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# Requirements for a Dashboard Application to Facilitate Climate-Smart Planning for Sustainable Resilient Green and Blue Cities

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## 1 ABSTRACT

To ensure a liveable, resilient and sustainable city in the future, climate change adaptation and mitigation measures must be integrated into urban development projects. This is necessary to counteract the negative effects of climate change, as Austria is already experiencing a noticeable increase in the number of hot days and an increase in extreme weather events (ÖKS 15). Adaptation to climate change requires that the impact of an urban development project on the local microclimate be assessed as early as possible in order to minimise the effects and optimise the project. Microclimate analyses can be used to assess the impact of a development project or to compare different variants of a project and show the effects on local temperature, perceived temperature, wind field or humidity (Oswald et al. 2020). At the same time, urban planning processes are increasingly influenced by digitalisation in the form of Building Information Modelling (BIM).

Linking microclimate simulation and BIM is therefore an important step for the future of sustainable cities. So far, however, no tool exists that combines the various requirements and enables microclimatic assessment or optimisation of urban development projects. Some planning or assessment tools, such as microclimate models or green area indicators, allow for sectoral assessments. What is missing is a comprehensive tool that makes it easy to present the various impacts of a project to spatial planning and development decision-makers, investors and planners and, last but not least, to the general public, such as (future) residents.

This contribution analyses and describes the requirements for such a tool in the form of a web-based dashboard that uses BIM models, links them to microclimatic simulations, and additionally presents key performance indicators (KPI), such as green area indicators, in a structured way. The design of the dashboard is data and task dependent (Conrow et al. 2023); in light of the challenges and opportunities associated with optimising urban development projects from a microclimatic point of view, we set out to address issues related to (i) the requirements for the user interface, i.e. the dashboard, (ii) the requirements for the models (BIM model and microclimatic numerical simulation model), (iii) the possible applications in different planning phases, and (iv) the necessary requirements for data and data preparation.

The aim of the contribution is to analyse and describe the requirements, implementation perspectives and application possibilities of a web-based dashboard, which enables climate impact assessments, macro-ecological data for properties and neighbourhoods in an early planning phase ("climate check") on the basis of three-dimensional building models.

Keywords: Simulation of microclimatic effects, Building Information Modelling, Dashboard, Climate change adaption, Blue and green infrastructure

## 2 INTRODUCTION

Climate change puts pressure on the sustainable development of cities. To ensure a liveable, resilient and sustainable city in the future, climate change adaptation and mitigation measures must be integrated in urban development projects. This is necessary to counteract the negative developments of climate change, as a noticeable increase in hot days and in extreme weather events is already present in Austria (ÖKS 15). Cities suffer from heat islands also known as the Urban Heat Island effect (Oke 1967). This is the warming of cities compared to the surrounding countryside. The main reason for the stronger heating in fine weather periods is above all the overbuilding and sealing of natural, water-permeable surfaces and thus the related loss of green and blue infrastructures. This leads to the fact that hardly any precipitation can be absorbed within urban spaces, and thus the subsequent local cooling of the ambient air by evaporation and transpiration cannot take place. Urban heating is intensified by heat-absorbing building materials such as asphalt, concrete or glass. This effect is exacerbated by inappropriate building (block) layouts that prevent ventilation (MA22 2015).

### 2.1 Climate change adaption in urban development projects

The consideration of these microclimatic effects in planning processes of urban development projects is crucial for the successful adaptation of cities to climate change. Assessing these effects as early as possible in the planning process is necessary to minimise the negative climatic impacts of urban development projects by optimising the project. Optimisation of urban development projects in terms of microclimate and outdoor comfort can address the modification of the urban form, the building orientation and position, the architectural design, façade configurations, the building materials, but also urban green and blue infrastructure etc. There are four areas of action for adapting to climate change and anchoring in urban planning: i) precautionary reservation of land or forward-looking consideration of its use regarding climate change adaption measures, ii) unsealing or avoiding further sealing and increasing the infiltration capacity of the soil, iii) increased use of green and blue infrastructure and nature-based measures and iv) technical measures and protection of property (Jiricka-Pürrer et al. 2021). Adaptation measures of urban development projects can range from minimising sealed surfaces, to appropriate shading and ventilation considerations, and, of course, integration of blue and green infrastructure on both, plot and buildings. The effects of these adaptation measures are well known and have been proven by numerous research projects (e.g. Choi et al. 2021, Dennis et al. 2020, Elmqvist et al. 2015, Demuzere et al. 2014, Peng and Jim 2013). Nevertheless, a concrete assessment of the (inter-)effects of such measures is a complex task. Many variables need to be considered and aligned in order to successfully implement climate change adaptation for urban development projects.

