4TU.School for Technological Design

STAN ACKERMANS INSTITUTE

Professional Doctorate in Engineering (PDEng) program

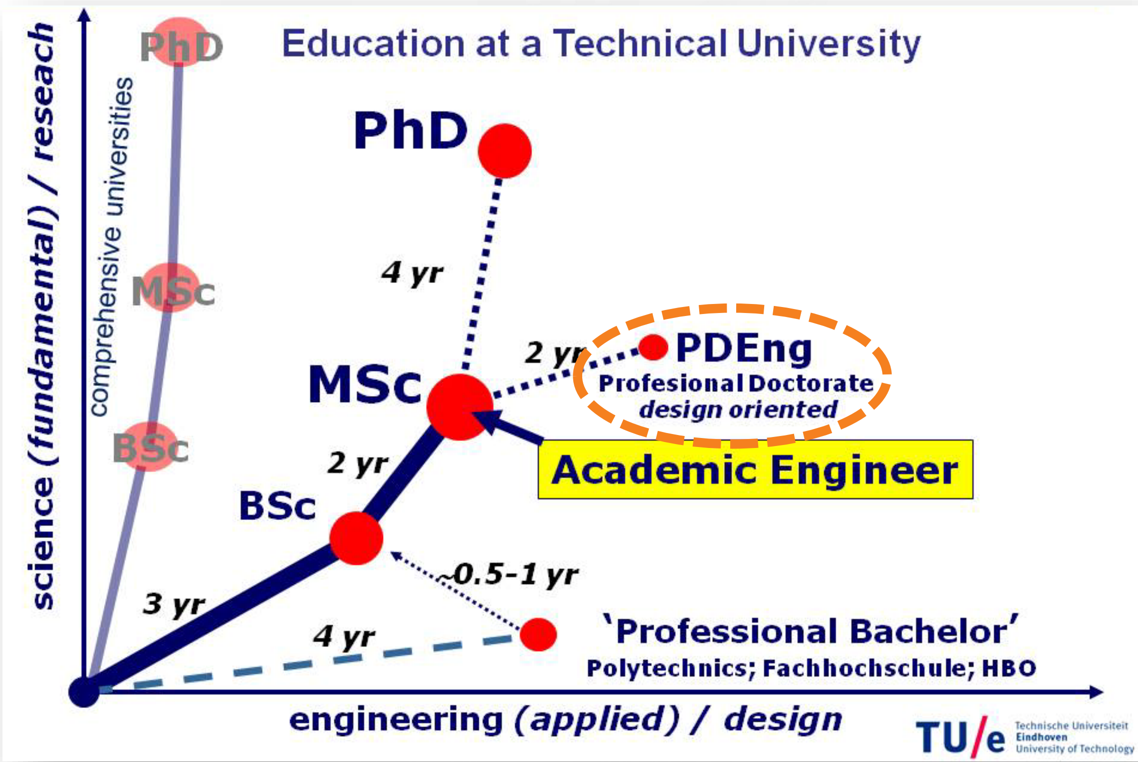
Smart Buildings & Cities

April 2018

Technische Universiteit Eindhoven University of Technology

Technological Designer programs

Overview of educational programs at the TU/e



Technological Designer programs

Research vs. design

Issue	Research	Design
questions	why? curiosity	what if? needs
starts from	empirical data	requirements
leads to	theory →	artifact
searches	truth →	product
aim	knowledge →	value

Technological Designer programs

PDEng programs

- 12 PDEng programs at the TU/e at various departments

- SB&C is hosted by the department of the Built Environment (BE)
- In collaboration with other departments:
  - Electrical Engineering (EE)
  - Mechanical Engineering (ME)
  - Mathematics and Computer Sciences (CS)
  - Industrial Engineering & Innovation Sciences (IE&IS)

Smart Buildings & Cities

Mission of SB&C

SB&C wants to contribute to the transition towards smart, intelligent and sustainable cities where quality of life is high

