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Glazed spaces for a resource efficient, social and healthy living

Part 1: Inventory of geometries and functions by study visits and interviews

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ABSTRACT

The main aim of the Spaces project is to support architects in the design of well-functioning glazed geometries, such as atria and rooftops, in residential buildings.

The studied geometries are primarily spaces for communication and leisure in residential buildings. These spaces may have a varying indoor climate, which is governed by the construction of the building, as well as residents' activities, rather than by building services. The project contributes with examples of geometries and usages, methods to evaluate the performance early in the design process and to provide guidance for architectural design and increased social interaction. The project also investigates obstacles that exist in current practice and Swedish legislation for glazed geometries.

In this report, the first part of the project "Inventory of geometries and functions by study visits and interviews" is presented. Methods used in this first part is literature studies, interviews and case studies. The topics investigated are social and human aspects, technical aspects such as thermal comfort, energy, air quality, humidity, acoustics and to some extent urban farming. From the literature and by contacting architects and consultants in the building industry, eight case study buildings were found, located. The buildings were either housing cooperatives or rental buildings, and the glazed spaces in the buildings were either atria, glazed balconies or glazed rooftops.

For the case studies, information was gathered from databases, through interviews and during study visits. The opinions of the residents were captured during structured interviews and through quantifiable surveys, and the results were analysed by the project group with input from the reference group.

For social interaction, the investigations show that even with a developed design for social interaction (such as common areas, kindergarden, private areas in connection with glazed space), the interaction might fail. Social activities are highly dependent on individuals and thus, engaged persons are very valuable to obtain a social environment. In addition, a clear purpose of the space and a sense of ownership is beneficial to the social environment. In this

study, the projects that worked well socially were the four housing cooperatives and one rental building. The three projects that worked less well were all rental.

There are slightly different opinions of the optimal size to achieve social interaction. The architect of one of the projects that works well socially suggests a maximum of 60 persons (25-30 families) and at another socially successful building, there are 48 apartments. Two out of the three largest buildings (71 apartments and 126 apartments) did not function well socially.

Daylight levels are usually considered good in the glazed spaces. However, there are darker areas, in particular under access balconies, and this also affects the daylight levels in the apartments. The air quality is usually perceived as good in the glazed spaces and the most common problem connected to air quality is a high level of moisture in the air, which can result in condensation on windows.

For thermal comfort, the expected level of comfort is important for the experience of the space. If the space looks like it is indoor, the expectation is room temperature in wintertime and, consequently, people are disappointed if it's much colder. Both studied rooftops have problems with high temperatures in summertime. The temperature in the glazed space depends to a large degree on shading and ventilation, but also on the thermal mass of the materials in the glazed space. This is further investigated in part 2 of the project (Wahlgren et al. 2021), where also evaluation tools and design guidelines are presented.

CONTENTS

Preface

This project, “Spaces-Glazed spaces for a resource efficient, social and healthy living”, is a joint project between architect and engineers with the aim to investigate and improve glazed spaces in residential buildings. Researchers and investigators from Chalmers University of Technology, Division of Building Technology and Division of Building Design, and from Sweco Architecture AB have been involved in the project, and a reference group with representatives from other divisions at Chalmers and from industry, mainly consultants, were connected to the project.

For the first part of the project, ‘Inventory of geometries and functions by study visits and interviews’ the project group consisted of the following persons:

Architecture:
Kajsa Crona, Architect/Adjunct professor, Department of Architecture and Civil Engineering, Chalmers University of Technology and Sweco AB, project leader
Ruxandra Bardas-Dunare, Architect, Sweco architects
Alesia Westfeldt, architect, Sweco architects
Ola Nylander, Architect/ Professor, director of the Centre of Housing Architecture, Department of Architecture and Civil Engineering, Chalmers University of Technology

Building physics, all at the Department of Architecture and Civil Engineering, Chalmers University of Technology:
Paula Wahlgren, Associate Professor in Building Physics, project leader
Carl-Eric Hagentoft, Professor in Building Physics
Fredrik Domhagen, PhD student
Toivo Säwén, PhD student

We would like to thank everybody, residents as well as professionals, who has contributed with their time and experiences during interviews and study visits. This project would not have been be possible without your help.

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Paula Wahlgren
Gothenburg, Sweden, June 2021

1. INTRODUCTION

Climate change and possibly more unstable weather in the future requires more adaptable and resilient housing design. Social sustainability is a key factor to strengthen communities and well-being in residential buildings and is necessary for people to thrive. This combination inspired to the project 'SPACES- Glazed spaces for a resource efficient, social and healthy living'. The project investigates glazed geometries in residential buildings as a robust solution from a health and resource perspective. The hypothesis is that glazed geometries, with a volume adapted for thermal comfort, daylight and use, can increase well-being and social interaction without increased energy use.

The studied geometries are primarily spaces for communication and leisure in residential buildings, consisting of wind protected glazed areas such as atria and rooftops (see Figure 1.1). Furthermore, these spaces may have a varying indoor climate, which is governed by the construction of the building, as well as residents' activities, rather than by building services. The project contributes with examples of geometries and usages, methods to evaluate the performance early in the design process and to provide guidance for architectural design and increased social interaction. The project also investigates obstacles that exist in current practice and Swedish legislation for glazed geometries.

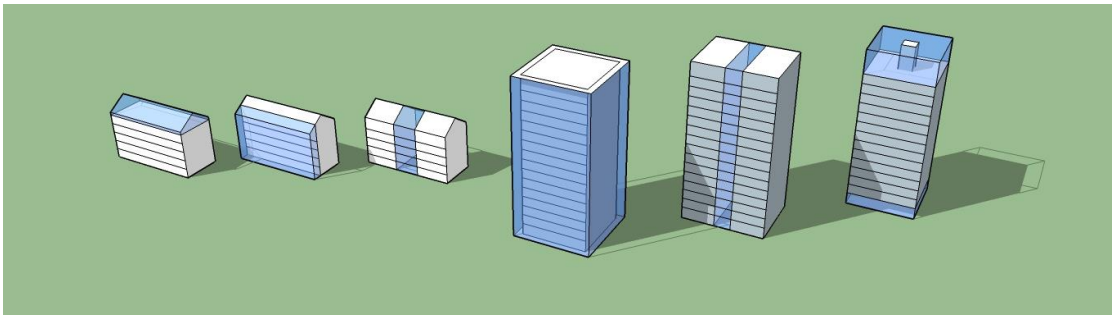


Figure 1.1. Examples of glazed spaces in residential buildings.

The glazed spaces are investigated from both an engineering perspective (daylight, thermal comfort etc.) and from an architectural perspective (building design, well-being, social activities etc.). The project includes literature studies, study visits to glazed buildings, interviews with consultants, residents, project managers et al., surveys, numerical modelling and analytical calculations of the technical performance of the glazed space, architectural program work, measurements on site and communication activities.

This report contains a summary of the first part of the project, which includes, for example, a literature review (Chapter 2), case studies with visits and interviews (Chapter 4), a thematic summary of the interview results (Chapter 5).

1.1. AIM OF PART 1 OF THE PROJECT

The initial investigations concern the impact of the glazed spaces, with focus on the experience of the residents in the buildings. One aim of the first part of the project is to find glazed spaces that work well or poorly, socially and technically, and to connect the performance to the physical building, or to the organisation or interest of the people in the building. Another aim is to determine the parameters that are of importance to the success or failure of a glazed space in terms of indoor climate and social interaction, so that these can be further analysed in part 2 of the project.

1.2. METHODS USE IN PART 1

Initially, a literature review was conducted, with focus on six topics: daylight, energy, air flows, resident health, urban farming and social aspects (see Chapter 2). With this as a basis and by contacting architects and consultants in the building industry, relevant case studies were found. For the case studies, information was gathered from databases, through interviews and during study visits. The opinions of the residents were captured during interviews and through quantifiable surveys, and the results were analysed by the project group with input from the reference group.

1.3. LIMITATIONS

The literature review is not geographically delimited, but glazed spaces in colder climates are in focus. The case study objects are all located in Sweden, from Malmö in the south to Umeå in the north-east. The objects are residential buildings in which mechanical ventilation and cooling of the glazed spaces is limited and natural ventilation is predominant. Additional energy use caused by the glazing is not determined (see literature review for such estimations), but the use of heating devices to obtain thermal comfort (or for plants) is described. The number of interviews is not sufficient to statistically determine the impact of each parameter that is included in the study. However, the interviews are used to find important parameters that are later included in part 2. The glazed geometries in the case studies are atria, balconies and rooftops.

2. LITERATURE REVIEW

The literature review was conducted with focus on six topics: daylight, energy and air flows, health, urban farming and social aspects. The emphasis was on projects in colder climate and have included several Swedish projects. The databases Scopus, Web of Science and ProQuest were mainly used.

The main part of the literature that was found related to glazed geometries in residential buildings and concerned atria, balconies and glazed facades. Other types of glazed spaces such as stairwells, exterior corridors, on-top glazed spaces and entrances were not as commonly found. In some respects, mainly from social and health perspectives, there was little information that related to residential buildings. Consequently, work on other domains, such as public or office buildings, were included in some cases. Research work on both unheated and heated glazed spaces was included even though the focus is on unheated spaces. For some papers on atriums, it was not specified if the atrium was heated or not. Approximately 100 papers were gathered, whereof approximately 50 had a high relevance (in terms of climate, type of glazed space and perspective) and were analysed more in detail.

The most relevant papers are shown in Table 2.1. and in the following, a short summary of the main categories is presented. Complete references are given in Chapter 9.

Table 2.1. Main papers resulting from the literature review

CATEGORIES of articles divided by themes	KEY WORDS In the search on the databases	No. of papers	REFERENCES Sorted chronologically
DAYLIGHT Literature that refers to daylight in glazed spaces and adjoining spaces. Energy aspects, glare, natural light, aspects of human behavior in relation to daylight.	daylight	5	Wilson et al., 2000, Sharples et al., 2007, Kim et al., 2009, Samant, 2010, Xue et al., 2016
ENERGY (including passive technology and shading) Literature that covers energy aspect in different glazed spaces including energy calculation. Also, that refers to size, shape, height ratio.	energy efficiency, preheating, passive design, energy conservation, low-energy, zero-energy, overheating, Nordic climate, Canada, cold climate, air flows, ventilation, shading, louvres, perforation, passive, passive design	13	Wall, 1996, Hilliaho et al., 2015, Hilliaho et al., 2016, Amani, 2017, Premov et al., 2017, Hawila et al., 2019, Kim et al., 2013, Bauer et al., 2013, Kainlauri,1993, Gaudet, 2014, Teleghani, 2013, Aldawoud, 2012, Laouadi et al., 2002
SOCIAL Literature that analyses how glazed spaces influence human activities and social interaction. Other relevant literature that discusses these aspects even when not in association with glazed spaces.	social activities, social interaction		(Danielski et al., 2016, Kearney, 2006, Mengual et al., 2015

HEALTH Literature describing how the indoor climate in glazed spaces influences human well-being.	health, well-being	1	McKeever, 2010
URBAN FARMING Literature that discusses technical aspects of urban farming in indoor glazed climate (required measures, climatic conditions, pest control). Also, the social dimension in connection with urban faming.	greenhouse, plant, urban farming	2	Mengual et al., 2015, Gaudet, 2014
AIR FLOWS & VENTILATION Literature that describes different types of ventilation in atria, in particular natural ventilation in atria and basic principles.	ventilation, air flow, ventilation strategy, natural ventilation, atria, atrium		Heiselberg P et al. 2018, Moosavi et al. 2014 Larsen, 2006, Ji et al. 2007 Kleiven, 2003 Holford et al. 2003

2.1. DAYLIGHT

Daylight in glazed spaces is a large topic in the academic field. Several aspects are covered in most of the literature: direct sunlight, glare, over lit, reflectance and penetration of daylight into adjoining spaces.

A very thorough literature review covering the main literature on the topic from some decades back is done by Samant (2010). He emphasises the need for more comprehensive approaches when discussing daylight in the atrium, especially with regards to the aim of creating sustainable architecture in such spaces. He stresses the lack of comprehensive reference guides for design proposals and the need to examine the emerging trends or to better analyse the gaps between research and practice.

Sharples & Lash (2007) include a definition of an atrium as well as a short history of the different forms (geometries) in which atria have appeared in the international context. Several classifications of atria from the geometrical point of view are described. A display of and explanations for terminology for the geometry of the atria, the daylight factor and the surface reflectance are also provided. The paper shows that different studies provide conflicting results regarding the relationship between the shape of the roof structure and the distribution of the illumination in then atrium. Little information on the performance of atrium roofs in real buildings exists within the literature, the paper states. Significant differences were found between the measured and predicted values of daylight (Sharples & Lash, 2007).

According to Samant (2010), several studies (ranging from late 60s to the early 2000s) show how dimensions, shape, well index, plan and section aspect ratio, etc. are linked with the quality, spread and distribution of natural light. They offer a number of design guidelines for atria regarding improved illumination inside.

Many authors identified a big potential for daylight in the atria, but they argue that this potential is not well utilised in the spaces adjoining the atria (Sharples & Lash, 2007 and Samant, 2010). A wide range of guidelines to improve this is provided in the investigated papers. A conclusion drawn in many papers is that there are gaps in understanding between the research and the practice (Sharples & Lash, 2007 and Samant, 2010).

Three papers from the literature review discuss balconies and their impact in daylight in residential buildings. Wilson et al. (2000) indicate that good daylight amount as well as energy savings can be achieved using glazed balconies. Kim et al. (2009) found a relationship between daylight amount and the balcony geometry, stating that a light attenuation of 70-90% was the effect when increasing the well index above 1 m and the balcony depth above 3 m. Xue et al. (2016) considered the effect of sun shading devices in balconies, and found that they reduced glare and overheating, but also reduced daylight amount in the apartment (Wilson et al., 2000, Kim et al., 2009 and Xue et al., 2016).

Most of the literature refers to atria and balconies (and not all are about enclosed glazed spaces) while there are few references to other forms of glazed geometries in the project.

2.2. ENERGY AND THERMAL COMFORT

There are many papers concerning evaluation of energy demand for glazed spaces, and some studies also provide guidelines for the most energy efficient design. In Wall (1996), several examples of existing buildings with glazed spaces with different dimensions, both residential and non-residential, are presented and energy calculations are performed for each building (Wall, 1996).

There are studies that propose that the energy demand of a building can be reduced by using different kinds of glazed spaces. For instance, the energy demand of a residential building can be lowered by adding a glazed add-on, which is shown in a study by Bauer et al. (2013). It is also explained how to use a free parametric program together with an energy simulation software in the early design stage of a project (Bauer et al., 2013).

A concept for passive heating in rural areas with cold climates was provided by Wang et al. (2019). Having performed numerical investigations, the study suggests an on-top sunspace as a passive heating design solutions fit for the cold climate in northern China. With an optimal angle, an indoor temperature of 14.7°C and improved daylight conditions were achieved. The study notes the importance of a high thermal mass in the sunspace (Wang et al., 2019).

Three studies have been done by Hilliaho et al. (2015, 2016(1), 2016(2)) on the topic of energy savings in buildings in cold climates by using glazed balconies. The studies include field measurements, software simulation and a simplified calculation method that can be used by architects and engineers. Identified key factors are the building ventilation system, heat transfer between interior, balcony and exterior air, airtightness and absorption coefficients of balcony enclosure surfaces. It was found that the effect of balconies was higher in colder climates. (Hilliaho et al., 2015, Hilliaho et al., 2016 (1) and Hilliaho et al., 2016 (2)).

In a study, Laouadi et al. (2002) use computer simulations to understand how different atrium and atrium skylight designs affect thermal and energy performance of atrium buildings. Three types of atria are investigated: enclosed, three-sided and linear for the cold climate of Ottawa, Canada. Pitched skylights in the atrium were found to increase the solar heat gain ratio by up to 25% compared to flat skylights. Depending on the U-value and solar heat gain coefficients of the glazing, and the geometry of the atrium, the skylight was found to have both positive and negative effects on annual cooling or heating energy. Atriums open to the adjacent spaces were found to have a reduced annual cooling energy by 76% but an increase annual heating energy by 19% (Laouadi et al., 2002).

