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On Urban Planning and Procedural Modeling

MASTER'S THESIS

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Supervisor
Univ.-Prof. Dipl.-Arch. Dr.sc.ETH Urs Hirschberg
Institute of Architecture and Media

Graz, October 2018

Affidavit

I declare that I have authored this thesis independently, that I have not used other than the declared sources/resources, and that I have explicitly indicated all material which has been quoted either literally or by content from the sources used. The text document uploaded to TUGRAZonline is identical to the present master's thesis dissertation.

Date Signature

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Table of Content

Abstract

The city as a living space and research object is gaining in importance due to its complexity, progressive urbanization and the increasing quality demands. The requirement on urban planning in cities is constantly growing - by 2050 an estimated 70 percent of the world's population will live in megacities with more than 10 million citizens.[1]

1 See: Renner 2018, 12.

This growth requires efficient methods for planning, densification and expansion of cities for example the application of procedural modeling techniques within the urban planning process. Procedural modeling means a rule-based creation of 3-dimensional (3D) models and textures based on a set of parameters. The development and use of digital tools are highly discussed in papers, but literature lacks the application of methods for a whole urban planning process. This thesis explores a flexible, adaptable approach using the 3D modeling software Rhinoceros, the parametric plug-in Grasshopper, the GIS-software QGIS and other standalone analysis software. Expert interviews are conducted with urban planners and researchers to bring up different perspectives on the urban planning process and goals that support and improve the development of my methodology.

This methodology includes already existing and self-developed digital tools for an urban planning project and is applied on a case study in the 20th district, Brigittenau, of Vienna. Austria's capital was ranked again as the most livable city of the world by Mercer in 2018[2] and provides a great range of open data available online. Whether this data serves as a sufficient basis for planning an urban neighborhood is examined in this thesis.

The existing train station structure of the ‚Nordwestbahnhof' complex will be replaced by a new neighborhood and offers 44 hectares mixed-use in a central location of Vienna. Following the vision guidelines of the city different scenarios will be developed and evaluated throughout the process and serve as a decision base for stakeholders and clients. Traffic flow, use-mix, energetic and climate aspects influence the concept as key parameters and are used to compare the proposals with each other. An urban planning process contains different influencing factors besides the use-mix and site conditions, social and cultural constellations of the society need to be integrated within the process as well. This inclusion can occur in a drawing, a design decision or by the parameters of the parametric model.

The aim of this thesis is to demonstrate the use of digital tools in the early stages and the possible impact on negotiations with stakeholders, planners and residents. How to measure the quality of an urban design will also be discussed. A combination of urban planning knowledge and digital tools is crucial for the development of a qualitative, sustainable urban design. The outcome of this thesis is a theoretical discussion of the interviews, the developed methodology and the graphical representation of the case study.

2 See: Knolle Kristie: Meet the cities with the highest quality of life. (2018, 21 March). https://www.weforum.org/agenda/2018/03/vienna-unbeatable-as-worlds-most-liveable-city-baghdad-still-worst?utm_source=Facebook%20Videos&utm_medium=Facebook%20Videos&utm_campaign=Facebook%20Video%20Blogs [08/30/2018]

Introduction

Living in a large city offers a wide range of jobs, leisure activities and housing - good infrastructure is indispensable to ensure the quality and sustainability of everyday life. We are constantly surrounded by technology and digital media containing large amounts of data. In the age of digitalization a wide range of data about the urban structure, the usage, public facilities, local supply and traffic is available which is useful for the intelligent planning, consolidation and expansion of cities.

01

The online open data platform by the city of Vienna offers a wide variety of useful information about buildings, land-use, traffic, topography, educational institutions and public transport that serve as a planning basis for my case study on the ‚Nordwestbahnhof' territory in Vienna.[3] Additional information to feed the site analysis with information comes from the open source platform Openstreetmap.[4] The online platform Foursquare additionally provides information about restaurants, café's, bars and many other amenities within the city. For the planning carried out, the block outlines provided in the vision guideline and the space requirements for residential, office, commercial and social use are taken into account and combined with my ideas for this project. In the following, aspects such as accessibility, visibility, microclimate and solar radiation are combined with a concept for qualitative, urban living and working.

The main focus is drawn on the planning process: on which data to build, how to perform intelligent, adaptive planning using Rhinoceros 3D and the parametric plug-in Grasshopper and validate it in early phases through simulations and analyses. Expert interviews are conducted to capture the current attitude on a planning process and combine the traditional way of working with the possibilities of digital tools.

This thesis is divided into several parts: the first part deals with the description of urban planning, the current literature and research. Followed by a discourse on the methodology and goals of urban planning and finishes with the resulting design process. The second part is the case study carried out in Vienna at the 'Nordwestbahnhof' territory with focus on the application of digital tools.

The aim of this thesis is to combine urban planning practice and research which run in parallel and to show the need for digital tools to enable better planning in the future.

My personal ambition for this topic is the experienced efficiency of using parametric modeling during my studies and internships, which I consider as necessary for qualitative, sustainable urban planning. The experience of living in a big city has shown me the advantages and disadvantages and awakened my striving for an optimal solution. Whether there is an optimal solution or not, in any case a constant optimization of the process is necessary to be able to fulfill the increasing requirements.

3 See: Datenauftritt - Stadt Wien: https://www.data.gv.at/auftritte/?organisation=stadt-wien [08/30/2018]

4 See: Openstreetmap: www.openstreetmap.org [08/30/2018]

Urban Planning

2.1 Urban Planning

In the literal sense of the word, urban planning refers to the construction of cities.[5] Urban planning, design and regulation of the uses of space that focus on the physical form, economic functions, and social impacts of the urban environment and on the location of different activities within it. Urban planning deals with engineering, architecture, social and political concerns around a project with political ambition and public participation as well as an academic discipline. Urban planning contains the development of open land, the revitalization of existing parts of the city which involves the setting of goals, data collection and analysis, forecasting, design, strategic thinking, and public consultation.[6]

Therefore traffic, ecological, energetic, demographic and financial aspects play a key role in the daily work of an urban planner.

In Austria, statistically, every municipality with more than 10,000 inhabitants with their main residence is considered as a city, although some cities have less they are recognized as a city due to city law.[7] Currently 53 percent of the population of Austria live in 201 cities in 9 federal states, with 21 percent of the 8.82 million inhabitants living in the capital Vienna with an increasing tendency.[8,9]

5 See: Frick 2008, 19.

6 See: Fainstein S. Susan: Urban planning. https://www.britannica.com/topic/urban-planning [08/13/2018]

7 See: Gemeinden: Defintion Stadt: http://www.gemeinden.at/contents/14617/definition-stadt [09/03/2018]

8 See: Statista: https://de.statista.com/statistik/daten/studie/19292/umfrage/gesamtbevoelkerung-in-oesterreich/ [09/27/2018]

9 See: Wikipedia: https://de.wikipedia.org/wiki/Liste_der_St%C3%A4dte_in_%C3%96sterreich#St%C3%A4dte_(Gemeinden_mit_Stadtrecht), [09/03/2018]

The status of a city usually goes hand in hand with the number of inhabitants, but many other factors such as the range of facilities, the infrastructure and the inhabitants are decisive for the quality of a city.

„Houses make a town, but citizens make a city."

Jean-Jacques Rosseau[10]

10 Marxists: The Social Contract. Jean Jacques Rousseau (1762): https://www.marxists.org/reference/subject/economicsrousseau/social-contract/ch01.htm [10/01/2018]

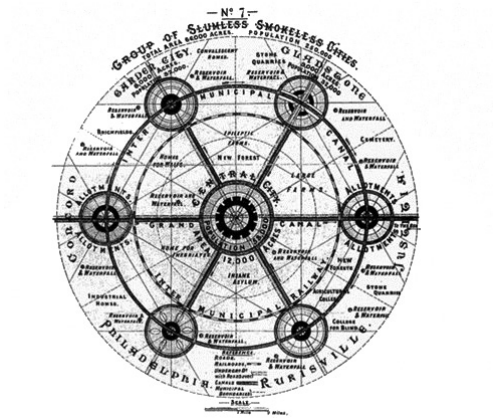


Figure 1: Ebenezer Howard, Garden City model, 1898

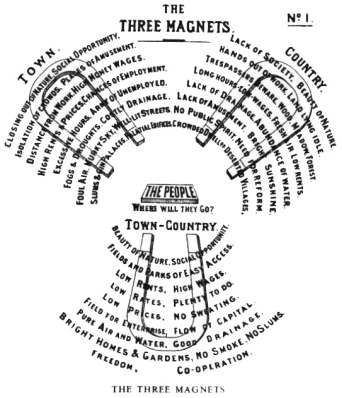


Figure 2: Ebenezer Howard, Three magnet diagram, 1898

The first urban models trying to define the configuration of cities and the population distribution have been developed since the beginning of the 19th century and contain the principle of central places and functions.[11] The three magnets diagram by Howard Ebenezer shows the town, the country and the town-country as attractions for the central placed people. More than one hundred years later, despite increased complexity of urban structures, the distribution of the population can still be described in rural, trans-rural and urban.

Kevin Lynch, a famous American urban planner and architect of the 20th century, introduces mental maps as the a construct of people in urban situations. Mental maps are composed of paths, edges described as boundaries, districts, nodes as orientation points and landmarks.[12]

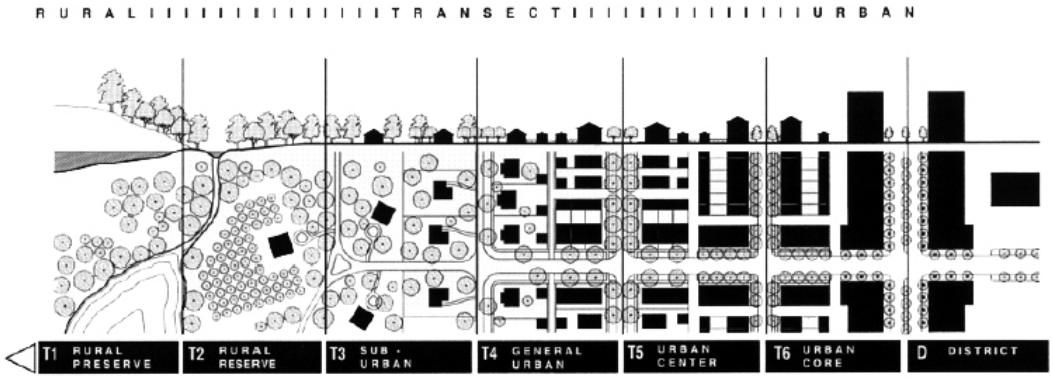


Figure 3: From rural to urban - Transect

11 See: König (unpublished), 2.

12 See: De Lange, Michiel: review: Kevin Lynch – The Image of the City. (2009, March). http://themobilecity.nl/2009/05/08/review-kevin-lynch-the-image-of-the-city/ [09/24/2018]

2.2 Urban Design

Urban design deals with issues that exist due to the gap in responsibility between the two disciplines of urban planning, with focus on land-use patterns and socio-economic aspects, and architecture. It mainly involves the design of public realm, containing public streets and squares, which is created by the physical boundaries of private buildings.[13] Public realm has wider significance than 'public space' because it includes building facades and anything that can be seen at eye level.[14]

2.3 Urban Climate

The urban climate is especially addressed during heat waves in the media due to health risks and emerging heat islands which lead to problems due to built-up and sealed areas especially in large cities. Niyogi, who co-chaired an urban climate symposium in New York in August 2018 lists the topic of cooling dense populations high on the political and academic agenda. Reducing heat through actions in water conservation, creating shades and sun protection are methods how cities can be modified to deplete heat and are taken in many places of the world.[15]

An online article published by the Guardian describes four ways to cool down cities: gardens in the sky, reflective roofs, water as a cooling tool and dynamic shades. Vegetation can be a powerful tool by providing shade and reducing temperature by water evaporating from plants' leaves on balconies, sky gardens, parks and vertical greenings. The idea of reflective roofs addresses the properties of the built environment by replacing dark, absorbing materials with reflective, light materials. The use of water to cool the temperature was formerly used in the form of water basins and wells in the city and inner courtyards and still provides a solution today in the shape of ponds, pools, fountains, sprinklers and misting systems. The issue with shading systems is that it is not enough to design a pure sun protection, but to follow the trajectory of the sun and apply an intelligent solution for large-area glass facades.[16]

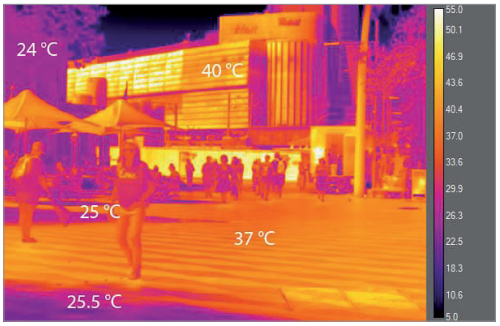


Figure 4: A thermal imaging photograph of Sydney shows high surface temperatures of asphalt roads and buildings, with lower temperatures in the shade

13 See: Frey 1999, 9.

14 See: Karssenberg/Laven/Glaser 2016, 17.

15 See: Watts/Hunt: Halfway to boiling: the city at 50C. (2018, 13 August). https://www.theguardian.com/cities/2018/aug/13/halfway-boiling-city-50c [08/13/2018]

16 See: Oldfield Philip: What would a heat-proof city look like?. (2018, 15 August), www.theguardian.com/cities/2018/aug/15/what-heat-proof-city-look-like [08/18/2018]

2.4 GIS in Urban Planning

Geographic Information Systems (GIS) were developed in the late 1960s, however, back then not yet widely used by planning departments because of the enormous cost of hardware and with limited capabilities of the software.[17]

Originally developed to manage large, space related data sets GIS are doing basic evaluations and urban analysis rather than being used for an urban development or design aims.[18] The constraints of GIS are not technical but the availability of data, which partly changed within the past years through the digitalization, though still appears in developing countries.

2.5 Parametric Urbanism

In D'Arcy Wentworth Thompson's famous text „On Growth and Form", he establishes a connection between biology and mathematics. By showing morphogenesis, the transformation of patterns formed in plants, animals and human beings.[19] In parametric design practice, such dependencies between the individual processes and elements are also created and enable the use of these tools to increase efficiency in responsive, interactive systems.[20]

Parametric design has been applied from the pyramids to contemporary buildings in architecture. The integration of climate, technology, use, character, environment and culture into the design is facilitated by the integration of a computer, but has always been part of the profession to design innovative buildings under demanding conditions.[21]

What is known as performance based computational design contains the support in spatial analysis, synthesis and evaluation that mainly focuses on the performance during the design process.[22]

Urbanism deals with large, dynamic urban data and uses various urban code systems for data collection. The collection of this data is rather simple in comparison with the capacity of processing.[23]

In Patrik Schuhmachers point of view the goal of parametricism allows a higher diversity and complexity of social institutions and life processes by the use of scripting to organize and relate design elements within a spatial configuration.[24]

17 See: YEH 1999, 877.

18 See: König (unpublished), 11.

19 See: Shabtay, Ran: Advanced Architecture Group. (2014, 25 November). http://www.iaacblog.com/programs/1098/ [08/14/2018]

20 See: Beesley 2008, 12. <?> See: Beesley 2008, 12.

21 See: Philips, Steven: Parametric Design: A brief history (2012, 25 June). http://www.aiacc.org/2012/06/25/parametric-design-a-brief-history/ [08/14/2018]

22 See: Nourian 2016, 62.

23 See: Feng/Zhang 2009, 1097.

24 See: Schuhmacher, Patrik: Patrik Schumacher on parametricism -‚Let the style wars begin'. (2010, 6 May). https://www.architectsjournal.co.uk/the-critics/patrik-schumacher-on-parametricism-let-the-style-wars-begin/5217211.article [08/14/2018]

„The assumption is that the urban massing describes a swarm formation of many buildings whereby the urban variables of mass, spacing and directionality are choreographed by scripted functions."

Patrik Schuhmacher[25]

His urban design examples mainly focus on formal aspects of urban elements such as rivers, roads and topography but do not respond to the human scale. The use of parametric tools in urban design builds a bridge of using existing datasets and the collection and analysis of own data on and off site. Based on the idea that urban information is not static and therefore can not be the only starting point for urban projects, parametric methods are applied.

The use and application of the plug-in Grasshopper are already taught at universities. Compared to traditional GIS-based planning software, these require knowledge of the individual parameters used and the digital data workflow.[26] New tools allow the simulation of different qualities based on parametric and algorithmic processes to capture the city with all its layers.[27]

2.6 Parametric Thinking

Parametric thinking positions itself between the search for a static, final solution and dividing the design into individual factors and parameters that influence the result. It is not a method to find a single solution, but to show the different possibilities by using algorithms and modern calculation techniques. This method needs advanced skills in logical thinking during the process, which demands time and experience.[28]

Instead of using CAD software as a display tool for your own ideas, it is used as a design tool. The advantages of this process are obvious, because we are not depended on existing tools but able to develop our own tools. This minimizes the effort for creating and testing design outcomes by changing the parameters, eliminates repetitive tasks and performs sophisticated calculations at the same time.[29]

25 Schuhmacher, Patrik: Architectural Design 2009, 17.
26 See: Speranza 2015, 661-664.
27 See.: Kwinter 2010, 68.
28 See: Suyoto 2015, 328.
29 See: Parametric Camp: http://www.parametriccamp.com/en/what-is-parametric-design/ [08/14/2018]

Literature Review

3.1 Related Work

There is a great number of literature specialized on urban planning and urbanism. Jan Gehl for example is well known for his book ‚Cities for People' which is pointing out the importance of the citizens eye level. The focus on the inhabitants should not be lost with the large scale of a city.

The Urban Strategy Playground for example is a research group within the Chair of Architectural Informatics at the Technical University of Munich. They investigate different densification strategies as a decision support for authorities with focus on the integration of digital models including data layers within the analogue planning methods.[30]

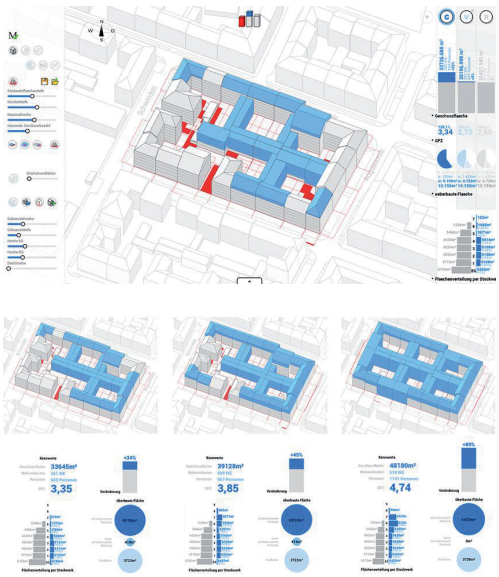


Figure 5: Urban strategy playground examples and interface

30 See: USP Urban strategy playground: http://wp.usp.ai.ar.tum.de/?lang=en [08/15/2018]

The company Decoding Spaces that employs international architects and urban planners based in Weimar, Germany, is working on the free software DeCoding Spaces Toolbox for Grasshopper which offers a range of analysis and generative components. Their approach is efficient architecture and urban planning with higher quality.[31, 32] Some of their generative and analysis tools are applied on the case study.

Universities from all over the world are doing research in the field of computational urban planning as well as big architectural and urban planning offices by performing their own research within their companies.

The field of design computation and computational performance assessment is addressed as well by Pirouz Nourian in his research at the Technical University Delft. It aims for a topological design methodology for architectural layouts and a spatial network analysis library for accessibility studies.[34]

This figure by Suyoto shows the interaction process between human and computer during a design process. It suggests the stop point of calculation by the computer and interpretation by the human, the planner.[35]

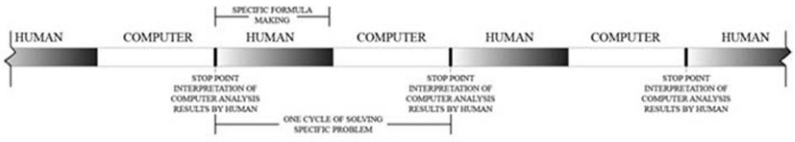


Figure 6: Design Methodology

In addition to the research carried out at many universities, several well-known offices such as Arup, Foster and Partners are also involved in computational urban analysis, simulation and design. Research by Arup regarding the accessibility of cities will be discussed more in the following chapter.

Philip Speranza, an assistant professor at the University of Oregon, focuses his teaching and research on urban design, computation and data visualization exploring the use of new geospatial design-methods.[33]

The term procedural modeling is generally understood as the use of agent-based or rule-based models. The main benefits are the enormous saving of time compared with modeling in a non-procedural way and the consequent reduction of costs.[36] The need for an intelligent city model has been stated by different parties.

31 See: DeCoding Spaces: https://decodingspaces.de/#aboutus [08/15/2018]

32 See: DeCoding Spaces: https://decodingspaces-toolbox.org/#aboutToolbox [08/15/2018]

33 See: Speranza, Philip: Architecture + Urban Design: https://www.speranzaarchitecture.com/new-page-2/ [08/18/2018]

34 See: Nourian 2016, 28.

35 See: Suyoto/Indraprastha/Purbo 2015, 329.

36 See: Watson/Müller/Wonka 2008, 18.

Procedural modeling is used in different fields of expertise from product to urban scale. The advantages remain the same, but the output varies a lot.

Karimi argues that an urban design process can be improved by using analytical methods at specific stages. An objective analysis of various design scenarios reduces the risk of failure and supports the development. The selection of analytical tools and their correct application are important.[37]

Software

Rhinoceros 3D is a commercial Computer-Aided-Design (CAD) software developed by Robert McNeel & Associates that bases geometry on mathematical nurbs models. This means that the representation of freeform surfaces is produced in a mathematical precise way. The parametric plug-in Grasshopper serves as a visual programming tool and enables the simple creation of complex algorithmic structures.[38]

37 See: Karimi 2012, 2-3.

38 See: Wikipedia: https://en.wikipedia.org/wiki/Rhinoceros_3D#Plug-ins_and_add-ons [08/18/2018]

3.2 State of the Art

3.2.1 Urban Analysis Tools

Accessibility

Arup addressed the accessibility to opportunities within a city in their ‚30 minute city' web application that is showing different amenities like essential services, education institutions and recreation in relation to travel distances within the region of Sydney.[39]

3.2.2 Space Syntax

Space syntax is the methodology used to study the relationship between the built environment and social, economic and ecological phenomena in a scientifically based approach. It was developed by Prof. Bill Hillier, Prof. Julienne Hanson and colleagues at Bartlett, University College London in the 1970s. Patterns of movement, awareness, interaction, density, land use and land value, urban growth and social differentiation, security and crime distribution are addressed in the analysis. Space syntax is state of the art and practiced by universities and professionals all over the world for analysis of spatial configurations of all kinds and levels.[40]

As output of the space syntax analysis defined by betweenness centrality estimates the potential traffic passing by each location in the graph and the closeness shows how near each of these locations is to all others within a given distance threshold.[41]

39 See: Arup: https://30minutecity.arup.digital/ [08/15/2018]

40 See: Space Syntax Network: http://www.spacesyntax.net/ [08/18/2018]

41 See: Sevtsuk (unpublished), 9-10.

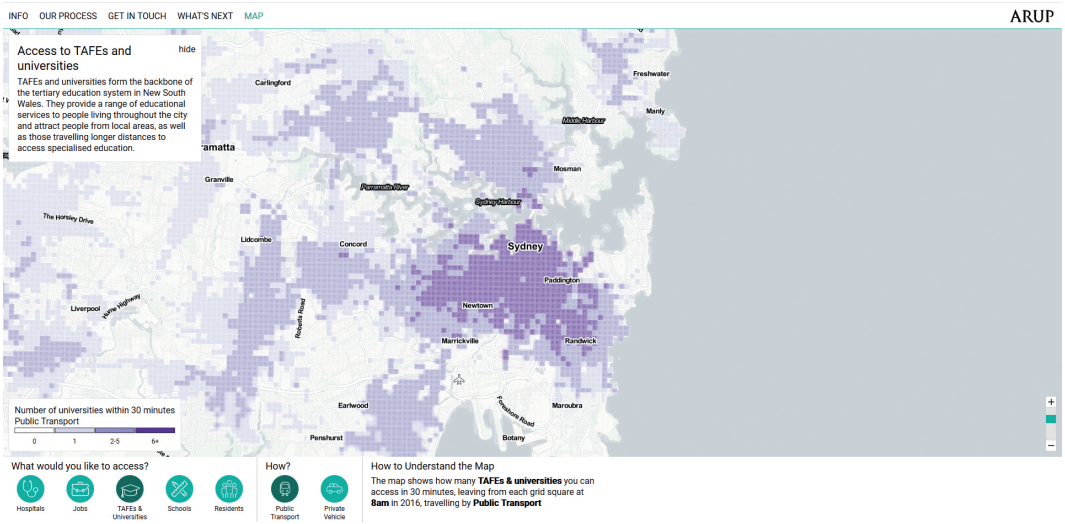


Figure 7: ARUP: Access to TAFE's and Universities in Sydney

Network analysis concepts have been used in urban planning for decades. The use of network analyses for design purposes by architects, planners and builders has been made much easier by the availability of data and tools in recent years.[42] The figure below shows the workflow of an urban network analysis toolbox by Sevtsuk et al. (2012) developed for ArcGIS.[43] The sequence of the individual work steps also remains the same for other graph analysis tools.

STEP 1: Adjacency matrix construction

STEP 2: Graph construction

STEP 3: Node weights retrieval

STEP 4: Centrality computation

STEP 5: Results table writing

STEP 6: Results display

Figure 8: Workflow of an urban network analysis

42 See: Sevtsuk(unpublished), 2.

43 See: Sevtsuk/Mekonnen 2012, 13.

Urban Simulation Tools

Ladybug and Honeybee are tools used within the Rhinoceros 3D plug-in Grasshopper the workflow. Ladybug tools focus on environmental design and simulate sun and shadow studies. Honeybee allows to run simulation on the energy demand and microclimate. Considering these aspects by using the life time feedback the scenarios can be further optimized and as a consequence the quality of the design increased.[44]

The simulation of outdoor comfort in the public realm is simulated in microclimate models, energy performance and fluid-dynamics of winds. For the evaluation of this output data in comfort indexes an Envi-met algorithmic app called Envibug was developed by Grasshopper to rapidly calculate the distribution of local ‚Predicted Mean Vote' (PMV) using the library Ladybug.[45]

The commercial simulation platform UrbanSim supports urban planning and analysis including land use, traffic, economy and environment by using urban simulation, 3D visualization and open data.[46]

Another commercial parametric urban design software is Modelur. It allows the creation of conceptual mass compositions based on key parameters and returns important information in real time to enable informed decision making in the early project stages.[47]

44 See: Roudsari/Pak/Smith, 2013, 3128.
45 See: Fabbri/Nunzio/Gaspari 2017, 517.
46 See: UrbanSim: www.urbansim.com [07/18/2018]
47 See: Modelur: www.modelur.eu [07/18/2018]

Human Movement and Interaction

The quality of the geometry can be evaluated using environmental and economical analysis methods, while the quality of the public space is highly defined by the use of people.

To understand the human interaction on public space Whyte (1980) and Gehl (1989/2013) used time-lapse videos to analyze different movement patterns. The time sequence and duration of activities were used for understanding the connection between urban spatial configuration and human activity that occurred. Research in this field was performed by Vroman and Lagrange by the application of the lewinian learning model by Kolb from 1983.[48]

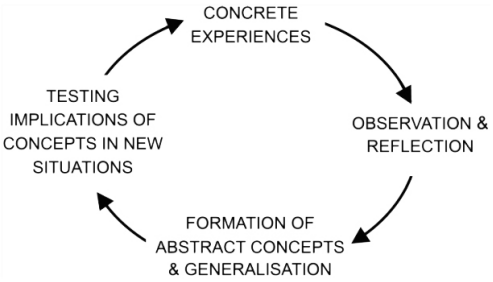


Figure 9: Lewinian learning model (Kolb 1984)

This model suggests: "Immediate concrete experience forms the basis for observation and reflection. These observations are assimilated into a "theory" from which new implications for action can be deduced. These implications or hypotheses then serve as guides in acting to create new experiences."[49]

48 See: Vroman/Lagrange 2017, 3253.
49 Vroman/Lagrange 2017, 3254.

The application of this methodology can be further developed by integrating machine learning to feed in best practice examples to predict the use of public spaces. Additionally, social media data like tweet locations, ratings for locations and mobile data could be added for evaluating larger areas.

Visit Potential of Public Spaces

The visit potential model (VPM) by Herthogs et al. (2018) suggests a graph based representation of the public spaces and considers the three main objects population, transport and attractor points in the first step. The estimated number of people as a result of a visit frequency law, gravity-type measures, and shortest paths is the result of the calculation model. Last step builds the multi-criteria assessment where the rated quality of spaces and streets is included as weights in the calculation.[50]

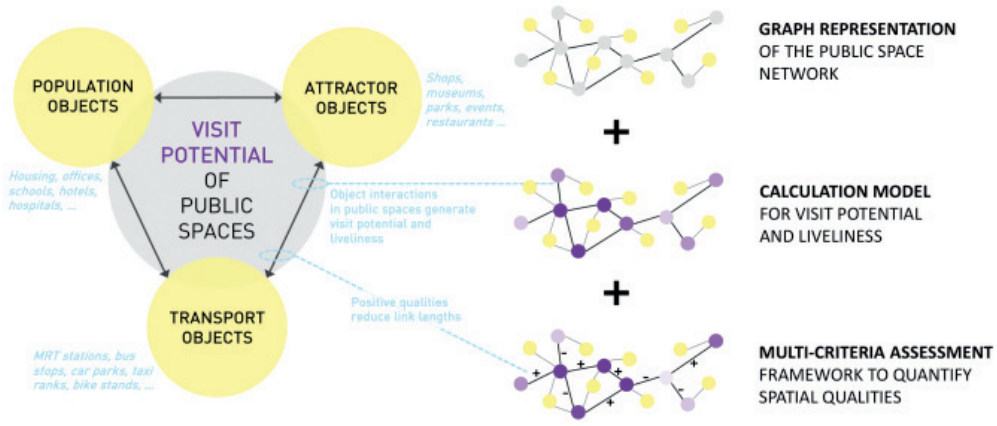


Figure 10: Diagram of the visit potential model

50 See: Herthogs/Tuncer/Schläpfer 2018, 612-613.

3.2.3 Synthesis Tools

Esri CityEngine converts 2D GIS data to intelligent 3D city models that can be exported and used to present ideas to decision makers. The integrated swipe tool allows the comparison of the design proposal to other scenarios.[51]

3.2.4 Design Space Exploration

Design exploration draws on the design ideas that emerged in the first phases of the design process, which arise from the parametric models in variations of the generic and geometric components. This method is particularly useful at the beginning, when the formal and geometric configuration has not yet been decided. This allows a high degree of flexibility in the parametric model.[52]

For this purpose an open source online tool for exploring design spaces was developed by core studio, the Design Explorer. The interface allows the visualization and filtering of design and group iterations that are related or scattered across the possibility space. CSV-files (Comma Separated Values), images and spectacle models are generated in parametric applications and used as input for the design space data.[53]

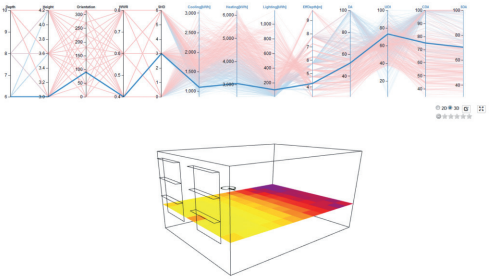


Figure 11: Design Explorer example

The discussion between team members and stakeholders is supported by the use of design space exploration. To coordinate the possibly big amount of different variations design space exploration tools can help to structure and filter. For tools like this, the input is expressed in keys and parameters with the possibility to include images and 3D objects. The Design Explorer components support the export of geometry, parameters and images from Grasshopper to a defined folder. The upload to the online tool works via zip compressed folder, server link or shared folders by GoogleDrive and OneDrive.[54]

51 See: Esri: http://www.esri.com/software/cityengine [07/18/2018]

52 See: Barrios 2011, 205.

53 See: Core Studio: core.thorntontomasetti.com/design-explorer/ [08/17/2018]

54 See: DesignExplorer: http://tt-acm.github.io/Design-Explorer/ [10/01/2018]

Fuchkina et al. (2018) propose a design space exploration framework consisting of a combination of different methods. Therefore a modular approach on three structural levels reflects different requirements on the design. In the first stage, the ‚strategy level', the designer creates a ‚solution space' of variations. The second stage serves the reduction of possible solutions and is called ‚processing level'. The ‚instance level' is for a more detailed analysis and interaction with one of the design variants.[55]

The ability to export directly from the environment of Grasshopper to the server, hosted by the Infar[56] institute (Planning Systems) of the Bauhaus University Weimar, enables an efficient workflow.

3.2.5 Visualization Tools

There are several ways to present the outcome of an urban design project to clients, stakeholders and citizens.

A commercial online decision-making solution was developed by SmarterBetterCities, a swiss company founded in 2012 that focuses on web-based tools for urban planners, municipalities, local governments and consultants to visualize 3D models packed with information.[57]

The statistical data analysis and visualization of urban data and data in general within the environment of Grasshopper can be achieved with the toolset by DeCoding Spaces. The box plot figures shown in this thesis were created by using the data analysis component. The comparison of different performance values within the parametric design surface in diagrams enables the targeted adaptation of parameters during work and avoids switching between different applications.[58]

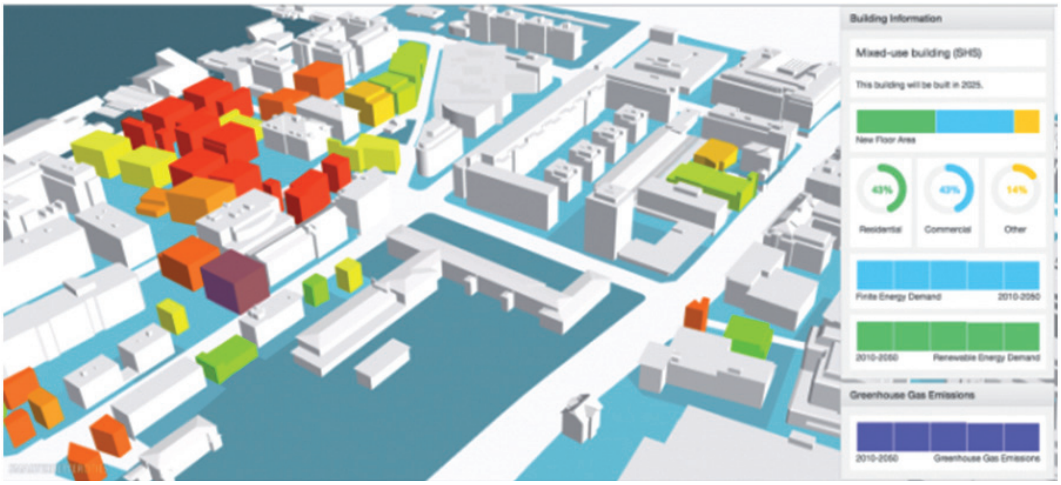


Figure 12: Interface of a SmarterBetterCities tool

55 See: Fuchkina/Schneider/Bertel 2018, 370.

56 See: Infar: http://infar-vm.architektur.uni-weimar.de/dse2/dse [09/30/2018]

57 See: SmarterBetterCities: http://www.smarterbetterci-ties.ch/about-us/index.html [08/30/2018]

58 See: Abdulmawla/Schneider/Bielik 2018, 319.

Urban Mapping

As a second step after filtering the scenarios and decreasing the number of possible solutions other tools can be used for presentation as well. To provide online access to the proposed geometry is recognized as an easy way to share information with clients, stakeholders and citizens. The interface and navigation of online maps is well known by most of the people and can help as a negotiation base.

