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Green Facades – How they Matter for Working Environments, Public Spaces and the Livability of a City

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1 ABSTRACT

Sustainable urban development is the focus of many research initiatives, especially due to increasing urbanization and climate change. Buildings and their renovation are central to the European "Green Deal". In the new Austrian climate and energy program, the topic of buildings comes first with a target renovation rate of 3%. Current climate change adaptation strategies call for an increase in greening of existing buildings and on facades. Public spaces are shaped by the surrounding buildings. The facades and roofs of these buildings can have a high potential to mitigate urban heat island effects. Social change and innovation in working cultures result in reshaping working environments and the need for public space.

Large-scale glass buildings are widely considered architectural highlights, but pose problematic challenges to urban spaces. Glass has a significant impact on the microclimate inside the building and in the immediate outdoor environment: a concentration of radiant energy and high indoor temperatures put a strain on the energy balance and the well-being of the occupants. The retrofit greening of glass facades is a gap in building expertise and there is a lack of standard applications for the retrofit shading and insulation of glass buildings to obtain associated microclimatic benefits.

The project GLASGrün aims to develop, implement, test and monitor modular vertical greening standards for active external shading by deciduous plants on commercial buildings with large glazed facades. Transferable modular-based designs are to be developed. Additionally, sociological surveys on acceptance and perception will be implemented. GLASGrün generates quantitative data on energy, temperature and microclimate balance as well as qualitative data on the perception of the building situation before and after greening interventions and on public awareness. New findings on the acceptance and well-being of employees and customers, on purchasing behavior and market-economic parameters will be available.

GLASGrün is developing guidelines for constructive solutions, submission processes and care and maintenance management plans for the systems under consideration and for the vertical green standards tested, which are scalable and transferable and form an economic basis for future adaptations of further buildings as well as for their maintenance.

A socio-ecological transformation faces the challenge of how integrated solutions can be developed in dialogue with the users and to what extent these produce the desired effects such as greenhouse gas reduction or better indoor climate. On the other hand, the best solutions in the technical sense can also fail due to social barriers: the acceptance of decision-makers, a lack of willingness to cooperate on the part of employees, or a loss of image in the neighborhood, to name just a few examples. Acceptance depends amongst other factors on both the concrete technical implementation and the process of introduction. Thus, acceptance is not a static variable, but is in a relationship with the technical solution options themselves.

Public spaces are key to the discussion on sustainable urban development in their function against urban heat islands. Their diversity of uses and users allows for both a broad discussion and start of discourses and the testing of innovative sustainable measures, in this case greening of facades on buildings perceived in public space. In this paper we will present 2 case studies in Austria with the first results of interviews with employees and users of glass facade buildings and the users of public space.

Keywords: perception, vertical green, sustainable urban development, green infrastructure, urban public space

2 INTRODUCTION AND GLASGRÜN PROJECT

In the face of rapid urbanization and climate change research focuses on sustainable urban development mitigating and adapting the severe risks of heat in cities. The European "Green Deal" states the importance of the built environment and the renovation and sustainble use of buildings. The new Austrian climate and energy program gives a target renovation rate of 3% for buildings. Adapting to the risks of climate change

calls for strategies to increase the greening of existing buildings, including their surroundings as much as their roofs and facades. Vegetation on facades and roofs can play an important role in preventing urban heat islands, especially as public spaces are shaped by the surrounding buildings. Access to urban public spaces with shadow, cooling effects and fresh air for all citizens is getting more important with rising numbers of heat days. New forms of working cultures with more flexibility, sharing and homeoffice regulations need innovative concepts for adapted working environments.

Cities with their densly built areas are characterized by higher temparatures and prone to produce urban heat islands. Lacking the possibility to enlarge horizontal green spaces, greening initiatives need to resort to facades and roofs as vertical and elevated space and their potential for vegetation. The effects of vegetation on microclimate, air quality, noise pollution, biodiversity but also on the building substance and the quality of life of users have been shown (Stangl et al., 2019; Schmauck, 2019; Stadt Wien MA 22, 2019).

The city of Vienna has gained experience with greening facades and a growing network of experts and scientists has contributed to Guidelines for greening facades in Vienna (Statd Wien MA 22, 2019). Some of these best practice projects and the learnings of implementing green facades are presented by the competence centre for greening buildings “GrünstattGrau” (https://gruenstattgrau.at/). Greenpass software has been developed as a smart tool for sustainable urban planning and assessing the effects of greening efforts (https://greenpass.io/).

