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	Eliana Sofía Chuquizuta Bustamante
Student number	5245184

Studio		
Name / Theme	Building Technology Sustainable Design Graduation Studio	
Main mentor	Dr. Alessandra Luna Navarro	Façade and Product Design
Second mentor	Prof.dr.ir Atze Boerstra	Building Services Innovation
Argumentation of choice of the studio	I chose Façades and Building Services because I believe that the energy consumption and decarbonization of the built environment can be highly influenced by these two topics. Moreover, the health and comfort of the users can be jeopardize if one or the other are not addressed properly. The integration of these themes drew my attention for the potential of the effect and importance my work done during my thesis can have for the greater good.	

Graduation project	
Title of the graduation project	Stand-alone serviced façade panel
Goal	
Location:	The Netherlands and Mexico City.
The posed problem,	The built environment accounts for 40% of the annual global CO2 emissions. Of the total, 27% accounts for building operations, and the embodied energy of materials and construction accounts for 13% annually. (IEA, 2022). Population in cities worldwide is expected to increase from 55% to 68% by 2050, and to decrease in rural areas (United Nations, 2018). This will translate into a higher demand for the housing market stock. The built environment has a challenge towards 2050, it needs to deliver housing for cities at a fast pace while reducing the CO2 emissions of the industry. In that sense, if the goal is to reduce the carbon emissions generated by the built environment, the more feasible and rather rapid option is to refurbish pre-existing buildings and, continue the decarbonization across the globe. However, according to the 2021 status report of the Global Alliance for Buildings and Constructions, the pace at which the building stock

	decarbonization is being addressed is not enough to meet the Paris Agreement goals. (United Nations Environment Programme, 2021). Building retrofitting often requires new façade panels installation, while the services renovation is an often-intensive process specially in terms of time and space. Moreover, the integration of building services in the façade requires a circular design approach to ensure its efficiency during the operability of the parts. This way, renovations can be transformed into a more efficient and integrated process between the façade and the building services. However, the environmental assessment of building retrofits depends on different model assumptions such as climate and user behaviour.
research questions and	"How can a **circular façade** design **integrate building services** to **provide** better **user comfort** for **building retrofitting**?" Sub questions: ▪ To what extend are the integrated building services technologies effective to meet the comfort demands? ▪ What is the comfort demands of an Oceanic Subtropical Highland climate (Cwb) and a Marine West Coast Climate (Cfb)? ▪ What are the integrated building services façades that have already been developed? ▪ How can building services be integrated in a circular façade?
design assignment in which these result.	The design assignment will result in an efficient and aesthetic circular design façade panel that integrates heating and cooling through a decentralized ventilation system. It will generate energy with PV panels, the goal is for this energy to be sufficient to make a stand-alone façade panel. At the same time, this panel will meet occupants comfort requirement, and aims to provide better comfort levels in terms of thermal, acoustics and indoor air quality.

Process

Method description

To answer the sub questions to afterwards, be able to answer the main research question, this thesis will follow a process divided in three steps: literature review, technologies performance validation and design set-up, and performance validation in future case climate scenarios. The methodological approach of the presented thesis builds on design through research.

Literature review (P1-P2)

The first part of the thesis comprises a general understanding and overview of the topic. During this stage the thesis topic was selected, the problem statement was defined along with the research question and the sub questions. The general understanding and approach to the topic

allowed me to make the decisions regarding which building services and what domains to focus in the integration of the façade panel. The literature research was led by the four sub research questions, each of them had a different focus and therefore were answered differently: by literature research (first and last question), a regulations desktop-research (second question), and state-of-the-art analysis of current market products (third question).

Technologies performance validation and design set-up (P3)
The data gathered during the literature research regarding the available technologies for the heating, cooling and energy generation will be assessed and compared with Energy Plus to determine the best technology for the case studies climates. At the same time, information on the case studies will be gathered such as comfort demands, architectural plans, sections and 3D model of the buildings. This first part will end up with the elaboration of the design requirements from the building and the technologies for the circular façade panel.
After, the set up for the design of the circular façade panel will take place. Different iterations will be tried and tested. The architectural design will be led by the three architectural principles of durability, utility, and beauty. Once a final design prototype has been accepted, it will undergo a performance validation to test the performance of the all the integrated services at the same time in Design Builder.

