Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

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

Personal information	
Name	Yamini Patidar
Student number	5055288

Studio		
Name / Theme	Sustainable design Graduation Studio	
Main mentor	Dr. Regina Bokel	Building Physics & Services
Second mentor	Dr. ing. Marcel Billow	Building Product Innovation
Argumentation of choice of the studio	Not applicable	

Graduation project	
Title of the graduation project	Housing Refurbishment using Earth, Wind & Fire system- Towards a nearly energy-neutral housing in the Netherlands.
Goal	
Location:	The Netherlands
The posed problem,	In the European Union (EU), Buildings are accountable for nearly 40% of energy consumption and 36% of CO_2 emissions, making them one of the biggest energy consumers as compared to the other sectors (Energy Performance Of Buildings Directive (EPBD) - BIBM). In the recent Climate Agreement in 2019 in the Netherlands, the Dutch government has set a goal to reduce the greenhouse gas emissions by 49% by 2030 and 95% by 2050, when compared to 1990 (IEA, 2020). Among the various building sectors, the Housing stock in the Netherlands has a major share accounting for around 62% of the total building area (Climate-KIC). While new housing constructions have to be nearly energy neutral as of 2020, a large portion of the existing housing stock has a huge share in the energy consumption and have a worse energy label of D or lower in the rating scale from A to G (Oorschot et al., 2016). The existing stock is thus in need of urgent energy-efficient refurbishment. While various refurbishment techniques are available, there is a need to develop an integrated system that addresses the energy-retrofitting of the building in a holistic manner. The Earth, Wind & Fire (EWF) system developed by Dr. Ben Bronsema during his PhD research, harnesses the environmental energy of Earth, Wind & Fire through the use of three responsive building

	elements which can significantly reduce the energy consumption of the buildings thereby also serving as a means to utilize renewable energy sources for energy production. The EWF concept shows huge potential to reduce the operational energy of the building and achieve a nearly energy neutral building. However, the system has been designed initially for office buildings in the Western European climate and the potential of the system has not been researched in depth for Housing buildings. It is vital to conduct an investigation for the applicability of EWF system in the Housing buildings in terms of its energy-efficiency potential without compromising the indoor comfort for the occupants. Considering the aforementioned aspects, the research aims to: • Investigate the potential of the EWF system as an energy-retrofitting method for the Housing buildings with indoor comfort and energy neutrality as performance indicators. The energy neutrality goals are formulated based on BENG regulations. • Designing a refurbishment project by selecting a case study building as a part of the research to find out the design strategies for integration of EWF and evaluate the performance through simulation tools. • Derive technical guidelines for integrating the system for the Housing refurbishment in the Netherlands.
research questions and	The aim of the research paper is to answer the following question: *"How can the Earth, Wind & Fire system be integrated in the Housing refurbishment in the Netherlands to achieve energy neutrality and improve the indoor comfort of the building?"*
design assignment in which these result.	In order to derive the EWF integration criteria and technical guidelines, a housing building in the Netherlands in the need of refurbishment is taken up as a case study. The design assignment would be to find out the design strategies for integrating the EWF system and perform simulations for its energy performance and indoor comfort. The final design shall incorporate the technical details of the EWF elements integrated in the building.