A similar study is done by Aldawoud (2012), where four enclosed rectangular atria with different width-to-length ratio are compared regarding energy demand. This is done for four different climates. Conclusions are drawn regarding best fitted shape and height of the atrium

building for different climates: it was found that the total energy consumption of a narrow, elongated atrium is significantly higher than that of a square shaped one (Aldawoud, 2012).

A Swedish study by Danielski et al. (2016) compares two buildings, one with glazing and one without. Conclusions are drawn regarding the effect of adding glazing and also about how the shape factor of the building affects the energy behavior. It was found that heated atria have a potential to reduce the total final energy demand in Nordic countries. Three requirements were noted: the shape factor of the entire building should be reduced, a minimum glazed area should provide enough natural light and visual comfort, and adjustable solar shading should be installed to avoid overheating (Danielski et al., 2016).

Another study by Taleghani (2013) also compares two atrium buildings with and without glazing. An enclosed rectangular atrium is used in this study and evaluated for four different climate scenarios. Recommendations are given regarding when it is convenient to use each atrium type: in the Dutch context, an open courtyard is proposed in May through October while an atrium is proposed for the rest of the year.

Design guidelines regarding glazed spaces, orientation, building envelope, HVAC-systems, acoustics and indoor air quality are proposed by Kainlauri (1993), where the research is based on several university buildings with different atrium orientations. Louvers and shades are proposed to reduce glare in orientations with a lot of direct sunlight. Lighting fixtures are proposed in deep atria to improve lighting conditions. A high “loft” space at the top as well as openable windows are proposed to avoid overheating in the top occupied spaces. Proper HVAC system design to tackle both temperature gradients and improve air quality is required. Separation of spaces is proposed to reduce acoustical issues (Kainlauri,1993).

Wall-to-glass ratio and building geometry can strongly affect the energy consumption in a building. This is shown in a study by Premrov et al. (2017), which also gives building design advice for six different European climates. It was found that two-storey buildings performed better than single storey buildings in cold climates. However, this study refers to small scale residential buildings (Premrov et al., 2017).

Studies that could be found on energy aspects in glazed spaces mainly addressed glazed atria, glazed balconies, glazed facades, on-top glazed spaces or window-to-wall ratio.

Thermal comfort in glazed spaces is not necessarily the same as inside the apartment or building. Pitts (2013) shows that communication areas (glazed or not) can have a lower temperature than the living space and still maintain sufficient thermal comfort, since people spend a shorter time in the transport areas. This would thereby decrease the heating demand by 7%, for a temperature that is 3°C lower than standard, and by 11,5% if the temperature is 5°C lower. In addition to the temperature levels, the energy use is also affected by the location of the transport space. For a transport space located around the building, a 13% decrease in energy use has been reached (Pitts & Saleh, 2007).

In Moosavi (2014), a compilation of different designs of atria and a description of evaluation tools and influencing parameters is provided. An atrium provides considerable cooling in many cases, but one of the conclusions from the study is that there are no tools for design of atria, and that most evaluations of atria are made to validate more advanced tools and not suitable to be used in the early design process. Corresponding reasoning also applies to e.g. glazed facades and balconies.

2.3. SOCIAL ASPECTS

Many scientific studies show the benefit of having stronger, more active communities with increased social interaction. Some studies give guidelines on how to design the built environment to achieve this. Williams (2005) investigates how to design communities for better social interaction by studying and comparing two examples of co-housing. It is found that density, layout, division of private and public space and quality, type and functionality of communal spaces are key factors to achieve social interaction. It is also noted that because of cohousing residents' predisposition towards higher levels of social interaction, the findings may not be directly applicable to other housing types (Williams, 2005).

In Nordic climates, social interaction among neighbours could be achieved by providing a properly designed residential building (Danielski, 2016). This is shown by studying an existing residential building with a heated atrium in northern Sweden. The study is based on a survey with residents and discussions with the cooperative housing association. It was found that the additional conditioned space created by the atrium could increase senses of "neigbourliness and belongingness" which could improve social sustainability (Danielski, 2016).

Another study discusses urban housing developments in Seattle, Washington, USA, with a focus on proximity to nature, sense of community and residents' satisfaction (Kearney, 2006). The paper discusses design aspects such as density, clustering, shared nature spaces and nature views. The study provides a survey with residents and concludes that density and proximity to shared nature areas was not very important for residents' satisfaction. Instead, opportunities to visit nearby shared space and nature views from home improved satisfaction (Kearney, 2006).

One innovative residential building with focus on urban farming is studied in a report by Wester and Carlsson-Kanyama (2018). Thirteen households from the building are participating in the study by participating in surveys, interviews and by writing diaries, with a resource and energy use perspective, along with social expectations and social interaction. It was found that the resource use of residents was reduced by between 26-45% for all residents. The residents had high expectations on social interactions, which were fulfilled, and it was found that communal farming on balconies and in shared spaces was met with positive reactions (Wester & Carlsson-Kanyama, 2018).

Few studies could be found specifically on social interaction in glazed spaces, but many studies are done on the topic of how residential building design affects social behavior (Williams, 2005).

2.4. HEALTH

There is a large number of studies that connect people's physical environment with human health and well-being. Among found topics were presence of nature, social aspects and daylight. Many studies also show health benefits of gardening, closeness to nature and nature views.

Community gardening

An extensive summary of the benefits of urban farming are presented by Bellows et al. (2003). The paper is based on research in the fields of health, social studies and urban agriculture. Among the benefits are improved physical and mental health, social sustainability, food security, nutrition values, economic benefits, improved physical environment, improved air quality. The study also takes into consideration potential risks with urban farming, such as heavy metals, air pollution and pests (Bellows et al., 2003).

Healing gardens
A horticultural therapy garden or healing garden is a garden with healing potential, which can be located indoors or outdoors. The term horticulture refers to garden management. An extensive literature review on horticultural therapy has been done by Söderback et al. (2009). They have also studied the Horticultural Therapy Garden at Danderyd Hospital in Sweden and its horticultural therapy program. According to the authors, there are four main approaches to horticultural therapy: viewing images of nature, viewing actual nature, being in nature and actively participating in gardening activities (Söderback et al., 2009).

The numerous positive effects of horticultural therapy and therapeutic gardens on health are discussed in a study by Detweiler et al (2012), who also present many previous studies on the topic. Mentioned effects on health are improved sleep, reduction in pain, improved attention, reduction in stress, increased feeling of calm, improved social interaction, sense of responsibility and improved self-esteem (Detweiler et al., 2012).

Closeness to nature
A positive association between perceived health and the amount of green space in people's living environment is found in a study by Maas et al (2005), where more than 200 000 people from the Netherlands, with different socioeconomic backgrounds, participated in a survey about their perceived health. The answers were then related to the amount of nature in the living environment of the participants. In Maas et al. (2006), they report that in areas where 90% of the environment around the home (within 3 km) is green, only 10.2% of the residents feel unhealthy, as compared to areas in which 10% of the environment is green, where 15.5% of the residents feel unhealthy.

Glazed spaces & health
Adams et al. (2010) look at childre''s perception of a glazed space, namely a childre''s hospital atrium. The research is done to gain understanding about how architecture affects humans and seeks to give guidelines for architects and designers. Aspects that are looked at are comfort, socialisation, interface, wayfinding, contact with nature, flows and dimensions of the space (Adams et al., 2010).

Evans et al. (1998) investigate psychological stress and show a number of architectural dimensions and aspects that may affect human health. These factors are grouped into stimulation, coherence, affordances, control and restoration, and interior design elements coupled to these are presented. The restorative aspect is sometimes important in for example green and glazed atria, and the restorative elements described in the study are: minimal distraction, stimulus shelter, fascination and solitude.

The studies presented above are only some examples of research in the field, and many health-related studies focus on the effect of horticulture on human health. Elderly people are the most common focus group for these studies. It is difficult to find specific research regarding human health connected to glazed spaces, but a large amount of research is done on the topic of how healthcare environment affects human health. Some of these studies discuss large glazed spaces as atria and lobbies in healthcare facilities.

Nature seems to have a huge influence on human health (Orians et al. 1992, Kaplan, 1989). Other related topics that are also connected to health and living are daylight, loneliness and social interaction.

There are several ongoing studies tying the design of the living environment in residential buildings to residents' health.

2.5. URBAN FARMING

The identified literature on urban farming treats social, communal and technical aspects of urban farming and provides concrete guidelines on how to design glazed spaces for enhanced produce. In some cases, it is difficult to separate literature on urban farming from literature on social aspects and health, as these topics are often interconnected.

Urban farming can help to achieve urban food security and self-sufficiency, to promote health and it has numerous environmental and social benefits (Sanyé-Mengual et al., 2015, Bellows, 2003). Different stakeholders can have different perceptions on urban farming. A study by Sanyé-Mengual et al. (2015) investigates how these perceptions affect new urban agriculture projects and development. It was found that while urban agriculture is largely viewed as a social activity, there is a potential to conceptualise urban farming as a food production activity, which poses new challenges for acceptance (Sanyé-Mengual et al., 2015).

One type of urban farming is vertical farming. Al-Kodmany gives an overview of vertical farming and its types, describes its function and technologies involved, gives reasons for having it, discusses its development and points out current disadvantages, based on current research (2018).

Some studies can give us a clue on how to design glazed spaces from food perspective. In cold climates, different types of glazed structures and greenhouses can be used for food production. An optimal shape of glazed structure for maximal produce year around is proposed in a paper by Gaudet et al. (2014). The study is performed for cold climate with greater than 60-latitude in Canada. The proposed design is a 40 ft. shipping container oriented in an East-West direction with a glazed south facing wall and horizontal roof. In addition, the roof can be closed at night to save energy (Gaudet et al., 2014).

Another study by Çakır & Sahin (2015) investigates 5 common greenhouse types and proposes the design best fit for cold climates regarding shape, size and orientation. The article also points out the advantage of using greenhouses in cold climates during spring and autumn. According to the authors, the script developed in the study can also be used for other types of buildings, for solar energy evaluation (Çakır & Sahin, 2015).

2.6. AIR FLOW AND VENTILATION

The ventilation of the glazed space is very important to the thermal comfort in the space, in particular for cooling of the space in summertime. This has not been addressed much in colder climates, but due to increased glazing and increased temperatures, this becomes more important. In the work of Annex 62 (“Ventilative cooling”) of the International Energy Agency, IEA, the problem is acknowledged and Heiselberg et al. (2018) state that: “Cooling and overheating in residences have so far not been considered a design challenge, especially in colder climates. Therefore, the developed solutions to address cooling issues available for residential application are very limited, often too simplified and might not be well adapted for practical application. In the few cases, where the cooling challenge is addressed by a one-of-a-kind design, the solutions were expensive and needed careful commissioning to function.” Consequently, the combination of residential buildings with atria in colder climate is even less investigated. Nevertheless, ventilation strategies and descriptions for a number of cases is presented in the annex which has been useful to determine the governing parameters for airflow.

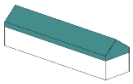
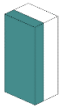
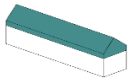
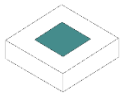
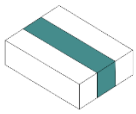
There are several papers that concern how to numerically simulate air flows in a space, such as an atrium (e.g. Ji et al. (2007)) and for particular climates but it is very difficult to find guidelines for the design of atria with respect to airflows. The basic equations for natural

ventilation induced by wind and stack effect are well known and described by Li & Delsante (1999), Holford and Hunt (2003), and Larsen (2006), but in order to use this for evaluation of thermal comfort and overheating a numerical program that takes all factors into account is needed. In Moosavi et al (2014) a review of natural ventilation in atria is presented. The paper describes the parameters that determine the thermal performance of the atrium and the different possible ventilation strategies. Advantages and disadvantages of atriums are presented both in Moosave et al. (2014) and, from a Scandinavian perspective, in Kleiven (2003). The latter also presents a number of buildings with atriums, but no residential buildings.

3. METHODS FOR CASE STUDY DATA COLLECTION

The first part of the "Spaces" project, which is the main focus of this report, is based on study visits and interviews. A pre-study was made in order to develop templates for gathering data from different sources. These were then used in interviews with residents, consultants, and operational managers as well as in the process of collecting data from databases/literature and study visits. Eight case study buildings with glazed geometries, from Malmö to Umeå, (see Table 3.1) have been studied and were visited. The buildings were either housing cooperatives or rental buildings and the glazed spaces in the buildings were either atria, glazed balconies or glazed rooftops.

Table 3.1. General information on case study buildings.

NAME	CITY/YEAR OF CONSTRUCTION	GLAZED SPACE GEOMETRY	APT. NR	OWNERSIHIP STATUS
Bovieran	Hönö 2014		48	Housing coop.
Cinnober	Göteborg 2018		89	Housing coop.
Greenhouse Augustenborg	Malmö 2016		32	Rental
Gärdsåkra	Eslöv 1983		126	Rental
Höstvetet	Stockholm 1986		71	Rental
KTH Hemmet	Stockholm 2016		54	Rental
Musteriet	Stockholm 1983		42	Housing coop.
Sjöjungfrun	Umeå 2005		32	Housing coop.

In total 14 interviews with residents have been performed and a survey to quantify different aspects was handed out. The interviews and surveys focused on thermal comfort, daylight, air quality, geometry, social and human aspects and urban farming, and the material from the interviews and surveys was processed in a workshop with the project group, where trends and results were extracted. The results were then also discussed with the reference group in a workshop and conclusions and future work were extracted.

3.1. DATA SOURCES

Data for the case studies has been collected from databases, authorities, at study visits, by interviews with consultants, architects, operational managers and from residents, see Figure 3.1. The databases have been used to obtain for example building permits and energy certificates.

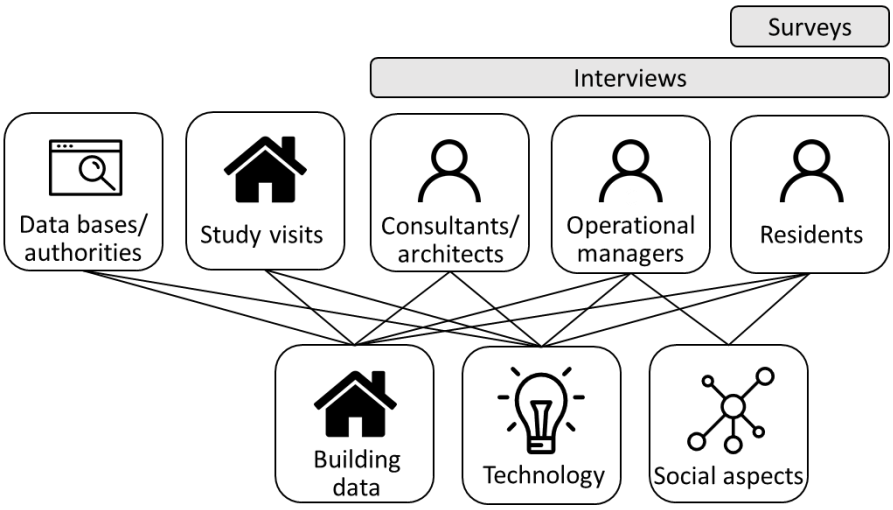


Figure 3.1. Data collection structure.

3.1.1. STUDY VISITS

Study visits were made to the eight case study objects. At the study visits, a representative of the building guided the Spaces project group and provided information on the function of the building. Temperature, relative humidity and daylight were measured, and photos were taken for documentation and illustration. The general impressions were also documented, and a number of interviews were conducted. The study visits took place from April to November 2019.

3.1.2. INTERVIEWS

Interviews were made with a variety of professionals and with residents. The different professionals provide information about the building and its use in different stages. For example, consultants involved in the design of the building can give an overview of the intended function, while the residents and managers can describe how it works in reality. Of particular interest is trying to get an idea of the solutions that have changed during the life of the building, what problems have arisen and how they have been solved. Interviewed professionals were energy/building services engineers, operational managers, developers, architects and one gardener.

Templates for the different types of interviews were prepared in advance and were used to as guides during interviews. However, since one of the aims with the interviews was to identify important, and sometimes unknown, aspects of the glazed spaces, open questions were also used. The guides for the interviews included different aspects depending on who was interviewed. Discussions with property managers were important to get technical information. This type of information was also provided by representatives of housing associations (also living in the building).