Mapbox is a location data platform used for mobile and web applications, that provides building blocks where locations and features can be added in a developer-friendly interface. These open-source tools allow the visualization of properties in 2D and 3D, understanding of big geographical data but also augmented reality (AR) and virtual reality (VR) capabilities.[59]

Virtual and Augmented Reality

Urban planners, architects and designers are used to maps and graphical representations of their design, but normal users might need a different representation to understand a design. A user experience of the proposed design can be created and experienced via virtual reality (VR) and augmented reality tools (AR). Therefore the possibility of a walk through the proposed design on eye level can be developed and serve the understanding. The main difference between VR and AR is that the user of VR is exclusively in the virtual world and AR represents a overlapping of reality and the virtual world.

The Vuforia engine, an AR platform, allows to develop apps and supports phones, tablets and digital eyewear across Android, iOS and UWP. The use of the Vuforia engine within the game engine Unity offers the creation of AR experiences of different scenarios.[60]

Enscape is a real-time rendering plug-in that allows a walkthrough the geometry in Rhinoceros, Autodesk Revit, SketchUp and Graphisoft ArchiCAD via live link.[61]

This bar chart shows the worldwide continuous increase of consumption on AR and VR content and apps. As more and more people use this technology the application for decision finding processes seems reasonable. The possibility to experience a space by moving through can add another perspective and is, as I experienced by myself, an overwhelming feeling.

59 See: Mapbox: https://www.mapbox.com/ [08/17/2018]

60 See: Vuforia: https://www.vuforia.com/engine.html [10/01/2018]

61 See: Enscape: https://enscape3d.com/ [10/01/2018]

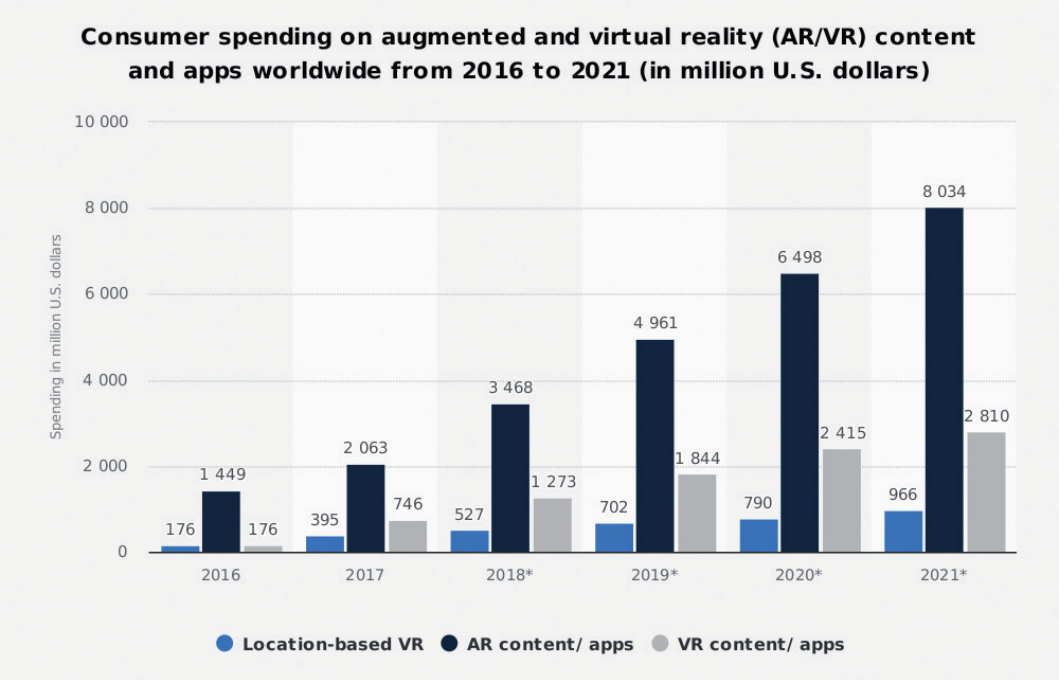


Figure 13: Consumer spending on augmented and virtual reality (AR/VR) content and apps worldwide from 2016 to 2021

The Change in Urban Planning

Based on the literature review and state of the art of computational urban planning the methodology for my urban planning process was developed. This includes the data collection, design process stages and selection of different digital tools. To improve this approach and to review the current change of urban planning within the digitalization, the conducted interviews with four experts in the field of urbanism and urban planning are discussed in the following chapter.

Starting with an introduction of the interview partners and their relation to urban planning, followed by their opinion on the urban planning and design process, the possible support of using digital tools, the impact of digitalization and society values and closes with their expectations on urban planning.

04

Professor Aglaée Degros[62] is the head of the Institute of Urbanism of the Graz University of Technology, an architect, urbanist and director of the office Artgineering in Brussels. The core business of her office is Urbanism and the relation with public space although they did some urban planning studies as well.[63]

Junior Professor Dr. Reinhard König is Principle Scientist at the Energy Department at the ‚Sustainable Buildings and Cities' unit at the AIT Austrian Institute of Technology in Vienna and Junior Professor for computational architecture at the Bauhaus University Weimar. His main research topics are smart spatial planning methods like the multi-criteria optimization for planning synthesis, cognitive design computing and correlations of computed measures of spatial configurations with human cognition and usage of space.[64] His approach is a mixed perspective to understand the real urban planning process and the support by digital tools and methods.[65]

Roland Krebs, MSc, MBA is an urban planner and designer with an office for urbanism and architecture called Superwien Urbanism ZT OG. He does plannings, designs and research projects and teaches at the Institute of Urban Design and Landscape Planning[66] at the Vienna University of Technology. Some projects are for the city of Vienna, the Inter-American Development Bank in Latin America, ÖBB, FFG and other research organizations.[67]

DI Ernst Rainer works as a University Project Assistant at the Institute of Urbanism of the Graz University of Technology specialized on sustainable urban development.[68]

62 See: Artgineering: Aglaée Degros: http://www.artgineering.eu/about/aglaee-degros/ [08/27/2018]

63 See: Interview with Aglaée Degros, conducted by Theresa Fink, Graz [04/25/2018]

64 See: Bauhaus-Universität-Weimar: https://www.uni-weimar.de/de/architektur-und-urbanistik/professuren/computational-architecture/team/, https://www.ait.ac.at/ueber-das-ait/researcher-profiles/?tx_aitprofile_pi1%5Bname%5D=Koenig-Reinhard [07/27/2018]

65 See: Interview with Reinhard König, conducted by Theresa Fink, Wien [05/14/2018]

66 See: Urban Issues: Bio: http://www.rolandkrebs.net/bio/ [07/27/2018]

67 See: Interview with Roland Krebs, conducted by Theresa Fink, Wien [04/26/2018]

68 See: Institut für Städtebau: https://www.tugraz.at/institute/stdb/institut/team/, https://www.zt-forum.at/index.php?seitenId=13&referentenId=152 [07/27/2018]

4.1 The Aim of Urban Planning

Degros and König state the need for a balanced mixture of the site analysis, community involvement, energetic, ecological and traffic aspects for an urban planning process.[69] König names the design concept as the most important thing with the integration of all named aspects based on data and simulation.[70] Krebs and Rainer define all aspects as necessary but they emphasize the community and stakeholder involvement with growing importance. The knowledge of the citizens and participation processes is a crucial point for them to create a valuable urban project on eye level for the citizens.[71,72] The importance of the human scale and the needs of the people is defined as a main objective by Jan Gehl in his book‚Cities for People'. [73]

4.2 Different Methods of the Urban Planning Process

Rainer mentions due to their focus on the stakeholder involvement they start in a specific way. The knowledge of the citizens has a strong impact on the site analysis. Their approach includes the work with scenarios as a decision base which might transform into a transition concept - a combination of some parts of various scenarios - after involving different stakeholders.[74]

As König is not a practical urban planner his idea is to understand the site, start with first proposals and establish a digital design loop where the evaluation is included for internal discussions and with stakeholders to increase the level of detail remaining in the loop.[75]

A people centered approach with interviews and workshops in combination with emerging topics is the course of the planning process by Krebs. The emerging topics include the definition of the problem, challenges, potentials and positive aspects. Due the demand of some projects which are based in developing countries and lack of data they rely on qualitative data retrieved from interviews and community participation.[76]

Degros considers a comprehensive collection of all available documents as stage one, that is followed by a precise analysis. Profound knowledge about the field you are working in is necessary to understand the extent of the project which can be very large in urban projects. A strong vision for the project is evolved after exploring every layer of the city which inclusion of the water system, the green structure and the circulation.[77]

69 See: Interview with Aglaée Degros, conducted by Theresa Fink, Graz [04/25/2018]
70 See: Interview with Reinhard König, conducted by Theresa Fink, Wien [05/14/2018]
71 See: Interview with Roland Krebs, conducted by Theresa Fink, Wien [04/26/2018]
72 See: Interview with Ernst Rainer, conducted by Theresa Fink, Graz [04/25/2018]
73 See: Gehl 2010, 6.
74 See: Interview with Ernst Rainer, conducted by Theresa Fink, Graz [04/25/2018]
75 See: Interview with Reinhard König, conducted by Theresa Fink, Wien [05/14/2018]
76 See: Interview with Roland Krebs, conducted by Theresa Fink, Wien [04/26/2018]
77 See: Interview with Aglaée Degros, conducted by Theresa Fink, Graz [04/25/2018]

The Change of the Planning Process due to the Progress of Technology

The following part of the interviews deals with the changes of the urban planning process due to the progress of technology and how new digital tools influence the role of an urban designer.

Rainer describes the city as the global market that is strongly influenced by the economy and companies that try to sell their ICT (information communication technology). The demand on the city administration is to select which technologies are valuable for them and how to use them in the best way while being pressured by the economy.[78]

König highlights that the use of digital tools became simpler and opens the user field from experts to urban planners and others to evaluate the most important aspects at least on a rough level of detail. The integration of various tools within a digital modeling system shows to tendency we are heading to and reveals the question of artificial intelligence.[79]

Krebs points out the evolution from working in 2D drawings and physical models to digital 3D models within the past five years. This brought up the combination of physical models and 3D models as the current workflow in their office. Experimenting with parametric software like Grasshopper and VR technologies is done in some projects but not their state of the art.[80]

The collection and analysis of data got much easier and allows to simulate the impact of a proposal. This supports working with different scenarios without disregarding a strong vision to keep an improved general quality of living and other factors the general goal.[81]

78 See: Interview with Ernst Rainer, conducted by Theresa Fink, Graz [04/25/2018]

79 See: Interview with Reinhard König, conducted by Theresa Fink, Wien [05/14/2018]

80 See: Interview with Roland Krebs, conducted by Theresa Fink, Wien [04/26/2018]

81 See: Interview with Aglaée Degros, conducted by Theresa Fink, Graz [04/25/2018]

4.3 Digital Tools - Blessing or Curse?

Since the progress of technology has produced numerous new tools and technologies, there is a risk of misuse by inexperienced users. The opinion of the urban planners and researchers about a possible misuse of tools is discussed in the following chapter.

In Krebs opinion every site is unique and needs a different point of view to be able to decide on the design. He rather relies on his own design than on automated ones but rates the analysis and simulation tools as very good. The investigation of applying digital tools for practical planning processes he considers as worthy. They experienced virtual reality as useful to get a different perception and understanding of the project but mostly there is no budget from the client's side to support this approach.[82]

In addition to misusing a tool Degros mentions the ownership of the data as a big risk as information sometimes is not openly accessible but owned by private companies that either charge money or do not support research. A strong ethic regarding the use of information and the organization of actions should prevent the manipulative use of data.[83]

Rainer emphasizes the importance of the needs of the people where in his opinion digital tools can help to analyze and simulate scenarios but not to develop the solution.

The pressure to create BIM (building information modeling) models for whole districts is seen as risky due the fact that urban planning is different to architecture in scale. Nevertheless he agrees that a certain level of detail in digital models is a necessity to control the design output.[84]

„If you have a working model, don't be afraid to change and optimize it."

Aglaée Degros

82 See: Interview with Roland Krebs, conducted by Theresa Fink, Wien [04/26/2018]

83 See: Interview with Aglaée Degros, conducted by Theresa Fink, Graz [04/25/2018]

84 See: Interview with Ernst Rainer, conducted by Theresa Fink, Graz [04/25/2018]

König thinks that the misuse of a tool is not dependent on the tool itself, but on the user. Digital tools differ in paper and pencil that they can support the user in a smart manner. He sees the goal of digital tools is to support the user in a smarter way and allow to deal with the potentials of artificial intelligence (AI) approaches. The hope is that AI will improve planning by the use of positive case studies stored in a database to collect the knowledge of a human urban planner and replace repetitive steps of the process. The promise of AI is that you can capture something and represent creative tasks as it is already done with cooking and medical diagnosis, so the opinion of König.

The level of control that the planners have within a digital process is very crucial to ensure a qualitative livable urban environment as the goal is not to end up with a technocratic solution.[85]

Degros mentions that some parametric models are restrictive in the way that they can be applied without the possibility of doing changes. The selection of the parameters needs to be done carefully to keep the creativity and quality of space in mind. We need to think about every step we do and should not be afraid of changing a working model.[86] A parametric model offers the advantage of being able to change basic parameters at a later stage. A precise knowledge of the model used is important so that the result corresponds to one's own ideas.

85 See: Interview with Reinhard König, conducted by Theresa Fink, Wien [05/14/2018]

86 See: Interview with Aglaée Degros, conducted by Theresa Fink, Graz [04/25/2018]

The outcome will be hopefully better and integrate more aspects in a fast and therefore more effective way by the use of digital tools.[87]

„A project should have a storyline and this storyline is not told by the computer."

Roland Krebs

Krebs divides the working method of urban planners in two categories. On the one hand there are planners that like to design, sit, talk and draw and on the other hand there is the technology oriented planner that creates practical solutions.

Urbanism is not a architectural shape but involves social, economical, cultural and governmental issues that need to be combined. Still, this complex solution needs an easy storyline that can be told in five minutes if needed. If you are using digital tools within the process it might not affect the project, but it definitely affects the planning process which has an atmospheric rendering that delivers the vision.

87 See: Interview with Reinhard König, conducted by Theresa Fink, Wien [05/14/2018]

Krebs' working method shows that they use parametric thinking in an analogous manner. First, they set the rules - for each block they define the number of at least three openings - and after that they implement their exceptions.[88] This approach can be compared with the parametric workflow where you set your parameters in the very beginning and manually change the outcome based on your knowledge and experience.

Rainer sees the use of digital tools first to manage complexity of information and second in the use for formal design decisions as it can be seen for example in Zaha Hadid architecture.[89]

4.4 Analysis and Simulation vs. Generative Components

The opinion about the use of generative and analysis tools is very different among most of the interview partners.

Degros has mainly worked with analysis tools up to now and regards the development of designs as part of the designer's scope. Planners have the responsibility to base their design on a strong vision.[90]

In König's point of view analysis and generative tools are coupled with each other. To come up with a meaningful development tool to reach the formulated goal you need the evaluation of the analysis tools.[91]

Krebs shares this opinion that you need both tools and additionally a clear idea of what you want to achieve with your project.[92]

Rainer sees a gap between the mainly market-driven development tools (for example BIM) and the analysis tools. He considers the integration of social experts and other disciplines into the development tools worth considering.[93]

88 See: Interview with Roland Krebs, conducted by Theresa Fink, Wien [04/26/2018]

89 See: Interview with Ernst Rainer, conducted by Theresa Fink, Graz [04/25/2018]

90 See: Interview with Aglaée Degros, conducted by Theresa Fink, Graz [04/25/2018]

91 See: Interview with Reinhard König, conducted by Theresa Fink, Wien [05/14/2018]

92 See: Interview with Roland Krebs, conducted by Theresa Fink, Wien [04/26/2018]

93 See: Interview with Ernst Rainer, conducted by Theresa Fink, Graz [04/25/2018]

4.5 Values of the Society in Digital Tools?

The difficulty of including the values of a society is that you have to translate them into indicators that give information. The process of rationalizing these values is difficult.[94]

The book ‚The Future of Planning' by Yvonne Rydin includes the UK national well-being indicators set. This set consists of individual factors like relationships, health, what we do, where we live, personal finance, education and skills. Further counts more contextual domains with governance, the economy and the natural environment.[95]

The same view is shared by König that as long as you can express, capture or predict the values of a society in measureable data it is possible to include it in the planning process. He sees this as a challenge due to the fact that the society will probably always change.[96] Krebs would appreciate to see the integration of information evolved by qualitative research transformed to a dataset in a digital tool. In his opinion projects are sometimes far away from reality and the people.[97]

Rainer states that digital tools have a positive influence on the organization of the complexity, the site analysis in different shapes and information levels, but also on the involvement of stakeholders.

94 See: Interview with Aglaée Degros, conducted by Theresa Fink, Graz [04/25/2018]

95 See: Ryding 2013, 100.

96 See: Interview with Reinhard König, conducted by Theresa Fink, Wien [05/14/2018]

97 See: Interview with Roland Krebs, conducted by Theresa Fink, Wien [04/26/2018]

GIS work like this by exploring each layer separately and reduce the complexity of the available data in different parts.[98]

Degros has the opinion that we have to be careful not to rationalize the planning through the use of digital tools by using the same elements over and over again. The danger of copy/paste solutions can be seen in the smallest elements of architecture, one should always question whether it really has to be this one element or maybe something new. She argues not to lose creativity by taking already working solutions.[99]

With a research background König's perspective is that not only urban planning but also other professions will be affected by digitalization which means that many things can be automated so the role of urban planners will be different. Tasks that were done by humans like drawing the plans in 2D can be done by a computer now. He sees the urban planner to become and a moderator or manager for this negotiation process between stakeholders and other interest groups in the future.[100]

98 See: Interview with Ernst Rainer, conducted by Theresa Fink, Graz [04/25/2018]

99 See: Interview with Aglaée Degros, conducted by Theresa Fink, Graz [04/25/2018]

100 See: Interview with Reinhard König, conducted by Theresa Fink, Wien [05/14/2018]

„You need to understand how to use the technology. First of all, based on the usage of the tool itself, but also how to integrate it in the process which is more the real life difficulty."

Reinhard König

Krebs annotates that the use of parametric methods should support the designer and not build a limitation. If there are different scenarios, it is up to the designer to decide which one to choose and sell the main ideas of the project.[101]

The idea is, that the use of digital tools allows a bigger range of possible solutions according to König. That depends on whether the parametric model is based on meaningful parameters, like topological aspects to develop a variety of scenarios, or only varies in length, width and height.[102]

Degros sees digital tools as great support for urban planning to filter the big amount of information and summarize it in a picture. The development of a concept is then an important step to remain critical and not to head to a pure, pragmatic, and boring solution.[103]

Rainer believes that more information goes along with more complexity which allows to develop many different scenarios. The type of information is also crucial as we have a lot of information about motorized mobility but there is a lack of information about public space and pedestrians.[104]

101 See: Interview with Roland Krebs, conducted by Theresa Fink, Wien [04/26/2018]

102 See: Interview with Reinhard König, conducted by Theresa Fink, Wien [05/14/2018]

103 See: Interview with Aglaée Degros, conducted by Theresa Fink, Graz [04/25/2018]

104 See: Interview with Ernst Rainer, conducted by Theresa Fink, Graz [04/25/2018]

4.6 Measuring the Quality of a Design

Quality assurance is an important topic for Krebs, as he sees the design process as finished once a project is implemented and self-sustaining. For this reason, the 'Nordwestbahnhof' territory, for example, has a quality commission or committee. For him, a good committee in Vienna consists of a representative of Magistrat, someone from the city development team, at least two to three architects, an urban sociologist, a traffic planner and landscape architect as a minimum requirement. The development of an indicator set to measure the quality of a design would be very important, their office suggested this service to a client but they did not see the necessity.[105]

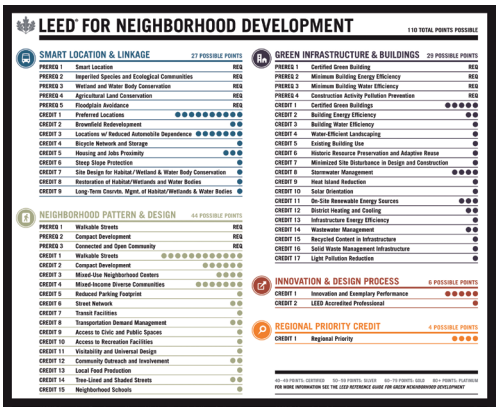


Figure 14 : LEED Neighborhood development criteria

105 See: Interview with Roland Krebs, conducted by Theresa Fink, Wien [04/26/2018]

There exist some indicators by LEED (Leadership in Energy and Environmental Design) used for their neighborhood development certificate that contain smart location and linkage, neighborhood patterns and design, green infrastructure and buildings, innovation and design process, and regional priority credit as valuating indicators.[106]

König represents the view that in theory quality can be measured to the full extent or at least to the same as we can do it today. The decision if a design is good or bad usually is the result of a discussion by experts like the committee of a competition. If you have many designs rated by experts or others, they can be used with new data analysis techniques like machine learning approaches to predict the probability of how a new design will be evaluated based on past experiences and not on future needs and wishes of the people.[107]

Degros considers the evaluation process as very difficult and done too little as we are pleased when something is ready. This is why the investigated different methods upon their research.[108]

For Rainer the most important quality criteria is the use by humans which defines the success of a project for him and refers to the rules developed by Jan Gehl.[109]

106 See: Szibbo: Assessing Neighborhood Livability: Evidence from LEED® for Neighborhood Development and New Urbanist Communities (2016) https://journals.openedition.org/articulo/3120#toc [08/14/2018]

107 See: Interview with Reinhard König, conducted by Theresa Fink, Wien [05/14/2018]

108 See: Interview with Aglaée Degros, conducted by Theresa Fink, Graz [04/25/2018]

109 See: Interview with Ernst Rainer, conducted by Theresa Fink, Graz [04/25/2018]

An urban planner‘s tool can be digital or analog - if the concept is not good enough - none of these tools can make the project a success.

4.7 Conclusion

The four executed interviews showed that the traditional planning process seems to be state of the art, although the urban planners include digital tools for analyses and simulations. The acceptance of implementing digital tools within the workflow is given to different degrees. The need for further development of this framework to ensure an advantage for practical uses is consistent.

The ongoing change of technology already influences the daily work in form of competition demands that may include 3D models or VR technology. We have seen the change from hand sketches to digital 2D plans as well as from 2D plans to 3D models. Expectations of future technologies are high, but they are characterized by mistrust due to the possible loss of control by humans. All interview partners see the ongoing change and have stated their forecast how this can improve and influence future plannings.

All advices and comments on the suggested urban planning process were pointing in the same direction. To mention first, that all four interview partners consider a strong vision as substantial to create a livable urban development. Second, to focus on the human needs and scale is seen as the most important task within the planning course.

The time schedule of an urban planning was commented that it begins before the competition with the definition of the design brief. The end of this process is not the final design but the completion of the built structure and the residents‘ move in and guiding quality control management.

Various aspects of the planning process were introduced in the course of the interviews. Many of them can be brought in the form of analyses and simulations, while others require the ability of the designer to influence the design. Conversations with the citizens as well as the personal experience to explore the property and the initial situation requires the traditional method. Therefore citizen participation in the form of apps and online platforms is seen as a step in the right direction. The investigation of the history of a place, the atmosphere and the surrounding plays an essential role in the development of a concept and requires an emotional engagement by the designer.

The interview partners present different approaches of practical urban planning methods. Partly intelligent digital tools are already included in different stages of their work and they appreciate the investigation of the a digital planning process.

In the following chapter the digital urban planning framework is introduced with the incorporated advices as explained.

Urban Planning Process

This suggested urban planning framework was developed by me and has already been applied on a case study in Astana. It was adapted and optimized with the feedback by the city council and advices from the interview partners. The selection of digital tools and their application on the case study in Vienna will be shown in detail.

The master planning framework by Jan Gehl suggests to do the scoping and site visit in advance and after that start with phase one: discovery, that contains the analysis of life, space and buildings. The next phase: vision, is split into public life and space and into buildings and functions where density, functions and parking are discussed.[110]

110 See: Gehl (2018, 21 June) https://gehlpeople.com/news/masterplanning-frameworks/ [07/28/2018]

An overview of the current possibilities and the application of various tools are the main components of the practical part of this thesis. The creation of different scenarios using rapid urban prototyping forms the basis for the development of a project.

A project is not created by geometry but requires an atmosphere, details and further elaboration. Individual scripts in combination with existing libraries and components are applied on the project to illustrate a fast and efficient workflow. This allows to develop different ideas to a higher level without spending too much time on one of them. By formulating details and incorporating exceptions, one reaches the limits of such a master plan model.

Once the idea has been translated into geometry and evaluated, further elaboration by applying traditional methods has proved to be useful. Every location and project need a fine-tuning by the planner, to add an unique quality.

The aim of this thesis is not the elaboration and detailing of one design, but the investigation of this methodology. The automation of processes such as the extrusion of building outlines in three-dimensional volumes and the real-time control of gross floor area (GFA) to enable an efficient workflow. The application of solar, microclimate, visibility and accessibility studies during the development supports the control of the output.

5.1 Site Analysis

The site analysis phase includes the collection of all available information that is done at the very beginning.

The open data platform by the city of Vienna[111] provides all kinds of information in various file formats. As result of the interviews a walk on the 'Nordwestbahnhof' territory, the personal perception and photographs of the nearby surrounding are included in this phase.

As noted by Rainer the reduction of complexity by exploring each layer of the city separately is visualized in various maps. To import data from different sources and to translate it in the correct projection and data format is the first step in the process. In the following project osm-files, demographic csv-files and shape-files including geometry and information were used.

A combination of Grasshopper libraries that support the import and export of different file formats is applied.

For the import of shape files to Grasshopper the python script component by 'Hiteca' based on the PYSHP library was experienced as particularly useful. To import information from Excel via live link or file path the libraries 'Lunchbox' and 'TT Toolbox' can be recommended. It is very important to filter, simplify, evaluate this multitude of available data and show the retrieved information in form of understandable graphics.

111 See: Open government Vienna: www.data.gv.at/ [07/28/2018]

5.2 Concept Development

Defining the story of the project in words, pictures and atmosphere with the aim to achieve a qualitative space for living, working and spending time.

The existing vision and documents about the 'Nordwestbahnhof' provide an excellent base to develop an overall concept. The result of this phase is a clear statement about the vision for this neighborhood considering the scope of the competition and the comments of the citizens.

Jan Gehl's rules for designing the cities deal with the accessibility of public transport and green spaces, the public life in urban design, the aim for multisensory experiences and the ban of cars and better conditions for public transportation.[112] For the concept the accessibility to local supply, culture, green systems, social infrastructure and public transport are important key parameters for my proposal.

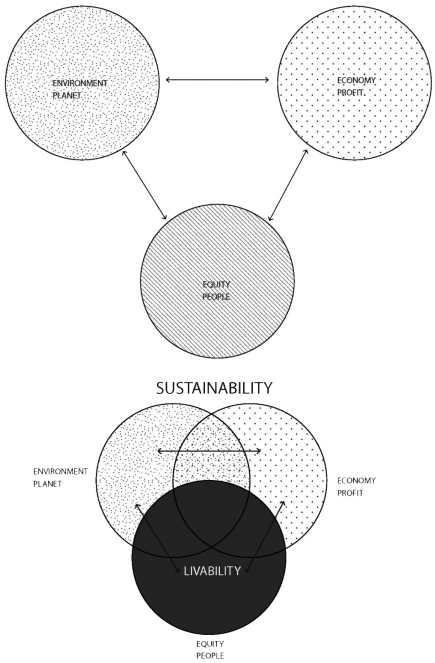


Figure 15 : The aim of livability

112 See: Martinez Gaete, Constanza: Jan Gehl's 5 Rules for Designing Great Cities. (2016, 16 December) https://www.archdaily.com/801431/jan-gehl-5-rules-for-designing-great-cities [08/30/2018]

„When we deal with cities we are dealing with life at its most complex and intense. Because this is so, there is a basic esthetic limitation on what can be done with cities: a city cannot be a work of art.“

Jane Jacobs[113]

5.3 Design Development

In this phase the design concept is transformed into geometry by using the parametric modeling plug-in Grasshopper.

Geometric parameters can be defined in advance, but should be tested in different variants and scenarios to proof the performance of the concept. Different residential typologies, building dimensions and volume compositions are tested in a parametric model and correspond to the declared space requirements by the city. The creation of different typologies, street layouts and scenarios enables the comparison based on the key parameters. This intends to provide information on which proposals should be shortlisted, combined or selected for further elaboration.

The designer's influence depends on the choice of tools, whether one uses prefabricated, generative tools, develops tools oneself or draws the outlines in a conventional way. The information output of the model depends on the level of detail and can be adjusted to personal needs. As many work steps can be automated to relieve the user of repetitive tasks an efficient way of planning is enabled.

113 AZ Quotes: https://www.azquotes.com/author/7295-Jane_Jacobs [10/01/2018]

5.4 Simulations and Analyses

The execution of analyses and simulations during and after the creation of the parametric 3D model is essential for this methodology.

The ongoing evaluation helps to improve the project and enables the comparison of different scenarios with the same requirements. The result of different typologies and street layouts can differ a lot, this is why the evaluation is done for typology and street layout separately before applying the geometry on the block layout itself.

The aim of these analyses is to understand the impact of different geometries on human use. Accessibility studies are carried out to create a path network that allows the ways of daily use in an efficient way. The visibility and visual integration studies express the perception on eye level on an open space and the views from the windows. Due to the increasing urban population and complexity of cities the demands on ecological planning's are high. Therefore the environmental studies like microclimate analysis are taken into account as well.

5.5 Scenario Evaluation

The evaluation of the results is at least as important as executing the analyses and simulations.

In order to create comparable basic conditions, the road networks are first compared with each other and the following decisions base on that.

Three scenarios with different distribution of use, elevation profiles and green are compared which fulfill the total area requirements of the model. The comparison of these scenarios as a basis for stakeholder and team member discussions takes place in the following ways. The visualization in form of plans, tables and diagrams as the traditional way suggests is done.

In addition to that some of the discussed visualization tools like Mapbox, the Design Explorer and an AR app using Unity and Vuforia are applied as well. Various analyses are conducted on the different scenarios with the same GFA demand to present them in a comparable way. The advantages and disadvantages of different analysis tools, urban structures and typologies are worked out. Based on this differentiation, one scenario is selected and presented in more detail.

5.6 Visualization

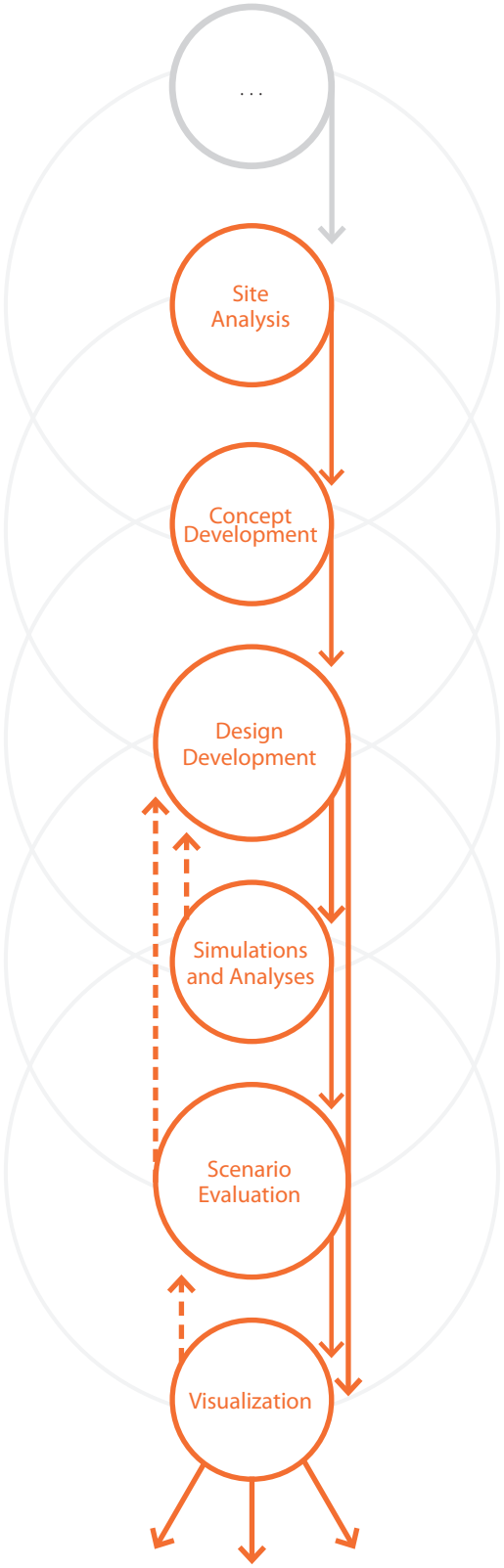
At the end of this digital urban planning process the visualization of the project results takes place.

Whether the various design proposals will lead to a final design or serve as a discussion base was debated in the interviews. The work of urban planning involves many stakeholders and therefore brings up different opinions and goals. For this reason a negotiation base to support information based decision making is very valuable.

This thesis suggests to document and visualize the shortlisted scenarios including their analyses results to understand the choice of the preferred solution. The shown geometry is more a basis for further detailing than a final design.

Overview

This infographic shows the urban planning process for the ‚Nordwestbahnhof' territory in Vienna. This process is mainly pursued using the modeling software Rhinoceros 3D, the parametric plug-in Grasshopper, available open source libraries, self-made scripts and from other researchers.



Infographic on the urban planning process

Vienna

Austria's capital Vienna as a city to live, work and spend free time in is well known all over the world for its living quality due to international rankings. How this life could look like in the new development of the 'Nordwestbahnhof' territory is topic of the practical part of this thesis.

Vienna named world's most liveable city 2018

Vienna looks back to a history when it was the capital of a large empire and counted 2.1 million inhabitants before the first world war. The city is currently leading the ranking by the Economist Intelligence Unit's global livability index which began in 2004. For many years in a row Vienna tops the ranking of cities compiled by the consulting company Mercer as well. The amount of green spaces, lakes and vineyards are besides the good and efficient public transport reasons why it presents itself as a city worth living in.[114]

114 See: Reuters: Vienna named world's most liveable city as Melbourne loses crown. (2018, 14 August) www.theguardian.com/australia-news/2018/aug/14/vienna-named-worlds-most-liveable-city-as-melbourne-loses-crown [08/15/2018]

6.1 General Information

6.1.1 ‚Nordwestbahnhof' Territory

The ‚Nordwestbahnhof' territory with 44 hectares offers the potential to test and evaluate my urban planning process with the inclusion of digital tools.