As glass facades enhance heat even more through reflection and radiation, the project GLASGrün[1] aims to find solutions for livable cities, climate change adaption and innovative paths for sustainable urban development. Large glass buildings are still built widely, but pose some challenges for sustainable urban development. Glass facades have an impact on the microclimate inside the building and in the immediate outdoor surroundings. The concentration of radiant energy and high indoor temperatures put a strain on the well-being of all occupants of a building, mostly on employees concerning the work place environmental standards but also on clients, customers and visitors, who are more or less attracted to enter the building. The retrofit greening of glass facades is a gap and challenging. Currently, standard applications for the retrofit shading and insulation of glass buildings and the associated microclimatic benefits are completely lacking. The project GLASGrün aims to develop, implement, test and monitor vertical greening solutions for green retrofit and external shading by deciduous plants on commercial buildings with large glazed facades. We have the goal to develop economically sound and transferable modular-based standard designs which are socially accepted.

Surveys on acceptance and perception of greening glass facades will give us insight in the factors influencing positive or negative reactions to greening efforts. GLASGrün generates quantitative data on energy, temperature and microclimate balance as well as qualitative data on the perception of the building situation before and after greening interventions and on public awareness. New findings on the acceptance and well-being of employees and customers, on purchasing behavior and market-economic parameters will be available. GLASGrün is developing guidelines for constructive solutions, submission processes and care and maintenance management plans for the systems under consideration and for the vertical greenery tested, which are scalable and transferable and form an economic basis for future adaptations of further buildings as well as for their maintenance.

A socio-ecological transformation faces the challenge of how integrated solutions can be developed in dialogue with the users and to what extent these produce the desired effects such as greenhouse gas reduction or better indoor climate. On the other hand, the best solutions in the technical sense can also fail due to social barriers: the acceptance of decision-makers, a lack of willingness to cooperate between employees and employers, or a loss of image in the neighborhood, to name just a few examples. Acceptance depends on both the concrete technical implementation and the process of introduction. Thus, acceptance is not a static variable, but is in a reciprocal relationship with the technical solution options themselves.

Public spaces are key to the discussion on sustainable urban development in their function against urban heat islands and green open space for all citizens. Their diversity of uses and users allows for both a broad

[1] GLASGrün, project funded by FFG, Stadt der Zukunft, August 2021 – Juli 2024, project lead Institut für Ingenieurbiologie und Landschaftsbau (IBLB) BOKU Vienna; Projektpartner Institute of Social Ecology, BOKU Vienna; MPREIS; rataplan; lichtblauwagner; IBO - Österreichisches Institut für Baubiologie und -ökologie und GRÜNSTATTGRAU. - https://nachhaltigwirtschaften.at/de/sdz/projekte/glas-gruen.php

discussion and start of discourses and the testing of innovative sustainable measures, in this case greening of facades on buildings perceived in public space. In this paper we present 2 case studies in Austria with the first results of interviews with employees and users of glass facade buildings and the users of public space.

3 CASE STUDIES IN VIENNA AND SÖLL

In the GlasGrün project we cooperate between academic researchers and experts on greening buildings on creating new solutions for glass facades. We further cooperate with two companies who operate in buildings with glass facades. They are interested in greening these facades to improve thermal comfort conditions and are willing to test the first solutions developed for their specific buildings as demonstration sites. The transdisciplinary project team develops vertical greenery components as standard modules. These are sought to be aesthetically fully integrated in the architectural and constructural design, whilst highly effective referring to indoor and outdoor microclimate and the energy balance. The GLASGrün concepts and designs will be implemented and monitored in 2 demonstration sites.

3.1 Urban office building: Vienna

In Vienna an "Engineering office for technical building equipment and technical physics" has office space at Kreuzgasse 74 behind a high glass façade. The building is at the edge of an open space frequented by customers of several shops and citizens using public transport at the tramway station with very little green infrastructure. The employees work behind the glass façade. The employer hopes to find a green and climate friendly solution providing protection from heat and views. (Fig. 1)