The headings for the interviews with residents were:

- General questions- for example time spent in the glazed area, why the person moved to this particular building and when, occupation.
- Technical function of the building- for example temperatures and thermal comfort during different seasons, daylight conditions in glazed space and apartment, indoor air quality, draft.
- Own use of glazed space – how, when, what part is used, etc.
- Common use of glazed space- how many persons use the space, when, conflicts, privacy etc.
- Social aspects – contact with neighbours (more or less than before), type of activities and interaction, organisation, safety and security etc.
- Urban farming- for example type of plants, maintenance (who and how), benefits/drawbacks.
- General building and social qualities

The complete interview form is shown in Appendix A. In most case studies 3-4 persons were interviewed, providing insight into the living conditions in each building and into the use of the glazed spaces. For each case study, there are recorded interviews (for documentation and internal work), and the information is going to be stored and used according to the GDPR form that interviewees signed.

3.1.3. QUANTIFIABLE SURVEY

In connection with the interviews, residents filled in a quantifiable survey. The survey was made to quantify some of the questions in the interviews with the residents and to be used for comparison of the different case studies. The aspects concerned both the use of the building (activities, social interactions etc), the performance of the building (daylight, thermal comfort etc) and how important the different aspects were rated. The social part focused on how and how often the glazed space was used, and an evaluation of impact on outlook, health and integrity. The technical performance was quantified in terms of good or poor performance and the importance of the particular performance. For example, for thermal comfort two groups of questions were asked for each season (winter, spring, summer, autumn):

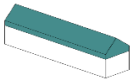
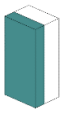
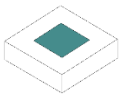
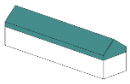
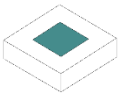
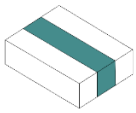
1. How do you perceive the thermal comfort in the glazed space? Answers range from “much worse than expected” to “just as desired”
2. If the performance is poor, what is the main reason? Answer options are “too warm”, “too cold”, “too drafty”.

In most cases, a project team member was participating when the survey was filled in so that additional comments or views could be documented. The full survey is shown in Appendix B.

4. CASE STUDIES

From the literature review and by contacting architects and consultants in the building industry, several interesting case study buildings were found. The buildings were either housing cooperatives or rental buildings, and the glazed spaces in the buildings were either atria, glazed balconies or glazed rooftops, see Table 4.1. The buildings are located in Skåne (southern Sweden), in Göteborg with vicinity (south-west Sweden), in Stockholm with vicinity (south-east Sweden) and Umeå (northen Sweden). Building locations are shown in Figure 4.1.

Table 4.1 Information on case study buildings investigations. All chairmen were also residents.

NAME/ STUDY VISIT DATE	**GLAZED SPACE GEOMETRY**	**INTERVIEW/ DATE**	**STRUCTURED INTERVIEW RESIDENTS/ DATE**	**QUANTIFIABLE SURVEY/ DATE**
Bovieran April 4th 2019		Chairman April 4th 2019	Yes October 31st 2019	Yes October 31st 2019
Cinnober June 16th 2019		Chairman June 16th 2019	Yes October 14st 2019	Yes October 14st 2019
Greenhouse Augustenborg Sept 30th 2019		Property manager and residents Sept 30th 2019	Yes October 14st 2019	Yes October 14st 2019
Gärdsåkra Sept 30th 2019		Property manager Sept 30th 2019	No	No
Höstvetet July 7th 2019		Resident July 7th 2019	No	No
KTH Hemmet July 7th 2019		Users and residents July 7th 2019	Yes July 7th 2019	Yes July 7th 2019
Musteriet July 7th 2019		Chairman July 7th 2019	No	No
Sjöjungfrun July 9th 2019		Chairman July 9th 2019 Architect November 29th 2019	Yes (Skype) October 15th 2019	Yes (Skype) October 15th 2019

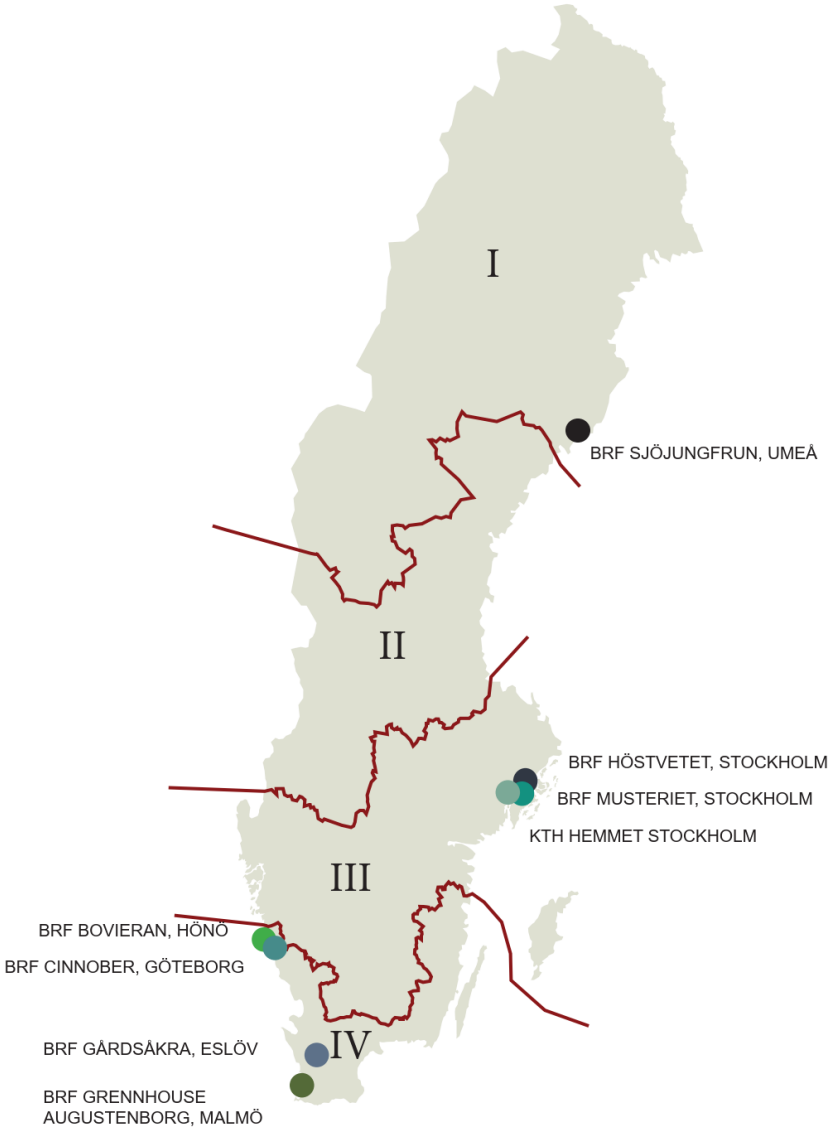


Figure 4.1. Case study buildings placement and relation to the climate zones

In the following, the case studies are described in terms of general information, experiences gained at study visits and knowledge gained during interview and from surveys with residents. The amount of information about each building is different, mostly because more time has been devoted to buildings with interesting and relevant glazed areas with available information. A compilation of the experiences from the interviews is shown in Chapter 5 where the different aspects of the glazed spaces are analysed.

4.1. BOVIERAN

Address: Heinövallen 11, 47540 Hönö
Founder/developer: Göran Mellberg
Year of construction: 2014
Number of apartments: 48
Type of housing: Senior +45, housing cooperative

4.1.1. General information

The building is a three-storey building, consisting of three parts in a U-shape. There is an atrium (winter garden) in the middle, facing the north with a completely glazed facade, and a glazed roof. Apartments are reached through an access balcony inside the courtyard. All apartments have bedrooms and entrances towards the winter garden and a balcony opposite to it, some of them glazed. The atrium is sometimes heated.

Figure 4.2 Bovieran. Up left: the glazed roof. Up right, down left and right: view over the Mediterranean inside garden.

The concept of Bovieran is that the inner climate should resemble the French riviera, therefore the climate is moist and temperate. There is a Mediterranean garden inside, with

specific flora. There are very strict rules about the plants. The space is heated so the temperature inside does not drop below 10°C.

The building is a so-called “building for seniors”. The lower age limit for moving in is 45 years and the average age is approximately 75 years. The atrium is used for social activities all year round. There are several Bovieran concept buildings in Sweden and the one described here, located at Hönö, was built in 2014.

4.1.2. Study visit

Bovieran at Hönö was visited several times. The most thorough study visit was made in April 2019 and most of the information below is from this occasion. At this study visit, a representative from Bovieran was present and supported with information of the concept, including social activities, and provided contact with residents. In addition, the technical consultant on energy and ventilation was also present to share information on the function of the building. At another occasion, the person in charge of the maintenance of HVAC systems was questioned.

TECHNICAL ASPECTS

There are sometimes high moisture levels in the winter garden (60-70%), mainly caused by plants and watering. This has led to moisture damage at the eaves since the facades are not designed for this moisture load. There is also occasionally dripping from the roof, caused by condensation on the inside of the roof. The newer Bovieran buildings have tripled glazed facades and some sun protection on the facades facing south. The double-glazing used for Bovieran is filled with argon gas and has a U-value of 1,1 W/m²K, while the newer tripled glazed facades have glazing U-values of 0,54 W/m²K. The reason for changing to triple glazed structures was both to increase the temperature inside, but also to decrease condensation at the inner surfaces of the windows due to the high mositure levels in combination with cold surfaces. Nevertheless, there are challenges when building a roof with triple glazing; the glazing is heavy, expensive and the snow on the roof does not melt. For the snow to slide off the roof properly, the roof slope would need to be at least 20°, and the roof of Bovieran has a 10° slope. Therefore, double glazing is used for the roof.

The atrium is **ventilated** by automatic opening of hatches when the temperature is too high (average atrium temperature exceeds 22°C) and heating is turned off if hatches are open. The first Bovieran brought air from the atrium to the apartments but it only worked well occasionally, so this function was removed. Tropic fans in the ceiling of the atrium are used to mix the air so that the warmer air does not stay at the top. The maximum temperature inside should preferably not exceed 27-28°. The plants, and especially the moist soil, have a small cooling effect. Most Bovieran buildings, including the one at Hönö, have an atrium facing north, which helps to avoid overheating. The south facing Bovieran building can also work, but the ventilation system needs to work more frequently. On some occasions, there have been comments about draft under the ventilation hatches but none of the interviewed residents (next section) mention this.

The atrium is usually **heated** in March-May and October-December. During January and February plants need to be dormant and consequently the temperature is kept around 10°C. The desired temperature for plants is 10-12°C for six weeks. If warmer, they become too high and rickety.

The **daylight** in the atrium was overall perceived as good during the study visit. However, when visiting an apartment, the entrance hall felt dark due to the access balcony at the entrance. Some residents have solved this problem by adding a window in the entrance door.

According to the housing representatives, there might be problems to reach daylight levels according to requirements in the bedrooms facing the atrium with an access balcony over the window.

The **plants** in the atrium are not typical for Scandinavia, such as lemon trees, figs and palm trees, and they require a controlled climate to thrive. The palm trees produce a large amount of moisture, and moisture conditions would probably be better with a local flora, or other plants that produce less moisture (like cacti). The plants are taken care of by both a company and the residents (approximately 50/50).

It is problematic to obtain a **building permit** for this type of building (residential building with glazed atrium) due to energy regulations, and the glazed part is at Bovieran classified as a greenhouse. The Bovieran developers are interested in research to be able to change the building regulations. Since a new Bovieran building is a repetition of an already ready concept, it only requires about six weeks of design planning compared to 9 months for a regular one. They have now found the optimal size of the association (not too big, not too small) and technical solutions are mostly working well. The monthly cost at Bovieran is approximately the same as in any other tenant owned housing outside the city.

SOCIAL ASPECTS

The residents use the winter garden for different types of social activities every week, such as boule and bridge, and they also care for the garden on a regular basis (in addition to the hired garden help). Garden parties are organised on a regular basis (a couple of times a year). During January and February people rarely use the winter garden in the evenings. In addition to the common winter garden, people also often use the space in front of their apartments during the evenings. There is an access balcony for transportation and for resting, from which people can look into each other's apartments, but is not seen as an integrity problem as only few neighbours are passing by front of the apartments.

Most people enjoy living in Bovieran, appreciate the winter garden and not many people move voluntarily. Some have passed away and some have moved into homes for elderly.

4.1.3. Resident interviews

Four residents were interviewed about living at Bovieran, Hönö.

TECHNICAL ASPECTS

All the residents are quite satisfied with the **thermal comfort** inside the garden and they think that the thermal comfort is an important factor. The residents have been able to adjust the temperature inside the winter garden according to their needs. They have, for instance, increased the temperature for parties in wintertime. When it is hot outside, the ventilation system works well. For example, one summer when it was extremely hot outside, it was cooler inside the winter garden than outside. On the other hand, it gets hot inside the apartment during summer, up to 26 °C, otherwise the temperature is usually around 23°C.

Three of the interviewers were satisfied with the **acoustics** in the glazed space. They said you can hear the voices of people being there, but it is not a disturbing sound. One complained that there is an echo inside the garden.

There is only minor complaint on the **air quality** in the winter garden. It can sometimes be moist inside the garden and when it is cold outside, the water can condensate on the glass of the winter garden and drip down. There have previously been some problems with the

ventilation system, but this has been fixed now. Drafts in the atrium have generally not been a problem and usually it is desirable to have some air movement during warmer periods.

The interviewees have not noticed any problem with **drafts**, it is even desirable to get some air movement, since it gets hot inside the building. Several people complained about food smell inside the winter garden and that it sometimes smells a bit like soil, when the plants are watered. One person mentioned that the ventilation inside their apartment is not working completely to satisfaction.

There are different opinions among the interviewees about the **daylight** level in the garden. Most think there is enough light when including the artificial light, but some are complaining about the atrium being too dark. It would, for example, be valuable with more light when playing bridge. All the interviewees say that the winter glazed garden is not affecting the level of daylight in their own apartments. Three of them live on the upper storey though and the fourth person on the ground storey (but this person does not spend that much time at home). One resident, however, states that other people on the ground storey have darker apartments.

SOCIAL ASPECTS

The interviewees describe several activities that take place in the **winter garden**, as long as there is enough light. Some take place on a weekly basis (such as boule, bridge, betting on horses), while others are more spread around the year. For many people boule is important for socialising and approximately 15-20 persons participate each time. There is also a gardening group that takes care of the plants and the ponds once a month (previously every other week). Some residents stay a bit longer after common activities to socialise, some people are too ill to participate in common activities, and some are not interested. There are no common lunch or dinner activities in the atrium.

The common parties that takes place every year are: Midsummer party, New Year's festivity, Easter party and seafood party (kräftskiva). There is not a lot of organisation connected to these parties, if you want to join, you just help out and join.

When the neighbours are gathering, they mostly use the central space of the garden (the square). Some residents prefer particular furniture-groups before other, some choose the one closest to them and some just pick the one that is free. There is a path in the garden, which is frequently used for walking, which is especially useful during winter. Most of the residents use the winter garden and when residents have guests, they usually bring them to the winter garden.

In the **access balcony** outside each apartment there is a small terrace with space enough for two chairs. This space is used by some residents for having their morning or afternoon coffee, reading or chatting with neighbours. From here, they can have a good overview over the atrium. Overall, not that many people use the access balcony and it is more used by the physically impaired, who also sometimes use the balcony for shorter exercise walks. There is also a larger open space on the access balcony which has some sofas and which no one ever uses, according to one resident.

There are many different **plants** in the winter garden, such as ferns, palm trees, monstera deliciosa and also figs, free for everyone to use. According to one resident, there is a large interest among Bovieran residents in urban farming and there are many opinions about how the garden should be. Of the four interviewed residents, two were interested in urban farming and the other two were not. Residents think that, of course it is a possibility to meet other persons through gardening as in all other Bovieran activities, but the garden group in Bovieran does not mainly work as a social activity. Residents participate in the garden group because they want to help out in the association. More and more people get old and ill, so the

garden group has shrunk a lot over the years. The less people that help out, the more money needs to be spent on garden services. Overall, it would be good if younger people, round 65 years, would move into Bovieran, so that more people can help manage the house.

