Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

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	Irum Faisal
Student number	5277310

Studio		
Name / Theme	Energy & Climate design studio	
Main mentor	Andy van den Dobblesteen	Climate Design & Sustainability
Second mentor	Atze Boerstra	Building Services Innovation
Argumentation of choice of the studio	The theme of topic is connected to a real-life proposal i.e. the sustainable renovation and extension of rowing facility Proteus Eretes. The challenge lies in transforming the current building into energy neutral complex abiding by the regulations for rowing accommodation design and EU energy goals. The studio would result in practical implementation of the theoretical research work which makes it interesting for me to improve understanding and problem solving ability in the field of energy and climate design.	

Graduation project	
Title of the graduation project	Towards a nearly zero energy building with high indoor quality and user comfort: Renovation of Proteus Eretes Rowing Facility
Goal	
Location:	Proteus Eretes, Delft, Netherlands
The posed problem,	Buildings, which account for almost half of all annual energy and greenhouse gas emissions, are the most critical focus for any climate change strategy. To reach Europe's 2030 climate goals, the construction sector must reduce emissions by 60%. That means annual renovations must increase by an order of magnitude; they are currently creeping along at 1% each year. Worse, ordinary renovations save very little energy, only 9% in residences and 16% in commercial structures. It's the deep renovations that cut energy by 60% or more, but that's only happening under 0.3% of the stock (Wind, 2021). The existing building stock is therefore coming into highlight to

	meet higher level renovation activity, as well as more research into the long-term viability of building renovation and energy extension. The starting point of such a subject would be the pre-evaluation of a building's functionality and the experience of using it, which provides a baseline for post-evaluation. While many refurbishment and renovation strategies have come into practice with time, there is a need to develop integrated climate design strategies that can be easily adapted and accepted in the existing building envelope and also by the occupants, respectively. Iterations with passive and active solutions should be developed and tested in order to reach nearly zero energy in buildings while enhancing indoor quality. Following the above problem, the renowned rowing facility of Delft, DSR Proteus Eretes which was built in 1997 calls for attention to sustainable renovation. The board members of the rowing association reached out to Prof. Ir. Andy van den Dobblesteen for the renovation and extension of the building with a vision of energy neutrality and sustainability. The energy performance of most old buildings, particularly sports buildings, has been severely neglected. Not only because physical activity challenges microclimate perception, but also because athletes have higher expectations for a healthy environment in which to practice their sport. According to the Konijnklijke Nederlansche Roeibond handbook, sustainable design of rowing accommodations points at five recurring themes: Energy, Environment, Health, Quality of use, Future value. Energy savings and lowering CO_2 emissions are an integral part of the architecture which can be simply achieved by proper sustainable planning, installations, insulation and in-house energy generation. Integrated design systems that can collaborate different disciplines in such architecture projects together can suffice the objective of energy-neutral building. The main reasons that lead to the introduction of this topic are increasing occupancy, high energy consumption and uncomfortable indoor environment in the current Proteus Eretes building. The underperforming building envelope

<table>
<tr><td></td><td>with outdated mechanical systems causes poor indoor environment which affects the occupant’s experience and results in high energy consumption overall. This project is an opportunity to analyse, evaluate and implement climate design strategies for sustainable renovation of the building. Therefore, the research aims at the transition of the rowing accommodation into an energy-neutral complex that provides high indoor quality to the users by:

- Investigating integrated climate design strategies that can improve the thermal performance, daylighting, energy usage behaviour, indoor air quality and occupant comfort in a holistic manner.

- Designing solutions that combine passive and active solar technologies to reduce operational energy and installation of RES, thus tending to become energy neutral.</td></tr>
<tr><td>research questions and</td><td>What are the sustainable strategies that can be used in renovation projects to reach nearly zero energy (NZE) and high indoor environmental quality (IEQ) for user comfort?</td></tr>
<tr><td>design assignment in which these result.</td><td>An integrated climate design system that uses passive and active strategies to refurbish the rowing club building for better indoor quality, energy efficiency and user comfort.</td></tr>
<tr><td colspan="2">The research offers a beginning point for understanding the difficulties in existing facilities with outdoor sport (case of Proteus Eretes) with respect to indoor environment quality and energy consumption. It reflects the occupants behaviour towards the indoor climate and their participation and adaptability to sustainable changes. The research will study the effects of current indoor environment on the energy usage behaviour in the rowing facility. Further, it will also include the operational energy emissions from existing systems and methods to make the building energy efficient using renewable energy sources and integrated climate design, but the research will not focus on embodied energy of materials or performing LCA for carbon emissions.