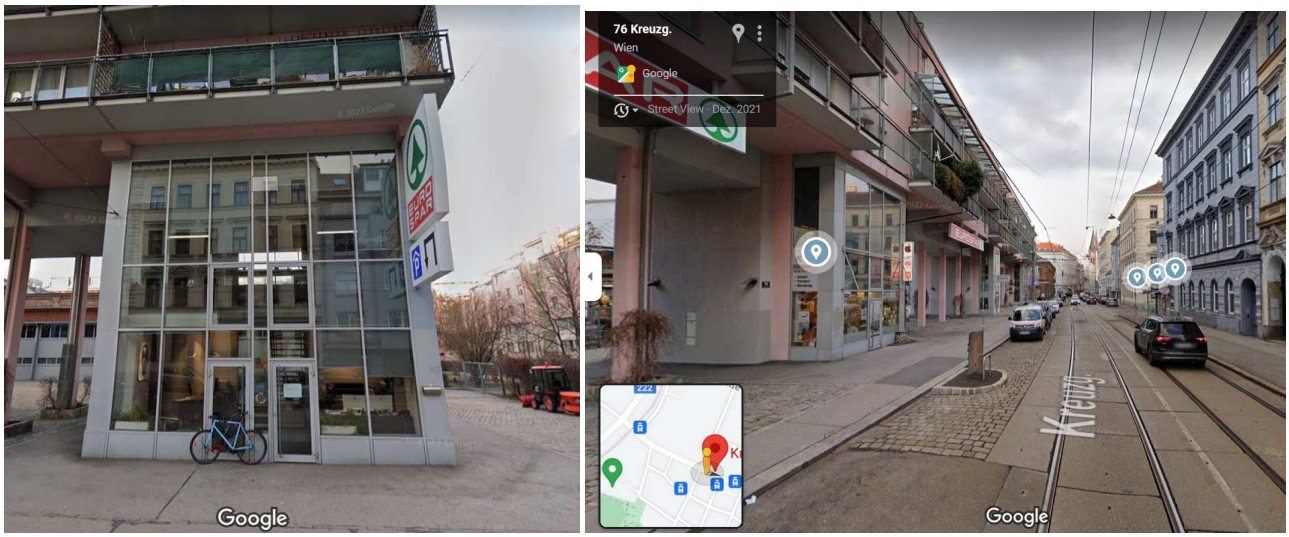

Fig. 1: Google Street View: Kreuzgasse 74, 1180 Wien

Due to juridical and planning issues not yet solved, the greening installation has not been developed yet. The survey on acceptance and perception of passersby and employees of the office were conducted in May 2022.

3.2 Rural supermarket: Söll

On the outskirts of Söll, a village (4,200 inhabitants, 703 m above sea level) in the Tyrolean tourist region "Wilder Kaiser", the company MPreis has a supermarket which is frequented by villagers, tourists and costumers approaching via the highway. The supermarket has a large glass facade allowing for an open inviting view, as this is a generally acknowledged architectural up-to-date concept for commercial buildings. The company tried to lessen problems of high indoor temperatures by shading the glass front with a wall of timber. (Fig. 2)

The physical monitoring of indoor conditions and electricity consumption was implemented in February 2022. Surveys on acceptance and perception of costumers and employees of the supermarket were conducted in May 2022 prior to the first steps of installing new vertical greening systems. The installation of the innovative and effective GLASGrün systems as integrative addition and the intended pre-measurement setups were completed in 06/2022. Follow-up surveys are planned for spring 2023, when plants are successfully growing and in spring 2024, when shadowing effects can be expected.

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Fig. 2: Söll MPreis outdoor view; https://www.wilderkaiser.info/de/soell/info/mpreis-supermarkt-soell.html

4 PERCEPTION AND ACCEPTANCE: SURVEYS AMONG USERS AND EMPLOYEES

4.1 Perception of vertical greenery and green facades

Various studies prove the positive effect of green environments on people (Bringslimark et al., 2009; Fjeld et al., 1998; Flagler et al., 2018; Lohr, 2007). Green open spaces and gardens have been shown to have therapeutic effects, as the plant-human interaction exerts regulatory functions to reduce stress, anxiety, anger, blood pressure, muscle tension, and more. Reinwald et al. (2021) point out, that urban green infrastructure and open spaces support in coping with the consequences of crises and climate change referring to human health and well-being. Vertical gardens are increasingly seen as important natural structures that can positively influence people's moods. Urban green has been linked via various pathways with positive effects on mental health (Chen 2021; Dzhanibov 2018; Lee 2019). There is also evidence of the benefits of gardens and plants in workplaces and schools, reducing absenteeism and stress levels and increasing productivity (Fjeld, 2000).

There is little empirical work available on the acceptance of façade greening, but a few surveys are available for Cologne and Genoa (Magliocco & Perini, 2015; Schlößer, 2003), and a master's thesis on the perception of green façades in Vienna has recently been approved at BOKU Vienna (Pichl, 2021). Radić et al. (Radić et al., 2019), for example, highlight the ambivalent perception of citizens, which on the one hand is characterized by positive effects on the environment and well-being and at the same time by uncertainties such as "expensive and problematic" (Magliocco & Perini 2015, p. 906).