The garden creates only minor conflicts, for instance if someone signs up for a garden activity, but then does not show up. There are people who never help with anything in the building, which can annoy some residents. In addition, of course many people want to taste the fruit that is produced in the garden, but it is too little for everyone to get some. All these conflicts are, however, perceived as very small by the residents.

Most residents think that it is easier to get in **contact** with neighbours in Bovieran comparing to a single-family house, which is how all the interviewed residents lived before moving to Bovieran. One suggested reason for appreciating the contacts at Bovieran was that when people get older, they no longer have same energy to organise dinners etc., so the close contacts are valuable. Another reason was that in a common single-family neighbourhood, people mostly socialise with the neighbour next door and not so much with people further away. In Bovieran everyone lives so close to each other, meet each other when getting mail etc., so contacts are frequent. One resident thought that Bovieran worked as a row-house community. Another comment was that people usually go out outdoors more when the weather is good and not so much when it is cold, Bovierans glazed roof is positive from this point of view.

Some residents commented that in Bovieran you need to pay **respect** to other residents in a different way, comparing to having your own house, where you can decide everything by yourself. There is no specific welcoming ceremony for newcomers. When people move into Bovieran it is up to them to take contact. One resident thinks that you best fit into Bovieran if you are a little bit social.

Concerning **safety**, one resident stated that many single persons, especially women feel safe in this type of building. Reasons for not feeling safe in a single-family house were for example a worry to not to be able to take care of an own house and garden when getting older, and a worry for burglaries. At Bovieran, neighbours notice immediately if something is wrong, for instance if a neighbour has not opened the blinds. The women that were interviewed felt safer at Bovieran comparing to previous living but men that were interviewed did not notice any difference in feeling safe.

GENERAL COMMENTS

In general, the residents are pleased with the size and geometry of the glazed space. One resident thinks it is important to have a large garden to have space to walk around. Many residents have had different injuries and walking is good for rehabilitation. Some residents think that a more narrow courtyard with less distance to neighbours would affect privacy. One resident thinks that it does not matter if a neighbour lives far away or close, because they still meet in the garden. When asked if they would like to have more space outside their own apartment, one resident agrees and for the others, this space is less important. When asked if something should be added to Bovieran, a sauna comes up as a suggestion twice.

The apartments were quite inexpensive when the Bovieran was built but now, 5 years later, the apartment prices have increased by 1-2 million SEK. One resident says that they are not sure if they would afford this type of apartment today.

People who live in Bovieran are generally very pleased with the building and atrium. Some residents describe that Bovieran is convenient since you do not have to take care of an own house anymore. Another aspect that is appealing to residents is the type of community that

Bovieran offers compared to an ordinary multi-family building. The winter garden concept was also appealing. Some residents could not think of any negative aspects of the building. Two of the residents could not come up with a reason for moving and did not want to. The other two said that a reason for moving from Bovieran could be if there would be a conflict with residents.

Among aspects that residents liked most with the building were the winter garden, the community and the size of the apartment. Among aspects that residents liked least with the building were that the common room on ground level could have been designed better and that the gym could have been better fit for the target group.

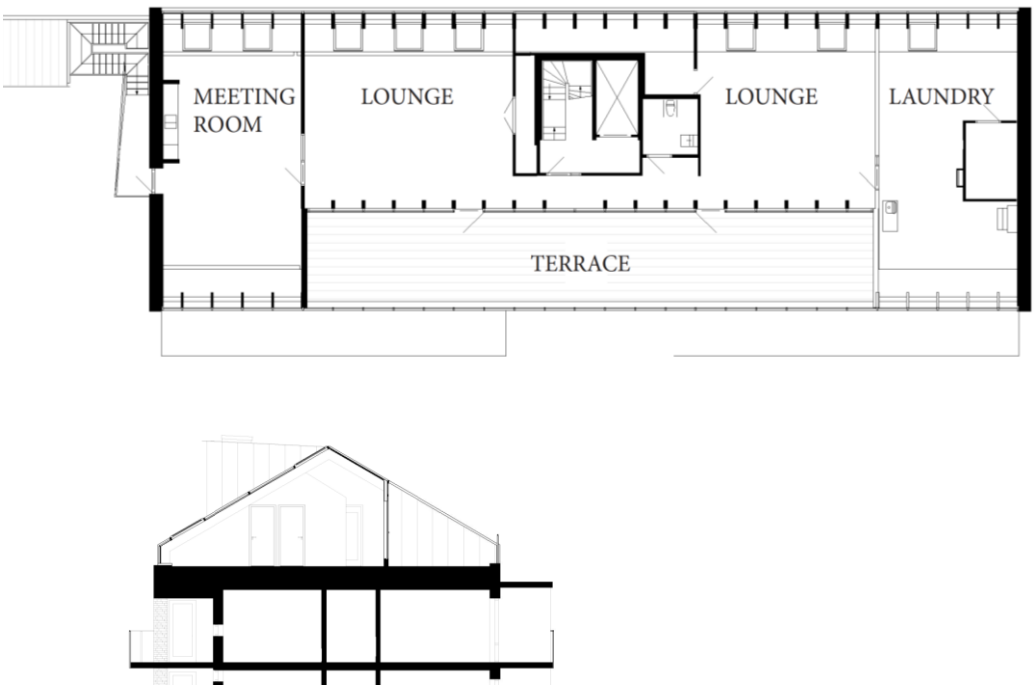
4.2. CINNOBER

Address: Gustav Dalénsgatan 18, Kvillebäcken, Göteborg
Architect: Sweco
Year of construction: 2018
Number of the apartments: 89
Type of housing: housing cooperatives

4.2.1. General information

The Cinnober building is located in the northern part of Göteborg, about 15 minutes commuting from the central station. It is a new, 5-8 storeys high, multi-family building with a glazed rooftop garden. The glazed rooftop accommodates common spaces: kitchen, sitting places, laundry room (see Figure 4.3). The glazed space is divided into four parts: one lockable room in one end of the glazed space that is possible to book, a laundry room in the other end, two open areas in the middle connected with a passage and a direct connection to a rooftop terrace outside.

The glazed space is unheated and therefore requires no heating energy. Automatic opening windows regulate the air and temperature inside. An automatic shading system (textile curtains) is used.



F*igure 4.3. Plan and section of the glazed roof space.*

4.2.2. Study visit

The study visit to Cinnober took place on the 14th of May with a guide from the housing cooperative and a specialist on the technical systems. It was an unusually sunny and warm day and, consequently, the thermal conditions of summertime were experienced.

At the time of the study visit, the shadings and ventilation hatches were not operating as intended and consequently the rooftop was slightly too warm. Along the side of the roof there are plant beds as well as pots with plants. The plants contribute to a slightly tropical feeling. In winter it is important to decrease moisture levels in the rooftop. On occasions, moisture condensate on the inside of the roof, causing water running on the inside of the glass roof.

Figure 4.4 Cinnober. Up left and down left and right: the glazed roof and plants beds. Up right: view over the space from the outdoor terrace.

4.2.3. Resident interviews

TECHNICAL ASPECTS

Three residents at Cinnober were interviewed. Overall, the **thermal comfort** in the glazed rooftop space was considered fine during spring and autumn, but too hot in summertime. One interviewee lived in the building during wintertime and thought that the temperature was good also during this period. Initially, the **ventilation** of the glazed roof was insufficient, since the window openings were malfunctioning, which often caused overheating in the glazed space. The problem has now been resolved. All residents say that the **daylight** access is very good inside the glazed space.

The opinion on **air quality** in the roof space vary among residents. There are no problems with drafts, one resident even thinks the air can be a bit musty. When the ventilation system (automatic window opening) works, it works well. It is also possible to open the terrace door to create cross ventilation. Some moisture and smells are produced by the plants, but the smell is not perceived as unpleasant. One resident thinks that moisture level is a bit too high.

Acoustics are fine in general but, according to one resident, there is a slight echo in the room. Another resident suggests acoustical panels inside the glazed space. During parties some bass sound can be heard two storeys below the glazed space. It is also the case when furniture is moved around, but no voices are heard. The furniture is considered a bit too heavy, unstable and noisy when moved.

There are mainly ornamental **plants** but also some wine plants and herbs that are free to use for all residents. A company takes care of all the plants, which is quite expensive. In the beginning there were problems with dying plants for a variety of reasons. One was improper care by the plant company, other problems were drainage problem, overheating and lack of water. The cooperation says that they might consider letting residents care for some of the plants. This would save some money for the cooperation. The residents have not been encouraged to cultivate in the glazed space, but the interviewee says that it is possible for residents to cultivate if they want to, they just have to inform the board about it. One resident thinks that there is too little surface to both cultivate in and use as social area. One resident thinks that plants inside the glazed space is a bad idea, this person would prefer design and art instead.

SOCIAL ASPECTS

The residents in Cinnober are of different ages. The ages 25-35 are overrepresented, there are no or few persons between 10-25 and there are approximately 12-15 children under 10 years of age. Only three persons are over 65.

Common activities are arranged approximately 1-3 times per year and are arranged by the housing cooperation. The glazed space is mainly used for parties. Other activities mentioned by residents are: relaxing, enjoying the sun, housing cooperation meetings, reading (in the smaller part outside the laundry room). The space is mostly used during weekends and during weekend the space can be booked both during the day and evening, depending on if the party is for kids or grownups. During parties there can be 20-50 people in the space. Not many people use the space during weekdays. In summertime many people use the terrace outside the glazed space for barbeques.

Figure 4.5. The glazed rooftop is divided so that there can be different activities simultaneously, for example parties and meetings.

Since the space is divided it can be used for different purposes by residents, for instance one part for dining and one for dancing, or if someone wants to be by themselves, they can move to the part closest to the laundry room. If people book the lockable room, they often act as if they booked the whole space. If someone books the room and other residents show up, they tend to leave after a while. The interviewees think that the space is mostly used by young people with friends, but other age groups use the space as well.

The cooperation has decided that people only can book the lockable room, but the ones who book this part are responsible for cleaning the whole glazed space. Since some people think that they can book the whole space, this creates some conflict. Also, there are some conflicts regarding cleaning of the space. If someone mismanages the cleaning several times the cooperation can prevent this person from booking the glazed space. If someone has not cleaned properly, they are reminded by the cooperation and most times people agree that they have made a mistake and clean up afterwards.

Neighbours interact with each other occasionally, mostly in the glazed space and at the outdoor terrace. Two residents thought that the glazed space makes it easier to interact with neighbours. One resident did not think the glazed space made it easier to get contact with the neighbours, but that the more common meetings and parties for residents might help. Two of three residents did not think they got more socially active life thanks to the glazed space.

Residents do not feel safer in this building than previous housing. One resident thought that the building feels less safe since the glazed space attracts many people from outside during parties when there might be alcohol consumption and a lot of people moving in the building and the elevator.

Overall, the residents were happy with the design of the glazed space. Two residents thought that it is good that the large glazed space is divided so that it can be used for different purposes. One resident commented that if the glazed space was not divided it might feel more welcoming.

GENERAL COMMENTS

Two persons pointed out that the roof slope is too low towards the street, one consequence being that the room becomes smaller, another that the roof restrains access to the flower beds. This was not considered as a big problem though. One resident noticed that it is difficult to access windows without stamping into flower beds, which could be fixed with small plank bridges across the beds. One resident thinks it is important to have enough space to be able to furnish, also access to fresh air is important. The association have had many complaints about the concrete floor which is polished but do not have any finish so that it easily gets stained.

Two of three interviewees said that they chose the building because of its location and economic benefits, and the same persons said that the best aspect of the building was the glazed space. The third person said that the glazed space was a big plus when choosing the apartment and that it would be missed the most when moving. The glazed space is an expensive area. One resident questions if it is worthwhile to have this kind of space 10 years from now, considering the high operation cost.

Among the aspects that residents liked most with the building was the glazed space on the roof and the guest apartment. Among the negative aspects of the glazed space was that there sometimes are too many people there. Another comment was that the space is very good, but it is hard to make people take care of it and clean up after themselves and sometimes unauthorized persons have entered the building. A concluding remark is that the residents like their rooftop, are proud of it and like to show it so visitors.

4.3. GÅRDSÅKRA

Address: 1b-19d Gårdsåkra, 241 35 Eslöv
Architect: Landskronagruppen
Year of construction: 1983
Number of the apartments: 126
Type of housing: rental apartments

4.3.1. General information

The studied block Gårdsåkra was finished in 1983. It consists of two rows of apartment buildings (mostly three storeys high) connected by a 375 m glazed street, see Figure 4.6 and Figure 4.7. The width of the street varies from 22 to 11 m (Wall, 1996). The buildings also accommodate a school (combined kindergarten and school to 6th grade). The apartments on the second storey are reached from access balconies and the first storey has entrances with a small semi-private yard in connection to the glazed street. The complex was designed by Landskronagruppen and included many visions such as an outdoor subtropical climate (the glazed street), social activities, high quality common areas, mixed functions (incl. offices, schools, shops), low energy use and exposed building services (but protected from outdoor conditions since they are placed in the glazed street). The glazed street had automatically controlled ventilation hatches, mechanical ventilation (preheated air) and automatically controlled interior solar shading. The hatches toward the wind open, and the wind is measured by a weather station.

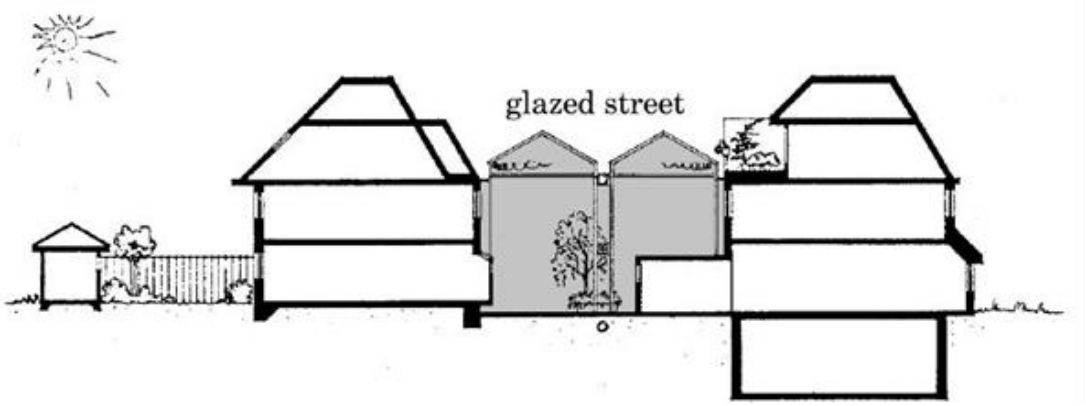


Figure 4.6. Section of two buildings with glazed street in between.

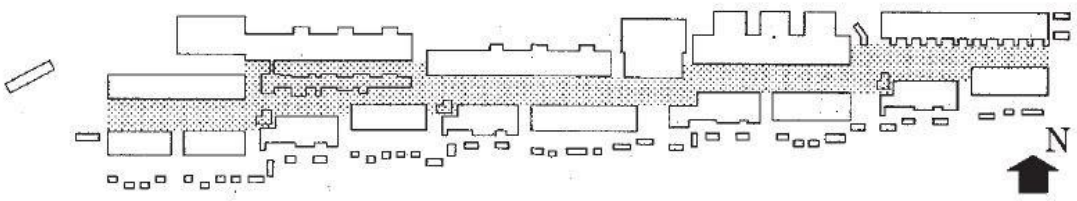


Figure 4.7. Overview of the buildings and the glazed street.

The initial ambition on energy was high and included using excess heating from industry (wool factory), thermal storage, heat recovery and using the glazed street to capture solar heat. The aim was to keep the glazed street at more than 5 degrees all year round, but this required more energy than calculated and resulted in additional installations for h Inge Pihlström, bostadsföreningen eating. The complex was thoroughly evaluated when it had been in use a couple of years. This is reported in Lange (1986) who for example showed that the glazed street caused a higher energy use than if it had not been glazed (i.e. an outdoor area).

