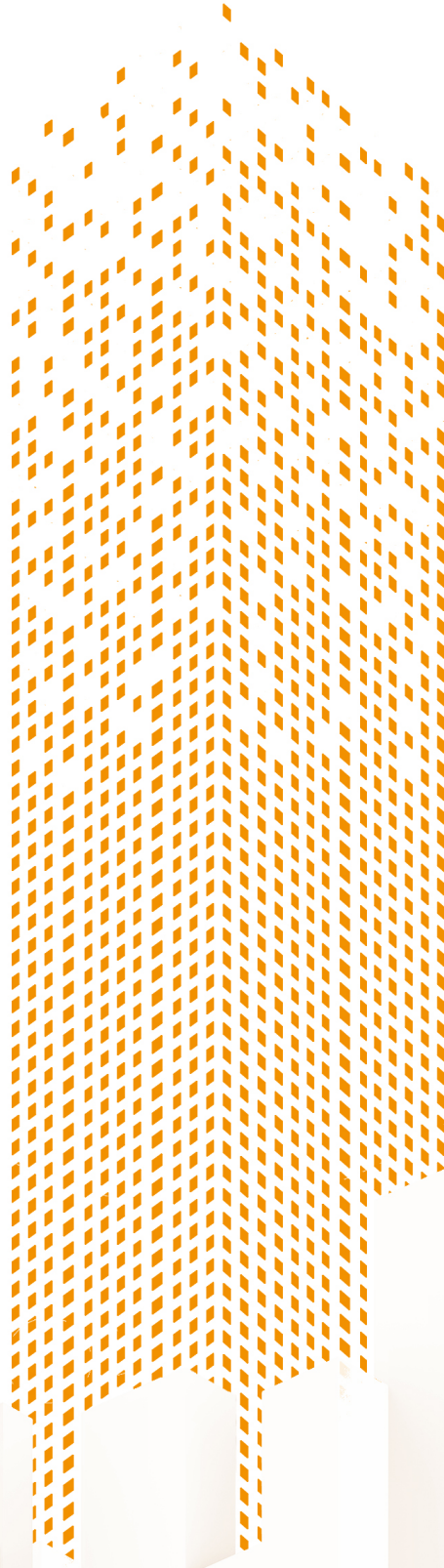


Reflection

Computational Design Analysis of Height Scenarios in

Residential High-rise under BENG 2020



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in Residential High-rise under BENG 2020**

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General information about the study

This research is based on the exploration of the energy performance of a residential high-rise building in the Netherlands under the BENG 2020 regulations. The aim is to investigate the building's maximal height limit that can be reached within the conditional boundaries of the regulations and the user's comfort. The research was based on a referential building layout used by the RVO, and readapted accordingly, where parameters related to the early design stage and the facade were applied with ranges of variables. The literature study has led to conclude that both the passive and active design affect each other, and requires a deeper investigation of the selected parameters to reach an efficient energy balance.

To conduct this study, the computational approach is selected to serve the complexity of the interrelated parameters and variables. Additionally, advised by the mentors, some variables were disregarded for a lack of importance to this research, from which the wall-to-floor depth and the in-between ratio of the plan layout, as well as a reduction of ranges due to the restricted time span and the time-consuming optimization and simulation.

In order to reach the outcome of this thesis, the process of the work was organized in steps, which allowed to speed the process of optimization, rather than merging all variables together, as following:

1. Background information on BENG regulations at the current time
2. Research question and sub-questions refinement
3. Literature study of the design parameters and the computational methodology of work
4. Organization of the upcoming computational workflow into sub-categories
5. Parametric modeling of the high-rise in Grasshopper
6. Computational workflow for energy simulation in Grasshopper
7. Orientation and geometry optimization in Grasshopper linked to modeFRONTIER
8. Lower floors optimization of the selected facade parameters under different surrounding buildings in Grasshopper linked to modeFRONTIER
9. Facade parameters optimization
10. Exploration of the BENG results in parallel to the height increment of the optimized design
11. Design guidelines establishment for a residential high-rise according to BENG 2020
12. Conclusion

From the outcome of the optimization, the most influential design parameters selected in this research are used to define guidelines for future development of residential high-rise, in the temperate climate according to BENG.