### 2.2 Building Information Modelling

Meanwhile, planning processes are increasingly influenced by digitalisation in the form of Building Information Modelling (BIM). BIM is a digital and integrated approach to managing projects in the construction industry. In this process a three-dimensional model stores all architectural, technical, (structural-) physical and functional building data in a structured way to create a digital twin of the planned object(s). The "Open BIM" approach (exchange of data via an open, universally readable format) was established for the mutual exchange of this data. Central to this approach is the IFC format (anchored in ISO 16739 and readable for at least 60 years), which provides a standard for structuring the data and is constantly evolving. Compatibility of data formats is a major challenge. Object-related planning is currently largely decoupled from the prevailing microclimatic conditions of the site. Although (landscape) architecture has always responded to its built environment, building design usually follows only spatial-infrastructural parameters or influences such as the course of the sun. However, planning for adaptation to climate change requires the consideration of a number of other conditions. Current planning software (e.g. ArchiCAD, Revit, ...) is only able to consider parameters such as precipitation, temperature gradients, wind situation or shading performance of greenery on building optimisation to a very limited extent. The simulation of ecological and microclimatic effects – if carried out at all – is only done in a decoupled manner and thus causes additional costs (double modelling).

### 2.3 Microclimate analyses

In parallel, specialists deal with the simulation of the microclimatic effects of buildings and neighbourhoods. These microclimate analyses allow for an impact analysis of a project or the comparison of different variants and show the effects on local temperature, perceived temperature, wind field or humidity (Oswald et al. 2020). Meteorological large-scale and meso-scale models used for weather forecasts do not resolve surface features in the built environment to the extent that allows small-scale microclimate assessment. There are only a small number of different simulation software packages available that are capable of this and consider the conjugate heat transfer, radiation and evaporation effects, which is needed to accurately simulate urban microclimate conditions. Almost all models use regular computational grids with a fixed, spatial resolution, so that there are computational limits for resolving small/thin structures like shading structures.

All of these mathematical models for simulating microclimate in the urban/built environment at neighbourhood level require technical experts to run them and most of them also require high-performance computing. The technical complexity and large amount of data, that these simulations generate means, that the results are not readily available to the layperson or even to urban planning experts.

### 2.4 Urban planning indicators and certification schemes for assessment

The use of various urban planning indicators is another approach to analyse the qualities of a project in relation to climate change adaptation. In the field of climate change adaptation, there is a wide set of possible indicators. These range from "classical" urban indicators of density and land use (e.g. floor area, built-up area, building mass) to climate indicators (e.g. perceived temperature, wind comfort) to so-called green space indicators. These green and blue area indicators make the extent of blue and green infrastructure measurable and comparable (Ring et al. 2021). In addition, indicators such as the percentage of imperviousness or the degree of sealing are used, which document soil consumption and are an indicator of local water cycle disturbances as well as water drainage.

Another approach used, which usually includes or evaluates several indicators, is certification schemes at building or neighbourhood level, such as klimaaktiv, ÖGNI (Austrian Sustainable Building Council), TQB and LEED (Leadership in Energy and Environmental Design). They play a crucial role as urban planning indicators for evaluation. They consider factors such as energy efficiency, water management, indoor air quality, materials used and the overall environmental impact of the building (klimaaktiv 2023, ÖGNI 2023). By incorporating these certifications into urban planning processes, city authorities can ensure that new developments meet sustainable standards that can be documented and contribute to the creation of more sustainable and resilient cities.

### 2.5 Tools and instruments for a “climate check”

The link between microclimatic simulations, BIM and climate change adaptation indicators is an important step for the future: A "climate check" for urban development or redevelopment projects is included in or required by numerous national and international climate adaptation strategies or spatial development concepts (e.g. Stadt Wien 2022, Greater London Activity 2023). Within the framework of these development procedures, fundamental decisions are made at a very early stage on urban design and building typologies, which have a major influence on later (climate) resilience, energy requirements or greening options. The assessment of the impact of a project is usually carried out on a sectoral basis and through expert assessments.

So far to the best of our knowledge no instrument or tool is available that unites the multiple requirements and enables an assessment or optimisation. Some planning or assessment tools, such as microclimatic models or green area indicators enable sectoral assessments. What is missing is a comprehensive tool that makes it easy to present the different impacts of a project for decision-makers in spatial planning and development, to investors and planners and, last but not least, to the general public such as (future) residents.