4.3.2. Study visit

The study visit took place on the September 30th 2019 and we were guided by a project manager as a representative of the owner EBO (Eslövs bostadsbolag) with good knowledge on the technical functions and social situation in the area. Information on the situation was also obtained from Tengbom architects who conducted an investigation of the area in 2017 to prepare for possible renovations and a new school. No interviews with residents were made.

The glazed street is today mainly heated by electrical heat convectors (when the temperature sinks below 5°C) and the buildings are connected to district heating. When the temperature in the glazed street is adequate, heat is transferred to the apartment by heat recovery. The exposed and visible installation in the glazed street are not appreciated today, they collect dust and leaves and have not always been repaired in an aesthetic way (instead for example using duct tape).

The **thermal comfort** is usually good in the glazed street. The interior textile solar shadings work well, and the street is rarely too warm. They operate automatically and are also used during night-time to protect from the cold sky. They have been replaced once. The glass roof itself is not leaking, but there are problems with water leaking from the rainwater gutter on the roof into the glazed street. The glass roof requires regular cleaning which is a large cost. Figure 4.8 shows the glazed street with solar shadings and visible piping.

Figure 4.8. Glazed street with solar shading, top storey to the right.

During the study visit, the **daylight** in the glazed street was measured in several locations. The brightest area was the large open stage, Figure 4.9. There are some dark areas on the first storey, even though, in the access balcony floors on the second storey, there are openings that allow daylight to penetrate to the first storey. These openings also create some privacy for the residents, since they prevent people from walking up to the apartment windows.

Figure 4.9. The open stage area on the first storey and the (right) openings in the access balcony floors that let more daylight into the first storey.

The **acoustics** in the glazed street is problematic. There are not as many plants as in the original plan for the street, there are many hard surfaces, and school children use the street regularly. The school children are always accompanied by a teacher, and sometimes they have no shoes (for noise reasons), but the problem still remains.

The street is open to everyone during the day so sometimes young people (both residents and non-residents) hang out in the area, skateboarding for instance, which creates a lot of noise. Some residents perceive children in the yard as a problem.

The initial vision on **social interaction** between residents is not occurring. There is a mix of residents but the opportunities for interaction are not taken; the small semi-private yards in from of the apartments are not used, the possibilities to grow plants in the street is not used much and people prefer the outside to the street. There is a need for an organisation to increase the social interaction and activities, which could consist of both residents and representatives of the owner, Eslövs Bostads AB. This is a wish of the owner and they are also willing contribute financially to this. The rents in Gårdsåkra are relatively low and there is good access to larger apartments (compared to the average in Eslöv) which makes the block popular to those with these preferences.

GREENHOUSE AUGUSTENBORG

Address: Augustenborgsgatan 5, 214 47 Malmö
Architect: Jaenecke Arkitekter
Year of construction: 2016
Number of the apartments: 32 in the tall part of the house, 12 apartments in the lower part of the house, 2 collective apartments with 6 bedrooms each.
Type of housing: rental apartments

4.3.3. General information

The innovative building Greenhouse is situated in Augustenborg in Malmö in southern Sweden. It is owned by Malmö municipality, MKB, fulfills the requirements of Passive house and Miljöbyggnad Guld, and aims to facilitate a lifestyle with less impact on the environment. The Greenhouse consists of two parts, one lower and one higher. The studied part is the 14 storey building in Figure 4.10, with large balconies and a glazed space on the top storey, the Orangery.

Figure 4.10. Greenhouse Augustenborg in Malmö and the dome (right).

The glazed balconies and the common orangery are suitable for social activities and for vegetables and plants. There is also a green terrace with a glazed dome on the roof of the lower part of the building (Figure 4.10). This space is used for cultivation and social gatherings. Small experiment of hydroponics cultivation is carried by the residents in the basement. Potential residents had express interest in plant cultivation in order to be able to rent the apartments.

4.3.4. Study visit

The Greenhouse was visited on 30th of September 2019 with guidance of a resident.

BALCONIES

The balconies face all the all the cardinal directions except north. They are quite large (appr. 20 m^2) and half of the balcony is glazed. Plant beds are integrated in the architecture of the balconies along the exterior perimeter. The glazed balconies are not heated and there is no integrated shading system. The balconies are spacious and commonly serve as an extra living room. In some cases, residents have installed extra heating devices (infrared heating or stove).

Figure 4.11. The unglazed part of the balconies with plants and seating.

ORANGERY

The glazed space at the top of the house is called the orangery in all drawings and was intended to act as a room where plants could be stored and be dormant during winter. The room has a glazed wall and partly glazed ceiling towards the south. The Orangery is connected to a generous balcony that offers a nice view of Malmö, and it has an area corresponding to a smaller living room, see Figure 4.12.

Figure 4.12. The Orangery and the view of Malmö from the attached balcony.

OTHER COMMON AREAS AND EQUIPMENT

The house has several common areas: the rooftop room called Orangery with associated balcony, an outdoor roof terrace with a small greenhouse (the dome), a common room on the ground storey called the Green room, the laundry room and the bicycle storage room,.

The bicycle storage room and the laundry room are two spaces that work very well. They are nice bright rooms with natural daylight. The parking lots for bikes are arranged so that the bikes that are used most are the most accessible. There is also a small hydroponic unit in the bicycle room. The laundry room is a nice place according to several residents.

Figure 4.13. The hydroponic horticulture set in the basement by a resident.

4.3.5. Resident interviews

Seven residents, living in four apartments (storey 7 with south balcony, storey 9, 10, 11 all with west facing balconies) were interviewed and filled in the survey. (No balconies face north.)

BALCONY

Overall, the residents are very pleased with the balconies. The glazed part is more popular than the unglazed part, and some residents suggested that the whole balcony should be glazed (mostly because the location is quite windy). The balcony is commonly used as an extra living room and is also considered a good place to have guests for dinner. The door to the balcony is often left open and when the balcony door is open, the heating system in the apartment is automatically shut off. The interviewed persons used the balcony for **cultivation** of herbs, vegetables, berries, fruits, but less for flowers. There is a wet area in the apartment where plants can be taken care of. It was mostly appreciated but one family had turned the area into a children's room. Water is available in the balcony.

As for **thermal comfort**, without additional heating in the glazed balcony, it becomes a bit too cold to use during winter but is possible to use it approximately from March until November without heating, which is considered good. In wintertime, the temperature never sinks below freezing. Several residents have installed an extra heat source in the balcony, even though it is not completely sealed and will cause extra energy consumption.

The glazed balconies are easy to **ventilate** by opening the glazing, and there is an opening in the lower part of the balcony. Several residents have experienced drafts from the opening and have tried to seal it. The glass panels are not airtight either, so the outdoor air can always get in, even with shut glazing. When it is very windy the panels are rattling.

If the glazed balcony is open, the ventilation is good, and it never becomes too hot. One resident who, for safety reasons for cats, was unable to open the glazed panels for airing, got 25-27 °C in the apartment and 40 °C in the glazed balcony during summer. For safety reasons it would be good if the balconies could be locked in a position that results in small openings. There are no noise complaints from other neighbours and the **acoustics** in the glazed balcony is considered good.

The **daylight** access in the apartments is perceived as good, even though the shading balcony is quite wide. This is probably due to the height of the building (above other buildings) and the large window openings. The plants can cause some solar shading during summer, which is perceived as positive. Some residents would like shading in their apartments. No interior shading has been installed and due to hard concrete walls, it is difficult for residents to mount shading devices themselves.

Some residents would like to have a completely glazed balcony, since the open part is quite **windy**, and some would like to switch the two spaces because of the wind conditions.

Some residents have arranged a watering system in the balcony. Sometimes, the watering of plants causes some problems with water leakage. If an excess of water is used, it pours down to the balcony below depositing dirt on the glazed panels.

ORANGERY

The Orangery is the glazed space at the top of the building and was intended for storing plants during wintertime. It has glazed wall and a partially glazed ceiling facing south. The room has an area of a smaller living room and is attached to a large balcony, see Figure 4.12.

In general, the residents are dissatisfied with how the orangery has been designed and many feel that the word orangery is misleading. Several technical aspects have been overlooked, for example, the room completely lacks ventilation. During summertime, the **temperature** can exceed 40 °C and in wintertime it becomes far too cold for the plants. For the plants to thrive, adjustable ventilation hatches are needed in summertime, but apart from the balcony door, there are no openable doors or windows in the room. Another problem is that pests easily spread between plants, so many residents have stopped using the room for plant storage to avoid getting their plants infected.

The respondents also describe that the **acoustics** are poor in the room, which is due to the many hard surfaces and few plants. However, while the residents have pointed out that the acoustics are something that could easily be fixed, there is no motivation to do this because there are so many other aspects that work poorly. In the beginning, when the building was completely new, several residents got involved in the orangery but gave up after a while.

The room does not have a booking system and since it is quite small, it can easily feel crowded, or that you disturb, if there is another group in the orangery or on the balcony. However, there is a common Facebook group where you can communicate about the use of the room with the others in the building. Even if the room is not used as it was originally intended, it still serves some purposes. In the spring, some residents leave plant cuttings there so that others can take them. There are also some young people who use the room do homework, to get some peace and quiet, or just hang out. Some bring their friends to look at the beautiful view.

The room is too small to be used for meetings. Today, the “Green room” on the bottom storey is used for this purpose instead. The “Green room” has a kitchen and a larger area. It is also easier to use for joint activities due to its location on the bottom storey. As described by a resident: “it is easy to pass by for a cup of coffee when you are on your way out”.

Some of the residents suggest that the orangery would have worked better if the room had been larger and better equipped. If it, for example, had a kitchen, ventilation, solar shading, it would have been easier to use for joint activities. Right now, it is quite a dull environment, with bare white walls, and the residents express that they would have liked a cosier environment. In addition, if there had been more room for **cultivation** and for taking care of plants, people would have had a purpose to be there and it might have become a more natural meeting place.

ACTIVITIES IN THE DIFFERENT AREAS

There are several common activities in the building: coffee on Sundays at 10:00 and Wednesdays 19:00, potluck supper once per month. Up to 12 people come to coffee gatherings and up to 25 to potluck supper. Sometimes lectures and similar events are arranged in the Green room on the bottom storey. There are about 10-15 people that come to joint activities and those are mostly the same persons each time. There were more common activities when the building was newly constructed, but this has decreased over time. An observation by one of the residents is that a driving and interested person is needed to keep the social part working.

Neighbours interact during scheduled activities mostly in the Green room and in the laundry room. When residents were asked if they have become more active socially after moving to Greenhouse Augustenborg, there were no clear trends. However, all respondents stated that it is much easier to get in contact with neighbours in this building comparing to an ordinary multi-family house. The reasons for this were the frequent common activities and common interest in urban farming in the house.

The outdoor roof terrace is perceived as very positive by most residents and is used extensively, especially in the warmer period. There is also a dome-shaped greenhouse here. Unfortunately, there have been some technical aspects that have not worked so well with the roof terrace, however, many of these have been resolved. The greenhouse on the roof terrace, the dome, has some technical shortcomings when it comes to the construction. There are, for example, no ventilation hatches at the top but an open gap at the bottom that causes drafts. The acoustics are also a bit troublesome in the greenhouse. Despite some technical concerns, the greenhouse is used much more than the glazed room on the roof, the orangery. It may have to do with the fact that it is located in the middle of the roof terrace and is easily accessible. The only people who are less satisfied with the roof terrace are people who have their apartments facing the terrace, who are disturbed by children being lively when on the roof terrace.

The residents had different opinions about safety in the house. One person stated that it feels safe to know who the neighbours are, for instance it is easy to ask a neighbour to look after your child when they are at the rooftop terrace. On the other hand, there have been some problems with safety outside of the building and also some problems with unauthorised persons entering the building.

GENERAL COMMENTS

Main reason for moving into this building among all interview participants was interest in environmental questions and cultivation possibility. Some also mentioned the social aspect. All respondents said that they will miss their view from the balcony most if they would move. They all felt that the glazed balcony had an effect on their well-being. One comment was that the balcony felt a bit like to open a door towards a garden. The possibility to be able to work with plants and soil in the house was appreciated.

Among the aspects that residents liked most with the building was the view, the balcony, the community and the possibility to cultivate. They also commented on the practical living environment. Among the aspects that residents liked least with the building were the technical problems in the in orangery and in the dome on the rooftop terrace.

4.4. HÖSTVETET

Address: Gällerstagränd 11, Stockholm
Main consultant: VBB
Year of construction: 1986
Number of apartments: 71
Type of housing: rental apartments

4.4.1. General information and previous investigations

The building was originally an experimental residential building in a project called the Stockholm project, "Stockholmsprojektet" (Hallstedt, 1993), in which six other buildings were included. In the project, this building was called the Suncourt building, having a glazed courtyard, 25 bore holes with heat exchangers and apartments that are heated by air. The glazed courtyard has an area of 650 m² and double pane windows, see Figure 4.14 and Figure 4.15. The aim of the glazed courtyard and the boreholes was to use the solar heat gain in the courtyard and store it in the ground (seasonal storage) and, when needed, use it for heating and hot water. The system also had air cooling. The system has now been replaced by district heating.

The building has been thoroughly investigated in the 80s and 90s, see for example Engvall (1989) and Norrby (1992) and it has also been compared to other buildings in the Stockholm project, such as Bodbetjänten which is a very similar building but with an opaque roof instead of the glazed roof on the courtyard.

Figure 4.14. The glazed courtyard of Höstvetet with access balconies.

When Höstvetet had been in use for five years, a survey was made to find out how the residents liked the courtyard and how it compared to Bodbetjänten. Overall, it was noticed that the glazed yard in Höstvetet performed better than the one in Bodbetjänten and that the residents have better contact with neighbours in Höstvetet. However, the courtyard was perceived as much less important than the quality and function of the residents' own apartments and the residents value their integrity highly. The residents appreciate the courtyard, but they do not use it much. One reason for this could be that there are many problems associated with the design, equipment and function of the yards. Only a few of the problems that existed in the beginning have been solved, several still remain today. Many of the problems were built into the building, and it has therefore not been possible to do anything about them. New problems have also arisen, according to the 5-year follow-up investigation by Norrby (1992).

The glazed courtyard was not considered a place you want to spend time in. It was originally called a winter garden, but it was not perceived as cosy or green. Plants died, had pests and

there were problems with smell in the courtyard. There were also some problems with acoustics due to the many hard surfaces on the ground of the courtyard, and on the walls (bricks and metal railing), see Figure 4.15, in particular when children play in the courtyard.

The perception of temperature in the courtyard is different in Höstvetet (glazed roof) and Bodbetjänten (opaque roof). It appears that the residents perceive the temperature as too cold when the roof is opaque (indoor feeling) more than when the roof is transparent (Norrby, 1992).

Figure 4.15. Two views off the courtyard of Höstvetet.

4.4.2. Study visit

The study visit took place on the 7th of October 2019. Our guide had been a resident since 1998 and was well informed on the functions, use and development of the Höstvetet building.

Many things had changed from the first years, concerning use and technical aspects. The building also changed owner in 2001. As previously mentioned, the building is now connected to district heating. Ventilation of the glazed courtyard is not working properly. Some hatches open as they should when the temperature becomes too high, but one remains open all the time. There is also mechanical ventilation and no problems with condensing water on the inner roof surface. The interior solar shading curtains worked well previously but have not functioned the last few years. The minimum temperature in the courtyard is 10°C and in addition to heating from the mechanical ventilation, there are also some radiators. There is automatic watering system for the plants, but it does not work properly so the plants are usually watered manually, by a contractor.

The apartments have airborne heating. However, there is a problem with the distribution, resulting in higher temperatures in the apartments close to the heating central and too low temperature in the apartments further away. The residents also complain about the noise from the ventilation unit in the apartment.

The glazed courtyard does not contribute to social interaction in the building and it is not used much. The previous owner was more engaged in the building and arranged social activities. Also, our guide noticed a difference in the games and behaviour of the children of today, compared to the children in the 1980s. Previously, there was a playground in the courtyard, but it was removed, partly due to noise problems. There is also an area on an access balcony on the top storey where youngsters hang out, which also causes some noise problems. Otherwise, the access balconies are not used much. The windows toward the access balconies

usually have curtains for increased integrity in the kitchen area. The daylight into the apartments from the access balconies is perceived as too little (even without curtain) but the courtyard has enough daylight. The access balconies in Höstvetet are solid, as opposed to Bovieran and Gårdsåkra that have holes in the balcony floors for more daylight admission.