The following sub questions will answer the main research question by analysing the problem to the core for the renovation of Proteus Eretes rowing facility:

1. How to evaluate the relationship between a building's energy performance and the occupants' acceptance of the indoor environment?
2. What type of climate integrated design solutions are suitable for such renovation projects? How to combine passive and active solutions to reduce the heating, cooling, lighting and ventilation demand?
3. What building factors contribute to thermal performance and thermal comfort? How to easily incorporate thermal mass system in the rowing facility to enhance the indoor climate?
4. What are the factors affecting indoor air quality? How can the indoor air quality be improved?</td></tr>
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5. What are the ways to optimize the use of available natural sources and increase the rate of usable renewable energy source?
6. What are the technical challenges in retrofitting climate responsive solution in the current Proteus Eretes building? How to overcome these challenges in a conscious manner?
7. How to measure the effectivity and adaptability of the integrated climate design in the renovation of Proteus Eretes?

Process

Method description

The methodology is divided into three parts which would be adopted for the graduation as described below along with the following methodology flow chart with phase-wise objectives and graduation timeline.

a. **(P1-P2) Literature research, site visit and surveys–**

The beginning of this research focuses on establishing an understanding of the themes that would facilitate the sustainable renovation of the rowing facility. In order to identify issues in the building, site visits and user surveys will be performed to gather information regarding occupants' perceptions of the current indoor environment. This step is followed by data collection from the association that explains the requirement list, vision for sustainability and Koninklijke Nederlandsche Roeibond (KNRB) standards. Simultaneously, an intensive study will be done on performance indicators for the energy transition; nZEB and indoor environmental quality, to define criteria for successful renovation proposal for the rowing accommodation. In-depth study is crucial for planning methods to include energy-efficient technology, passive and active solutions to improve thermal comfort, ventilation, lighting and energy performance of the building. This literature review will guide in sorting out the main parameters that are relevant for the case of Proteus Eretes.