The development of my proposals is based on the block layout as a result of the competition won by the swiss architect ENF in the year 2008. The goal of the empirical part of this thesis is the generation and evaluation of different designs to achieve a decision base and possible outline for architectural competitions.

The Magistrat 21 of the City of Vienna gave me the official master plan competition outline of the year 2007 for this development territory. This vision guideline includes the space requirements for the use-mix that is dominated by housing with a 70 percent share.

In the direct surroundings of the ‚Nordwestbahnhof' is the 85 hectare ‚Nordbahnhof' territory of ÖBB[115] (Austria's largest mobility service provider). The completion of this area is scheduled for 2025 and half of the development has already been completed.[116]

The competition in the year 2007 requests a unique selling point which is given by the accessibility to recreation areas close by, local supply, educational institutions and public transport.

A number of comments from local residents were presented at an information evening in 2016 and incorporated into the design proposals. In addition to the location of the skyscrapers, the separation of the individual buildings from their surroundings was also mentioned. My approach includes the shifting of the block boundaries and the integration of green spaces at the edges to ensure optimal integration within the neighborhood.

115 See: ÖBB: https://www.oebb.at/ [10/01/2018]

116 See: Stadt Wien: https://www.wien.gv.at/stadtentwicklung/projekte/nordbahnhof/projekte/index.html [09/03/2018]

6.1.2 History

Until the 19th century a branch of the Danube in significant size characterized the Northwest Railway Station area as shown on historical maps. Only the regulation of the Danube between 1870 and 1875 made it possible to use the resulting island between the wildly branched Danube river system. Due to the constant changes in the many tributaries, it was difficult to imagine any structural use. Until in the 14th century a Danube bridge was built which made the trade route from Vienna to the north possible, one could only reach the city of Vienna via a river crossing.[117]

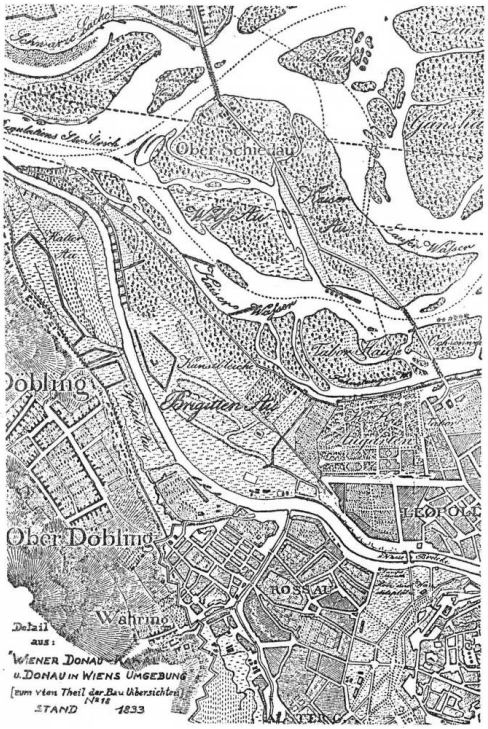


Figure 16 : Site map of the year 1833

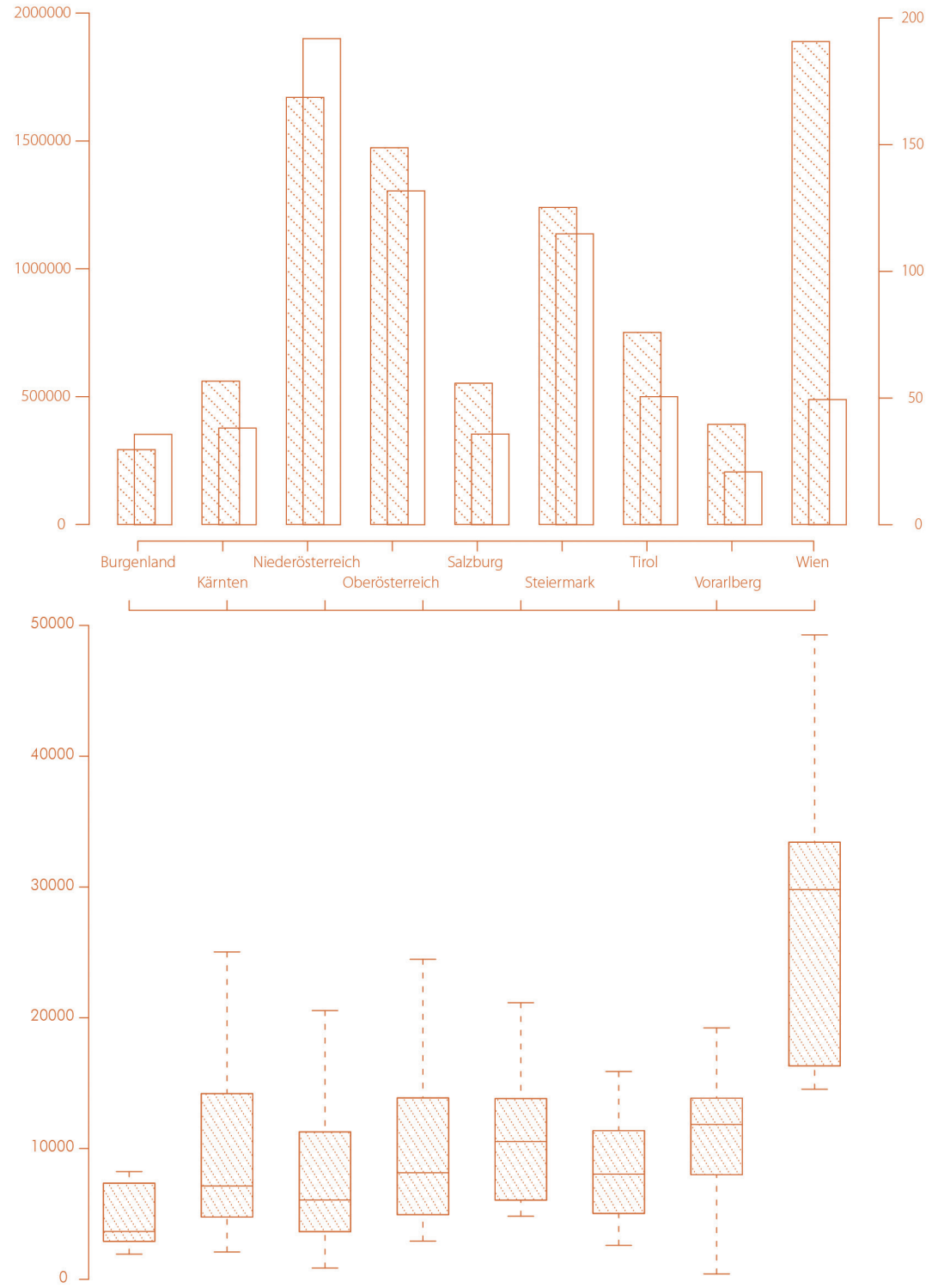
117 See: Wettbewerb Städtebauliche Leitidee Nordwestbahnhof 2007, 5-6.

The population and the area of the federal states are shown in the graphic on top of the right page. Vienna leads with a population of 1.89 million, followed by Lower Austria with 1.67 million and Upper Austria with 1.47 million inhabitants. While the correlation between area and inhabitants is high in most of the federal states the capital Vienna stands out as a city.

An interesting aspect can be seen in the representation of cities with population in the individual federal states. Although Vorarlberg is a small federal state in terms of area, the average population of the cities is the second highest after Vienna. Burgenland has the lowest average number of inhabitants in the cities, in the other federal states it is similarly distributed.

These figures are shown to give an impression about the urban-rural population distribution in the country the planning is carried out.

Data source: Statista: https://de.statista.com/statistik/daten/studie/19292/umfrage/gesamtbevoelkerung-in-oesterreich/ [09/27/2018]



Population and area distribution within the federal states of Austria

„The point of cities is multiplicity of choice."

Jane Jacobs[122]

6.2.1 Site Analysis

The preparation for the site analysis was a profound search for data and information about the project site. There is a number of sources I have used to cover a great range of different topics.

As stated before the open data platform by Vienna[118] offers besides planning and traffic plans, amenities, demographic information and a 3D city model. In addition to the amenities that are already covered by the city of Vienna more points of interest from Foursquare[119] and Openstreetmap[120] serve as a base.

For the site analysis the most important data source is 'Open Government Data'[121] that offers a great load of data licensed with creative common and can be accessed via QGIS or downloaded from the webpage.

The collection and validation of different data sources forms the start of the presented urban planning process. To get an overview of the different data sources, types and scale is very important. Information about the geographical elements is relatively easy to get in western Europe and provided by Openstreetmap and the data platform.

118 See: offene Daten Österreichs: www.data.gv.at [08/13/2018]

119 See: Foursquare: https://de.foursquare.com/ [08/13/2018]

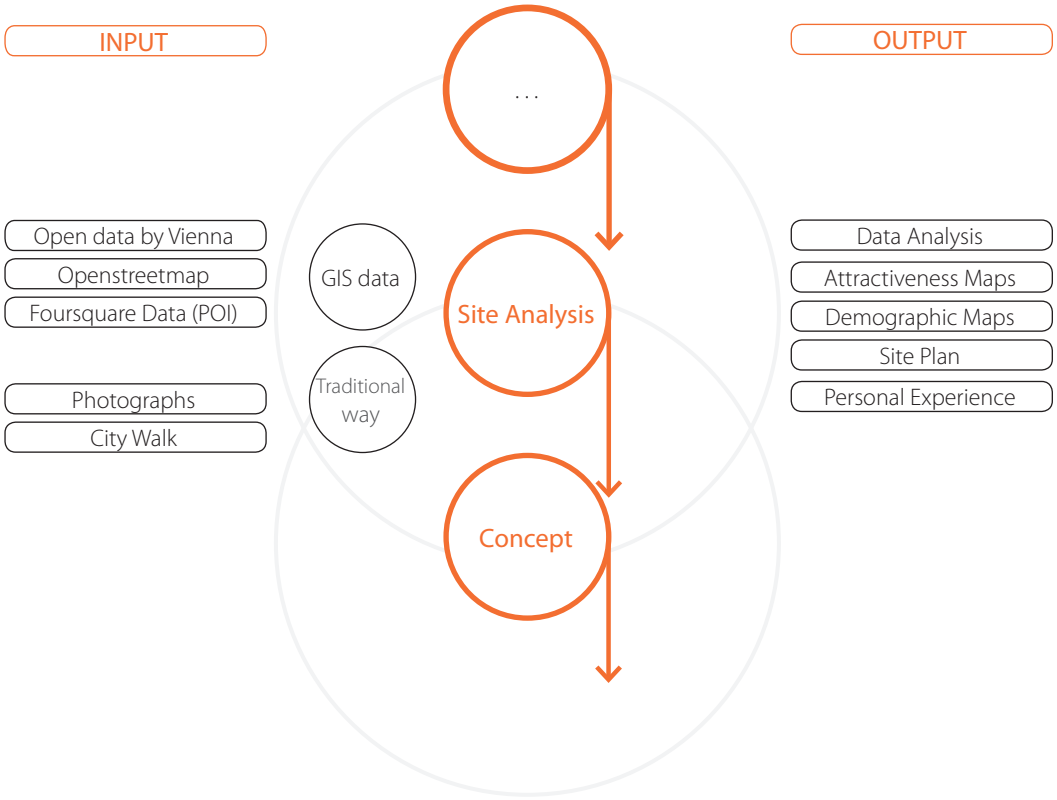
120 See: Openstreetmap: www.openstreetmap.org [08/13/2018]

121 Datenauftritt Stadt Wien: https://www.data.gv.at/auftritte/?organisation=stadt-wien [08/30/2018]

122 AZ Quotes: https://www.azquotes.com/author/7295-Jane_Jacobs [10/01/2018]

A census dataset includes different parameters like demographic information, population figures and household structures that can be used for the planning of housing programs and to improve public infrastructure. As reliable sources for census data the FH Joanneum[123] lists ‚Statistik Austria', the ‚Census Reporter' and ‚eurostat'. The demographic information about the citizens of Vienna is available as open source per counting district, if you are interested in more detailed data you have the possibility to purchase them.

The data collection as stated by Prof. Degros is needed as the first step to get an overview about the current situation - to browse through available data in different formats like shape- and csv-files and text documents. Since the competition for the vision of the ‚Nordwestbahnhof' territory was done in the year 2007, the current situation is well documented. The project's design brief includes the space requirement per use, traffic demands, sustainability aspects and general information.[124]



123 See: Koller, Sarah: Zensusdaten – drei Quellen (2013, 20 November) http://datablog.fh-joanneum.at/2013/zensusdaten-drei-quellen/ [09/26/2018]

124 See: PDF, Magistrat Wien

The City of Vienna

1 888 776
people

Other countries:
16.9 %

EU:
12.7 %

Austria:
70.4 %

06

35 m²

Average housing space per resident

2.07

Average number of residents per apartment

1 379 km

Bicycle paths and lanes

2 828 km

Total length of roads in Vienna

+38.9°C
- 13.8°C

in 2017

Ø 46
people/hectare

Life expectancy

men 2016
78.3 years

women 2016
82.9 years

Data source: Vienna City Administration, Vienna in Figures (2018, August) www.statistik.wien.at [10/06/2018] (own graphics)

The process of searching for suitable data, downloading the needed files from online platforms and prepare them for further use is the following. Once the data is downloaded the next step is the re-projection using QGIS to the common projection EPSG: 31256 that is used for Vienna. Working in the right projection is crucial to measure real distances and create geometry in the following phases.

Once the base data is stored in the right projection the import to the framework of Grasshopper, using the open source library PYSHP follows. Thereupon the extracted information can be used for design development and evaluation. Geometry is 'baked' to Rhinoceros 3D while including the extracted attributes as user text to avoid permanent imports. Especially useful is the stored information about the district names, hierarchy, land use and public transport stops and lines. For the organization and further use of this user text, a Rhinoceros toolbar with python scripts was created to provide a user-friendly interface.

Site Plan

This includes various points of interest in the closer surrounding, public transport and the use of the proposed design. Showing the public transport system for different means of transportation for the city of Vienna to get an overview of the location within the city.

Demographic Maps

Based on the available census data and population forecast density maps are created and include the average age based on estimated population per counting district. This information can be used for future plans as the demographic information extracted by census data and the forecast contain the same level of detail. The figures on the right page show the years 2018 and 2030 in Vienna. The dot density shows the density while the color shows the average age in the forecast areas.

Land Use

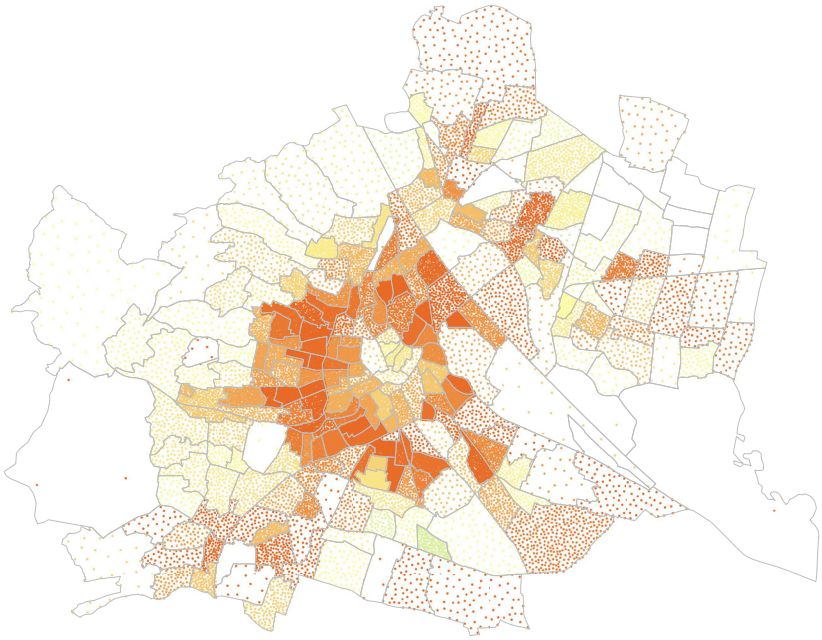
The analysis of the land use is based on the available real-use map from 2016 of the city of Vienna. The attributes extracted by the shape file are utilized for the calculation. This figure shows the distribution of different uses within the city. About a third of the city surface is covered by farming, nature, recreation, leisure and water while living and mixed uses make up another third. The numbers for streets, technical and social infrastructure as for industry are relatively low.

Green Systems

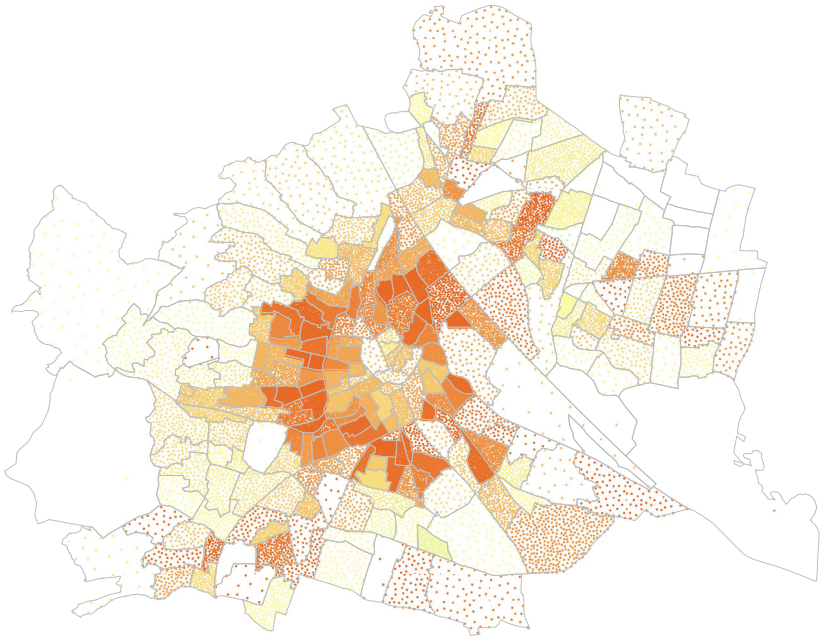
The twelve percent natural spaces contain 60 percent wooden area and 40 percent meadow. As the map shows the distribution of green spaces spread all over the city, the high number of trees is also worth mentioning.

Data source: Open data Vienna (own graphics)

Population of Vienna in 2018



Predicted population of Vienna in 2030



Maps of Vienna showing the density and population average age based on census data for 2018 and 2030[127]

Public green, trees and waters in Vienna


Mixed-Use
Mixed-Use - Commercial
Mixed-Use - Industry
Residential
Residential - Business
Recreation
Traffic
Special Zone
Protected Area
0
100
500m
N

Space requirement	Vision 2008	Vision 2016
Residential [m²]	494.200	571.200
Office [m²]	156.400	131.500
Commercial [m²]	35.300	57.500
Social Infrastructure (incl. Schools) [m²]	30.400	44.600
	43.000	
GFA [m²] +/-	**730.000 - 780.000**	**800.000 (+/-5%)**
Density	2,9	3,1
Residential Units (100m² / RU)	4.900	5.700
Residents	11.800	13.700
Workplaces	5.100	4.700

Parking requirement	Vision 2008	Vision 2016
Residential	4890	4145
Office / Commercial	1930	1708
Social Infrastructure	120	45
Total	**6940**	**5898**

This table shows the adjustments of space requirements from the vision 2008 competition to the vision in 2016. (Data source: City of Vienna)

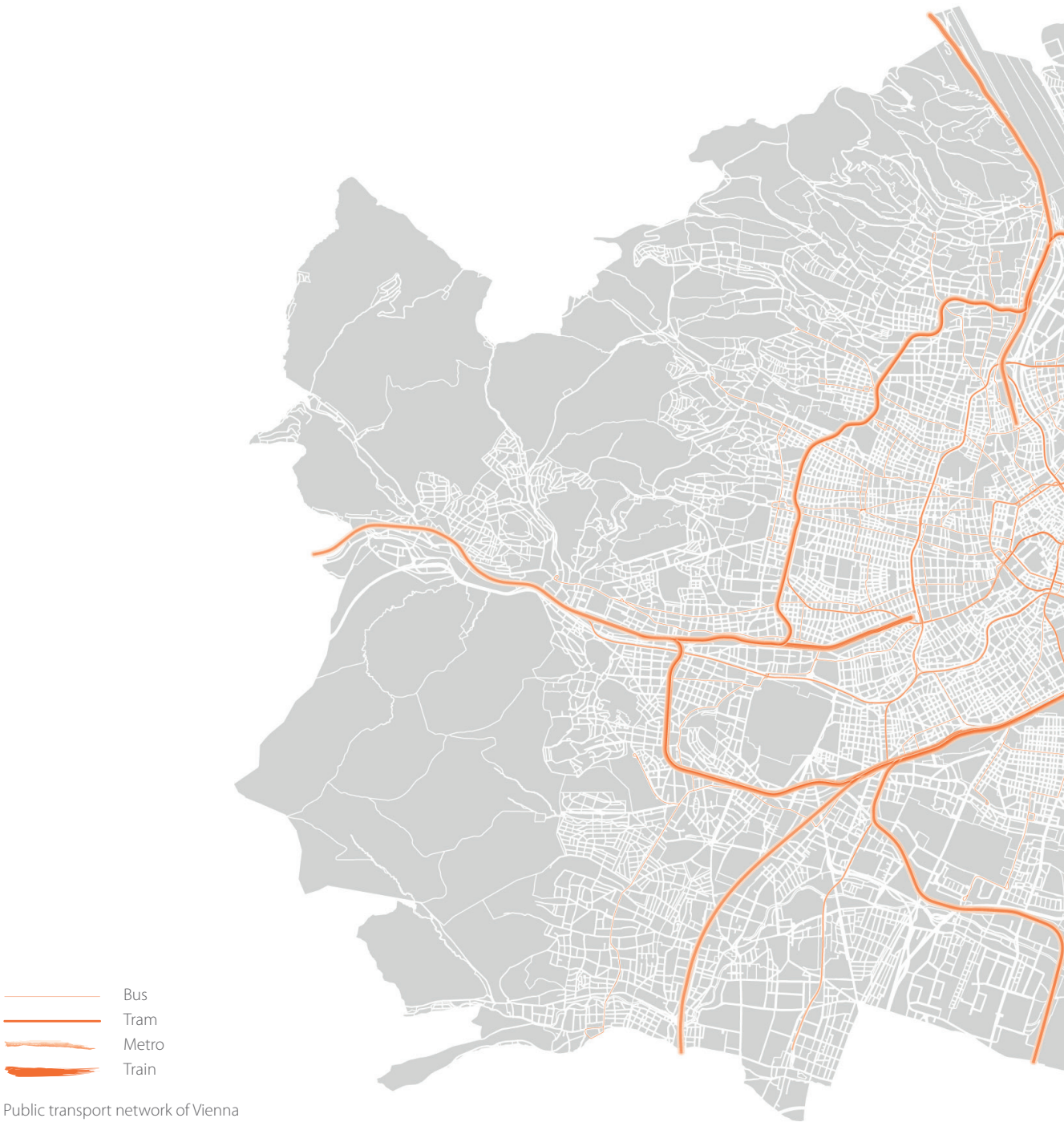
Planned distribution of use 2016

Surroundings

Residential (incl. Student Housing, Hotel, etc.)
Office
Mixed-Use (Residential, Office, Commercial)
Social Infrastructure

0 100 500m

N



Public transport network of Vienna

Public transport network of Vienna in the surrounding of the 'Nordwestbahnhof' territory


Bus
Tram
Metro
Train

Distribution of cafés, restaurants and bakeries (Data source: Foursquare & Openstreetmap)

Distribution of shops (Data source: Foursquare & Openstreetmap)

City bike station on the 'Dresdner Straße'

A tram on 'Tabor square' in the south of the planning territory

City Walk

A site visit was defined as a necessary part of the analysis at the beginning of the design process. The following pictures show the atmosphere and impressions at specific locations around the site.

Exploring this area by myself allowed me to strengthen my design proposals. The term ‚Genius Loci' describes the special atmosphere, spirit of a place.[125] The experience of this ‚Genius Loci' lead to an important part of the concept, whereas the vision of an urban oasis is combined with an attentive handling of the history of this place.

The inclusion of old relicts of the former train station in the shape of urban elements for paths and materiality is planned. In addition the special arrangement of green spaces serves the re-embracement of the history.

Specific elements of the public realm are pointed out by color in the photographs taken by myself. These elements can be formed by green spaces, trees, traffic or the most important element: people. The built structure, variety of facades, spaces and streets gave me a sense of this place. I strongly felt the border of the 'Nordwestbahnhof' which forms a separation of east and west in a 1,5 kilometer long slender site.

125 See: Collins dictionary: https://www.collinsdictionary.com/de/worterbuch/englisch/genius-loci [09/24/2018]

The entrance of the metro station 'Dresdner Straße'

Passing tram on the 'Dresdner Straße'


76
76
74

Buildings on the 'Nordwestbahnstraße' with an outdoor seating

Existing building on the 'Nordwestbahnhof' territory

Current situation of the 'Nordwestbahnhof' territory

‘Nordwestbahnhof‘ Territory

The exploration of the ‘Nordwestbahnhof‘ territory in the form of a walk was interesting and informative.

The cargo terminal with its rails and buildings dominates this territory. The space itself is without any scale due to the wide open areas. The photographs show some buildings and the visible occupation of the nature on this site.

The territory is completely enclosed and fenced, except of a few entrances. Therefore no interaction with the surroundings is happening.

While walking down the ‘Nordwestbahnhof-straße‘ the building shown on the next page has awakened my attention. This green facade brings diversity to this street, as the ivy naturally climbs up the wall. Monotone facades can get more appealing by adding a layer of green and the urban climate benefits by the plants as well.

A building with a green facade in the 'Nordwestbahnstraße'

Side street of the 'Dresdner Straße' street with green


30
Zone

„Streets and their sidewalks-the main public places of a city-are its most vital organs.“

Jane Jacobs[126]

126, 127 AZ Quotes: https://www.azquotes.com/author/7295-Jane_Jacobs [10/01/2018]

„Cities have the capability of providing something for everybody, only because, and only when, they are created by everybody.“

Jane Jacobs[127]

Side street of the 'Nordwestbahnstraße' without any green

Side street located in the south of the territory

Attractiveness Maps

In describing the city geographically, such as topography, zoning and density, analyses were carried out and presented in the form of maps. Given facts as locations and boundaries are easy to describe in maps while a high quality of living in a city depends on more factors.

The attractiveness potential for Vienna is calculated in a grid size of 250 meter by proximity to amenities partitioned in the categories public transport, green, local supply, social infrastructure and culture. Amenities within a walking distance of 1000 meters per raster point were included in the calculation.

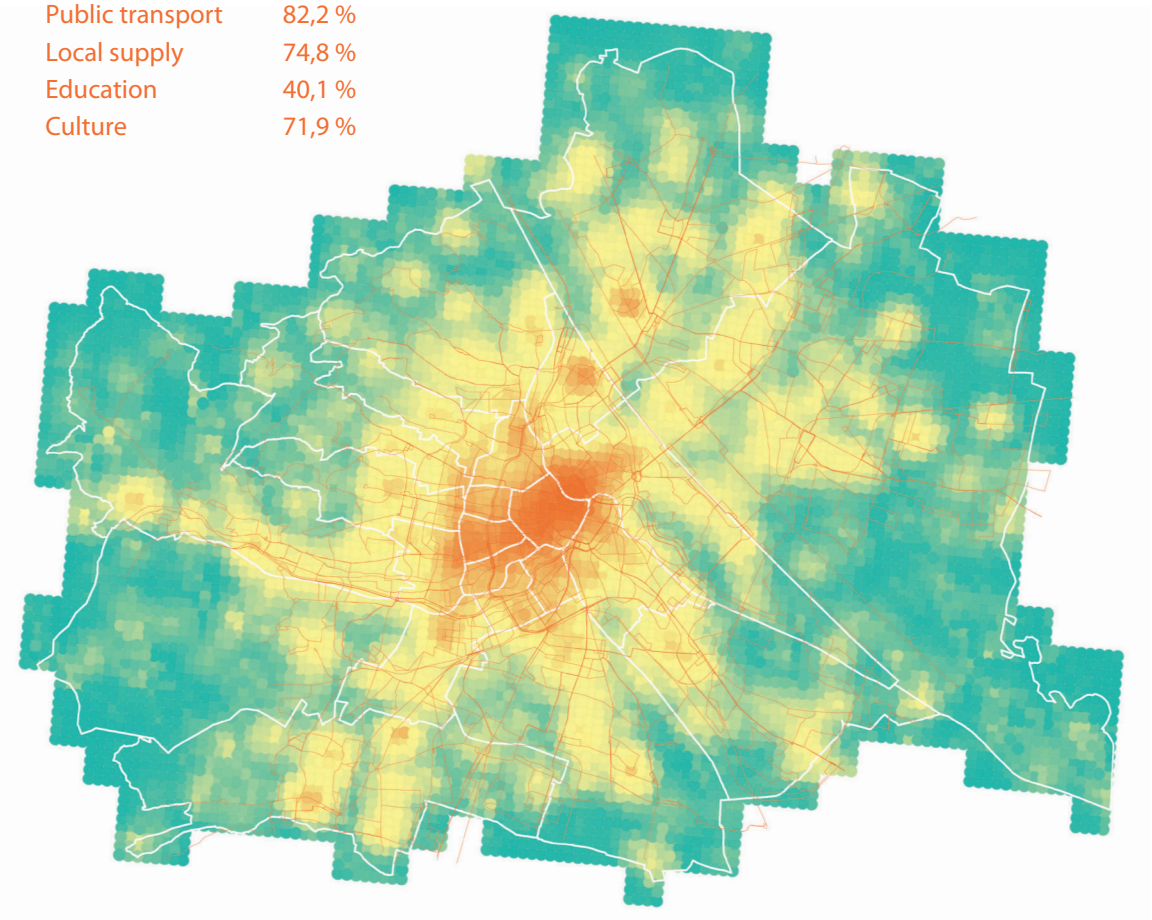
This calculation includes the distance to all amenities over the city, the distance to the closest, the number of amenities in walking distance and the resulting attractiveness of a grid point.

As the weighting of the benefits of different amenities depends on social, cultural and personal aspects, a model was created to allow the user to adjust the weights. This model could be used in participatory processes with citizens to extract attractive locations for different groups. The possibility to rate different groups allows the application of this method in different cultures and countries.

The visualized attractiveness values (a) for each grid point range from 0-1 and represent a good quality with a high number (shown in orange). The results of this calculation depend on the quality of the data basis. Data from different sources (Openstreetmap, Open Government Vienna, Foursquare) was used as a basis to present the methodology, but a precise validation of the data basis was not part of this thesis.

Weighting for the attractiveness value of the amenity groups

Public green	66,2 %
Public transport	82,2 %
Local supply	74,8 %
Education	40,1 %
Culture	71,9 %



Weighted attractiveness values

The weighting of the different amenity groups is based on the survey by Köhler carried out in Dresden. He reviewed the priority of proximity to different amenities for different milieu groups, those numbers were simplified in averages an taken into account.[128]

128 See: Köhler 2012. 43-61.

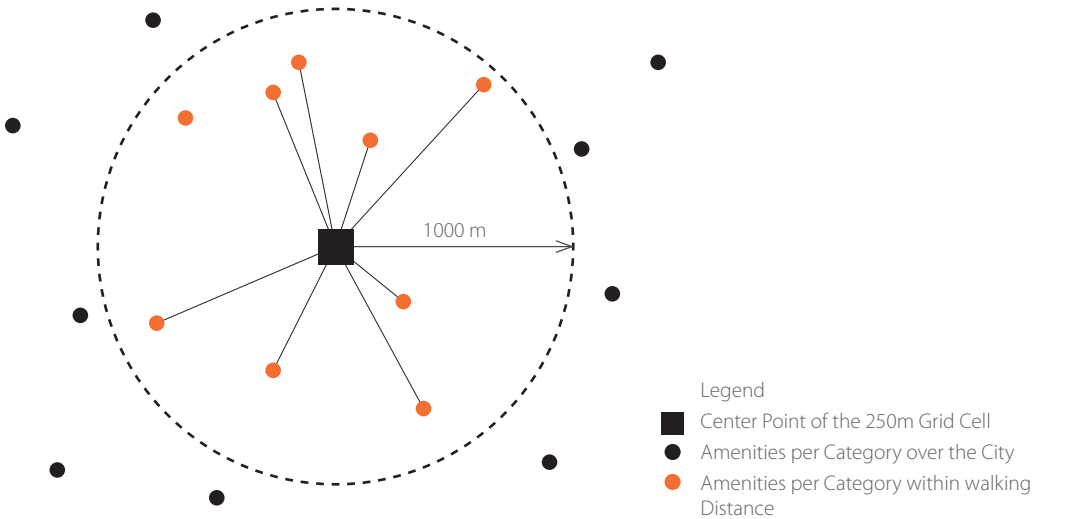
A calculation of Eucledian distances from grid point to each category [c] is executed for 7340 grid points in Vienna. This calculation includes the distance [m] from grid pt [ID_pt] to the closest [c], the radius in meter [r], the number of [c] within the defined radius, the average distance to all [c] in Vienna, the average distance within [r] and the average distance to the closest 10 [c].

These values are stored as user text on the point geometry for each category. The categories within the city are clustered into five groups that are used to weight the priority of different points of interest. This calculation can be applied on the site analysis to estimate the attractiveness potential and reveal strengths and weaknesses for districts and neighborhoods.

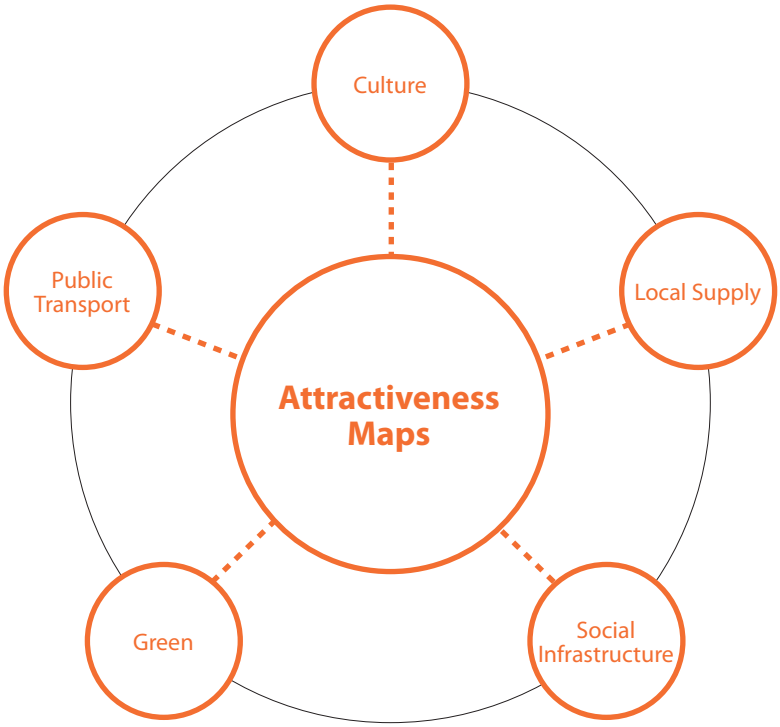
The population forecast includes the number of inhabitants and the estimated average age per counting district and offers the possibility to adjust the planning to the future needs of the people.

