Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before

P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information

Name: Stephan Kolman

Student number 4493001

Studio

Name / Theme Building Technology Graduation Studio

Main mentor Eric van den Ham

Second mentor Arie Bergsma

Argumentation of choice of the studio:

The motive of this studio is related to the author's interest in the heating systems of buildings. The design, integration, simulation and validation of these systems will lead to a bigger knowledge about the existing systems which can lead to the energy transition of the existing building stock.

Graduation project

A heat pump decision tool for homeowners

Goal

Mapping the current energy problems in the Netherlands related to space heating. In addition, discussing solutions for possible other sustainable alternatives for space heating. Then integrate these findings into an independent heat pump decision tool for homeowners. By using this tool, the homeowners receive advice with all the important aspects that come with it before they engage an installer to install a heat pump. The goal is that the advice that the homeowner receives has a major contribution to the energy transition of the built environment and the living comfort of the homeowner himself.

Location: Netherlands

Background

The Netherlands is currently in the middle of an energy transition, the large scale combustion of fossil fuels around the world lead to a CO_2 increase in the atmosphere, which caused temperature increase (global warming) on the planet. Environmental policies aim to phase out the use of fossil fuels entirely (van Leeuwen, De Wit, & Smit, 2017). In 2015 the united nations signed the Paris Agreement. The Paris Agreement had three stated objectives: (1) to grip the increase in global average temperature to “well below” 2° C above pre-industrial levels; (2) to increase the ability to adapt to the negative impacts of climate change; and (3) to make financing flows consistent with both of the above. The goal is to reduce the greenhouse gas emissions as soon as possible and to reach emission neutrality in the second half of this century (Horowitz, 2016). To do so the united nations had to make changes in their national policies and regulations. In the Netherlands this resulted in the Dutch climate agreement (klimaatakkoord) in 2019. This is the Dutch elaboration of the international Paris Agreement. One of the agreements is that 30 ergoregions in the Netherlands investigate where and how sustainable energy can be generated the best. And also which heat sources can be used to disconnect neighbourhoods and buildings from the gas network ("Nationaal Programma,"). The climate agreement states that the Netherlands is at the start of the energy transition of the built environment. 7 million households and 1 million buildings, which are currently poorly insulated and almost all heated with natural gas need to be transformed to well insulated buildings, which are heated with sustainable heat and electricity from renewable sources (*Klimaatakkoord*, 2019).

The Dutch building sector has to contribute to minimize the effect of global warming and climate change. Various measures have been taken in order to ensure this. The building sectors introduces every year lower energy performance coefficients for new buildings by tightening the building standards (Camarasa et al., 2018). Government-supported large scale energy renovations such as ‘stroomversnelling’ and ‘energiesprong’ for existing houses are performed (Camarasa et al., 2018). Subsidy schemes are provided from the government for heat from renewable sources, such as heat pumps and district heating projects based on waste heat streams and renewable sources (van Leeuwen et al., 2017).

Problem statement

With the measures and incentives as stated in background the Dutch government is phasing out the use of natural gas, they encourage homeowners to change the way their homes are being heated and change the homes heating system to a sustainable heating system, for example a heat pump.

Heat pump manufacturers and independent organisation are responding to these government measures and the energy transition by making online heat pump decision tools. These heat pump tools can be used by homeowners to check whether a heat pump system can be used in their home. Heat pump manufacturers often do this out of self-interest in order to sell more heat pumps. Independent organizations are doing this more in interest of the energy transition. The tool being designed in this thesis is an independent heat pump decision tool, with the aim of making a major contribution to the energy transition by any homeowner who uses the tool. On top of that they will also experience a better living comfort in their home.

The difficulty in designing such a tool is that every home is different, every home has different characteristics, different spatial aspects (indoors and outdoors) and a different dimensioned heat emission system. On top of that every home has different energetic quality, since homes can be post-insulated over the years. The purpose of the tool is to be able to map all these aspects of a

specific home and then provide a targeted advice in all these areas before a heat pump system can be applied.

Existing heat pump decision tools will be analysed in order to determine how they collect all the necessary information by questioning the homeowner. The shortcomings of existing tools will be improved in the final tool.

In order to be able to provide independent advice to the homeowner who utilizes the tool, the overall energy issue based on space heating must be first mapped out. The possible solutions and sustainable energy systems must be discussed, which will serve as advice in the final tool.

Main research question

In order to achieve this goal, the following main question has been formulated:

How is a heat pump decision tool for homeowners with limited technological knowledge designed, which gives an advice that contributes to the energy transition of the built environment and which provides an advice on which heat pump system and additional measures a homeowner should consider before engaging an installer?

Research sub-questions

In order to collect the necessary information to answer the main research questions, the research will be divided into three consecutive parts with each part having its own sub-questions.

Research part 1: 'Theoretical framework'

What are the current energy usages and energy sources of the built environment for in particular space heating of households in the Netherlands, what problems do they cause and what are potential renewable energy sources? (chapter 1)

What policies are already introduced to support the energy transition of the built environment and what are their influences on the built environment and how can these be important in the design of the heat pump decision making tool? (chapter 2)

What heat pump systems are integrated in existing building renovation cases and which envelope improvements are performed and can these techniques be used for the advice in the final heat pump decision tool? (chapter 3)

What heat pump systems and other sustainable heating sources have potential in supporting the energy transition of the built environment and which will be included in the heat pump decision tool? (chapter 4)

Research part 2: 'Empirical research'

What aspects from the analysed existing heat pump decision tools should be combined in the new tool and which aspects remained missing in the existing tools which needs to be included in the new tool? (chapter 5)

What are the boundaries of the selected heat pump systems leading to certain advice formation of the heat pump decision tool? (chapter 6)

In what way can the heat pump decision tool fulfill an educational function for the benefit of the homeowner in terms of insulation, cost and indoor comfort and how can it contribute to the energy transition of the built environment? (chapter 7)

Research part 3: 'Research by design'

How is the heat pump decision tool designed? (chapter 8)

Outline and methodology + data collection and data analysis

This thesis is structured in three consecutive parts. The theoretical framework, empirical research and research by design. This structure of research is necessary because the information gathered in the section leads to a follow-up step in the next section.

Reflection

1. What is the relation between your graduation (project) topic, the studio topic (if

applicable), your master track (A,U,BT,LA,MBE), and your master programme

(MSc AUBS)?

The heating systems are always present during the BT master. But the integration of the system always stays at the surface and this thesis will change this and will dive deep into the integration of the system in the building.

2. What is the relevance of your graduation work in the larger social, professional and scientific framework.

Home owners can use the decision making diagram for the choice of a sustainable heating system during a buildings renovation, which ensures the speed up of the energy transition in the Netherlands. The needed innovations resulting from the integration of the system in the case study buildings can lead to product innovations.

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