Process

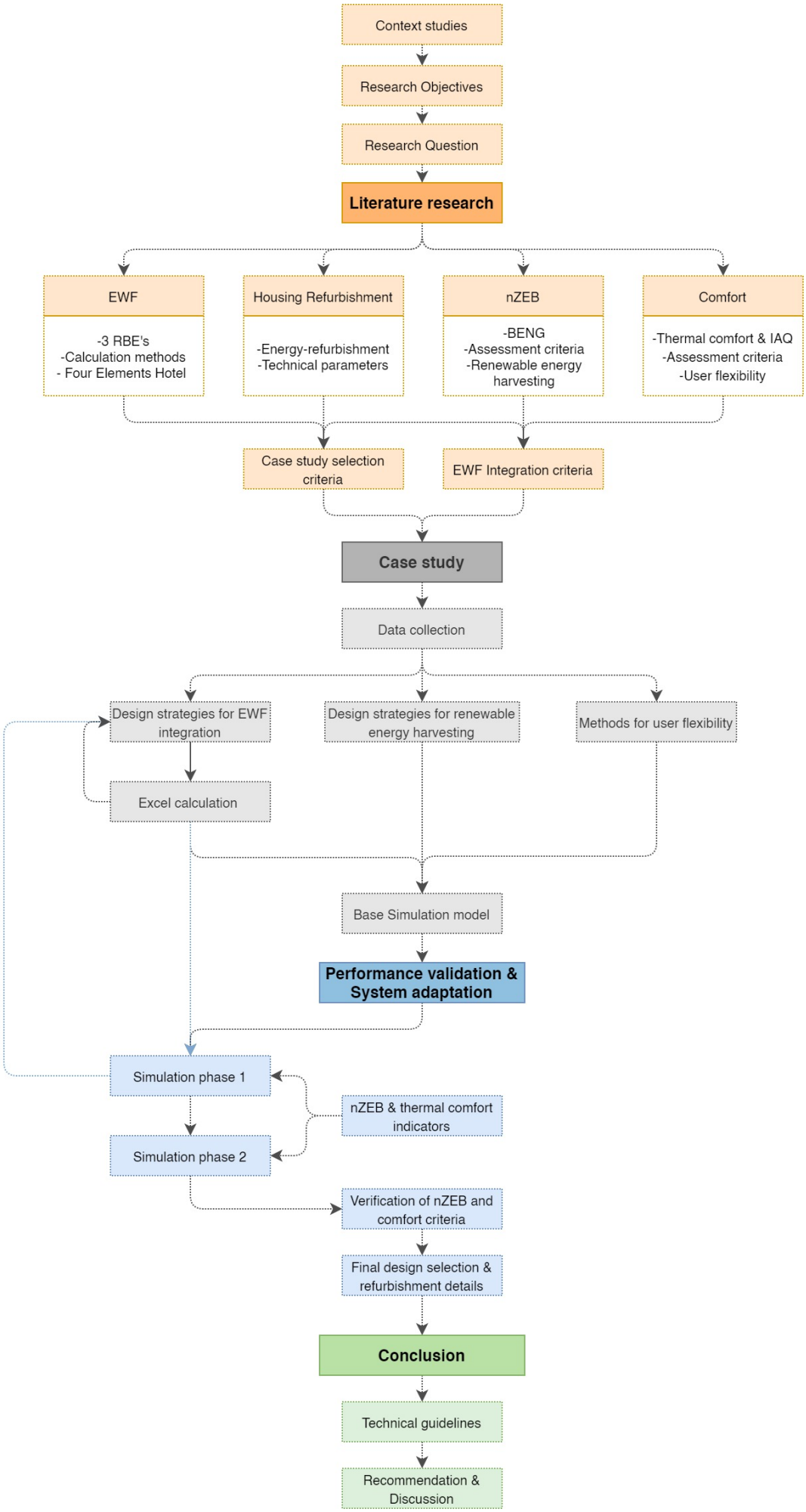
Method description

In order to answer the research question, this study has three main processes: Literature review, Case study design exploration and Performance validation & System Adaptation. Before the start of the case study, it is required to establish the different criteria and guidelines related to energy neutrality and indoor comfort which serves as performance indicators for the case study design and simulation phase. An extensive research on the Housing refurbishment would give an overview of the prevailing refurbishment strategies and the issues to tackle while designing a refurbishment project. Finally, an in-depth research on the EWF system would establish the criteria for selecting the case study and identify the integration criteria serving as a starting point to design the case study. The aim of the Literature review is to contribute to sorting out the main parameter regarding the case study design and evaluation phase through simulation. The process followed by literature review is elaborated below:

Case study design exploration
A housing building which is in need of renovation is selected for case study and the data regarding the existing construction, HVAC system, energy consumption will be collected and analyzed to further proceed with the design phase. Different methods to integrate solar chimney and climate cascade will be explored based on architectural and technical (EWF and renovation) parameters. A simultaneous exploration will be conducted to find ways to adapt the EWF system to user flexibility since this also plays an important role to influence the design.

Performance validation & System Adaptation
The different design options will be then simulated to check their energy consumption performance and thermal comfort using the ESP-r software, excel calculation developed by Bronsema (2013) and Design builder software for CFD analysis. This phase will follow a circular process to simulate and modify design in a continuous loop to achieve a design which meets the BENG requirements and Thermal Comfort criteria identified during literature review. The circular process of simulation and designing might result in the need of certain adaptations to the EWF system. The final design which meets the requirements shall be selected and then the refurbishment details for solar chimney and climate cascade shall be carried out.

Conclusions
The final design shall result in formulating case study specific conclusions as well as general technical guidelines and constraints for integrating Earth, Wind & Fire system in the refurbishment of Housing buildings in the Netherlands.


Context studies
Research Objectives
Research Question
Literature research
EWF
-3 RBE's
-Calculation methods
- Four Elements Hotel
Housing Refurbishment
-Energy-refurbishment
-Technical parameters
nZEB
-BENG
-Assessment criteria
-Renewable energy harvesting
Comfort
-Thermal comfort & IAQ
-Assessment criteria
-User flexibility
Case study selection criteria
EWF Integration criteria
Case study
Data collection
Design strategies for EWF integration
Design strategies for renewable energy harvesting
Methods for user flexibility
Excel calculation
Base Simulation model
Performance validation & System adaptation
Simulation phase 1
nZEB & thermal comfort indicators
Simulation phase 2
Verification of nZEB and comfort criteria
Final design selection & refurbishment details
Conclusion
Technical guidelines
Recommendation & Discussion

Literature and general practical preference

Alwetaishi M.S.(2016). Impact of Building Function on Thermal Comfort: A Review Paper

Atanasiu, B. & Kouloumpi, I. (2013). Boosting building renovation. An overview of good practices Brussels: Buildings Performance Institute Europe (BPIE).

Athienitis, A., & O'Brien, W. (2015). Modeling, design, and optimization of net-zero energy buildings. Modeling, Design, and Optimization of Net-Zero Energy Buildings. https://doi. org/10.1002/9783433604625

Balvers, J., Bogers, R., Jongeneel, R., van Kamp, I., Boerstra, A., van Dijken, F. (2012). Mechanical ventilation in recently built Dutch homes: technical shortcomings, possibilities for improvement, perceived indoor environment and health effects. Architectural Science Review 55, 4-14.

Boerstra, A. C., Van Hoof, J., & Van Weele, A. M. (2015). A new hybrid thermal comfort guideline for the Netherlands: Background and development. Architectural Science Review, 58(1), 24–34. https://doi.org/10.1080/00038628.2014.971702

Bronsema, B. (2013, June 07). Earth, Wind & Fire: Natuurlijke Airconditioning. Retrieved November 20, 2020, from https://doi.org/10.4233/uuid:d181a9f2-2123-4de1-8856-cd7da74e8268

Bronsema, B., Luijk, R. V., Swier, P., Veerman, J., & Vermeer, J. (2018). Natural air conditioning: What are we waiting for? *The REHVA European HVAC Journal, 55*(2), 21-25. Retrieved December 30, 2020, from https://www.rehva.eu/rehva-journal/chapter/natural-air-conditioning-what-are-we-waiting-for

Chaouat, J. (2016). How to integrate natural air-conditioning in the transformation of structural vacant office buildings to apartments in the Netherlands? (Master thesis). Delft University of Technology, Delft.

Climate KIC: Building Market Brief, The Netherlands. (n.d.). Retrieved December 18, 2020, from https://cuesanalytics.eu/wp-content/uploads/2018/07/181023-CK-BMB-BMB_NETHERLANDS-DEF-CIE-Edition-PREVIEW.pdf

Climate Policy: Government of the Netherlands. (n.d.). Retrieved December 18, 2020, from https://www.government.nl/topics/climate-change/climate-policy

Clancy, E. (2011). Indoor Air Quality and Ventilation - CIBSE Knowledge Series: KS17. CIBSE. Retrieved January 04, 2020, from https://app.knovel.com/hotlink/pdf/id:kt00U1DRK1/indoor-air-quality-ventilation/requirements-good-iaq

EPA, United States Environmental Protection Agency. (n.d.). Retrieved January 02, 2020, from https://www.epa.gov/indoor-air-quality-iaq/introduction-indoor-air-

quality#:~:text=Indoor%20Air%20Quality%20(IAQ)%20refers,and%20comfort%20of%20building%20occupants.&text=Health%20effects%20from%20indoor%20air,or%2C%20possibly%2C%20years%20later.

Energy performance of buildings directive | Energy. (n.d.). Retrieved December 18, 2020, from https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en?redir=1

European Commission. (2020). Retrieved December 18, 2020, from https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en

Eurostat. Final energy consumption, by sector, EU-28, 1990 and 2017(%). Retrieved January 02, 2020 from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Final_energy_consumption,_by_sector,_EU-28,_1990_and_2017_(%25).png&oldid=448078

Filippidou, F., Nieboer, N., Visscher, H. (2016). Energy efficiency measures implemented in the Dutch non-profit housing sector. Energy & Buildings, volume 132, 2016, pp 107-116.

Franx, L.L. (2018). Post-War Refurbishment- Making post-war era houses sustainable. (Master thesis). Delft University of Technology, Delft.

Giebeler, G., Fisch, R., Krause, H., Musso, F., Petzinka, K.-H., & Rudolphi, A. (2009). Refurbishment manual: maintenance, conversions, extensions. Basel: Birkhauser.

Health and Safety Executive. Retrieved December 26, 2020, from https://www.hse.gov.uk/temperature/thermal/factors.htm

Heirbaut, J. (2019). Sustainable sleeping. *De Ingenieur*, (March), 22–25.

Hoof, J. van, Mazej, M., & Hensen, J. L. M. (2010). Thermal Comfort: Research and Practice. Frontiers in Bioscience, 15, 1–22.

IEA The Netherlands 2020- Energy Policy Review. (2020). Retrieved December 18, 2020, from https://www.iea.org/reports/the-netherlands-2020

Klien T., Santin O.G., Boess S., Silvester S. (2015). An integrated design process for a zero-energy refurbishment prototype for post-war residential buildings in the Netherlands.

Klip, D. (2017). The transition of the residential heating system.

Konstantinou, T. (2014). Facade Refurbishment Toolbox: Supporting the Design of Residential Energy Upgrades. (Doctoral degree Dissertation), Delft University of Technology, Delft.

Leitão, A. F. J. C., & Graça, G. C. da. (2017). Building Performance Evaluation: A Dutch Perspective in Thermal Comfort and Energy Consumption.

Mărginean C.M. (2019). Optimized Facade Design towards Nearly Zero-Energy Residential High-Rises. (Master thesis). Delft University of Technology, Delft.

NASA: Climate Change and Global Warming. (n.d.). Retrieved December 18, 2020, from https:// climate.nasa.gov/

Nicolai, M.A. (2017). Residential Buildings with low heat demand.
Oorschot J.A.W.H. van, Haas G.D., Volf M., Lupíšek A., Borodinecs A., 2016.

HOUSING TYPOLOGY ASSESSMENT MORE-CONNECT WP3.1. Retrieved December 29, 2020, from https://www.more-connect.eu/wp-content/uploads/2018/04/HOUSING-TYPOLOGY-3.1.pdf

Ortiz, M., Itard, L., Bluyssen P.M. (2020). Indoor environmental quality related risk factors with energy-efficient retrofitting of housing: A literature review. Energy & Buildings 221 (2020) 110102.

OZ Architect. (2019). Hotel Breeze Ijburg Amsterdam. Retrieved from OZ website: https://www.ozarchitect.nl/projects/hotel-breeze-ijburg/

Pearson, A. (2019). Force of nature – naturally ventilating Amsterdam's Breeze Hotel. Retrieved from CIBSE Journal website: https://www.cibsejournal.com/case-studies/force-of-nature-naturally-ventilating-amsterdams-breeze-hotel/

Peeters L., Dear, R.d., Hensen, J., D'haeseleer, W.(2009). Thermal comfort in residential buildings: Comfort values and scales for building energy simulation. Applied Energy, Volume 86, Issue 5, 2009, pp. 772-780.

Rijksoverheid.nl. (n.d.). Building Decree 2012 | Building regulations. Retrieved December 20, 2020, from
https://rijksoverheid.bouwbesluit.com/Inhoud/docs/wet/bb2012

RVO. (2020). Energy performance – BENG. Retrieved January 03, 2020, from https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/gebouwen/wetten-en-regels/nieuwbouw/energieprestatie-beng

Santangelo, A.; Tondelli, S. (2017). Occupant behaviour and building renovation of the social housing stock: Current and future challenges.

Sørensen P. A. & Nielsen J. E. (2016). 9 - Renewable district heating and cooling technologies with and without seasonal storage. Renewable Heating and Cooling,

Technologies and Applications, 2016, pp 197-220.
Sauvé, G. (2019). Barriers impairing energy-efficient renovation in the Dutch Housing sector.

Tensen, E. (2011). Refurbishment solutions for post-war housing blocks. (Master thesis). Delft University of Technology, Delft.

Van Den Ende, E. (2017). A revolution: The Netherlands kisses gas goodbye – but will it help the climate? Retrieved December 20, 2020, from https://energypost.eu/a-revolution-the-netherlands-kisses-gas-goodbye-but-will-it-help-the-climate/

Van den Brom, P. (2020). Energy in Dwellings: A comparison between Theory and Practice.

Van Eck, H. (2016). Implementation of EPBD in the Netherlands. https://epbd-ca.eu/ca-outcomes/outcomes-2015-2018/book-2018/countries/netherlands

Van Oorschot, J. A. W. H. (2016). Implementation of EPBD in the Netherlands. Retrieved December 28, 2020, from https://www.more-connect.eu/wp-content/uploads/2018/04/HOUSING-TYPOLOGY-3.1.pdf