Smart Buildings & Cities

Focus areas / themes of SB&C

- **A carbon neutral city**
  - Designing intelligent and energy efficient building components and building concepts
  - Designing and implementing renewable energy generation in the built environment
  - Designing intelligent networks aimed at matching supply and demand
- **A climate proof, nature-based city**
  - Designing buildings and cities that mitigate the effects of climate change
  - Designing buildings and cities based on the principles of the circular economy
  - Designing buildings and cities that promote healthy living
- **A city with autonomous vehicles**
  - Designing a infrastructure for autonomous vehicles

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Goal of SB&C

Deliver post-master designers:

- with a broad technological understanding of concepts relevant to the smart cities themes (architecture, mechanical engineering, electrical engineering, building engineering, innovation science and ICT),
- who excel in their own discipline, and
- who are able to:
  - work in multidisciplinary design teams,
  - contribute to design issues outside their own core disciplines,
  - integrate different technologies into new products and concepts, and
  - who understand the commercial aspects of these innovative products and concepts.

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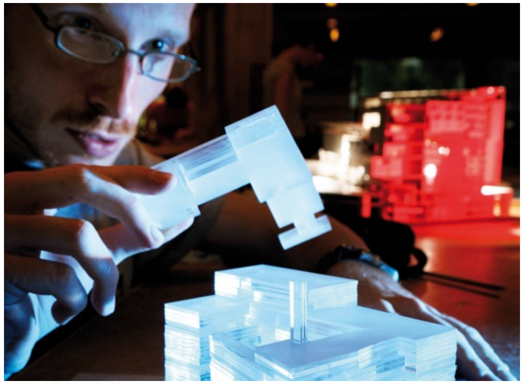
Curriculum of SB&C

Education

- Design methods and co-creation
- Entrepreneurship
- Professional development
- Technical courses (BE, EE, CS, ME, CE, IE&IS)
- Planning: ca. 60% of available time in first year, ca. 40% of available time in second year



In-company assignment

- Use skills and knowledge gained in workshops
- Excel with innovations for the built environment
- Planning: ca. 40% of available time in first year, ca. 60% of available time in second year

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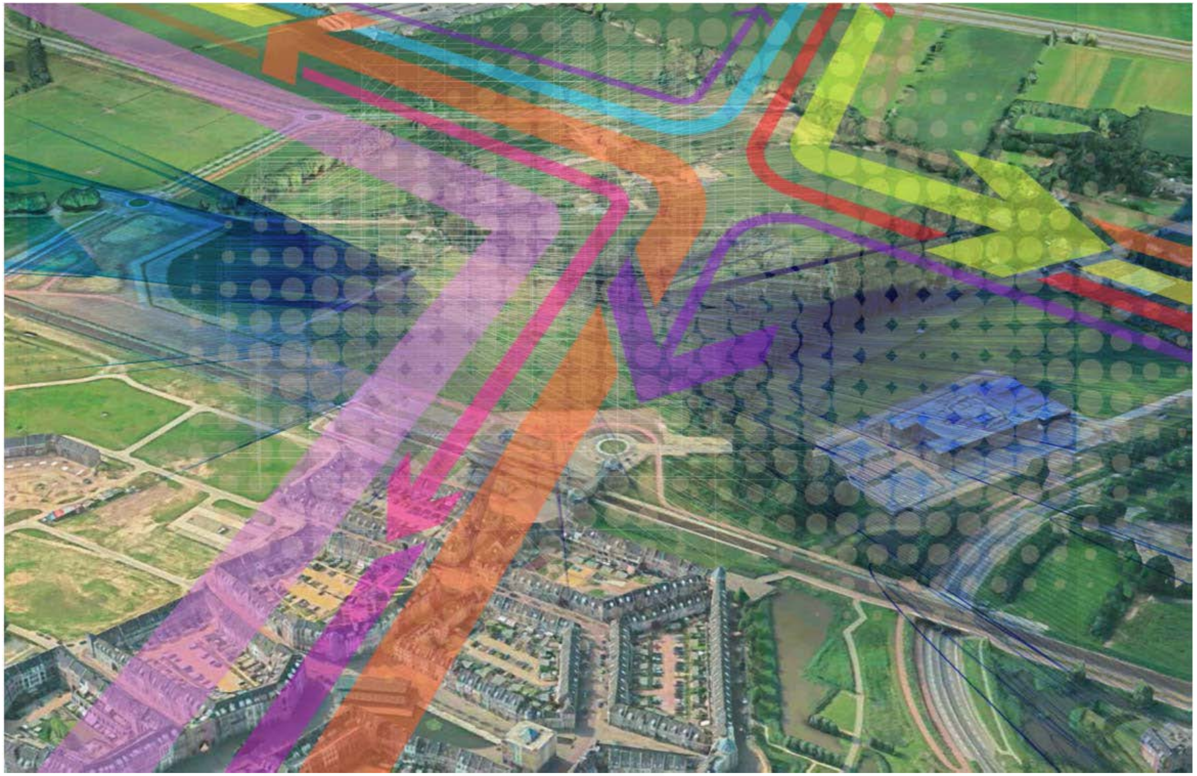
Group design project 2017-2018

