P4 Reflection

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Title: Energy Roof – integrated with photovoltaic-thermal, heat pump, ventilation, storage and heat recovery for NoM renovation.
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Research and design

The aim of this graduation research is the development of an innovative full-roof installation system (Energy Roof) which provides all the dwellings required energy with renewables as source and which is suitable for the Nul op de meter (NoM) renovation. The scheme below show the methodology of the research and design subdivided in four parts. Research is mainly done in the literature study which is followed by the system development (design). The design is assessed and optimized in the simulations part. Finally the results are presented in a concept design of the roof components and the financial feasibility.

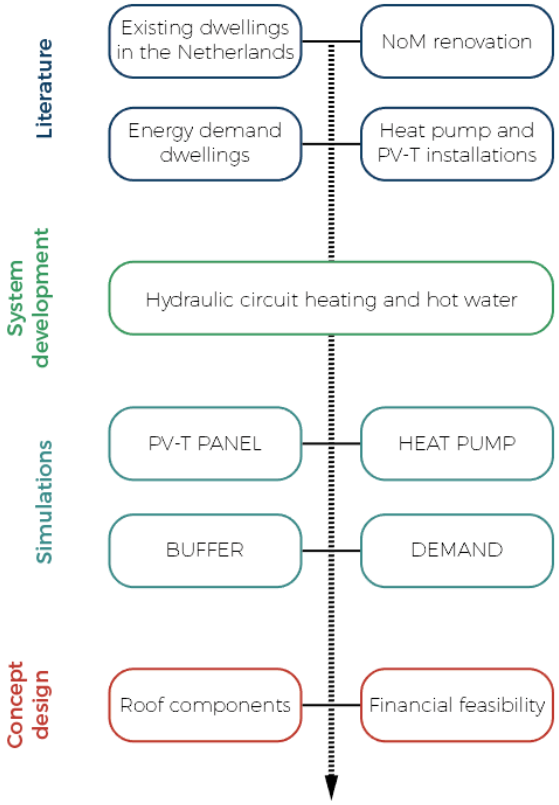

Figure 1. Methodology of the research

In order to develop the system a literature research was performed which can be categorised in the following 4 aspects:

Existing dwellings of the Netherlands – The literature research was essential in order to select the building type which is most suitable for the Energy Roof combined with the NoM renovation. The study showed that the Dutch row houses build between 1960-1980 have the most potential. Also information on building sizes, construction method and installations of this building type is obtained.

NoM *renovation* – The Energy roof is being developed for the NoM renovation where the annual net energy consumption of the dwelling is zero. The requirements for NoM and the strategy to achieve this objective are important boundary conditions.

E*nergy demand dwellings* – In order to renovate a dwelling to NoM it is essential to map the current energy demand of the dwelling. The different energy streams are presented for an existing dwelling and for a dwelling with a NoM intervention. The Energy Roof should deliver the energy for the NoM dwelling. This sets the boundary conditions of the Energy Roof.
H*eat pumps and* PV-T *installations* – The literature study in the heat pump and PVT technology helped to develop the system. The understanding of the use of low quality energy of the ambient and the sun and the synergy with low temperature heating is essential to design an optimal system. Also the necessity of thermal storage and a backup system for the heat pump is obtained from the literature study.

In the system development the knowledge from the literature study is used as input. Secondly the boundary conditions of the research assignment set two important components of the system. These are: the solar assisted heat pump (SAHP) whereby the photovoltaic (PV) panel is used as evaporator (PV-DX panel) and the PV-thermal solar boiler with a water drain down system. This decision was made at the end of the literature study and was very important to set the scope of the research. The core of the research, and the innovative part of the system, is the PV connected with a direct expansion solar assisted heat pump (PV-DX-SAHP) which supply heating and hot water for the dwelling.
Great effort was made in setting up the MATLAB/Simulink model in order to simulate the performance of the system. The subdivision in 4 models helped to give a good overview and to use the output of one model as input for another.
Finally the results from the simulations are used to dimension the components. Different options for the integration of the components in the roof are presented together with the financial feasibility study.

Theme of the graduation studio and the subject
The topic of the research fits within the theme of energy refurbishment, where the focus lies on the integration of sustainable building services and climate design in Dutch. In the studio Climate Design of the master Building Technology at the Technical University Delft this topic is very relevant. The previous years in the Masters gave a good basis for the topics that were addressed in the research. Also a holistic design attitude was obtained in this period which was applied in the development of the integrated system.

Methodical line of approach of the graduation studio and the used method
The method used in this thesis is a very general approach which is presented in figure 1 and described above. In the graduation studio a software model is often used to validate the develop energy system. Dynamic simulation software DesignBuilder is used to simulate the demand of the dwelling. Thermodynamic calculations of the system is done with MATLAB/Simulink. Use of MATLAB is very seldom in the studio. Physical validation has not been done within the graduation period, but is by Van Dorp planned for after the summer.

Societal relevance of the thesis
The societal relevance of this research is on different levels. The first level is on the worldwide scale, to reduce the human-made CO2 emissions determined in the Kyoto protocol (2005) and the Climate Change Conference (2015). To prevent that climate change has a catastrophic effect on the planet, it is very urgent that the world act now in reducing CO2 emissions and move from fossil to renewable energy sources.
On the scale of The Netherlands the societal relevance is found in the large quantity of existing dwellings with high (fossil) energy consumption. In addition existing dwellings have moisture and draught problems. The industrially produced and on large scale applicable Energy Roof with NoM renovation can have a significant impact in reducing the CO2 emissions. On top of that the inhabitants benefit financially and by improved health and comfort conditions.