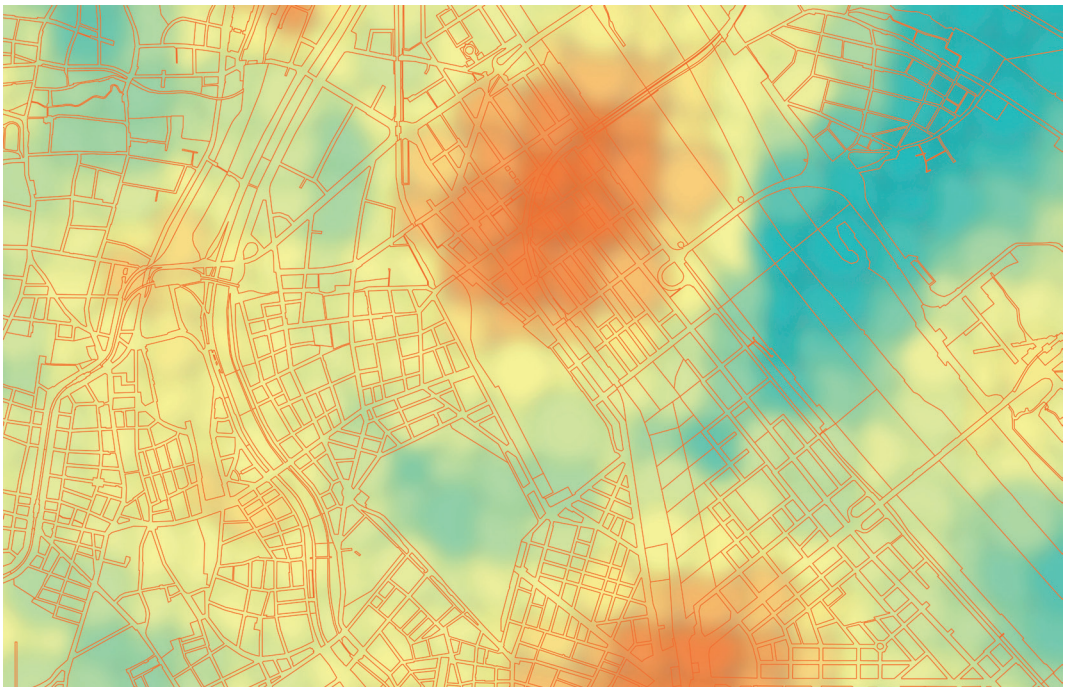
The average distance [dist] to [c_x] within walking distance and the number of [c_x] within the radius [$count_x$] are used for the visualization. The shown attractiveness value [a_x] per [c_x] is the average of the normalized [$dist_x$] and normalized [$count_x$]. A small average distance presents a higher attractiveness than a larger number and balances between 0 and 1000 meter. This number is combined with the number of [c_x] and presents the attractiveness value.

This figure shows the five groups of different amenities (points of interest) within the city. The map reveals the attractiveness only in the form of proximity to amenties but other factors could be included as well. Aspects, such as crime, the rate of foreigners and socio-economic characteristics of the neighborhood, can influence the attractiveness. Since the evaluation of personal preferences depends very subjectively on the user, these aspects are not included in this thesis.

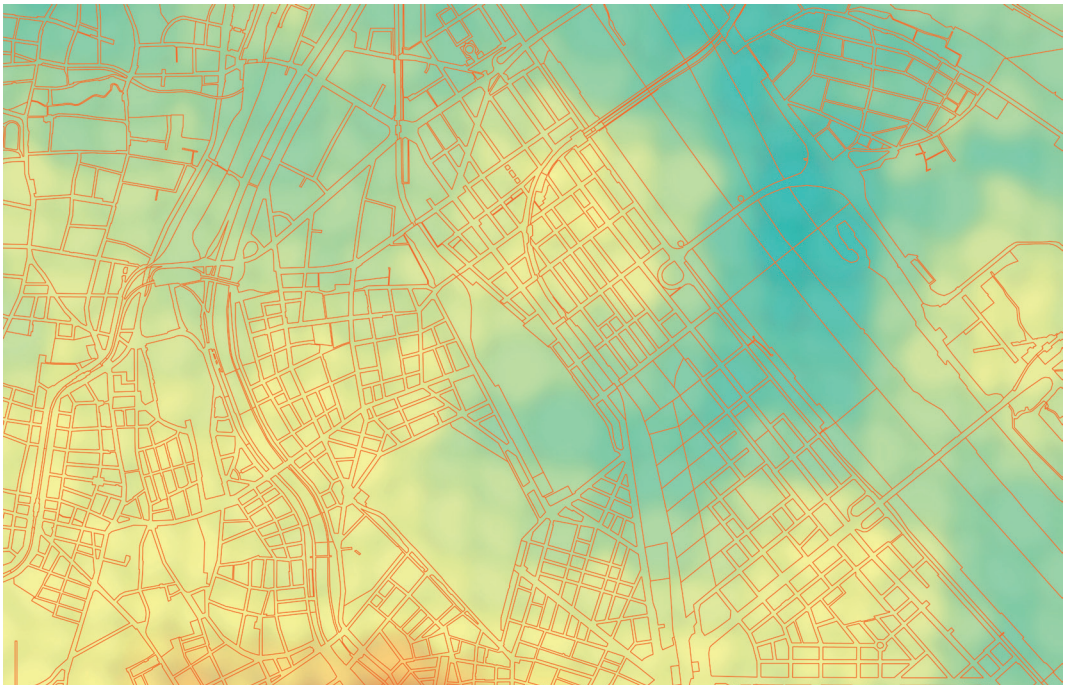


Attractiveness map for public transport and public green

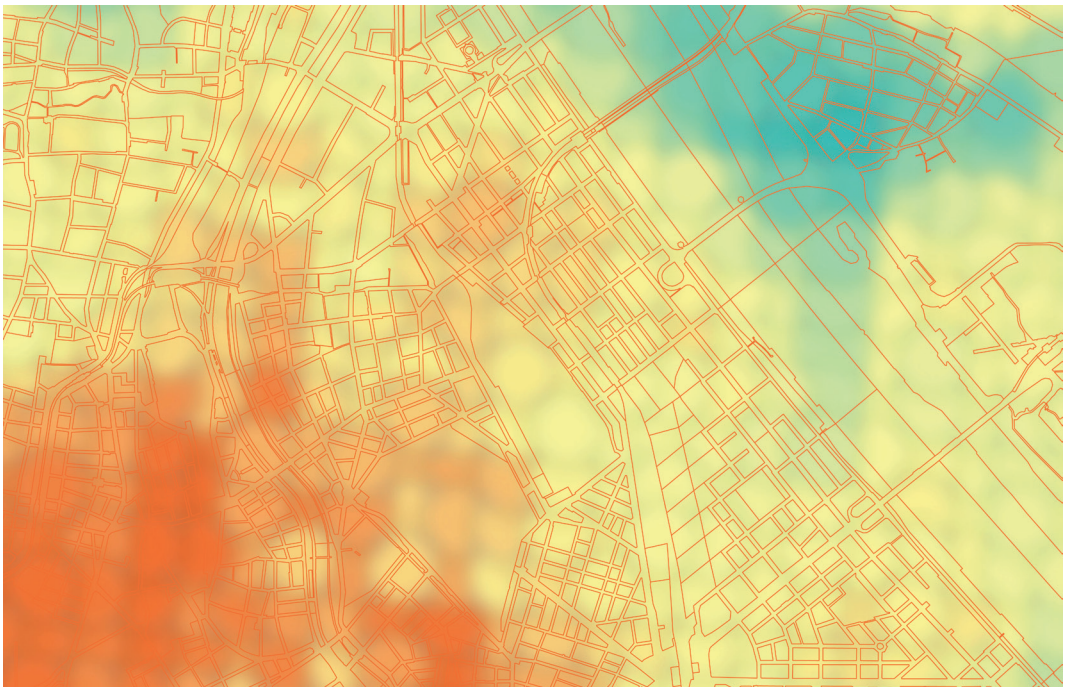




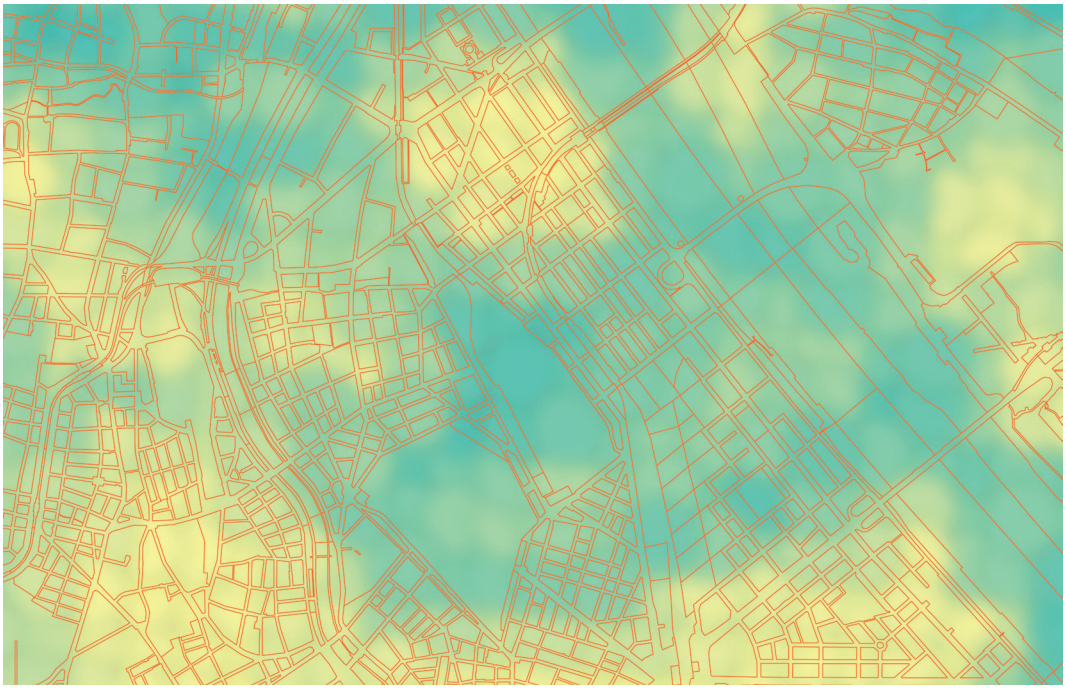
Public transport attractiveness around the‚Nordwestbahnhof' territory



Local supply attractiveness around the‚Nordwestbahnhof' territory



Educational institutions attractiveness around the ‚Nordwestbahnhof' territory



Cultural attractiveness around the ‚Nordwestbahnhof' territory

6.2.2 Concept Development

A green urban design that positively influences the neighborhood beyond the border of the site.

My aim is to create a new development that attracts people to move there but should also be beneficial for the ones that already live nearby. All of them should be able to enjoy new amenities, green spaces and urban quality. The location in the 20th district offers a good connection to the public transport system, short bike paths, the 'New Danube' and the 'Danube Canal'.

The environment medical professional Hans-Peter Hutter speaks of approximately 15 days per year with more than 30 degrees with the forecast of 40 days per year in 2045 and notes that urban planning, agriculture and the society need to adjust to this change.[129]

Climate measurements, forecasts like this and the experience of myself staying in a central city apartment in Vienna during summer have led me to consider the urban climate as an important aspect for this project.

According to a recent german survey by Forsa, 94 percent of the city's population believe in the positive effect of green spaces on body and soul. Almost 75 percent use green areas and parks in their surroundings several times a month. Parks, greened streets or roofs or any kind of bushes or lawns, is rich in variety and significantly increases the quality of life.[130]

129 See: Krause, Sonja: Sonja Krause mit Umweltmediziner Hans-Peter Hutter, in Kleine Zeitung, Graz, 2018, 9 August, 28-29.

130 See: Grün in die Stadt: https://www.gruen-in-die-stadt.de/informieren/vorteile-von-stadtgruen/lebensqualitaet-durch-staedtisches-gruen/ [08/11/2018]

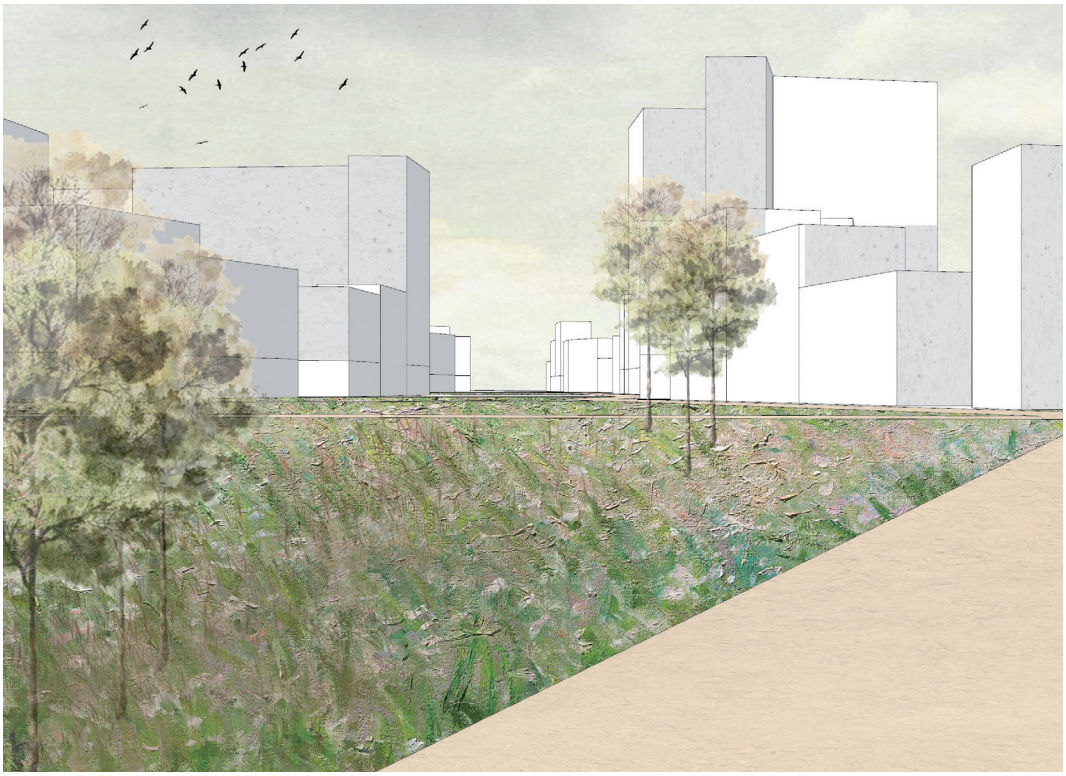
As Oldfield pointed out in an online article by the Guardian as well, many towns and cities already use parks and trees for urban cooling, which provide additional benefits for the psychological well-being of their inhabitants. The city state of Singapore is a role model due to its reaction on the growing population and urban density since 1967 with intensive tree planting, creating new parks, vertical and roof planting.[131]

131 See: Oldfield, Philip: What would a heat-proof city look like?. (2018, 15 August) https://www.theguardian.com/cities/2018/aug/15/what-heat-proof-city-look-like [08/17/2018]

The main part of the architectural concept is the central green oasis in the urban environment with reference to the past and the character of the place: the‚Genius Loci'.

An area with character where all age groups would like to live in and children can move without fear. Even the working population who commutes to there because of their work should like to spend their free time in the park.

Based on the design idea, the data resulted from the site analysis and the block outlines by the architects, the planning process enters the design development phase.



6.2.3 Design Development

Once the design intention is defined, it is time to start building up the parametric model. In this case study the vision outlines by the competition in 2008 are used to base the design proposals on.

An adaptive master plan script allows to change ruling parameters in a later stage and modify the geometry in real time to simulate their impact on the performance outcome. In order to enable the comparison of different scenarios, the same basic requirements must be met. To distinguish the influence of different factors on the evaluation result is difficult. Therefore different street layouts are compared with each other and the different typologies tested on the same block to ensure same analysis conditions.

A main part of this thesis is the comparison of various scenarios and to figure out appropriate analysis tools for an urban planning process.

The integration of a new design in an existing urban structure was challenging due the consideration of existing streets, blocks and nodes. The selection of analysis tools covers a variety of different aspects.

Block Typologies

At the beginning of the design development, different residential typologies are tested according to their performance in solar radiation, pedestrian comfort, visibility on the open space and visual integration in the neighborhood. Second, the comparison of the results is done by graphics and tables. The morphology of the typologies are adjusted to common practice in Vienna and overall Austria. A block typology and L-shaped buildings along the boundary of the blocks are investigated for their performance.

Typology One

Typology one (block) generates an urban residential block layout and can be applied on a block outline while offering a number of parameters to create the geometry. This block curve can be further divided in different parcels by setting the parcel dimension and distance between the new parcels [parcel_ dimension] [distance_parcels]. These parcels build a subdivision of the block layout. For the creation of the parcels the same cluster is used for typology one and two.

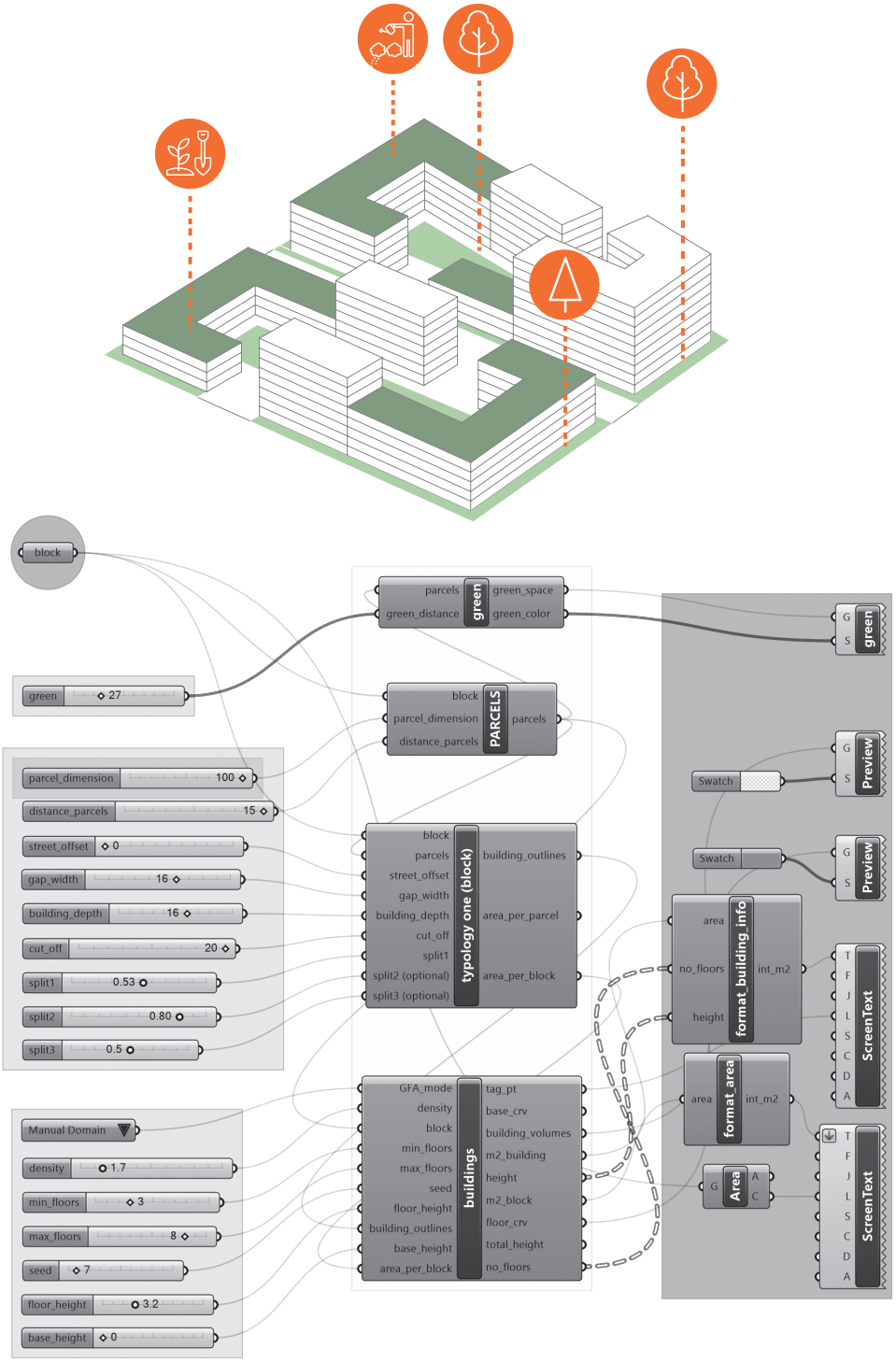
The ruling parameters are the offset of the buildings to the surrounded street [street_ offset], the building depth [building_depth], the position of openings and building splits per block side [split_1-3], the opening width of the gap [gap_width] and a threshold of cutting off short pieces of the buildings [cut_off].

After the creation of the parcels the generation of the building outlines is the next step. A typology cluster generates the building outlines, calculates the area per parcel and area per block. A cluster is a collection of different components in Grasshopper that supports the structure and transparency of the definition. The definition setup was completely developed by me with the use of the parcel component of the DeCoding Spaces Toolbox.

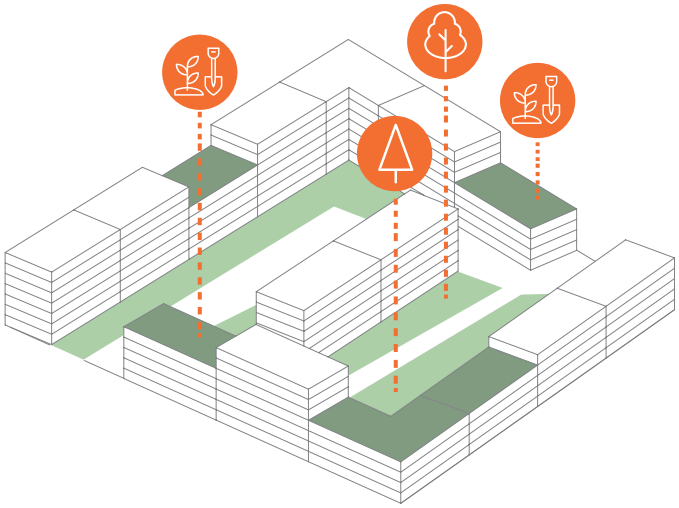
The input parameters for the building cluster are the selector for the GFA [GFA_mode], the density in numbers [density], or manually defined minimum and maximum floor height [min_floors] [max floors], a seed for the height variation within the buildings [seed], the floor height [floor_height] and the base height which defines the ground plane of the building [base_height]. The base height for a building is needed, for example if offices or other uses are situated in the floors below.

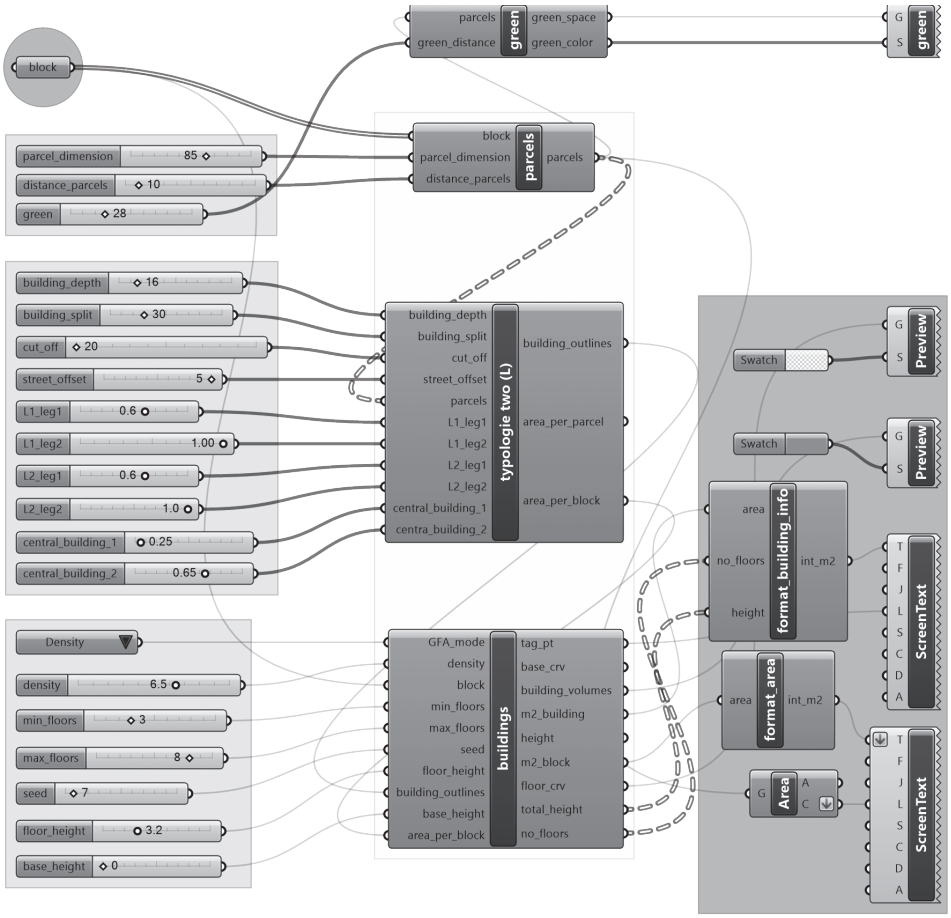
Typology Two

The definition for the creation of typology two (L) contains the parameters for the parcel dimensions, the building depth [building_ depth], a number for the building width [building_split], number sliders to define the extent of the L-legs [L1_leg1] [L1_leg2] [L2_ leg1] [L1_leg1] and the possibility to define the central building in length [central_building1] [central building2]. Once those input sliders are positioned the building outlines [building_ outlines] as output of this component are used in the following to create the building volume.



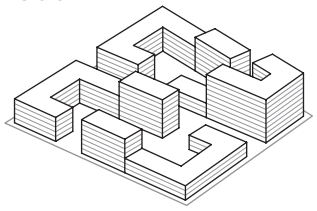
Grasshopper defintion of the typology one creation





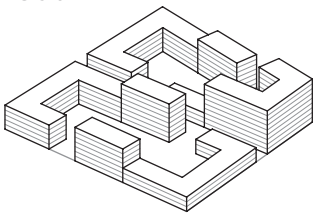
Grasshopper defintion of the typology two creation

Version 1



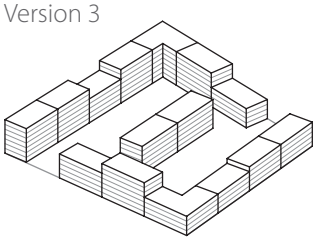
Building coverage ratio	43 %
Density	2.5
Plot coverage m^2	7.870 m^2
GFA	44.847 m^2
Average number of floors	6
Compactness	0.29

Version 2



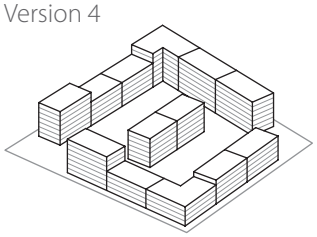
Building coverage ratio	48 %
Density	2.8
Plot coverage m^2	8.836 m^2
GFA	50.524 m^2
Average number of floors	6
Compactness	0.30

Version 3



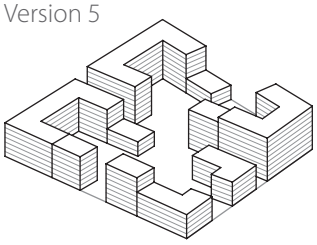
Building coverage ratio	43 %
Density	2.7
Plot coverage m^2	7.827 m^2
GFA	49.441 m^2
Average number of floors	6
Compactness	0.30

Version 4



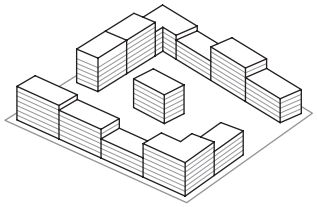
Building coverage ratiio	36 %
Density	2.3
Plot coverage m^2	6.539 m^2
GFA	42.130 m^2
Average number of floors	6
Compactness	0.30

Version 5

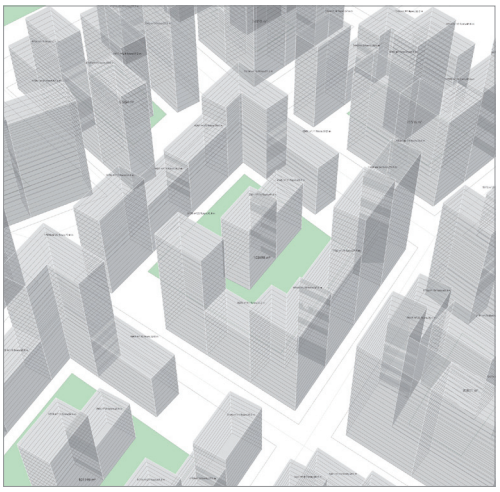


Building coverage ratio	42 %
Density	2.9
Plot coverage m^2	7.616 m^2
GFA	51.981 m^2
Average number of floors	6
Compactness	0.31

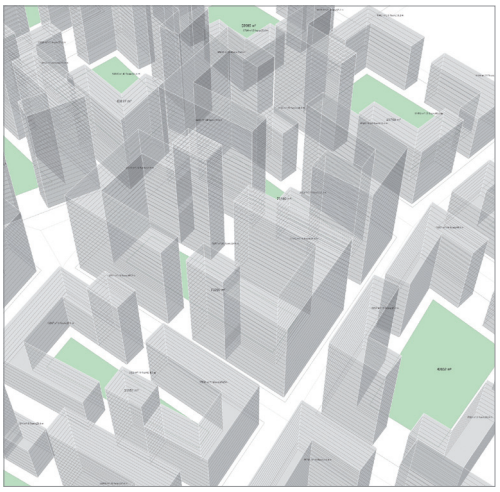
Version 6



Building coverage ratio	33 %
Density	2.9
Plot coverage m^2	6.047 m^2
GFA	52.299 m^2
Average number of floors	9
Compactness	0.27



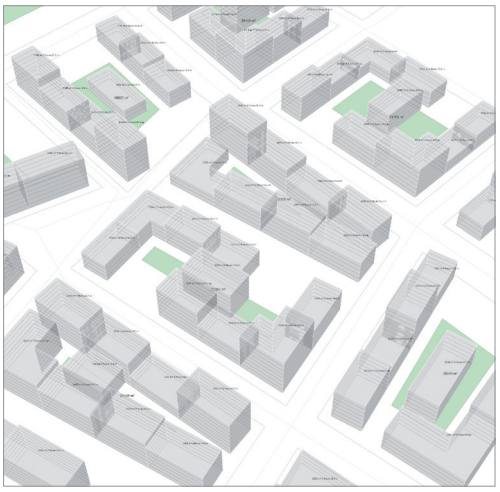
L-typology with high density



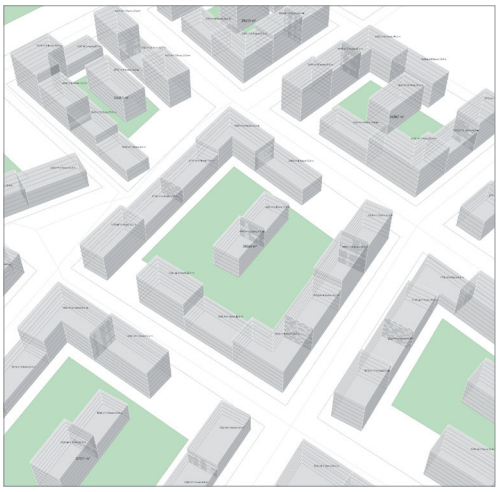
Block typology with small blocks and high density

These figures show examples how the typological generative components, that were scripted for the use of the 'Nordwestbahnhof' territory, could be applied. These developed typologies do not represent a universal solution for every project and city, but demonstrate the way how digital tools could be applied to an urban planning process.

After defining the vision it is important to start working on proposals that convey the main idea behind them. Whether a project is characterized by high density, block structures or high rise the application of some components can always be introduced in different steps of the workflow.



L-typology with small blocks and low density



L-typology with large blocks and low density

Parametric Model

This paragraph contains a description of the individual steps to create the parametric model in Grasshopper. The modeling process starts with the definition of the boundary, which usually is built by the project site, shown as step 1 in the figure on the right page.

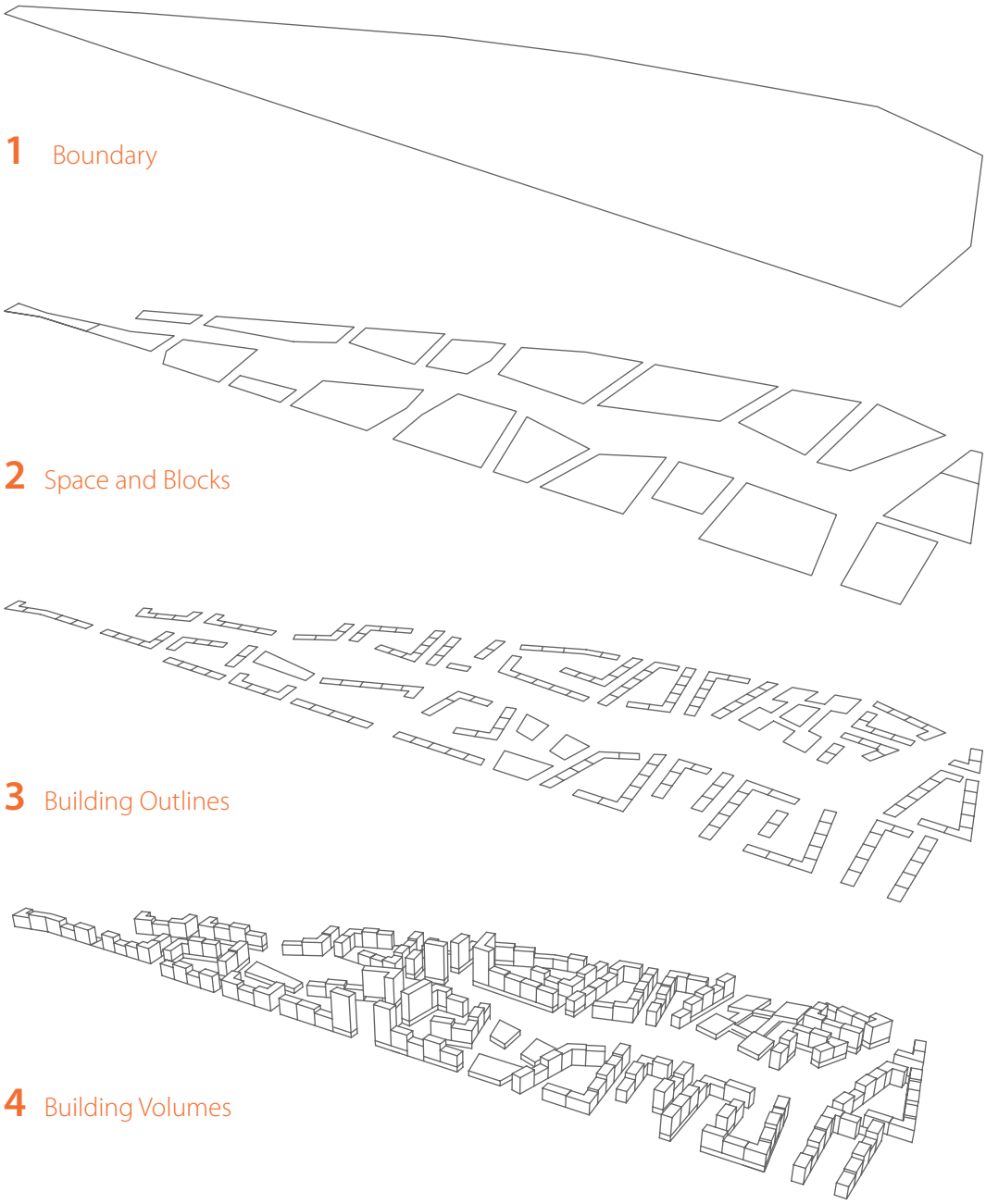
The second step is the creation of the street network that serves as a base for the block layout. The possibility to link the existing street network to the new layout is given. The assigning of public space, residential areas or commercial hubs to blocks supports the allocation to different use typologies. This allocation of use can be based on evaluation measures or follow the designers intention.

