SMART ENERGY BUILDINGS

Development of a photovoltaic thermal system configuration with additional envelope-integration into a multi-family building

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Graduation thesis

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AR3B025 Sustainable Design Graduation
Master program Building Technology
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Faculty of Architecture and the Built Environment

As part of the Sustainable Design Graduation (AR3B025), a reflection is presented which discusses the course of the graduation project. The goal of this reflection is to explain various key elements of the graduation thesis, such as an explanation of the chosen research theme, the research approach and the relationship between the research methodology and the final outcome.

A subject that has triggered me more and more during my education in Building Technology, is the current transition between fossil fuels and renewable energy and what this means for the built environment. What kind of systems are possible and how can we implement renewable energy technologies in our buildings? The photovoltaic thermal (PVT) collector is a system that converts solar irradiation into electricity and heat. This system seemed an interesting graduation topic to me. Fortunately, interest was sparked as I approached one of the mentors of the research theme *Smart Energy Buildings*, Sabine Jansen. Sabine recently performed a feasibility study into a sustainable and integrated energy system for the Buiksloterham neighbourhood in Amsterdam. A part of the proposed energy systems was the recommendation to introduce PVT. However, there still was a demand for the way in which PVT could be applied on a more local scale, not least because it is known that PVT has a higher energy output per square meter than photovoltaic panels and solar thermal collectors separately. A multi-family building was interesting in this case, for such a typology has a relatively small roof area compared to the energy demand. Besides this, it is also interesting to find out how PVT can be integrated into a multi-family building, other than the more conventional way of adding it to a building. In this way, a PVT collector can become an integral aspect of a building. I approached Arie Bergsma to guide me in this process, which meant that Sabine and Arie would become my mentors. Although the exact outline of the research theme is aimed at energy storage, the research methodology is somewhat similar: performing a literature study, an energy concept development and an energy simulation.

The first part of the research was the literature study. This part should give an incentive of why we have to foster the switch-over from fossil fuels to renewable energy. That is why I talked about the aim of the Dutch government first. I continued, after a brief introduction about renewable energy systems, with PVT. For me, it was of great importance to grasp the phenomenon of PVT. I wanted to know how it exactly works, what kind of PVT types there are and how PVT can be applied in the built environment. Despite the fact that PVT is into existence for approximately four decennia, its research and development is still in its experimental phase because of the various aspects and complexities of PVT. The website ScienceDirect provides – after proper searching and reading – enough and endless information that could be used for the literature study. Various papers and data from distributors helped me to eventually make a choice for the PVT collector type with which I would continue.