This contribution analyses and describes the requirements for a tool in the form of a web-based dashboard that uses BIM models, links them to microclimate simulations and additionally presents KPIs such as green area indicators in a structured way. Starting with (i) the requirements for the user interface, i.e. the dashboard, (ii) the requirements for the models (BIM model and microclimatic numerical simulation model), (iii) the possible applications in different planning phases as well as (iv) the necessary requirements for data and data preparation are presented.

The aim of the contribution is to analyse and describe the requirements, implementation perspectives and application possibilities of a web-based dashboard that enables climate-impact assessments, macro-ecological data for properties and neighbourhoods in an early planning phase ("climate check") on the basis of three-dimensional building models.

## 3 MATERIAL AND METHOD

This contribution presents a simulation and visualisation framework representing an interdisciplinary approach to urban microclimatic assessment. This contribution is based on the collaboration of the following fields of expertise: architecture, microclimatic simulation, building information modelling, planning sciences, compliance with quality assurance aspects, e.g. the standard L1136 and L1131 (Austrian Standards, 2010, 2021) and planning practice. In order to provide a microclimatic simulation and visualisation framework, desktop research was carried out on (geospatial) dashboards as well as on the requirements of dashboard design in order to analyse existing methods and steps to conceptualise the dashboard architecture. The development of a dashboard for visualisation of microclimatic data of urban development projects relies on a cyclical process that involves various data, model and user interfaces (Oates 2005).

### 3.1 Digital Models and Simulators operation

In order to find a convenient workflow for the integration of microclimatic analysis into the planning process of urban development projects, the interdisciplinary project team works at the interface of digital models and tools from different disciplines (architecture, landscape architecture, microclimatic analysis/modelling) to qualify a transdisciplinary workflow for the exchange of data and digital geometry as well as the display of the microclimatic model and information. In particular, a 3D visualisation of an exemplary development project embedded in the existing urban environment is created and the analysis of its microclimatic impact on the urban development project are interactively presented to the user. The simulation model has two main interfaces with the BIM model:

(1) Geometric and spatial information, like terrain, building envelopes, vegetation are inputs for the simulation model. Also, physical properties that influence the microclimate simulation, like heat capacity, heat conductivity, albedo, opacity (for glass surfaces) etc. which are defined in the building information model, are inputs for the simulation.

(2) Simulation results (temperatures, fluid velocities,…) are imported into the BIM Model and displayed in the dashboard alongside the 3D model as supplementary information.

The microclimatic simulation model "UHISolver" was developed by Rheologic on basis of the widely used OpenFOAM library (Jasak 1996, Weller et.al. 1998, Jasak et.al. 2007). The simulation are run transiently (time dependent) over typical time periods of 24h and even longer with coupling of the various heat transfer effects. The spatial resolution is flexible: surface areas are usually resolved around several tens of centimetres, so that the BIM geometry can be represented with high accuracy in the simulation.

## 4 RESULTS – REQUIREMENTS FOR A CLIMATE CHECK DASHBOARD

The basic idea of implementing a climate check instrument is that of a "dashboard". A dashboard is generally referred to as a graphical user interface that is used to visualise data. The name comes from the English term for a dashboard in a car that displays information from various sources at a glance. Originally, the term referred to the board or leather apron at the front of a vehicle that prevented horse hooves and wheels from spraying mud into the passenger compartment (Mattern 2015).

So-called geospatial dashboards have been used in research and practice since the 1990s (Jing et al. 2019). In the beginning, there was the development of dashboards that were located at the level of the entire city. Only later were object and building-related dashboards developed.

A dashboard usually comprises a user interface that is coupled with models or analysis methods, which in turn process and evaluate certain data bases in order to display (key performance) indicators (Jing et al. 2019, Stehle and Kitchin 2020).

In order to develop a dashboard for the assessment of climatic impacts, an interplay of these elements is necessary. In the following, the requirements for the individual elements are described to enable both experts and laypersons to evaluate and compare projects.

### 4.1 Requirements for the user interface

To provide planners and other users with valuable insights, the output of simulations and models needs to be effectively presented in the dashboard interface. Planners typically develop different design variants through integrative processes or through competition procedures in the early development stages of urban development processes. A key requirement for the use of a dashboard in these early development stages is therefore to evaluate different variants in order to assess their potentially divergent qualities and compare their microclimatic impacts. This evaluation requires the selection and display of KPIs representing microclimatic information, urban design features and information about green and blue indicators in the interface of the Dashboard. The interface should be designed with clarity and simplicity, presenting the data in a concise and visually appealing manner.