The space requirements for residential, office, commercial and social use are given per block and in total for the 'Nordwestbahnhof' territory.

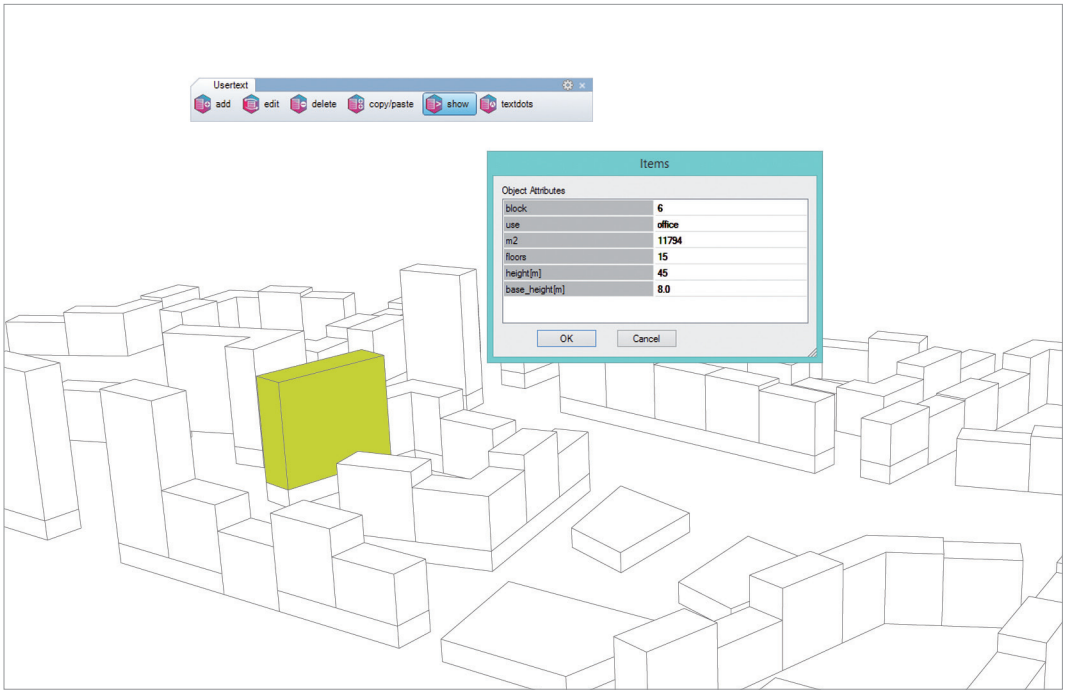
The third step of the modeling process is the creation of the building outlines inside the block layout. In the presented case study the two suggested generative typology components are used for this purpose.

As last step of this process the information loaded building volumes are created with the self-developed buildings component. By using the density or height range as input the generated curves are extruded to volumes based on the given floor height.

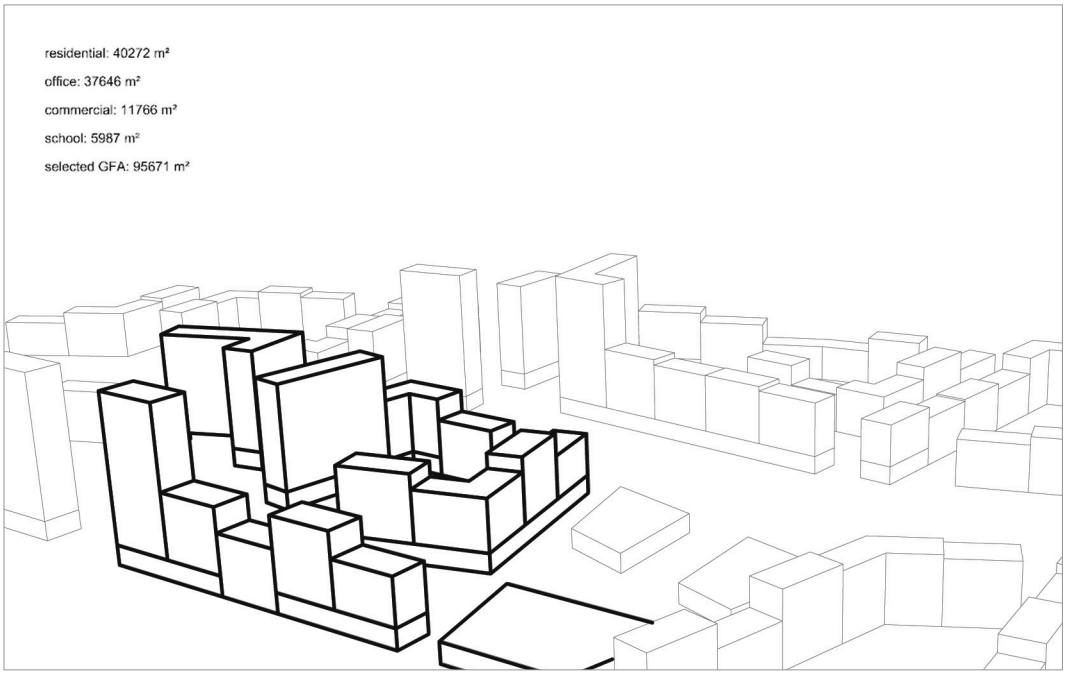
As an advantage can be highlighted that urban planners can draw their building outlines in 2D, still use this component to create intelligent models.



Step by step workflow of the urban geometry creation



Rhinoceros toolbar to work with user text



Rhinoceros screenshot with display of user text via Grashopper

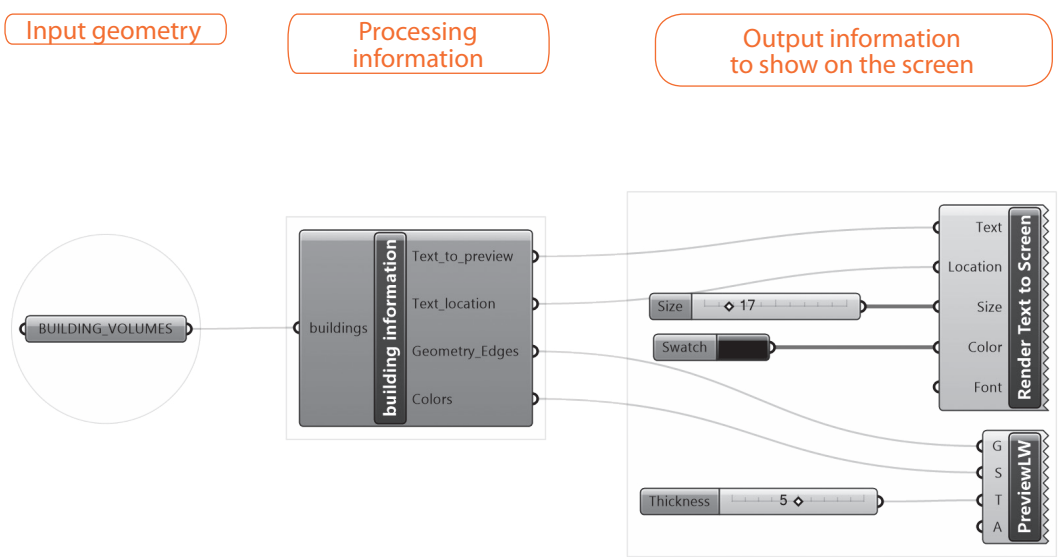
Intelligent Geometry by User Text

In order to ensure real-time control on the planned building geometry, the calculated areas and heights, in every step of the planning course - the application of user text chosen.

While creating a scenario, the calculated areas can be seen in the Grasshopper user interface. However, this information should not be lost by the export to other formats or "baking" the geometry. (= creating objects in Rhinoceros) For this reason user text is utilized to store keys and values on the geometry objects. This user text can be retrieved, changed and added by using the self-developed python toolbar. This toolbar is shown on the left page and allows to retrieve information without opening Grasshopper.

A Grasshopper definition has been developed to display the information of selected geometry on the screen. The library ‚Human' is used to display the text on the screen and the library 'Elefront' is needed for the user text in Grasshopper. This definition is shown at the bottom of the page and includes a simple input component for the building volumes, a cluster that processes the information and the preview components on the right side.

The advantage of this method is, that scenarios can be extended or changed at any stage, and the area calculation can easily be updated. The work with parametric models may contain a 'design freeze', where you start to manually add and change geometry due to comments or discussions. This method allows these changes without complicating the further workflow.



Grasshopper definition to show the GFA of selected buildings

6.2.4 Simulations and Analyses

The analysis of the shortest paths to points of interest within the closer area shows the accessibility of a design proposal. Graph analysis is used to calculate the real walking distances. Visibility is expressed by the use of 2D isovist analysis for the public realm between the built environment.

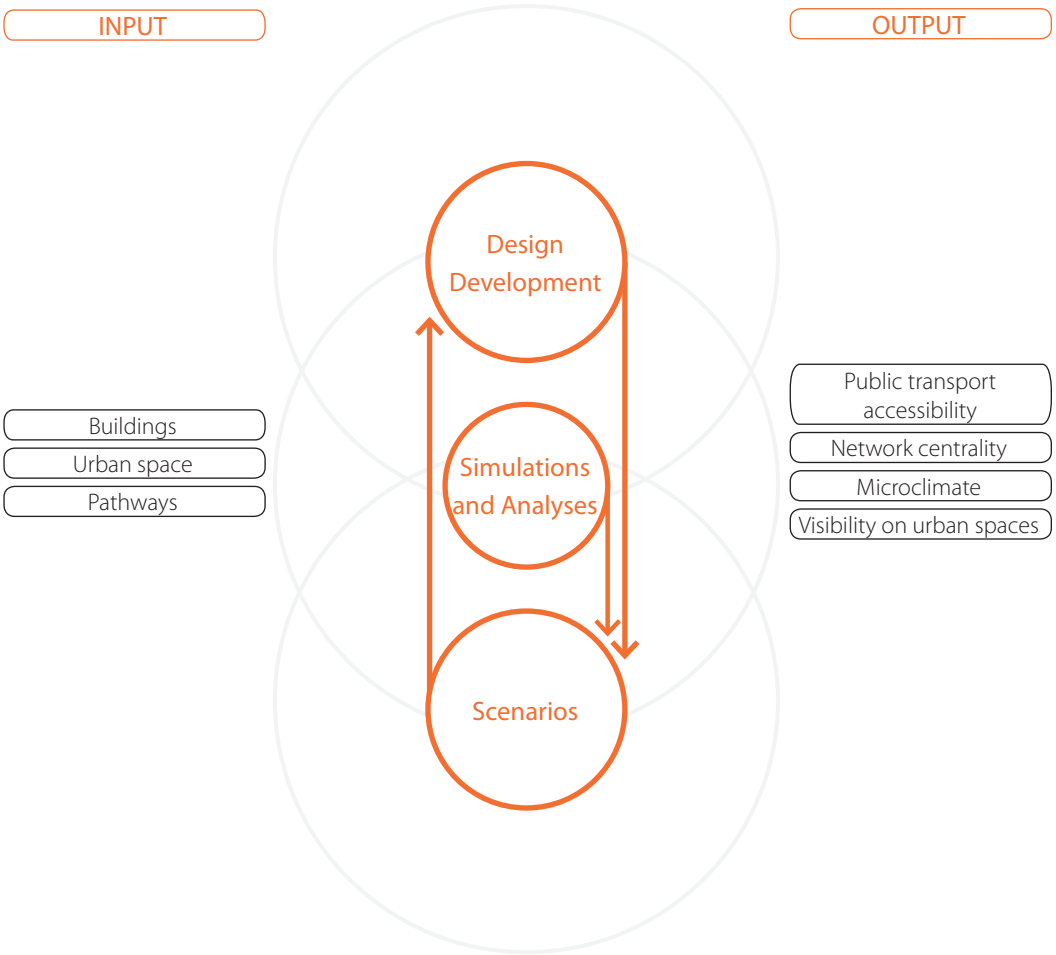
Solar radiation studies are carried out using the plug-in 'Ladybug' in Grasshopper to reveal the differences throughout the typologies. The results of these analyses are shown graphically and in solar hours per anno and m^2 on the building's envelope.

Pedestrian comfort also contributes to the quality of a design and therefore requires attention.

The microclimate map shows the expected temperatures and the stress condition of a person. This stress condition ranges from -3 expressing a strong cold stress to +3 strong heat stress. The calculation was done at noon for the January, 21st as coolest day and August, 21st as hottest day as a representation for the entire year. These numbers are taken by the available whether file (epw) from Vienna Schwechat.

Parameters to describe urban morphology are building coverage ratio (BCR), average building height (BH) and compactness (C).[132]

132 See: Xu/Ren/Ma, Urban morphology detection and computation for urban climate research. (2017, November) https://www.sciencedirect.com/science/article/pii/S0169204617301561?via%3Dihub [09/28/2018]


INPUT
OUTPUT
Design
Development
Simulations
and Analyses
Scenarios
Buildings
Urban space
Pathways
Public transport
accessibility
Network centrality
Microclimate
Visibility on urban spaces

Network Analysis

Information about the city can be retrieved by the use of space syntax analysis methods as described in an earlier chapter of this thesis. This allows to evaluate the centrality of the street and public transport system.

The analysis is carried out on the existing street layout and three path variants for the 'Nordwestbahnhof' territory. As input geometry serves the available street graph by the open data platform of Vienna. For the creation of the different path layouts and the execution of the analysis the components by the DeCoding Spaces Toolbox in Grasshopper were used.

This real time feedback about the centrality measures can be included in the design.

The creation of an optimal solution can be achieved if there is no existing street layout. In case of construction within urban structures the initial streets can be considered in the new street layout. The centrality is shown in a color gradient where orange means that this street segment is located more central. The output values of betweenness and closeness are explained in detail in the theoretical part in the first chapter.

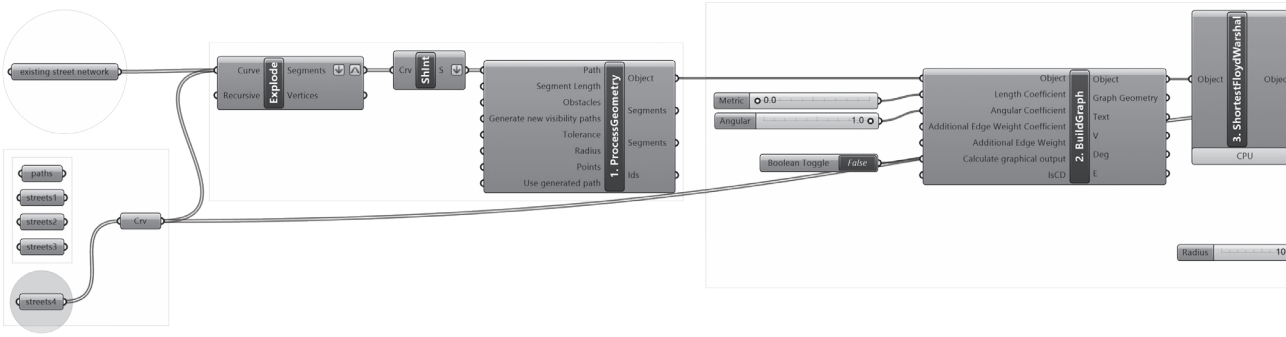
	Betweenness	Closeness	Closeness original	Total street length
Existing network	2 944.0	3 057,9	0.836	
Vision block outlines	3 100.5	3 449.0	0.841	4696.6 m
Street layout 1	3 174.6	3 472.7	0.837	5364.9 m
Street layout 2	3 048.6	3 511.7	0.858	5088.5 m

Paths retrieved from the vision's block outlines from 2008

Street synthesis layout 1

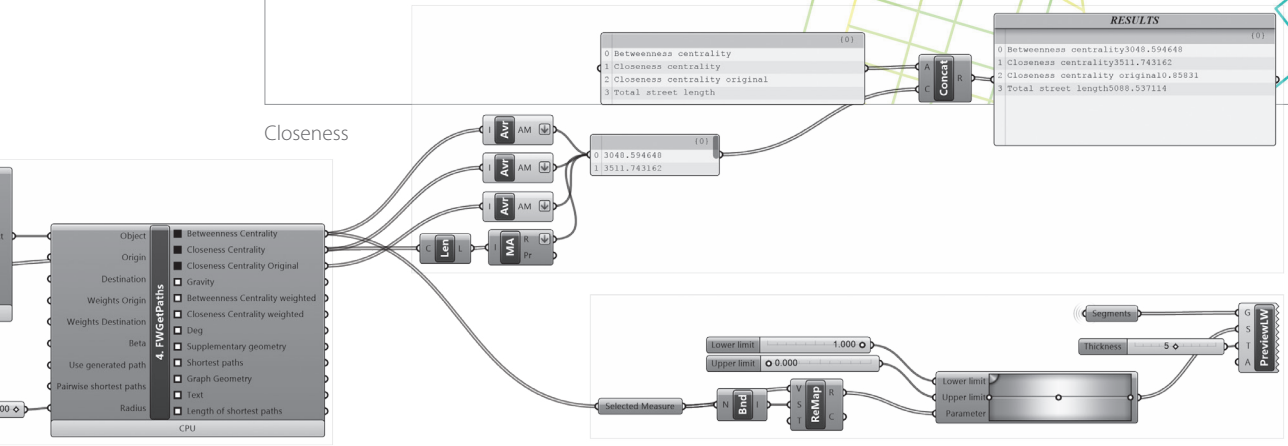
Street synthesis layout 2

Betweenness



Network analysis executed on the existing street network

Closeness


RESULTS
0 Betweenness centrality
1 Closeness centrality
2 Closeness centrality original
3 Total street length
Concat
Avr
AM
Len
MA
4. FWGetPaths
Object
Origin
Destination
Weights Origin
Weights Destination
Beta
Use generated path
Pairwise shortest paths
Radius
Betweenness Centrality
Closeness Centrality
Closeness Centrality Original
Gravity
Betweenness Centrality weighted
Closeness Centrality weighted
Deg
Supplementary geometry
Shortest paths
Graph Geometry
Text
Length of shortest paths
CPU
Lower limit
1.000
Upper limit
0.000
Selected Measure
Bnd
ReMap
Parameter
Segments
Thickness
5
PreviewLW

Train stations	PT1	PT2	PT3
Praterstern	2279	1971	1415
Traisengasse	737	533	1036
Handelskai	1268	1482	1985
Average	1428	1329	1479
Closest	Traisengasse	Traisengasse	Traisengasse

Metro stations	PT1	PT2	PT3
Handelskai	1155	1482	1985
Jägerstraße	1007	1260	1763
Dresdner Straße	520	847	1350
Friedensbrücke	1478	1420	1717
Taborstraße	1926	1599	1152
Praterstern	2279	1971	1415
Average	1394	1430	1564
Closest	Dresdner Straße	Dresdner Straße	Taborstraße

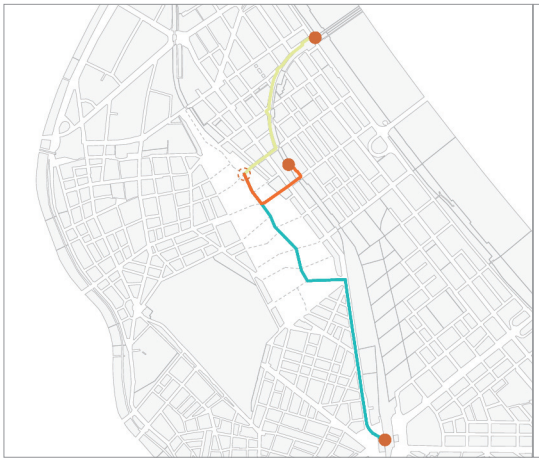
After the evaluation of the street network, the individual routes within it are tested for their true walking distance.

The development of this area provides an immense improvement for the western building blocks of the 20th district. In the current use the area is not crossable and therefore forms a barrier between the train station 'Traisengasse' and the western part of the district.

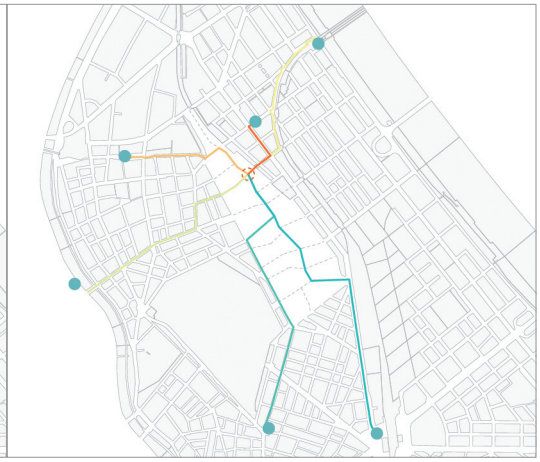
Graph analysis is used to calculate the real walking distances in the road network to the nearby public transport stops. Three locations in the 'Nordwestbahnhof' territory form the starting points and are checked for the shortest routes to the metro and train stations nearby.

The Grasshopper definition used to perform this calculation builds on components of the DeCoding Spaces toolbox. There is also the possibility to weight individual points or segments as it is done by Herthogs et al. (2018) in a further developed graph model.

The allocation of social infrastructure, restaurants and playgrounds can base on this evaluation to ensure an optimal distribution. Due to the accessibility of PT 2 in the centre of the territory, the commercial and office areas are mainly located there, to enable short travel distances for the commuters.

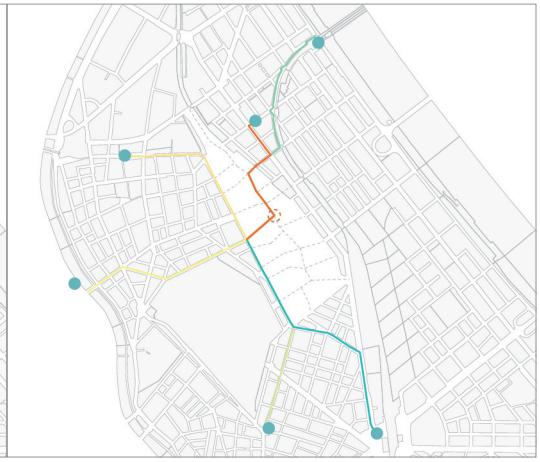


PT 1 shortest paths to train stations

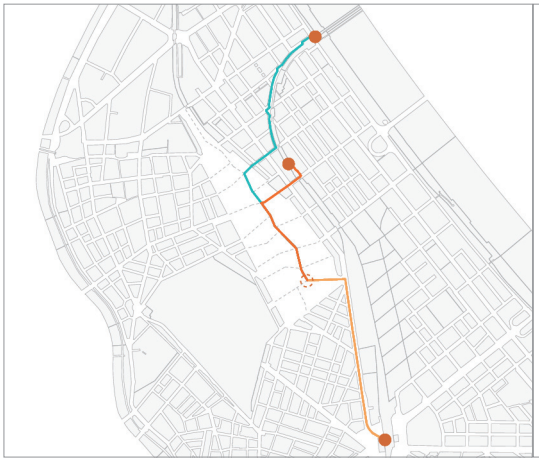


PT 1 shortest paths to metro stations

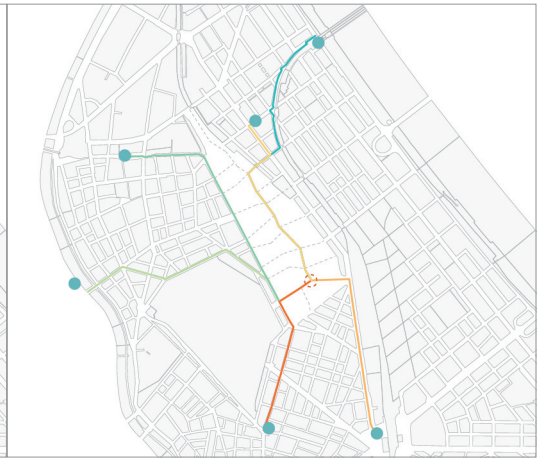
PT 2 shortest paths to train stations



PT 2 shortest paths to metro stations



PT 3 shortest paths to train stations



PT 3 shortest paths to metro stations

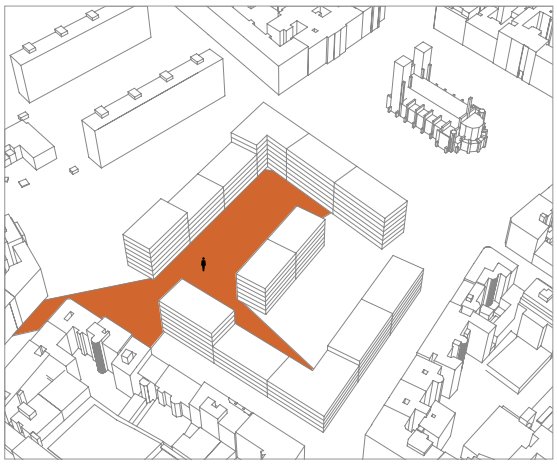
Visual Integration

The visibility analysis is executed for the different typologies by using test points on the public realm that represent the possible locations of a person.

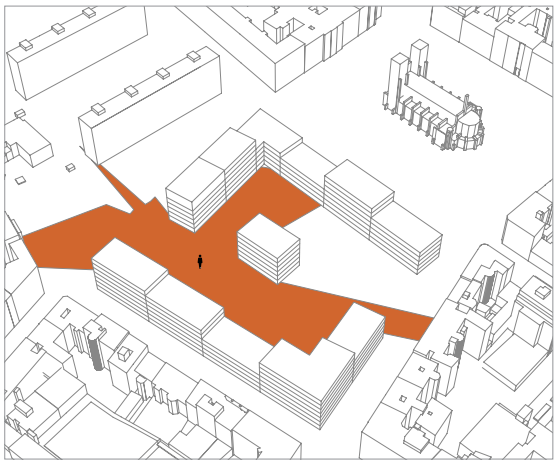
The distance weighted area for one position in each scenario is colored orange. In the following page the figures show the results for 1500 possible location points and their visible area in each scenario. The isovist analysis component by DeCoding Spaces was used for this analysis and includes various other output parameters to explore the public realm.

As the boundary of buildings builds the 'obstacle' for the analysis, this method can be applied on 3D geometry as well by including the volumes of the buildings. The sky factor is a representative output especially within the work in dense districts and structures.

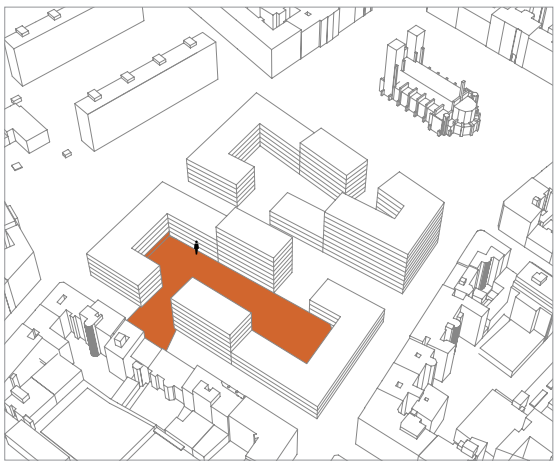
The application of this isovist analysis within the urban planning workflow I regard as very useful as the importance of the eye level of users was named several times during the conducted interviews. If a person feels comfortable on a wide open space or prefers small streets depends on the personal perception, but generally this analysis can be used to describe the public space.



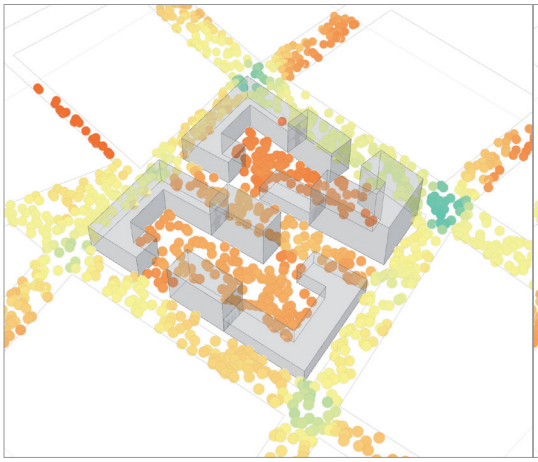
Visible weighted area 6373 m^2



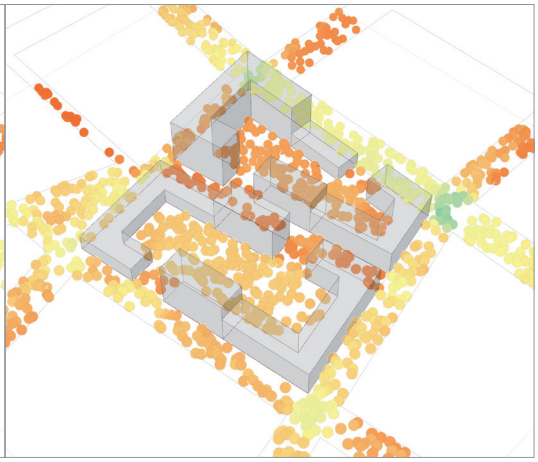
Visible weighted area 9649 m^2



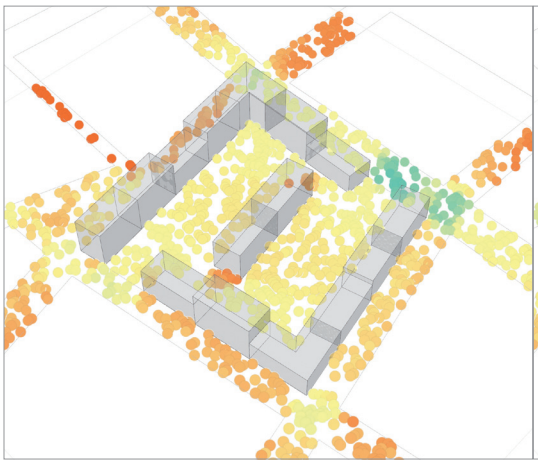
Visible weighted area 3550 m^2



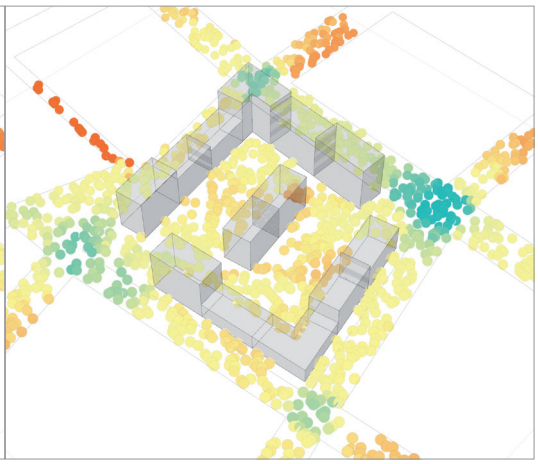
Version 1: Average visible area 5096.7 m^2



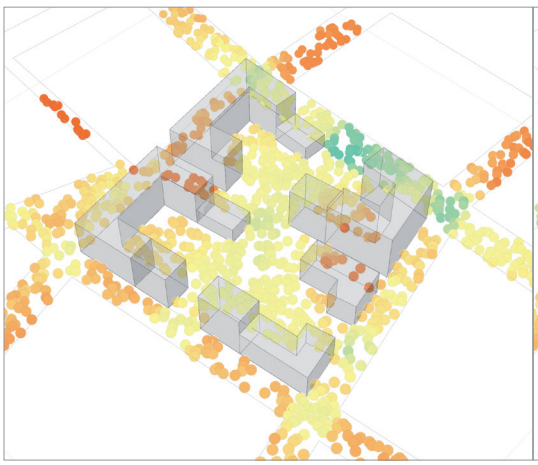
Version 2: Average visible area 5096.7 m^2



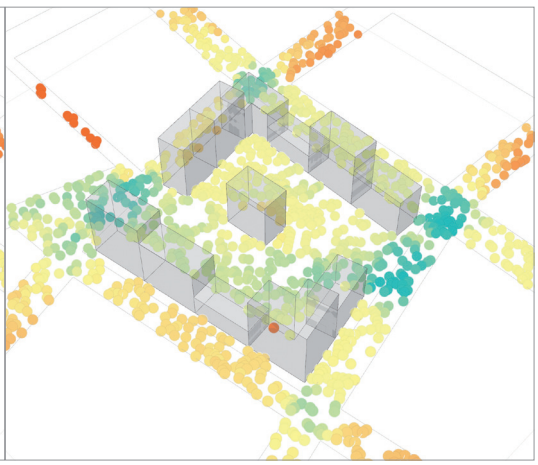
Version 3: Average visible area 5133.8 m^2



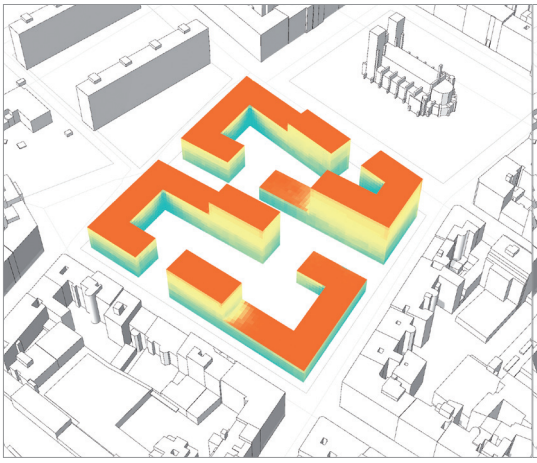
Version 4: Average visible area 6427.2 m^2



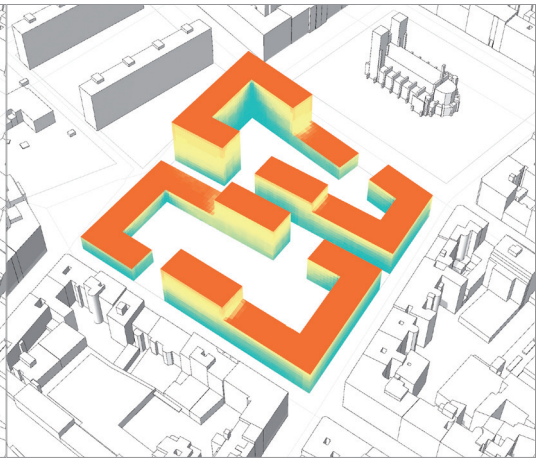
Version 5: Average visible area 5478.9 m^2



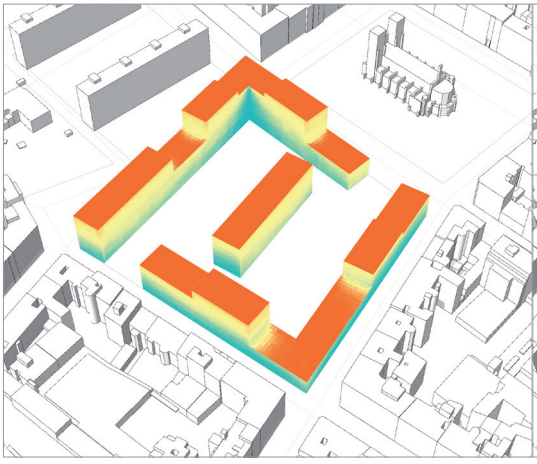
Version 6: Average visible area 7060.4 m^2



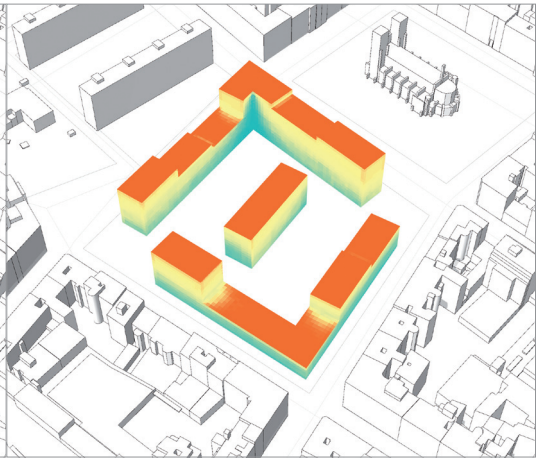
Version 1: Visual integration measure 40.659303



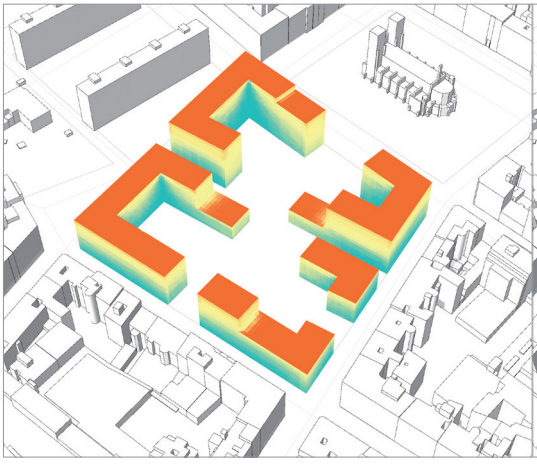
Version 2: Visual integration measure 40.489371



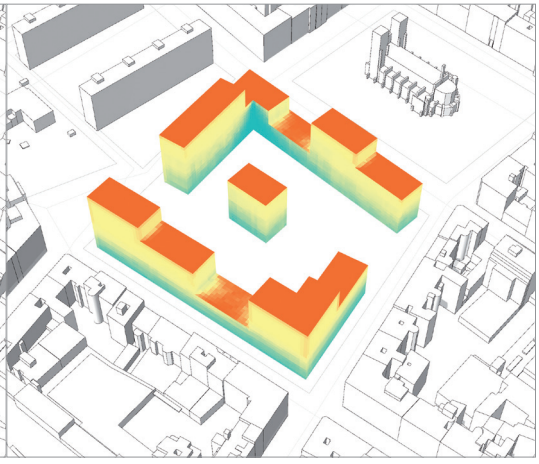
Version 3: Visual integration measure 41.37596



Version 3: Visual integration measure 41.37596



Version 5: Visual integration measure 41.183628



Version 6: Visual integration measure 42.400188

Environmental Analyses

To evaluate the environmental performance of the typologies the solar radiation analysis and the outdoor comfort calculation are executed within the Rhinoceros and Grasshopper workflow.