People sometimes temporarily leave their garbage can on the access balcony, since they do not pass the garbage room on the way out. This contributes to the smell that sometimes occur in the courtyard. Also, in the laundry room cleaning habits cause problems. The previous owner was more supportive both regarding social aspects, technical aspects and cleaning which has led to a decrease in satisfaction in the building.

4.5. MUSTERIET

Address: Reimersholmsgatan 13, Stockholm
Architect: From Skanska
Year of construction: 1983
Number of the apartments: 42
Type of housing: housing cooperative

4.5.1. General information

There are 45 apartments in the building, that consists of both older and newer parts. The older parts previously contained offices and industries (Vin & Sprit). The building was purchased by HSB and turned into a cooperative housing. In 1984 people moved into the building, which has not been renovated since 1985. The apartments are surrounding a courtyard with transparent, plastic roofing.

Figure 4.16. The transparent roof with openable hatches over the courtyard at Musteriet (left) and acoustic sound panels under the access balconies (right).

4.5.2. Study visit

The study visit took place on the 7th of October 2019 and the chairman of the housing cooperation guided in the courtyard, the social/conference room, an apartment, and on the roof terrace.

TECHNICAL ASPECTS
The courtyard is **ventilated** by opening hatches in the roof. These are automatically controlled, they open at appr. 22-23°C and close if it is raining or cold outside. The hatches also function as smoke hatches and they open to an angle of appr. 22°. The plastic roof is original, but parts were replaced appr. 10 years ago.

There is sometimes poor **thermal comfort** in the summer. There is no solar shading in the roof construction. When it is hot outside, the courtyard becomes very warm, in particular the upper parts. In those cases, the residents open the door to the roof terrace, which is accessed

on the second storey. Apartment windows facing the courtyard are not openable except for the row next to the elevator (not on entrance level). Many of the residents express that they would like to be able to open windows to the courtyard. The courtyard is unheated and is cold in during winter, with temperatures sinking to about 10-15°C in wintertime. The courtyard gives a slightly gloomy impression. There are particularly dark areas under the access balconies.

The **acoustics** in the courtyard are good, residents are not disturbed by noise from the courtyard in their apartments (no one has ever complained). There are acoustic panels under the access balconies and on the walls. The roof is rarely cleaned but inspected once a year. The plants in the courtyard (in pots) are taken care of by an entrepreneur.

SOCIAL ASPECTS

There are three main areas for social interaction, the courtyard, the common social/conference room, that is in connection with the courtyard, and the roof terrace. There are many different types of residents in the building, many families with children but also older people (several above 90). Consequently, many people are at home during the day. The residents know each other quite well, help each other with mail and watering plants etc, and there is a good dialogue within the housing cooperation. The cooperation is run by a board, requires almost daily attention, and the chairman and four other board members receive financial remuneration. Nevertheless, it is difficult to find people who want to devote time to the housing cooperation.

Several social gatherings are organised, both in the courtyard and in the conference room. Every year there is a Christmas party and Lucia celebration. A joint cleaning day is also organised, which ends with coffee or dinner. Even if you cannot participate in the cleaning part, you are encouraged to attend the social gathering afterwards. The courtyard and the conference room can also be booked for private parties, such as children's parties, but this is not an option for the roof terrace. There is little spontaneous activity in the courtyard and the furniture is rarely used, with the exception of some visitors such as cleaning staff helping elderly.

Around the courtyard, there are access balconies. For fire safety reasons, this area cannot be used for storage or to put furniture. Consequently, the balconies are only used for transportation and not for leisure. For economic reasons, it would be better if the area of the balconies and the courtyard could be used for apartments instead. Nevertheless, the access balconies contribute to the well-being of the residents. They facilitate contact between residents, and you get to know the people both on your own storey and on other storeys. In comparison with a building with 2-3 apartments on one storey, one gets to know many more people. Rooms that have windows towards the access balconies and the courtyard are usually kitchens and, in some cases, living rooms. Several residents have covered the windows facing the courtyard to create more privacy, in particular if it is a living room window and if it is close to the elevator. As previously mentioned, residents would like to have the opportunity to open windows towards the courtyard.

The roof terrace is an area that contributes to spontaneous social interaction and also sometimes for parties. It is possible to have your own garden lot to for growing flowers and greens, but there are two appointed residents that take care of the area. The flowers and vegetables that they grow are free to use for all residents.

Figure 4.17 Reimersholme. Up left and right: view over the inner courtyard. Down left: the glazed roof. Down right: the common garden on the roof.

4.6. KTH HEMMET

Address: Drottning Kristinas väg 43B, 114 28 Stockholm
Architect: Sandell Sandberg
Year of construction: 2016
Number the apartments: 54
Type of housing: rental student apartments

4.6.1. General information

The building Hemmet is eight storeys building with a glazed rooftop and glazed balconies on both long side facades. The glazed rooftop is rented by the Daylight dept of KTH and contain study places and lecture room for students. The rooftop has one inner part with indoor climate and one outer part without heating/cooling. The building has 54 apartments of 21-26 sqm, with glazed balconies, that are mainly intended for international students. The balconies are glazed, mainly for noise protection, and has inner wooden cladding, as opposed to the gable walls made of brick.

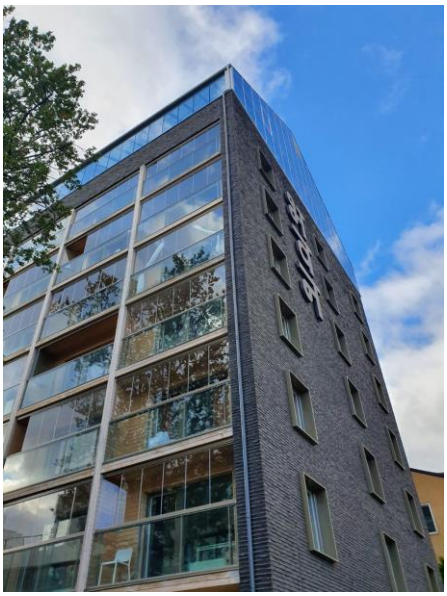


Figure 4.18 KTH Hemmet showing the glazed balconies and glazed rooftop.

4.6.2. Study visit

The study visit took place on October 7th, 2019, and two student and one employee from KTH were guiding.

GLAZED ROOFTOP AND LECTURE ROOM

The outer part of the glazed rooftop is unheated and has an automatic system to open and close the windows for ventilation. The intended use of the outer part in not clear, but there are some study places, see Figure 4.19, and it is also used for storage. According to the people using the outer rooftop, it becomes very warm in the summer, mainly since there is no shading system in place, but also since the automatic window opening system often fails (usually problems with the thermostat). One of the windows has been manipulated to stay open to avoid overheating, which has led to rain leakage. There is also some rain leakage in other locations in the outer rooftop, see Figure 4.10. During our visit, the temperature in the

glazed rooftop is agreeable, but according to our guides it will be too cold to use for studying already in two weeks. Students sometimes cover the window with paper to avoid glare when working in the outer roof part.

The inner part of the rooftop is similar to a box in a glazed roof (Figure 4.19). It contains a lecture room and has heating (heated air and radiators) and cooling, and curtains to protect from solar radiation and daylight.

Figure 4.19. Study places in the unheated part of the rooftop.

Figure 4.20. There were some problems with rain leakage around windows (left), glazed balconies (right).

STUDENT APARTMENTS WITH GLAZED BALCONIES

The glazed balconies are part of the student home and are separated from the upper storey by lecture rooms. The students in the student home would like to have access to the roof space, for example to relax and look at the view, but in order to get access they need to know a

student that works in the space. There is no common space for students in the building, but there are possibilities to re-organise, setting this up either in the ground storey or on the roof. Access to the roof would have to be arranged since the only way is through the lecture hall, as it is now.

The thermal climate in the apartments is sometimes too warm (extra fans are commonly used) but also sometimes too cold so extra heating devices have been used (commonly by students from warmer climates). The glazed balconies are mainly used as a part of the living area in spring and early autumn. The balcony of one of the interviewed students is on the 5th storey and almost faces north (NNW). In this case the balcony is too cold by mid-September and too warm in July-August. It is also quite windy at the location. The other student has a balcony facing more south (SSE) which is more used and generally the balconies facing more south are more furnished.

The balconies are approximately 70 cm deep. This is too small to be able to hang-out on the balcony (and smoking is prohibited). Consequently, it is more used to look at the view (for example nice sunsets), for airing (in particular after showering) and storage. Nevertheless, the balcony is appreciated. It is seen as positive to have a good contact with the outside, a rain sheltered outdoor area (one of the two students always keeps the glazing closed) and it does not limit the daylight in the apartment. The glazed balcony has a slight smell of wood due to the wooden panel. This is neither positive nor negative.

4.7. SJÖJUNGFRUN

Address: Sjöfruvägen 165, 907 51 Umeå
Architect: Anders Nyqvist
Year of construction: 2005
Number of the apartments: 32
Type of housing: housing cooperatives

4.7.1. General information

The housing cooperative Sjöjungfrun is located in Tomtebo in Umeå in the north-east of Sweden. The 5-storey building consist of two lamella buildings connected with a largely glazed yard with two lanterns on the roof, see Figure 4.21. The bottom four storeys consist of apartments and the fifth storey is occupied by storage space, technical space and a playhouse for children. The buildings have balconies facing both toward the yard and toward the outside. The construction and the façade are made of timber/wood, the deck on the bottom storey is made partly of wood, and the balconies have wooden flooring, see Figure 4.22. The design of the building is determined by the architect's vision aiming for a social and ecological living. More information on the building and the residents' perception can be found in Itai (2016).

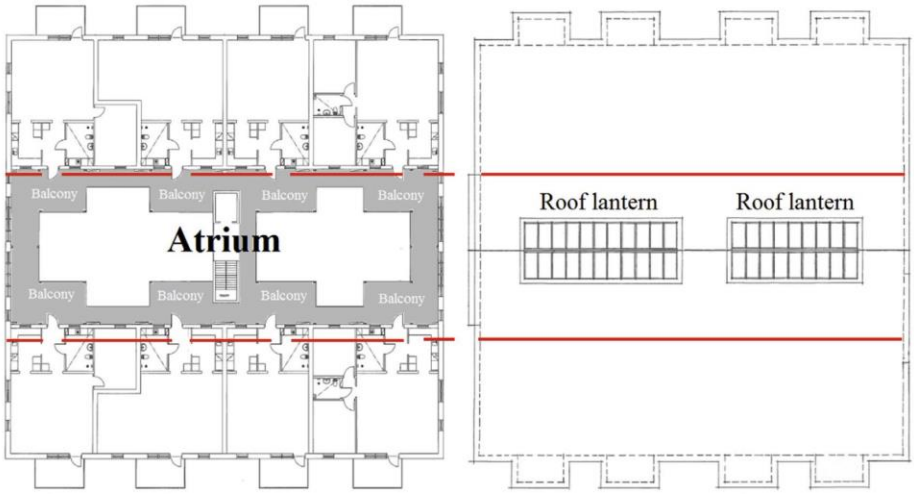


Figure 4.21. The glazed yard is surrounded by interior balconies and (left) on the roof there are roof lanterns (figure from Itai, 2016).

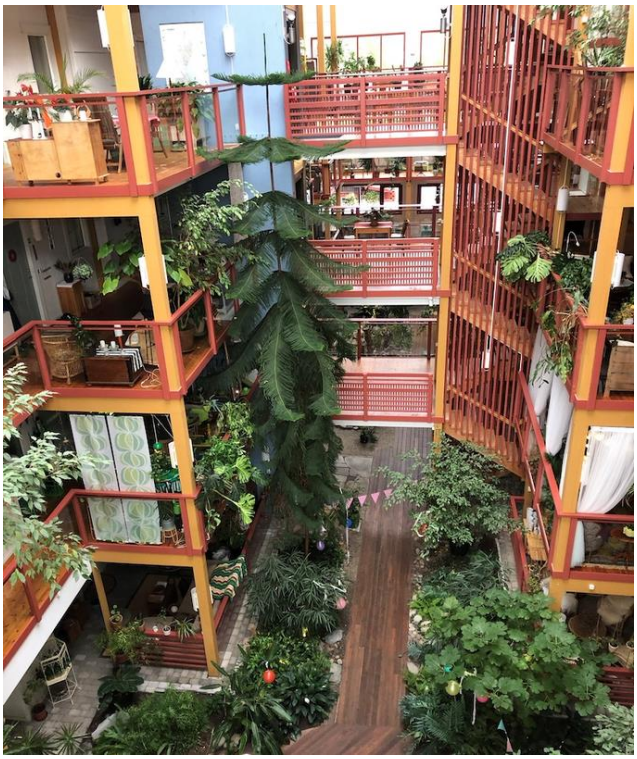


Figure 4.22. A view from the glazed yard showing balconies and floor area (photo from web site).

4.7.2. Study visit and interviews

The building was visited on the June 9th, 2019, and the study visit was facilitated by two members of the building cooperative association. On July 17th 2019, the architect Anders Nyquist was interviewed with provided valuable information on the background of the building.

TECHNICAL ASPECTS

This building is a success with regard to social aspects. Most of the technical parts work well but some, such as the original plan for sewage, were changed during construction or operation. The glazed roof originally had smoke hatches for **ventilation**, but these were not working appropriately for natural ventilation of the yard (it was too difficult to control the air flow). The ventilation of the yard has been improved by the addition of openable windows in the gables.

The **thermal comfort** in summertime is usually good, but people on the upper storey experience too high temperatures in the summertime, more than 30°C on the top storey and 25-26°C on the first storey. The experience is that there is approximately a two degrees difference between each storey. On the southern gable wall, shadings were added, but the operation was problematic, and it also reduced the daylight for the plants.

The glazed yard is heated in wintertime and when the exterior temperature is -20°C, the temperature in the yard is approximately 12-15°C. In general, the experience is that the temperature is slightly too low in wintertime and too high in summertime, but the opinions vary greatly. However, the residents are very pleased with the glazed yard and usually accept the temperatures (except for some residents on the top storey, in summertime). The winter temperature is a balance between energy use, thermal comfort and plant conditions.

The roof of the yard is made of transparent plastic but is not completely clear. Most of the **daylight** in the yard comes from the windows on the gables of the yard and the deep access balconies create some shaded areas. The residents state that it would be good if the yard was a bit brighter (which would have been the case with a more transparent glass roof). For some plants, there is too little daylight, for example the olive trees in the northern part of the yard have died while the trees in the southern part survive.

Rooms in the apartments that face the yard, and that are not on top storey, are too dark and some residents have added extra led lights in those rooms. Of the interview participants, the only resident who was completely satisfied with the daylight conditions in the apartment was the one living on top storey towards the south.

The **air quality** in the yard is good. The residents often have doors open to the yard so sometimes there is a smell of food in the yard, but this is not perceived as a problem. Nor is there a problem when the plants in the yard are fertilised once a year (residents are informed in advance). The **sound** level is generally good in the yard. You can hear people talking in other parts of the yard, but not exactly what they say, and there is no annoying noise penetrating into the apartments.

The **plants** inside the winter garden are mostly ornamental plants and trees, cherry trees, apple trees, currant bushes, rhubarb and one olive tree that is placed towards the south gable. Cultivation of own vegetables is done on the outside of the building and all plants inside the winter garden are managed by the garden group.

There has been an ongoing discussion on cultivation inside the yard, one person thinks there is too little space, another thinks that the building is not fitted for cultivation because the house is made of wood which could create problems with containers for plants, the plants require a lot water, plant diseases and bugs spread easily to other plants, also there is also too little light for the plants.

One resident, active in the garden group, states that it is important to think about what plants you propose for this type of building. The residents have had difficulties finding plants that can survive in the building due to insufficient daylight and it is also very important to avoid getting plant pest.

