

## Reflection

Sustainable design has already played a role within the entire Architecture programme for over a decade. It is particularly relevant to the master track Building Technology since developing sustainable buildings depends in large part on the use of technical installations. As the demand for sustainable building designs, such as Net Zero Energy Buildings and passive buildings has drastically increased in the past few years, this role has become ever more important. Within the Building Technology programme, sustainable design has always interested me, especially sustainable refurbishment.

In the last years an increasing number of research papers have been published within this field. Most of these papers focus on one or multiple application case studies which have actually been refurbished in reality. The real results after refurbishment play an important role in this field as this really proves how successful the refurbishment was. In contrast, in this graduation thesis I took a theoretical approach by reviewing completed projects and performing simulations. I reviewed and analysed multiple refurbishment projects performed in the past based on research papers of completed case studies and I performed simulations of three strategies with two energy performance programs. Furthermore, I also aimed to provide a clear overview of all the available techniques possible when refurbishing a building thereby providing relevant information and laying the groundwork for future research and projects in this field.

During my research I used Design Builder and Uniec for the simulations. Design Builder is a very useful program for building development and I had used this program before during other courses and projects in the Master programme. Uniec was a new program for me but due to its simplicity very easy to learn. By simulating the models during the development process, I was able to locate problems easily and immediately apply improvements. My first mentor had a good understanding of the programs and helped me solve a number of problems encountered during the development process.

By making Design Builder and Uniec models of all the different situations, I was able to compare the models and test the reliability of the models. Having undertaken this task, I now appreciate the complexity and the time needed to make the initial model of the current situation of a house. Especially the free-standing and semi-detached houses were difficult as these houses had very unique forms. Due to the limited possibilities in Design Builder it was difficult to make models of the houses which adequately represented the form of the houses: the roofs were the most challenging. For the semi-detached house the second issue was the heating installation for which none of the pre-sets could be used as with the other houses and unfortunately, I was never able to achieve an output which was consistent with the observed energy consumption for this house. Luckily, once the initial model was made for the row and free-standing house, I was able to improve this model very easily as I had predicted.

During the project I had regular meetings with my mentors to discuss my progress and help me with difficulties. My mentors helped me to focus my research and see new possibilities when I encountered problems. Furthermore, the regular meetings helped me to set intermediate deadlines for myself which helped me plan my work, and the meetings led to new insights. After simulating the strategies my mentors motivated me to design the technical application of the strategies. I find creating the technical details one of the most challenging parts of any project. Nevertheless, once I get started I often find this the most interesting part. Once started, I can work for hours on the details with dedication and passion to make sure that everything connects correctly and no unresolved issues remain in a design.

As my research was based on case study houses, the building plans were an important information source. Unfortunately, the plans I received of the row house were not entirely accurate, forcing me to make a number of assumptions. Furthermore, I did not have direct contact with the inhabitants so I did not know their wishes. This was better for the semi-detached house as I have a good relationship with the inhabitants. Observation and discussion provided me with accurate information on their heating habits and improvement wishes for the house. The plans of the free-standing house were provided by the previous inhabitants so no information of the current state was available. Therefore, the approaches were tested on the old state of the house and it is unclear if this is still the state of the house. From my experience during this project I was able to conclude that good contact with the inhabitants and accurate information on the house is crucial to achieve a suitable result.

Throughout this graduation project I have learned many things, not only in the field of sustainable design and refurbishment but also about myself and what motivates me. As I already knew before starting the project planning and especially sticking to a plan is challenging for me, especially when working alone. When working in a group I feel more motivated to work as I don't want to let down the group by not doing my share of the work. In a group there is always some pressure to work which I really miss when working alone. Another benefit of working together is that you can easily motivate each other by discussing your work with one another. Although I did at first work at the faculty, I found it difficult to discuss my work with others as they were working on completely different topics. Finally, I have really enjoyed this graduation project and after performing all the simulations and designing the technical details I am really interested what the real results of the strategies would be. Hopefully I will be able to test this during my career.