Research on the perception of façade greening shows the need for an early involvement of people who might feel and judge positive or negative effects of façade greening. Furthermore, the acceptance of greening measures must primarily be asked of building owners, financiers, planners and architects. Schmauck (2019) points out that communication and public relations work carried out in parallel to the greening implementation contribute to raising awareness and acceptance among the population.

4.2 Pre-greening survey with costumers and employees

Prior to the greening installation students conducted surveys on the 2 sites in the form of online and personal interviews. The same questionnaire was used for employees in Vienna and Söll and for supermarket customers in Söll and for passersby using the public space in Vienna. The questionnaires on the 2 sites differed only in the presentation of the foto of the object without and with potential greening.

The surveys were conducted by 2 teams of students of the Bachelor programme Environment and Bioresources Management at BOKU Vienna. The questionnaire was developed within the project course “Interdisciplinary projects” under guidance of the authors. Students approached passing persons personally and gave them questionnaires to be filled on site or flyers with a QR code for the online survey. The printed questionnaire was formatted in 2 pages, containing 2 fotos and 16 questions on vertical greening, sustainable development and personal preferences and 8 demographic questions. After an opening question followed a mix of open questions, multiple choice questions and a Likertscala to assess a series of statements from

former studies. Lime Survey was used for the online survey, the data from personal interviews were added to Lime Survey by the students. In sum we can draw on a total of 187 filled questionnaires for the case in Vienna and 64 filled questionnaires for Söll by users/costumers. The questionnaire for employees had the same structure with questions modified to the specific role of the persons working on the sites, resulting in data from 5 questionnaires in Vienna and 10 questionnaires in Söll.

4.3 Post-greening survey with costumers and employees

We plan a next round of the survey when the greening installation is in place, plants are growing and visible to a certain extent from inside and outside the building. The questionaire will contain the same questions modified to the new situation, in order to grasp the perception of actual plants and their effects. This will then allow to explore the difference in perception between an imaginated greening and an actual green façade shading. Data and information from technical monitoring will then be available and used for additional questions.

5 FIRST RESULTS AND DISCUSSION

The survey conducted by students provides first impressions on the perception and acceptance of vertical greening by passers-by, costumers and employees and the factors possibly influencing their perceptions. We present and discuss the first results along selected topics asked in the survey, showing data for costumers in Söll and passersby in Vienna and add the summary of responses from employees.

5.1 Advantages and disadvanteges of green facades

The open questions at the beginning situate the respondents in view of the façade as is (with the glass face) and ask their impression. They then are asked to comment on 2 pictures, one of the façade at the moment without greening and one with a potentially green façade. When asked for the most important advantages and disadvantages of greening facades in an open question costumers of the supermarket in Tyrol state 80% positive and 20% negative effects. Respondents name mostly aspects of aesthetics and nature and climate protection and refer to the importance of improving air quality, protecting wildlife habitat and controlling temperature. In Vienna approval of greening the glass façade is lower with 68% positive and 32% negative items. The passers-by provide the same items as in Tyrol but add the improvement of noise pollution on the positive side and molesting insects as negative effect.

To the question “In your opinion, do the advantages or disadvantages of greening the façade prevail?” customers in Söll state 70% advantages, 29% balanced and 1% disadvantages. In Vienna passers-by see 91% advantages, 5% balanced and 4% disadvantages (Fig. 3).