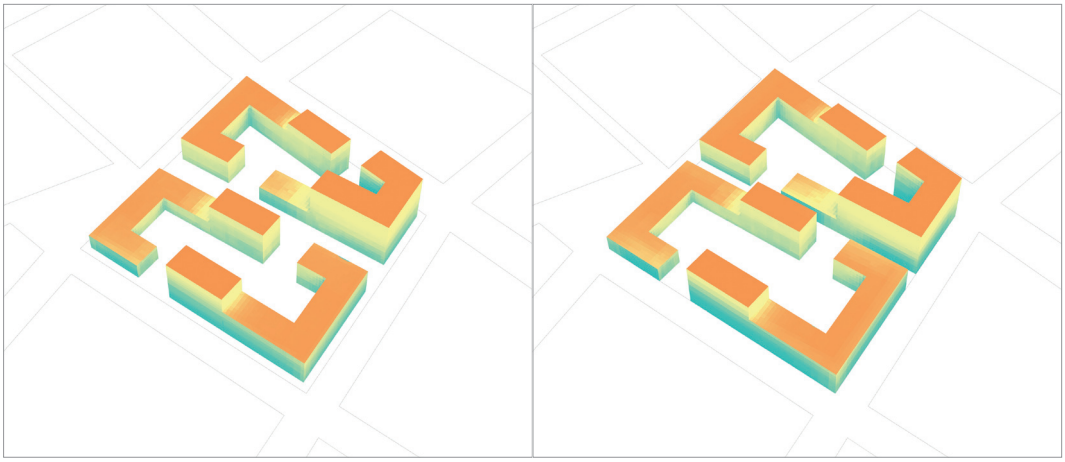
As input for the outdoor comfort calculator by 'Ladybug' the building geometry and weather files (epw, stat) for the location are needed. The closest location with available weather data is Vienna International Airport Schwechat.

The analysis can be executed for a whole year or a selected analysis period. The output of this component is the universal thermal climate index (UTCI), the condition of the person in form of a stress level and the percentage of time this space is considered as comfortable.

The UTCI value is given in degrees and describes how the weather situation is felt by a person including the solar radiation, humidity and wind speed.[133]

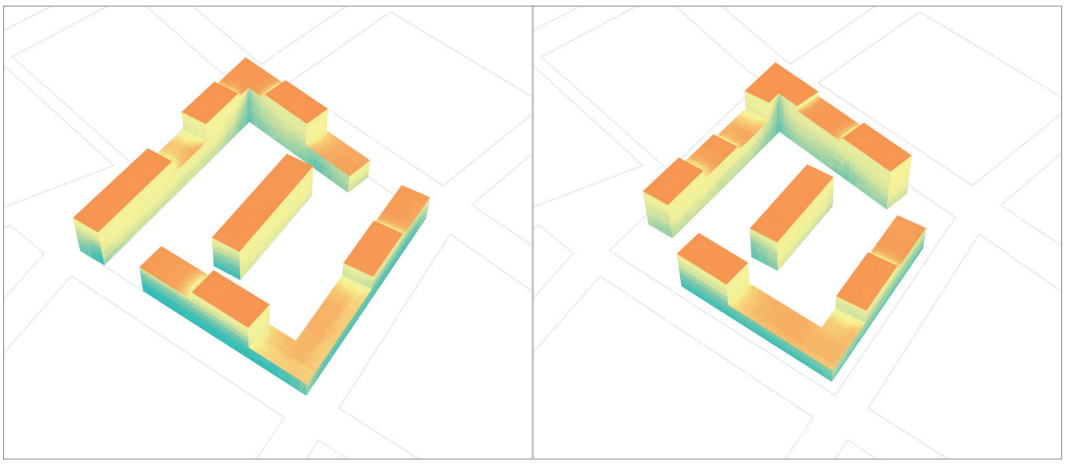
The solar radiation analysis shows the average solar radiation per year and m^2 of the building's envelope. The outdoor comfort calculation is executed for the hottest and coldest day of the year that is stored on the epw file.

133 See: Grasshopper: https://rhino.github.io/components/ladybug/outdoorComfortCalculator.html [10/07/2018]



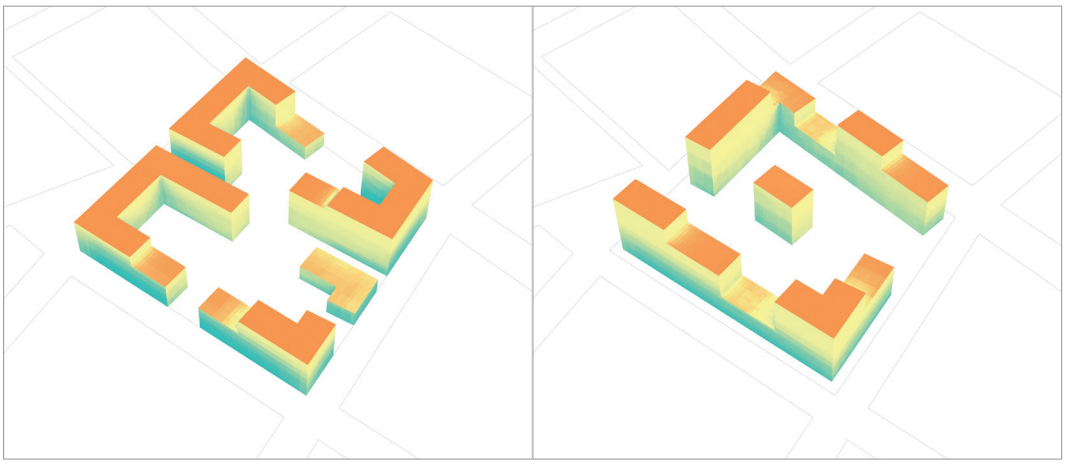
Version1: 525 solar hours/m²anno

Version 2: 508 solar hours/m²anno



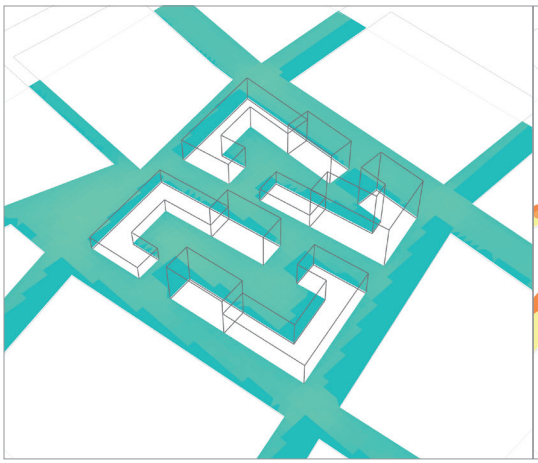
Version 3: 530 solar hours/m²anno

Version 4: 539.5 solar hours/m²anno

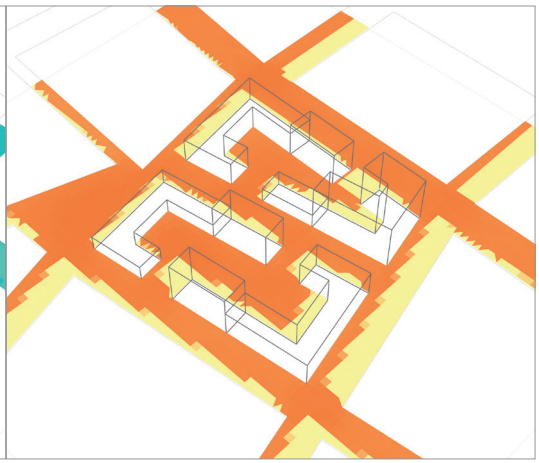


Version 5: 499 solar hours/m²anno

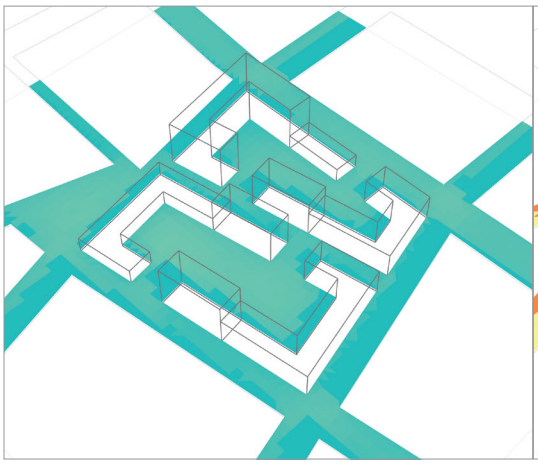
Version 6: 508 solar hours/m²anno



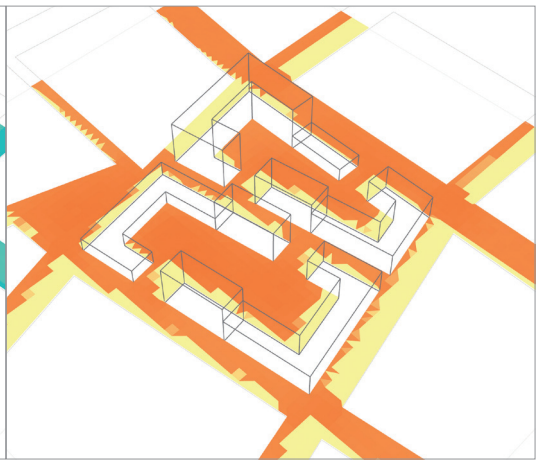
Version 1: Universal thermal climate index 29.03851



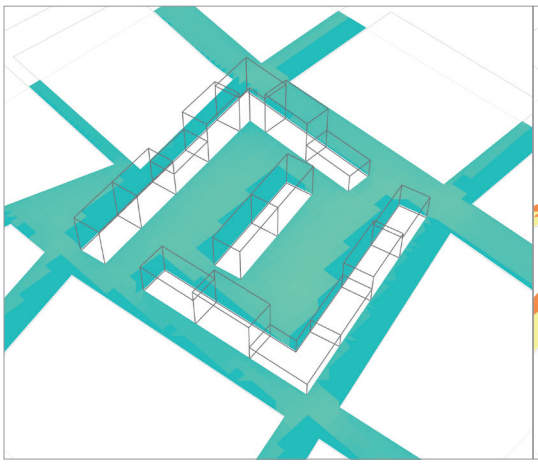
Version 1: Universal thermal climate index 29.25533



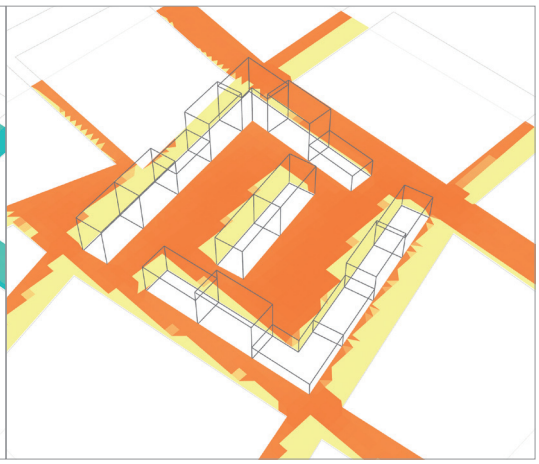
Version 2: Universal thermal climate index 8.693858



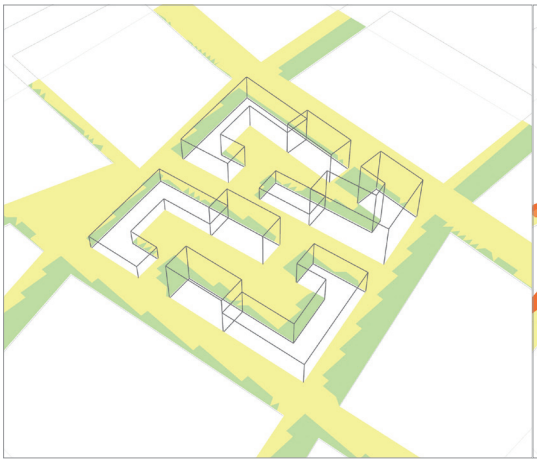
Version 2: Universal thermal climate index 29.005109



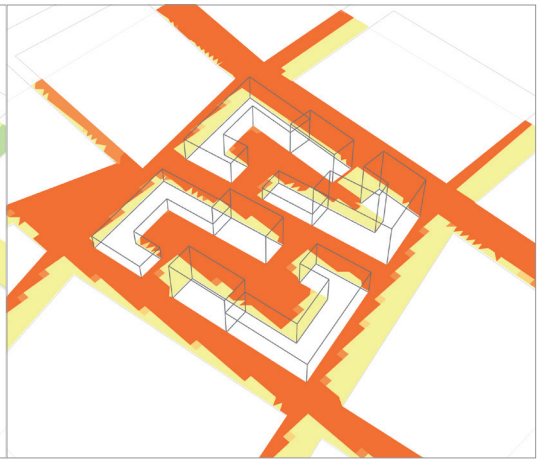
Version 3: Universal thermal climate index 8.62563



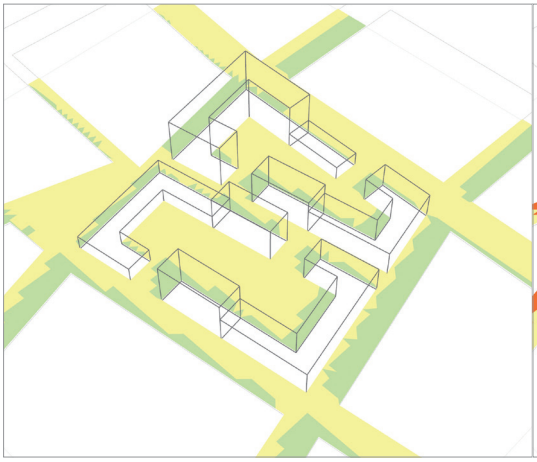
Version 3: Universal thermal climate index 28.955297



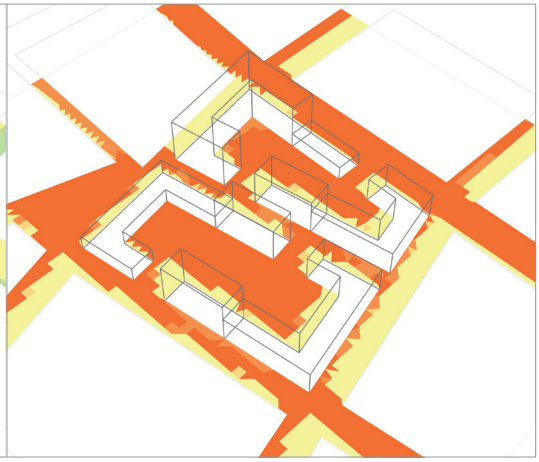
Version 1: Condition of the person -0.363857



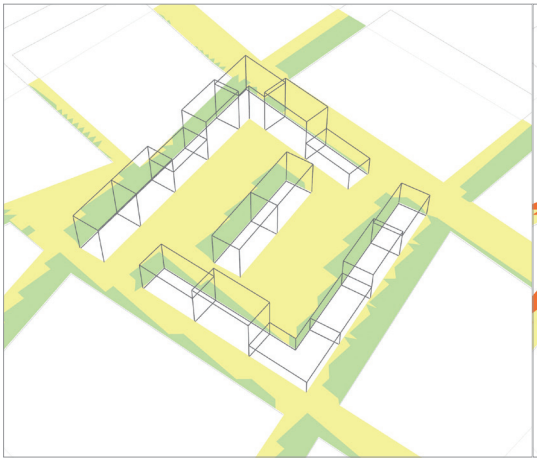
Version 1: Condition of the person 1.857258



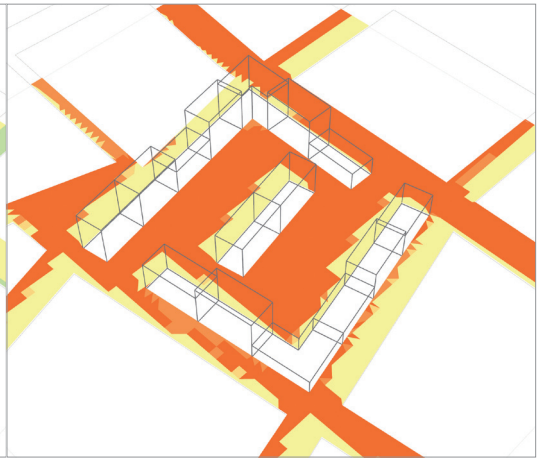
Version 2: Condition of the person -0.386364



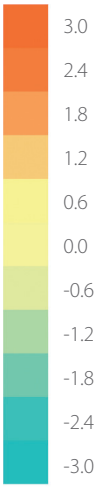
Version 2: Condition of the person 1.746148

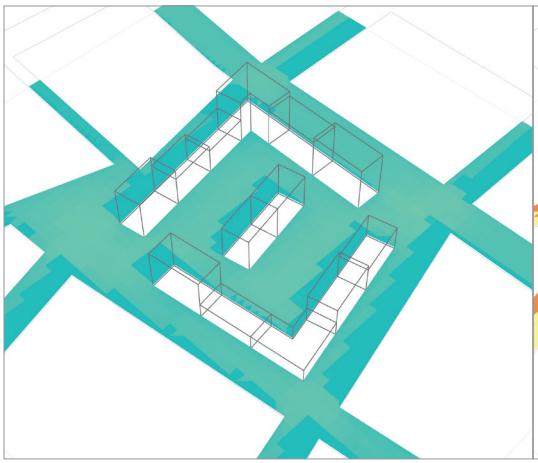


Version 3: Condition of the person -0.393506

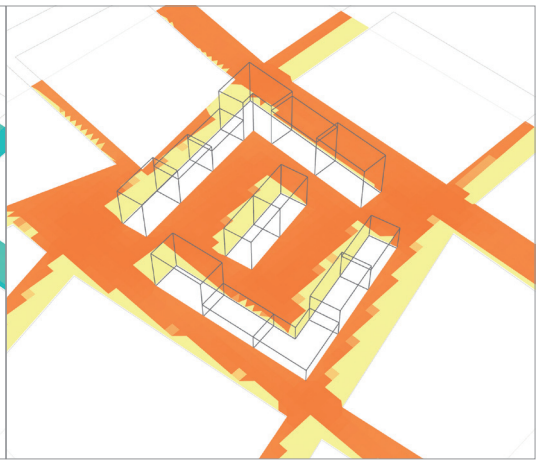


Version 3: Condition of the person 1.734441

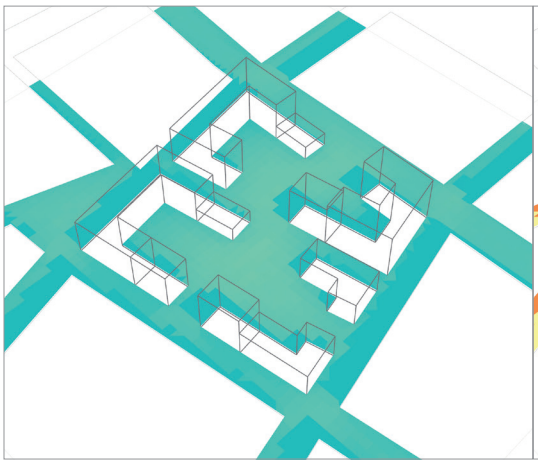




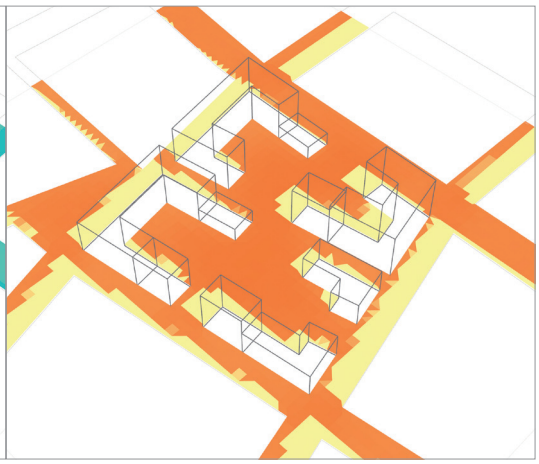
Version 4: Universal thermal climate index 9.041816



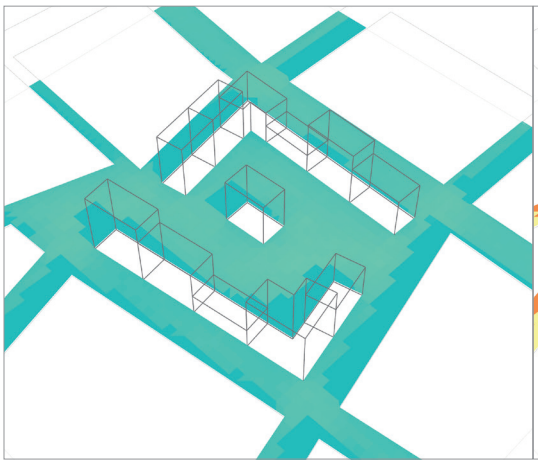
Version 4: Universal thermal climate index 29.262154



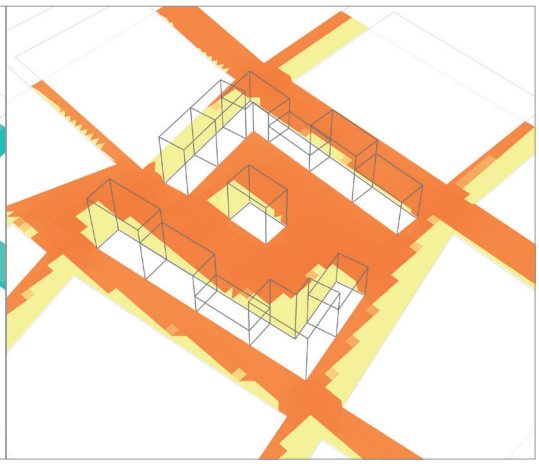
Version 5: Universal thermal climate index 8.676767



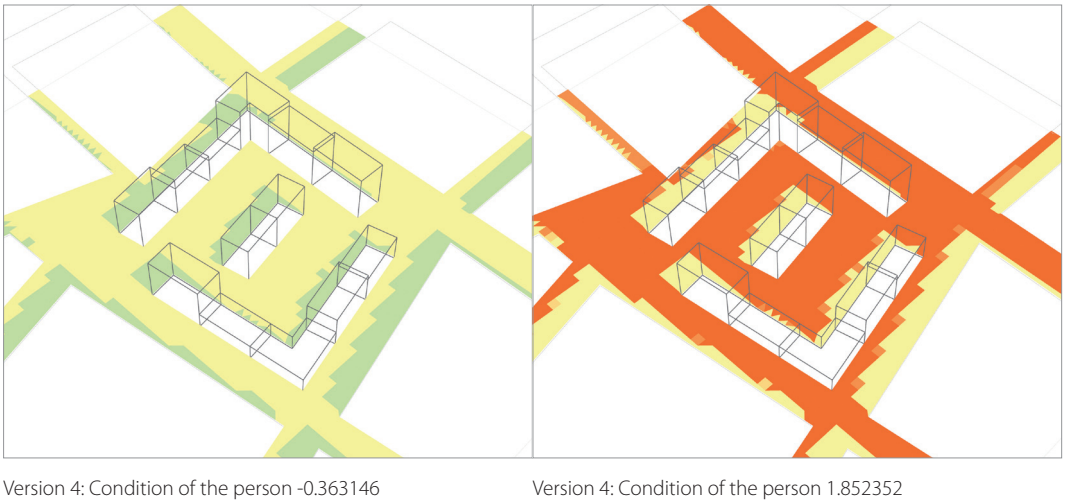
Version 5: Universal thermal climate index 29.000885



Version 6: Universal thermal climate index 8.997056

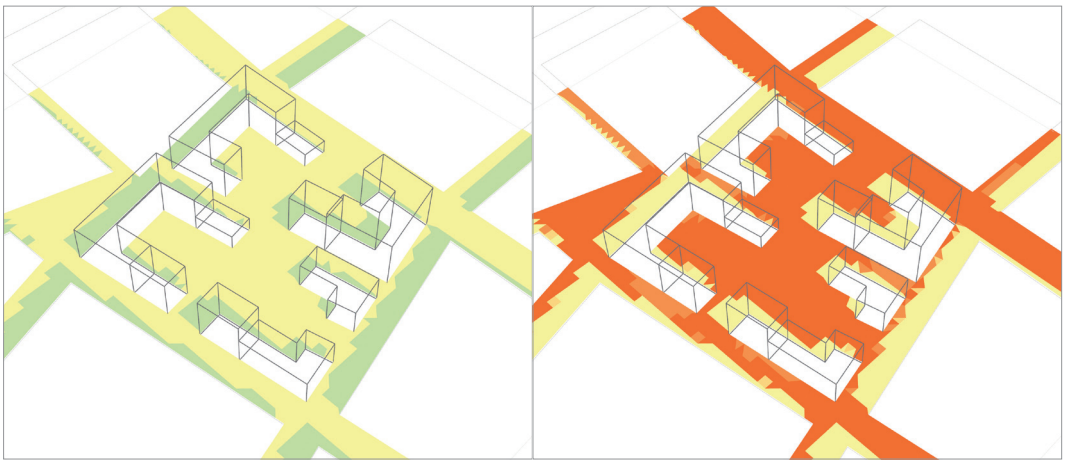


Version 6: Universal thermal climate index 29.234056



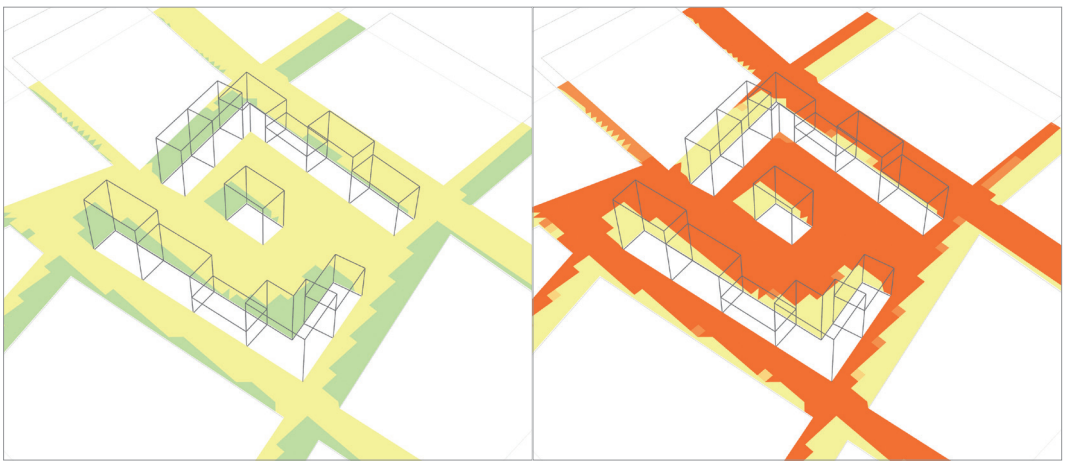
Version 4: Condition of the person -0.363146

Version 4: Condition of the person 1.852352



Version 5: Condition of the person -0.388294

Version 5: Condition of the person 1.735272



Version 6: Condition of the person -0.363917

Version 6: Condition of the person 1.849653

Microclimate Analysis

The evaluation of the microclimate performance is carried out in the environmental standalone analysis software Envimet. The import of the evaluation output files by Envimet is currently supported via Ladybug components for Grasshopper.

Once the building geometry is developed and the tree arrangement including their height and soil attributes are defined, the export is the next step. In this step, the boundary curves are exported to a shape file using the PYSHP library. After this procedure the files were given to a colleague of mine to examine the Envimet calculation.

This evaluation was conducted by Romana Stollnberger who is working as a Junior Research Engineer at the AIT Austrian Institute of Technology in Vienna.

The results of the evaluation were imported back to Grasshopper and further investigated by me. The reason for this procedure is the consideration of different available software applications for microclimate analysis and to compare the results and performance.

The comparison of the processing time is in favor of Ladybug which comes to a result within minutes, but in a lower level of detail. Since the calculation in Envimet took 13 hours of computing time for one typology on a single day, it is recommended to examine selected scenarios in more detail. In my opinion it can be classified as suitable for the use in urban development processes in exchange with Rhinoceros and Grasshopper.

The comparison of different typologies and scenarios within the user interface of 'Ladybug' with a closer look at the shortlisted variants in Envimet is integrated in the workflow. There are more analysis and simulation applications available that execute microclimate studies, like the QGIS plug-in Umep which has not been used for this thesis, but could be included in future research.

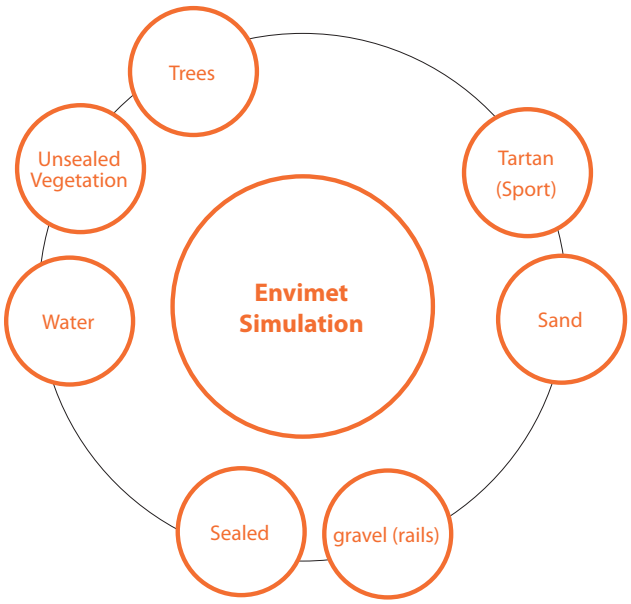
The export files for the 'Envimet' simulation include, as shown in the figure below, the soil attributes, building and tree heights. For the setup of the typologies the green in the courtyards was defined as unsealed and the paths as concrete.