Conceptual plan for the Brainport Smart District in Helmond



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Current in-company assignment portfolio

Companies:	
Multinationals	5
Large Nationals	9
SME's	12
Start-ups	

Project on:	
Component level	14
Building level	26
District level	15

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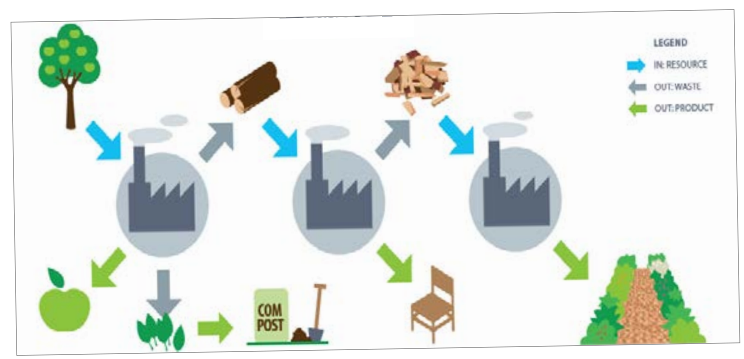

Industrial symbiosis: a tool to connect companies and exchange (waste) materials (SBH)

PDEng Smart Buildings & Cities symposium

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Development of a Design Support Tool for an Innovative BICPV Façade System

Trainee: **Antía Varela Souto**
University advisor: ir. Roel Loonen
Company advisor: ir. Stan de Ridder

wellsun

Background

Lumiduct is an innovative building-integrated concentrating PV (BICPV) façade system, developed by the company Wellsun, which provides shading control and energy harvesting to glazed building façades (Fig.1). The system consists of a double-skin façade with an array of movable panels located in its cavity, which track the sun during the day. This optical system treats the diffuse and direct part of solar irradiation in a different manner. The diffuse component freely passes the modules and reaches the room as soft daylight. The direct part, on the other hand, is concentrated onto tiny, ultra-high-efficiency III-V solar cells to generate electricity. Lumiduct provides many functions to a glazed façade. It reduces solar gains, protects against glare, generates electricity, lets daylight in, and allows for a view to the outside.

Aim of the Project

The objective of this project is to develop a blueprint of a **design support tool (DST)** that provides a straightforward way for analysing the performance of the façade system in different environments. This blueprint will serve as a detailed plan to design this tool, based on insights obtained from literature, analysis of the potential users and stakeholders and other available design support tools.