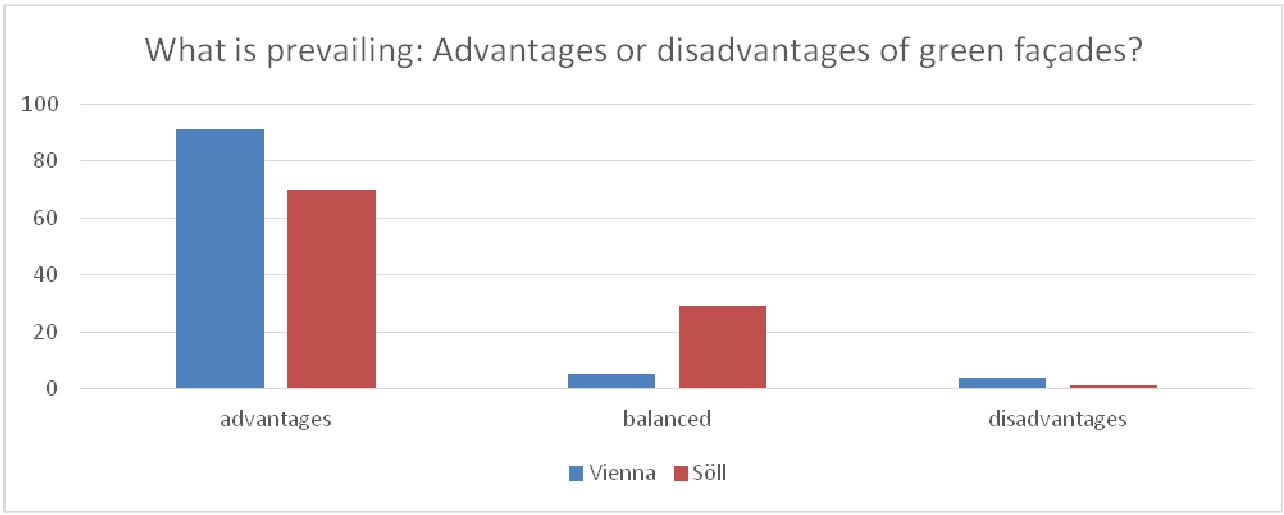

Fig. 3: Advantages or disadvantages of green façades (Seminar paper IP UBRM, 2022)

Small differences can be seen, when controlling for age, with higher approval in older people. No differences come up with educational level and sex. But persons with caring responsibilities for children show slightly more approval.

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Overall all groups (customers, passersby and employees) give a high approval of greening facades with higher approval rates as well as more critical aspects named in Vienna.

5.2 Effects on climate and nature protection

Climate and nature protection are further issues with high approval, reflecting either awareness or desirable responses. Nevertheless, as ist is not possible to control for these effects, the data show high agreement with the needs to alleviate climate change effects and the aim to find adaptation measures to achieve foremost control over temperature, air and noise pollution and protection of wildlife habitats. Customers agree to the statement that supermarkets should contribute to climate and nature protection (82,8% agreement).

The question “Does climate change require quick and decisive action?” 78% of respondenst in Söll say “yes,” or “rather yes” and 3% say “no” (Fig. 4) . In Vienna affirmative responses sum up to 96% with only 1% negative response.

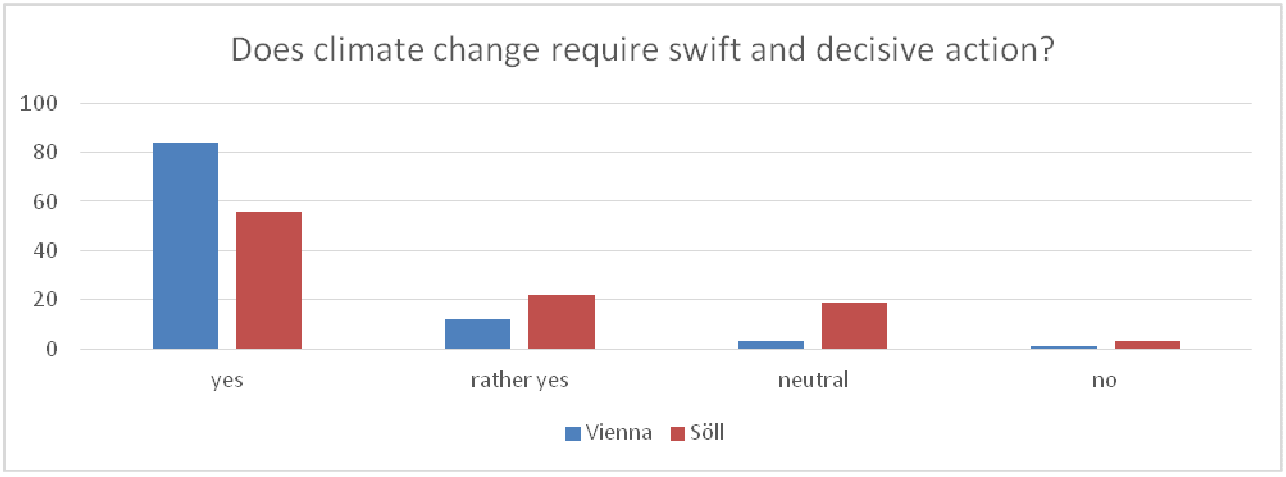

Fig. 4: Action on climate change (Seminar paper IP UBRM, 2022)

Combining the 2 questions we see a clear linkage between the perceived advantages of greening facades and the need for action on climate change (Fig. 5).