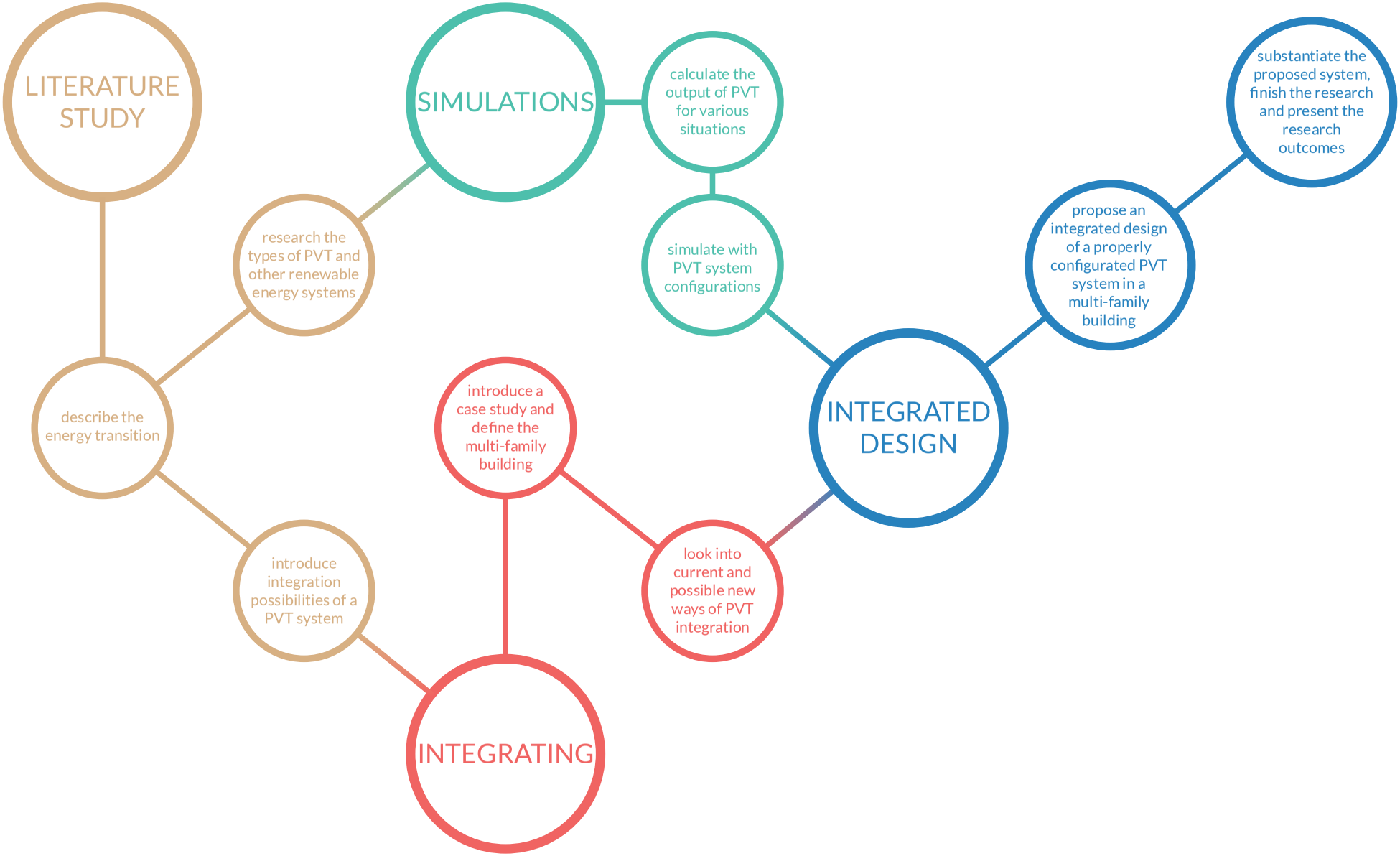
At this point in the graduation process, my approach slightly changed. I had to move from scientific essays to a more practically-aimed strategy. Now that PVT was thoroughly examined, it had to be integrated into the facade of the multi-family building. Also, additional renewable energy technologies had to be discussed which – together with PVT – could form a system configuration concept for the multi-family building of my research. All this had to be substantiated with calculations and energy performance simulations. The knowledge that I gained during the seven years of my education was put to the test: what do I know and what do I have to know for this research? The work that I produced during those seven years, together with some books, hand-outs and – frankly – the internet, that all provide (basic) knowledge about the field of research, proved to be very useful at this point. However, it took quite a while to grasp the calculations of the thermal, temperature and electrical output of a PVT collector. Not only their parameters are intertwined, they also need to be properly substantiated and grasped. And frankly, I underestimated this. For example, a PVT or solar collector is usually connected in series in order to achieve a higher output temperature. Overall, it can be said that especially the calculations entailed into a lot of learning moments for me. For the facade integration, some details I produced during my education were helpful, as well as some standard details and reference cases of integrated solar energy systems. The parts of the system configuration are explained in various books about building physics. Simulating the proposals was quite difficult, as one has to understand how a simulation program exactly works. It has to be said that for a graduation

process of this time span, only the basics of the simulation program can be unravelled. Anyway, it was up to me to gather all the information and to propose and clarify an integrated PVT system configuration. To be honest, all this was very complex and sometimes tending towards mechanical engineering, though this complexity made it very challenging and educational. It also showed that there is so much I do not know, but – putting things in perspective – that the basic knowledge that I have, proved to be of essential importance.

With PVT – and to a lesser extent other renewable energy technologies – being the main topic of this research, the focus was more aimed at research. Nevertheless, integrating PVT collectors into a building and developing a system configuration also asked insight in my design qualities. However, creating a design by researching design possibilities showed that in the context of this thesis, research had the upper hand. Moreover, I also think that design by research fits my nature, as I like to use proven outcomes and methodologies on which I can build further and eventually can create something new. This being said, I think that my approach worked in this case, because the topic demands proper research. This does not alter the fact that there are various aspects that I underestimated.

A part of the conclusion of this research discussed the aspect of optimisation and maximisation. My process showed a number of PVT-related parameters that I maximised in order to achieve a higher thermal and temperature output together with the optimisation of the PVT integration to get a more practical facade-integration. Especially during the last part of my graduation process, I was advised by my mentors to thoroughly explain a more integral approach, which is not linear (like my process). This means that I had to look at the interaction between various parameters and see how they influence each other. It is important to take a look at how a PVT energy concept can be applied on other - similar - buildings.

In my opinion, this research could be an important contribution to the understanding and application of renewable energy technologies in the built environment. Energy harvesting systems that use solar irradiation should not be seen as a stand-alone element in the built environment, but more as an integral and coherent part. With this research, I did an attempt to offer more clarity when it comes to renewable energy systems and their integration into the built environment.


LITERATURE STUDY
describe the energy transition
research the types of PVT and other renewable energy systems
introduce integration possibilities of a PVT system
SIMULATIONS
calculate the output of PVT for various situations
simulate with PVT system configurations
INTEGRATING
introduce a case study and define the multi-family building
look into current and possible new ways of PVT integration
INTEGRATED DESIGN
propose an integrated design of a properly configurated PVT system in a multi-family building
substantiate the proposed system, finish the research and present the research outcomes