Approach

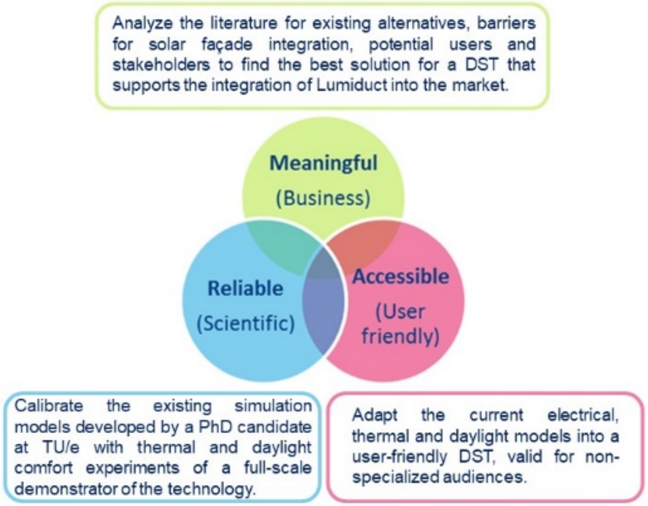

Figure 2. Main concepts of the Design Support Tool.

Design Solution

The environment of the DST, including the parties involved in the development of the tool and its different audiences, is

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Designing a guideline of thermal comfort control strategies and building parameters for designing office buildings with high energy flexibility

Trainee: Christina Papachristou
University advisor: dr.ir. P. Hoes
Company advisor: TAJ van Goch, M.Sc., PDEng

Background

When stepping forward as a society, any move towards a greener future should include buildings as a main focus. The vast majority of the energy used in buildings is consumed in order to make the occupants feel comfortable; and this is ensured by following specific guidelines for thermal comfort when a building is designed. Current thermal comfort research including research conducted within the iCARE program [1], shows that these comfort limits can be exceeded or bypassed in certain ways without compromising the thermal comfort of occupants. With more relaxation in thermal requirements, the building could use less energy or could be used as a dedicated thermal storage means. The use of this storage potential can alleviate the fluctuating supply of renewable energy sources (RES).

Aim of the project

The aim of this project is to design a guideline that supports designers to design buildings with high energy flexibility. The guideline will be developed based on the iCare thermal comfort operational strategies [1]. The guideline investigates specific thermal comfort control strategies and building parameters such as the thermal mass, the heat/cold delivery system and the façade and how these strategies and parameters affect the flexibility of a specific building based on specific indicators that will be chosen. The designer can use the guideline in the design

Methodology

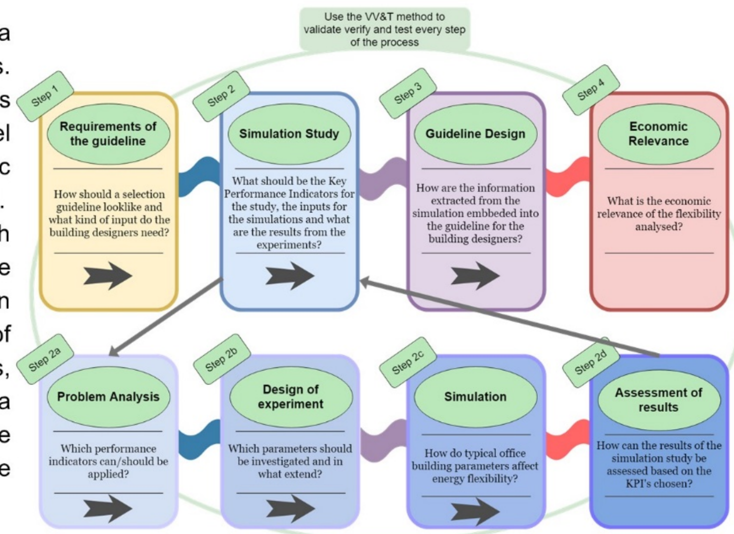

Figure 1: Methodology [2]

The technique that will be used in this study, is a simulation based study and the methodology is presented in figure 1. The simulation study starts by studying the building performance when using Common Practice comfort control strategies in order to create a reference. Progressing with the simulation phase, other comfort control strategies (e.g. iCARE project's thermal comfort research outcome) will be implemented and a sensitivity analysis will be conducted in order to understand the magnitude of the effect of the design parameters to the outcome of the simulations.