SOCIAL ASPECTS AND LIVING

The bottom storey garden is mainly used for transportation, parties, annual meetings and similar events. Children use the space to play and learn how to bike and some seniors use the space as well. There is no official booking system for the space, but it is possible to leave a note if someone want to use it for having a party for instance. There are 32 apartments in the building and the residents know each other. The yard is not open to the public, so the building feels like a small village where the people look out for each other and leave the doors open. If someone gets sick it is easy to get help with daily tasks as walking the dog, watering flowers and it is easy to borrow for example food from a neighbour. According to the experience of the architect, a good social environment in a building like this requires a minimum of 30 families (approximately 100 people) and has an upper limit of 50-60 families. The building should not be more than five storeys high and it is beneficial to be able to talk to the neighbours across the yard.

All interviewed persons said that they use the interior balconies much more than the bottom storey. Balconies are like an extra living room and are used for eating breakfast, dinner, inviting guests, reading, and you’re responsible for your own balcony. Residents have furniture and plants in pots on their balconies and one resident says that it feels like walking

through a neighbour's living room when you walk through the access balcony. One resident says that they do not even have a living room in the apartment, only on the balcony.

Everybody who lives in the building is informed about the vision of social living and also accept the particular conditions of the building, even though not all residents participate in activities. When recently having moved in, some people thought the closeness of the other residents was a bit strange and draw the curtains, but then quickly accepted it and adapted. When your apartment door is open, others are invited to come by, and when it is closed, the resident wants to be alone.

All interview participants state that it is easier to get in contact with neighbours in this building comparing to previous ones. Two residents state that they do not have a more socially active life since they have moved to this building and one resident means that they socialise more with neighbours, but the total interaction amount is the same as before. On the other hand, some residents feel more intellectually stimulated in this building compared to previous ones. One person means that in this building they can socialise with people from other professions that they normally would not have socialised with. Some residents mean that people who move into this building need to have a will to interact with neighbours to appreciate the building.

There are not many scheduled common activities but 3-4 times per year there are common parties (30-50 people), some meet for coffee regularly and some meet to make dinner once a week. Some residents express that they would have liked larger and more hard surfaces on the yard (instead of gravel and wood) since it would have increased the possible uses of the yard, mostly gatherings and playing. (On the other hand, compared to other case studies, Sjöjungfrun has no complaints on noise levels, which probably partly is due to few hard surfaces.)

The residents have several common working groups: garden group, IT, culture group, compost group, janitor group. Being part of a working group contributes to a lower maintenance cost, which decreases rents, but there is no system to even this out for residents. It is important to have engaged residents so when an apartment is sold, it is vital that it is sold to someone who wants to contribute to minimise the risk of having to increase rent and consequently so that people will not be forced to move out. Approximately one apartment is sold yearly. There is a policy document describing how to act when living at Sjöjungfrun.

Most residents are in their 60s in the building but persons and couples around 30, have started to move in. There are many single households and there are not many families with small children in the house. These families tend to move to own houses and the ones in this building live on ground level. The residents do not represent all the social groups in society. There are many academics (the building is close to the university), and some examples on professions that can be found in the building are nurses, doctors, teachers and engineers.

Some of the residents put forward that the winter garden is mostly used during cold periods and not so much during summer. The yard has a semi-outdoor climate and outdoor clothing is necessary in wintertime. However, since winters in northern Sweden are long, cold, dark and with snow, it is very valuable with this space, where for example children can bike and play (cats and dogs off leash are not allowed in the yard). In summertime, many residents travel to their summer houses, so they do not benefit from the advantages of the yard, nor are they affected by overheating.

To sum up the social part, all interviewed participants said that they appreciate the glazed yard and the social interaction between residents, and they do not want to move from the building.

5. EXCERPTS FROM RESIDENT SURVEY

The survey was made to quantify some of the questions in the interviews with the residents. This helped to clarify some of the aspects that were investigated and was also used for comparison between the different case studies. A majority of the surveys were filled in together with the residents after the structured interviews, so it was possible to discuss the survey results with the interviewees to obtain more information. The number of answers are not enough to provide statistically significant answers, so the discussions with residents are important. The survey questions are shown in Appendix B.

The answers from the survey are integrated into Chapter 4 and 6, but some comparisons between case studies are also presented here.

In Figure 5.1, the percentage of residents that answered “important” or “very important” to the question “How important is the thermal comfort in the glazed space for you?” are presented. There were four possible answers: “not at all important”, “of some importance”, “important”, “very important”. In the discussions that followed after this question, the thermal comfort is graded as important or very important both in cases when the thermal comfort is poor (for example in Augustenborg, glazed rooftop, where a majority rated negative on thermal comfort for all seasons) and good (for example Bovieran, where all rated positive on thermal comfort for all seasons). In both roof tops there were problems with overtemperatures in summertime and the Augustenborg, glazed rooftop is also perceived as too cold in wintertime. As described previously and in the following section, ratings are closely connected to expectations on thermal comfort in the glazed space.

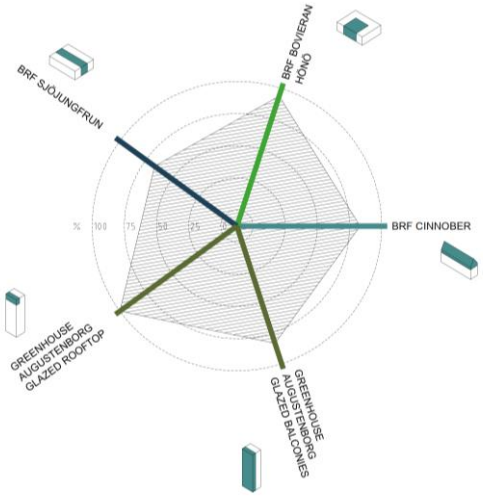


Figure 5.1. Percentage of residents that graded thermal performance important or very important.

The survey indicate that it generally is very important to be able to use the glazed space for social interaction and relaxing. (Figure 5.2. show percentage of residents that answered “important” or “very important” to the question “Is it important that the glazed space can be used for social activities and relaxing?”.) The glazed balconies at Augustenborg are private and part of the apartments, but residents say that when they have guests over, including neighbours, they mostly stay in the glazed balconies.

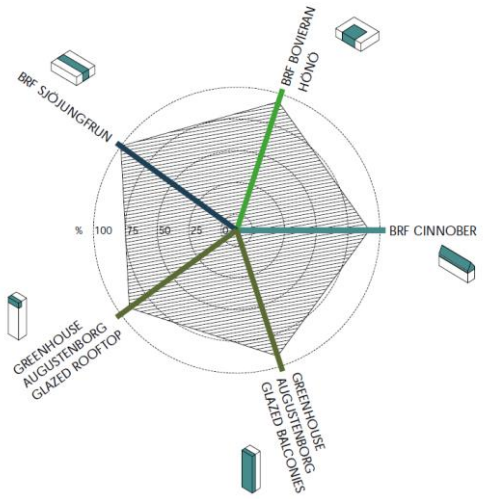


Figure 5.2. Percentage of residents that graded social interaction important or very important.

In terms of well-being, the residents answered the question "How much do you think the glazed space influence your well-being?" and in Figure 5.3 the percentage that answered "quite a lot" and "very much" are shown (other options are "not at all" and "a little"). The rooftop in Augustenborg was the place that contributed the least to well-being, probably for two reasons. It was not functioning well neither from a technical perspective, nor from a social perspective, and the purpose of the space was not really clear. Consequently, it was not used as much as the other areas. The other rooftop (Cinnober) contributed more to well-being and the residents also stated that they were proud of their rooftop.

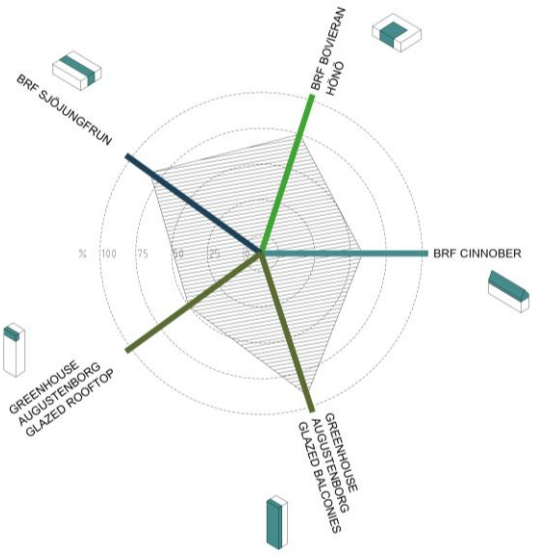


Figure 5.3. Percentage of residents that graded the impact of glazed space on well-being as "quite a lot" and "very much.

6. THEMATIC SUMMARY

Social interaction is a complex human mechanism and hard to predict, and the interviews and study visits are important parts of understanding the interaction between people and how this is facilitated by the building. In the following, the learnings gained from the interviews and study visits are thematically summarized. Some learnings from the surveys are also included. The interview templates are shown in Appendix A and the survey in Appendix B.

6.1. Thermal comfort

Most of the residents are satisfied with the thermal comfort in the glazed spaces in the spring and autumn time. There are mostly complaints about the thermal comfort in summer, but also in wintertime. The opinion on thermal comfort is strongly affected by the expectations, in particular for the winter case. If you expect to use the space as a normal room, a normal room temperature is expected, but if you see the space as a greenhouse for example, there is a larger acceptance for variations in room temperature and thermal comfort.

The glazed space is commonly designed to be cold in wintertime and with as little extra heating as possible (to save energy). In a few cases the winter temperatures are considered good ("it is better than being out in the snow" or "I'm already dressed for outdoor when I'm in the atrium"). However, in several cases, in particular for glazed spaces that are either private (balconies) or rooftops, there is a strong wish to increase the temperature in wintertime for better thermal comfort and larger flexibility in use. Extra heating has thus been installed in some spaces, more or less successfully. In the two atria that performed well with respect to social aspects, there were also some requests for increased winter temperatures. The atria winter temperatures were raised in one case, but not in the other, with consideration to energy/cost and due to the plants, that need a winter rest.

Most of the glazed spaces become warm in the summertime. The two largest spaces (Bovieran and Gårdsåkra) had good thermal comfort in the summertime too. Bovieran has an additional glass wall facing north, automatically openable hatches in the roof, solar control coating on windows and large amounts of plants, soil and moisture. Gårdsåkra has openable roof windows and movable solar shading that are automatically controlled and large thermal mass in the flooring material of the atrium which is mainly concrete. There seems to be a connection between high thermal mass in the glazed space and less problems with thermal mass. This will be further investigated in the project using numerical simulations.

The glazed balconies and the rooftops became very warm in summertime. One rooftop had movable solar shading and openable hatches, but it did not (yet) run as intended. The balconies were controlled by the residents and a good thermal comfort was achieved once the windows were opened. One glazed rooftop was turned into an apartment (without the glazed roof) since the thermal comfort was only acceptable to the users during autumn and spring.

Some tenants do not consider high summer temperatures in an atrium a problem since they spend more time outdoor in summer, or even go to summer houses etc. over the summer.

The ventilation strategy for the glazed spaces varied a lot. Sometimes it became part of the apartment ventilation in summertime when the apartment doors were opened to the atrium and on the opposite side (Musteriet, Bovieran, Sjöjungfrun). This created a cooling draught through the apartment, in particular if it was possible to open doors to the outside in the atrium as well. One building (Sjöjungfrun) had a large temperature gradient in the atrium in the summer. Consequently, the residents at the upper storey were dissatisfied in summertime and the ones on the lower storey were satisfied. There had been attempts to solve this issue by

installing movable solar shading and openable hatches, but the matter had not been completely resolved.

6.2. Daylight

Most people thought that the amount of daylight in the glazed space was good and they also considered the daylight aspect to be important (rather important/very important). There are darker corners in some glazed spaces, but these were not mentioned as a problem.

For the buildings with an atrium, there are different opinions on whether they are satisfied with the level of daylight in their apartments. This depends to a large extent on the design of the building. The glazed atrium usually has access balconies that serves as a transport to the apartments. These decrease the light that enters the apartment from the glazed space, and particularly apartments on the lower levels have less daylight in the apartment. In addition, people living in apartments that are not affected that much by the lack of daylight (usually the ones living in apartments on the upper level of the building), tend to grade admittance of daylight in the apartment less important (in addition to the perception of adequate levels of daylight). Opposite to them, the ones that have darker apartments (usually the ones living in apartments in the lower part of the building), tend to say that access to daylight is a very important.

In some of the buildings, the access balconies had cut outs in the proximity of the apartment windows in order to provide more daylight to the apartments, see Figure 5.1. The major benefit of this seems, however, to be that the residents feel less exposed, since people cannot get close to the windows. Without the cut out, the residents often covered their windows and, consequently, even less daylight entered the window. The level of coverage is also dependent on the social environment; better social environment, less coverage). At the study visits, the two atria with least daylight had no glazed walls and little glazed roof area (all buildings were 2-4 storey buildings).

Figure 5.1. Solid access balconies create darker areas (left) while cut outs provide more light (right).

In general, daylight conditions were in most study cases good, and in some cases perceived better than we anticipated. However, if the general feeling about the building is good, there

seems to be less incentive to complain about daylight, in particular if the building is a housing association.

6.3. Humidity and air quality

The air quality in the glazed spaces were generally considered good. There were little or no complaints about smells. Large amount of plants in the glazed space, can result in high levels of relative humidity in the air. If the glazing is not sufficiently warm on the inner surfaces in wintertime (have poor thermal properties), this can lead to condensation and problems with moisture damage. The solutions have been increased ventilation (with slightly heated air), air flow towards the windows, better windows, and decreasing moisture production by changing watering strategy for the plants. The larger buildings have air outlets aiming at the roof windows that helps prevent condensation on the glass.

There was a large variety in ventilation strategy in the case studies. In some cases, there also seemed to be a poor understanding of how the residents would like to use the space and what kind of ventilation was appropriate for the use. In particular the strategy for natural ventilation (airing) was troublesome.

Figure 5.2. Warm air can be blown toward the glass ceiling in wintertime to prevent condensation (Höstvetet).

6.4. Acoustics

In some cases, there were complaints about poor acoustics in the common glazed spaces, which also affected the sound levels in the apartments. The glazed spaces with a smaller amount of hard surfaces in the space had less complaints about noise levels. The building with the most problems had a concrete floor, few plants and school children that used the glazed space when transporting between different activities.

6.5. Social and human aspects

The social and human aspects and the impact of the building. However, it is important to remember that the people are the most important in order to get social interaction and the building can to some extent support the interaction.

If there is a clear **expectation** of interaction, either through information when considering moving to the premises, or through discussions with neighbours, this will facilitate interactions. In many of the studied cases, activities were highly dependent on one or a few individuals and thus, engaged persons are highly valuable. There were no economic benefits for these individuals, but possible contributions were discussed in several cases.

In order for a space to be used, there has to be a **purpose**. Just to provide a space for social activities has not been proven successful. Spaces that seem to work are for example a common entrance, possibility for children to play (if the acoustics allow it) or private areas (in connection to the apartment). If there are several entrances, there is less control of persons coming into the common space and there are also less opportunities to meet. A common space on the bottom storey also seems more widely used than a space on the upper storey since you can pass it on your way out. In one building, there was a social space on both the bottom and top storey and one tenant described the advantages of the bottom storey room as "The room is also easier to use for common activities because it is located on the ground level, it is easy to stop there for a cup of coffee with other residents on your way out" (Interview 4 Augustenborg).

The sense of **belonging** seems to be central and also **feeling safe** in the glazed space. If a part of the glazed area can be occupied and considered private, it is sometimes more used. In for example Sjöjungfrun, the access balconies were very wide and served as an extra living room. This was much appreciated and there were a lot of social contact across the central winter garden. Even if there is a well-designed common area in the building, some people tend to stay close to their home. However, fire regulations often prohibit people from having furniture on interior access balconies.

Common spaces that were designed for social activities but without a clear purpose or an engaged person rarely worked. The possibility of using the space privately for parties, with a kitchen or water, seems to be one of the more popular solutions. The organisation of the booking were either more formal, by for example a Facebook group or just putting up a note, and in one case it was possible to use the room privately but not possible to stop others from using the room. (This was a glass roof that also opened up to a balcony.)