#### 4.1.1 Requirements for the display of data and indicators in the Dashboard

A successful dashboard must be adapted to the characteristics of its users, so one of the initial steps is to define the target users of the climate check dashboard (see chapter 4.4.). Following Fernandes (2017) the following rules will furthermore help design and implement a successful dashboard:

- "Enable drill-down or drill-through to underlying data sources or reports and filters for flexibility and customisation;
- Provide explanation and context prior to information;
- Require minimal training and easy to use by anyone;
- Stay within single screen boundaries without displaying excessive detail;
- Use modularity to compact information and visual cues to direct attention" (Fernandes 2017, 18f).

#### 4.1.2 Three-dimensional and interactive representation of the urban/architectural model

To present the three-dimensional BIM model in the dashboard interface, a web application with a 3D/BIM viewer can be used. This web application serves as a user-friendly platform for interactive exploration and visualisation of the urban development project and its various information layers. The 3D/BIM viewer provides a realistic and immersive representation of the urban environment, including the architectural elements and spatial layout of the buildings. This viewer acts as a visual medium to convey information and facilitate understanding of the project design. As the design process progresses, urban development projects are further optimised based on an initial assessment. It is therefore necessary to present and evaluate development variants – which may differ in terms of building structure, urban layout, height or density – and design variants – which may differ in terms of different surface textures and colours, or the proportions and locations of green and blue infrastructure. As mentioned above, a central requirement for the use of the Dashboard in the early stages of development (see also chapter 4.3) is the ability of the 3D/BIM viewer to evaluate and compare these different project variants in order to assess their different (microclimatic) impacts and qualities. In Summary, the BIM model must be represented as an interactive 3D model in the projected 3D space with users being able to freely move, zoom, rotate and interact with the model.

#### 4.1.3 Representation of climate indicators

The user interface will present climate indicators such as the typical summer- or hot-day that is used for the simulation – for example according to the DEED-Standard.[1] The external "forcing" conditions for the project domain are for example the air temperature or velocity of incoming wind. Climate KPIs such as the apparent temperature (e.g. UTCI[2]), or wind comfort are derived from these basic indicators (see chapter 4.1.5.) to analyse the projects microclimatic performance and evaluate different development and design variants of the project.

The 3D model of the Dashboard will show spatially resolved KPIs for the local microclimate in the form of color-coded 3D surfaces that can be overlaid optionally. To further enrich the information, it will be possible to select points within the geometry to display time-series of variables at that point, for example the 24h air temperature or surface temperature over time. This gives users deeper insights into the dynamics of the microclimate.

#### 4.1.4 Representation of urban design and planning indicators

The use of different urban planning indicators is a further approach to analysing the qualities of a project in relation to climate change adaptation. Typical urban indicators can either address the building or the plot and usually describe the density and land use intensity (e.g. floor area, built-up area, building mass).

These indicators (see Table 1), such as gross floor area, number/size of flats, and the area of (semi-)private open spaces, offer a quantitative representation of the built environment. Gross floor area serves as a

[1] https://rheologic.net/articles/definition-DEEDS/
[2] Universal Thermal Climate Index


ISBN 978-3-9504945-2-5. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER, H. R. KAUFMANN – Ljubljana, Slovenia

measure of the overall size and scale of a building or development project, indicating its spatial footprint. It helps assessing the intensity of land use and the potential population density in a given area.

By representing these urban design indicators, planners can assess the spatial layout, functionality, and amenity provision within neighbourhoods and developments. They can use this information to inform decision-making processes, such as zoning regulations, building codes, and urban design guidelines.

Additionally, the area of balconies, loggias, and gardens provides insights into the availability of open spaces within the urban fabric. These private open spaces contribute to enhancing the quality of life, promoting well-being, and improving the overall liveability of urban areas (Giannico 2022).

### 4.1.5 Representation of green and blue area indicators

Green and blue infrastructure and nature-based solutions make a significant contribution to the adaptation of urban areas to climate change. Only by identifying the benefits that nature provides, and by understanding the value of these benefits can planners, managers and decision-makers move towards creating a sustainable city. The four most important functions of green infrastructures are: (i) shading of surfaces and spaces, (ii) low reflection of incoming solar radiation, (iii) cooling of themselves and the surrounding environment due to evapotranspiration, and (iv) storage of CO2 in biomass and substrate. These so-called ecosystem services include the Provisioning services, Regulating services, Habitat or Supporting services, and Cultural services (Millennium Ecosystem assessment 2005; TEEB Foundations 2010). The Provisioning services describe the material and energy outputs from ecosystems (like food, water, medicinal resources, etc.); the Regulating services are the services ecosystems provide by regulating the quality of air and soil as well as providing flood and disease control; the Habitat or Support services means that ecosystems provide and maintain living spaces for a diversity of plants or animals; and the Cultural services include the non-material benefits like aesthetic, spiritual and psychological benefits that people obtain from contact with ecosystems (TEEB 2011).