Process of the work

The implementation workflow in Grasshopper was coupled with several platforms such as Honeybee, Ladybug, Energyplus, Daysim and Openstudio, which required more time to finalize the energy simulation than expected. In fact, as the amount of information required to run the simulation was heavy in terms of data, many aspects of the workflow had to be adapted to minimize the time calculation such as the daylight. Also, in order to reach a similar outcome, different methods of implementing the data were possible such as the orientation of the building, the daylight points distribution among the surfaces, the modeling of the shading devices and more. Thus, all the methods had to be explored to ensure the correct continuity of the workflow, but also to select the ones that require the least calculation time.

The exploration of the design was made through an external platform in modeFRONTIER where several types of design algorithms are provided. Due to the lack of time, it was not possible to evaluate all the different algorithms according to the objectives and to reach the results in a shorter time. Deeper understanding of this software would facilitate the design exploration and the reliance of the outcome. Additionally, while the software is processing, it is not possible to use Grasshopper, which was slowing the work process.

Relevance to the social framework

The building sector is responsible for 40% of the global energy consumption having a great impact on the environment. More sustainable strategies are essential for future development in urban areas. In the Netherlands, starting from 2020, new regulations known as BENG are implemented to control the energy performance and consumption of buildings that are restrictive for certain types of construction

such as residential high-rises. In addition, the Dutch housing market is facing an exponential increase of the demand and supply that necessitates an increase of the number of dwelling units per acre. Building vertically can provide a larger amount of accommodation for similar land areas in comparison to a horizontal skyline. Thus, optimal strategies for designing residential high-rises that are energy efficient can be applied for both the Netherlands, but also, countries under the same temperate climate conditions. The workflow outcome will serve as guidelines for energy saving in the design of residential high-rises in respect to the height increment, with a minimal impact on the environment while ensuring the comfort of the users.

Relevance to the professional framework

The developed workflow of this research is in the advantage of several disciplines in the professional framework such as architects, facade designers, engineers and climate consultants. The parametric integration of the building geometry, the facades features and the embedded systems allows to explore multiple combinations of parameters to assess the energy performance and user's comfort in a high-rise residential building. The computational tool assists the designer in manipulating parametrically and instantly a complex, multi-objective design, with access to simulate, visualize, analyze and compare different strategies depending on the goals. As such, reaching optimal solutions is possible in a shorter time compared to traditional, manual work.

In this study, the results serve as guidelines for residential high-rises in the Netherlands. With the flexibility and integration of the data, the workflow can be adjusted to any type of building height and function depending on the project and adapted to different climate conditions and location in another country. In addition, a larger range of parameters can be included in this workflow to assess their efficiency and impact on the design. Based on the required data as outputs, it is possible to extract further information by adjusting the workflow and adapting it to meet regulations such as the nZEB and BENG, while verifying overall costs, environmental impact, user's behavior or quantifying material amount.

Relevance to the scientific framework

Reaching for computational tools can provide designers, engineers and consultants a gap filling knowledge on the relationship their different disciplines contribute to the building design. Thus, the integration of the architectural, climate and facade fields into a single workflow facilitates the approval of the decision making from each sector. Aiming for nearly-zero energy high-rise, the outputs from the workflow highlight the interrelated impact of the building and facade parameters, the energy performance and the indoor comfort. To reach the most efficient outcome, optimization algorithms evaluate and assess all the combinations in order to provide a near optimal range of variables where a balance is established between active and passive design strategies.

Conclusion

Overall the study has allowed to explore a greater depth of how different studied subjects can be related and combined under a workflow, and be able to relate all the knowledge that has been acquired to reach a conclusion based on computational results. The tool facilitates the observations and the analysis of data, which were lacking previously to this research. Due to complexity, it is not feasible to optimize all parameters at once where there is a heavy amount of data within the workflow requires considerably more calculation time, and therefore slows down the work progress. It is advised to select the most influential parameters or the features that need to be evaluated. In addition, although it might lead to less accuracy, dividing the total work into several phases can facilitate the methodology of the work by reducing the number of parameters to assess in one single phase and reach results faster. Thus, it is up to the user to balance between the level of accuracy and refinement required, and the time needed to achieve the study. Also, a greater knowledge of the software used can provide a greater depth of study in the future, and provide a better control of the workflow. The tools have served to verify the performance of the decision making in the project related to energy consumption and the user's comfort simultaneously. which brings a better understanding of how to balance between parameters and guide decision taking.

From urban planning, to architectural design, to specific components in the building facade and integrated systems, computational method is not restricted to building design only, but can contribute to a larger field of study. In the future, with the rise of the new regulations in all countries, it will be necessary to rely on these tools to verify that requirements are satisfied, reach optimal solutions and achieve sustainable design.