Graduation Plan

Thermal Energy Autarky Of Small Residential Buildings

M.A. Nicolaï

student number: 1315420

TU Delft
MSc Building Technology
AR3B025 Sustainable Design Graduation Preparation

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Personal Information

Name: Marc Adriaan Nicolaï
Student number: 1315420
Telephone number: +31 644139071
TU e-mail: M.A.Nicolai@student.tudelft.nl
Private e-mail: marcnicolai@gmail.com
Postal Address: Balthasar van der Polweg 526
2628 BT Delft

Studio

Studio name: Sustainable Design Graduation Studio

1st mentor: Sabine Jansen
2nd mentor: Engbert van der Zaag

Studio Motivation

Since I started my education in Delft I have been interested in the technological side of architecture and detailed solutions to problems related to sustainability in architecture. But over the years I became disillusioned with the casual approach you’re forced to take when you’re doing the overall design of a building. This studio allows me to fully explore the building science side of a project and go in-depth into the solutions that can make a building more sustainable.
Graduation project

Project title
Thermal Energy Concept For An Autarkic Residential Building

Problem Statement
Housing corporation Eigen Haard, based in Amsterdam, has requested the development of an energy concept for a mostly autarkic (self-sufficient) residential building of 6 dwellings. Their aim is to develop such a building on a plot in Amstelveen with its own thermal energy generation and storage. Their request is for an energy concept that takes into account usage, generation and storage on-site. A thermal energy concept that will allow the building to be autarkic throughout the year. In this energy concept the building physics aspects of the building, the installation schemes and operational strategies should be specified.

Despite the mildness of the Dutch climate there is still a big dissonance in energy supply and demand in summer and winter: in summer the potential for generation is high while the usage is low and in winter the generation potential is low while the usage is at its peak. The challenge will be to develop a thermal energy concept that incorporates systems for generation and storage in such a way that it will allow for sufficiently comfortable usage throughout the year without turning to outside sources of heat.

Objective
This graduation project will focus on developing a thermal energy concept that should allow for sufficiently comfortable usage of a six (6) family residential building throughout the year.

Research questions
What is the optimal thermal energy concept for the comfortable habitation of an autarkic residential building with six (6) apartments and how can such a concept be developed?

- What energy storage and generation systems are best applicable to this building type?
- What is the energy use pattern in this building type?
- What can be learned from comparable reference projects?
- What are the relevant performance indicators for a thermal energy concept?
- How can the performance of proposed thermal energy concepts be reliably determined?

Boundary conditions
Building will be situated in Amstelveen for purposes of climate and environment.

Limitations
Although the original request is for a fully autarkic building, in this study this will be limited to the thermal energy aspect only. This will allow the study to go in-depth on this one aspect instead of remaining a superficial overall study due to time constraints.
Methodology

Background
Literature study of
- design strategies to minimize thermal energy loss.
- design strategies to minimize thermal energy usage.
- design strategies to maximize thermal energy generation.
- design strategies for thermal energy storage in buildings.

Tools inventory for calculation and simulation of thermal energy concepts.

Inventory of thermal generation and storage systems and their specifications.

Inventory of reference projects.

Approach
Analysis of reference projects for design strategies.

Tool selection for thermal energy concept validation through calculation and/or simulation.

Development of specific performance indicators. E.g. user comfort, system efficiency, exergy.

Design development
Development of thermal energy system options.

Energy simulation, integrating thermal physics calculations with proposed systems specifics, building physics and the spatial dimensions of the proposed building concept.

Conclusions
Final thermal energy concept for the Eigen Haard case including systems schematics, building specifics and operational strategies.

Guidelines based on final thermal energy concept that are generally applicable to the development of a thermal energy concept for comparable cases.
Relevance

Societal relevance
The energy supply of many European countries is still very reliant on imported fossil energy sources. By investing in buildings that will be less reliant on external sources of energy now we can at least partially mitigate energy supply uncertainties of the future.

Scientific relevance
Autarkic buildings that don’t rely on large regional infrastructure remain an interesting alternative to the large scale regional energy systems that are being developed in dense cities like Amsterdam. This is especially so for buildings located in regions that are too sparsely populated for regional solutions.

Time planning

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- Background studies
- Reference analysis
- Task selection
-LOCATION
- Performance indicators
- Concept development
- Concept simulation and feedback
- Concept adjustments
- Final concept development
- Guideline development
- Report finalization
- Final presentation preparation
Literature

Design strategies

Reference projects
RVO referentiewoningen
NZEB buildings
Solar architecture

Energy use patterns

Thermal Energy Generation

Thermal Energy Storage
Pierie, F., & Someren, C. E. J. v. Energieopslaglabel: Een methode voor het vergelijken van het volledige spectrum van opslagsystemen
Subias, L. e. a. (2011). *D2.1. Inventory of existing technologies for energy storage and conversion*.

Exergy