In order to integrate nature-based solutions into urban development projects, the share of green and blue areas is required as a basic indicator (see Table 1). Other factors, such as the green area factor or rainwater management indicators, are based on the area share of green and blue infrastructure. Thus, to convey the importance and microclimatic impact of nature-based solutions, the area share of green and blue infrastructure must be displayed as key information.

| **Climatic indicators/parameters** | | **Urban indicators/parameters** | | **Green and blue infrastructure indicators/parameters** | |
|---|---|---|---|---|---|
| Urban heat | Wind | Quarter/Parcel | Building | Green infrastructure | Blue infrastructure |
| Air temperature | Wind velocity | Sealed surfaces | Building height | Extensive green roof area | Area of waterbodies |
| Air humidity | Wind direction | Partly sealed surfaces | Façade area | Intensive green roof area | Stream lines |
| Solar Radiation | … | Unsealed surfaces | Roof area | Façade greening area | Retention areas |
| Calendarday/solar angles | | … | Built area | Green surfaces with/ without floor connection | Infiltration areas (through/ infiltration ditch) |
| Diurnal air temperature | | | Underbuilt area (incl. spill height) | Existing vegetation | … |
| … | | | Gross/ Net floor area | Number of trees | |
| | | | Private available free space | Canopysizeoftrees | |
| | | | … | … | |
| **Derived KPIs** | **Derived KPIs** | **Derived KPIs** | **Derived KPIs** | **Derived KPIs** | **Derived KPIs** |
| Apparent temperature – AT | Wind comfort | Degree of sealing | Floor area number | Green area factor | Blue area indicator (BAI) |
| Universal Thermal Climate Index – UTCI | Wind danger | Degree of building density | Building mass number | Extended Degree of sealing | Rain water management (RWM) |
| Surface temperature | Air quality(optional) | … | … | Biodiversity indicators | Discharge coefficient/water circle |
| … | … | | | Carbon capturing | … |

Table 1: Overview and examples of indicators/KPIs that should be presented to assess the performance of a project

### 4.1.6 KPIs for the assessment

From the many variables and indicators that can be used to qualitatively and quantitatively describe and evaluate urban development projects, it is crucial to select those indicators most relevant for climate change adaptation. The selection of appropriate KPIs for the dashboard is critical to the effectiveness of the evaluation of different design and development options (De Marco et al. 2015). The KPIs should be comprehensive, comparable and independent to avoid overlap. The indicators and further calculations should be easy to understand and should be able to provide information to address upcoming design or development issues. Current and historical data should be presented and available, e.g. wind statistics at specific times (Fernandes 2017).

In Table 1 the chosen indicators are listed, representing climate (temperature, wind), urban indicants (quarter, parcel, building) and green/ blue infrastructure. From these basic indicatorsand parameters further KPIs can be derived which enable a simple evaluation or comparison of different variants. The statistics on wind velocity and direction contribute to wind comfort and wind danger. The sealed surfaces add to the degree of sealing and degree of building density. The building height, façade area, roof area, built area and gross/net floor area conduce to the floor area number and building mass number. The green area factor (GAF), biodiversity indicators and the extended degree of sealing derive from the number of trees, façade greening, roof greening and green surfaces with or without floor connection. In the column of the blue infrastructure the natural waterbodies, retention areas and infiltration areas contribute to the blue area indicator, discharge coefficient and rain water management.

### 4.2 Requirements for the models

This chapter focuses on the necessary conditions and constraints for the models, with the aim of providing flexibility and ease of implementation. By keeping requirements to a minimum, it is easier to adapt and modify the model in the early stages of development. This flexibility allows better exploration of design alternatives and consideration of various factors that contribute to sustainable design.

#### 4.2.1 BIM Model

In the early stages of an urban development project, not all information, both geometric (e.g. details of faced) and alphanumeric(e.g. data on the materials used), may be readily available. In addition, different development and design variants of the project are typically developed. Therefore, the BIM model is required to accommodate the different variants as well as a gap of detailed information. As the development process progresses and more dependencies are established, the complexity of implementing changes increases significantly. Therefore, by reducing the constraints on the model from the outset, it is possible to capitalise on the opportunity for sustainable and impactful changes in the early stages, when they are most feasible and affordable.