When the space is on top of the building it cannot be controlled and overviewed in the same way as a central atrium or similar. Problems with unknown people using the space, with smoking and with poor cleaning were problems that occurred in the roof spaces. In one case, the glass roof was used by teenagers and even though they were not disturbing, they made other people feel less welcome. This would probably be less of a problem if the incentive or purpose to be in the space was stronger, such as in an entrance, in a laundry room or in an area in connection to your apartment, provided that you feel safe.

Beyond the needed infrastructure that facilitates social activities there are other factors, not so evident at first glance, that influence the dynamics of the social interaction. For example, at Gårdsåkra, the provided infrastructure for social interaction was highly developed (a glazed covered pedestrian street, little greenery, big common centred semi-public space, housing in connection with schools and kindergartens). But the reality was that the space hardly worked to promote social gatherings. One reason could be that the **ownership** of the apartments has an impact, being rental apartments in Gårdsåkra. People might become less engaged with the common spaces when do not own the apartments. This concerns both in taking care of the common spaces and being involved in social activities. In the study, the project that worked well socially were the four housing cooperatives and one rental building. At the housing cooperative Sjöjungfrun, they had agreed upon a policy document to provide a common framework for the interaction between the residents and expectations on participation in common activities. The three projects that worked less well socially were all rental. Time also seems to be an important parameter. A well-functioning social environment can gradually disappear if not tended to.

To sum up, important aspects to consider when working with social interaction in residential buildings are: expectations, purpose of space, sense of belonging, feeling safe and ownership.

6.6. Geometry and size

The geometry affects the architectural and engineering aspects of the space. First of all, the general size of the building cannot be too large. There are different opinions of the size. The architect of one of the projects that works well socially, Sjöjungfrun, suggests a maximum of 60 persons (25-30 families) and the Sjöjungfrun building has 32 apartments. At Bovieran, also socially successful, there are 48 apartments. Two projects that were large and did not function well socially are Höstvetet (71 apartments) and Gårdsåkra (126 apartments).

There are several factors to consider when deciding the size of an atrium. It is important to be able to get an overview of the whole atrium from the access balconies, therefore balconies close to each other is beneficial. The feeling of being safe is also enhanced if you get a good overview of the space, and if you can see who is coming into the building. On the other hand, the floor area of the atrium has to be of a certain size to be useful as common space. It is valuable if the atrium can be used as a party/dinner room for the tenants to use for common parties. The common atrium is also seen as buffer zone, with respect to both climate and people.

An interesting aspect of the geometry is that people often appreciated the size of their atrium and had not considered if it should be larger or smaller until we asked.

6.7. Urban farming

In the investigated spaces, only private balconies were actually used for farming. The atrium had plants but not for farming. The plants were cared for by the residents or by contracted firms. One reason for not having farming in the atrium was the risk of insects and pests. There were cases were the residents wanted the possibility to grow their own plants and not only have decorative plants. They also thought it could be a good way to build relations. Daylight is essential for the plants and in one atrium they had to substitute some plants to more resilient plants with respect to daylight. Plants that die also cause some frustration so a proper design concerning plants, daylight, temperature conditions and care is important.

The large private glazed balconies in Augustenborg were very appreciated and used both for farming and decorative plants. The balconies were prepared with large containers with soil, piping for watering the plants and an adjacent utility room for preparation of plants. Most interviewees used the balconies for farming and flowers, and as an extra living room. The glazed balcony was much more used than the adjacent open balcony, which was perceived as windy.

Figure 5.3. Glazed balcony with room for farming.

In general, not everybody wants to cultivate plants, but most people seemed to enjoy having a garden in connection to their apartment. In the cases where plants were cared for in common, this was mostly perceived as an activity that built relationships rather than causing conflict between residents.

7. LEARNINGS CONCERNING METHODOLOGY

Collecting information from different sources, documenting, analysing and concluding has provided some challenges in the project. The type and amount of information available for each case study has been very different, and contact persons have been very important. In the following, some learnings from the project concerning the methodology are provided to support future projects that need to collect a large amount of technical data and personal opinions.

TECHNICAL DATA
It is clear that it is crucial to have a wide network of contacts linked to each case study, as information is distributed among a number of stakeholders and it is often unclear who is responsible for a certain aspect of the building's technical function. The tenant-owner associations have proven to be a good source of contacts to persons in charge of the building's management, and often have an overview of the problems that have arisen over the years.

INTERVIEWS WITH RESIDENTS
At least two persons conducted the structured interviews with the residents, but it was still difficult to write proper notes. Consequently, the structured interviews with residents were recorded. This also helped so that the digital forms of the interviews could be complemented after the interviews, with all the feedback and information that was provided by the residents.

Skype interviews required little technical work in advance. There were some problems to find technical solutions that worked for all on-line interviews, why both private Skype and private Facetime had to be used.

Residents are of course the best source to obtain information on the social aspects and on the use of the building. However, since residents are closely connected and committed to the building, they can give a non-representative and embellished view of the building (and the opposite in some cases). Therefore, several persons in a building should be interviewed and interviews should be supplemented with study visits to get a broader view of the actual use of the glazed space.

QUANTIFIABLE SURVEY WITH RESIDENTS
It is good to fill in the survey together with the residents instead of handing or sending it. In one of the buildings, due to lack of time, we printed out the survey and we asked the residents (four persons) to fill in the papers by themselves and to send it later (photos or scans of the papers to be sent to one of our e-mail account). No person sent the papers. We managed to reach them by phone later which resulted in two out of four surveys. Misinterpretations of questions also decreased when filling in the survey together.

STUDY VISITS
Having a direct experience of the building gives a deeper understanding of the space and its use. Being two or more at the study visit helps to be more objective and efficient, and photos is a valuable support to remember and for written communication.

GENERALLY
A good practice is to digitally document the answers, the findings, personal thoughts, etc. very shortly after the interviews and the study visits took place (with a fresh memory). Otherwise, there is the risk of forgetting important details.

In order to compare information between different study objects and with different researchers who collect data, it becomes crucial to always have a definition linked to each data point. This is particularly important if architectural parameters such as visibility,

integrity or activity are to be quantified. A workshop with the group of researchers involved in interviews and study visits, was very valuable to discuss and analyse the results.

8. CONCLUSIONS AND DISCUSSION

The main aim of the Spaces project is to support architects in the design of well-functioning glazed geometries. This report presents the findings of the first part of the Spaces project; "Inventory of geometries and functions by study visits and interviews". The interviews, study visits and surveys have provided an overview of the challenges and opportunities of glazed spaces and have shown a number of areas that needs to be addressed in the Spaces project.

The early design stages of a project are essential, in particular with respect to how the residents want to use the space, i.e. the purpose of the space, but also with respect to thermal comfort. When designing a space, the human and technical aspects need to be harmonised. The actions of the people that live in the building is what makes the building (and the glazed spaces) work and the building structure can only support, or hinder, their actions. Therefore, clear expectations on the intended use of the space, in combination with an organisation, is very supportive for a well-functioning, social, glazed area.

For thermal comfort, the expected level of comfort is important for the experience of the space. If the space looks like it is indoor, the expectation is room temperature in wintertime and, consequently, people are disappointed if it's much colder. The temperature in the glazed space depends to a large degree on shading and ventilation but also on the thermal mass of the materials in the glazed space. This is further investigated in part 2 of the project.

Daylight levels are usually considered good in the glazed spaces. However, there are darker areas, in particular under access balconies, and this also affects the daylight levels in the apartments. Additional problems arise when there is an integrity problem and residents cover windows adjacent to the glazed space. Lower floors are more affected by a lack of daylight than upper floors.

The air quality is usually perceived as good in the glazed spaces. The most common problem connected to air quality is a high level of moisture in the air, which results in condensation on windows with visibility problems or dripping water.

For social interaction, it is clear that even with a developed design for social interaction (such as common areas, kindergarden, private areas in connection with glazed space), the interaction might fail. Social activities are highly dependent on individuals and thus, engaged persons are highly valuable to obtain a social environment. In addition, a clear purpose of the space and a sense of ownership is beneficial to the social environment. In this study, the projects that worked well socially were the four housing cooperatives and one rental building. The three projects that worked less well were all rental.

There are slightly different opinions of the optimal size to achieve social interaction. The architect of one of the projects that works well socially, Sjöjungfrun, suggests a maximum of 60 persons (25-30 families) and at Bovieran, also socially successful, there are 48 apartments. Two projects that were large and did not function well socially are Höstvetet (71 apartments) and Gårdsåkra (126 apartments).

In part 2 of the paces project (Wahlgren et al. 2021), the learnings from the study visits, interviews, resident surveys and literature study are further analysed and the remaining parts for glazed geometries are treated, which are; obstacles that exist in current practice and Swedish legislation, methods to evaluate the performance early in the design process and guidance for architectural design and increased social interaction.

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10. APPENDIX

A. INTERVIEW TEMPLATE
B. SURVEY QUESTIONS

A. INTERVIEW TEMPLATE (Originally in Swedish.)

1. General questions

1.1 Do you usually spend a lot of time at home? For example. pensioner, maternity leave, etc.

1.2 Is it ok to ask about your age?

1.3 How long have you lived in the house?

1.4 Why did you choose to live here?

2. Technical questions

2.1 How do you experience the glazed space when it comes to:

2.1.1 Temperature (during the different seasons)

2.1.2 Do you think it is too hot / cold and when in that case (night / day, seasons)

2.1.3 Acoustics

2.1.4 Humidity

2.1.5 Ventilation / problem with drafts

2.1.6 Air quality (eg bad air, odors, mold)

2.1.7 Light

2.1.8 Do you think that the glazed space affects the light in the apartment?

2.1.9 What works and does not work with the glazed space?

3. Own use of space

3.1 How do you use the glazed space? (Activities)

3.2 How often do you use it? When in the day? When in the year?

3.3 What part of the glazed space do you use?

4. Common use

4.1 How many people usually stay in the glazed space?

4.2 How do people use the glazed space?

4.3 How often do you use it? When in the day? When in the year?

4.4 Who do you think uses the glazed space the most?

4.5 Is there a booking system?

4.6 Is it possible to be at peace in the glazed space?

4.7 Do you think that glazed space helps build relationships with your neighbors? Or create conflict?

4.8 Do you think that the glazed space would be used / experienced in a different way if it had a different size / shape (longer, more square, larger)?

4.9 If you had changed the geometry, how would you have changed and why?

(We describe the consequences of the geometry change) is it still relevant?

5. Plants

5.1 What type of plants are there?

5.2 Is there a possibility to cultivate here? Do people usually do that?

5.3 Do you cultivate? Why (environmental aspects, hobbies, etc.)? What type of plants?

5.4 Are there any problems with pests?

5.5 Do you prefer cultivation/vegetables or plants that you do not need to take care of?

5.6 (If there is cultivation) Do you think cultivation helps build relationships with your neighbors, or does it create conflict?

6. Social

6.1 How often do you socialize with your neighbors?

6.2 Would you like to spend more or less time with your neighbors?

6.3 Where in the house do you socialize with your neighbors?

6.4 How often are joint activities organized (cleaning day, party, boules, games, etc.) and by whom?

6.5 Do you feel that you have had a more socially active life since you moved here?

6.6 Do you feel that you have received a higher social and intellectual stimulus since you moved here?

6.7 Is it easier or harder to get in touch with neighbors in this building compared to before? Why, why not?

6.8 Have you had more deep contacts (and not just superficial contacts) with your neighbors in this building compared to before?

6.9 Do you feel more secure in life after moving to this building compared to your previous residency? Why?

6.10 Do you ever feel involuntarily lonely after moving in here (more or less compared to your previous home)?

7. Generally

7.1 What do you like most / least about this building?

7.2 If you choose to move from here, why would that be?

7.3 What would you miss if you moved?

7.4 Is there anything you think we should have asked about that you think is important?

Thank you for your participation/

The Spaces team

B. SURVEY QUESTIONS (Originally in Swedish.)

Circle the alternative that fits best.

1. THERMAL COMFORT

Thermal comfort describes how a space is perceived by humans in terms of temperature. The thermal comfort depends mainly on air temperature but also on the temperature of the surrounding surfaces (eg window glass and floor) and draft.

How do you experience the thermal comfort in the glazed space?

During **winter**?

1 (Much worse than desired) 2 3 4 (Exactly as desired)

If worse, what is the main cause?

Too hot too cold too draughty

During **spring**?

1 (Much worse than desired) 2 3 4 (Exactly as desired)

If worse, what is the main cause?

Too hot too cold too draughty

During **summer**?

1 (Much worse than desired) 2 3 4 (Exactly as desired)

If worse, what is the main cause?

Too hot too cold too draughty

During **autumn**?

1 (Much worse than desired) 2 3 4 (Exactly as desired)

If worse, what is the main cause?

Too hot too cold too draughty

Comment:

How important is thermal comfort?

1 (not at all important) 2 (of some importance) 3 (important) 4 (very important)

Comment:

2. AIR QUALITY

Poor air quality can feel unfresh or stale. You can also sense the smell of, for example, smoke, emissions from materials, mold or soil odor, or the air can feel dry or humid.

How would you rate the air quality in the glazed space?

During **winter**?

Bad Good

If bad, what is the main cause?

Trapped air Smells Moist air Dry air

During **spring**?

Bad Good

If bad, what is the main cause?

Trapped air Smells Moist air Dry air

During **summer**?

Bad Good

If bad, what is the main cause?

Trapped air Smells Moist air Dry air

During **autumn**?

Bad Good

If bad, what is the main cause?

Trapped air Smells Moist air Dry air

Comment:

How important is the air quality in the glazed space?

1 (not important at all) 2 (of little importance) 3 (important) 4 (very important)

Comment:

3. DAYLIGHT

How would you rate the availability of daylight is in the glazed space?

1 (very bad) 2 (quite bad) 3 (quite good) 4 (very good)

How important is it that there is daylight in the glazed space?

1 (not important at all) 2 (of little importance) 3 (important) 4 (very important)

How good is the light in your apartment (the glazed space can sometimes make it dark in the apartment)?

1 (very bad) 2 (quite bad) 3 (quite good) 4 (very good)

Comment:

4. SOCIAL ACTIVITIES AND RELAXATION

How much do you use the glazed space for social activities or relaxation?

During **winter**?

1 very often (every day) 2 quite often (several times a week)

3 not often (a few times a month) 4 almost never

During **spring**?

1 very often (every day) 2 quite often (several times a week)

3 not often (a few times a month) 4 almost never

During **summer**?

1 very often (every day) 2 quite often (several times a week)

3 not often (a few times a month) 4 almost never

During **autumn**?

1 very often (every day) 2 quite often (several times a week)

3 not often (a few times a month) 4 almost never

Comment:

Is it important that the glazed space can be used for social activities and relaxation (instead of just ventilation, storage, cultivation, etc.)?

1 (not important at all) 2 (of little importance) 3 (important) 4 (very important)

Comment:

5. CULTIVATION

How often are you in the glazed space to cultivate (flowers, edible plants, spices, etc.)?

1 very often (every day) 2 quite often (several times a week)

3 not often (a few times a month) 4 almost never

How satisfied are you with the cultivation possibilities in the glazed space?

1 (not at all satisfied) 2 (somewhat satisfied) 3 (satisfied) 4 (very satisfied)

Comment:

6. TRANSPARENCY

How much does the glazed space affect your sense of the area/outlook/overview?

(Transparency means that you should, for example, be able to look out over the city or that you should be able to look out over your yard and get a good overview of your surroundings.)

1 (not at all) 2 (a little) 3 (quite a lot) 4 (very much)

Comment:

7. HEALTH / WELL-BEING

How much do you think the glazed space affects your well-being?

1 (not at all) 2 (a little) 3 (quite a lot) 4 (very much)

Comment:

8. MATERIALITY / DESIGN / QUALITY

Are you satisfied with the quality and design of the glazed space?

1 (not at all satisfied) 2 (somewhat satisfied) 3 (satisfied) 4 (very satisfied)

Comment:

9. GEOMETRY

Are you happy with the size of the glazed space?

1 (not at all satisfied) 2 (somewhat satisfied) 3 (satisfied) 4 (very satisfied)

Comment:

10. INTEGRITY

Do you feel exposed when you are in the glazed space?

1 (not at all) 2 (a little) 3 (quite a lot) 4 (very much)

Comment: