Climate-resilient urban planning and architecture with GREENPASS illustrated by the case study ‘FLAIR in the City’ in Vienna

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Abstract. Urban growth and climate change are 2 of the main challenges worldwide [20]. Cities are growing rapidly while average temperatures are rising, and extreme weather conditions, as heavy rain events, are becoming more frequently. Soon 4 out of 5 EU citizens are living in cities [6]. The results are increasing costs for health expenses and infrastructure damages. Urban planning processes have to consider future climate conditions and the impact on people, buildings and the urban environment. Until today there was no simple solution to measure and calculate the climate impacts of urban developments. GREENPASS® is a technological breakthrough, the world’s first software-based technology for climate-resilient and resource-efficient urban development. After 9 years of scientific research and development the technology can easily be used by urban planners as architects and be integrated into existing urban planning workflows and processes. With GREENPASS® the impact of buildings, materials and plants on urban climate become measurable and comparable in a standardized way – powered by ENVI-met®. It supports optimization of investments towards effects of Green Infrastructure (trees, green roofs and walls, ...) such as cooling, thermal comfort, water retention and carbon sequestration. GREENPASS® allows to identify the optimal solution for any urban development. Supported projects receive finally a GREENPASS® certificate on their overall performance. The technology has already been applied successfully for more than 25 projects within Austria and Europe [3] and will be explained more in detail using the case study of ‘FLAIR in the City’ - the world's first GREENPASS® Gold-certified residential building, located in Vienna/Austria.

1. Background
Urban growth and climate change are 2 of the main challenges worldwide [20]. Cities are growing rapidly while average temperatures are rising. Along with climate change not only heat waves occur more frequently, but also heavy rain events that may cause pluvial flooding. Soon 4 out of 5 EU citizens are living in cities [6].

The results are increasing costs for health expenses and infrastructure damages. Urban planning processes have to consider future climate conditions and the impact on people, buildings and the urban environment. Green Infrastructure is accepted as one key measure of urban climate change adaptation...
and improvement of urban climate resilience. This has been acknowledged by many official entities as the UN, IPCC, IUCN, EEA, EC, national and regional governments and authorities [1][5][7][13][15][19].

While all the named guidelines and recommendations are of high value, they remain generic and conceptual. Planning processes request detailed information of benefits and costs of green infrastructure to allow decision making.

2. GREENPASS® technology
The GREENPASS® technology is the worldwide first software-based technology for climate resilient and resource-efficient urban planning and architecture. It has been developed in the last 9 years within international R&D projects with more than € 4. Mio of funding [7][8][14][15].

The GREENPASS® technology consists of the GREENPASS® Toolbox, GREENPASS® Software and GREENPASS® certification and includes ENVI-met® microclimate simulation for climatic inputs within the planning-, evaluation- and optimization process [10][11][17][18].

2.1. GREENPASS® toolbox
An international review of planning processes [7] revealed that worldwide, planning processes follow a standardized pattern, starting with preliminary design, followed by concept design and detailed design. To every phase of the planning process different resources (personnel and budget) are allocated.

The GREENPASS® toolbox (see Figure 1) accounts for that and provides tailored services for every phase of the described planning process in accordance with the given resources and budget [10]:

- Assessment for preliminary design phase (01): low detail grade and low resources available (budget and time)
- Pre-certification for concept design phase (02): low detail grade and moderate resources available (budget and time)
- Certification for detailed design phase (03): high detail grade and high resources available (budget and time)

![Figure 1. GREENPASS® Toolbox delivers the tailored tool for the respective planning process phase for a worldwide application](image)

2.2. GREENPASS® Editor
The GREENPASS® Editor is an independent GIS-based software and the crucial interface between scientific world of microclimate simulation and practical planning world. Common planning data, like CAD (.dxf) or GIS (.shp), can be imported to the software in a straight and easy way. The planning project can then be edited within the software, e.g. assigning materials from a comprehensive data base
(linked with ENVI-met®) to project elements, adding green infrastructures etc. The software finally automatically transforms the modelled data to a digital simulation model in ENVI-met® compatible data file format (.inx) [8].

2.3. GREENPASS® Certification

The GREENPASS® Certification is an ongoing optimization process with the aim to deliver the best results on climate resilience and return on investment. To that end it is comparable to many other fields of planning in the detailed design phase. The final design of the project is rewarded an official certificate.

The certification system is based on existing building certification systems like, DGNB, LEED or BREEAM. The comprehensive set of in total up to 28 certification indicators allow to analyse each project and progressively optimize it with regard to three overarching topics: climate resilience, water management and costs. The analyses provide detailed information on exemplary the effects of building structures, greenery elements and surface materials on the thermal comfort, the wind flow, water run-off, CO₂ sequestration, cooling degree hours, air temperature, water demand, and many more. And relates these to installation and maintenance costs for green and blue infrastructure [10][17].

Additionally, to the project plans, three standardized and rule-based reference scenarios are applied and simulated within the certification frame. The reference scenarios are based on the actual architectural planning inclusive landscape design, changing the materials and implementation of green infrastructures as follows:

- **Worst case scenario:** e.g. 100 % sealed with asphalt
- **Moderate greened scenario:** e.g. 50 % of flat roofs - extensive green roof, façade greenery with focus on S exposition, 50 % unsealing of private roads, sidewalks, parking lot, additional trees
- **Maximum greened scenario:** e.g. 50 % of flat and inclined roofs - intensive green roof, façade greenery with focus on S, W and E exposition, 100 % unsealing of private roads, sidewalks, parking lot, additional trees

These scenarios subsequently form the framework for the certification evaluation and support the optimization process. The official GREENPASS® certificate is a planning certificate and available in: Platinum, Gold, Silver and Certified (see Figure 2). Two years after completion of the building construction, the evaluated measures will be controlled by a reviser for quality management purposes, if they got implemented correctly and flourishing well. Otherwise, a re-certification will be offered or in worst case the certification will be officially revoked.

![Figure 2. Official GREENPASS® certification for building projects, districts and entire cities](image)

3. Case Study – ‘FLAIR in the City’

‘FLAIR in the City’ is a residential building project with a size of app. 0.6 ha, located in the south of Vienna in ‘Atzgersdorf’. The building plot is part of the ‘Carré Atzgersdorf’ masterplan for an app. 7 ha large integrative urban development area in the 23rd district of Vienna and aims to be the first realized building plot of the ensemble with 133 apartments [12]. The plot shapes the southern part of the
masterplan area and is located adjacent to the public ‘Bruno-Morpurgo-Park’ in the south of the area, which also brings climatically benefits for the building plot (see Figure 3).

The co-creative multi-year development process inclusive public participation started 2014 with the zoning map. 2015 ‘FLAIR’ developer provided the building plot for an urban gardening initiative, called ‘Freiluftsupermarkt’, as temporary use. The GREENPASS® certification was applied in the detail planning phase in December 2015, in cooperation with ‘FLAIR’ developer and the Municipality Department of Vienna for Environmental Protection (MA22). The progressive planning and optimization process together with the developer and architectural team was finalized in September 2016. The ground-breaking ceremony took place in August 2018, while the building project is actual still under construction and will be finalized expected in 2020 (see Figure 4).

3.1. Data processing
For the generation of a digital simulation model for microclimate simulation, respective data is needed. Beside an architectural model (see Figure 5), the team from “uma architects” provided the data in .dwg and .pdf formats. The plans were edited in the respective data layer structure with containing information’s, based on GREENPASS® data specifications.
Based on the project plans the rule-based reference scenarios have been elaborated. For every scenario a digital simulation model with a horizontal cell resolution of 2 m was generated (see Figure 7). The models have a size of 150 x 300 m inclusive surrounding buildings and park adjacent to the building plot.

Figure 5. Architectural model of the draft version of the residential building complex ‘FLAIR in the City’ in concept design phase from ‘uma architects’

Figure 6. Digital simulation model for ENVI-met®, based on the architecture draft version inclusive surroundings: Scenario Planning

Figure 7. Digital simulation model for ENVI-met®, based on the architecture draft version inclusive surroundings: Scenario Planning optimized
3.2. GREENPASS® results

The microclimate simulation input is generated by ENVI-met® [1][19], one of the worldwide most famous and validated software for microclimate simulations. The following figures show exemplary results of the evaluation and optimization process for ‘FLAIR in the City’ – in form of the Key Performance Indicator (KPI) - Thermal Performance (PET).

- KPI - Thermal Performance - PET (physiological equivalent temperature) on 21st July at 3 pm and 1.8m height for scenario planning and planning optimized (see Figure 8 and Figure 9)

![Figure 8: GREENPASS KPI - Thermal Performance (PET) for ‘FLAIR in the City’ on a hot summer day (21st July) at 3pm and 1.8m height - for the scenario planning](image)

![Figure 9: GREENPASS KPI - Thermal Performance (PET) for ‘FLAIR in the City’ on a hot summer day (21st July) at 3pm and 1.8m height - for the scenario planning optimized](image)
3.3. Optimization process

The project optimization was performed in close cooperation with the architectural team and the developer in an iterative process. Figure 7 shows the design amendments via Green Infrastructure leading to an improved thermal comfort (PET) as well as Thermal Comfort Score for the optimized planning, in comparison to the former planning scenario (see Figure 10 and Figure 11).

![Figure 10. GREENPASS® TCS bar for different scenarios of ‘FLAIR in the City’ showing the performance ratio](image)

![Figure 11. GREENPASS® KPI - TCS – Thermal Comfort Score for ‘FLAIR in the City’ Planning and Planning optimized](image)

3.4. Certification results

The overall results of the GREENPASS® certification show that the planning area has been optimized with regard to climate resilience and the use of green and blue infrastructure and their multiple effects. A cost/benefit analysis enabled the most cost-efficient and resource-efficient solution to be found. The original ‘FLAIR in the City’ planning design had the performance of a total degree of fulfillment of 67 % (see Figure 12).
The optimized planning for ‘FLAIR in the City’ reaches with 79 % total degree of fulfillment finally the worldwide first GREENPASS® Gold certificate. The results are presented in form of a comprehensive and detailed report (app. 100+ pages) and summarized in a project factsheet including project details, evaluation results and performance facts. The results per indicator and urban challenge are further shown in form of an assessment flower graphic (see Figure 13).
The performance facts show e.g., that the planned actions have a cooling performance of up to 1°C air temperature and 10°C PET (see Figure 14). Regarding the average run-off coefficient, ‘FLAIR in the city’ performs with an average of 0.2 again very well. For the performance, the plants have a need of 1.312 m³ of water by same time saving 274 m³ of water recurrently, depending on the intensity of rain fall events. And many more (see Figure 14).

Figure 14. GREENPASS® facts – ‘FLAIR in the City’ – 1st GREENPASS® Gold certified project

4. Discussion
For an effective climate change adaption of urban areas, the optimization of urban development projects is nowadays crucial. Therefore, every single urban development project should consider microclimate and urban climate related aspects, to optimize the quality of life for residents and citizens.

GREENPASS® has been successfully used for optimization purpose to improve the planning regarding climate-resilience, water retention and cost. A typical microclimate simulation provides only thermal maps (e.g. PET, PMV, UTCI, AT, …) and wind flow information. An optional evaluation of planning projects remains only on a descriptive level. A comparison of different designs and actions, as well as the interpretation and understanding of results is hardly possible and limited to urban climate experts.

Compared to classic microclimate simulations, GREENPASS® additionally delivers now a decision support for urban development planning and architecture, due to a standardized certification process,
sophisticated Key performance indicators (KPIs), clearly defined reference scenarios and an easy understandable graphical presentation of results. In an iterative planning process, hot spots can be analysed, defined and optimized in cooperation with the developer, architects and other involved trades. Because the building structure was set already at this point of time, the applicable actions have been limited to specific improvement measures, like the additional integration of Green and Blue infrastructure.

5. Conclusion

The GREENPASS® approach has been successfully proven itself in practice, based on the Case Study ‘FLAIR in the City’ – the worldwide first GREENPASS® Gold certified project.

Figure 15. Visualization - ‘FLAIR in the City’ Planning optimized (FLAIR GmbH)

It is following recommended, to use GREENPASS® as standardized tool for climate-resilient urban planning processes, in parallel to the energy pass for buildings. This international award is further proof that not only costs can be saved with the right choice of building integrated greenery and targeted green space design, but also maximizing the thermal comfort for all residents. This result shows that the consideration of green and blue infrastructure ensures climate-resilient urban planning in a simple and cost-effective manner. The thermal comfort and the quality of life for residents in urban areas can thus be significantly increased. In addition, biodiversity and habitat quality can be promoted, too.

The worldwide applicable GREENPASS® technology has been already applied for more than 35 projects in Austria and the EU [3] and is summarized, an efficient planning approach and realization tool that provides profound decision-making ground. It helps to prevent urban heat islands and other urban challenges in times of climate change and to make our cities climate-resilient and livable.

Nevertheless, it’s important to consider climate adaption aspects and the integration of innovative planning tools in urban design process as early as possible, due to a strong impact of the building structure and used materials to its surrounding and on humans and to be able to optimize the building structures, if necessary. Lesson learned is following, that climate adaptation in urban design processes should be considered from the very early beginning of the detailed planning process (or even in urban planning processes before) to get the best out of the project.

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