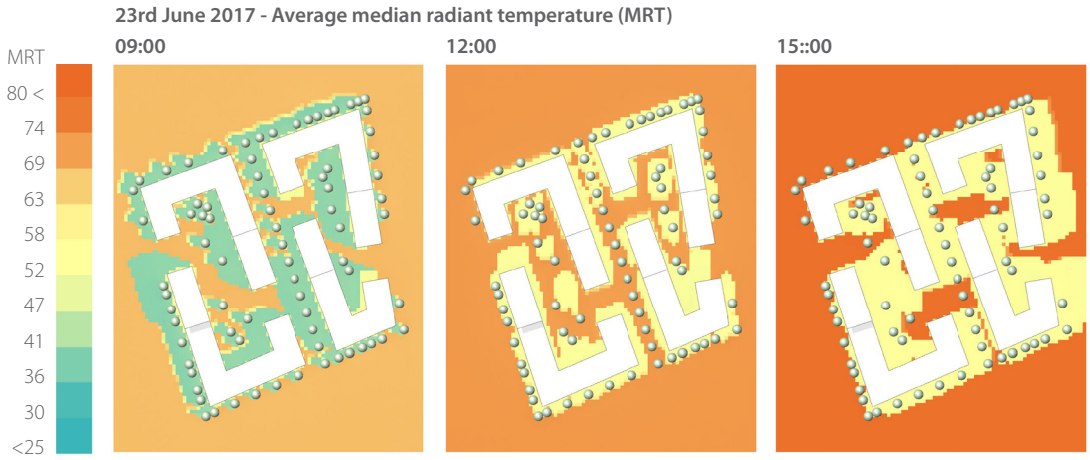
Due to the results of the analysis the average surface degree on one day at different times is shown in the graphics. As mentioned earlier in the theoretical part of this thesis the urban climate gains in importance and should be considered in the early stages of urban plannings.

The first typology is characterized by green courtyards, many trees, green sky gardens, and created by the block typology component. The buildings have five meter distance to the street and offer additional green spaces and a wider pedestrian sidewalk.

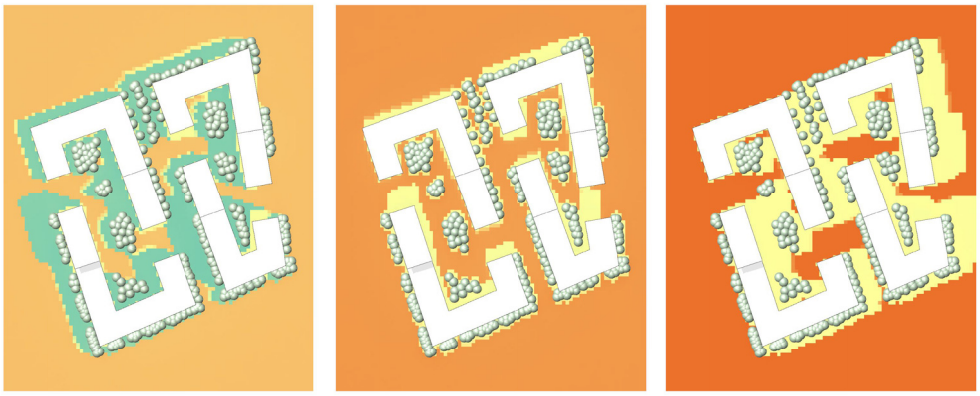
The second test scenario is based on the same setting of geometry, but includes more trees and green facades as shown in the diagram. The impact of increasing the green is tested to evaluate the microclimate performance of the different landscape arrangements.

A third scenario consists of the L-typology with one courtyard and a central placed building. Green sky gardens and trees are included but no green facades were considered for the calculation.

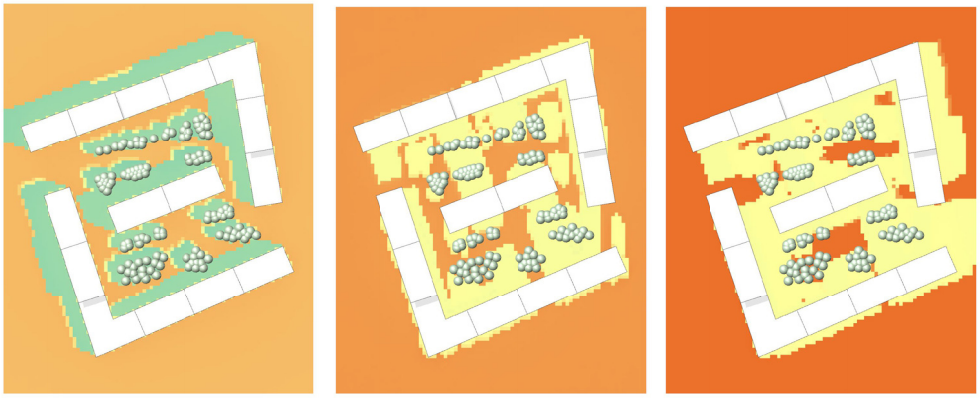




Typology 1 MRT performance evaluation

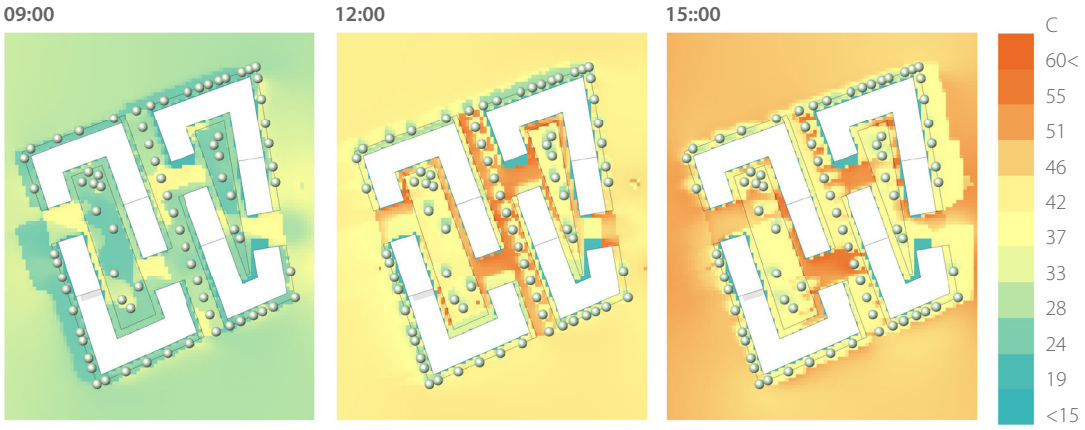


Typology 1 + green facades and more trees, MRT performance evaluation

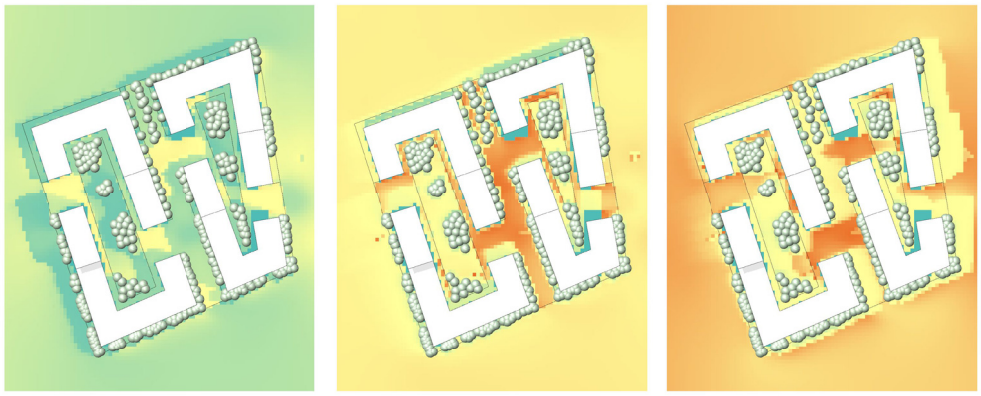


Typology 2 MRT performance evaluation

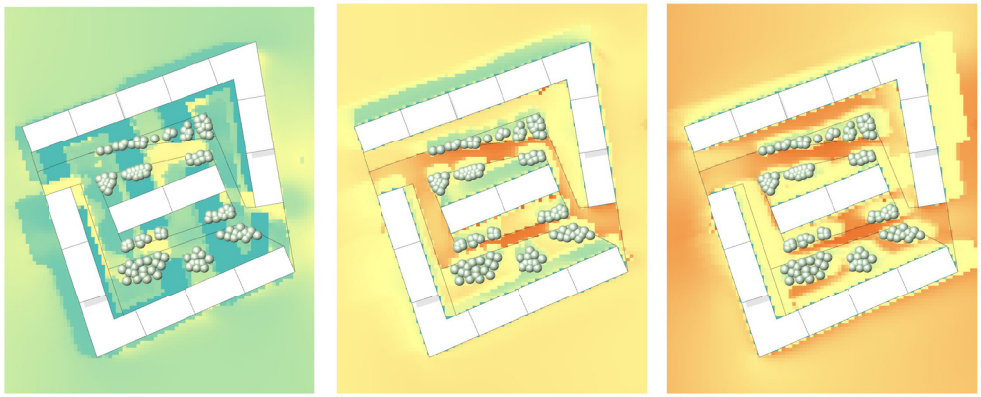
23rd June 2017 - Average surface temperature



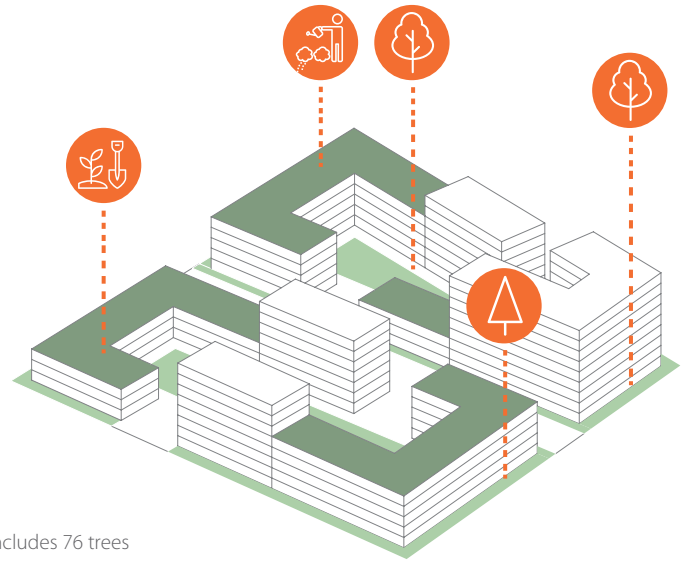
Typology 1 average surface temperature



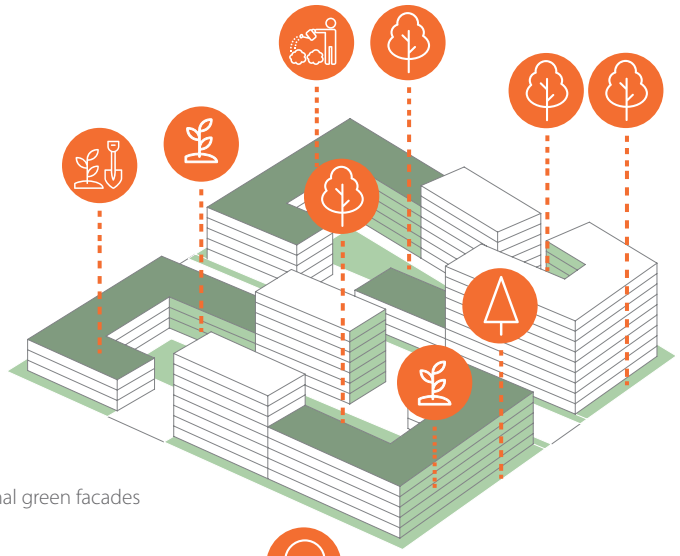
Typology 1 + green facades and more trees, average surface temperature



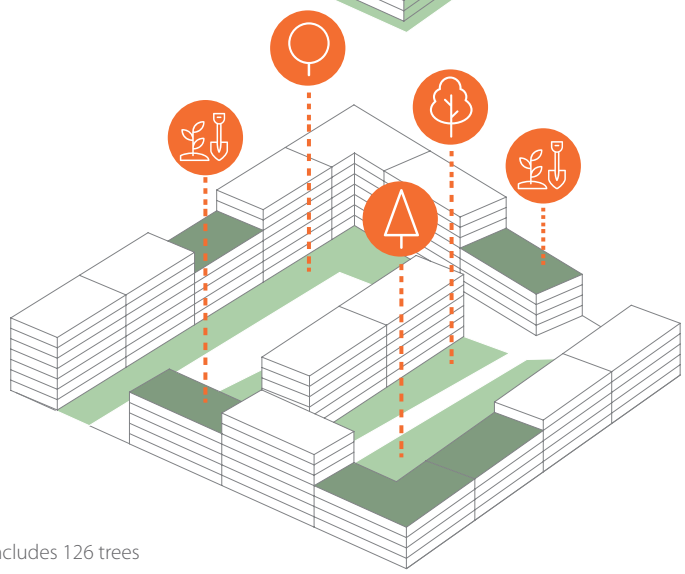
Typology 2 average surface temperature



Envimet typology 1 includes 76 trees



Envimet typology 1
302 trees and additional green facades



Envimet typology 2 includes 126 trees

	09:00	12:00	15:00	19:00
Typology 1	27.161954	36.675912	39.186636	28.56815
Typology 1 +	26.821519	36.241697	38.955961	28.482419
Typology 2	27.277009	36.470691	39.431808	28.469301

	MRT 09:00	12:00	15:00	19:00
Typology 1	56.138024	63.866893	65.470731	30.796897
Typology 1 +	55.223792	62.873382	65.183981	30.796897
Typology 2	56.807809	64.030419	67.703476	30.796897

To read the analysis output of the Envimet calculation an explanation for the given values is necessary. The surface temperature is expressed in degrees while the mean radiant temperature (MRT) is a combination of different factors and gives the measured average temperature of the surrounding surfaces of a point differing between inside and outside.

MRT = globe temperature + 2.42 x air velocity in m/s (globe temperature – air temperature)[134]

The globe thermometers (Vernon 1930) gives an accumulated value of the radiation, air temperature, air velocity on the human comfort.[135]

As a clear result of this calculation can be said that the implementation of trees and green facades have a positive effect on the urban climate. The temperature differences might seem minor in numbers, but during hot summer days one degree temperature difference means a lot.

The integration of many trees in the design proposals around and inside the blocks is retrieved by this analysis.

134 Designing Buildings Wiki: https://www.designingbuildings.co.uk/wiki/Mean_radiant_temperature [10/07/2018]

135 See: Designing Buildings Wiki: https://www.designingbuildings.co.uk/wiki/Mean_radiant_temperature [10/07/2018]

6.2.5 Scenario Evaluation

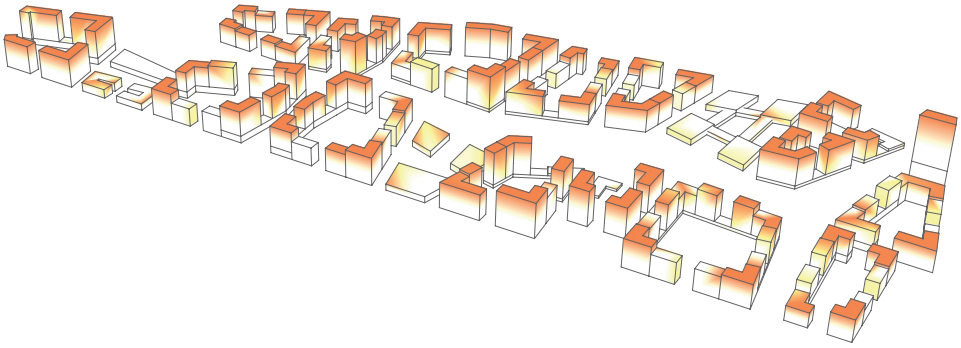
A comparison of the different typology versions shows the results of geometry, solar radiation, visual integration and microclimate on a normalized scale. Typology two (L) that was chosen in version four shows the best performance and is characterized by an open building structure and includes a distance to the street. As a result of this comparison, the retrieved knowledge is incorporated into the following design proposals.

The comparison of different design proposals is divided in categories. The use is evaluated in m^2, use-mix and distribution of density. The developed design tool can create different density settings, but is set to the space requirement of the vision for the 'Nordwestbahnhof' in order to achieve a decision base for further elaboration.

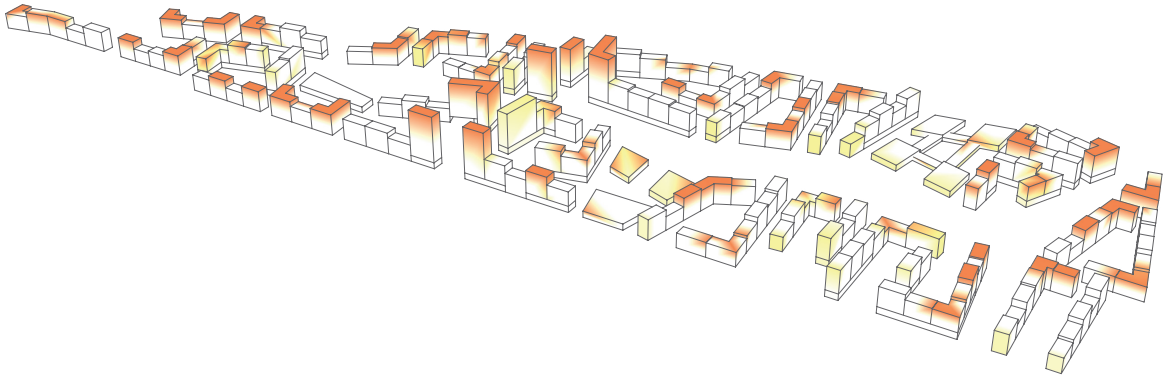
Environmental aspects are mainly expressed by the execution of solar and microclimate studies. The experiments with different analysis applications showed that microclimate analysis takes a long time to run. The Grasshopper plug-ins 'Ladybug' and 'Honeybee' and the standalone software 'Envimet' were tested on the usability and performance.

Traffic analysis is mixed with the accessibility studies and walking distances as the implementation of motor vehicle routes is not part of the concept.

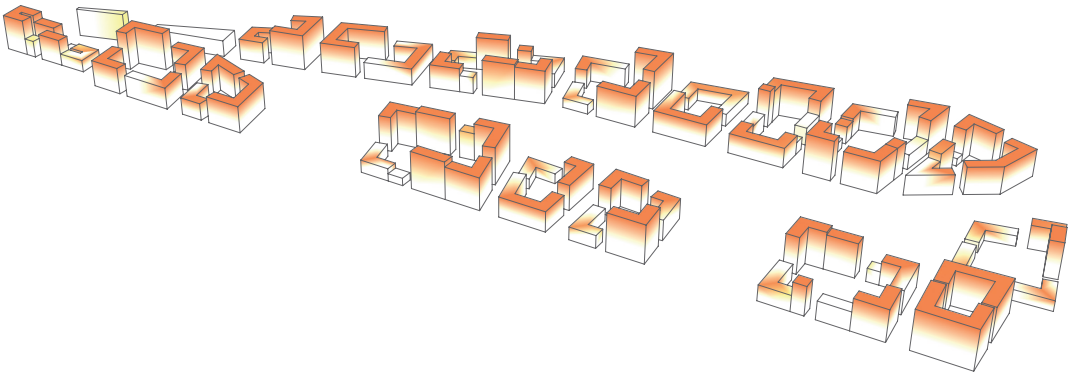
	1	2	3	4	5	6
Building Coverage Ratio (BCR)	43.470854	48.808668	43.233422	36.117775	42.070456	33.399564
Density	2.477072	2.790593	2.730805	2.326998	2.87109	2.888657
Compactness	0.298819	0.294583	0.298038	0.299958	0.307262	0.272227
	-	-	-	+	+	+
Solar hours/m²anno	525,00	508,00	530,00	539.5	499,00	508,00
	-	-	+	+	-	-
Percent of Time comfortable (winter)	63.614328	61.363636	60.649401	63.685428	61.17062	63.608327
Percent Comfortable for short Periode (winter)	36.385672	38.636364	39.350599	36.314572	38.82938	36.391673
Universal Thermal Climate Index (winter)	9.03851	8.693858	8.62563	9.041816	8.676767	8.997056
Condition of Person (winter)	-0.363857	-0.386364	-0.393506	-0.363146	-0.388294	-0.363917
	+	-	-	+	-	+
Percent of Time comfortable (summer)	35.900889	38.289676	38.886741	35.967618	38.523336	36.16037
Percent comfortable for short Periode (summer)	0.807972	0.808937	0.811751	0.462606	0.803366	0.501157
Universal Thermal Climate Index (summer)	29.25533	29.005109	28.955297	29.262154	29.000885	29.234056
Condition of Person (summer)	1.857258	1.746148	1.734441	1.852352	1.735272	1.849653
	-	+	+	-	-	-
Visual Integration	40.659303	40.489371	41.37596	41.958758	41.183628	42.400188
Average Visible Area	5096.7	5096.7	5133.8	6427.2	5478.9	7060.4
	-	-		+		+



Urban planning scenario 1 - solar analysis

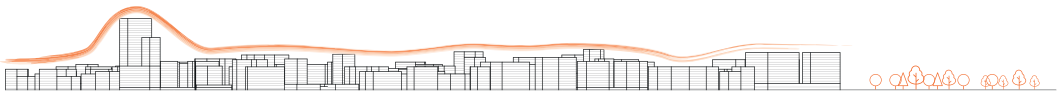


Urban planning scenario 2 - solar analysis

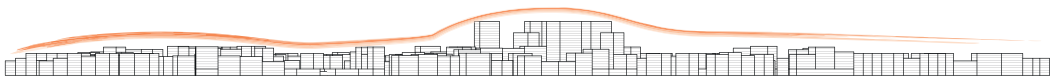


Urban planning scenario 3 - solar analysis

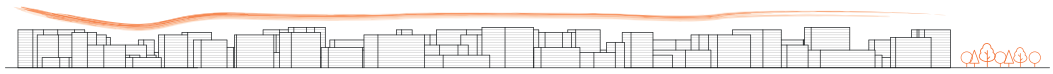
	Scenario 1	Scenario 2	Scenario 3
Sunlight hours/m²anno	4.67	4.66	4.49
Solar hours/m²anno	470.45	480.10	457.43
Plot Coverage	95 896 m²	10 5592 m²	81 586 m²
Building Coverage Ratio (BCR)	22 %	24 %	18 %
Density	1.81	1.87	1.85
Gross Floor Area (GFA)	785 959 m²	811 029 m²	802 728 m²
Average Number of Floors	8,1	7,1	9,8



Urban planning scenario 1 - building heights



Urban planning scenario 2 - building heights



Urban planning scenario 3 - building heights

The comparison of the three developments reveals that scenario two, that consists of the l-shaped building typology shows the best performance for the sun exposure, even though it has the highest density. The average number of floors per building is the lowest and therefore refers to the human scale while the area requirements are fulfilled.

The wide open green spaces seem attractive, but probably not affordable for this central location in Vienna, since the Augarten is located right next to this development territory.

The comparison of the height development of the scenarios shows significant differences whereas the first and third scenario include a urban gardening in the north of the site.

Design Explorer

The online design exploration tool 'Design Explorer' is used to compare the generated typologies under the aspects of GFA, density, shape and evaluated performance values. This allows to browse through all possible solutions and consider variants that might end up as the best solution.

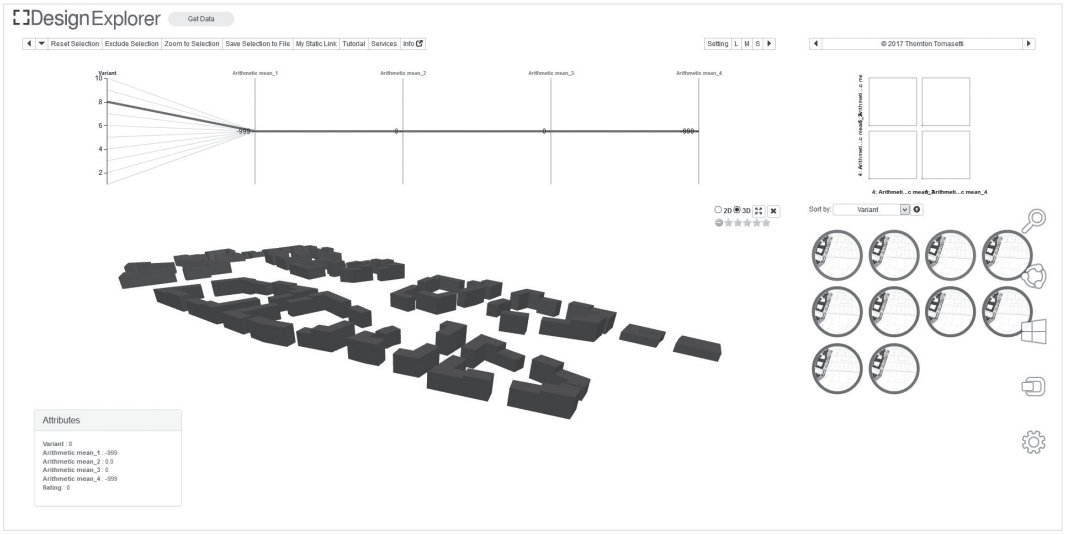
As the procedural generation of geometric scenarios easily reaches a high number of different scenarios the selection, filtering and short listing is really important. Only via doing selections and heading in a certain direction by analysis of the evaluation outcome it is possible to increase the level of detail.

For the use of the Design Explorer the library Anemone within Grasshopper is needed to export the csv-file, images and 3D specle files.

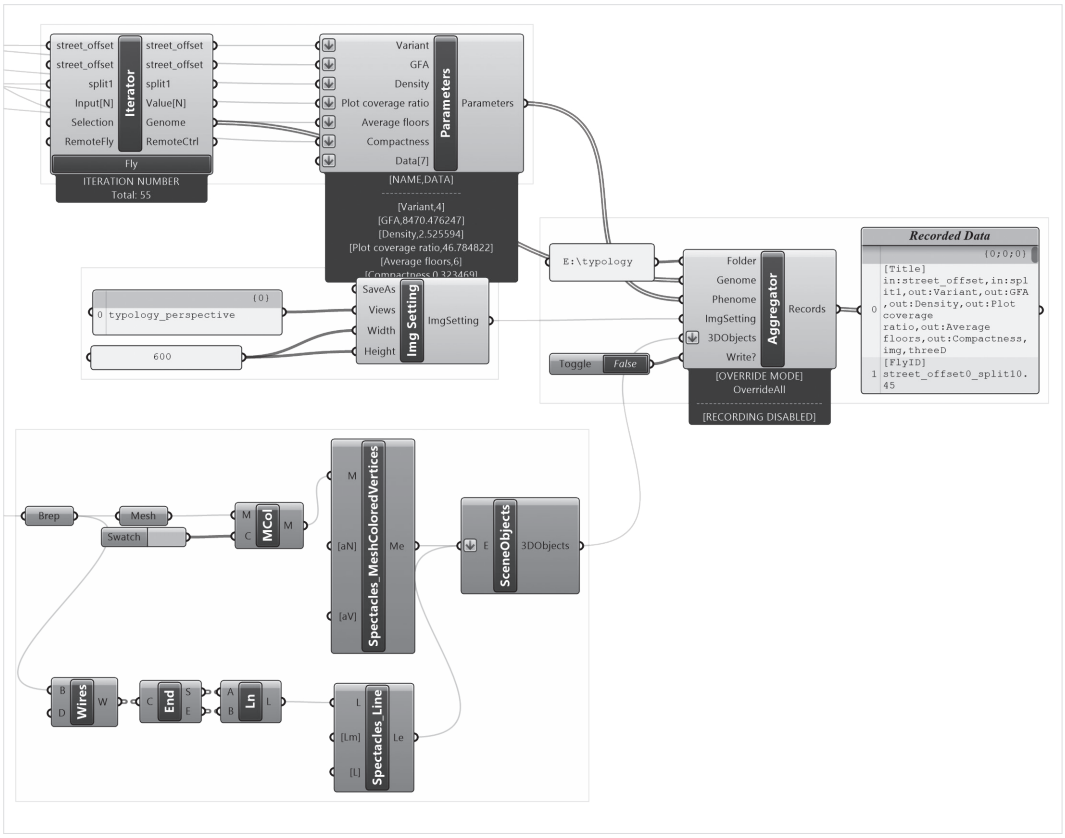
This workflow includes the storing of keys and values in the csv-file to filter and sort the different variants within the exploration space.

It is important to widen the different parameters to get scenarios you would not regard as suitable but might be the best performing solution. The online interface allows to share the link to the comparison, save a selection and filter the uploaded variants regarding their parameter range. Which parameters are shown and used for the selection is possible to switch in an intuitive way. This tool might be very useful in negotiation processes with neighbors, stakeholders and cities.

Only if the uploaded scenarios contain meaningful parameters, the use of this tool is supportive, otherwise it ends up clicking through and selecting randomly.



Interface of the Design Explorer with uploaded 3D geometry



Grasshopper defintion to export geometry and attributes as csv-, jpeg- and geojson-file

Design Space Exploration

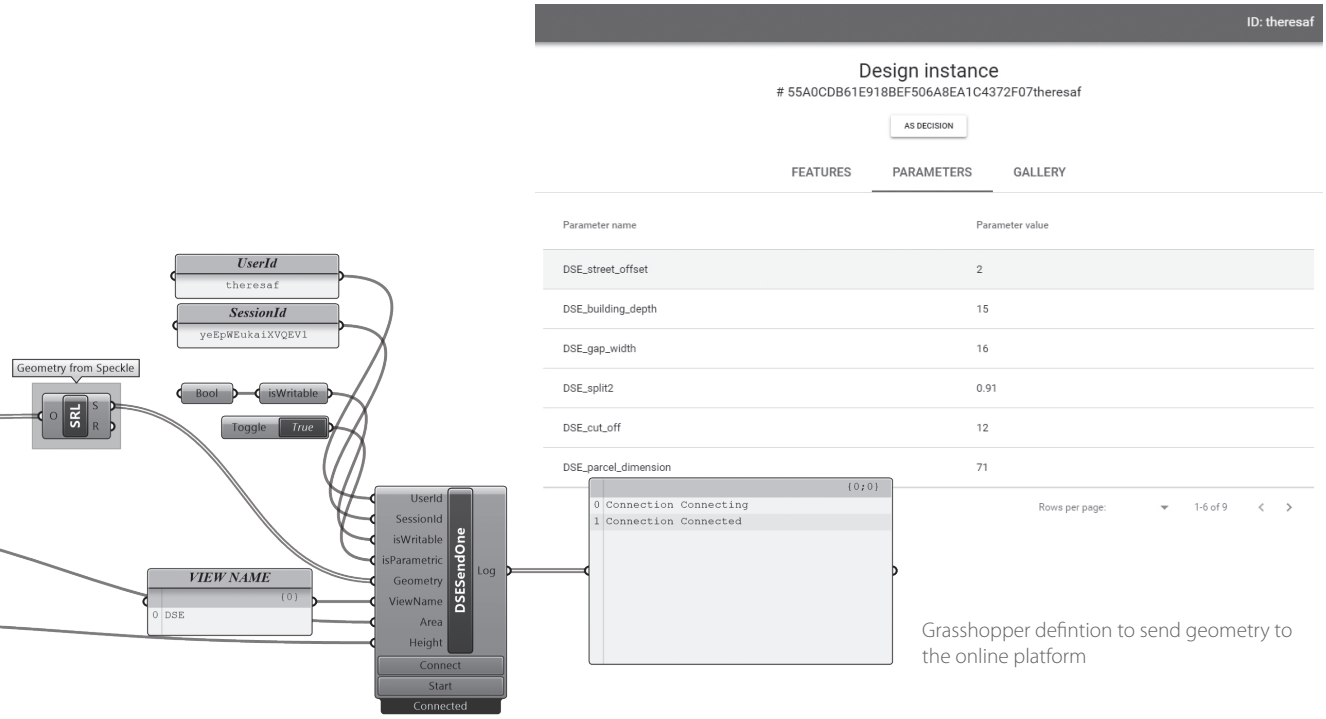
The design space exploration framework introduced by Fuchkina et al. (2018) allows to filter, select and cluster design variants as described in the related work chapter.[136]

This methodology supports the comparison of different design variants by the use of DeCoding Spaces Grasshopper components to send scenarios to the server and the online exploration tool. The upload includes the geometry, stores the input parameters and allows to sort and filter by evaluation results. The self-organizing map locates similar solutions close to each other and visually presents the performance of scenarios.

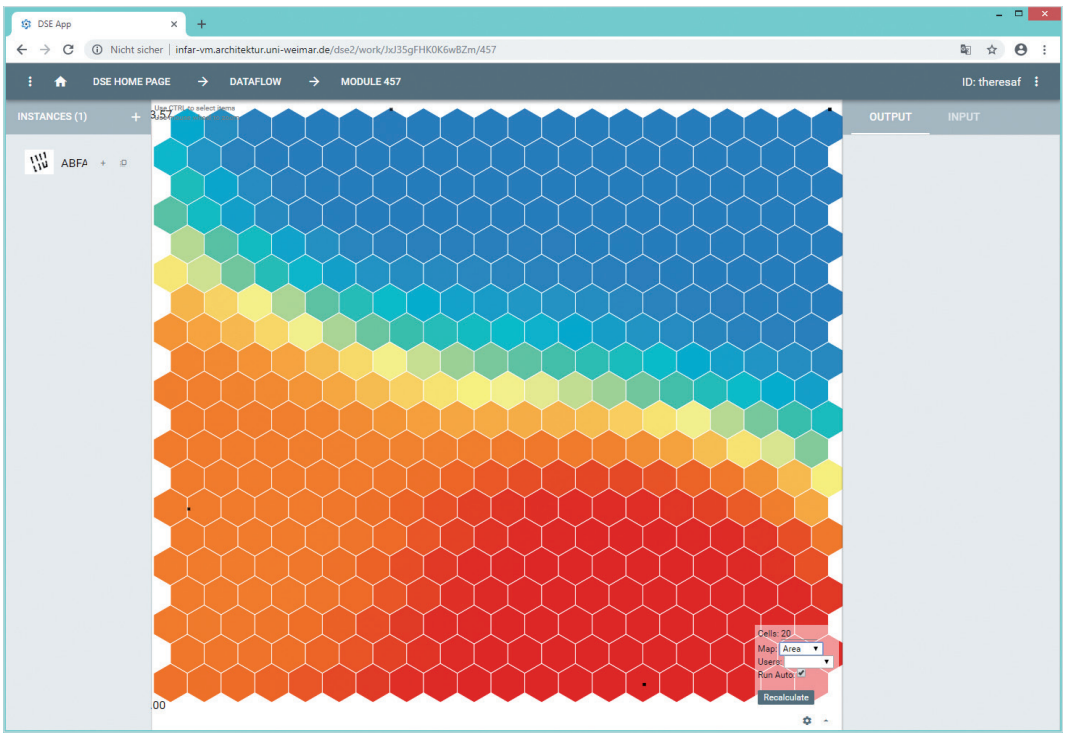
Selected scenarios can be marked as 'decision' and added to the shortlist for the next decision stage.

While the analysis results are used to filter the scenarios and locate the variants within the exploration space the input parameters are stored online as well. This I regard as very useful, since the ruling parameters of the model need to be known, to understand the relation between input and performance.

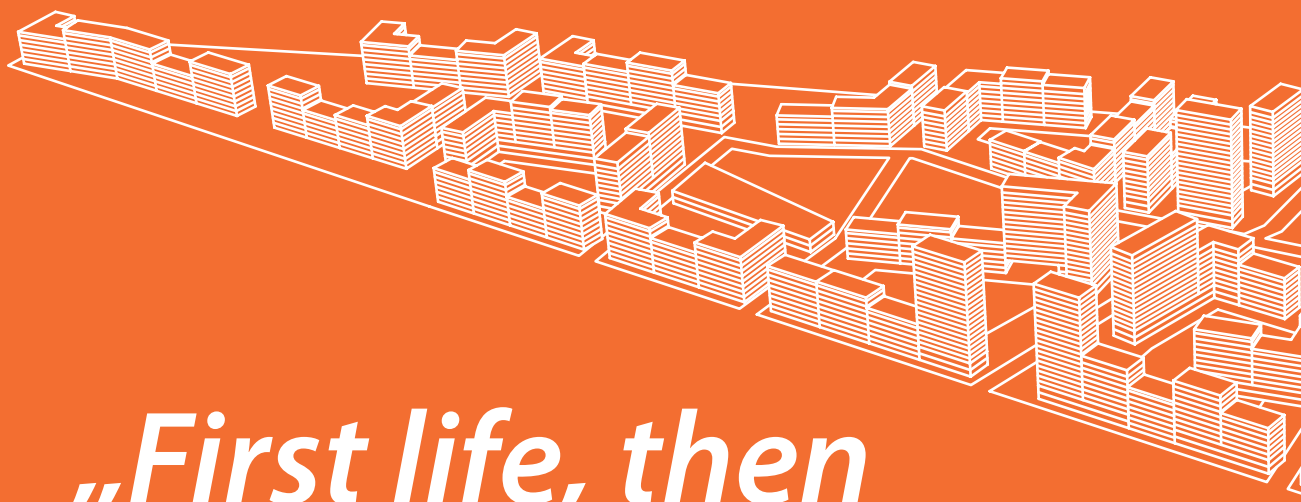
136 See: Fuchkina/Schneider/Bertel 2018, 370.



Grasshopper defintion to send geometry to the online platform



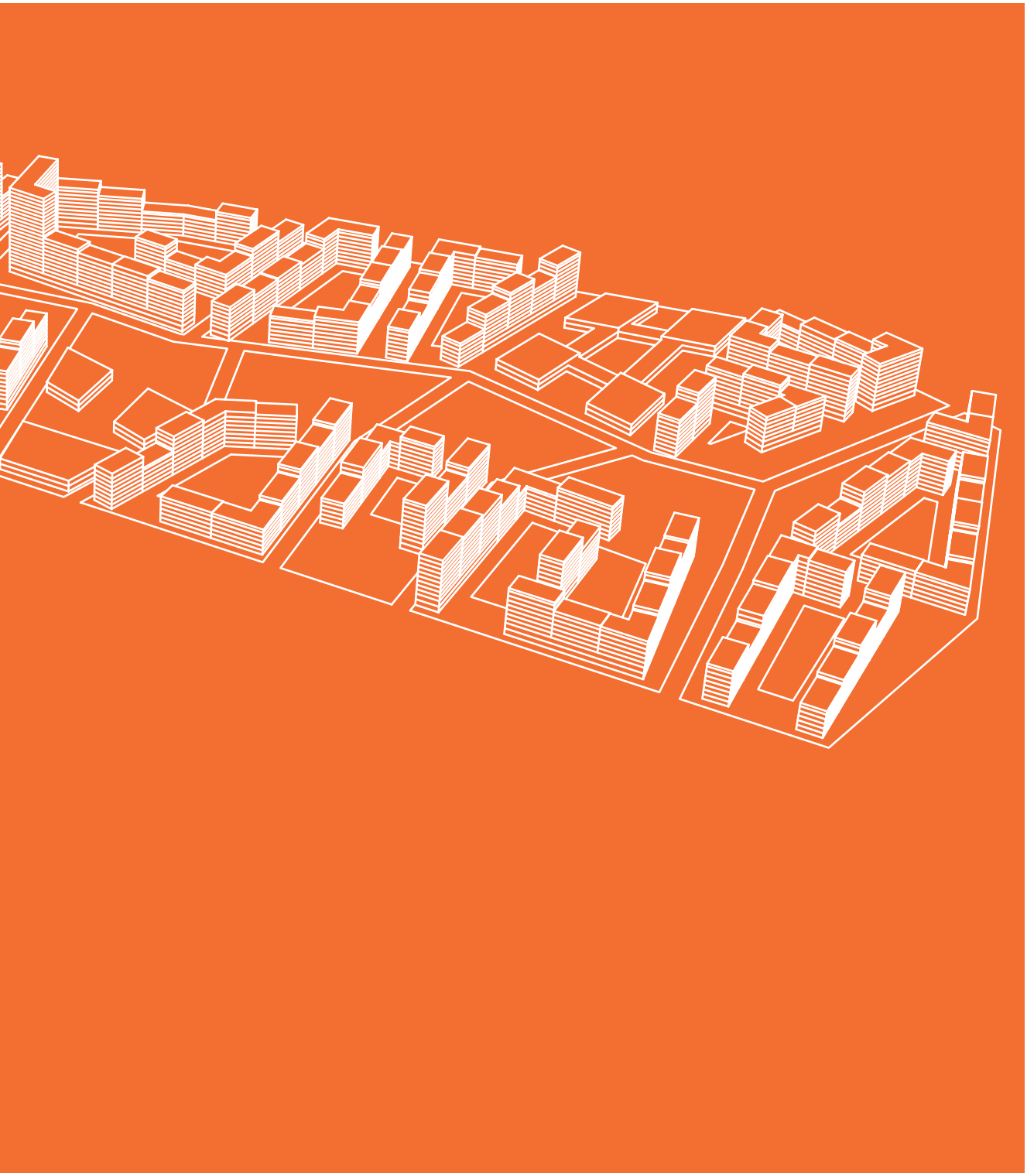
Online interface of the design exploration tool showing a self organizing map



„First life, then spaces, then buildings - the other way around never works.“

Jan Gehl[137]

137 AZ Quotes: https://www.azquotes.com/author/24967-Jan_Gehl [10/05/2018]



Preferred Planning Proposal

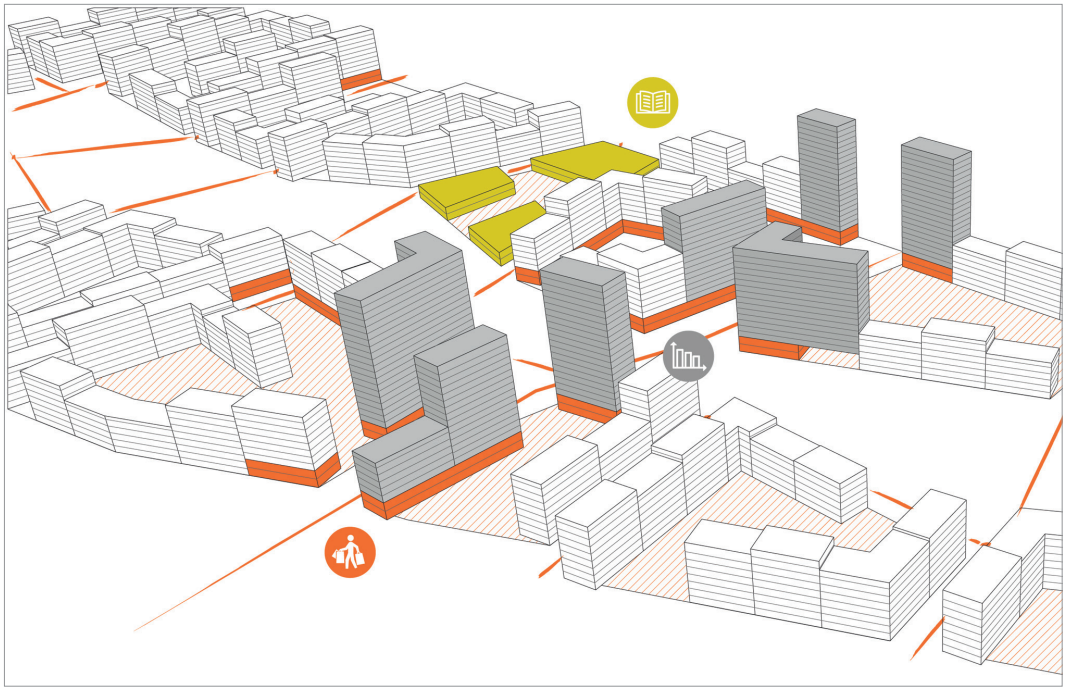
As the preferred solution, the second scenario integrates the design concept, the comments by the citizens and performs well throughout the executed analyses and simulations. The aim is an urban development, that opens up green and public space to the surrounding area and surprises with a green, urban oasis in the middle of the territory. The potential of this central located development area in Vienna is big and therefore deserves further investigation.

6.000 Residential Units

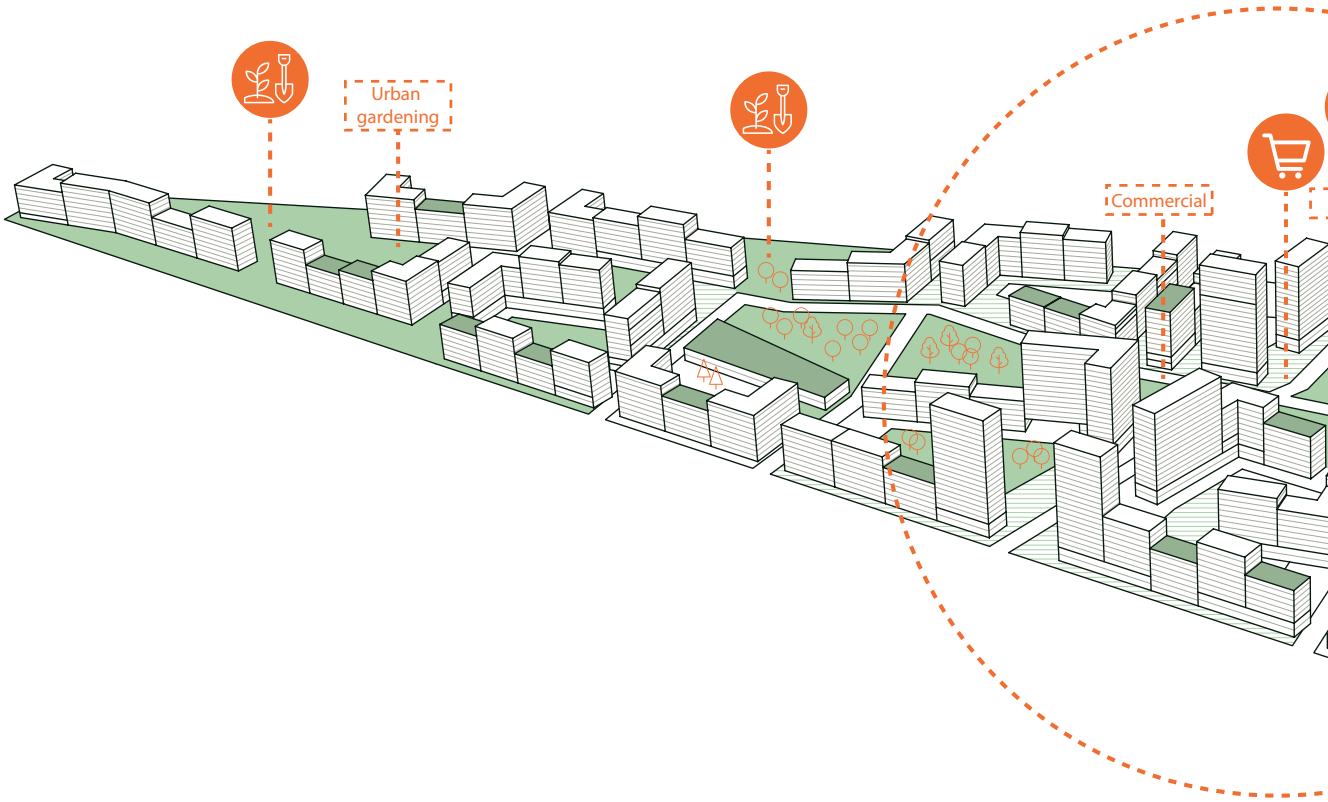
14.400 Residents

5.000 Work Spaces

810.000 m^2 GFA



Zoom on the central part of the development



For this scenario the northern part mainly inherits residential use and includes urban gardening. Considering the high accessibility of the central part of this development territory it is dominated by office and commercial use.

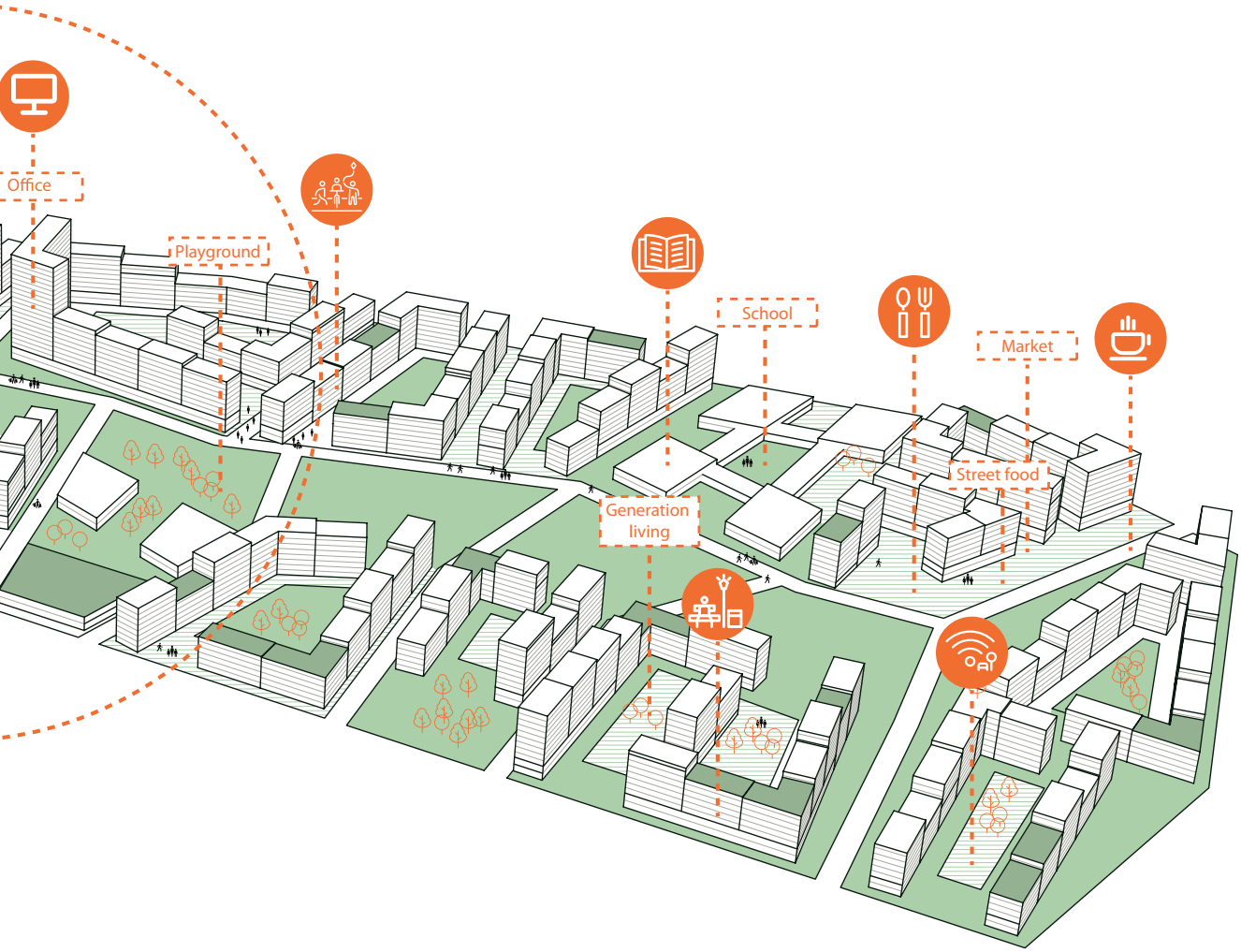
The construction of playgrounds, sport facilities and open space is planned in the southern part of the area.

In the south of the site a square links to the 'Nordbahnhof' development, and offers a variety of cafés, restaurants and pop-up stores.

A farmers market or market hall would also be beneficial for people, as I imagine this as a place where neighbors know each other and community activities take place.

The construction of green areas, trees and roof gardens to this extent causes high costs, but not only the analyses but also studies show the positive effect of green in the city. The inhabitants of a city appreciate the wide range of attractions, but do not want to miss the quality of nature. A balance between the built and the natural environment is considered to be essential for sustainable living.

138 AZ Quotes: https://www.azquotes.com/author/24967-Jan_Gehl [10/05/2018]



„A good city is like a good party - people stay longer than really necessary, because they are enjoying themselves.“

Jan Gehl[138]

6.2.6 Visualization

As the presentation of the planning outcome was always (and probably will always be) an important stage due to the fact that in the end we need to sell the project idea.

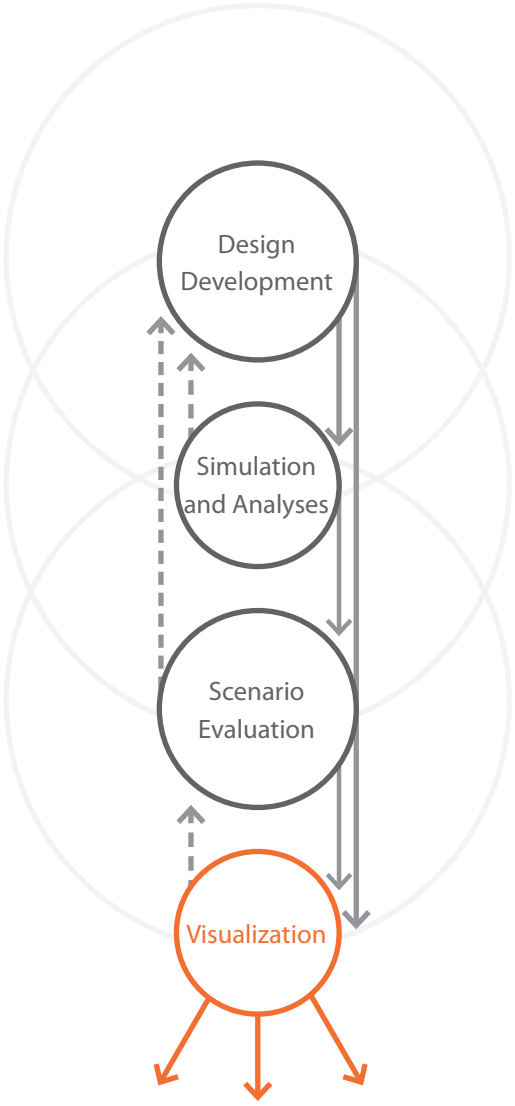
There are different methods to include the results of evaluations in graphics, maps and tables. Nowadays there exist even more tools to present, compare and experience scenarios as explained in an earlier chapter.

An atmospheric rendering, sketch or painting can still transfer the abstract idea of a project in its best as it was always used for competitions and projects.

In the traditional way of planning the presentation of a design proposal is done in plans, pictograms and atmospheric renderings.

By increasing the complexity of the master plan models with analysis and simulation data the way of presenting the output during the design phases might change.

The generation of many different scenarios that can be shown without losing the overview is a difficult task. Some ways to present the complex models are shown in the following pages.


Design
Development
Simulation
and Analyses
Scenario
Evaluation
Visualization

Online Urban Mapping

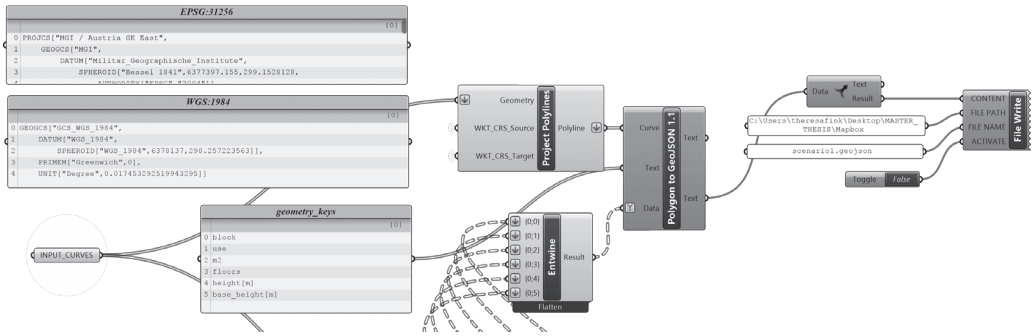
The online platform Mapbox studio provides basemaps that can be filled with own data. To customize these maps you need to create a tileset in form of points, lines or polygons.

To create a tileset in the online interface you need to upload a geojson-file that contains geometry with keys and parameters. These stored values can be used to st yle the uploaded geospatial information. As it is shown in the figure on the right page the interface offers a range of possibilities to individualize your data regarding your imagination.

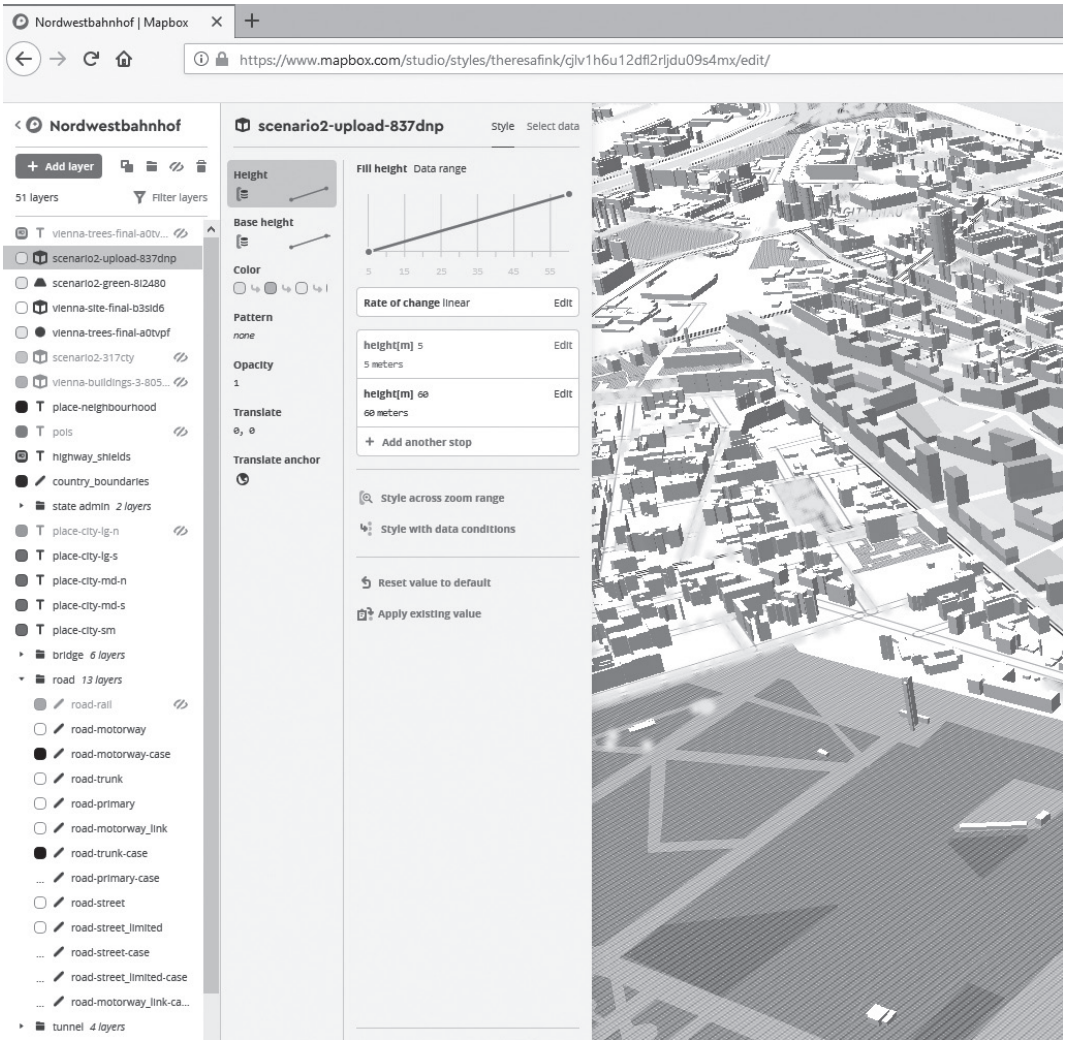
The color, extrusion height and base height are used to style the created curves as the building geometries that can be seen at the picture.

While feeding in the information, it is possible to style your data, create a legend or an interactive map. This approach affords the knowledge of the programming language javascript to style the homepage.

An application example for this online mapping tool could be within a community workshop to support the exchange of ideas. To use Mapbox as a pure media for sharing information and design proposals via link, would be another possibility.



Grasshopper defintion to export the geometry and attributes



Screenshot of the Mapbox online interface

AR Visualization

The city of eye level refers to the perception of citizens that walk through a city. This experience could be created by the use of AR technologies and setting up the project as an virtual environment.

By using the 'Vuforia' engine in combination with the game engine 'Unity' an overlay of the proposed geometry on a target image can be created. This overlay can be compiled as an app and used on a tablet or mobile device. The shown example of the scenario is an Android app that can be utilized to present different scenarios of urban planning.

To create this app the geometry needs to be exported from Rhinoceros as a 3ds-file in meshes. The picture, defined as target image, can be any kind of picture, that get's tracked by the camera and the app overlays the 3D

AR technology used on a tablet to present

object. The positioning of the geometry in reference to the image target is done in the game engine 'Unity' using the 'Vuforia' asset. The photograph shows the developed Android app on a Samsung tablet with a preview of one proposal.

The site plan of the 'Nordwestbahnhof' territory serves as a base to virtually build the scenario on top. The navigation around the site by tablet or mobile is intuitive as we are used to film and take photographs with our devices.

Again, the colors and the geometry can be applied beforehand and help, to provide information about use, height, density, green and many more aspects. The increased use of AR technologies within the past years introduced this technology to many different professions.

The target image is printed on the following pages and can be used to test and experience the developed app.

Conclusion

As a conclusion of this work can be said that the use of digital tools and methods increases the planning efficiency. Still, the influence of the designer is particularly needed in the phase of concept development. The understanding of cultural and historical aspects of the location in combination with the analyses results is needed to retrieve a design concept. I consider this to be the main task of an urban planner.

The efficient generation of design variants, analyses, simulations and design space exploration can support the designer in his role. This framework is not a copy-paste solution to apply anywhere in the world, but can be adjusted to different locations, cultures and needs.

The precise elaboration of a project in all facets and details requires the sensitivity and the introduction of the designers intention. The smaller the scale of a project and the more densely populated the surrounding area is, the more a designer's handwriting can be recognized from the design.

The use of digital tools and methods does not replace the designer, but supports intelligently during planning. For this reason it is extremely important to understand the tools used in the planning's in order to be able to adapt the tools to the own design ideas if necessary.

07

The work with a parametric software, like the plug-in Grasshopper, offers many advantages as shown in the case study. The flexible way of working and the handling of large amounts of data are only two of them. Importing data from different systems and switching between different applications and formats is a challenging task that requires further investigation and improvement.

The development of the design in a familiar user interface gives the user the feeling of security and control. The export of this geometry and information to another system, or the transfer of data is often a difficulty. For me as an architecture student, data acquisition and working with shape-files in GIS programs and the use of different projections was new, but highly instructive.

As particularly important I felt the handling of information content of geometries in GIS programs to and also in Rhinoceros and Grasshopper with attributes and user text. Furthermore, the included information can be used for urban mapping, design space exploration and export to other formats. Urban planning as an interdisciplinary discipline that requires the knowledge of all kinds of fields to achieve a well thought design.

In the end it can be judged if the designs presented are better or worse than others, but definitely a greater variety is possible in a short time. Whether urban planners are familiar with the use of digital tools is decisive if they consider this digital process as an option. The main advantage of the presented methodology is that individual subcomponents can be used without changing the entire workflow.

To summarize the experience of going through this planning process by myself, this thesis presented that there is a lot of potential in the application of digital tools. Another advantage of this step by step process is the possible computer-human interaction that allows to enter this framework at any stage.

The interviews taught me that this framework would not work out for every urban planner but different components, tools and methods could be applied in several ways.

In the end all executed analyses, simulations and visualization techniques aim to create a human centered urban development that people want to live and work in.

Future Research

08

The presented methodology for a digital urban planning process contains currently available digital tools, plug-ins and data sources. This approach could be extended by integrating machine learning and optimization processes within the design development phase. The design evaluation would benefit by taking into account the human interaction and movement within the public realm.

Furthermore, cultural aspects could be addressed through the integration of citizen involvement. Participation platforms, tools or apps could be developed and integrated within this process to collect and filter the needs of the citizens. Nowadays this participatory process happens in form of conducted interviews and workshops can only be considered by the designer.

Due to the large number of different analysis and simulation tools available with strongly fluctuating performance, benchmarking with a focus on application and result quality is essential. I also consider the development of a strategy for interdisciplinary data exchange an enrichment for the future.

The application of digital tools within the urban planning process is state of the art, in business and research. To create an efficient workflow in the future, I consider open source tools as a driving force to support the research. The collaboration between different institutions and the share of knowledge is important to strive for better solutions.

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9.2 Interviews

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Interview with Reinhard König, conducted by Theresa Fink, Wien [05/14/2018]
Interview with Roland Krebs, conducted by Theresa Fink, Wien [04/26/2018]
Interview with Ernst Rainer, conducted by Theresa Fink, Graz [04/25/2018]

Thank you

to all developers who share their libraries, tools and best practice examples within the online community

3D Modeling Software
www.rhino3d.com/

Parametric Plug-Ins + Libraries
www.grasshopper3d.com/
https://decodingspaces-toolbox.org/
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Figure 3
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Figure 8
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Figure 10
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Figure 13
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Figure 14
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Figure 15
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Figure 16
Detail aus der Karte „Wiener Donaukanal und Donau in Wiens Umgebung aus dem Jahre 1833 (entnommen: Wiener Heimatkunde. Die Brigittenau. 1975).

All other figures were created by the author of this thesis and the data sources named in the literature references.

Appendix

The interview questions that were asked to the urban planners and researchers and the presented urban planning process are shown in the appendix.

10

Interview Questions

1. How do you relate to the urban planning process?

2. What is particularly important to you: Site analysis, community involvement, energetic aspects, traffic planning or any other field?

3. How would you describe the course of your planning process?

4. What changes due to the progress of technology do you observe?

5. Do you see a risk in inexperienced users working with ready-made digital tools?

6. Do you see any advantages or risks in implementing digital tools in the urban planning process in different stages?

7. Can creative processes be programmed in a tool or are they always new tasks that do not contain repetitive steps?

8. To what extent does the use of parametrical tools affect the urban planning process and the outcome in your opinion?

9. Is your opinion on analysis tools different from your opinion on development tools?

10. Is it possible to include the values of a society in digital tools?

11. What is the impact of implementing digital tools on the urban planning process?

12. Do parametric methods limit the designer or allow a bigger range of possible solutions in your opinion?

13. To what extent can the quality of a design be measured?

On urban planning
and procedural modeling

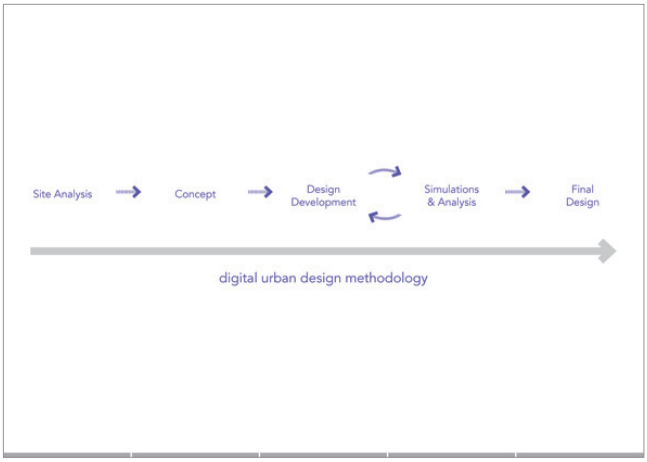
Can digital tools and parametric approaches positively influence the urban planning process?

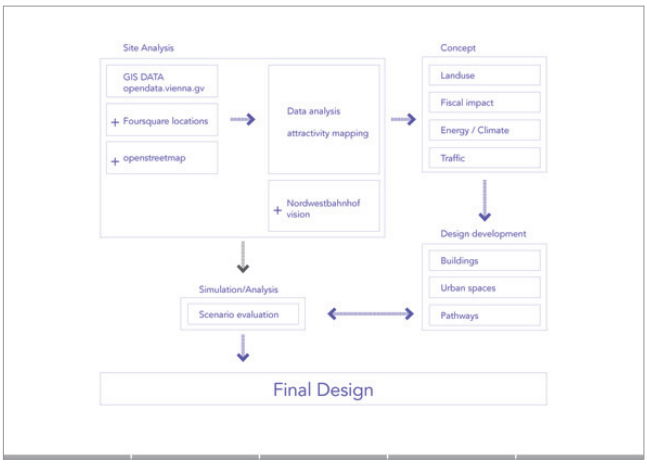
Is an open source data a sufficient basis for the planning of an urban neighborhood?

What could an urban development concept look like using digital tools in Vienna?

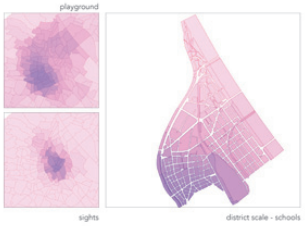
Research Questions

Case Study
Nordwestbahnhof Vienna


Site Analysis
Concept
Design Development
Simulations & Analysis
Final Design
digital urban design methodology


Site Analysis
GIS DATA opendata.vienna.gv
+ Foursquare locations
+ openstreetmap
Data analysis
attractivity mapping
+ Nordwestbahnhof vision
Concept
Landuse
Fiscal impact
Energy / Climate
Traffic
Design development
Buildings
Urban spaces
Pathways
Simulation/Analysis
Scenario evaluation
Final Design


metro
train
Analysis
used the space syntax centrality measures with metro / train



Attractivity maps

Attractivity mapped on counting districts

Use Mix

aiming a landuse mixture that activates the open spaces during the whole year

Fiscal aspects

creating valueable spaces that pay themself back in long-term

Energy / Climate

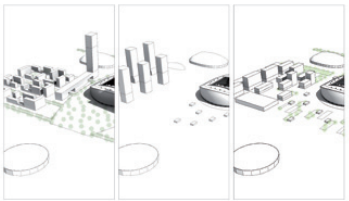
considering the environmentel influences to develop an intelligent design

Traffic

structuring the car and pedestrian flows on site

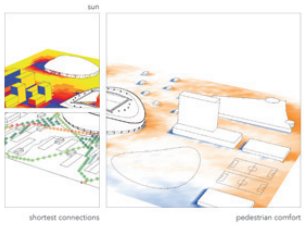
Concept

Design key parameters



Design Development

Scenario development to test different configurations



Analysis & Simulation

Final Design

48° 13‘ 55.668“ N
16° 22‘ 51.492“ E

ON URBAN PLANNING AND PRO CEDURAL MODELING