Performance validation in future case climate scenarios (P3-P4)
Finally, a simulation analysis of the behaviour of the prototype on two different future climate scenarios will be assessed in Meteonorm to determine the feasibility and applicability of the product designed in the future. These will be based on the case studies climates. The design will suffer the last updates and the potentiality of its implementation at a larger scale will be analyzed. Results and reflections will be developed at this stage.

In figure 1 we can see the methodology description process. Whereas diagram 2 is a timeline proposed to the fulfilment of the topics along the thesis year.

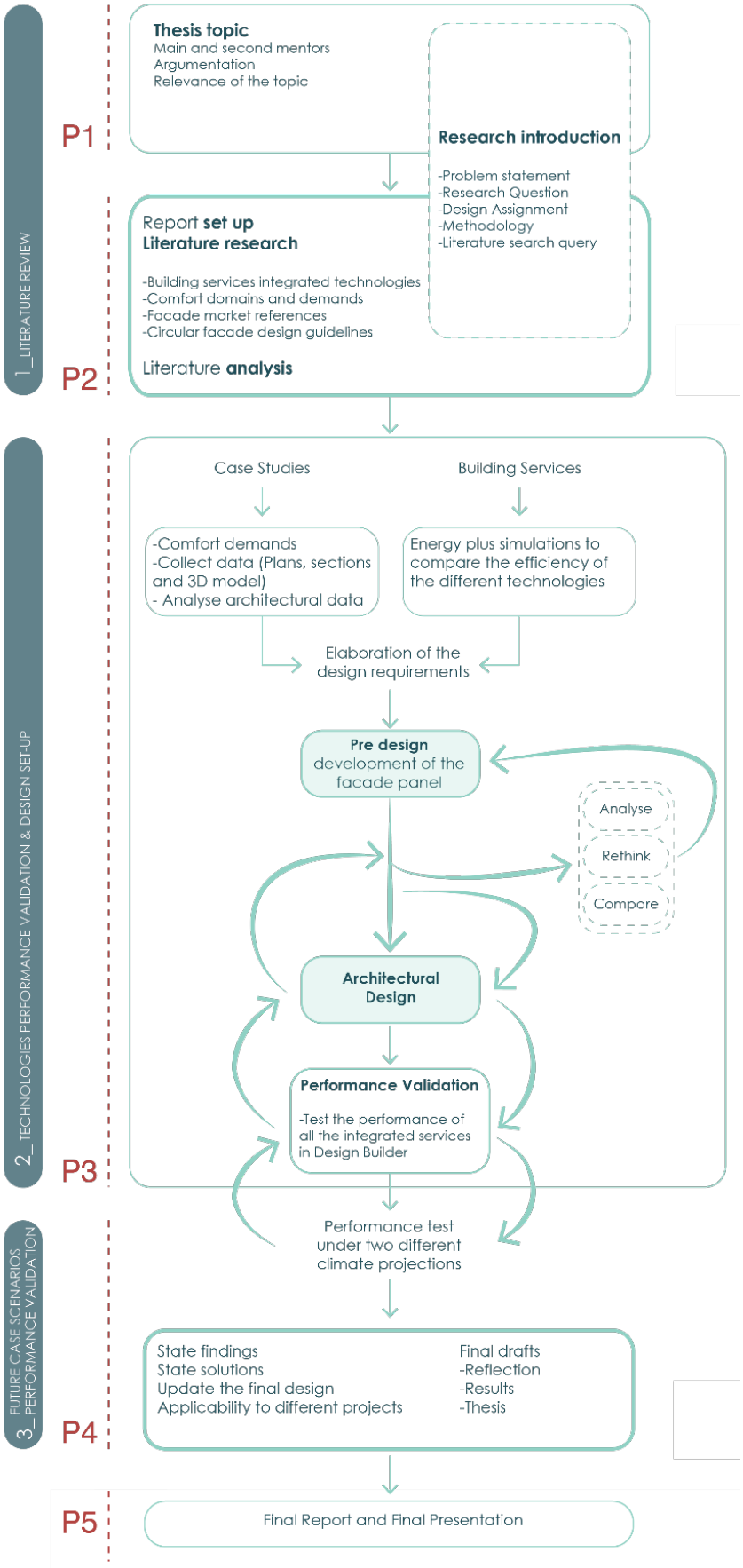
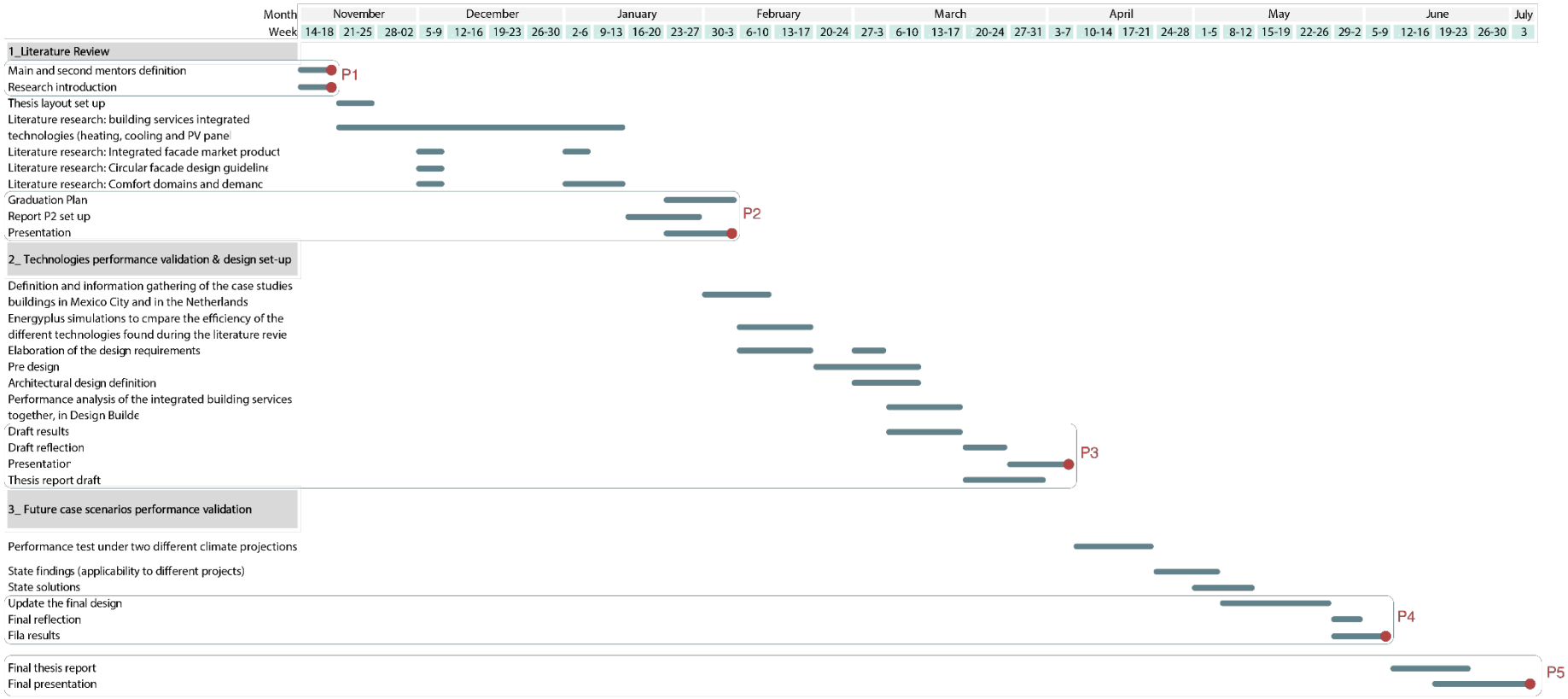


Figure 1. Methodology description process

Figure 2. Thesis year timeline



Literature and general practical preference

First, a search was done in Scopus with the keywords; integrate, façade, envelope, cooling, heating, ventilation, and light. Additionally, recommended papers, PhD dissertation, and company's products PDF were also added into the literature database. The data results from Scopus were filtered on their relevancy to the scope depending on the title and the abstract, the duplicates, and the inaccessible sources. This left a final data base of 24. The type of sources are mostly journal articles, followed by articles, doctoral thesis, company websites, and journals. This process is further exemplified in Figure 3 below.