A key requirement is that the IFC model, which stores the architectural, technical and functional building data, has a closed surface. The closed surface requirement for the IFC model ensures that the model accurately represents the physical boundaries of the building. This information is critical for microclimate simulations and other analyses related to climate impact assessments. The ability to easily modify and adapt the model allows designers to iterate on different design options and evaluate their impact on sustainability. The second requirement is to assign accurate properties to the surfaces in the model to ensure that the microclimatic analysis properly accounts for the characteristics and attributes of the surfaces (see the next chapter for more information).

#### 4.2.2 UHISolver – Microclimatic Simulation Model

The microclimate simulation model – OpenFOAM based UHISolver in this case – draws on mesoscale weather data usually but not necessarily for summer/hot-weather conditions. Input factors for the simulation domain are air temperature, direction and speed of wind, humidity and solar radiation, all of which need to be available in reasonably resolved time series over the 24 hours of a usual simulation. Typically, hourly values are used, but two-hourly values are also acceptable and even quicker simulations over just 1h are possible with some compromise on quality (for example, surface temperatures will not necessarily be accurate for simulations that only span a short time).

Buildings are included in the simulation with their albedo, thermal conductivity, thermal capacity and of course their geometry. At a minimum, building envelopes, including roofs, are resolved; depending on the requirements of the project, smaller details such as balconies, alcoves, passageways and shading structures may also be represented. The project also requires a geo-location and date so that solar angles can be accurately represented. For example, the DEEDS definition for heat wave days provides not only the daily and hourly input factors for the simulation, but also the annual day on which a heat wave day typically occurs. If this information is not available, the summer solstice is often used (Xu et al. 2019; City of London 2022; Rheologic 2022).

Blue (water) and green (vegetation) infrastructure in the simulation domain can also evaporate water, converting sensible heat into latent heat trapped in moisture. Evaporation rates are set according to literature data.

#### 4.2.3 Interaction of the models and representation in the interface/dashboard

By integrating data from the microclimate simulations into the 3D/BIM viewer, the web application enhances the viewer's capabilities by overlaying additional layers of information. By visualising these KPIs on the 3D model, users can easily understand the spatial distribution and variation of microclimatic conditions within the urban environment.

The interface should be designed with clarity and simplicity, presenting the data in a concise and visually appealing manner. Users should also be able to toggle information on and off – for example, to display certain variables (such as wind speed or air temperature) in the model. These variables are typically colour-coded on top of 3D surfaces. 2D representations fall short due to many of the variables not being projected onto simple z-normal planar surfaces, but onto more complex surfaces, that follow the elevation changes of the terrain, overlap (for example under bridges, on rooftops, in underpasses and thoroughfares) or are even completely vertical (for example wind speed over height). Without the ability to rotate, zoom and toggle, this information cannot be easily conveyed.

In addition to the spatial information users should ideally be able to see the temporal information too: for example, a colour-coded surface can show the air temperature at certain points in the geometry at one point in time (often 15:00 local time is shown, as this is often the hottest time). Ideally, a user should be able to select a point in the geometry and have the time information for that point – in this example, the temperature over 24 hours – displayed as a time series graph in a side panel.

### 4.3 Requirements for data preparation of input data

Data is the basis for the creation of the BIM model, the microclimate simulation and the calculation of the various indicators. In addition, a dashboard provides the ability to integrate and display existing data and indicators, for example about the location and mesoclimate.

#### 4.3.1 Necessary input data for the BIM-model and the microclimatic simulation model

The basis for both models is terrain data and building cubature of the existing neighbourhood, as well as for the actual development project. In addition, microclimatic simulations need the implementation of (existing) green spaces and trees. In terms of buildings structure, the surrounding is used/necessary to show the “visual fit” of the new project to the neighbourhood. Concerning the microclimatic simulation, it is mainly necessary to evaluate the wind conditions for higher buildings.

As mentioned above, mesoscale weather data are necessary to set the correct input factors for the simulation. The time resolution should be at least 2 hours or better. A good data source for this data are the ERA5 or ERA5-LAND dataset published by the ECMWF. These data sets are available in hourly resolution globally. The spatial resolution is 0.25° respectively 0.1° (about 30km respectively 9km).