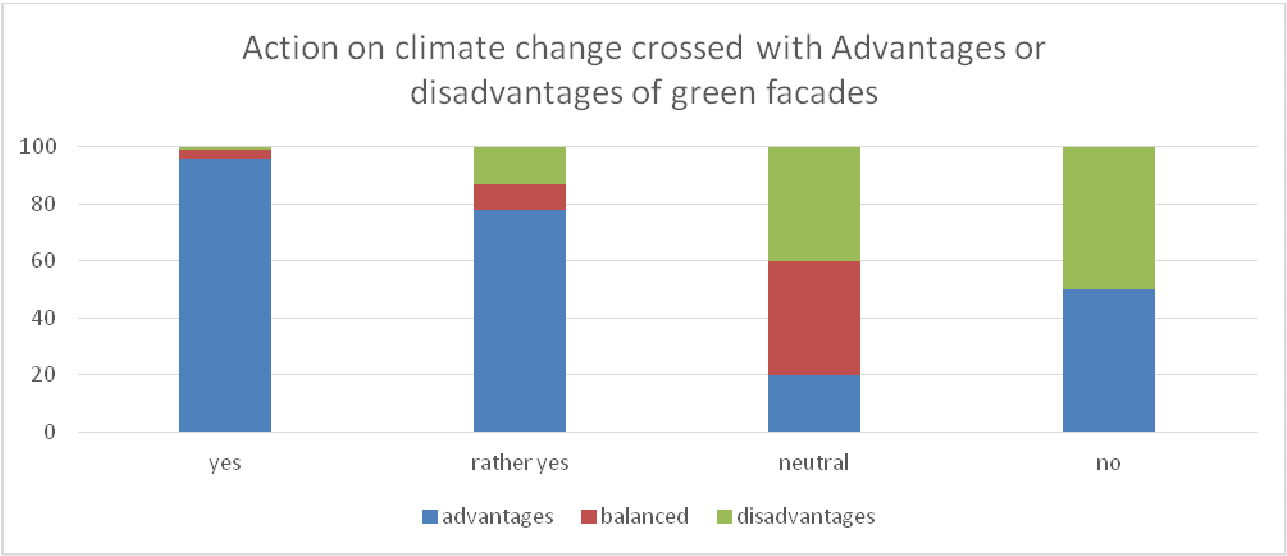

Fig. 5: Action on climate change crossed with Advantages or disadvantages of green facades, survey Vienna (seminar paper team Vienna, 2022)

5.3 Perceived burdens: insects and birds

Annoyance with insects and birds was amongst the disadvantages we asked to be rated. In rural Söll only a very small share of respondents agreed to the statement that this is a big burden, while about half of the respondents rather agreed. Interestingly enough, in Vienna the share of agreeing was significantly higher, but the group stating that this is rather a burden was far smaller (for plaguing insects about a quarter and for annoying birds below 10%). Maybe this hints at a bigger group potentially more strongly opposing greening

intiatives, but with a smaller support base from other people who rather see a problem here in Vienna. In the rural area there might be more differentiated views with a very small group in strong opposition regarding these issues, but more people who may need to be addressed but are more likely to be responsive.

