If given more time and resources, I would focus on validating the A-Brick ASTF system through full-scale outdoor testing to assess real-world performance under varying weather conditions. Long-term monitoring would help evaluate durability, thermal consistency, and reliability over time. I would also develop a more advanced control strategy to optimize when the system operates as a solar collector or heat exchanger, enhancing its overall efficiency.

In addition, I would improve the accuracy of system simulations by using hourly weather data and dynamic usage patterns and run parametric studies to optimize design variables like flow rate and pipe configuration. Exploring the economic feasibility—such as cost-benefit analysis and payback time—would be essential for market adoption. Lastly, I would investigate how the ASTF could be adapted to different building types and climates, extending its application beyond single-family houses to high-density or retrofit projects.