It is also possible to use data from meteorological weather stations, however due to the low height of these stations wind directions and velocities are often not representative. Using the high-quality data from the abovementioned re-analysis, high quality datasets that are error-corrected according to highest standards avoids that problem. It should be noted however that this synoptic wind is not influenced by small scale terrain, so the simulation model has to be tuned carefully to include enough terrain and surface features (buildings, forests, etc.) so that the simulated wind conditions at pedestrian height are accurate.

### 4.4 Application in different planning phases and for different stakeholder

The development of urban planning projects usually comprises several steps, which include both the area of development planning – i.e. open procedures as well as regulatory planning – i.e. legally binding planning instruments. A dashboard for assessing performance can be used in different phases and for different target groups. These are: (i) (landscape) planners and (landscape) architects, (ii) city executives and expert juries for urban development competition processes and possibly also (iii) laypersons like local or future residents.

The first step is usually the development of a basic urban planning model that serves as the basis for zoning and development planning, or builds on these existing planning instruments. Based on these, often master plans with detailed specifications and detailed qualities for the individual construction sites and public spaces are developed. The next steps usually include the preliminary draft, the design and the submission planning for the authorities before it comes to a detailed implementation planning for both the buildings and the open spaces (Reinwald et al. 2021a).

The use of the dashboard is particularly beneficial in the early phases of development, when there is still a great deal of design freedom and all the relevant parameters – building volume, building position, green space distribution, etc. – can still be modified to improve the project's (microclimatic) performance. Of course, it is also suitable for further planning steps and, above all, for quality assurance in the ongoing process, as there are often decisive changes in the project. Remastering the models according to nature-based solutions (blue/green infrastructure) is a great advantage of assessing the microclimatic effects of a project in early development stages. With regard to the different target groups mentioned above, it can be used as part of public relations work to inform local residents in general about the project. On the other hand, in the competition phase, it can be used by the expert jury to compare the submitted projects in terms of ecological parameters and thus select the submission with the most beneficial impact on the local microclimate and the best climate resilience. Depending on the target group, different modes are recommended/practical (basic vs. expert mode).

## 5 CONCLUSION – THE "GREENPLANOUT" DASHBOARD

This contribution aimed to describe the requirements, implementation perspectives and application possibilities of a web-based dashboard, which enables climate impact assessments ("climate check") on the basis of three-dimensional building models. The result is a conceptual architecture for the GREENplanout Dashboard (see Figure 1).

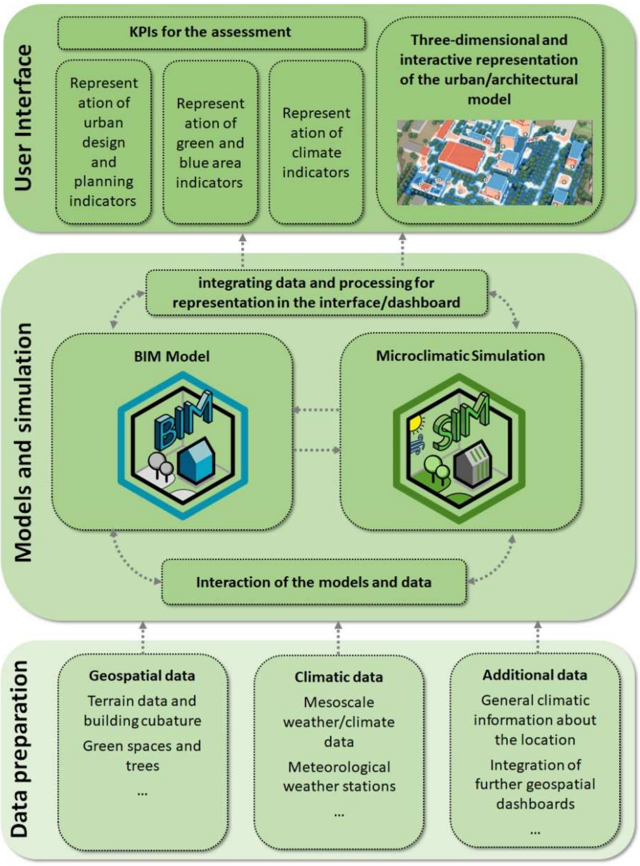


Figure 1: Conceptual architecture for the GREENplanout Dashboard

Requirements were analysed and collected for three areas: (i) Requirements for the user interface (ii) Requirements for the models and (iii) Requirements for data preparation of input data. The user interface should be accessibility for all users via a web portal that is easily readable/navigable by the user, since this


ISBN 978-3-9504945-2-5. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER, H. R. KAUFMANN – Ljubljana, Slovenia

dashboard is aimed for various users from different professional backgrounds. To display information interactive display should be integrated. The user can click on a point in the geometry and an information window pops up with information, parameters and KPIs (see Figure 2). The displayed three-dimensional model is based on the interaction of two models used (BIM and UHIsolver) and the underlying data. These include geospatial and climatic data and can be enriched by additional data (e.g. general climatic information about the location).

