P5 Reflection

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Title: Energy Storage Strategies - Comparative analysis of short term storage systems for low quality heat in Dutch dwellings

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Research and design

The aim of this research was the development and assessment of an energy system for a residential building. The schematic below shows the methodical subdivision of the process. Research was mainly done in the literature part and during the comparative analysis of the developed products (design).

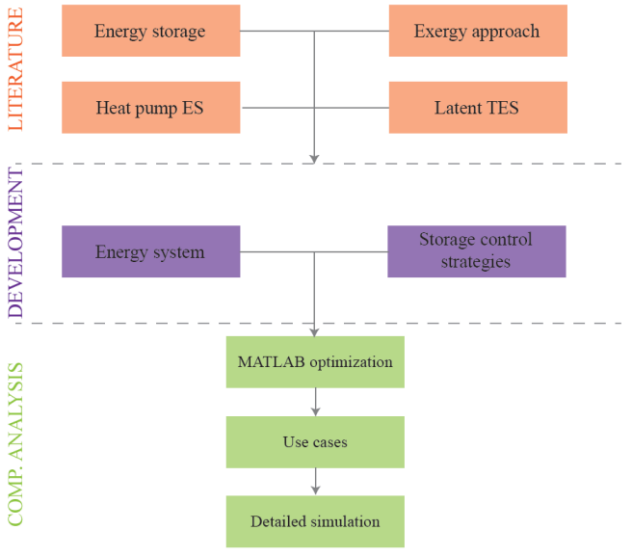

Figure 1 – methodology of the research

In order to properly design different components of this energy system, a literature research was performed that could be categorized in the following aspects:

Energy storage technologies – The literature study was essential in order to distinguish different solutions for the mismatch problem described in the problem definition. It was hard to narrow down from the broad approach to a well-defined direction for further investigation. The literature study placed the potential of short term thermal energy storage in perspective to other storage systems and demand/supply mismatches on different scales and for different energy forms.

Exergy analysis – Getting a notice of the added value of exergy analysis within the built environment. Exergy analysis was used in the development of the storage control strategies and it gave insights in the final performance of the system.

Optimal energy system design for a heat pump – Research was required to optimal integration of a heat pump within an energy system. This research could have been a bit shorter, since at the end only general notions of it were used in the developed control strategies (part of the insight were too practical for this theoretical investigation).

Study to short term storage of low temperature heat – The research to latent thermal energy storage was very interesting to perform, and resulted in clear design guidelines for the thermal storage system for short term storage. The system also showed good performance in the TRNSYS simulations.

The theory from the literature study was implemented in the development/design of an energy system and the control optimization strategies. This integration was successful, although when looking back, the literature study should have been a bit shorter in order to ensure more time for the comparative analysis and further development of the control strategies in simulation models. There was too little time left to completely fine-tune the detailed simulation model.
Also, additional simulation of an energy system with a different energy generator (gas boiler instead of heat pump) would have provided a more deviating case for comparison with the optimization strategies, and would in particular have resulted in more interesting conclusions from the exergy analysis.
In future studies to the developed control strategies, economic feasibility and heat pump on/off frequency should be considered in an early stage. This thesis focused on the energetic performance.

Relation studio theme and subject/case study

This study is performed within the context of the Green building Innovation studio. The thesis fits within the general goal of this studio, which aims to investigate how the built environment can be made more sustainable. Although the research was very theoretical (the emphasis was on the theoretical development of the control strategies), the developed strategies were applied to a case study residential building. Insights that were obtained during the previous years in the master Building Technology on thermal comfort, building physics and building services provided a good basis for the topics that were addressed within this research. The performance of the developed storage strategies was assessed by simulations and needed to ensure good thermal comfort.

Methodical line of approach of studio and method of this thesis

The methodical approach of this thesis is presented in **Figure 1**. It is a very general approach, which is often used in the studio. Designed (or developed) energy systems or solutions are often validated using simulation software. In this thesis, exergy and energy analysis was performed using dynamic simulation software. In the studio, TRNSYS software is one of the programs that is often used for this, although most of the studies do focus more on the TRNbuild kernel and not on the energy/generation system as detailed as in this thesis. Use of MATLAB within the studio is very seldom. In this study however it provided a huge advantage over Excel, since the numerical model of the explorative study included iterative actions. Physical validation has not been done, which is often the case since the time span of graduation projects is too short to include that as well.

Social relevance of the project

Well-designed thermal energy storage systems can reduce the primary energy consumption while maintaining high comfort level in a building. The application of air-source heat pumps within residential buildings is foreseen to increase. Compared to conventional gas-fuelled energy generators, heat pumps are associated with lower CO2 emission, and make use of scarce energy resources into a smaller degree. Air-source heat pumps are cheaper than ground-source heat pumps but less efficient. Also, the exergy approach could help to slow down/minimize the current depletion of scarce fossil fuel resources because it enables more advanced utilization of renewables (in this case low-quality energy contained by ambient air). Quality levels of the space heating demand (low-temperature emission systems will become the standard) can be met with energy with similar quality levels.