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Optimization of air curtain technology through temporal and spatial jet excitation

Trainee: **ir. Claudio Alanis Ru**

University advisors: dr. ir. Twan van Hooff
prof. dr. ir. Bert Blocke

Company advisor: ir. Frank Hoving

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Introduction

Air infiltration is responsible for a major share of building energy losses, in addition to contributing to the transport of contaminants and negatively affecting the thermal comfort conditions in indoor environments. In building applications, air curtains (turbulent impinging jets) are used to generate an aerodynamic barrier that reduces infiltration and separates a controlled environment, in terms of temperature, pressure or concentration, from an unconditioned environment, while allowing an easy access of people, vehicles and material across the two environments. The aerodynamic seal provided by air curtains aims to improve thermal comfort, air quality, energy efficiency and fire protection in buildings (Figure 1). The performance of air curtains is commonly assessed based on the heat and/or mass exchange between the environments separated by the air curtain through the criterion known as "separation efficiency". Understanding how the separation efficiency depends on the involved transport processes and their influencing parameters, is essential for the optimization of current air curtains and the development of new air curtains.

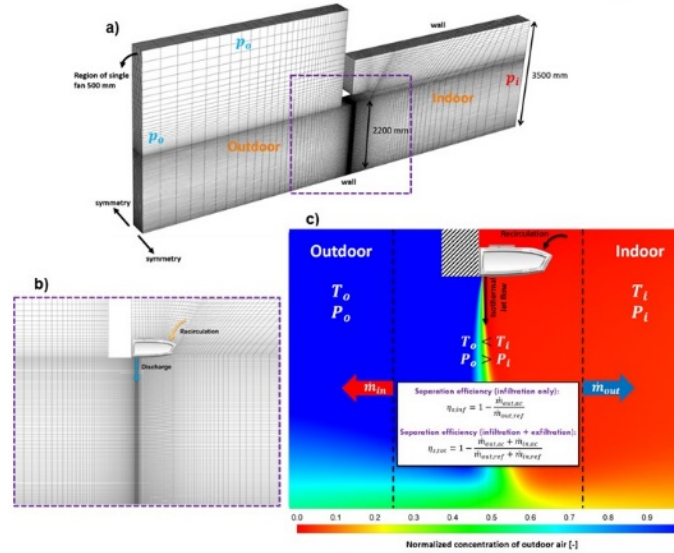

Figure 2. a,b) Computational domain and grid for the CFD simulations (Reynolds-averaged Navier-Stokes simulation) of the air curtain. c) Visualization of numerical simulation results with an indication of the calculation of separation efficiencies.

Methodology

Numerical simulations using Computational Fluid Dynamics (CFD) are conducted to analyze the fundamental flow behavior, systematically evaluate the performance of air curtains under different operational settings and environmental conditions (i.e., cross-jet temperature and pressure variations) (Figure 2), and parametrically optimize the air curtain efficiency through the incorporation of temporal and/or spatial jet excitation strategies. These simulations are being accompanied with dedicated water tank experiments (Figure 3) and field measurements for

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Design of Thermal Energy Balancing Strategies for ATES system on TU/e campus

Investigating Operation Strategy of Atlas Building and Future Design Solutions for the ATES system

Company Name: Dienst Huisvesting (TU/e)

Trainee: M.Sc. Evangelos Kyrou
University advisor: dr.ir. P. (Pieter-Jan) Hoes
Company advisor: ing. M.M.W. (Thijs) Meulen

Background – Problem description

The 4th generation district heating systems are a promising solution to the transition to future sustainable energy systems, where heating and cooling energy match the individual buildings' demands within a district level connection. Seasonal thermal energy storage technology can be of great advantage in this regard.