b. **(P2-P3) Assessment methods, strategies and design set-up–**

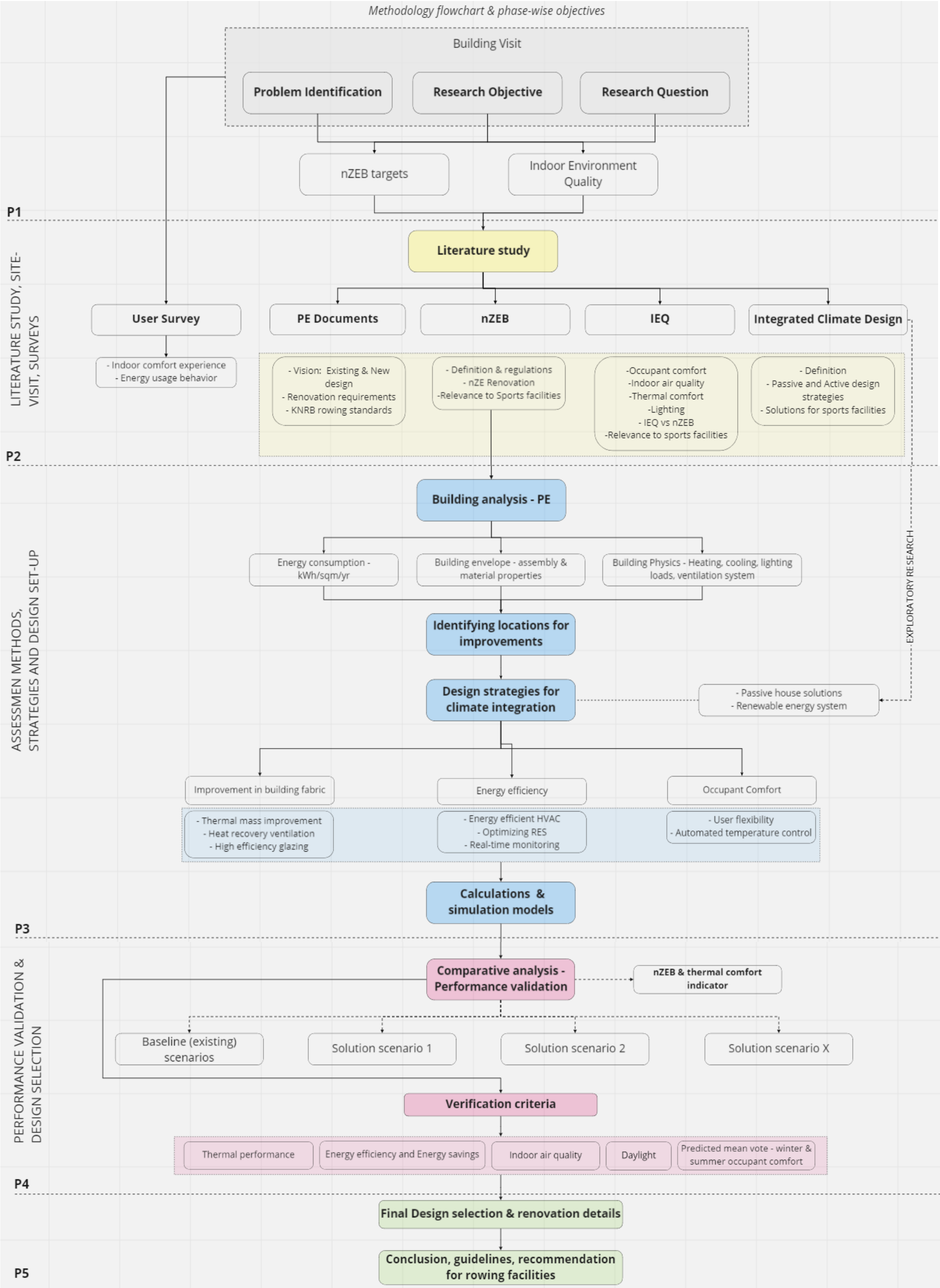
Subsequently, building analysis for rowing facility would be performed to assess building envelope, thermal performance, glazing efficiency, HVAC system, energy consumption and overall building physics. The key locations in the building for improvement will then be identified. Parallel to this, exploratory research will be a continuation of literature in order to design strategies for climate-responsive elements. Passive and active solutions would be explored to incorporate thermal mass systems, energy-efficient glazing, heat recovery ventilation, and renewable energy system for building retrofit. These would be quantified based on calculations and simulation methods that will be developed to achieve the adaptability and user flexibility of the system. This phase of graduation is very important for the following comparative analysis and performance validation for the long term viability of the rowing club building.

c. **(P3-P4) Comparative analysis and performance validation –**

To validate the design solutions, a comparative analysis technique will be used. Design scenarios with different climate solutions will be developed and compared with the existing baseline scenario on these aspects**:** energy savings, thermal comfort, daylight autonomy, indoor air quality, and predicted mean vote for occupant comfort. By using computation tools for energy analysis, such as ESP-r, Design builder, Energy plus with honeybee and ladybug plug-in, the different scenarios will be validated as per the verification criteria. The final design will then be selected for the most energy efficient and better indoor quality design, followed by the development of renovation details.

Conclusion

The outcome shall result in formulating case-specific conclusions, guidelines and limitations for integrating climate design solutions for the renovation of rowing facilities. Through this thesis, inputs regarding nZEB and IEQ for rowing accommodations shall be proposed for the edition of the KNRB handbook.



Methodology flowchart & phase-wise objectives
Building Visit
Problem Identification
Research Objective
Research Question
nZEB targets
Indoor Environment Quality
P1
LITERATURE STUDY, SITE-VISIT, SURVEYS
Literature study
User Survey
- Indoor comfort experience
- Energy usage behavior
PE Documents
- Vision: Existing & New design
- Renovation requirements
- KNRB rowing standards
nZEB
- Definition & regulations
- nZE Renovation
-Relevance to Sports facilities
IEQ
-Occupant comfort
-Indoor air quality
-Thermal comfort
-Lighting
- IEQ vs nZEB
-Relevance to sports facilities
Integrated Climate Design
- Definition
- Passive and Active design strategies
- Solutions for sports facilities
P2
ASSESSMEN METHODS, STRATEGIES AND DESIGN SET-UP
Building analysis - PE
Energy consumption - kWh/sqm/yr
Building envelope - assembly & material properties
Building Physics - Heating, cooling, lighting loads, ventilation system
Identifying locations for improvements
Design strategies for climate integration
- Passive house solutions
- Renewable energy system
EXPLORATORY RESEARCH
Improvement in building fabric
- Thermal mass improvement
- Heat recovery ventilation
- High efficiency glazing
Energy efficiency
- Energy efficient HVAC
- Optimizing RES
- Real-time monitoring
Occupant Comfort
- User flexibility
- Automated temperature control
Calculations & simulation models
P3
PERFORMANCE VALIDATION & DESIGN SELECTION
Comparative analysis - Performance validation
nZEB & thermal comfort indicator
Baseline (existing) scenarios
Solution scenario 1
Solution scenario 2
Solution scenario X
Verification criteria
Thermal performance
Energy efficiency and Energy savings
Indoor air quality
Daylight
Predicted mean vote - winter & summer occupant comfort
P4
Final Design selection & renovation details
Conclusion, guidelines, recommendation for rowing facilities
P5

Graduation Timeline :-

	P1									P2											P3								P4					
Calendar week	46	47	48	49	50	51	52	53	1	2	3	4	5	6	7	8	9	0	11	12	13	14	15	16	17	18	9	20	21	22	23	24	25	26
Academic week	2.1	2.2	2.3	2.4	2.5	2. 6	-	-	2.7	2.8	2.9	2.10	-	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.1 0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10	4.11
Building visit																																		
User survey																																		
Literature study															Exploratory research phase for design development																			
Graduation plan																																		
Building Analysis:																																		
Identifying locations for improvement																																		
Design strategies development																																		
Simulation set-up & optimization																																		
Comparative analysis																																		
Performance validation																																		
Final Design selection																																		
Final details																																		
Conclusion, guidelines and recommendation																																		
Final report																																		
Final presentation																																		

Literature and general practical preference

The literature review compiles three main topics: nearly zero energy buildings (renovation), Indoor environmental quality and integrated climate design systems. Each theme is discussed with the relevance to sports facilities specially with respect to rowing accomodations (wherever possible). The following literature references are used:

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Miller, E., & Buys, L. (2008). Retrofitting commercial office buildings for sustainability: Tenants' perspectives. *Journal of Property Investment and Finance*, *26*(6), 552–561. https://doi.org/10.1108/14635780810908398

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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 topic is part of energy and climate department which comes under the track building technology. The learnings from the track regarding climate design, building physics, zero energy design are related to the posed problem for the energy transition of Proteus Eretes. It is an exclusive opportunity for a student from building technology track to apply this knowledge in a 'research by design' method. From problem analysis and complexities in building renovation towards evaluation and validation process, this theme is an exposure to the pragmatic implication of the energy and climate notions.

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

Societal relevance –

The proposal for this real-life design problem should be able to represent itself as a strong business case serving a larger audience - a transition plan for the Dutch renovation industry that visions of sustainability and energy neutrality, especially sports facilities.

A large portion of society is becoming aware of high energy consumption and energy demands, including the energy of their buildings. This calls for attention to societal involvement in the transition of existing building stock towards nearly zero energy building. Not only energy is the issue, but human comfort and health are an integral part associated with the quality of building. This project includes interaction with individuals associated with the rowing club and other stakeholders that concern the building design. Therefore, the approach to propose design solutions for smooth energy transition of Proteus Eretes involves agreement and acceptability from the concerned individuals towards sustainable and healthy change.

Scientific relevance –

At the core of this project lies intervention for better energy performance and indoor comfort that affects user flexibility. By exploring and applying scientifically verified climate design solutions that respond to energy neutrality and indoor quality, the proposal aims at bridging the gap between building's quality, use of energy and health of occupants. The emphasis is specially made on the energy-efficient design of sports accommodation which has not been thoroughly researched in the past. Therefore, the methodology that will be followed in this thesis delves deep into problem analysis from different perspectives focusing on nearly zero energy renovation and indoor quality in small scale sports buildings. The literature not only highlights theories for integrating climate design, but also technical complexity and reasoning. The main idea is to influence architects and building engineers to strategize solutions and follow such a design process for building renovation that is acceptable by the existing users and results in the long term viability of the building.