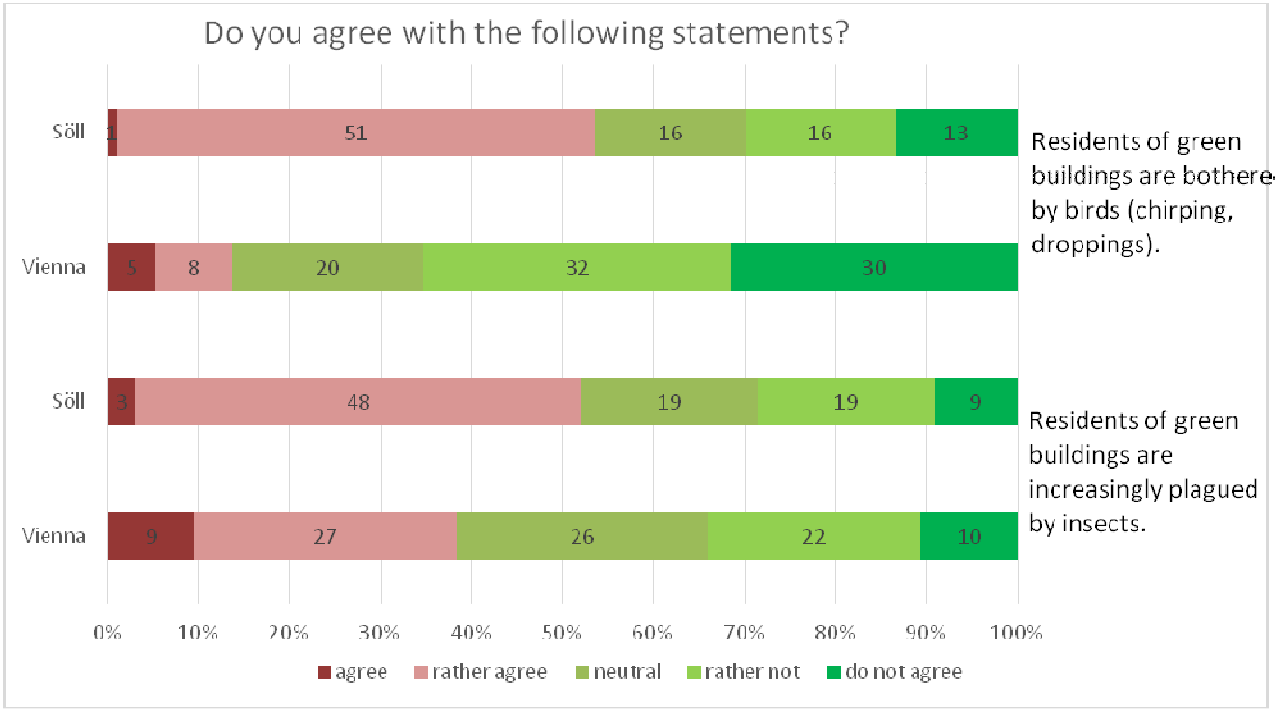

Fig. 6: Agreement to statements on birds or insects (seminar paper team Vienna, 2022)

5.4 Perceived benefit: Aesthetics

Most respondents agree on higher aesthetics of a green façade. A fact which seems rather surprising as glass facades seem to be the architectural choice of the moment. Eventually a change of perception on green infrastructure has already happened or is at least deemed as a desired response. The glass façade was perceived as: cold, dull, grey, dirty and only few characterized it as modern.

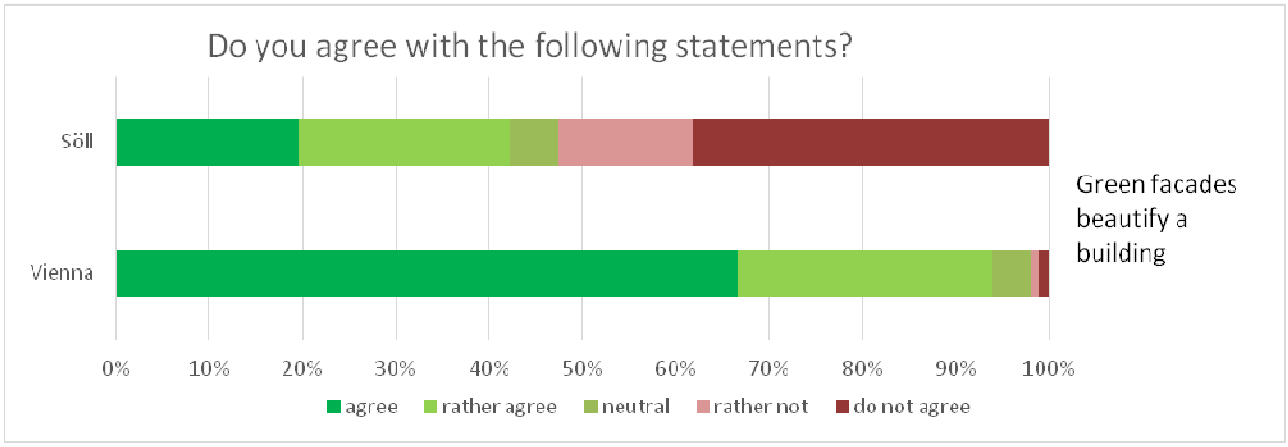

Fig. 7: Agreement to statement on beauty (seminar paper team Vienna, 2022)

Asked if greening beautifies facades, about 40% of customers in Söll agree or rather agree, whereas in Vienna over 90% of the passers-by agree or rather agree. Thus, beautifying facades could be a strong motivator in urban settings (Fig.7).

Employees give similar responses and agree strongly with the statement that greening efforts raise the image of the supermarket (90%).

5.5 Personal preferences

Respondents were asked for their personal preferences for example on greening the buildings they live in or the need for green environments. Surprisingly many have already green infrastructure on their houses in

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Tyrol in addition to gardens. Thus building on traditional forms of greening walls can be a promising way of promoting vertical green. In Vienna respondents have less green surroundings, and therefore most likely more need for it. On the other hand, bad experiences with old facades damaged by ivy are mentioned as bad examples in Vienna.

Employees see many benefits in greening the façade, hoping for shadow, cooler temperatures and less exposure to views. Albeit, they are concerned that green facades may require more work than glass façades and would need information on the amount and nature of work involved in an early phase of planning. The question of maintenance and willingness to participate in it is of upmost importance for a successful implementation of green facades.

6 CONCLUSION

6.1 Working environment

Employees hope for an array of advantages from green facades including lower temparatures in warm seasons, better indoor climate, less visibility and distraction from outside. They do appreciate a green ambiente and see that it could improve the image of their workplace. Yet they have questions regarding maintenance and practical issues. Their insecurity regarding the work eventually involved in greening facades has to be addressed early on.

6.2 Public spaces

Green public urban spaces will gain in importance under conditions of increasing heat days, especially for people who have small living spaces and no outdoor space. Additionally, green and cool space is of high importance for persons caring fro children and these children and young people in need of recreational space. In urban settings the beautification effect of greening is perceived as an important benefit. Access to free, cool, consumption free space within short distance is a must in urban planning under conditions of climate change. Green spaces have the complemnetary advantage of reducing stress levels and increasing human well-being.

6.3 Sustainable development and livability of a city

Reducing the advent of urban heat islands is key to sustainable urban development. Green and blue infrastructures need to be further advanced in order to make the most use of urban vegetation in reducing temperature, retaining excessive water and reducing air and noise pollution. Additionally, greening installations help to keep wildlife habitats in urban areas.

6.4 Summary and outlook

Overall, we see similar results as Jim (2022) in his survey on public opinion on green roofs and green walls (GRGW) in Tokyo, where it is mandatory to install greening in new building.

“Respondents mostly agreed with the contribution of GRGW to thermal comfort, air quality, and cityscape but weakly endorsed other potential benefits. High costs as well as mosquitoes and plant litter nuisances were the most recognized negative issues. Mandatory installation was the least preferred promotion policy. Instead, respondents expected installation on public buildings and provision of installation guidance. Respondents predominantly held a “moderate” view towards both the benefits and negative issues, showing indifferent attitudes towards GRGW. Income level and housing type shaped the overall perceptions, whereas age, sex, and current living environment influenced perceptions of individual aspects. Our findings signified a need for a bottom-up strategy to heighten public awareness for the advanced development of GRGW to complement and prime the top-down mandatory installation policy.” (Jim et al., 2022; p 35)

This moderate views in combination with a lack of information can be corroborated in our surveys for Vienna and Söll. In light of rapid climate change strong efforts to inform on the potentials of greening facades and roofs seem highly necessary.

GLASGrün is developing guidelines for constructive solutions, submission processes and care and maintenance management plans for the systems under consideration and for the vertical green modules tested, which are scalable and transferable and form an economic basis for future adaptations of further buildings as well as for their maintenance.

Greening glass facades will become more necessary in rural and urban areas for a variety of reasons: Stabilising indoor climate with low energy input in summer (mitigation), improving outdoor microclimate (adaptation), biodiversity (co-benefits), to name just a few. Therefore, the question of how to avoid failures and how to implement such projects with high quality and a high level of acceptance is important. Successful implementation requires successful technical implementation, but also good communication. Interactive communication processes can ensure that objections and concerns of the different groups are dealt with seriously and are reflected in the project planning. Such projects with interactive (two-way) communication processes enable broad implementation.

All pathways for socio-ecological transformation face the challenge of how integrated solutions can be developed in dialogue with the users and to what extent these produce the desired effects of green facades such as greenhouse gas reduction, better indoor climate and the necessary green urban spaces open for all citizens. As the best solutions in a technical sense can fail due to social barriers, we need to develop vertical green installations and guidelines for best installation and maintenance together with decision-makers, stakeholders (employees, customers) and the wider public. Information on gains from energy efficiency, on microclimatic effects in- and outdoors and on the costs and time needed for maintenance have to be specified. With best practice examples, adequate information and practical guidelines for each step of implementing greening in existing buildings we can start a public discourse, environmental education and raise awareness for the greening potential in cities. Such guidelines should be designed for being useful to further acceptance of decision-makers, the willingness to cooperate between stakeholders, and the awareness in local neighborhoods and the wider public opinion. In the GlasGrün project they are designed and developed for the retrofitting of glass facades in a socially, ecologically and economically acceptable version.

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