One of the largest Aquifer Thermal Energy Storage (ATES) systems in Europe operates on TU/e campus, using 16 warm and 16 cold wells, organised in 3 warm and 3 cold clusters, while being interconnected through a warm and a cold ring with campus buildings.

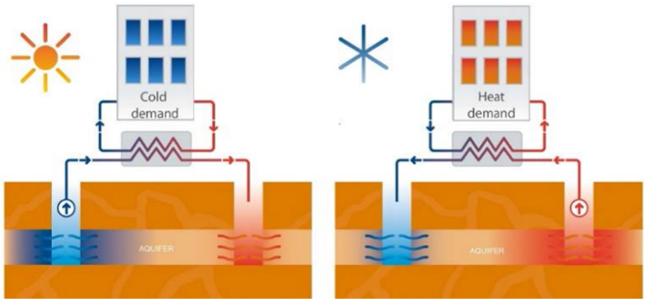

Figure 1: Operating principle of an ATES system
[Source: http://www.iftechnology.nl/aquifer-thermal-energy-storage-wko-in-dutch-is-catching-on-in-japan]

Since the design of the ATES system on TU/e campus involved many buildings with higher demand for cooling than heating energy, an overall imbalance problem has been created from the outset of operation. In order to balance the ATES plant over the year, in accordance with Dutch regulations, considerable use of cooling

It is estimated that the connection of Atlas building (Fig.3), which is currently being renovated, will create a positive impact on the ATES system balance, since it will require more energy for heating than cooling. Consequently, there is potential for the number of yearly operation hours of cooling towers to be reduced.

Figure 3: Model representation of renovated Atlas building and neighboring district area

Project aim

The aim of the project is to design strategies in order to achieve thermal energy balance of the ATES system on the district level of TU/e campus, while reducing or eliminating the necessity of cooling towers operation and contributing to 2030 targets of TU/e, regarding CO_2 emissions abatement.

Project objectives

To achieve the project aim, separate objectives can be identified, as follows:

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Design of a smart ventilation control strategy for ATLAS

Trainee: **Marlies Verbruggen**
University advisor: Twan van Hooff
Company advisor: Thijs Meulen

Summary of the Project

The main building on the campus of Eindhoven University of Technology, ATLAS, is being renovated with the ambition to be the most sustainable educational building in the world. It will be a multifunctional building where people can work, learn and relax in a healthy and comfortable environment. In August 2016, the design of the ATLAS building received an 'Outstanding' certificate by BREEAM, a worldwide rating system for the sustainability of buildings. To keep this certificate, it is important to correctly implement the designed innovations. One of these innovations is the application of natural ventilation. Over the building façade, parallel opening windows will be implemented. During the day, users can open the windows when desired by using the manual control. During the night, the windows can be opened automatically in order to cool the building down in summer, as well as to refresh the air inside, also known as night flush.

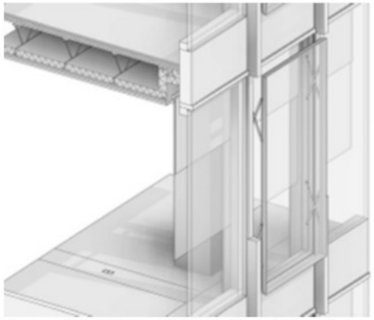

Figure 2. Impression of the parallel opening windows (source: Peutz)

Methodology

In order to understand the influence of the outdoor conditions on the indoor environment, and the influence of the position on the façade, the situation will be analysed using computational fluid dynamics (CFD), reduced-scale wind tunnel testing and full-scale on-site measurements.
With the CFD simulations, the airflow around the building and through the window openings will be analysed. Using CFD, it is easy to simulate different configurations and optimise the airflow inside the building depending on the wind speed, wind direction and position in the building. The wind tunnel test and the on-site measurements will mostly be used to validate the CFD results. Furthermore, during the on-site measurements, the indoor pressure will be measured to ensure the heating, ventilation and air-conditioning (HVAC) system will not experience any problems

Social housing from an empathic point of view

Stimulating independent living for seniors in assisted living facilities

Woningstichting Domus

Trainee: Marije Kortekaas
University advisor: Prof.dr.ir. M. Mohammadi
Company advisor: Ing. H. Oosterlee MBA

Background

The improved healthcare and hygiene is one of the reasons people grow older over time, this leads to new societal challenges. Common diseases are not as frequently lethal anymore, they turn into chronic conditions with which people can live for longer periods of time [1]. In Limburg the percentage of people age 65 and up is 22%. It is expected that this will increase to 40% in 2040 [2]. Even though there is an ageing population, the amount of people living in an institution has decreased since the '80's. This is both a result of the policy of the government, [3] and the fact that people prefer to live (independently) in their own homes [3,4,5]. Prof.dr.ir. Masi Mohammadi responds to this societal challenge with the empathic home, a home which takes care of its resident. Woningstichting Domus is interested in this concept and wants to know whether this concept can be implemented in social housing, more specifically in one of their existing assisted living facilities

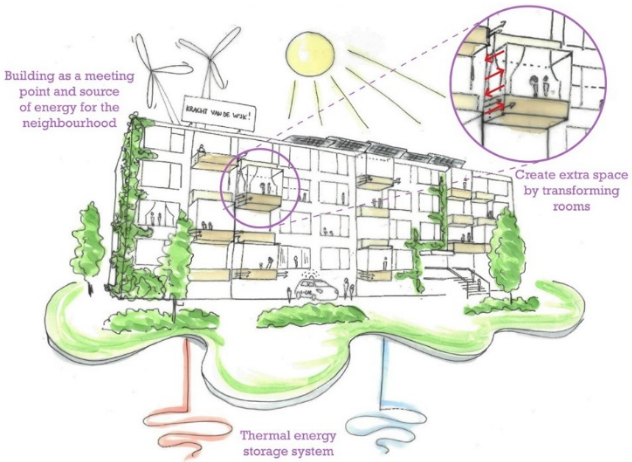

Figure 3: Possible interventions

Goal

The aim of the project is to define design principles for future oriented homes which stimulate an active and independent life for seniors with a low social economical background.

Methods

The empathic home needs a holistic approach and requires understanding of three principles: the target

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Stimulating care environment for Seniors living in a nursing home to improve Quality of Life

Trainee: **Joyce Fisscher, Msc.**

University advisor: Prof. dr. ir. Masi Mohammadi

Company advisor: Drs. André Groot Bluemink

Sint Jozefoord

Background

Seniors nowadays prefer to age at home, although many seniors will arrive at some point at a stage where living at home is no longer possible, due to severe physical and/or cognitive impairments, such as dementia. This group of seniors is very vulnerable. Loneliness, disorientation and lack of physical and mental activity are unfortunately common problems among seniors living in a nursing home. The design of the environment has a significant impact on the Quality of Life (QoL) and on the Feeling of Home. Therefore it is essential that the environment fits the needs of its residents.

Goal

This results in the following research question:
How can a nursing home (Sint Jozefoord) being transformed into a stimulating living environment, within the concept of 'just like home' to improve the Quality of Life?

The aim of the project is to develop design principles for cognitive, physical and social stimuli in architecture and technology to create a stimulating care environment for seniors with dementia and seniors with somatic problems living in a nursing home. The ultimate goal is creating a stimulating care environment which maximizes the Quality of Life and the feeling of home of the residents and advance durably happiness in the last phase of life.

Methods

Several literature reviews, interviews, spatial analysis and observations are used in this project to gain knowledge about the organization, target groups, location and State of the Art Smart Care. This data will finally be translated into design principles, which will be tested and measured in a living lab.

(expected) Results

By developing design principles for the common used spaces in a care home namely living room, corridor, main entrance and garden, this project aims to transform ordinary nursing homes into stimulating environments. There are several spatial, technological and care aspects explored which have a positive or negative influence on the Quality of Life and/or feeling of home. Design principles will be developed to enhance the positive aspects and mitigate the negative aspects.
For example, the impact of disorientation is an important reason for admission to a nursing home for people with dementia. However disorientation increases by relocation, which can result in even more stress, anxiousness etc. Therefore it is essential for a stimulating environment that it supports navigation and readability. What this exactly means for the design of the environment is part of this project.

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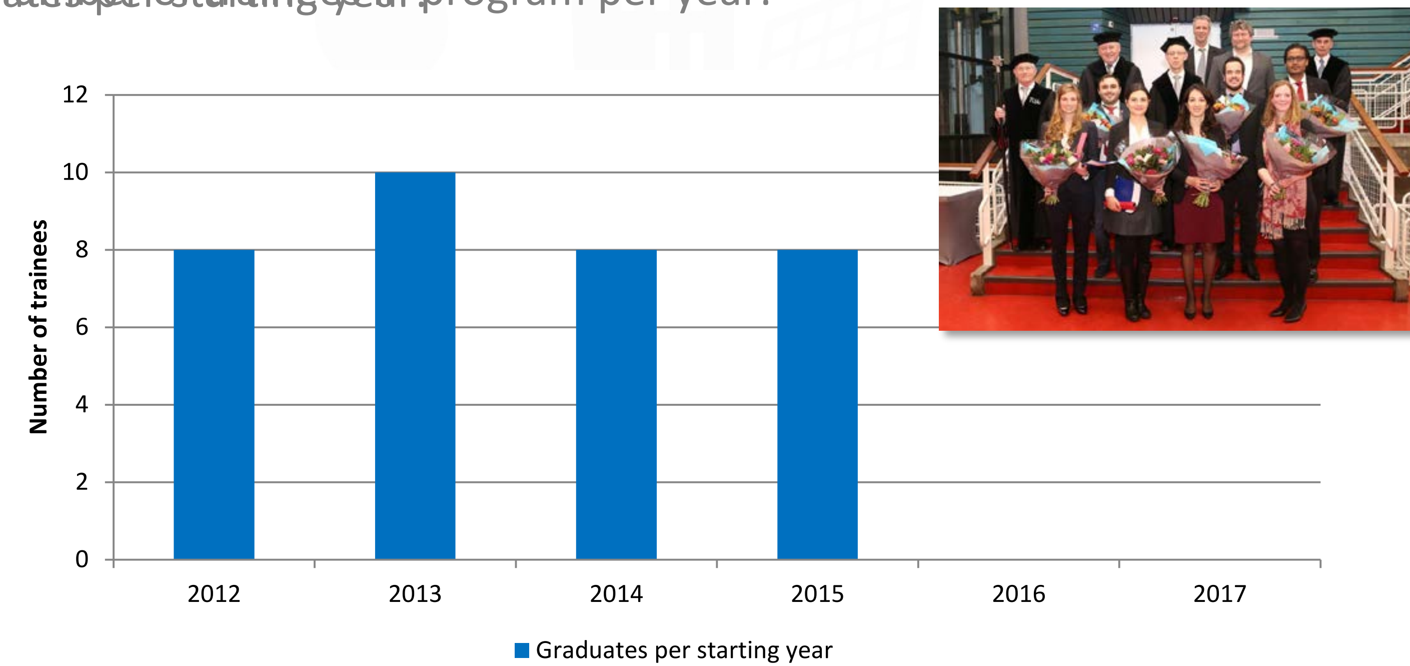
Overview of intake and graduates

Total number of trainees in program per year:

Graduates per starting year:



Since the start of the program in 2012:

- 56 trainees enrolled in the program
- **34 graduates**

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www.tue.nl/sbc