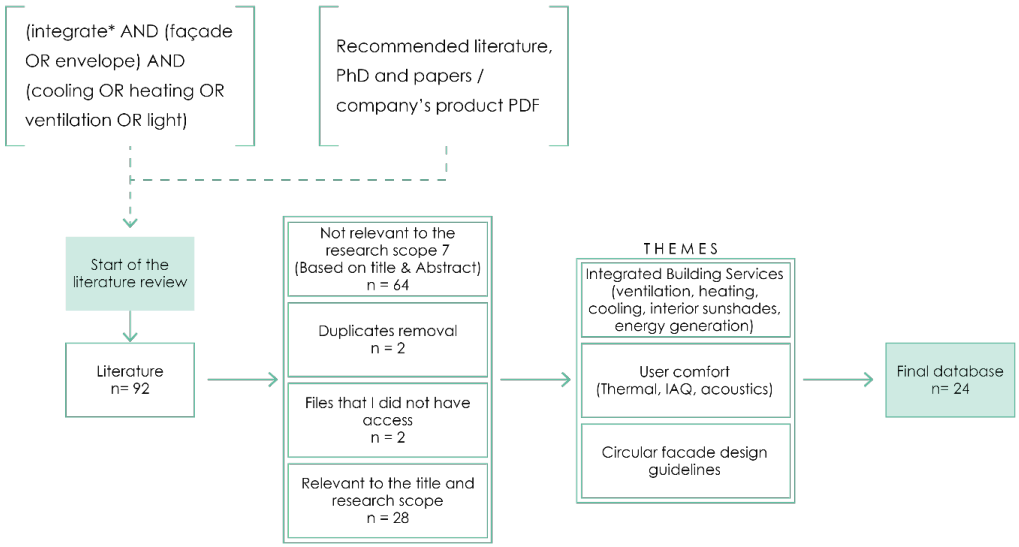


Figure 3. Search analysis

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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 MSc in Architecture, Urbanism & Building Sciences comprises all parts of the built environment. The building envelope functions as the interaction interface, an in-between of the outside world with the interior, with the user. It joins architecture with the urban life. In this sense, my master thesis aims to connect and design an envelope that integrates what for many years has been considered an addition in architecture to ensure its efficient operability, the building services.

My Master thesis is named "Plug-in services façade." The focus is to integrate building services in a circular façade to provide better user comfort. This thesis involves two research themes: Façade Design and Building Services Innovation present in the department of Architecture Engineering & Technology of the Master Track Building Technology at the Delft University of Technology.

Façade design is involved as the layer of the building that will integrate the building services. For this, a preliminary assessment of the current decentralized building services technologies, its performance in buildings and their effect on the user comfort will be done.

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

The integration of building services in the façade have a direct impact on the users comfort and health. As well as in the decarbonization of the built environment towards the worldwide goals, such as Architecture 2050, since it can represent a considerable number of energy savings in the field. Currently, the building stock retrofit is not going at the rate at which it should be. The use of new technologies with a perspective towards construction and operable efficiency could help professionals around the globe to meet the challenges of climate change.

The final design could start the conversation in the field to reflect on why we are designing architecture without the use of integrative building technologies such as services integrated in the façade envelope. Nowadays, we see architecture with its shearing layers, and they are, in a way, fragmented yet dependent on one another.

This thesis aims to extend the knowledge an reinforce the reliability on how different state-of-the-art services can be integrated in a circular façade panel while allowing adaptability over time, over different climates and giving designers the opportunity to design more sustainable. This is a rather new and integrative way of understanding, thinking, and designing architecture with an integrative technology.