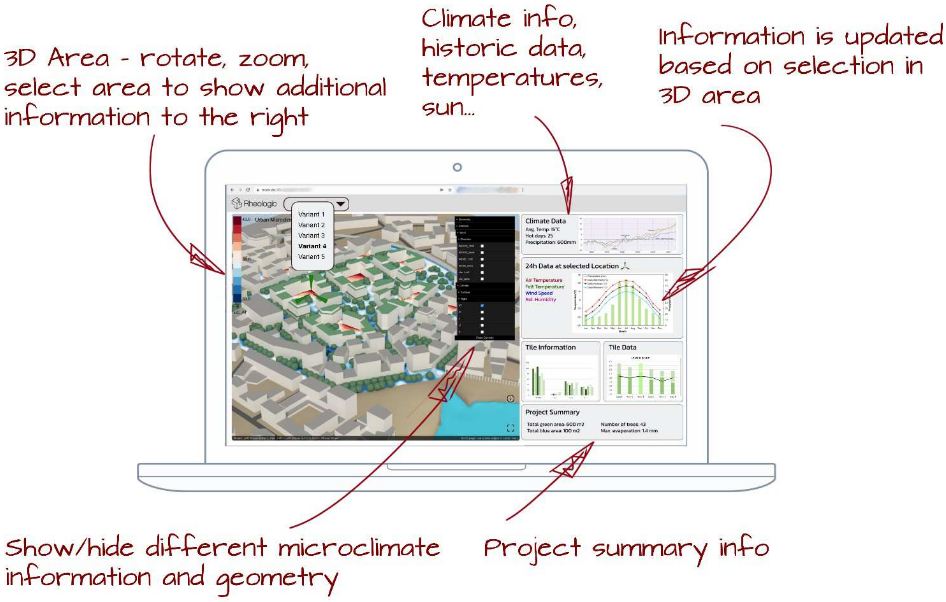


Figure 2: Mock-up of the planned dashboard. Based on the selected design variant the corresponding indicators like thermal load, wind speed etc. can be accessed via a selection menu (left side). Various KPIs allow an assessment of different variants and their performance in relation to the climate resilience of the building or neighbourhood (right side).

The interactive model and dashboard will provide much greater insight into the climatic “ground”-conditions than currently available synoptic weather and climate indicators can. From statistical weather data and meteorological models, it is only possible to indicate air temperature, radiation and humidity without the resolved influence of the built environment: on a shadeless, slightly rough plane without any obstacles. However, the built environment, that is often not resolved in meteorological models, has far-reaching and complex influence on the microclimate with large deviations in radiation (from trees and shading), wind velocity and direction (buildings), air temperature (conjugate heat transfer) and humidity (urban vegetation and water bodies). Insights into how, when and where these factors change allows urban planners to make much better-informed decisions throughout the planning process, ultimately resulting in a healthier, more resilient environment using best available tools. For the general public, it is an accessible way to become engaged in the design of public spaces already during planning, with the potential to foster increasing responsibility and a sense of stewardship for how we design urban space that is fit to the climatic challenges to come.

Especially for the greening building community (Enzi et al. 2021, Formanek et al 2020) this dashboard is very attractive, because the influence of green roofs and facades on the microclimate and the further effects of greening buildings (Mann and Mollenhauser 2021, Pfoser et al. 2013) such as biodiversity promotion, improvement of the albedo, production of evaporative cooling and stationary processes can be analysed and optimized. Greening thrives on visualization, and virtual models provide initial information about the possibilities, as well as a holistic view of radiative exchange in a neighbourhood network. In this way, the understanding of how to improve our future microclimates at specific locations and measures to improve climate protection can be promoted.

It should be noted that the dashboard primarily focuses on architectural or neighbourhood developments. How the object or the neighbourhood affects the surrounding neighbourhoods or the city as a whole can be analysed with other simulation tools that assess these larger-scale effects. A linkage of these levels is necessary to represent the interactions on a larger scale (Reinwald et. al. 2021b).

## 6 ACKNOWLEDGEMENT

The research was conducted as part of the project "GREENplanout" funded by the Vienna Business Agency and conducted within the program Research, Call “Zero Emission Cities 2022” (ID: 4536990).

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