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	Geunchan Song
Student number	4806115

Studio		
Name / Theme	Energy & Climate	
Main mentor	Martín Mosteiro Romero	Climate Design
Second mentor	Azarakhsh Rafiee	Design Informatics
Argumentation of choice of the studio	I personally have experience of analyzing energy performance in building scale, but I would like to extend my comfort zone to analyzing in urban scale. It would be interesting to see how urban form elements are related to energy performance, which I have never researched before.	

Graduation project	
Title of the graduation project	Urban form, urban heat island effect and energy demand: Insights from Seoul
Goal	
Location:	Seoul, South Korea
The posed problem,	Cities in these days experience UHI effect, which affects energy demand of the buildings. To mitigate the UHI effect and reduce the energy demand, research on urban form elements and find correlations are needed.
research questions and	How do urban form elements influence the Urban Heat Island (UHI) effect and building energy performance in a selected area of Seoul, South Korea?
design assignment in which this result.	Analyzing the Influence of Urban Form Elements on the Urban Heat Island (UHI) Effect and

	Building Energy Performance in a High-Density Urban context and predict energy demand in the future.

The Urban Heat Island (UHI) effect in cities like Seoul increases energy demand and impacts environmental quality, yet the combined influence of urban form elements on UHI and building energy performance remains poorly understood. This gap hinders effective urban planning and sustainability efforts.

Process

Method description

The research follows a 5-step methodology: temperature distribution, urban form elements, energy consumption, urban form elements importance, and case study for validation.

1. Temperature Distribution
Temperature Distribution Data on air temperature is collected from Landsat 8 satellite images and converted to air temperature using a multi-layer perceptron (MLP) model. The MLP model is trained using ground truth data from Automatic Weather Stations (AWS) and validated using S-DoT sensor data, which has a known systematic temperature difference of 1.8°C compared to AWS data.

2. Urban Form Elements
Six urban form elements are considered in the study: NDVI, building ratio, building height, building volume, floor space index (FSI), and ground space index (GSI). These elements are calculated using building footprint and height data provided by the Seoul Metropolitan Government. The urban form elements are analyzed at three spatial scales: pixel level (30m resolution), 100m, and 300m buffers around each pixel centroid.

3. Energy Consumption
Energy Consumption Building energy consumption data (electricity and gas) is obtained from the Korean Architecture Hub. The data is provided as monthly energy consumption for each building. To normalize the data for building size, energy use intensity (EUI) is calculated by dividing the total energy consumption by the gross floor area of each building. Buildings with unique addresses are included in the analysis to avoid duplicates.

4. Urban Form Elements Importance
The Genizi method and partial correlation analysis are used to examine the relationships between urban form elements, air temperature, and energy consumption. The Genizi method quantifies the relative importance of each urban form element in explaining the variance of air temperature and energy consumption, while partial correlation analysis identifies the direction (positive or negative) of the relationships between each urban form element and the dependent variables.

5. Case Study
A case study of District 3 in Heukseok-dong is conducted to validate the findings from the Genizi method and partial correlation analysis. District 3 has undergone significant redevelopment over the study period, with a dramatic reduction in the number of buildings and an increase in green spaces. The changes in urban form elements and their impact on air temperature and energy consumption are analyzed.

Literature and general practical references

Theoretical Framework

- Urban Heat Island (UHI) theory to understand the mechanisms driving temperature disparities in urban areas.
- Statistical methodologies like the Genizi method for quantifying the relative importance of urban form elements on air temperature and energy consumption, and partial correlation analysis for determining the direction of these relationships.
- Machine learning concepts, focusing on multi-layer perceptron (MLP) models, for converting land surface temperature (LST) to air temperature.

Research Data

- Historical air temperature data from Landsat 8 satellite images, converted from LST to air temperature using the MLP model.
- Ground truth air temperature data from Automatic Weather Stations (AWS) for training the MLP model and S-DoT sensors for validating the model's performance.
- Urban form element data, including NDVI, building ratio, building height, building volume, floor space index (FSI), and ground space index (GSI), calculated from building footprint and height data provided by the Seoul Metropolitan Government.
- Building-level electricity and gas consumption data from the Korean Architecture Hub, normalized by gross floor area to obtain energy use intensity (EUI) values.

Practical References

- Studies on UHI mitigation strategies, such as those by Santamouris (2014) and Bowler et al. (2010), to identify key urban form elements influencing temperature and energy demand.
- Liao et al. (2021)'s application of the Genizi method and partial correlation analysis to quantify the relative importance and direction of relationships between urban form elements and air temperature in Seoul.

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)?

   - This topic bridges the principles of **Building Technology (BT)** and **Urbanism (U)** by examining how urban form and building characteristics influence energy performance and environmental sustainability**.** From the BT perspective, the research explores the technical aspects of building performance, such as the impact of building geometry, volume, and FSI/GSI on energy consumption. It incorporates advanced analytical techniques, including machine learning and statistical modeling, to predict and optimize building energy use. From the U perspective, the project addresses the broader spatial dynamics of urban form, including the distribution of green spaces, building density, and layout, and their role in mitigating the UHI effect. It aligns with urban planning principles by focusing on creating sustainable and energy-efficient urban environments.

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

   - From the **social framework**, the research contributes to mitigating the adverse impacts of climate change on urban populations, particularly those in dense cities like Seoul. By identifying strategies to reduce the UHI effect and improve energy efficiency, the research can promote sustainable urban environments, better thermal comfort, and reduced energy costs for the cities.
   - From the **professional framework**, the research can provide insights for urban planners, architects, and engineers. It emphasizes integrating urban form and building technologies to achieve optimal energy performance and climate adaptation, supporting the development of sustainable building practices and urban designs.
   - From the **scientific framework**, the project advances knowledge by combining urbanism and building technology principles. It uses data-driven methodologies, such as statistical analyses and machine learning, to explore the correlations between urban form, UHI, and energy consumption, contributing to fields like urban climatology, sustainable building technologies, and predictive modeling.